National Beef Quality Audit – 2016:
Survey of carcass characteristics through instrument grading assessments


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ABSTRACT: The instrument grading assessment portion of the National Beef Quality Audit (NBQA) – 2016 allows the unique opportunity to evaluate beef carcass traits over the course of a year. One week of instrument grading data was collected each month from 5 beef processing corporations encompassing 18 facilities from January 2016 through December 2016 (n = 4,544,635 carcasses). Mean USDA yield grade (YG) was 3.1 with 1.37 cm fat thickness (FT), 88.9 cm² LM area, 393.6 kg HCW, and 2.1% KPH. Frequency distribution of USDA YG was 9.5% YG 1, 34.6% YG 2, 38.8% YG 3, 14.6% YG 4, and 2.5% YG 5. Increases in HCW and FT since the NBQA–2011 were major contributors to differences in mean YG and the (numerically) increased frequency of YG 3, 4, and 5 carcasses found in the current audit. Mean marbling score was Small75, and the distribution of USDA quality grades was 4.2% Prime, 71.4% Choice, 21.7% Select, and 2.7% other. Frequency of carcasses grading Prime on Monday (6.43%) was numerically higher than the average frequency of carcasses grading Prime overall (4.2%). Monthly HCW means were 397.6 kg in January, 397.2 kg in February, 396.5 kg in March, 389.3 kg in April, 384.8 kg in May, 385.0 kg in June, 386.1 kg in July, 394.1 kg in August, 399.1 kg in September, 403.9 kg in October, 406.5 kg in November, and 401.9 kg in December. Monthly mean marbling scores were Small73 in January, Small80 in February, Small81 in March, Small77 in April, Small70 in May, Small67 in June, Small70 in July, Small73 in August, Small74 in September, Small76 in October, Small80 in November, and Small79 in December. Both mean HCW and mean marbling score declined in the months of May and June. The month with the greatest numerical frequency of dark cutters was October (0.74%). Comparison of overall data from in-plant carcass and instrument grading assessments revealed close alignment of information, especially for YG (3.1 for in-plant assessment versus 3.1 for instrument grading) and marbling (Small70 for in-plant assessment versus Small75 for instrument grading). These findings allow the beef industry access to the greatest volume of beef value–determining characteristics for the U.S. fed steer and heifer population than ever reported, resulting in potentially more precise targeting of future quality and consistency efforts.

Key words: beef quality, carcass, instrument grading, meat grade, quality grade, yield grade


INTRODUCTION

The first National Beef Quality Audit (NBQA) was conducted in 1991 to target areas of improvement as well as to establish a baseline for future
studies. Following the first NBQA, successive audits were conducted every 5 to 6 yr to provide the industry with a current representation of the fed steer and heifer beef supply as well as to continue to evaluate progress on targeted areas of improvement.

One of the key messages from NBQA–2005 was the need to implement instrument grading in the industry. With the increasing number of plants that had implemented instrument grading, the NBQA–2011 was the first to include the instrument grading assessments (Gray et al., 2012), which, for the first time, allowed seasonal trends in beef carcass traits to be evaluated. Instrument grading was approved for official USDA measurement of LM area in 2001 as well as yield grade (YG) and marbling score in 2007 (Mafi et al., 2014). Accuracy, precision, and producer confidence of USDA YG and quality grade (QG) were found to be greatly improved due to the transition to instrument grading (Belk et al., 1998; Cannell et al., 1999; Steiner et al., 2003a,b; Emerson et al., 2013).

For the NBQA–2016, beef carcass characteristics were obtained using traditional in-plant assessments (Boykin et al., 2017) and with instrument grading information. With more widespread adoption of instrument grading in the U.S. beef industry, collecting such information complements the historic data gathered through in-plant assessments. These data provide a unique opportunity to evaluate the value- and quantity-determining characteristics of the fed steer and heifer beef industry in a magnitude unparalleled.

**MATERIALS AND METHODS**

Institutional Animal Care and Use Committee approval was not required for this study because no live animals were involved.

**General Overview**

Representatives who manage instrument grading programs from 5 beef processing corporations were contacted to obtain carcass data from their plants. These representatives agreed to share these data with us so long as all information was merged and it would not be revealed by individual plants or corporations. The corporations represented 18 federally inspected beef processing facilities, and information was collected from 1 wk of production over a 12-mo period (January 2016 through December 2016). There were 4,544,635 beef carcasses represented in the overall data set.

Information obtained included harvest date, grade date, sex class (steer, heifer, and other), apparent breed type (native [predominately British/Continental European breeding without dairy influence] and dairy [predominately Holstein breeding]), marbling score, defects (hard bone, blood splash, and dark cutter), certified programs, fat thickness (FT), LM area, HCW, and KPH percentage. The value obtained for KPH value was that used by each facility. Once data were received, USDA QG and YG were calculated from these factors (USDA, 2016).

Data were received in Microsoft Excel (Microsoft Corporation, Redmond, WA) spreadsheets from all 5 corporations. All corporate identities were removed, and the spreadsheets were compiled.

**Statistical Analyses**

All analyses were performed using JMP software (version 10; SAS Inst. Inc., Cary, NC; 1989–2007) and Microsoft Excel for Mac 2016 (Microsoft Corporation). The Fit Y by X function was used for ANOVA, and least squares means comparisons were conducted using Student’s t test. Correlations were determined using the multivariate functions. Frequency distributions, means, SD, and minimum and maximum values were determined using the distribution function.

**RESULTS AND DISCUSSION**

**In-Plant Carcass Assessment and Instrument Grading Comparison**

The in-plant assessment (Boykin et al., 2017) included 9,106 carcasses, whereas the instrument grading included 4,544,635 carcasses (Table 1). Although the two assessments were not statistically analyzed, it is surprising how close some of the QG and YG factors were to each other. This is especially evident where the marbling scores were only five one-hundredths of a unit apart.

Collecting carcass information through both methods allowed comparison between the 2 and gives credibility to previous NBQA that solely used in-plant carcass assessments. The comparison of frequencies for various carcass traits between the in-plant and instrument grad-
ing (data not reported in tabular form) showed a similar percentage of carcasses that exceeded 477.3 kg (5%), percentage of carcasses that were Choice or Select, YG 2 or 3 (70.7% and 69.7%, respectively), and percentage of non-conforming (18.2% and 18.6%, respectively). Similar sex class frequencies were observed in both assessments. The instrument grading results reported a higher correlation between FT and marbling score \( r = 0.36 \) than the in-plant assessment \( r = 0.24 \); Boykin et al., 2017). Additionally, the in-plant results identified a greater frequency of dark cutters (1.9%) than the instrument grading data set (0.5%). Additionally, instrument grading data were not collected from all facilities surveyed in the in-plant assessment.

The instrument grading assessment reported a slightly decreased frequency of YG 2 (−2.1% points) and an increased frequency of YG 4 (+2.6% points) when compared with the in-plant data set (Fig. 1). When comparing the in-plant and instrument QG frequencies (Fig. 2), the in-plant assessment detected a slightly
lower frequency of Choice carcasses (−4.1% points) and a slightly higher frequency of Select carcasses (+1.5% points). The similarity of results between the in-plant carcass and instrument grading assessments gives confidence to either method of determining a nationwide overview of beef carcass characteristics, which has been one of the primary features of the NBQA.

Instrument Grading Information:

Instrument grading means for NBQA–2016 are presented in Table 2. The mean USDA YG was 3.1 with a distribution of 9.5% YG 1, 34.6% YG 2, 38.8% YG 3, 14.6% YG 4, and 2.5% YG 5 (Fig. 1). In comparison, the YG distribution from NBQA–2011 (Gray et al., 2012) was 15.7% YG 1, 41.0% YG 2, 33.8% YG 3, 8.5% YG 4, and 0.9% YG 5. For the present study, mean YG factors (Table 2) were 1.37 cm FT, 88.9 cm$^2$ LM area, 393.6 kg HCW, and 2.1% KPH. For the NBQA–2011 (Gray et al., 2012), mean YG factors were as follows: 1.20 cm FT, 88.45 cm$^2$ LM area, and 371.28 kg HCW (Table 3). Similar to the in-plant carcass assessment results (Boykin et al., 2017), the increases in HCW and FT from NBQA–2011 were the major contributors to differences in mean YG and the (numerically) increased frequency of YG 3, 4, and 5 carcasses found in the current audit. Mathews and Haley (2015) attributed several factors to the increased weights including heavier cattle entering the feedlots, extended days on feed, and the greater proportion of steers versus heifers in the slaughter mix.

Since the NBQA–2011, some USDA certified programs have updated their specifications to account for increased carcass size and weight (Certified Angus Beef LLC, 2014). The current acceptable HCW range is 272.2 to 477.3 kg (USDA Market News Service, 2017). The present study recorded 95.0% of carcasses within this HCW range. Gray et al. (2012) reported 95.1% of carcasses within the HCW then-current range common to USDA certified programs (272.2 to 453.6 kg), compared with the 88.4% in the current study. This 6.7% point decrease in carcasses within the acceptable HCW range is consistent with the increase in mean HCW.

**Table 2. National Beef Quality Audit – 2016:** Instrument grading means, SD, and minimum and maximum values for USDA carcass grade traits

<table>
<thead>
<tr>
<th>Trait</th>
<th>n</th>
<th>Mean</th>
<th>SD</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>USDA yield grade</td>
<td>4,391,142</td>
<td>3.1</td>
<td>0.90</td>
<td>−2.0</td>
<td>9.3</td>
</tr>
<tr>
<td>Fat thickness, cm</td>
<td>4,532,166</td>
<td>1.37</td>
<td>0.55</td>
<td>0.0</td>
<td>6.35</td>
</tr>
<tr>
<td>HCW, kg</td>
<td>4,516,858</td>
<td>393.6</td>
<td>57.56</td>
<td>136.1</td>
<td>719.1</td>
</tr>
<tr>
<td>LM area, cm$^2$</td>
<td>4,508,422</td>
<td>88.9</td>
<td>12.74</td>
<td>19.69</td>
<td>219.3</td>
</tr>
<tr>
<td>KPH, %</td>
<td>3,877,100</td>
<td>2.1</td>
<td>0.40</td>
<td>0.0</td>
<td>8.5</td>
</tr>
<tr>
<td>Marbling score$^1$</td>
<td>4,544,634</td>
<td>475</td>
<td>110.73</td>
<td>100</td>
<td>1,099</td>
</tr>
</tbody>
</table>

$^1$100 = Practically devoid$^{00}$; 300 = Slight$^{00}$; 400 = Small$^{00}$; 500 = Modest$^{00}$; 700 = Slightly Abundant$^{00}$; 900 = Abundant$^{00}$ (USDA, 2016).

**Table 3. National Beef Quality Audit (NBQA): Instrument grading means for USDA carcass grade traits from NBQA–2011 and NBQA–2016**

<table>
<thead>
<tr>
<th>Trait</th>
<th>NBQA–2011 (n = 2,427,074)</th>
<th>NBQA–2016 (n = 4,544,635)</th>
</tr>
</thead>
<tbody>
<tr>
<td>USDA yield grade</td>
<td>2.86</td>
<td>3.10</td>
</tr>
<tr>
<td>Fat thickness, cm</td>
<td>1.20</td>
<td>1.37</td>
</tr>
<tr>
<td>HCW, kg</td>
<td>371.28</td>
<td>393.6</td>
</tr>
<tr>
<td>LM area, cm$^2$</td>
<td>88.45</td>
<td>88.9</td>
</tr>
<tr>
<td>KPH, %</td>
<td>2.10</td>
<td>2.10</td>
</tr>
<tr>
<td>Marbling score$^1$</td>
<td>449</td>
<td>475</td>
</tr>
</tbody>
</table>

$^1$100 = Practically devoid$^{00}$; 300 = Slight$^{00}$; 400 = Small$^{00}$; 500 = Modest$^{00}$; 700 = Slightly Abundant$^{00}$; 900 = Abundant$^{00}$ (USDA, 2016).

**Figure 3.** National Beef Quality Audit – 2016: Seasonal changes in mean fat thickness by month. Mean fat thickness is the mean for all observations.
Mean FT was at its minimum in May 2016 (1.26 cm; Fig. 3) and at its maximum in November 2016 (1.47 cm). Native heifer carcasses possessed the greatest FT ($P < 0.05$) through the entire year, whereas dairy steer and dairy heifer carcasses consistently had the least FT ($P < 0.05$). Gray et al. (2012) also reported native heifer carcasses to have the greatest FT.

Numerical comparisons (not statistically analyzed) for mean LM area and mean HCW are shown in Fig. 4 and 5. Mean LM area was the smallest (86.69 cm$^2$; Fig. 4) in June 2016 and reached its peak (91.38 cm$^2$) in October 2016. Native steer carcasses possessed the largest LM area throughout the year, reaching the greatest point (93.99 cm$^2$) in October 2016. Gray et al. (2012) also reported that native steer carcasses possessed the largest LM area, with a peak (93.0 cm$^2$) in November 2010. Monthly HCW means were: January (397.6 kg), February (397.2 kg), March (396.5 kg), April (389.3 kg), May (384.8 kg), June (385.0 kg), July (386.1 kg), August (394.1 kg), September (399.1 kg), October (403.9 kg), November (406.5 kg), and December (401.9 kg). Mean HCW reached its lightest point in May 2016 and its heaviest point in November 2016 (Fig. 5).
highest mean HCW (381.3 kg) from NBQA–2011 was recorded in November 2010 and the lowest (357.9 kg) in May 2011 (Gray et al., 2012). The lowest mean HCW from NBQA–2016 (384.8 kg) is greater than the highest mean HCW from NBQA–2011 (381.3 kg).

Native steer carcasses consistently had the heaviest HCW ($P < 0.05$) over all months and reached their heaviest (422.3 kg) in November 2016 (Fig. 5). Gray et al. (2012) also reported in NBQA–2011 that native steer carcasses had the heaviest HCW, with the highest weight (395.4 kg) in November 2010. Dairy heifer carcasses possessed the lightest HCW and reached their lightest weight (345.1 kg) in September 2016.

The lowest numerical percentage of YG 4 (11.6%) was observed in May 2016, whereas the lowest numerical percentages of YG 5 (1.5%) were observed in June and July 2016 (Fig. 6). The greatest percentage of YG 4 (17.0%) and YG 5 (4.3%) occurred in January of 2016 (Fig. 6). When comparing the current frequency of YG 4 and YG 5 with NBQA–2011 (Gray et al., 2012), YG 4 carcasses were up 6.1% points and YG 5 carcasses were up 1.6% points. Although not as numerically great, these findings mirror those for YG 4 (up 3.4% points) and YG 5 (up 0.9% points) carcasses for the in-plant assessments in NBQA–2016 (Boykin et al., 2017) versus NBQA–2011 (Moore et al., 2012).

The mean marbling score was Small75 (Table 2). This is numerically increased from the mean marbling score of Small49 from NBQA–2011 (Gray et al., 2012). One opportunity with this data set was to sort carcasses by the day of the week that they were graded (Table 4). Historically, for the in-plant carcass assessment portions of the NBQA, there was an attempt to not over- or under-sample carcasses that would have been chilled over the weekend and offered for grading on Mondays (McKenna et al., 2002). This was based on the findings of Calkins et al. (1980), in which carcasses that were chilled for additional time influenced USDA quality grading factors. Cattle slaughtered on Fridays and Saturdays and graded on Mondays have an increased chilling time compared with those slaughtered and graded in the same week (e.g., slaughtered on Tuesday and graded on Wednesday). Frequency of carcasses grading Prime on Monday (6.43%) was higher numerically than the average frequency of carcasses grading Prime overall (4.2%; Fig. 2). Additional chilling time alone may not explain this phenomenon, but it is interesting to note this occurrence.

Steers accounted for 65.9% and heifers accounted for 34.1% of all carcasses assessed, and the frequency of estimated breed types was 91.9, 7.8, and 0.3% for native, dairy, and other, respectively (data not reported in tabular form). The frequency of native steer, native heifer, dairy steer, and dairy heifer carcasses by month are presented in Fig. 7. Native steer carcasses were consistently the most prevalent followed by native heifers.
Figure 8 shows the frequency distribution of QG over the course of the year. Prime reached its highest frequency (5.0%) in November 2016 and lowest (3.0%) in August 2016. Choice was highest (72.6%) in February 2016 and lowest (68.7%) in August 2016. June 2016 had the highest frequency (24.1%) of Select, whereas August 2016 had the lowest (16.3%). Seasonal changes in mean marbling score are presented in Fig. 9. Monthly mean marbling scores were January (Small 73), February (Small 80), March (Small 81), April (Small 73), May (Small 70), June (Small 67), July (Small 70), August (Small 75), September (Small 74), October (Small 76), November (Small 80), and December (Small 79). There were 2 groups of months (January, February, and March and October, November, and December) when mean marbling scores were numerically the highest and 1 group of months (May, June, and July) when the mean marbling scores were numerically the lowest (Fig. 9). In NBQA–2011, Gray et al. (2012) reported the highest mean marbling score (Small 60) in March 2011. Dairy heifer carcasses possessed the highest marbling score ($P < 0.05$) throughout the year, with the highest mean marbling score (Modest 40) in September 2016.

The highest incidence of dark cutters (0.74%) occurred in October 2016 and the lowest (0.33%) in January 2016 (Fig. 10). Gray et al. (2012) reported the highest frequency (1.94%) in September 2011 and the
lowest (0.38%) in March 2011. These data are supported by Kreikemeier et al. (1998), who reported that the highest frequency of dark cutters was in August, September, and October. Scanga et al. (1998) reported that temperature changes 1 to 3 d before slaughter create stress and increase the occurrence of dark cutters.

As in the in-plant assessment (Boykin et al., 2017), the greatest proportion of carcasses was Choice YG 3 (30.37%; Table 5). The frequency of carcasses that were Choice or Select and YG 2 or 3 was 69.31% compared with the 70.5% reported in NBQA–2011 (Gray et al., 2012). Nonconforming carcasses are those that are

**Table 5. National Beef Quality Audit – 2016:** Instrument grading percentage distribution of carcasses stratified by USDA quality and yield grades

<table>
<thead>
<tr>
<th>USDA yield grade</th>
<th>USDA quality grade, %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Prime</td>
</tr>
<tr>
<td>1</td>
<td>0.03</td>
</tr>
<tr>
<td>2</td>
<td>0.58</td>
</tr>
<tr>
<td>3</td>
<td>1.88</td>
</tr>
<tr>
<td>4</td>
<td>1.37</td>
</tr>
<tr>
<td>5</td>
<td>0.37</td>
</tr>
</tbody>
</table>

¹Carcasses with missing values for USDA quality or yield grades are not included.

²Other includes Standard, Commercial, Utility, dark cutter, blood splash, hard bone, and calloused ribeye.

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**Figure 9.** National Beef Quality Audit – 2016: Seasonal changes in mean marbling scores by month. 100 = Practically devoid, 300 = Slight, 400 = Small, 500 = Modest, 700 = Slightly abundant, 900 = Abundant (USDA, 2016). Mean marbling score is the mean for all observations.

**Figure 10.** National Beef Quality Audit – 2016: Frequency distribution of dark cutting carcasses by month.
Standard or below and/or YG 4 or 5. Of the instrumentally assessed carcasses, 18.6% were nonconforming (data not reported in tabular form), compared with 18.2% for the in-plant assessed carcasses (Boykin et al., 2017).

Conclusions

The instrument grading portion of the NBQA permitted the unique opportunity to evaluate trends in carcass traits over the course of a year. Mean FT and HCW decreased to reach the lowest point in May 2016 and continued to increase through November 2016. Similarly, mean marbling scores were at their highest at the beginning and end of the year and were at their lowest in May, June, and July. These trends are remarkably similar to those observed in NBQA–2011. These findings allow the beef industry access to the greatest volume of beef value–determining characteristics for the U.S. fed steer and heifer population ever reported.

LITERATURE CITED


