NATIONAL BEEF QUALITY AUDIT – 2011: SURVEY OF INSTRUMENT GRADING ASSESSMENTS OF BEEF CARCASS CHARACTERISTICS

A Thesis

by

GATLAN DAVIS GRAY

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Approved by:

Co-Chairs of Committee, Jeffrey W. Savell
Kerri B. Harris
Committee Members, Dan S. Hale
John W. Siebert
Head of Department, H. Russell Cross

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ABSTRACT

The instrument grading assessments for the NBQA-2011 evaluated seasonal trends of beef carcass quality and yield attributes over the course of the year. One week of instrument grading data—HCW, gender, USDA QG, and YG factors—were collected every other month (n = 2,427,074 carcasses) over a 13-month period (November 2010 through November 2011) from four beef processing corporations, encompassing 17 federally inspected beef processing facilities, to create an overview of carcass quality and yield attributes and trends from carcasses representing approximately 8.5% of the U.S. fed steer and heifer population. Mean yield traits were: YG (2.86), HCW (371.3 kg), FT (1.19 cm.), and LM area (88.39 cm^2). The YG distribution was YG 1 (15.7%), YG 2 (41.0%), YG 3 (33.8%), YG 4 (8.5%), and YG 5 (0.9%). Distribution of HCW was <272.2 kg (1.6%), 272.2 kg to 453.6 kg (95.1%), ≥453.6 kg (3.3%). Monthly HCW means were: November 2010 (381.3 kg), January 2011 (375.9 kg), March 2011 (366.2 kg), May 2011 (357.9 kg), July 2011 (372.54 kg), September 2011 (376.1 kg), and November 2011 (373.5 kg). The mean FT for each month was November 2010 (1.30 cm), January 2011 (1.22 cm), March 2011 (1.17 cm), May 2011 (1.12 cm), July 2011 (1.19 cm), September 2011 (1.22 cm), and November 2011 (1.22 cm). The mean marbling score was Small^{49}. USDA QG distribution was Prime (2.7%), Top Choice (22.9%), Commodity Choice (38.6%), and Select (31.5%). Interestingly, from November to May, seasonal decreases ($P < 0.001$) in HCW and FT were accompanied by increases ($P < 0.001$) in marbling. These data present the opportunity to further

investigate the entire array of factors that determine the value of beef. Datasets utilizing the online collection of electronic data will likely be more commonly used when evaluating the U.S. fed steer and heifer population in future studies. These data indicate the wide array of carcasses produced by the beef cattle industry, and how the frequency of both YG and QG traits change from month-to-month.

DEDICATION

I dedicate this work to my family and friends who have helped me become the person I am today. Without their unwavering support, none of this would have been possible.

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NOMENCLATURE

AMS	Agricultural Marketing Service
Ch	Choice
Ch-Se	Choice-Select
FT	Fat Thickness
KPH	Kidney, Pelvic, and Heart Fat
NASA	National Aeronautics and Space Administration
NBMBS	National Beef Market Basket Survey
NBQA	National Beef Quality Audit
NBQA-1991	1991 National Beef Quality Audit
NBQA-1995	1995 National Beef Quality Audit
NBQA-2000	2000 National Beef Quality Audit
NBQA-2005	2005 National Beef Quality Audit
NBQA-2011	2011 National Beef Quality Audit
NCRBS	National Consumer Retail Beef Study
NNDB	National Nutrient Data Bank
Pr	Prime
QG	Quality Grade
RFP	Request For Proposal
Se	Select
U.S.	United States

USDA	United States Department of Agriculture
VIA	Video Image Analysis
WBS	Warner-Bratzler Shear Force
YG	Yield Grade

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CHAPTER I

INTRODUCTION

Beef carcasses grading is a valuable, voluntary program that has been available through the USDA as a national service since 1917 (USDA, 1997). The purpose of beef grading is to add value to the carcasses by reducing variability through the segregation of carcasses into more uniform groups based on the expected palatability of the cooked product, as well as the estimated amount of boneless, closely trimmed retail cuts from the round, loin, rib, and chuck. By doing this, eating experience and, ultimately, value are improved based on the performance of the carcass from the assigned QG and YG. Greater consistency in the beef industry is obtained through improved QG and YG, resulting in consumers who are willing to pay more, which then adds value back to the producers for their cattle.

Over the last 20 years, 4 NBQAs have been conducted (Lorenzen et al., 1993; Boleman et al., 1998; McKenna et al., 2002; Garcia et al., 2008) to improve the quality and consistency of cattle being produced, and each has served as a reference to the industry in the areas of research, education, and business activities. Continuing to follow the recommendation to survey the beef quality attributes of the U.S. fed beef supply every four to five years (Smith et al., 1992), the NBQA-2011 was conducted to assess the current status of the quality and consistency of fed steers and heifers. For the first time as part of the NBQA, the opportunity to measure quality attributes and trends seasonally and over the course of the year has been feasible because of the recent implementation of instrument grading.

For Phase II of the NBQA-2011, instrument grading data were used, in addition to the traditional collection of data in the cooler and on the slaughter floor, to compile the carcass information from multiple companies and facilities to allow for a more accurate assessment of the beef industry. Because of the immense amount of data included in the instrument grading dataset, seasonal changes were examined in the beef carcass characteristics over the course of the year in addition to the traditional evaluation of carcass characteristics.

CHAPTER II

LITERATURE REVIEW

The 1974 USDA consist, Grades of Fed Beef Carcasses (Abraham, 1977), was a useful study for comparison with the NBQA-1991. The survey of over 18,000 carcasses provided the industry with the realistic proportions of carcasses that fall into the evaluated factors. These carcasses were evaluated for USDA QG and YG factors. In the years after the 1974 USDA Market Consist Report, there were several changes in the beef industry, including the heavy impact of Continental European cattle that were influencing genetics, as well as the increasing concerns of consumers related to diet and health.

Prior to the NBQA-1991, the industry was becoming increasingly aware of the inconsistencies and waste that was leading to lost opportunities and a high value per head not being captured. From the NCRBS, Savell et al. (1989) found consumers to be more conscience of purchasing cuts with excess trim and stated that the U.S. beef industry needed to make an effort to reduce the amount of external fat. Consumers in the study preferred the taste fat, but did not want the waste fat.

Results of the NCRBS led researchers to conduct the NBMBS to convince the USDA to update the NNDB data because many of the retailers had began to trim the retail cuts to have less fat (0.64 cm vs. 1.27 cm) than they had previously (Savell et al., 1991). This caused the NNDB to report data that was inaccurate for the nutritional profile of beef, which would have been used for Nationwide Food Consumption Surveys and Continuing Survey of Food Intakes used by many individuals (Savell et al., 1991).

As a precursor to the NBQA-1991, Lambert (1991) authored a paper that highlighted areas in the beef production system that ultimately cost, or prevented, the industry from capitalizing monetary opportunities, thus increasing the end product price for consumers. These additional costs resulted in lost market share for the beef industry in the annual per capita consumption. Based on prices and production numbers for the beef industry, Lambert calculated values for areas that could use production practice improvements, such as: reproductive performance, death loss, hot iron branding, increased weaning weights, multiple ownership/processing, feed efficiency, outlier cattle, excess fat production, management losses, retail shrink, and products that are out-of-stock at the retail case. These management practices and inefficiencies totaled $11.999 billion in lost economic opportunities in 1991. Understanding there will always be some value in lost opportunities, Lambert highlighted many areas that had the opportunity to reduce costs in production.

The NBQA-1991 provided an update to the 1974 USDA Market Consist Report, along with a 10-year plan to improve the quality of the beef industry, and created a benchmark study for comparison with future NBQA studies. After the NBQA-1991 was completed, in addition to the creation of cattle production targets for producers, the economic impact of production practices were quantified as they related to carcass value. From the results of the NBQA-1991, it was announced that there was a total value of $279.82 per head in "lost opportunities" for every steer or heifer slaughtered because of quality defects (NCA, 1992). The mean carcass USDA YG and QG traits for the NBQA-1991 were: USDA YG (3.2), USDA QG (Se^{86}), adjusted FT (1.5 cm), HCW (345.0 kg), LM area (83.4 cm^2), KPH was (2.2%), and marbling score ($Small^{24}$).

Adjustments were revealed in the NBQA-1995, as the beef industry began to try to correct many areas of interest from the NBQA-1991. Data from the NBQA-1995 indicated that carcasses, compared to the NBQA-1991, were lower ($P < 0.05$) in USDA YG (2.8), USDA QG (Se^{79}), adjusted FT (1.2 cm), HCW (339.2 kg), KPH (2.1%), marbling score ($Small^{06}$), testifying to the qualitative improvements and dedication of the industry in the short time since the previous survey had been conducted (Boleman et al., 1998). The LM area was 82.6 cm^2 for the NBQA-1995, and the "lost opportunities" due to nonconformities decreased from the NBQA-1991. Although not all of the changes were in the desired direction, the majority indicated that management practices were improving and efforts were being made to enhance the quality of beef.

The data reported by McKenna et al. (2002) for the NBQA-2000 were USDA YG (3.0), USDA QG (Se^{85}), adjusted FT (1.2 cm), HCW (356.9 kg), LM area (84.5 cm^2), KPH (2.4%), and marbling score ($Small^{23}$). The percentage of carcasses grading Pr and Ch for the NBQA-2000 was greater than those reported by Boleman et al. (1998). The USDA QG and marbling scores increased to be more consistent with the levels reported by Lorenzen et al. (1993), while the HCW and LM area increased to new levels, surpassing previous NBQAs.

Garcia et al. (2008) reported that the means for the NBQA-2005 were USDA YG (2.9), USDA QG (Se^{90}), adjusted FT (1.3 cm), HCW (359.9 kg), LM area (86.4 cm^2), KPH (2.3%), and marbling score (Small^{32}). In addition to the increase in HCW, USDA QG and YG, the "lost opportunities" due to nonconformities ($55.68), using the 2005 logic and prices, decreased in comparison to the previous NBQA.

Instrument grading technology has been considered a high priority within the beef industry for 30 years, and in development since the U.S. General Accounting Office (Staats, 1978) reported to the U.S. Congress that the accuracy and the uniformity of the USDA beef grading needed to be improved. The need for the implementation of instrument grading was listed as a key message of the NBQA-2005 reported by Smith et al. (2006).

Cross and Whittaker (1992) reported on the history of developing instrument grading that the most viable option for the beef industry was ultrasound technology. In 1979, the USDA and NASA worked to determine a technology that would work as an objective measurement of QG and meet the needs of the beef industry, and from this, the two organizations determined that the best technologies would be VIA and ultrasound (Cross and Whittaker, 1992). In 1980, a RFP was developed to contract the work to generate a technology to fulfill the needs for the instrument. The RFP was awarded to Kansas State University, and from 1981 to 1983, the VIA was tested at the USDA's Meat Animal Research Center with promising results, especially as a means for assessing YG (Cross et al., 1983). However, the beef industry decided it would be better to develop a technology that could assess the carcass characteristics on an unribbed, unchilled carcass. This put the expansion of VIA efforts on hold, and funding began to be redirected toward the advancement of ultrasound technology. To date, an online ultrasound instrument grading system has not been developed and implemented.

Until the recent advancements and implementation of instrument grading, the method by which carcasses have traditionally been graded, since the introduction of beef grading in 1927,included subjective measurements. The traditional method by which beef is graded involves the assessment of YG and QG factors by a highly trained human grader. Although the YG process is less subjective than QG, and can be performed using ribeye dot grids and fat probes, there is not sufficient time to use these tools on every carcass that is presented for grading with the chain speeds in many of the large plants operating in excess of 350 carcasses per hour (USDA, 2003; Woerner and Belk, 2008).

In the last 10 years, the USDA has released the procedures for instrument approval and official use of instrument assessment for LM measurement (USDA, 2003), YG measurement (USDA, 2005), and marbling score assessment (USDA, 2006a, b). Greater accuracy and consistency, improved producer and packer confidence in the grades, and increased efficiency has been reported from the use of instruments in grading carcasses (Belk et al., 1998; Steiner et al., 2003a; Steiner et al., 2003b; Lorenzen, 2008). As value and quality-based marketing has become more of a standard within the meat and livestock industry, it has become even more imperative that conformity and consistencies are rewarded and that non-conformities and quality shortfalls are discounted. The development and application of instrument grading is increasingly important to instill more confidence back to the producers with an objective measurement verses the traditional subjective system (Cross and Belk, 1994).

CHAPTER III

MATERIALS AND METHODS

Data Collection

The instrument grading process is performed by aligning a calibrated camera onto the LM between the 12th and 13th rib for each side. The instrument calculates the YG using the HCW, the highest FT measurement, the mean KPH estimation and the mean LM area of the two sides of the carcass. The marbling score used to determine QG is the highest from the two observed sides. After the image is captured, it is stored and displayed for the USDA grader to verify that objective assessments for USDA QG and YG. The USDA grader may make adjustments to the grade, or if necessary, reject the instrument's assessment altogether. Adjustments are entered manually for maturity or any other defects (blood splash, calloused ribeye, dark cutter, frozen ribeye, etc.) that a carcass may possess. Additionally, the carcasses may be rejected for instrument grading if the one or both sides is ribbed on a bias, has a fat pull, is mis-split, ribbed in a location other than between the 12th and 13th rib, or if the carcass ID number does not match the carcass presented on the monitor (USDA, 2010). Factors that would not be ascertained from the camera, such as sex class, breed classification, and HCW, would have been entered into the computer system and follow each individual carcass using the trolley tracking system and the individual identification number of the carcass.

Instrument grading data (n = 2,427,074 carcasses) were collected over a 13–month period (November 2010 through November 2011) from four beef processing corporations, encompassing 17 federally inspected beef processing facilities, to assess the quality attributes and trends with a large quantity of data that could be evaluated on a periodic basis. Data for HCW, sex classification, USDA QG, and YG groups were obtained from one week's production, every other month, beginning in November of 2010. Carcass data collection included measurements of subcutaneous FT, LM area, HCW, marbling score, genetic type, and sex condition. From this information, USDA (1997) YG and QG were calculated. In addition, the frequencies of the quality defects and combinations of these categories were determined.

Statistical Analysis

Data were received from each of the four beef processing corporations in a Microsoft Excel spreadsheet (Microsoft Corporation, Redmond, WA). The spreadsheets were harmonized and consolidated and corporate identifiers were removed to protect the identity of individual processors. Analyses were performed using JMP Software (JMP Pro, Version 9.0.0, SAS Institute Inc., Cary, NC 1989-2010). The Fit Y by X function was used for analysis of variance, and least squares means comparisons were performed using Student's t test. Frequency distributions, means, standard deviations, minimum, and maximum values were determined using the distribution function. Correlations were determined using the multivariate function.

CHAPTER IV

RESULTS AND DISCUSSION

Means for instrumentally assessed YG traits and marbling scores are shown in Table 1. The mean YG was 2.86 and the mean marbling score was Small^{49}. The YG distributions (Figure 1) were YG 1 (15.7%), YG 2 (41.0%), YG 3 (33.8%), YG 4 (8.5%), and YG 5 (0.9%). The lowest observed percentage of YG 4 (%) and 5 (%) carcasses was in May 2011 (Figure 2). Within the YG distribution for dairy steers, it would be expected that the majority would be represented as YG 1 carcasses, however, the dairy steers had the highest percentage in YG 2 ($P < 0.001$) and the lowest percentage of YG 5 ($P < 0.001$) carcasses (Figure 3). As shown in Table 2, Dairy steers (n = 116,410) had a lower numerical YG (2.81) compared to native (non-dairy type) steers (n = 1,317,287) and native heifers (n = 986,162), as well as a smaller FT (0.71 cm) and smaller LM area (78.61 cm^2). As shown in Table 2, native steers had the heaviest HCW (386.45 kg) and the native heifers had the greatest marbling score (465).

The distribution of steers and heifers per month are represented in Figure 4. Distributions of carcasses and combinations of USDA QG and YG are shown in Table 3. Instrumental assessment indicated that 70.5% of the carcasses were Ch or Se, YG 2 or 3. Comparable percentages were 72.0% for NBQA-2011 (Moore et al., 2012), 67.2% for NBQA-2005 (Garcia et al., 2008), 70.5% for NBQA-2000 (McKenna et al., 2002), 75% for NBQA-1995 (Boleman et al., 1998), 67.2% for NBQA-1991(Lorenzen et al., 1993).

As shown in Figure 5, the percentage of Pr and Ch carcasses was greatest in January 2011 (67.7%) and March 2011 (67.8%). Due to fewer “Other” carcasses, May 2011 exhibited the greatest percentage of Pr, Ch, and Se carcasses (96.5%). Carcasses classified as “Other” consisted of no roll, Standard, Commercial, Utility, heiferette, dark cutter, blood splash, hard bone, and calloused ribeye. “Other” carcasses comprised of 4.3% of the instrumentally surveyed carcasses.

Many of the carcasses are presented for QG less than 48 h after slaughter. Carcasses killed on Friday and Saturday have the opportunity to have extra chilling time, as plants do not normally operate on Sunday. Compared to other days of the week, there was a greater percentage of Pr (3.51%) and Ch (65.26%) among carcasses killed on Friday during the study (Table 4). A greater percentage of Pr and Ch carcasses were observed on Thursday, Friday, and Saturday when compared to the earlier days of the week. These data support the notion that QG improves with greater than 24 h of chilling prior to QG. Calkins et al. (1980) reported improved marbling scores of carcasses subjected to 48 h chilling period compared to 24 h.

YG (Figure 1) and QG (Figure 6) frequency distributions and QG and YG trait means (Table 5) within the instrument grading dataset were found to be similar to the frequency distributions and means from the NBQA in-plant chilled carcass assessment dataset (Moore et al., 2012). The in-plant carcass assessments surveyed beef processors across the country to obtain data representing one day’s production. Previously conducted in-plant carcass assessments have had a total of approximately 9,000 head, and surveyed one time per plant, while the instrument grading dataset repeatedly evaluated multiple plants over the course of the year. The surprisingly similar results of the LM area, FT, YG, and marbling scores between the traditional in-plant carcass assessment and the instrument grading dataset adds credibility to the current, as well as the previously conducted surveys, that the sample sizes have been adequate to obtain a representative snapshot of the industry.

The mean USDA QG from the current study was the highest since the NBQA began in 1991 (Figure 7), however, there is still room for the percentage of Pr and Ch to improve to reach the levels observed by Abraham (1977). Carcasses in March 2011 had the greatest ($P < 0.001$) mean marbling score ($Small^{60}$), followed by a decline for the remainder of the study after May 2011 (Figure 8). Of the dairy type carcasses, data not shown in tabular form, May 2011 had the greatest ($P < 0.001$) percentage of Pr and Ch (68.43%) as well as the lowest percentage of Se (25.88%).

The Ch-Se reflects the daily mean price differential between these two grades in the marketplace (McCully, 2010; Suther, 2010). McCully (2010) reported a negative relationship between the Ch-Se spread and the percent of carcasses that graded Ch. The 2011 archived copies of the "National Daily Boxed Beef Cutout and Boxed Beef Cuts" report from USDA AMS were accessed to obtain Ch-Se spreads, which were plotted against the percentage of Ch carcasses for the same time period as the instrumental grading data collected for this study. The correlation coefficient value for the Ch-Se spread and percentage Ch (Figure 9) in the present study was -0.88. Also, McCully (2010) reported a strong correlation (-0.86), when examining the relationship between the Ch-Se spread and percentage USDA Ch carcasses using 2002-2009 data.

The Ch-Se spread is calculated using Commodity Ch, and does not take into account the price for Ch product that is marketed through a carcass program, thus demanding a premium price. As the number of branded carcass programs continues to increase and profit margins decrease, it is important that carcasses are sorted to utilize the most optimal marketing and fabrication method. Up to $115.00 per head increase in carcass value can be obtained through the utilization and augmentation of YG placement with instrumentation from the increased accuracy and sorting of the camera grading system (Lorenzen, 2008).

Carcass weight distributions are presented in Figure 10. As the carcass trait ranges that are important to various carcass programs evolve, it is pertinent for the industry to also adapt to meet the demand of these programs. The majority of the carcass programs that are currently on the list of USDA Certified Programs with a HCW provision use the range of 272.2 kg and 453.6 kg. Of the instrumentally assessed carcasses, 95.1% of the carcasses were between 272.2 and 453.6 kg. May 2011 mean HCW (Figure 11) was the lowest for the year (357.9 kg), which was 13.4 kg less than the mean HCW for the study (371.3 kg). The observed HCW means have continually increased each time a NBQA has been conducted from the initially reported mean of 345 kg in the NBQA-1991 (Lorenzen et al., 1993)

Table 6 reports the differences in steers and heifers collected from the instrument grading dataset. Heifers had a greater mean marbling score ($P < 0.001$) than steers in each HCW group (Table 6), and a larger LM area ($P < 0.001$) at HCW between 317.51–430.91 kg. Steers had a lower numerical mean YG and lower FT ($P < 0.001$) than heifers in each HCW group. For steers and heifers, FT, LM area, YG, marbling score, and HCW increased as the HCW group also increased. Although there have been many improvements throughout the years, these trends between steers and heifers still agree with those of Abraham (1977).

Historically, annual HCW trends typically reach a low point for the year in May 2011, which is reflected by the 2007-2011 archived "5 Area Weekly Weighted Mean Direct Slaughter Cattle" reports from the USDA AMS, which were accessed to obtain the HCW, weighted for steer and heifer proportions for historical comparisons. The seasonal differences in HCW could be because of the type of cattle being marketed at this period. Because these data were collected from carcasses and do not contain information on a live animal basis, it is not known if the carcasses were from cattle from a yearling-fed or calf-fed system, or from a spring- or fall-calved herd.

Lighter mean HCW and a greater percentage of YG 1-3 (92.5%) were observed for May 2011 when compared to the mean percentage of YG 1-3 (90.6%) for the entire survey (data not reported in tabular form). Native steers were heavier ($P < 0.001$) than dairy steers for each month except May 2011. Native heifers were heavier ($P < 0.001$) than dairy heifers (n = 6,697) for every month observed except March 2011 (data not reported in tabular form). The change in the mean HCW of native steers and heifers had the same trend from month-to-month ($P < 0.001$). Interestingly, dairy steers and heifers did not follow the same trend month-to month as the native steers and heifers. Steers were heavier than heifers each month with a mean difference of 35.28 kg between steers and heifers (Figure 11).

Presented in Figure 12, frequency of dark cutter carcasses was at the lowest points in January 2011 (0.43%) and March 2011 (0.38%) with an increase that peaked in September 2011 (1.94%). These findings were consistent with the trend of an increased frequency of dark cutter carcasses from January 2011 to October 2011 and a decline in November 2011 reported by Kreikemeier et al. (1998). As expected, the highest percentage of carcasses occurred in September, as weather patterns tend to be less consistent, and frequently change from warm to cold with little time for the cattle to become acclimated to the conditions.

Contrary to the results from Scanga et al. (1998), in the current study, steers (61.24%) accounted for a greater proportion of the dark cutter carcasses compared to the heifers (38.76%). Table 7 compares the carcass characteristics of dark cutter carcasses compared to normal or non-dark cutter carcasses. Dark cutter carcasses were leaner with a lower mean FT, HCW, and YG ($P < 0.001$), and a larger mean LM area ($P < 0.001$). Also, Janloo et al. (1998) found lower mean FT and YG and larger LM areas in dark cutter carcasses when compared to carcasses with brighter colored lean. Moore et al. (2012) reported 57.5% the dark cutter carcasses occurred between September 2010 and February 2011. In the current study, 62.0% of the dark cutter carcasses were observed during the months of September 2010 through January 2011, most likely because of environmental stress factors.

Dark cutter carcasses are of concern to the industry because of the negative consumer perception in the appearance of the resulting cuts, which in turn results in discounted product and a loss in revenue to the beef supply chain. More variation in

WBS has also been reported in dark cutter carcasses, which could lead to a less desirable eating experience compared to normal beef (Wulf et al., 2002). Based on the NBQA-2011 discounts reported for dark cutter carcasses and the percentage found in the instrument grading, dark cutter carcasses cost the industry $2.32 per animal slaughtered in the U.S., which is an improvement compared to previous audits. The mean frequency for the instrument grading dataset was 0.85%, however, the traditional cooler audit found a greater percentage (3.22%) of dark cutter carcasses (Moore et al., 2012).

The overall mean LM area for the instrumental assessment was 88.45 cm^2. The LM area has been higher than the previous in each NBQA since NBQA-1995. Many of the carcass programs that are currently on the list of USDA Certified Programs with a LM area stipulation use the range of 64.5 cm^2 and 103.2 cm^2. Of the instrumentally assessed carcasses, March 2011 and May 2011 resulted in the greatest percentage of carcasses (90.7%) with LM areas between 64.5 cm^2 and 103.2 cm^2 (Figure 13). May 2011 also had the lowest percentage of LM areas greater than 103.2 cm^2 (7.5%) for the year. Between steers and heifers, LM areas for steers were larger for each month ($P < 0.001$). May 2011 had the greatest percentage of dairy type carcass with LM areas between 64.5 cm^2 and 103.2 cm^2 (data not reported in tabular form).

As shown in Figure 14, November 2010 had the greatest mean FT (1.30 cm), which was greater than the total average for the study (1.19 cm). May 2011 had the lowest average FT (1.12 cm). Comparable fat thicknesses were 1.3 cm for NBQA-2011 (Moore et al., 2012), 1.3 cm for NBQA-2005 (Garcia et al., 2008), 1.2 cm for NBQA-2000 (McKenna et al., 2002), 1.2 cm for NBQA-1995 (Boleman et al., 1998), 1.5 cm for

NBQA-1991(Lorenzen et al., 1993). Steers had less FT than heifers in each month observed ($P < 0.001$) and dairy type carcasses had lower FT than the native type ($P < 0.001$). As the FT increased, the percent of Pr and Ch QG increased and the percent of Se and "Other" carcasses decreased (Figure 15). However, the premiums that would be gained from the increase in the percentage of USDA Pr and Ch carcasses may not outweigh the discounts that would be applied because of the loss in cutability.

In Table 8, as the QG decreased, from Pr, Ch, Se, and Other, the YG, FT, and HCW decreased with each QG category. The marbling score also decreased, but the Se QG had a lower marbling score than the Other category. This could be due to the fact that Other not only included carcasses that would be expected to have lower marbling scores than Se for A-maturity carcasses such as Standard, but would also include B-maturity carcasses with a Small amount of marbling. The Other category also included carcasses classified as Commercial, Utility, no roll, heiferette, dark cutter, blood splash, hard bone, and calloused ribeye.

The LM area increased as QG decreased, but the Se category had a larger LM area than Other. The smaller LM area in the Other category compared to those in Se are likely because of the carcasses with increased maturity (Utility, heiferette, and hard bone). Carcasses in advanced maturity categories have a smaller LM area as compared to the LM area of fed steers and heifers. Woerner (2010) found that the LM area was 79.9 cm^2 for fed cows, which were defined as having been in a finishing yard on a corn-based, high energy diet, while the current study had a mean LM area of 88.45 cm^2.

As YG increased from YG 1 to YG 5, the FT, HCW, and marbling score increased, while LM area decreased (Table 9). As expected, the YG, FT, HCW, and marbling score increased as the fat thickness increased (Table 10). Also shown in Table 10, the LM area decreased as the fat thickness increased. As HCW increased, YG, FT, LM area, and Marbling score all increased (Table 11).

Of interest was the relationship between FT and marbling. Using data from this study, as well as data from Moore et al. (2012), the correlation coefficients between FT and marbling for the instrument grading dataset (r = 0.35) was similar to that of the in-plant chilled carcass assessment (r = 0.34). Brethour (2000) reported the correlation of FT and carcass marbling score was r = 0.26 and r = 0.40, respectively, from two different groups of cattle. As it has been previously reported, carcasses with less marbling also had less FT, and carcasses with a greater amount of marbling had a greater FT (Jeremiah, 1996; Moore et al., 2012).

CHAPTER V

CONCLUSIONS

For the first time in the history of the NBQA, sufficient information was available to allow for QG and YG traits to be evaluated seasonally. Shifts in the magnitude of the mean of certain QG and YG traits did occur on a month-to-month basis. Seasonal variation could be because of the various production systems utilized that are necessary to continually supply the U.S. with a safe, high quality product. HCW declined from the heaviest point in November 2010 to the lightest mean HCW observed in May 2011. Mean FT followed the same trend line as mean HCW. Conversely, mean marbling score increased from November 2010 to the peak in March 2011, and then declined for the remainder of the study. This dataset presented the opportunity to further investigate the whole array of value-determining factors that influence the viability and profitability of the beef industry, and now with the opportunity to utilize this method of online, electronic collection of data, these datasets will allow a greater amount of information to be reported. These data demonstrate the month-to-month change in the consist of cattle type and carcass quality, and as future NBQA are performed, it will be interesting to determine if seasonal trends for these quality attributes are repeated.

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APPENDIX A

FIGURES

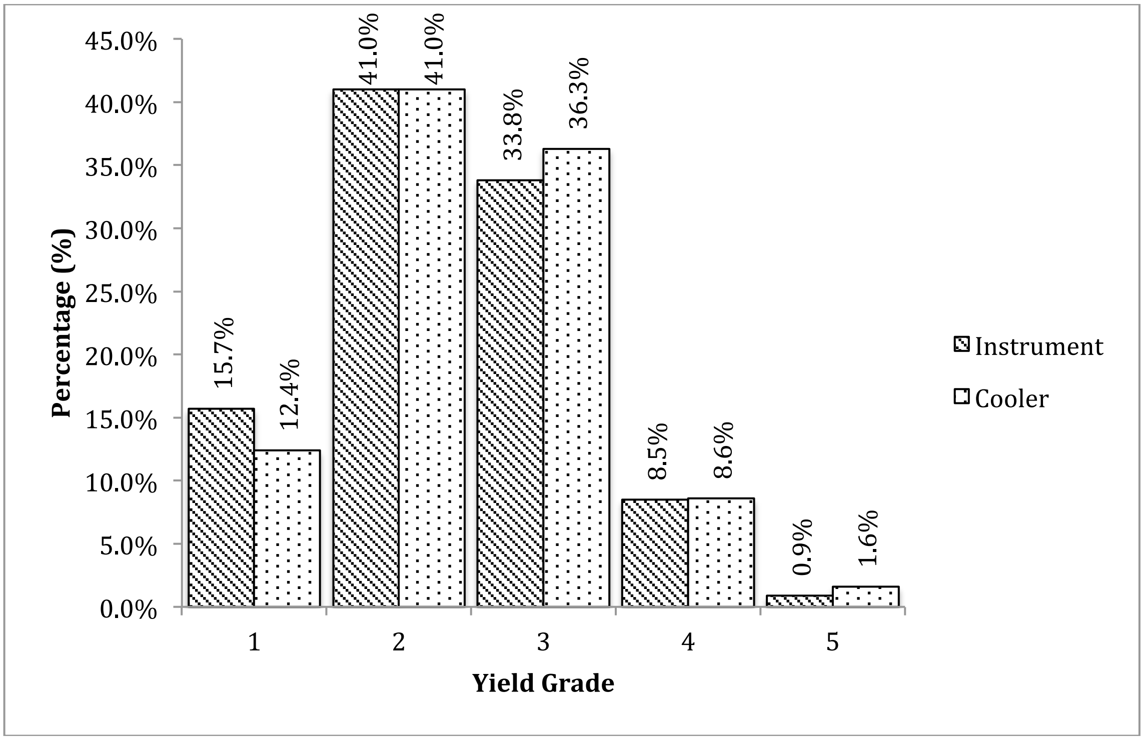

Figure 1. Frequency distribution of yield grades comparing the instrument grading dataset and the NBQA-2011 in-plant chilled carcass assessment dataset (Moore et al., 2012).

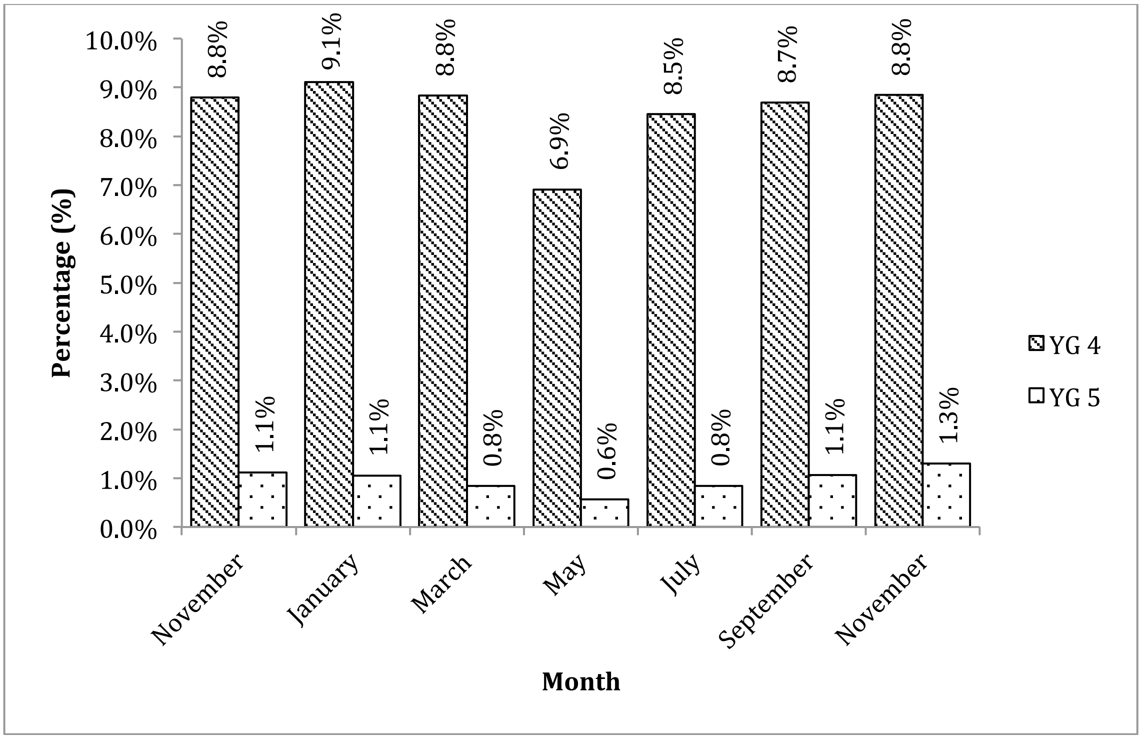

Figure 2. Frequency distribution of yield grade 4 and 5 carcasses by month.

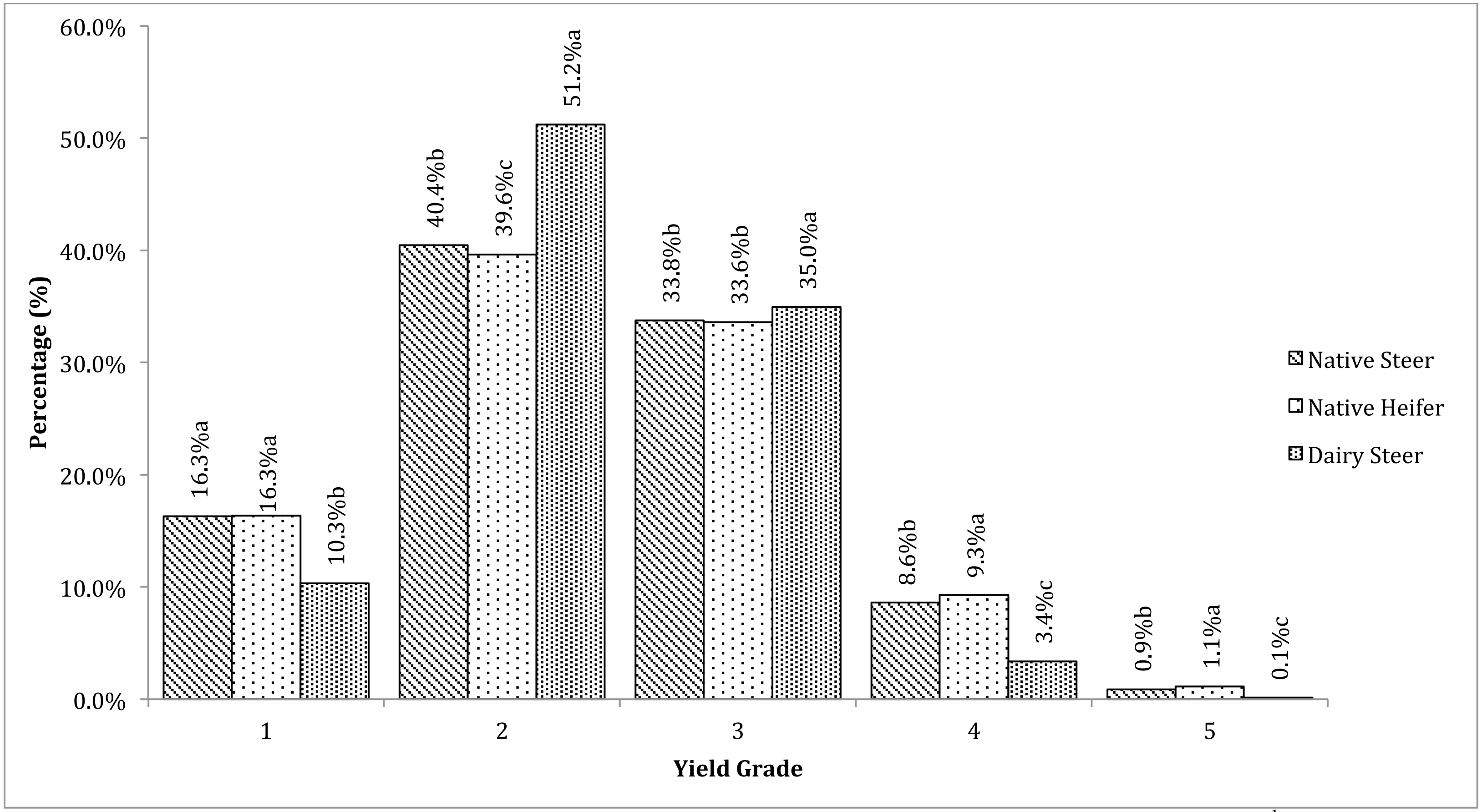

Figure 3. Frequency distribution of yield grades for native steers, native heifers, and dairy steers. The SEMs[1] by yield grade (YG) were: native steers (SEM = 0.0003 for YG 1, 0.0004 for YG 2, 0.0004 for YG 3, 0.0002 for YG 4, 0.00008 for YG 5), native heifers (SEM = 0.0003 for YG 1, 0.0005 for YG 2, 0.0005 for YG 3, 0.0003 for YG 4, 0.0001 for YG 5), and dairy steers (SEM = 0.001 for YG 1, 0.001 for YG 2, 0.001 for YG 3, 0.0008 for YG 4, 0.0003 for YG 5).

[a–c]Means within yield grades lacking a common letter differ ($P < 0.001$).

[1]SEM is the SE of the least squares means.

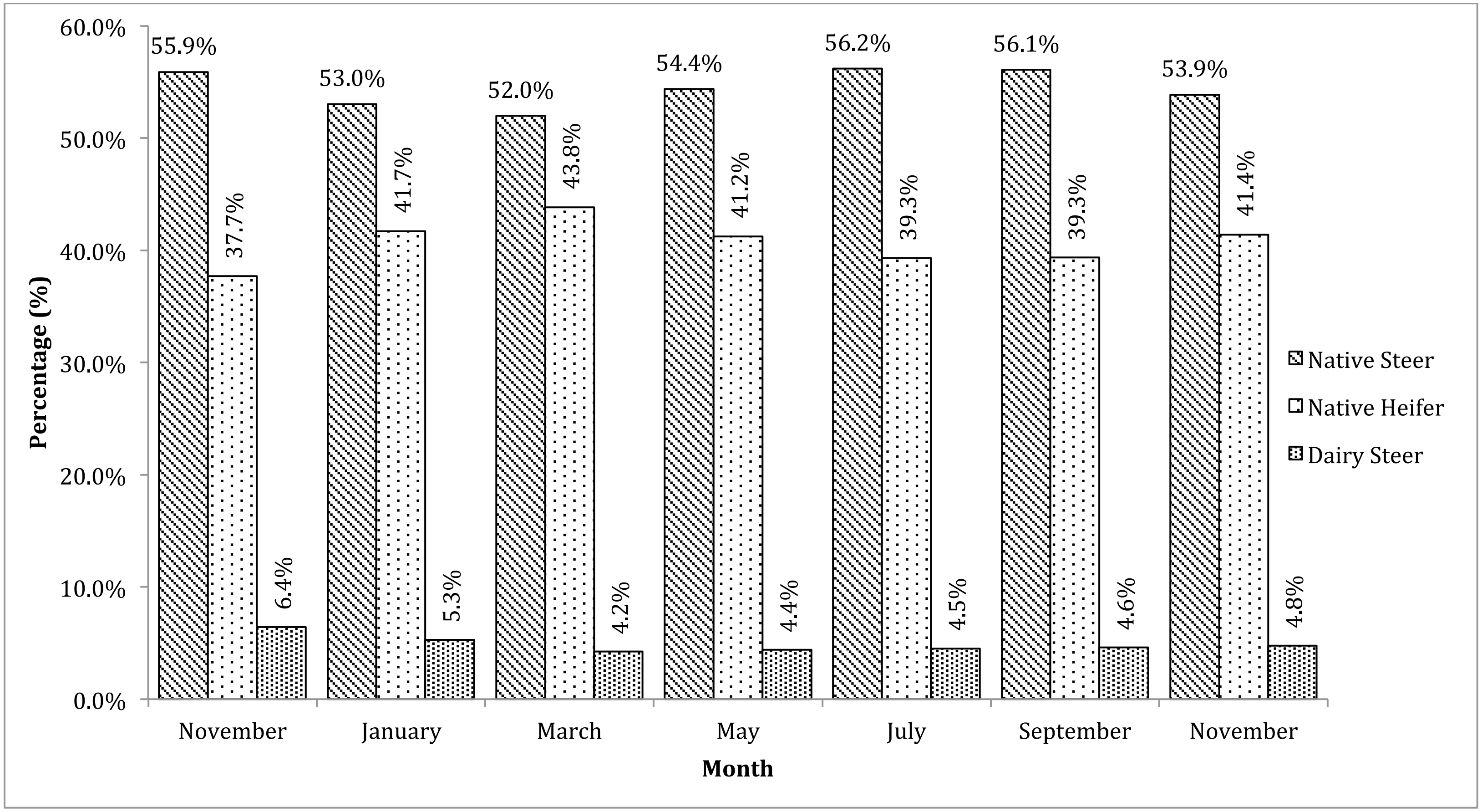

Figure 4. Frequency distribution of sex class by month.

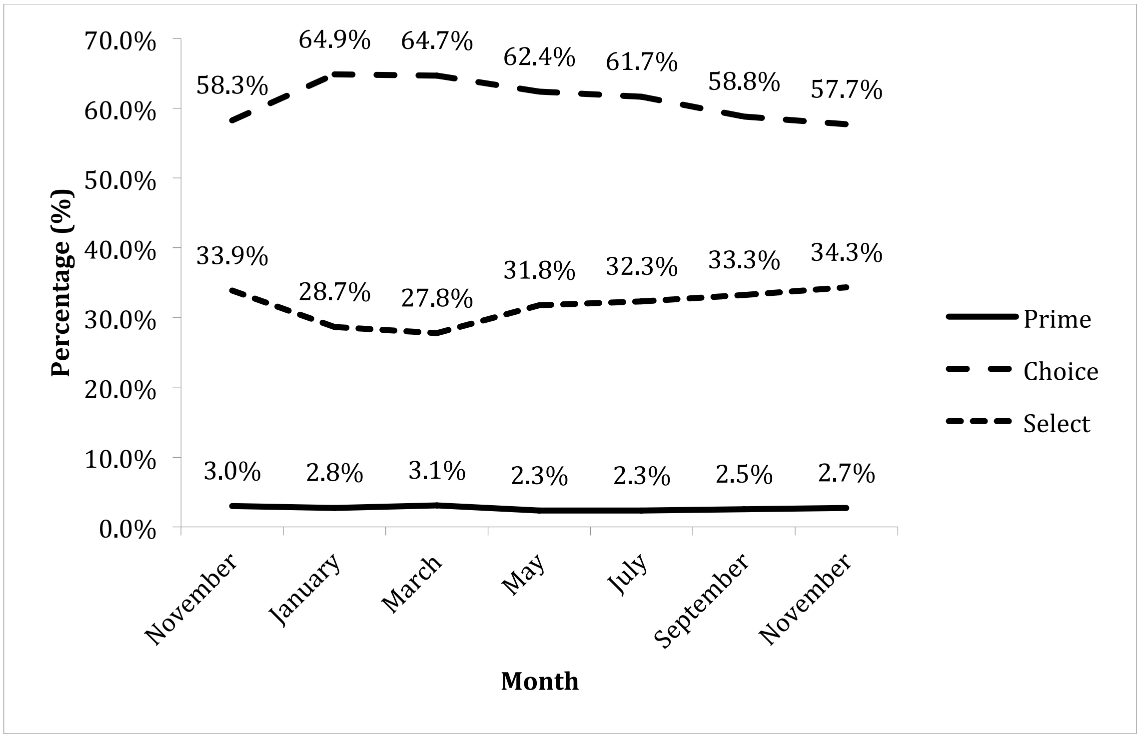

Figure 5. Frequency distribution of USDA quality grade by month.

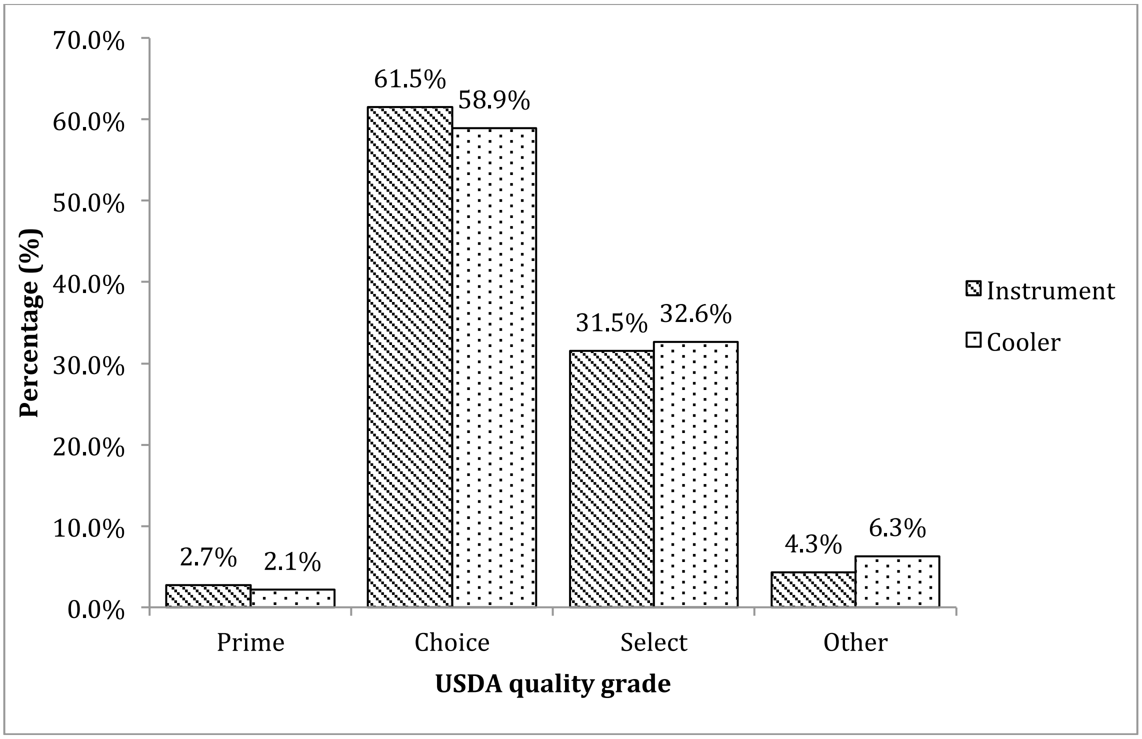

Figure 6. Frequency distribution of USDA quality grade comparing the instrument grading dataset and the NBQA-2011 in-plant chilled carcass assessment dataset (Moore et al., 2012).

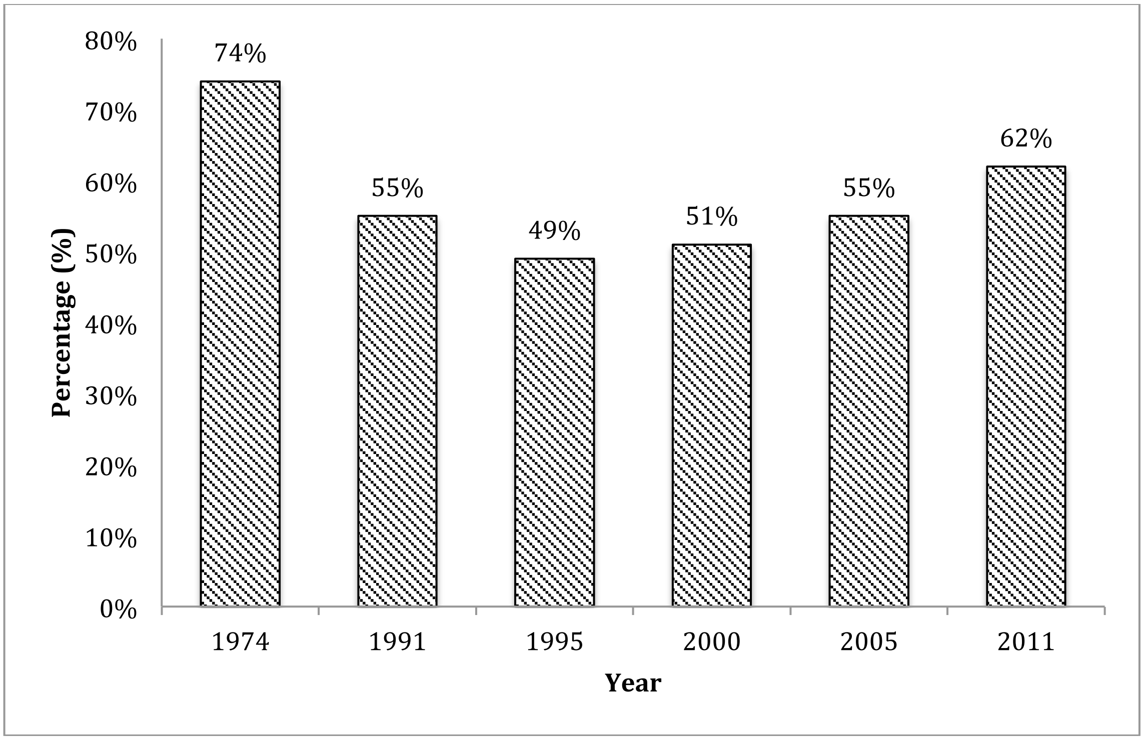

Figure 7. Comparison of percent USDA Choice from USDA-1974, NBQA-1991, 1995, 2000, 2005, and 2011.

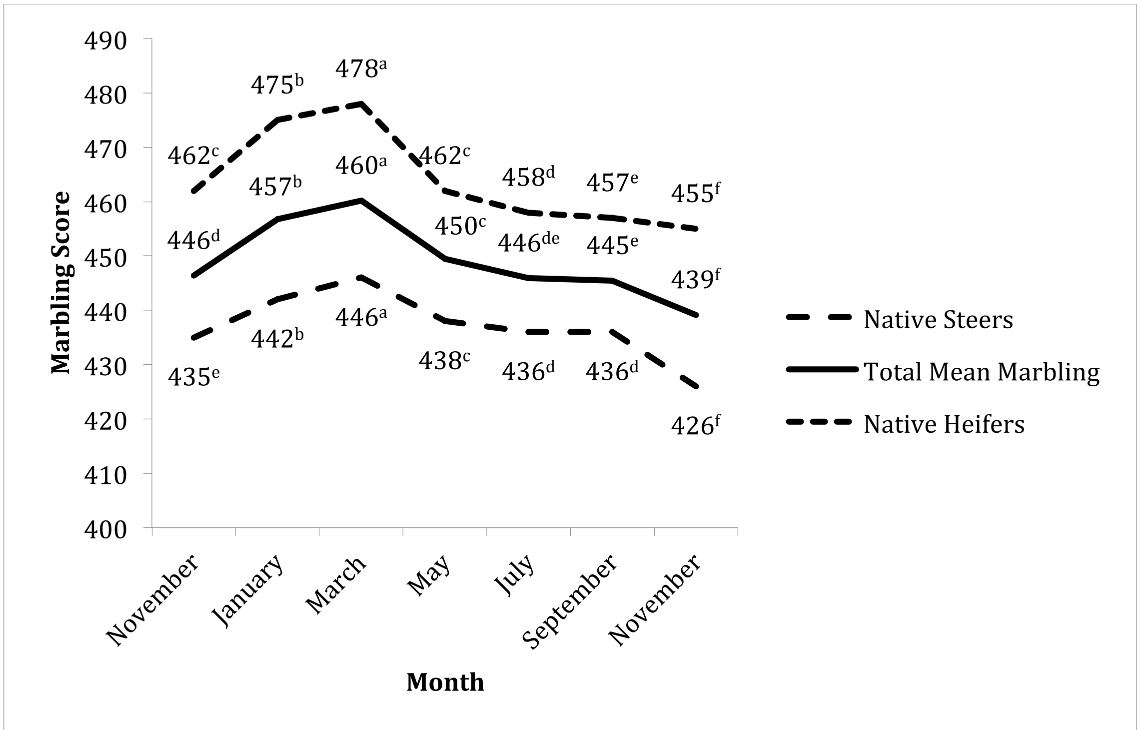

Figure 8. Seasonal changes in mean marbling[1,2] scores by month. The SEMs[3] by month were: total mean marbling score (SEM = 0.20 for November 2010, 0.17 for January 2011, 0.17 for March 2011, 0.16 for May 2011, 0.16 for July 2011, 0.17 for September 2011, and 0.19 for November 2011), native steers (SEM = 0.26 for November 2010, 0.21 for January 2011, 0.22 for March 2011, 0.21 for May 2011, 0.20 for July 2011, 0.21 for September 2011, and 0.25 for November 2011), and native heifers (SEM = 0.34 for November 2010, 0.26 for January 2011, 0.26 for March 2011, 0.26 for May 2011, 0.26 for July 2011, 0.28 for September 2011, and 0.31 for November 2011).

[a–f]Means within the mean marbling, native steers, and native heifers lacking a common superscript letter differ ($P < 0.001$).

[1]100 = Practically devoid^{00}, 300 Slight^{00}, 500 = Modest^{00}, 700 = Slightly Abundant^{00}, and 900 = Abundant^{00}.

[2]Mean marbling score is the mean for all observations.

[3]SEM is the SE of the least squares means.

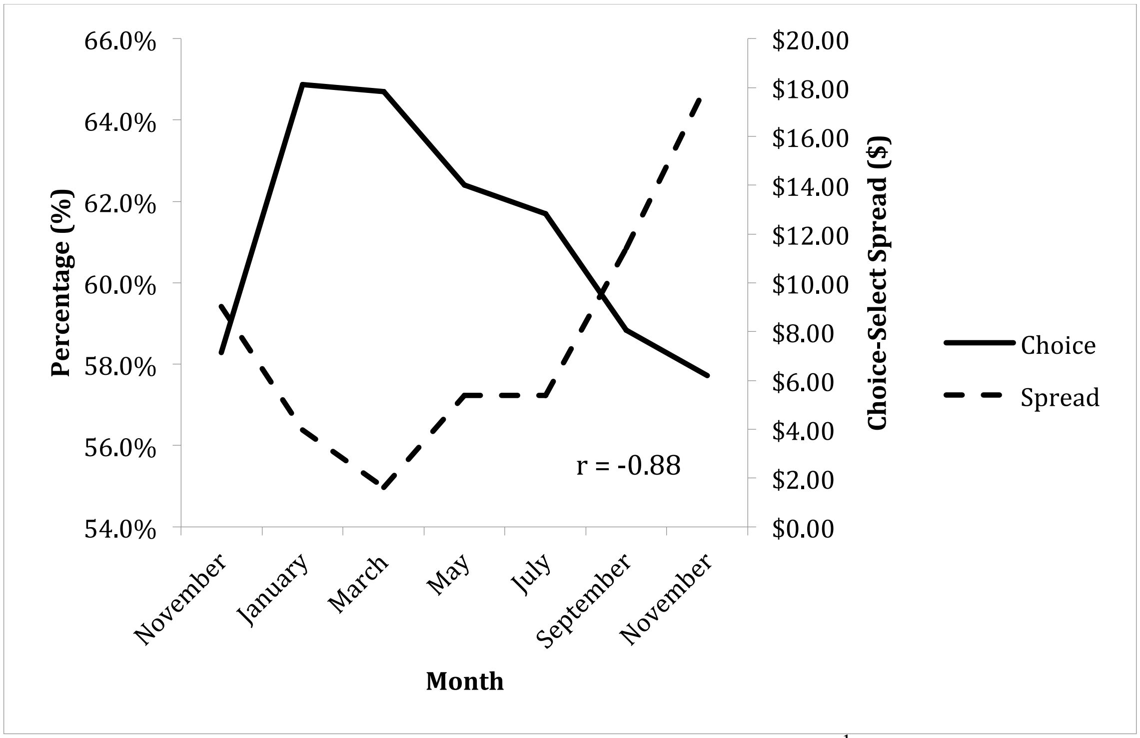

Figure 9. Percentage Choice by month and Choice-Select Spread[1].
[1]The Choice-Select spread reflects the average price differential between these two grades in the marketplace.

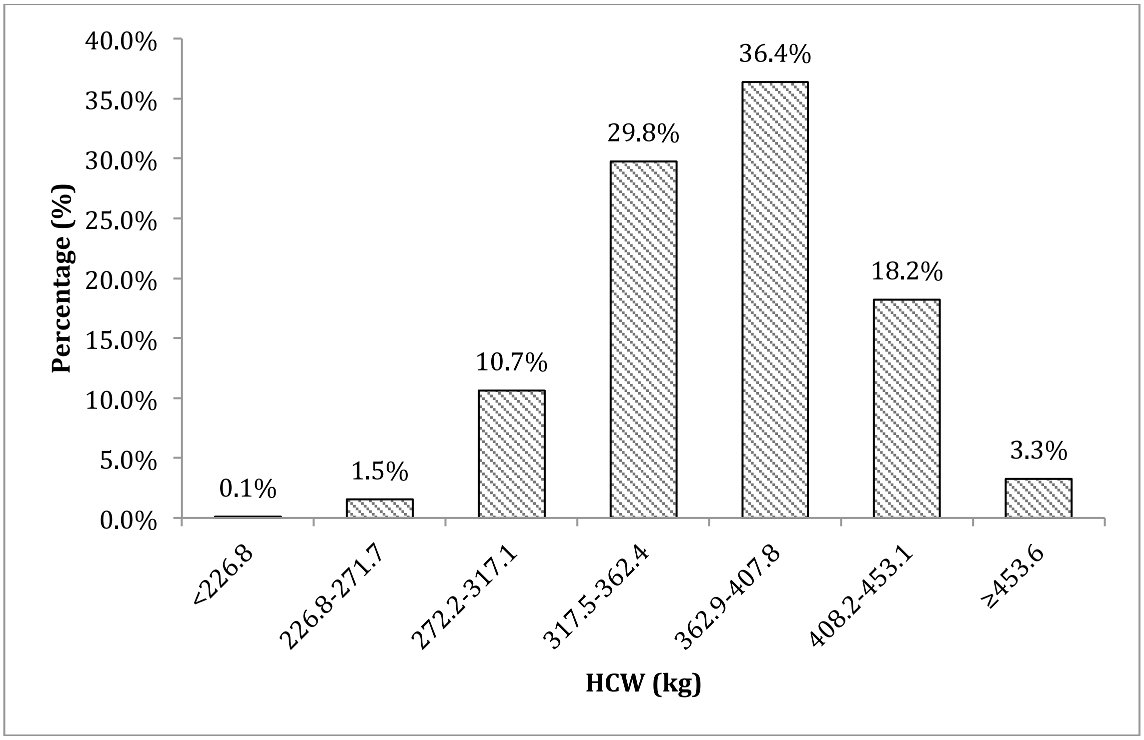

Figure 10. Frequency distribution of carcasses by HCW.

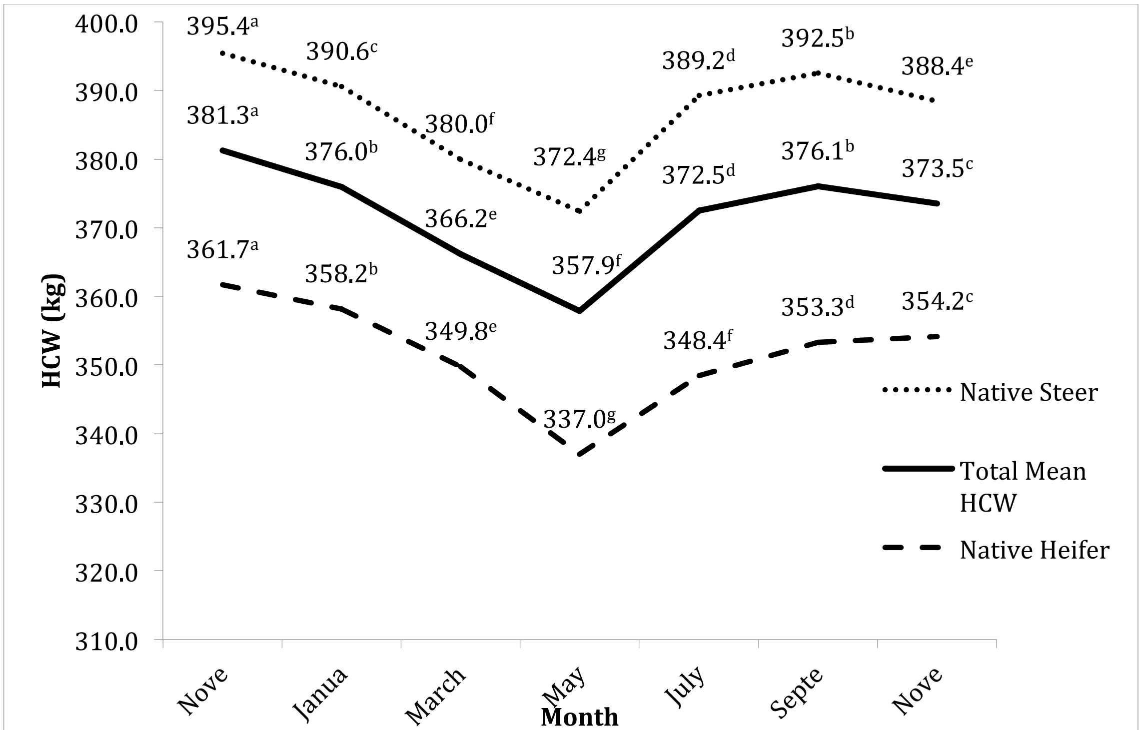

Figure 11. Seasonal changes in mean HCW[1] by month. The SEMs[2] by month were: total mean HCW (SEM = 0.09 for November 2010, 0.07 for January 2011, 0.08 for March 2011, 0.07 for May 2011, 0.07 for July 2011, 0.08 for September 2011, and 0.09 for November 2011) and Sex Class HCW for native steers (SEM = 0.11 for November 2010, 0.10 for January 2011, 0.10 for March 2011, 0.09 for May 2011, 0.09 for July 2011, 0.09 for September 2011, and 0.12 for November 2011), and native heifers (SEM = 0.13 for November 2010, 0.11 for January 2011, 0.11 for March 2011, 0.10 for May 2011, 0.10 for July 2011, 0.11 for September 2011, and 0.13 for November 2011).

[a–g]Means within the native steers, native heifers, and mean HCW lacking a common superscript letter differ ($P < 0.001$).

[1]Mean HCW is the mean for all observations.

[2]SEM is the SE of the least squares means.

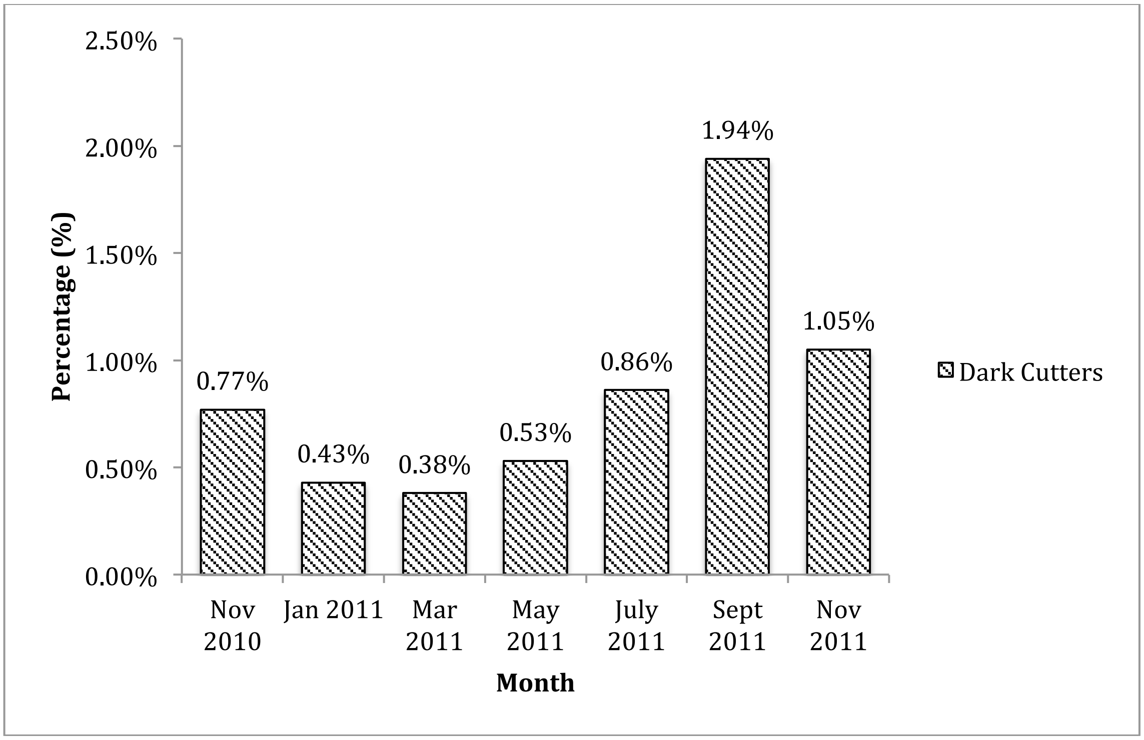

Figure 12. Frequency distribution of dark cutter carcasses by month.

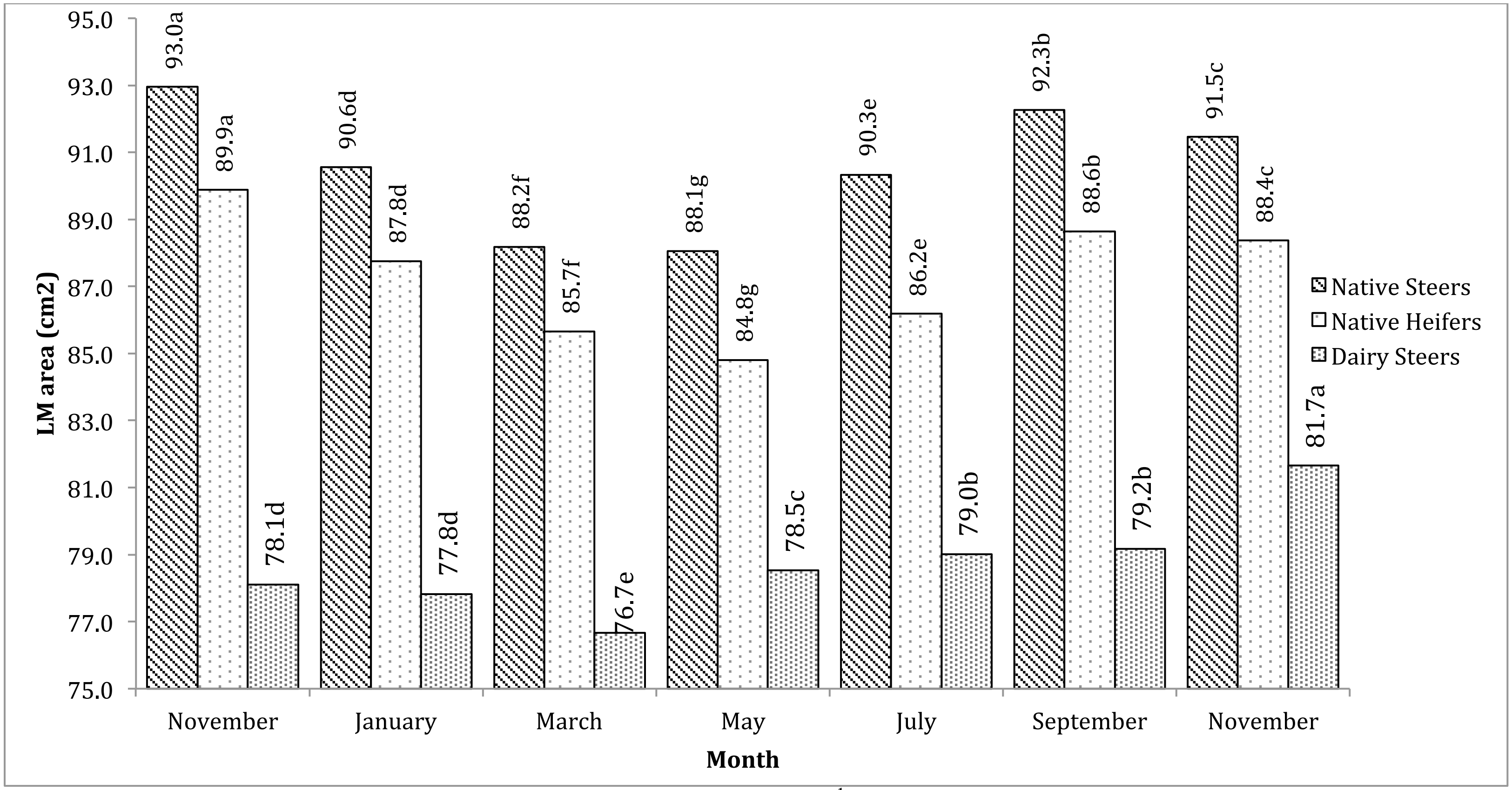

Figure 13. Seasonal changes in mean LM areas by month. The SEMs[1] by month were: native steers (SEM = 0.03 for November 2010, 0.03 for January 2011, 0.03 for March 2011, 0.02 for May 2011, 0.02 for July 2011, 0.03 for September 2011, and 0.03 for November 2011), native heifers (SEM = 0.04 for November 2010, 0.03 for January 2011, 0.03 for March 2011, 0.03 for May 2011, 0.03 for July 2011, 0.03 for September 2011, and 0.04 for November 2011), and dairy steers (SEM = 0.07 for November 2010, 0.06 for January 2011, 0.07 for March 2011, 0.07 for May 2011, 0.07 for July 2011, 0.08 for September 2011, and 0.09 for November 2011).

[a–g]Means within native steers, native heifers, and dairy steers lacking a common letter differ ($P < 0.001$).

[1]SEM is the SE of the least squares means.

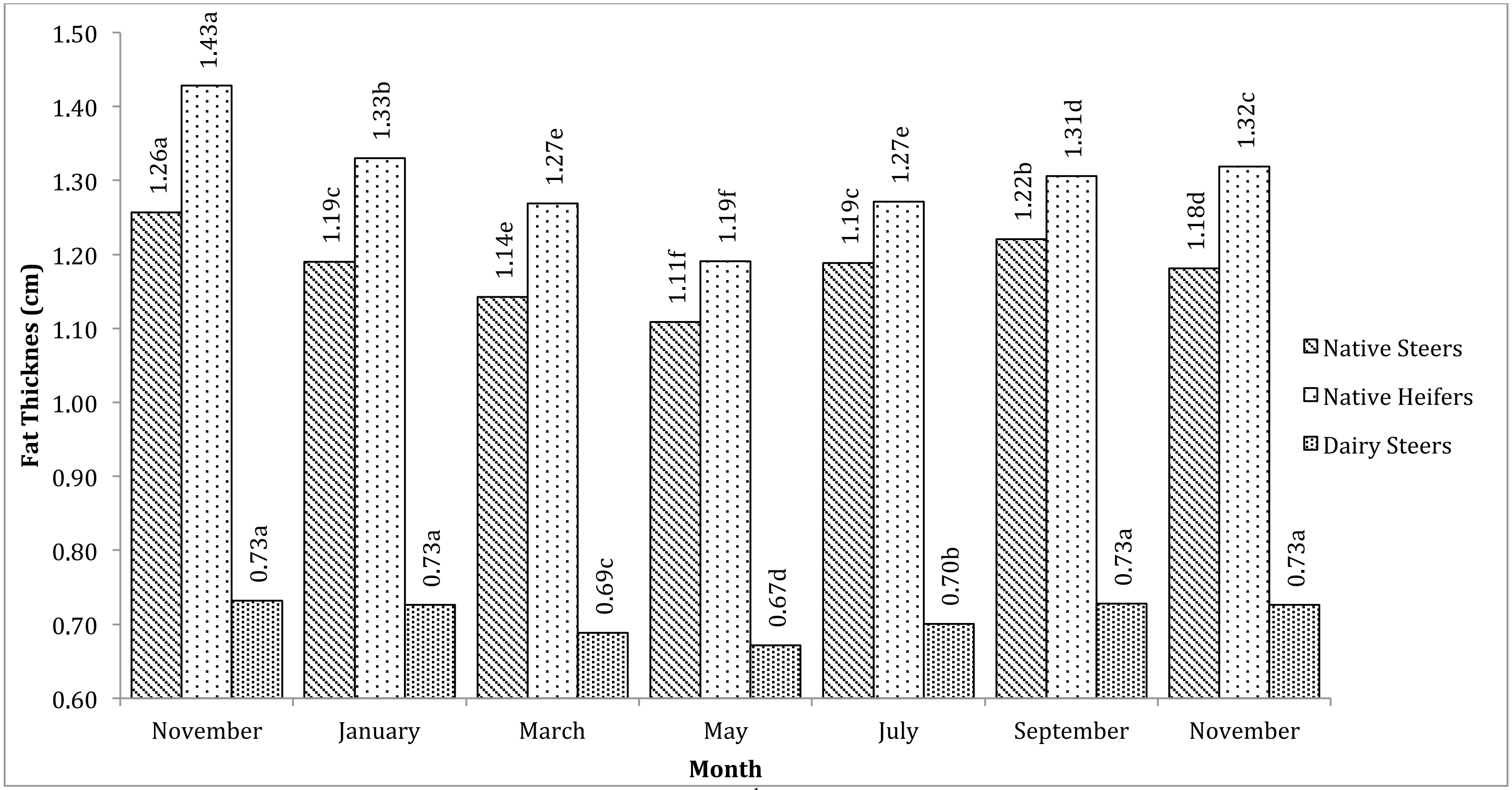

Figure 14. Seasonal changes in mean fat thickness. The SEMs[1] by month were: native heifers (SEM = 0.002 for November 2010, 0.001 for January 2011, 0.001 for March 2011, 0.001 for May 2011, 0.001 for July 2011, 0.001 for September 2011, and 0.002 for November 2011), native steers (SEM = 0.001 for November 2010, 0.001 for January 2011, 0.001 for March 2011, 0.001 for May 2011, 0.001 for July 2011, 0.001 for September 2011, and 0.001 for November 2011), and dairy steers (SEM = 0.002 for November 2010, 0.002 for January 2011, 0.002 for March 2011, 0.002 for May 2011, 0.002 for July 2011, 0.002 for September 2011, and 0.003 for November 2011).

[a–f]Means within native steers, native heifers, and dairy steers lacking a common letter differ ($P < 0.001$).

[1]SEM is the SE of the least squares means.

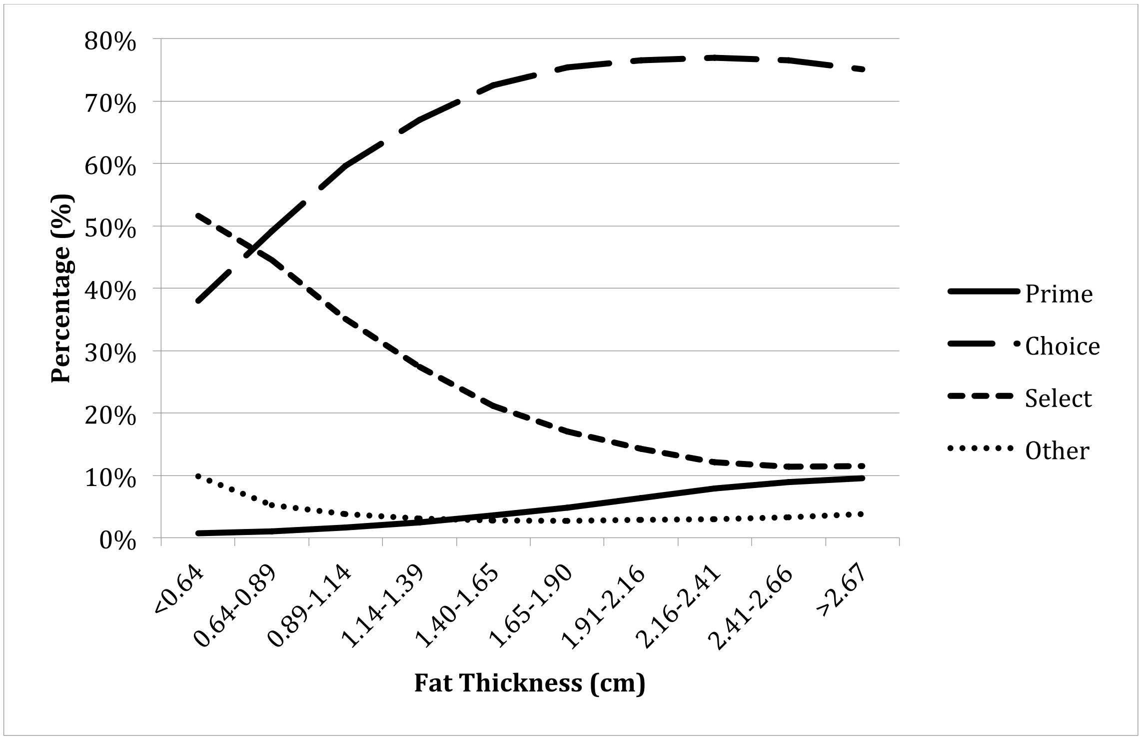

Figure 15. Frequency distribution of USDA quality grade by fat thickness.

APPENDIX B

TABLES

Table 1. Means, standard deviations, and minimum and maximum values for USDA carcass grade traits

Trait	Mean	SD	Minimum	Maximum
Yield Grade	2.86	0.9	-0.04	7.4
Fat thickness, cm	1.20	0.50	-0.98[2]	6.32
LM area, cm^2	88.45	11.85	28.67	181.94
HCW, kg	371.28	45.94	136.08	615.98
Marbling score[1]	449	94.8	100	1090

[1]100 = Practically devoid^{00}, 300 = Slight^{00}, 500 = Modest^{00}, 700 = Slightly Abundant^{00}, and 900 = Abundant^{00}.

[2]Minimum value is less than 0 because of converting data from a preliminary YG of less than 2.0.

Table 2. Least squares means (SEM[1]) for beef carcass characteristics of native steers, native heifers, and dairy steers

Trait	Native Steers (n = 1,317,287)	Native Heifers (n = 986,162)	Dairy Steers (n = 116,410)
Yield Grade	2.85[b]	2.87[a]	2.81[c]
	(0.00076)	(0.0009)	(0.00255)
Fat thickness, cm	1.18[b]	1.29[a]	0.71[c]
	(0.00043)	(0.00049)	(0.00143)
LM area, cm^2	90.40[a]	87.09[b]	78.61[c]
	(0.01003)	(0.01160)	(0.03375)
HCW, kg	386.45[a]	350.98[c]	372.89[b]
	(0.03711)	(0.0429)	(0.12485)
Marbling score[2]	437[c]	465[a]	457[b]
	(0.08707)	(0.10063)	(0.2929)

[a-c]Means within a row lacking a common superscript letter differ (*P* < 0.001)

[1]SEM is the SE of the least squares means.

[2]100 = Practically devoid[00], 300 = Slight[00], 500 = Modest[00], 700 = Slightly Abundant[00], and 900 = Abundant[00].

Table 3. Percentage distribution[1] of beef carcasses stratified by USDA quality[2] grades and yield grades

Yield Grade, %	USDA quality grade				
	Prime	Choice[3]		Select	Other
		Top Choice	Commodity		
1	0.03	0.81	4.09	9.28	1.53
2	0.47	6.92	17.01	14.97	1.65
3	1.30	11.00	14.32	6.33	0.89
4	0.72	3.71	2.96	0.87	0.22
5	0.13	0.45	0.26	0.07	0.03

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

[2]Other includes: no roll, Standard, Commercial, Utility, heiferette, dark cutter, blood splash, hard bone, and calloused ribeye.

[3]Top Choice=USDA quality grade Choice and marbling score ≥500, and Commodity=USDA quality grades Choice and marbling score <500.

Table 4. Percentage distribution of beef carcasses stratified by USDA quality[1] grades and day of week killed

Day of Week Killed	USDA quality grade			
	Prime	Choice	Select	Other
Monday	2.55[c]	60.47[d]	32.49[b]	4.49[b]
Tuesday	2.26[d]	59.66[e]	33.38[a]	4.70[a]
Wednesday	2.49[c]	60.68[d]	32.34[b]	4.49[b]
Thursday	2.58[c]	61.96[c]	31.19[c]	4.28[c]
Friday	3.51[a]	65.26[a]	27.70[e]	3.54[d]
Saturday	2.87[b]	64.26[b]	29.31[d]	3.56[d]

[1]Other includes: no roll, Standard, Commercial, Utility, heiferette, dark cutter, blood splash, hard bone, and calloused ribeye.

[a-e]Means within a column lacking a common superscript letter differ ($P < 0.001$).

Table 5. Means for beef carcass traits between in-plant survey[1] and instrument data

Trait	In-plant chilled carcass assessment (n = 9,802)	Instrument assessment (n = 2,427,074)
Yield Grade	2.95	2.86
Fat thickness, cm	1.30	1.20
HCW, kg	374.0	371.3
LM area, cm^2	88.77	88.45
Marbling score[2]	440	450

[1]Moore et al. (2012)

[2]100 = Practically devoid^{00}, 300 = Slight^{00}, 500 = Modest^{00}, 700 = Slightly Abundant^{00}, and 900 = Abundant^{00}.

Table 6. Means of qualty and yield grade characteristics of beef carcasses and distribution of gender by weight group and native steers and heifers

Weight group (kg)	Distribution (%)		Fat Thickness (cm)		LM area (cm^2)	
	Steers	Heifers	Steers	Heifers	Steers	Heifers
<226.80	24.96	69.33	0.46	0.55	69.42	68.41
226.80	25.55	70.43	0.54	0.72	73.04	73.25
249.48	25.49	71.16	0.63	0.84	76.19	76.30
272.16	26.29	70.58	0.74	0.97	79.10	79.10
294.84	28.82	67.65	0.84	1.08	81.93	82.05
317.51	34.23	61.28	0.94	1.20	84.44	84.81
340.19	43.00	51.15	1.04	1.30	86.96	87.42
362.87	54.61	38.88	1.13	1.40	89.37	89.89
385.55	66.86	27.33	1.22	1.50	91.72	92.12
408.23	76.61	18.81	1.32	1.60	93.92	94.22
430.91	82.44	14.00	1.41	1.68	95.76	95.99
453.59	86.43	10.87	1.50	1.74	97.21	98.05
476.27	87.06	11.08	1.59	1.84	98.66	98.89
498.95	87.14	11.21	1.67	1.87	100.25	100.08

Weight group (kg)	Yield Grade		Marbling[1]		HCW	
	Steers	Heifers	Steers	Heifers	Steers	Heifers
<226.80	2.00	2.13	356.14	373.07	212.90	212.47
226.80	2.06	2.26	368.62	395.42	240.63	240.51
249.48	2.14	2.36	382.99	412.52	262.78	262.70
272.16	2.25	2.50	394.97	428.90	285.15	284.99
294.84	2.39	2.62	405.88	442.58	307.54	307.16
317.51	2.53	2.74	416.20	455.27	329.91	329.27
340.19	2.66	2.87	425.66	466.32	352.26	351.31
362.87	2.79	3.00	433.83	476.71	374.52	373.43
385.55	2.90	3.13	441.05	487.13	396.67	395.59
408.23	3.03	3.28	448.61	495.53	418.67	417.79
430.91	3.17	3.42	457.46	504.47	440.64	440.08
453.59	3.34	3.53	467.79	511.00	462.80	462.48
476.27	3.50	3.70	477.58	519.59	485.03	485.07
498.95	3.67	3.82	485.95	526.12	512.88	514.33

[1] 100 = Practically devoid^{00}, 300 = Slight^{00}, 500 = Modest^{00}, 700 = Slightly Abundant^{00}, and 900 = Abundant^{00}.

Table 7. Least squares means (SEM[1]) for beef carcass characteristics of dark cutter carcasses and normal carcasses[3]

Trait	Dark Cutter Carcass	Normal Carcass
Yield Grade	2.48[b]	2.86[a]
	(0.0084)	(0.0006)
Fat thickness, cm	1.08[b]	1.20[a]
	(0.0047)	(0.0003)
LM area, cm^2	91.51[a]	88.43[b]
	(0.1117)	(0.0076)
HCW, kg	364.21[b]	371.31[a]
	(0.4267)	(0.0296)
Marbling score[2]	449[a]	450[a]
	(0.9437)	(0.0649)

[a,b]Means within a row lacking a common superscript letter differ ($P < 0.001$)

[1]SEM is the SE of the least squares means.

[2]100 = Practically devoid[00], 300 = Slight[00], 500 = Modest[00], 700 = Slightly Abundant[00], and 900 = Abundant[00].

[3]Normal carcasses are those that are not dark cutters.

Table 8. Least squares means for beef carcass traits (SEM[1]) within USDA quality grades[2]

Trait	Prime (n = 64,356)	Choice (n = 1,493,113)	Select (n = 764,881)	Other (n = 104,724)
Yield Grade	3.67[a] (0.00316)	3.08[b] (0.00066)	2.43[c] (0.00092)	2.40[d] (0.00248)
Fat thickness, cm	1.56[a] (0.0019)	1.30[b] (0.00039)	1.01[c] (0.00055)	1.00[d] (0.00149)
LM area, cm^2	81.44[d] (0.04555)	86.8027[c] (0.00946)	91.93[a] (0.01321)	90.76[b] (0.03570)
HCW, kg	379.84[a] (0.18006)	374.51[b] (0.03738)	365.96[c] (0.05223)	358.83[d] (0.14115)
Marbling score[3]	689[a] (0.3048)	482[b] (0.06328)	371[d] (0.08841)	409[c] (0.23894)

[a-d]Means within a row lacking a common superscript letter differ ($P < 0.001$).
[1]SEM is the SE of the least squares means.
[2]Other includes: no roll, Standard, Commercial, Utility, heiferette, dark cutter, blood splash, hard bone, and calloused ribeye.
[3]100 = Practically devoid^{00}, 300 = Slight^{00}, 500 = Modest^{00}, 700 = Slightly Abundant^{00}, and 900 = Abundant^{00}.

Table 9. Least squares means for beef carcass traits (SEM[1]) within yield grades

Trait	YG1 (n = 388,964)	YG2 (n = 986,776)	YG3 (n = 819,179)	YG4 (n = 208,873)	YG5 (n = 23,282)
Yield Grade	1.55[e] (0.00047)	2.53[d] (0.00029)	3.42[c] (0.00032)	4.34[b] (0.00064)	5.35[a] (0.00192)
Fat thickness, cm	0.69[e] (0.00054)	1.02[d] (0.00034)	1.43[c] (0.00037)	1.95[b] (0.00074)	2.59[a] (0.00221)
LM area, cm^2	100.57[a] (0.01599)	89.91[b] (0.01004)	83.66[c] (0.01102)	79.21[d] (0.02182)	75.57[e] (0.06535)
HCW, kg	355.38[e] (0.07116)	364.89[d] (0.04467)	379.45[c] (0.04903)	394.45[b] (0.0971)	409.18[a] (0.29084)
Marbling score[2]	382[e] (0.14737)	432[d] (0.09253)	481[c] (0.10155)	522[b] (0.20111)	550[a] (0.60236)

[a-e]Means within a row lacking a common superscript letter differ ($P < 0.001$).
[1]SEM is the SE of the least squares means.
[2]100 = Practically devoid[00], 300 = Slight[00], 500 = Modest[00], 700 = Slightly Abundant[00], and 900 = Abundant[00].

Table 10. Least squares means for beef carcass traits (SEM[1]) within fat thickness groups

Trait	<0.51 (n = 181,734)	0.51 to 0.75 (n = 284,425)	0.76 to 1.01 (n = 428,329)	1.02 to 1.26 (n = 520,845)	1.27 to 1.51 (n = 395,746)	1.52 to 1.77 (n = 304,545)	1.78 to 2.02 (n = 157,778)	2.03 to 2.28 (n = 88,010)	2.29 to 2.53 (n = 36,593)	>2.54 (n = 29,069)
Yield Grade	1.78[j]	2.11[i]	2.40[h]	2.77[g]	3.11[f]	3.46[e]	3.78[d]	4.11[c]	4.42[b]	4.89[a]
	(0.00132)	(0.00105)	(0.00086)	(0.00078)	(0.00089)	(0.00102)	(0.00141)	(0.00189)	(0.00293)	(0.00329)
Fat thickness, cm	0.38[j]	0.65[i]	0.88[h]	1.13[g]	1.38[f]	1.62[e]	1.88[d]	2.13[c]	2.39[b]	2.83[a]
	(0.00019)	(0.00016)	(0.00013)	(0.00012)	(0.00013)	(0.00015)	(0.00021)	(0.00028)	(0.00043)	(0.00049)
LM area, cm^2	90.38[b]	90.70[a]	90.43[b]	88.96[c]	87.88[d]	86.30[e]	85.38[f]	84.12[g]	83.33[h]	82.51[i]
	(0.02737)	(0.02188)	(0.01783)	(0.01617)	(0.01855)	(0.02114)	(0.02938)	(0.03933)	(0.061)	(0.06844)
HCW, kg	341.72[j]	355.02[i]	363.96[h]	370.89[g]	378.44[f]	383.51[e]	389.56[d]	393.66[c]	398.29[b]	403.56[a]
	(0.10263)	(0.2566)	(0.06685)	(0.06062)	(0.06955)	(0.07928)	(0.11014)	(0.00028)	(0.22871)	(0.2566)
Marbling score[2]	388[j]	407[i]	424[h]	448[g]	466[f]	485[e]	498[d]	512[c]	522[b]	527[a]
	(0.22172)	(0.17723)	(0.14443)	(0.13097)	(0.15025)	(0.17128)	(0.23796)	(0.31861)	(0.49412)	(0.55439)

[a-j]Means within a row lacking a common superscript letter differ ($P < 0.001$).
[1]SEM is the SE of the least squares means.
[2]100 = Practically devoid^{00}, 300 = Slight^{00}, 500 = Modest^{00}, 700 = Slightly Abundant^{00}, and 900 = Abundant^{00}.

Table 11. Least squares means for beef carcass traits (SEM[1]) within carcass weight groups

Trait	<227.0 (n = 2,686)	227.0 to 272.3 (n = 38,340)	272.4 to 317.7 (n = 261,956)	317.8 to 363.1 (n = 726,627)	363.2 to 408.5 (n = 881,799)	408.6 to 453.9 (n = 437,767)	>454.0 (n = 77,899)
Yield Grade	2.09^{g}	2.28^{f}	2.51^{e}	2.72^{d}	2.92^{c}	3.13^{b}	3.42^{a}
	(0.01626)	(0.0043)	(0.00165)	(0.00099)	(0.0009)	(0.00127)	(0.00302)
Fat thickness, cm	0.52^{g}	0.75^{f}	0.96^{e}	1.12^{d}	1.24^{c}	1.38^{b}	1.55^{a}
	(0.0093)	(0.00302)	(0.0043)	(0.00165)	(0.00099)	(0.0009)	(0.00127)
LM area, cm^2	68.43^{g}	75.36^{f}	80.83^{e}	85.63^{d}	90.01^{c}	94.18^{b}	97.60^{a}
	(0.21069)	(0.05577)	(0.02134)	(0.01281)	(0.01163)	(0.0165)	(0.03912)
HCW, kg	212.68^{g}	258.11^{f}	300.65^{e}	342.78^{d}	385.00^{c}	426.29^{b}	471.38^{a}
	(0.24625)	(0.04573)	(0.02494)	(0.01497)	(0.01359)	(0.01929)	(0.04573)
Marbling score[2]	368^{g}	401^{f}	428^{e}	445^{d}	454^{c}	461^{b}	476^{a}
	(1.933)	(0.5116)	(0.1957)	(0.1175)	(0.1067)	(0.1514)	(0.3589)

[a-g]Means within a row lacking a common superscript letter differ ($P < 0.001$).

[1]SEM is the SE of the least squares means.

[2]100 = Practically devoid^{00}, 300 = Slight^{00}, 500 = Modest^{00}, 700 = Slightly Abundant^{00}, and 900 = Abundant^{00}.