NATIONAL BEEF QUALITY AUDIT – 2016: A SURVEY OF THE MARKET COW AND BULL INDUSTRY TO DISCOVER AVENUES FOR IMPROVING QUALITY AND ENHANCING VALUE OF BEEF

A Thesis

by

MCKENSIE KAY HARRIS

Submitted to the Office of Graduate and Professional Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

Chair of Committee,	Jeffrey W. Savell
Committee Members,	Davey B. Griffin
	Dan S. Hale
Head of Department,	G. Cliff Lamb

December 2017

Major Subject: Animal Science

ABSTRACT

The National Beef Quality Audit – 2016 marks the fourth iteration in a series assessing the quality of live beef and dairy cows and bulls and their carcass counterparts. Conducted from March through December of 2016, trailers (*n* = 154), live animals (*n* = 5470), hide-on carcasses (*n* = 5279), hide-off hot carcasses (*n* = 5510), chilled carcasses (*n* = 4285), and offal items (*n* = 4800) were surveyed in 18 commercial packing facilities throughout the United States. Cattle were hauled in all types of trailers for a mean distance of 455.7 km for 6.7 h and had a mean of 2.3 m^2 of space during transit. Of the mixed gender loads of cattle arriving at the packing facility, cows and bulls were not segregated on 64.4% of the trailers surveyed. When assessed for mobility, 81.3% of cattle surveyed were sound. The mean body condition score for beef animals was 4.7 and for dairy cows and bulls was 2.6 and 3.3, respectively. Since the previous National Market Cow and Bull Beef Quality Audit (2007), dairy cattle have trended to be lighter muscled, yet fatter. Of cattle surveyed, 12.0% had horns, and 63.2% had no visible live animal defects. Beef cattle were primarily black-hided, while dairy cattle were primarily Holstein-patterned. Just over half (56.0%) of the cattle had no mud contamination on the hide, and an additional 34.1% only had small amounts of mud on the hide. Native (unbranded) hides were observed on 77.3% of cattle. Carcass bruising was evident on 64.1% of cow carcasses and 42.9% of bull carcasses. However, over half of all cattle surveyed had bruises which were only minimal in severity. Nearly all cattle (98.4%)

were free of visible injection site lesions. Harvest floor assessments indicated 44.6% of livers, 20.0% of viscera, 23.1% of lungs, 22.3% of hearts, 8.2% of heads, and 5.9% of tongues were condemned. Of the cows surveyed, 17.4% carried fetuses at time of harvest. Mean USDA quality grade attributes were skeletal maturity (D^{64}), lean maturity (C^{38}), overall maturity (D^{13}), and marbling score ($Slight^{64}$). The highest frequency of each USDA quality grade for cows surveyed were USDA Utility. The mean USDA yield grade attributes were preliminary yield grade (2.5), carcass weight (311.5 kg), LM area (65.4 cm^2), KPH (1.7%), and USDA yield grade (2.9) for all carcasses surveyed. The National Beef Quality Audit - 2016 is an important addition to the Quality Audit series. Comparisons across years allow for assessment of beef quality improvement. In addition, current results provide guidance for continued educational and research efforts for improving market cow and bull beef quality.

DEDICATION

This work is dedicated to all who have encouraged me along the way, in large and small ways. Most importantly, to my mom and sister who have been, and always will be, by my side inspiring me to reach for the stars, never settle for mediocrity, and explore my own potential while never letting me forget how much I love home. Next, to Kyle who was here through it all and offered words of encouragement and ice cream breaks whenever needed. And finally, I dedicate this work to the 2017 Fightin' Texas Aggie Meat Judging team. I will never be able to express how dear this team's members are to me. I appreciate how much they motivated me to finish strong. Thank you is not enough, but I hope I have inspired others to achieve success through the thick and the thin because it is definitely worth it.

ACKNOWLEDGEMENTS

I thank my committee chair, Dr. Jeffrey W. Savell, and my committee members, Dr. Davey B. Griffin and Dr. Daniel S. Hale. I also would be remiss if I did not thank the countless other professors and mentors who helped along the way, and all of the graduate and undergraduate students involved in this project; your guidance and support throughout the last year and a half is forever appreciated.

CONTRIBUTORS AND FUNDING SOURCES

Contributors

This work was supported by a thesis committee consisting of Dr. Jeffrey W. Savell, Dr. Davey B. Griffin, and Dr. Daniel S. Hale of the Department of Animal Science. It is also necessary to recognize additional professors and mentors who contributed to the success of the project: Dr. Ashley N. Arnold, Dr. Kerri B. Gehring, and Dr. Chris R. Kerth. Data collection was achieved through the contribution of multiple graduate and undergraduate students at Texas A&M University: Clay Eastwood, Courtney Boykin, Aeriel Belk, Baylee Besiree, Drew Cassens, Mark Frenzel, Micki Gooch, Brogan Horton, Jillian Jobe, Hillary Martinez, Adam Murray, Katy Jo Nickelson, Shelby Scheifelbein, and Spencer Tindel. Additional help with data collection was offered by the faculty and graduate and undergraduate students at Colorado State University, North Dakota State University, Oklahoma State University, University of Georgia, University of Nebraska-Lincoln, and West Texas A&M University. Support staff at the National Cattlemen's Association also helped in the coordination of data collection and presentation.

Funding Sources

This project was funded in part by the National Beef Checkoff with the support of the National Cattlemen's Beef Association.

TABLE OF CONTENTS

Page

LIST OF FIGURES

Page

Page

Page

Page

LIST OF TABLES

Page

Page

CHAPTER I

INTRODUCTION AND LITERATURE REVIEW

History

Chuck Lambert, in his presentation to the International Stockmen's School, initiated the wakeup call for the beef industry's cost of inefficiencies (Lambert, 1991). Outlining the lost opportunities the National Cattlemen's Association identified and then placing an economic loss resulting from those lost opportunities, Lambert (1991) reported $11.999 billion USD were lost annually. Divided over the number of cattle harvested in 1989, the economic loss per animal was calculated to be $458 USD per fed cattle. This economic loss was acknowledged as a culmination of multiple shortcomings through all beef sectors. Reproductive performance or calving rate among the United States cow herd contributed $2.6 billion USD in loss. Lambert (1991) determined that only 80% of the cows weaned a calf, and if this percentage were increased, the pounds of calves weaned would equate to increased quantity of end-product beef. Similarly, death loss of cattle prior to slaughter reduced the number of cattle marketed per year and therefore reduced the pounds of beef available for market by the packer, purveyor, or retailer. Death losses equated to be a $1.86 billion USD financial loss per year. Hot iron branding cost the industry $180 million USD, or $25 USD per head branded, per year. Too small cattle (<500 pounds) weaned were described as an economic loss ($299 million USD) as they offered fewer pounds to sell to the feedlot or stocker operator, required additional inputs for gain, and were higher risk for becoming sick and compromised even furthering the input costs for doctoring and holding during this time. Lambert (1991) realized calves under 500 pounds, in addition to cattle moving through multiple ownership, required greater processing costs associated with vaccinating, conditioning, and transporting. If processing points were minimized, the industry would realize a $110 million USD increase in net returns. Even today, cattle are sometimes inefficient converters of feed to pounds of gain. Improving feed efficiency by one pound of feed per one pound of gain would have saved the beef industry in the 1980s feed costs and increase returns by $325 million USD. Shortcomings that arose at the packer level, identified to be lost opportunities, included the existence of outlier cattle. Defined as cattle that were too light ($26.2 million USD), too heavy ($44.8 million USD), graded below USDA Select ($40.0 million USD), produced dark cutting beef ($22.0 million USD), and cattle that were too fat ($171 million USD), outlier cattle cost the industry $304 million USD dollars in the 1990s. Not only were cattle that were considered too fat (USDA yield grade 4 and 5) contributing to economic losses, but cattle that produced excess fat, that defined as fat over a quarter of an inch, were still producing this excess at a cost to the industry ($4.41 billion USD). Management losses to include those associated with carcass and offal condemnations, carcass bruises, injections, and abscesses totaled $143 million USD. Finally, the retail sector were included in the contribution to the losses through retail shrink ($852 million USD) and out-of-stock product ($916 million USD).

Now, all of these areas that lead to economic losses could not be expected to be completely remedied; there will always be some lost opportunities in the beef industry.

If expected deficiencies in areas such as reproductive performance, death loss, and others outlined by Lambert (1991) were taken out of the equation, it was found were still losing approximately $5 billion USD (Smith, 1991). This $5 billion USD loss resulted from things such as hot iron branding, outlier cattle, excess fat production, carcass and offal condemnations, carcass bruising, injections, and abscesses. A majority of these characteristics were estimated by Dr. Gary Smith at the National Cattlemen's Association Cattle Trends Seminar (January 1991) to total a $200 USD per head economic loss to the industry (Smith, 1991). Because there had been no comprehensive effort to benchmark the status of cattle for the market sector prior to the 1990s, there was little means for understanding where the industry stood on quality shortfalls and associated costs. Thus, Darrell Wilkes, Vice President of the National Cattlemen's Association said, "Because we don't know exactly where we stand on "quality" or what each quality shortfall costs or which quality shortfall might lead to beef's downfall, the U.S. beef industry must conduct, in 1991, a beef quality audit. From such audit we will determine where we are now and where we should be in the year 2001, relative to quality" (Smith, 1991). Initiated then, the first National Beef Quality Audit was conducted to survey the steer and heifer sectors of the beef industry (Smith et al., 1992; Lorenzen et al., 1993).

Following the conclusion of the National Beef Quality Audit – 1991, which benchmarked the fed steer and heifer beef industry, the National Cattlemen's Beef Association (NCBA) launched a similar campaign to benchmark the market cow and bull beef industry. The first National Market Cow and Bull Beef Quality Audit

(NMCBBQA), then titled "The National Non-Fed Beef Quality Audit" (NNFBQA), saw its inception in 1994. Under the direction of Colorado State University and NCBA, researchers undertook a three-phase approach for identifying beef quality defects in cows and bulls destined for market. Phase I involved a series of interviews conducted with industry leaders, veterinarians, packers, and end-users of beef derived from cows and bulls. Those interviewed were asked to identify the top quality defects in live cattle, as well as carcasses and offal. Phase II consisted of in-plant audits of packing facilities that process market cows and bulls. Data, aimed at capturing actual levels of quality defects identified in Phase I interviews, were collected in holding pens, on the harvest floor, and in the coolers. Phase III was designed to bring together industry leaders throughout all non-fed sectors to discuss the data and configure a strategy for improving beef quality as the industry moved forward. The specific goal for these strategies was to focus on management practices "which could be employed by beef and dairy producers to correct the quality non-conformities identified in phases I and II." The 1994 audit set benchmarks and standards for improving market cow and bull quality defects and promoted the opportunities for producers to garner increased returns if they produce beef in a consumer-responsive and quality oriented way (National Cattlemen's Beef Association, 1994).

Four years later, the National Cattlemen's Beef Association, again with the help of Colorado State University, conducted the National Market Cow and Bull Beef Quality Audit – 1999 (NMCBBQA-1999) (Roeber et al., 2000; Roeber et al., 2001). The intent was to provide a comparison to the data in the NNFBQA-1994 in efforts to gauge the industry's progress in improving the quality of beef from market cows and bulls. The audit was conducted in the same manner with a three-phase approach. In continuing the series, the most recent NMCBBQA-2007 was conducted in cooperation with Texas A&M University to again provide comparisons for the last thirteen year's improvements and set new benchmarks for the industry. All of these efforts not only allow for ongoing improvements in the market cow and bull industry, but also allow for advancements in producer education. The most current iteration of the Market Cow and Bull Beef Quality Audit (NBQA-2016) allows the continued efforts of beef and dairy cattle producers, as well as academic professionals, to improve beef quality and enhance producer education resources. Data was collected in the same manner as previous audits to allow for comparisons to be made over the last 22 years and determine continued areas of emphasis for research and educational efforts in the area of beef quality.

National Non-Fed Beef Quality Audit - 1994

The most significant finding from face-to-face interviews conducted during Phase I of the NNFBQA-1994 was many producers were reluctant to market cattle in a timely manner, subsequently exacerbating the health and condition of market cows and bulls arriving at harvest facilities (Roeber et al., 2000). Packers expressed the ten most severe problems or deficiencies of the market were: excessive bruises, too likely to be condemned, excessive brands, too small ribeyes in cows, too little muscling in cows, too much external fat, too heavy live weights in bulls, too low dressing percentage, too advanced lameness and too likely to have a disease (Roeber et al., 2000). Packers, members of the National Livestock Marketing and Grading Association and staff members of Market News Service offered the top-ten advice for increasing the salvage value of market cows: market more judiciously – timing/season (1), lessen disabled cattle (2), lessen ocular neoplasia (3), lessen emaciation (4), and don't bruise (5) or brand (6), as well as prevent injection-site lesions and abscesses (7), prevent cows from getting too light in weight (8), ensure cows aren't bred (9), and sell grade-and-yield and on-the-rail (10) (Roeber et al., 2000). As additions to this list, interviewees determined arthritis in bulls should be prevented, bulls shouldn't be allowed to get too big or too fat, and producers should minimize insect damage and scratches on the hide (Roeber et al., 2000).

Although the data from Phase II of the NNFBQA-1994 included both beef and dairy cows and bulls, findings focused most heavily on the contribution of dairy cattle, specifically dairy cows, to the market cow and bull beef supply (National Cattlemen's Beef Association, 1994). It was found that 14.5% of dairy cattle had udder or teat problems, 34.1% and 11.5% had latent hide damage (scars/scratches) and insect hide damage, respectively, 5.8% of dairy cattle were reported as lame, and 4.6% of dairy cattle were assigned a body condition score of 1 (too low) and 3.0% were assigned a body condition score 5 (too high). Muscle score was too low (score 1) in 34.7% of beef cattle and 57.5% of dairy cattle. About fourteen percent of dairy cows were seen to have a knot or abscess; both directly related to injection site lesions, which cost the industry an estimate of $4.2 million USD annually. This loss was most notably identified in hindquarters of dairy cattle, in which the outside round could no longer be marketed as a value-added product, but rather would be used in production of lower-valued ground beef (Smith et al., 1994).

Another quality concern identified by researchers was the prevalence of carcass bruising, which was believed to be a result of horn presence in cattle. Packers identified carcass bruising as the number one concern during the Phase I interviews. The in-plant assessment confirmed the high prevalence of bruises, as 80% of all cow carcasses (beef and dairy) were bruised. Not only this, the majority of carcasses surveyed had multiple bruises. The approximate weight of tissue trimmed from major, medium and minor bruises average 3.19, 1.54, and 0.66 lbs., respectively. It was estimated that the industry lost $75 million USD annually as a result of loss in beef from trimming these carcass bruises. Horns, a cause for bruising, were of size to be concerning in 24.2% of beef cattle and 11.9% of dairy cattle. The industry saw another economic loss in hide damage from brands - $16.6 million USD annually. Fifty-five percent of beef cattle hides and 20.9% of dairy cattle hides garnered a hot-iron brand (National Cattlemen's Beef Association, 1994).

Cooler audits revealed USDA quality grades were low Utility and average Cutter for cows and bulls, respectively. Loin muscle (LM) area was too small (criteria unknown) in 31.1% of cows and too large (criteria unknown) in 39.9% of bulls. Muscle score was too low (score 1) in 67.1% of cows and 14.8% of bulls. It was determined 26.4% of cows and 8.2% of bulls were assigned fatness scores that were too high (criteria unknown). Finally, USDA yield grade was too high in 31.6% of cows and 4.8%

of bulls. About 20.2% of bulls showed dark cutting beef causing two-thirds reduction in USDA quality grade (Roeber et al., 2000).

During Phase III of the NNFBQA-1994, attendees identified the top-ten strategies for improving the quality and competitiveness and value of cows and bulls for beef: (1) minimize condemnations, (2) effect end-product improvements, (3) decrease hide damage, (4) reduce bruising, (5) encourage competitiveness by implementing marketing practices that assure producer accountability, (6) assure equity in salvage value, (7) improve beef safety, (8) prevent residues and injection site lesions, (9) enhance price discovery by encouraging the development of effective live and carcass grade standards, and (10) encourage on-farm euthanasia of disable cattle and those with advanced cancer eye (Roeber et al., 2000). Three objectives for cattlemen and dairy producers were brought forth to minimize producer-related defects: (1) Manage cattle to minimize defects and quality deficiencies, (2) Monitor the health and condition of their cattle, and (3) Market cows and bulls in a timely and prudent manner. If producers prioritized these three goals, they could recapture $69.90 USD/head (Roeber et al., 2000).

The NNFBQA-1994 set benchmarks and standards for improving market cow and bull quality defects and enhancing the image of the beef industry, especially due to the threat posed to beef market shares with the increase in competition from pork and poultry, as well as the 1993 *Escherichia coli* O157:H7 foodborne illness outbreak. The NNFBQA-1994 concluded with remarks that the entire beef industry must work together in improving the quality and consistency of non-fed beef by focusing on the findings of the NNFBQA-1994 (National Cattlemen's Beef Association, 1994).

National Market Cow and Bull Beef Quality Audit – 1999

In an effort to measure improvement of quality and consistency of the market cow and bull industry, the National Market Cow and Bull Beef Quality Audit – 1999 (NMCBBQA-1999) was conducted five years after the inception of the first audit (Roeber et al., 2000; Roeber et al., 2001). This audit was conducted in a similar manner to the NNFBQA-1994. There were four objectives outlined: (1) Identify and quantify, numerically and monetarily, the incidence of quality defects in U.S. market cows and bulls, their carcasses and dress-off/offal items. (2) To characterize as many as possible of the causes of quality defects in market cows and bulls. (3) To compare the results of this audit to those of the NNFBQA-1994. (4) To determine which strategies and tactics to pursue and employ in efforts to reduce/eliminate specific defects in the quality of U.S. market cow and bull beef.

In achievement of objectives one and two, face-to-face interviews with affiliated industries, government agencies, associations, auction markets, packers, and trade associations uncovered the top quality challenges faced by the industry. After ranking the severity of producer-controllable concerns, expressing personal concern about the quality of market cows and bulls, and identifying the top five issues and directives necessary to present to producers in order to attain a defect-free cow and bull market, the 49 interviewed revealed the top three quality challenges were: (1) frequency of antibiotic residues, (2) frequency of lead shot in carcasses, and (3) potential need to modify pricing of, and prompt payment for market cows and bulls (Roeber et al., 2001). Most specific to packers, but pertinent to all interviewed, the concern with antibiotic residues and lead shot found in carcasses was of importance due to the food safety implications of these foreign materials in the product, and the inability of packers to detect all carcasses not in compliance with federal regulations regarding these. The presence of carcass bruises and arthritic joints was very closely associated to the concern of appropriate pricing and prompt payment during the industry interviews; both of these quality defects resulted in carcass trim, but if producers are selling on a carcass basis the final carcass weight is dependent on how much lean tissue is trimmed from the carcass to clear the bruise or joint. Roeber et al. (2000) determined options such as timely culling, increasing market power through the use of partnerships and collective marketing alternatives, use of source and process verification systems, and enhancing the value of market cow and bull products (eliminating carcass defects), among others were ways of improving the price point and payment concerns expressed in the Phase I interviews. Additional quality concerns were expressed including structural problems, condition of cows and bulls, timeliness of culling, frequency of downers, frequency of carcass and offal condemnations, and others. Nonetheless, it was put most simply by auction market owners and operators who unanimously expressed quality and value of market cows and bulls could be improved, no matter the quality challenges that were perceived (Roeber et al., 2000).

The second phase of the NMCBBQA-1999, an in-plant assessment of producer-related defects, gave substantial evidence to show improvement from the NNFBQA-

1994 benchmarks. Cattle in the holding pens had less incidence of cancer eye in 1999 than 1994 (4.3% vs. 8.5%). Even further improvement was evident, as only 0.6% of cattle had advanced stages of cancer eye in 1999 as compared to 2.4% in 1994. The NMCBBQA-1999 revealed there had been an increase in native (non-branded) hides since 1994, an improvement in quality for the hide market. In addition, structural defects in all cattle types and sexes declined from 1994, showing improvement in live animal well-being and more timely marketing of cows and bulls.

Unfortunately, the NMCBBQA-1999 audit revealed a drastic increase (44.4% vs. 9.6% for beef cows and 72.1% vs. 11.6% for dairy cows) in the number of cows that were lighter muscled since 1994. In the Executive Report published by NCBA, Roeber et al. (2000) stated 90.5% of beef cows, 15.1% of beef bulls, 99.8% of dairy cows, and 35.5% of dairy bulls had muscle scores that were too low (score 1 on a 1 to 5 scale with 1 being too thin, 3 being an average beef steer, and 5 being an extremely heavy muscled animal). In accordance with muscle scores, body condition scores are a valuable decision-making tool in determining the timely marketing of cows and bulls. Body condition scores were determined using a 1-9 point scale, 1 being thin and 9 being overly fat. The auditors found body condition scores in 1999 were more distributed over the moderate range (score 4 to 5) than they were in the 1994 audit, showing improvements in quality in live cattle at market. Hide contamination (feces, dirt, manure), an attribute of market cattle measured in the NMCBBQA-1999 and not in the NNFBQA-1994, was shown to be more prevalent on dairy cows than beef cows. Fortunately, the amount of hide contamination was relatively low for cows as 84% (beef cows) and 93.2% (dairy cows) exhibited no or only small amounts of hide contamination. The NMCBBQA-1999 observed only 16.8% of carcasses did not have a bruise, and there was a decrease in frequencies of major (30.7% to 21.6% in cows and 7.4% to 6.9% in bulls) and medium (53.9% to 41.7% in cows and 19.5% to 16.7% in bulls) size bruises on cows and bulls when compared to the NNFBQA-1994. In contrast, the frequency of minor bruises increased (51.5% to 77.2% in cows and 25.3% to 44.4% in bulls) in carcasses from 1994 to 1999. At least one arthritic joint, a serious food safety and quality concern in 1999 as identified by packers, was prevalent in 7.4% of all carcasses, and two were identified in 4.0% of carcasses. The frequency of whole cattle or carcass, liver, tripe, heart, and head condemnations decreased from 1994 to 1999. Carcass assessment in the coolers gave mean values for carcass weight, muscle score, finish score, fat color score, skeletal maturity, kidney, pelvic and heart fat (KPH) percentage, fat thickness, marbling, lean maturity, LM area, and USDA Yield Grade. Most notably, the NMCBBQA-1999 identified the carcass weights to be too low (<400 lbs.) in 16.5% of cows and 0.7% of bulls. These frequencies were similar to those reported in the NNFBQA-1994. The percentage of carcasses that were too light muscled increased from 1994 (Roeber et al., 2001).

To fulfill the final objective of the NMCBBQA-1999, a strategy workshop was convened to determine tactics to assist in the reduction/elimination of quality defects observed in the market cow and bull beef supply. Invited attendees from all sectors of the cow and bull industry, including producers, packers, extension specialists, academics, and government personnel, discussed their reactions to the results of the

NMCBBQA-1999 and offered insight as to how best to move forward with education programs, government regulation and program recommendations, and the next steps to improve total quality (Roeber et al., 2000). As an example, a beef cattle producer expressed the need to do something creative for forcing people to understand the cost and quality implications associated with defects in their cows. Another insight provided came from USDA, Agricultural Marketing Service personnel who stated the current grade standards for cow and bull beef are not widely used, yield grades are not a good measure of cutability differences amongst cows and bulls, and quality grades were not accurately representing market breaks based on quality because fat color is an important determining factor in consumer purchasing consideration.

Following these discussions, workshop participants concluded the top ten quality challenges in market beef cows and bulls were: (1) Too frequent incidence of birdshot/buckshot. (2) Too frequent and severe bruises. (3) Too frequent rib and/or multiple brands. (4) Too advanced cancer eye damage. (5) Too frequent injection-site lesions/knots. (6) Too advanced arthritis/severe structural defects. (7) Too frequent downers. (8) Too severe emaciation. (9) Too frequent antibiotic residues. (10) Inadequate muscling. The top ten quality challenges for market dairy cows and bulls differed slightly for order of importance: (1) Too frequent antibiotic residues. (2) Too frequent injection-site lesions/knots. (3) Too frequent downers. (4) Too advanced arthritis/severe structural defects. (5) Too severe emaciation. (6) Too frequent and severe bruises. (7) Inadequate muscling. (8) Too frequent incidence of birdshot/buckshot. (9) Too frequent rib and/or multiple brands. (10) Too advanced cancer eye damage.

Each of these quality shortcomings were identified to be not only quality challenges, but also causes for decreasing value of market cows and bulls. Researchers presented data on the economic costs associated with each of the quality defects identified in phase II (Roeber et al., 2000). Although most of these costs were lesser values than those determined in 1994, there were still significant areas where costs could be recouped through changes in management practices. It was determined that $13.82, $27.50, and $27.50 could be recaptured by managing cows and bulls to minimize quality defects, monitoring the health and condition of those cows and bulls, and marketing them in a timely manner, respectively (Roeber et al., 2001).

The conclusion of the 1999 Strategy workshop included an outline of four directives to be employed by producers, encouraged by extension personnel, and implemented into programs to increase the quality and value of the market cow and bull industry: (1) Recognize and maximize the value of your market cows and bull. (2) Be proactive to ensure the safety and integrity of your product. (3) Use appropriate management and handling practices to prevent quality defects. (4) Closely monitor herd health and market cull cattle promptly at the appropriate time to avoid severe quality defects. The Quality Assurance Code of Ethics was established to ensure the execution and implementation of these four directives (Roeber et al., 2000).

The results of the 1999 audit showed there were areas of improvement in the quality of market cows and bulls compared to the audit results from 1994. However, researchers stated there was still need for further work to continue to maximize producer profit in and industry acceptability of the cow and bull market.

National Market Cow and Bull Beef Quality Audit – 2007

Just as in the previous two audits, the National Market Cow and Bull Beef Quality Audit – 2007 (NMCBBQA-2007) was conducted in three phases: Phase I: face-to-face interviews, Phase II: in-plant live cattle and carcass evaluations, and Phase III: strategy workshop to develop direction for the next five years (Nicholson, 2008; Nicholson et al., 2013). The first phase of the NMCBBQA-2007 found the top three challenges facing the market cow and bull industry were: (1) food safety issues with pathogen control, (2) economic issues with market prices, import and export shortages, and access to markets, and (3) animal welfare and handling issues. In comparison to the NMCBBQA-1999, antibiotic residues ranked as the most pertinent quality challenge, but fell fifth in ranking in 2007. Nicholson (2008) also listed the top five improved quality challenges since 1999; interestingly, three were listed both as an Improved Challenge since 1999 and a Top Quality Challenge identified in 2007. This showed that while there had been strides of improvement, the issue of bruising, hide damage, and injection site location were still areas needing continued attention.

Phase II of the NMCBBQA-2007 incorporated the same type of data collected in 1999, with a few additions to more accurately decipher current industry quality related issues. One addition focused on animal welfare and handling, involving the evaluation of trucks and trailers hauling cattle to packing facilities, as well as the use of driving aids when handling cattle (Nicholson et al., 2013). Most heavily emphasized was the distance cattle were hauled to harvest. The mean distance traveled for all cattle types was 282.5 minutes, and of the trailers surveyed, the longest haul was 1250 minutes. It was found cattle hauled to harvest were allowed sufficient square footage with a mean of 3.2 m^2, which fell within the dimensions recommended by Grandin (2013). In addition, the type and manner of usage of driving aids showed 77.7% of all loads were handled without the use of an electric prod, when unloading the trailers (Nicholson, 2008).

Live evaluation of cattle provided benchmarks for hide color and identification type, at the same time as offering comparisons for characteristics surveyed in 1999. Nicholson (2008) determined 44.2% and 52.3% of beef cows and beef bulls, respectively, were black hided, whereas 92.9% and 90.1% of dairy cows and bulls, respectively, were Holstein patterned. The incidence of hip/butt brands (36.4% vs. 15.1%) and side brands (21.1% vs. 4.8%) decreased dramatically from 1999. Although horn prevalence was still apparent, there was a positive increase (83.4% vs. 77.2%) in cattle with no horns when comparing the 2007 to the 1999 findings. Cattle with cancer eye (any stage) decreased from 4.3% to 2.9% over the eight-year span. The evaluation of lameness by a five-point scoring system showed that beef cows and beef and dairy bulls showed improvements in soundness (a greater percentage of cattle assigned a score of 0). Conversely, only 51.4% of dairy cows were sound in 2007 compared to 76.5% in 1999. The NNFBQA-1999 showed that 44.4% and 46.1% of beef cows had a muscle score of 1 and 2, respectively, whereas in 2007 beef cows were more heavily muscled with only 13.8% falling into the muscle score 1 category, transitioning the distribution towards moderate muscling. Likewise, only 35% of dairy cows were assigned a muscle score 1 in 2007 as compared to 72.5% in 1999. Although muscle scores improved, beef and dairy cows showed higher incidence of low body condition scores (1 and 2) in 2007 than in 1999. It should be noted that the body condition scale changed from audit to audit; in 1999 all cattle were categorized on a 1 to 9 point scale, whereas in 2007 dairy cattle, due to differences in fat deposition, were categorized on a 1.0 to 5.0 point scale defined by Elanco Animal Health (2009). There was a decrease in abscesses, including lumpy jaw, from 1999 to 2007. There was a higher incidence (16.1% vs. 12.5%) of mammary defects in cows in 2007 compared to 1999. Cattle showed drastic reduction in hide contamination as only 5.7% of cattle had no hide contamination in 1999, while 42.7% of cattle showed no signs of hide contamination in 2007. Similarly, 36.6% of cow carcasses had no bruise present in 2007 compared to 11.8% of cow carcasses surveyed having no bruise in 1999. Fewer arthritic joints were observed in 2007 than in 1999, indicating improvement in trim loss over the eight years. Visceral, heart, head, and tongue condemnation rates increased from 1999; in particular, only 24.1% of livers were condemned in the previous audit compared to 45.3% condemned in the NMCBBQA-2007 (Roeber et al., 2000; Nicholson, 2008). Determination of the number of permanent incisors was an addition to the observations made on the harvest floor. Of all heads surveyed, 11.2% were gummers (no incisors) and 10.6% had broken mouths (Nicholson, 2008).

Assessment of carcasses in the cooler provided means for skeletal and lean maturity, marbling, adjusted fat thickness, LM area, KPH, and HCW. Results indicated that mean carcass weights for both cows and bulls increased from 1999. It appeared fat color scores shifted towards whiter fat in 2007 as 27.3% of carcasses were categorized as showcasing white fat versus only 0.82% in 1999 (Roeber et al., 2000; Nicholson, 2008).

As an addition to the NMCBBQA series, the 2007 audit collected information regarding the fabrication of cow and bull carcasses to educate the industry on the end product of cow and bull carcasses. Primals and subprimals, not just ground product, are produced from market cows and bulls. About 28% of carcasses were being used to produce whole-muscle cuts. Nicholson (2008) implied that there may have been a shift in production going from predominantly trim production to whole-muscle cut production. In addition, information regarding animal traceability was collected to determine if a carcass could be traced back to the ranch of origin. Seventy-one percent of beef animals and 56% of dairy animals were able to be traced to their origin. Even so, a large percentage of animals could not be traced back further than the livestock market auction (Nicholson, 2008).

Based on the data gathered from the NMCBBQA-2007, the National Cattlemen’s Beef Association, in its Executive Summary, again promoted the four primary directives outlined in the 1999 Market Cow and Bull Executive Summary. These were intended to continue educational efforts and provide resources to Beef Quality Assurance (BQA) programs throughout the country encouraging producers to “recognize and optimize the value of their market cows and bulls, be proactive to ensure the safety and integrity of the resulting beef products, use appropriate management and handling practices to prevent quality defects, and closely monitor herd health and market cattle timely and appropriately” (National Cattlemen's Beef Association Beef Quality Assurance Program, 2007).

The NMCBBQA-2007 set benchmarks for the industry to attain improvements in beef quality. Furthermore, the industry could use data provided by the NMCBBQA-2007 to focus on new, emerging, high-impact issues. Finally, producers were provided education and materials for working towards improved animal management to spearhead the effort in enhancing quality in the market cow and bull beef sector.

National Beef Quality Audit – 2016

The objective of the fourth iteration of the National Beef Quality Audit is to again understand the position of the current market cow and bull beef industry. The NBQA-2016 will provide an updated status report of the market cow and bull sector. Data collected will allow the beef industry to gauge improvement or digression of market cow and beef quality based on comparison to results of the NMCBBQA-2007. In addition, new benchmarks will be established to assist in the future direction of beef quality research studies and determine the needs of the industry for continuing improvement over the next five years.

CHAPTER II

MATERIALS AND METHODS

The National Beef Quality Audit – 2016 was conducted by eight collaborating universities (Colorado State University, Oklahoma State University, North Dakota State University, Texas A&M University, University of Nebraska-Lincoln, University of Florida, University of Georgia, and West Texas A&M University) through the duration of the 2016 calendar year. Visual assessment of live animals, carcass and offal appraisal, and evaluation of carcasses for determining grading was completed in eighteen predetermined federally-inspected beef processing facilities (Table A-1) in ten states. One-third of cattle, carcasses, and offal at each of the eighteen surveyed packing facilities were audited through an entire single production day; if the facility operated two shifts per day, cattle in both shifts were evaluated. Data were recorded in data books designed to incorporate collection points from the previous NBQAs, as well as include additional areas of collection based on past audit findings and current industry needs (Appendix B). When possible, all cattle and carcasses surveyed were classified by breed (beef or dairy) and sex (cow or bull).

Transportation and mobility

Truck and trailer information from 10% of all trucks to arrive at the 18 processing facilities were evaluated for type, dimension, use of compartments, and use of center gate. The truck driver was interviewed to determine the origin of cattle, date and time loaded, distance and time traveled, number and type of cattle on the load, if mixed-gender loads were segregated, and if cattle were unloaded during transit. If the driver was unsure of the distance traveled, a map was used to estimate the distance from origin to packing facility. Time traveled was calculated by taking the difference between time loaded and time unloaded.

As they were moved from the truck to the holding pen, cattle were assessed for mobility using the North American Meat Institute's 4-point scale (North American Meat Institute Animal Welfare Committee, 2015): an animal assigned a mobility score 1 walked normal and easily; animals given a score of 2 showed signs of minor stiffness, shortness of stride, and a slight limp, yet still were able to keep up with normal cattle; an assignment of a mobility score 3 was given to animals exhibiting obvious stiffness and discomfort, having difficulty taking steps due to a limp, and lagging behind normal cattle; and a mobility score 4 was given to an animal who was extremely reluctant to move even when encouraged. Animals who fell to the ground and could not rise were classified as "downers."

Live animal characteristics

Cattle were surveyed for live animal characteristics that could drive producer's culling decisions. Assessment of defects was completed before the animal was moved into the S-curve or stun box.

A muscle score was assigned to each animal surveyed (Fig. A-1). Muscle scores ranged from 1 to 5, 1 being a light muscled animal with little muscle expression and 5 being a heavy muscled animal displaying muscle shape and expression. Animals were also assigned a body condition score. Body condition scales were different for beef and dairy animals. Beef animals were assigned a condition score on a 9-point scale (Fig. A-2). A body condition score 1 represented a thin animal with little fat covering the skeletal structure (ribs, vertebra, etc), and a body condition score 9 represented an over-conditioned animal with excessive fat deposits especially over the ribs, spine, tail head and brisket (Texas A&M AgriLife Research & Extension Center, n.d.). A 5-point scale was used to determine condition in dairy animals; those that were extremely thin were classified as 1.0, and those with excessive fat cover over the ribs and hooks were categorized as a 5.0 (Fig. A-3) (Elanco Animal Health, 2009).

With the aim of identifying producer-related defects leading to a producer's culling decision, recorders made observations of multiple predetermined defects such as cancer eye severity, prolapses, and hide damage. Otherwise known as bovine ocular neoplasia, cancer eye was assessed for severity and assigned a score on a 5-point scale (Fig. A-4). Cancer eye severity progressed from 0, a normal eye, to 5, a prolapsed eyeball or necrotic condition associated with the eye. Cattle also were evaluated for presence and type of prolapse (rectal or vaginal). Additionally, insect and/or latent (any visible blemish that could devalue the hide) hide damage was assessed, along with presence and location of abscesses. Finally, the following specific defects were evaluated by recorders: bottle teats, broken penis, calf in pen, failed suspensory ligament, foot abnormality (any deformity of the lower limb or hoof), full bag (udder filled with milk), lumpy jaw, mastitis, multiple udder problems, retained placenta, swollen joints, warts, and "other" defects (those observed but not pre-determined by the research team). Bottle teats were the development of raised smooth or rough rings at the teat ends (Kahn and Line, 2010). A failed suspensory ligament was the insufficient attachment of the udder to the body cavity with the ventral portion of the udder falling below the hock and the teats splayed outward (Rasby, n.d.).

Recorders also assessed carcasses for presence and length of horns. In addition, the presence and location (neck, shoulder, top butt, round) of knots were recorded. The type of identification (ankle tag, barcode, electronic tag, individual ear tag, metal clip, lot tag, waddle, and "other") also was recorded.

Hide evaluation

Carcasses with hide still on were surveyed for primary hide color and pattern (baldy, roan, brindle, spots) were made. Primary hide color was decided based on the color represented on 51% or more of the hide. In addition, the presence of mud, location (legs, belly, side, top line, and tail region), and the amount (small, moderate, large, extreme) visible was recorded (Fig. A-5 through Fig A-9). The location (butt, side, shoulder) and size (in^2) of brands were recorded. As a final point of observation, recorders identified whether or not carcasses touched floors or equipment while moving through production. This observation point was included in the NBQA-2016 based on industry conversation concerning the large frame-size of cattle being harvested and the potential complications with existing harvest floor capabilities.

Hide-off carcass evaluation

Carcasses (hide removed) were evaluated for the number and location (round, rib, shortloin, sirloin, chuck and the combination of brisket, plate, and flank) of bruises present. If a bruise was present, the severity of bruise was determined using a 10-point scale (Table A-2). A bruise score 1 through 3 was considered minimal and resulted in less than 0.45 kg of surface trim; score 1 was equivalent to the size of a quarter, score 2 the size of a silver dollar, and score 3 the size of a deck of cards. Bruises equaling the loss of 0.45 kg to 1.36 kg of carcass trim (score 4), 1.81 kg to 3.18 kg of carcass trim (score 5), and 3.63 kg to 4.54 kg of carcass trim (score 6) were considered majorly severe. Critical bruising spanned anywhere from 4.99 kg to 9.07 kg of carcass trim (score 7) to 9.53 kg to 13.61 kg of carcass trim (score 8), and 14.06 kg to 18.12 kg of carcass trim (score 9). The most extreme form of bruising, classified as a score 10, was the display of an entire primal subjected to bruising. Furthermore, the number and location (round, rib, shortloin, sirloin, chuck, brisket/plate/flank) of injection-site lesions visible on the carcass surface were recorded. Recorders identified grub damage if any was visible on the exterior of the carcass.

Offal condemnations

Recorders were stationed near United States Department of Agriculture, Food Safety and Inspection Service (USDA-FSIS) inspectors to evaluate condemnation rate of livers, viscera, kidneys, lungs, and hearts. If selected offal were condemned, the reason for condemnation was recorded. Condemnation reasons for livers determined to be relevant from the NBQA-2007 and therefore carried forward into the current audit were: abscesses, flukes, telangiectasis, and contamination (Fig. A-10). Liver flukes cause localized abscesses and inflammation of the bile ducts in the liver, and were identified by small lesions on the exterior surface. Telangiectasis is the condition where vascular lesions are visible on the surface of the liver.

Cause for visceral condemnation was categorized as being a result of abscesses, ulcers, or contamination. Pneumonia severity was evaluated in lungs using a 3-point scale (1 = mild or 0% - 15% lung tissue consolidation; 2 = moderate or 15% - 50% lung tissue consolidation; or 3 = severe or 50% - 100% consolidation of the lung) (Fig. A-11). All cow viscera surveyed also were assessed for fetal presence. When present, approximate fetal age/size was documented as either “early” (less than 150 d old and 35.56 cm or less in length) or “late” (over 150 d or greater than 35.56 cm in length) (Sorensen, 1979).

Head and tongue condemnations

Heads were evaluated for condemnation by USDA-FSIS inspectors or trimming by plant personnel. Recorders classified condemnation and/or trimming due to a lymph concern, abscess, or contamination based on the USDA inspector’s decision. Tongues also were observed for condemnation and trimming and classified based on the following reasons: lymph concern, hair sore, cactus tongue, or contamination. A hair sore was an elevated lesion, usually 0.64 cm to 3.8 cm in diameter, located just in front of the dorsal eminence of the tongue (Fig. A-12) (Gill et al., 1996). Cactus tongue was defined as sporadically placed small lesions on the tongue resulting from the ingestion of cactus thorns.

Dentition

Heads surveyed for condemnation and trimming also were evaluated for number of permanent incisors. Number of incisors was determined using the USDA–FSIS standards. Gummers, an animal with eight adult incisors that were worn down to the gum, and broken mouths, any defect that prohibits normal mastication, also were recorded (Nicholson, 2008).

Carcass grading

Researchers measured and/or recorded hot carcass weight (HCW), LM area (measured with a dot grid), and quality defects (dark cutter, blood splash, calloused eye) for each of the selected carcasses. Lean and skeletal maturity, degree of marbling, preliminary yield grade (PYG), and kidney, pelvic, and heart fat (KPH) were evaluated for each selected carcass based on the United States Standards for Carcass Grades (USDA, 2016). Moreover, in-plant grades, if available, were recorded for surveyed cow and bull carcasses.

Quality grades were determined using the relationship between maturity and marbling and reported as outlined in the United States Standards for Grades of Carcass Beef (USDA, 2016). Yield grades were calculated by substituting the values recorded for PYG, HCW, LM area, and KPH into the following equation:
$2.5 + (2.5 \times ((PYG - 2) \times 0.4)) + (0.2 \times \%KPH) - (0.32 \times \text{LM area, square inches}) + (0.0038 \times \text{HCW, pounds})$. If any of the variables necessary for calculating a quality or yield grade were not recorded, a grade was not assigned.

Carcasses were assigned a muscle score on a 5-point scale (Fig. A-13). Carcasses assigned a score 1 were very lightly muscled with boney protrusions seen throughout. A muscle score 5 indicated a heavy muscled carcass that carried muscle shape and expression from top to bottom, covering any bony structures. Not only did recorders assign a whole muscle score, but they also included the degree (high, average, and low) within each of those. Fat color scores ranging from 1 to 6, with 1 being white fat and 6 being very yellow fat were assigned (Fig. A-14). Finally, arthritic joints, determined by removal of limbs at a skeletal joint, were recorded.

Antemortem and postmortem condemnations

Following the completion of the production day, audit personnel obtained antemortem and postmortem condemnation data from the packing facility. This included the type and sex of the condemned animal or carcass, as well as the reason for condemnation determined by USDA-FSIS inspectors.

Product fabrication

Information regarding the fabrication of carcasses were obtained after the completion of the production day. In some instances, plant personnel would send a cut-sheet to auditors, and in others the plant personnel would fill in the prepared data sheet given to them by the research group (Fig. B-9). Data were compiled in broad categories to determine the frequency of primal and subprimal fabrication.

Plant characterization

Information regarding chain speed, use and the type of pre- (before stunning) and post-harvest (after stunning) antimicrobial washes, use of electrical stimulation, protocol for hair sore and cactus tongue incidence, KPH removal, and carcass ribbing protocols were obtained from plant personnel.

Statistical analysis

Data were analyzed using JMP Software (JMP®, Version 10. SAS Institute Inc., Cary, NC, 1989-2207) and Microsoft Excel for Mac. Distributions, frequencies, means, standard deviations, minimums, and maximums were calculated using the Distribution and Summary functions of JMP. A z-test was used to determine differences, if any, in frequencies between 2007 and 2016 quality characteristics (significance was determined at the 0.05 level). A z-test was used because of the large number of degrees of freedom.

CHAPTER III

RESULTS AND DISCUSSION

Transportation

The primary type of trailer used to transport market cows and bulls to harvest was a pot belly trailer. These trailers offer greater capacity and allow for group separation through use of center gates and compartmental division. Of the pot bellies surveyed, 65.3% (*n* = 95) used the center gate to separate cattle (data not in tabular form). Ensuring cattle are separated between compartments is most important when hauling cows and bulls on the same load to prevent injury to both groups. Of all mixed-gender loads, 64.4% of them did not separate cows from bulls. This is only a slight increase from the 66.7% observed in 2007 (Nicholson, 2008). Of the pot bellies surveyed, 47.1% were mixed gender loads. Unfortunately, only one-third of the surveyed pot bellies with mixed gender loads segregated those genders. This trend was also seen in surveyed gooseneck trailers hauling cows and bulls on the same load, as only 40.0% separated genders.

Tables 1 provides a snapshot of travel and trailer information for all types of trailers surveyed.

Table 1. National Beef Quality Audit (NBQA): Mean values for time and distance traveled, number of cattle in the load, trailer dimensions and the subsequent area allotted per head for all trailer types surveyed[1]

Transportation characteristics	n^2	Mean	Std. Dev.	Min	Max
Time traveled, h	151	6.7	6.36	0.2	39.5
Distance traveled, km	145	455.7	440.76	3.2	2,273.8
Number of cattle in load	154	26	13.38	1	47
Number of compartments used	152	4	1.71	1	7
Trailer dimension, m^2	151	33.5	10.24	8.9	43.4
Area allotted per head, m^2	151	2.3	3.30	0.6	20.2

[1] Ten percent of cattle trucks were sampled within a day's production at each plant during the audit.
[2] These are the number of trailers that were surveyed at the plants.

Table 2 and 3 provide trailer and travel information for pot bellies and gooseneck trailers. Cattle loaded on pot belly trailers were transported across much further distances and for longer time intervals than cattle on gooseneck trailers. It is important, especially for cattle traveling for such time and distances, to have adequate room to minimize crowding and stress during transit. As outlined in the Recommended Animal Handling Guidelines, each animal should be given a minimum area in trailers; polled cattle weighing 455 kg and 636 kg require 1.1 m^2/animal and 1.7 m^2/animal, respectively, whereas horned cattle require 1.2 m^2/animal and 1.8 m^2/animal, respectively (Grandin, 2013). Mean area allotment per animal for all trailer types and all load types exceeded these standards. These data are in line with the results from the 2007 audit, in which cows and bulls brought to harvest arrived in trailers with sufficient space, thus minimizing animal welfare concerns and profit losses due to carcass defects.

Table 2. National Beef Quality Audit (NBQA): Mean values for time and distance traveled, number of cattle in the load, trailer dimensions, and the subsequent area allotted per head for pot belly trailers surveyed[1]

Transportation characteristics	n^2	Mean	Std. Dev.	Min	Max
Time traveled, h	100	9.3	6.25	0.2	39.5
Distance traveled, km	95	639.8	436.38	3.21	2,273.8
Number of cattle in load	102	35	4.88	23	47
Number of compartments used	101	5	1.08	2	7
Trailer dimension, m^2	101	40.0	2.89	17.8	43.4
Area allotted per head, m^2	101	1.2	0.17	0.6	1.7

[1] Ten percent of cattle trucks were sampled within a day's production at each plant during the audit.
[2] These are the number of trailers that were surveyed at the plants.

Table 3. National Beef Quality Audit (NBQA): Mean values for time and distance traveled, number of cattle in the load, trailer dimensions, and the subsequent area allotted per head for gooseneck trailers surveyed[1]

Transportation characteristics	n^2	Mean	Std. Dev.	Min	Max
Time traveled, h	45	1.6	1.60	0.2	8
Distance traveled, km	44	114.1	128.56	8.0	659.83
Number of cattle in load	46	10	5.98	1	20
Number of compartments used	45	2	0.78	1	4
Trailer dimension, m^2	44	20.6	5.56	8.9	32.7

Table 3. Continued

Area allotted per head, m^2	44	4.3	4.85	0.8	20.2

[1] Ten percent of cattle trucks were sampled within a day's production at each plant during the audit.
[2] These are the number of trailers that were surveyed at the plants.

Beyond the center gate, some pot belly trailers have the doghouse or jailhouse to further separate cattle within loads. Located in the back of the trailer, the doghouse is a smaller compartment intended for hauling smaller-framed cattle weighing under 317.5 kg (Beef Quality Assurance, n.d.). Only 10.8% of trailers surveyed used the doghouse. This is a positive percentage decrease from that seen in 2007, where 15.9% of trucks utilized this compartment when hauling cattle (Nicholson, 2008).

Pot belly trailers also have a front upper compartment to haul cattle under 317.5 kg in body weight. Of those surveyed, 67.0% used this compartment. The weight of cattle coming off of the trucks surveyed was not recorded, however the average market cow, and especially the average market bull, typically weigh over 317.5 kg. Thus, it is concerning that some cattle haulers are utilizing the front upper compartment at high frequency.

It seems the use of an additional compartment for separating cows from bulls on a load would be beneficial to decrease injury and devaluation of hides and carcasses, giving a reason for drivers to utilize the doghouse or front upper compartment. Data show that 64.4% of mixed gender loads used the front upper and 18.2% used the rear upper. No matter the benefits to gender separation, these compartments should not be misused for larger framed, heavier weight cattle. Recommendations by the Beef Quality Assurance Advisory Board include limiting the use of the doghouse/jailhouse and the front upper compartment for cattle over 317.5 kg to prevent increased incidences of carcass bruising, especially over the back, and animal welfare and handling concerns (Beef Quality Assurance, n.d.).

Tables 4, 5 and 6 depict the travel information according to the breed type of cattle in the load brought to harvest. There were a greater number of dairy loads brought to market than beef or mixed-breed loads. The greatest mean number of animals per load was observed when both beef and dairy animals were hauled on a single load. Mixed breed loads traveled the greatest mean distance and time. It is important for beef and dairy cattle producers to determine animals are fit for transport, especially if long hauls are known to be in store. This includes adequate mobility and body condition suitable for hauling any distance.

Table 4. National Beef Quality Audit (NBQA): Mean values for time and distance traveled, number of cattle in the load, trailer dimensions, and the subsequent area allotted per head for beef loads surveyed[1]

Transportation characteristic	n^2	Mean	Std. Dev.	Min	Max
Time traveled, h	41	6.6	5.65	0.2	24
Distance traveled, km	38	459.3	411.78	3.2	1,705.9
Number of cattle in load	41	26	16.14	1	47
Number of compartments used	40	4	1.94	1	7
Trailer dimension, m^2	40	32.8	11.80	10.4	43.3

Area allotted per head, m^2	40	3.4	4.83	0.9	20.2

[1] Ten percent of cattle trucks were sampled within a day's production at each plant during the audit.
[2] These are the number of trailers that were surveyed at the plants.

Table 5. National Beef Quality Audit (NBQA): Mean values for time and distance traveled, number of cattle in the load, trailer dimensions, and the subsequent area allotted per head for dairy loads surveyed[1]

Transportation characteristics	*n*	Mean	Std. Dev.	Min	Max
Time traveled, h	61	4.8	5.91	0.2	28.3
Distance traveled, km	60	260.1	307.5	8.05	1,400.1
Number of cattle in load	62	21	12.76	1	39
Number of compartments used	62	3	1.53	1	6
Trailer dimension, m^2	61	29.3	10.34	8.9	41.9
Area allotted per head, m^2	61	2.6	3.16	0.8	17.8

Table 6. National Beef Quality Audit (NBQA): Mean values for time and distance traveled, number of cattle in the load, trailer dimensions, and the subsequent area allotted per head for mixed-breed loads surveyed[1]

Transportation characteristics	*n*[2]	Mean	Std. Dev.	Min	Max
Time traveled, h	49	9.1	6.7	0.8	39.5
Distance traveled, km	47	702.7	488.10	80.5	2,273.8
Number of cattle in load	51	33	7.24	11	46
Number of compartments used	50	5	1.05	2	7
Trailer dimension, m^2	50	39.2	4.92	17.8	41.9

Table 6. Continued

Area allotted per head, m^2	50	1.2	0.24	0.6	2.1

[1] Ten percent of cattle trucks were sampled within a day's production at each plant during the audit.
[2] These are the number of trailers that were surveyed at the plants.

Just as was done with breed loads, trailer information was sorted based on loads of various genders (Tables 7, 8, and 9). The most important feature to mixed-gender loads is the separation of cows and bulls. As discussed above, separation of these two groups prevents injury and carcass devaluation. An average of five different compartments were used to separate these mixed-gender loads, giving positive evidence cattle transporters recognize the importance of gender separation to animal welfare and product quality.

Table 7. National Beef Quality Audit (NBQA): Mean values for time and distance traveled, number of cattle in the load, trailer dimensions, and the subsequent area allotted per head for cow loads surveyed[1]

Transportation characteristics	n^2	Mean	Std. Dev.	Min	Max
Time traveled, h	94	6.0	6.95	0.2	39.5
Distance traveled, km	94	387.3	442.62	4.8	2,273.8
Number of cattle in load	97	23	13.66	1	45
Number of compartments used	96	3	1.62	1	7
Trailer dimension, m^2	95	30.6	10.69	8.9	41.9
Area allotted per head, m^2	95	2.7	3.58	0.6	20.2

Table 7. Continued

[1] Ten percent of cattle trucks were sampled within a day's production at each plant during the audit.
[2] These are the number of trailers that were surveyed at the plants.

Table 8. National Beef Quality Audit (NBQA): Mean values for time and distance traveled, number of cattle in the load, trailer dimensions, and the subsequent area allotted per head for bull loads surveyed[1]

Transportation characteristics	n^2	Mean	Std. Dev.	Min	Max
Time traveled, h	6	3.5	3.72	0.5	10
Distance traveled, km	6	268.2	265.20	45.1	659.8
Number of cattle in load	6	15.5	12.55	1	27
Number of compartments used	6	4	2.4	1	6
Trailer dimension, m^2	6	29.5	13.68	14.9	41.9
Area allotted per head, m^2	6	6.2	7.08	1.6	15.8

[1] Ten percent of cattle trucks were sampled within a day's production at each plant during the audit.
[2] These are the number of trailers that were surveyed at the plants.

Table 9. National Beef Quality Audit (NBQA): Mean values for time and distance traveled, number of cattle in the load, trailer dimensions, and the subsequent area allotted per head for mixed-gender loads surveyed[1]

Transportation characteristics	n^2	Mean	Std. Dev.	Min	Max
Time traveled, h	51	8.3	5.05	0.2	19.3
Distance traveled, km	45	623.6	412.42	3.2	1,508.0
Number of cattle in load	51	34	8.71	5	47
Number of compartments used	50	5	1.21	2	7
Trailer dimension, m^2	50	39.5	5.33	15.6	43.4

Table 9. Continued

Area allotted per head, m^2	50	1.2	0.48	0.9	4.2

[1] Ten percent of cattle trucks were sampled within a day's production at each plant during the audit.
[2] These are the number of trailers that were surveyed at the plants.

Mobility assessments

Figure 1 shows 81.3% of all cattle (*n* = 3,673) were identified to be sound, a numerical increase from the 70% observed in 2007 (National Cattlemen's Beef Association Beef Quality Assurance Program, 2007). Over the 22-year audit history, dairy cows have seen the most fluctuation in soundness (Fig. 2). However, the current audit observed a substantial increase in sound dairy cattle since the 2007 audit. The highest rate of soundness (82.9%) in beef bulls was observed in the current audit. Dairy bull soundness has not oscillated drastically over the last 22 years.

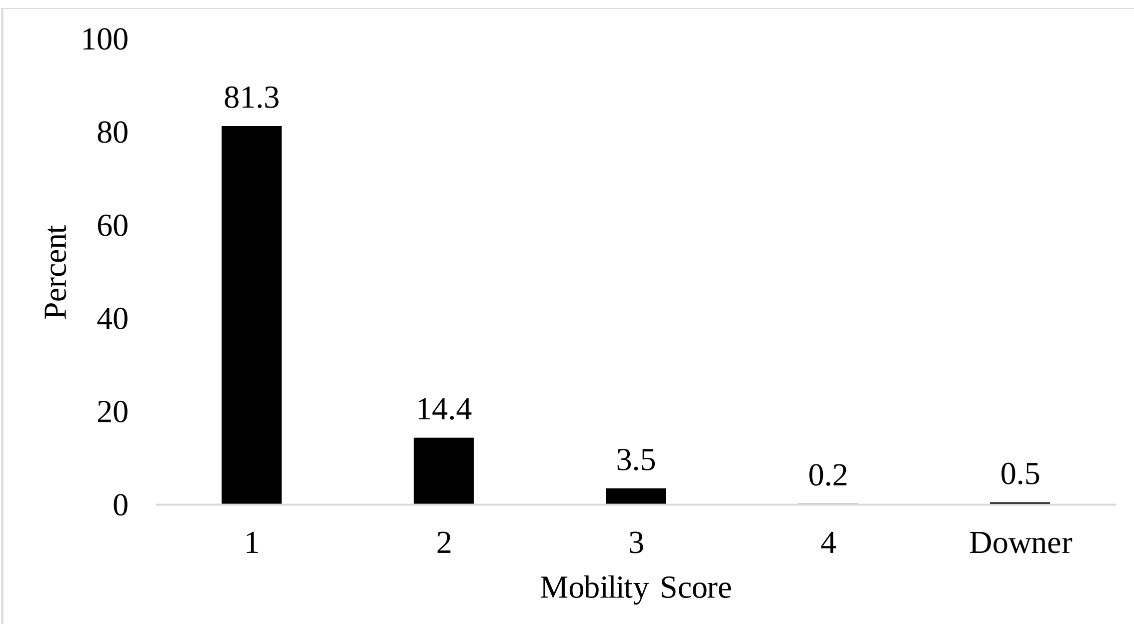

Figure 1. National Beef Quality Audit (NBQA): Mobility score frequencies in all cattle surveyed. Total number of observations was 3,673.

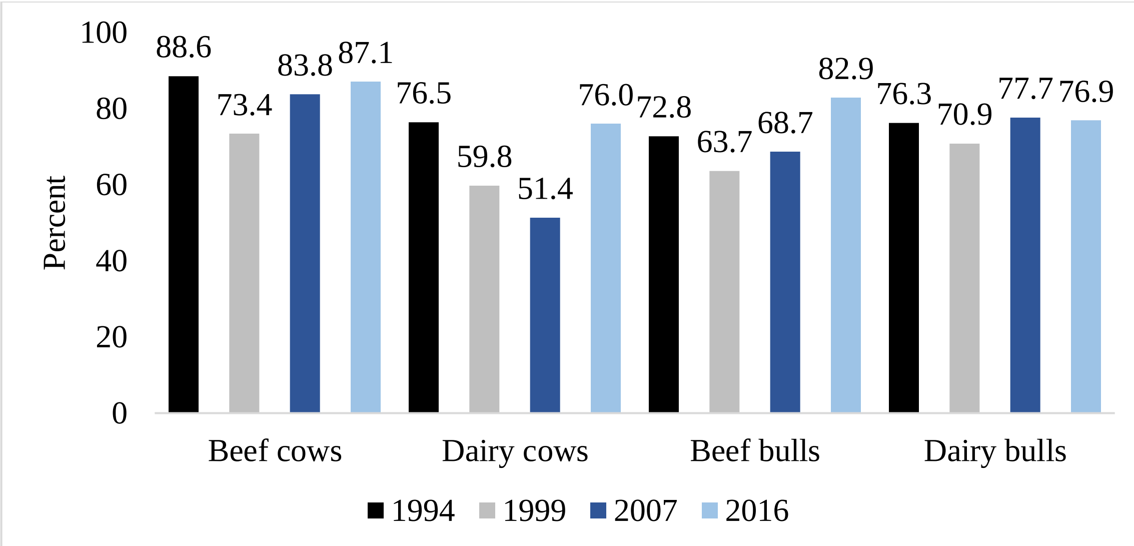

Figure 2. National Beef Quality Audit (NBQA): Percentage of sound (normal mobility) cattle observed in each of the National Market Cow and Bull Beef Quality Audits. Total number of observations were National Non-Fed Beef Quality Audit-1994: beef cows (*n* = 1,548), dairy cows (*n* = 1,013), beef bulls (*n* = 254), dairy bulls (*n* = 38); National Market Cow and Bull Beef Quality Audit-1999: beef cows (*n* = 2,237), dairy cows (*n* = 1,108), beef bulls (*n* = 419), dairy bulls (*n* = 79); NMCBBAQ-2007: beef cows (*n* = 2,807), dairy cows (*n* = 2,112), beef bulls (*n* = 431), dairy bulls (*n* = 130); NBQA-2016: beef cows (*n* = 1,557), dairy cows (*n* = 1,743), beef bulls (*n* = 321), dairy bulls (*n* = 52) (Smith et al., 1994; Roeber et al., 2000; Nicholson, 2008).

Table 10 indicates dairy animals had the highest incidence of minor stiffness, shortness of stride and a slight limp when coming off the trucks (score 2). This is not surprising given the production management system utilized in the dairy industry; 38.9% of all dairies in 17 dairy-producing states housed lactating cows in tie stalls or stanchions which have hard surfaces (USDA-APHIS Veterinary Services National Animal Health Monitoring System, 2016). Cook and Nordlund (2009) found the highest rates of lameness in dairy herds to occur in those intensively managed in zero-grazed free stall systems. Nonetheless, dairy cows have seen the greatest improvement in soundness (Fig. 2) since 2007, most likely due, in part, to the inception of the National Dairy Farmers

Assuring Responsible Management (FARM) Program, which encourages commitment to quality farm management practices and safe, wholesome dairy products (National Milk Producer's Federation, 2017). It may be positive that the industry is seeing dairy cattle assigned a mobility score 2 being marketed, rather than dairy cattle with higher mobility scores being marketed. This may indicate dairy producers are observing early lameness signs, thus eliciting the decision to market the animal/s in question. It is important to realize the advantage to culling cows before lameness is observed. Collick et al. (1989) and Lucey et al. (1986) reported lame cattle to have longer postpartum intervals and lower pregnancy rates at first service. In addition, Green et al. (2002) identified milk yield was reduced in lame cattle. Thus, lame cows should be culled early to reduce profit loss due to decreased reproductive health and milking efficiency.

Table 10. National Beef Quality Audit (NBQA): Percentage of mobility scores[1] and downers in all cattle surveyed

		Mobility score				
Type of animal	*n*	1	2	3	4	Downers[2]
Beef cows	1,557	87.1	10.2	2.3	0.1	0.2
Dairy cows	1,743	76.0	18.2	4.7	0.3	0.9
Beef bulls	321	82.9	13.7	3.4	0.0	0.0
Dairy bulls	52	76.9	19.2	3.9	0.0	0.0

[1] Mobility scores were assigned as 1) walks normal with no apparent lameness; 2) exhibits minor stiffness, shortness of stride, slight limp, but still keeps up with normal cattle; 3) exhibits obvious stiffness, difficulty taking steps, walks with an obvious limp and discomfort, and lags behind normal cattle; 4) extremely reluctant to move even when encouraged (North American Meat Institute Animal Welfare Committee, 2015).
[2] Cattle unable to rise.

Live animal evaluations

It is a producer's responsibility to determine the market readiness of cows and bulls. This market readiness is most often referred to the degree to which a cow or bull is unproductive, inefficient, or no longer suitable for the operation. Reasons for marketing beef cattle and dairy cattle may be multifaceted. The live animal evaluations made during the NBQA-2016 were aimed at identifying defects that could cause a producer to cull an animal.

Conditions in the dairy industry are much different than those in the beef industry. Dairy cows are continually solicited to produce milk at high efficiency, produce a calf-crop in a short, rigid window, and maintain condition all while doing so. On the contrary, beef cows and bulls are often strenuously managed to produce a calf-crop, maintain reproductive soundness, and continue being efficient in sometimes sparse nutritional environments. In order to evaluate condition of animals, researchers assigned muscle and body condition scores to assess the fitness of marketed animals. Figure 3 shows the representation of muscle scores amongst all cattle types surveyed. Beef cows, beef bulls and dairy bulls had the highest frequency of muscle scores 3, indicating average muscling. Nearly sixty-seven percent of dairy cows, however, were given the lowest muscle score (score 1). Before conclusions can be drawn however, it is inherent that dairy cattle are typically lighter muscled than beef cows, and cows are lighter muscled than bulls. Therefore, it should not be a surprise a higher percentage of score 1 dairy cows were seen versus other types of cattle. Nonetheless, 66.6% is almost thirty-two percentage points higher than observed in 2007 (Nicholson, 2008).

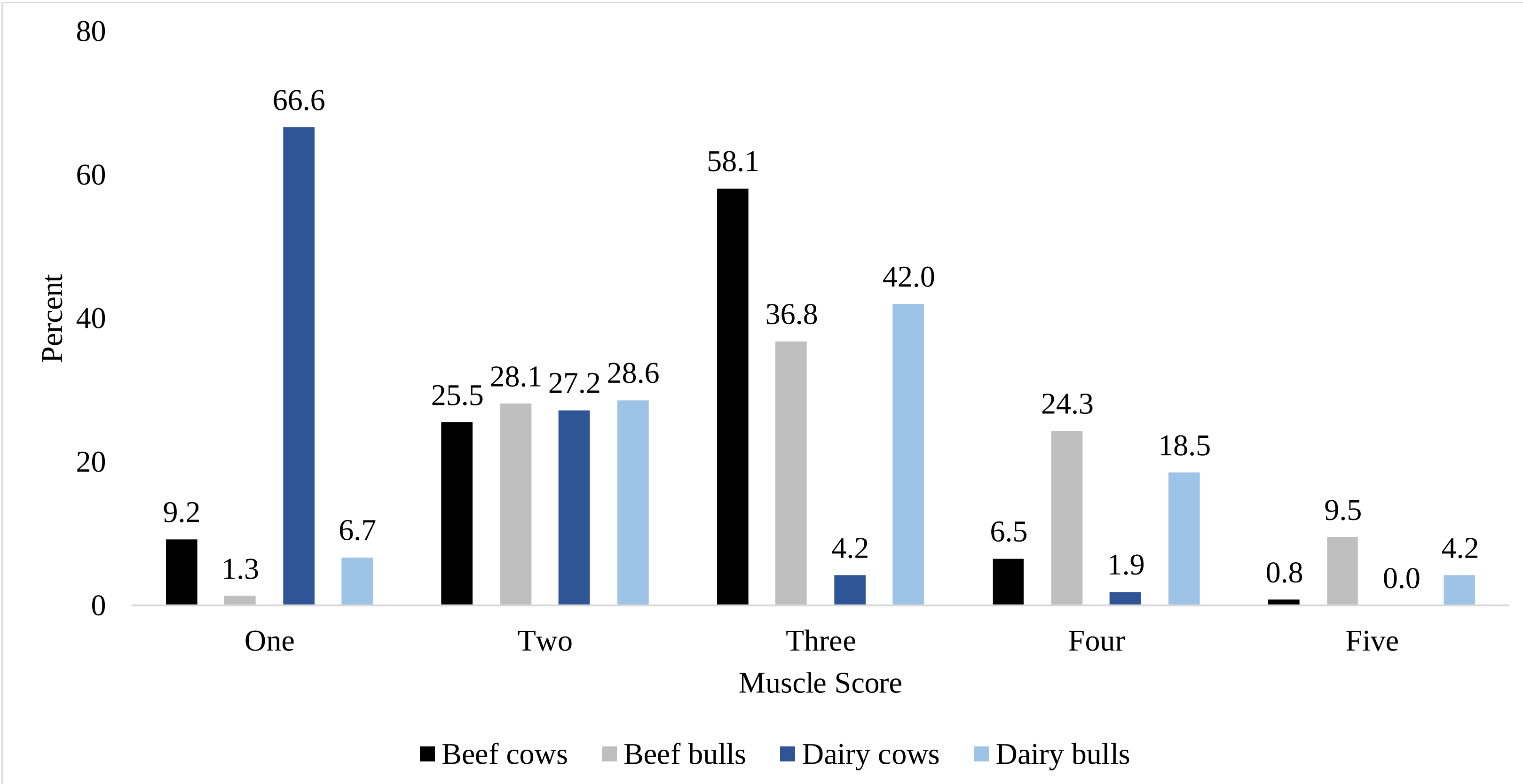

Figure 3. National Beef Quality Audit (NBQA): Frequency of muscle scores observed in surveyed animals. Total number of observations were beef cows (*n* = 1,860), dairy cows (*n* = 2,809), beef bulls (*n* = 399), dairy bulls (*n* = 119).

When compared across all audits over the 17 years (Fig. 4), it is apparent that the number of beef cows that are "too light muscled" (assigned a score 1 and 2) has decreased from 90.5% in 1999 to 34.7% in 2016. Figure 4 also shows dairy cows that are too light muscled were observed at a higher frequency than in 2007, but still a lower frequency than 1999. An evaluation of muscle score before marketing has potential to indicate if cattle are too thinly muscled. These types of cattle should be considered for increased feeding before market. Feeding concentrate diets prior to selling has been shown to increase muscle and fat in animals (Matulis et al., 1987).

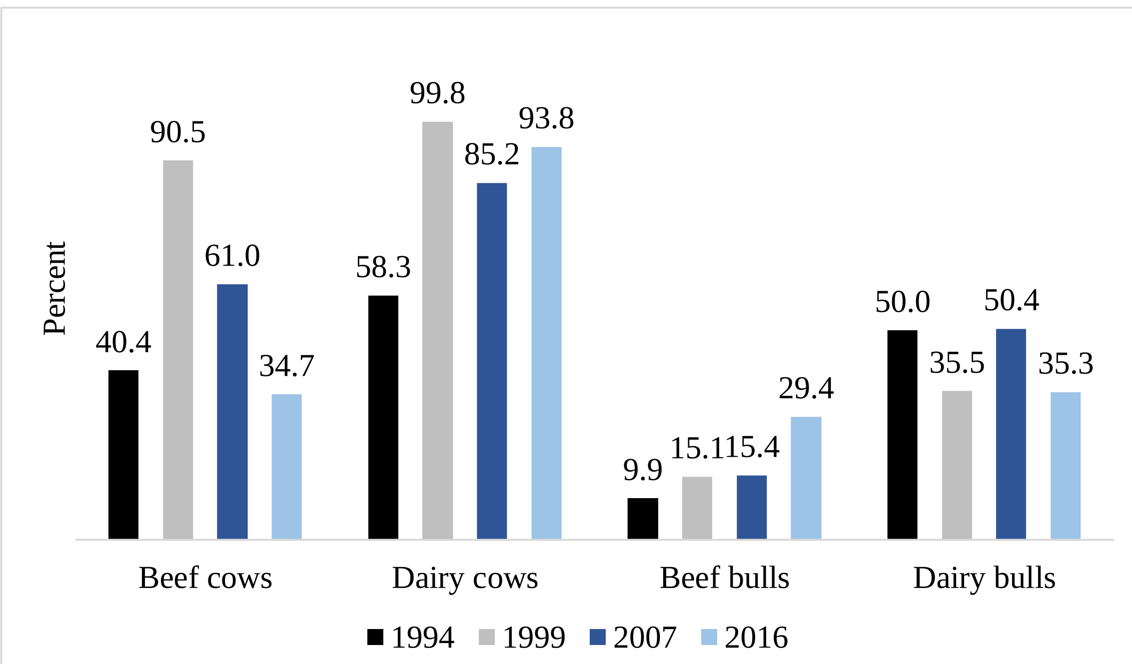

Figure 4. National Beef Quality Audit (NBQA): A comparison between the percentage of cattle that were inadequately muscled (assigned a muscle score 1 or 2 on a 5-point scale) in 1994, 1999, 2007, and 2016. Total number of observations were National Non-fed Beef Quality Audit -1994: all cattle (not determined), beef cows (*n* = 1,548), dairy cows (*n* = 1,013), beef bulls (*n* = 254), dairy bulls (*n* = 38); National Market Cow and Bull Beef Quality Audit -1999: all cattle (3,669), beef cows (*n* = 2,237), dairy cows (*n* = 1,108), beef bulls (*n* = 419), dairy bulls (*n* = 79);

Figure 4. Continued
NMCBBQA-2007: all cattle (*n* = 5,069), beef cows (*n* = 2,501), dairy cows (*n* = 1,954), beef bulls (*n* = 385), dairy bulls (*n* = 127); NBQA-2016: all cattle (*n* = 5,245), beef cows (*n* = 1,860), dairy cows (*n* = 2,809), beef bulls (*n* = 399), dairy bulls (*n* = 119) (Smith et al., 1994; Roeber et al., 2000; Nicholson, 2008).

In tandem with muscle score, body condition score, specifically too low of a score, is a strong indicator tool for marketing cows and bulls. The mean beef condition score determined for both beef cows (*n* = 1,910) and beef bulls (*n* = 406) was 4.7. The mean condition score for dairy cows (*n* = 2,878) and dairy bulls (*n* = 121) was 2.6 and 3.3, respectively. Figures 5 and 6 show the distribution of body condition scores observed for beef animals in 2016, as well as 2007.

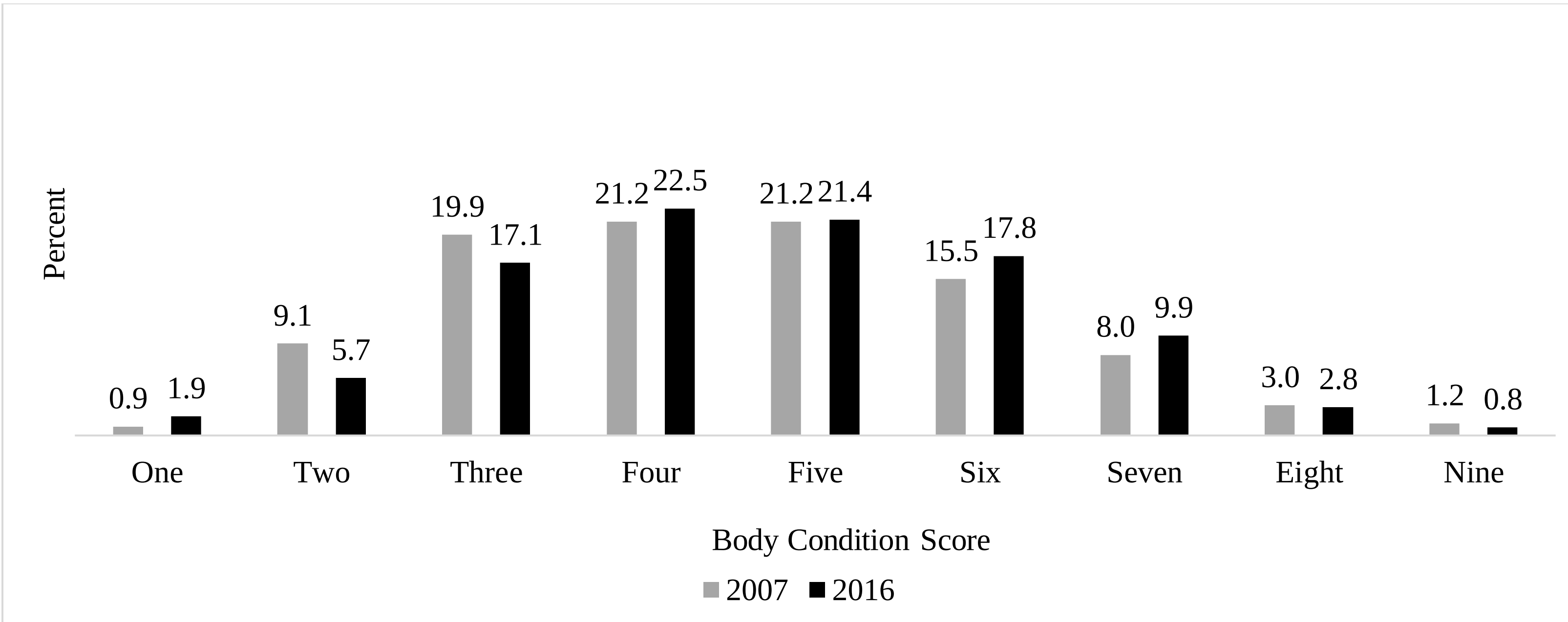

Figure 5. National Beef Quality Audit (NBQA): Distribution of body condition scores for beef cows in 2007 (*n* = 2,800) and 2016 (*n* = 1,910) (Nicholson, 2008).

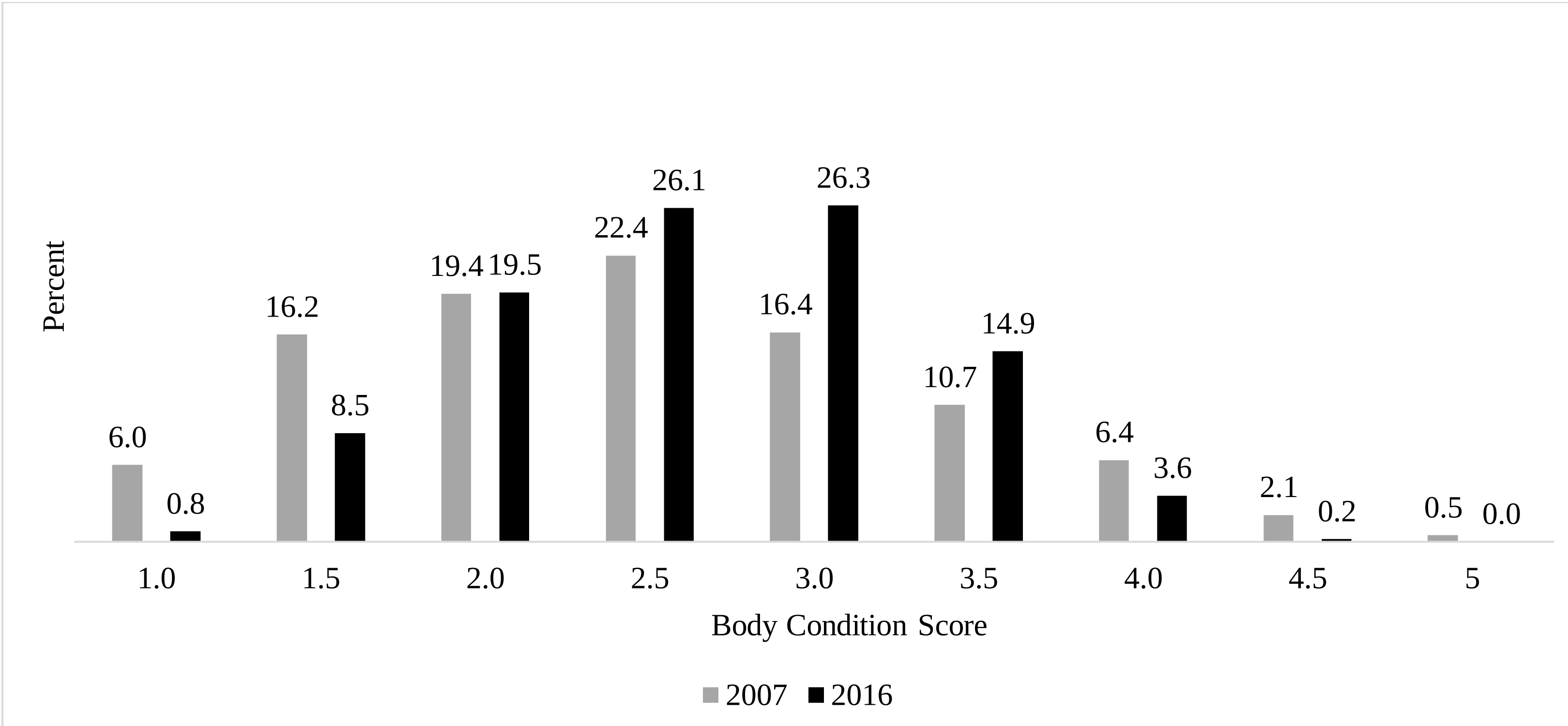

Figure 6. National Beef Quality Audit (NBQA): Distribution of body condition scores for dairy cows in 2007 (*n* = 2,103) and 2016 (*n* = 2,878) (Nicholson, 2008).

Figures 7 and 8 show the body condition scores for dairy animals in 2016, along with those reported in 2007. There has been a trend towards increased body condition scores in cows since 2007. It was apparent thin, average and fat cattle were being marketed as each of the gender and type classifications showed a fairly even distribution over the body condition scale. It should be realized that while dairy cattle that are classified in the upper range of the dairy condition scale are being marketed, this most likely does not give evidence these animals are overly fat for beef fabrication and retail marketing purposes. Conversely, beef cows and bulls with condition scores in excess of seven contribute to excessive packer trim rates. There were very few over-conditioned beef bulls marketed. This may indicate producer improvement in preventing beef bulls from becoming over conditioned before market.

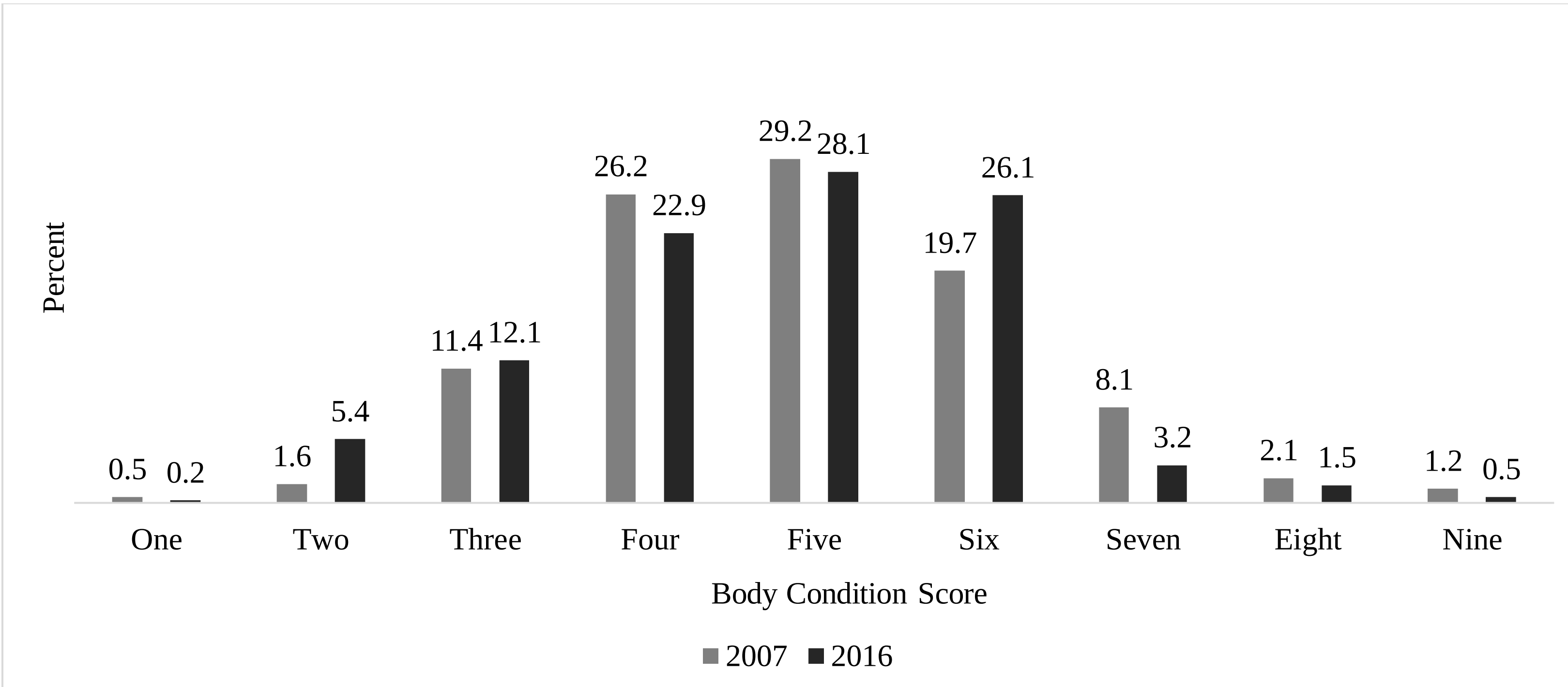

Figure 7. National Beef Quality Audit (NBQA): Distribution of body conditions scores for beef bulls in 2007 (*n* = 431) and 2016 (*n* = 406) (Nicholson, 2008).

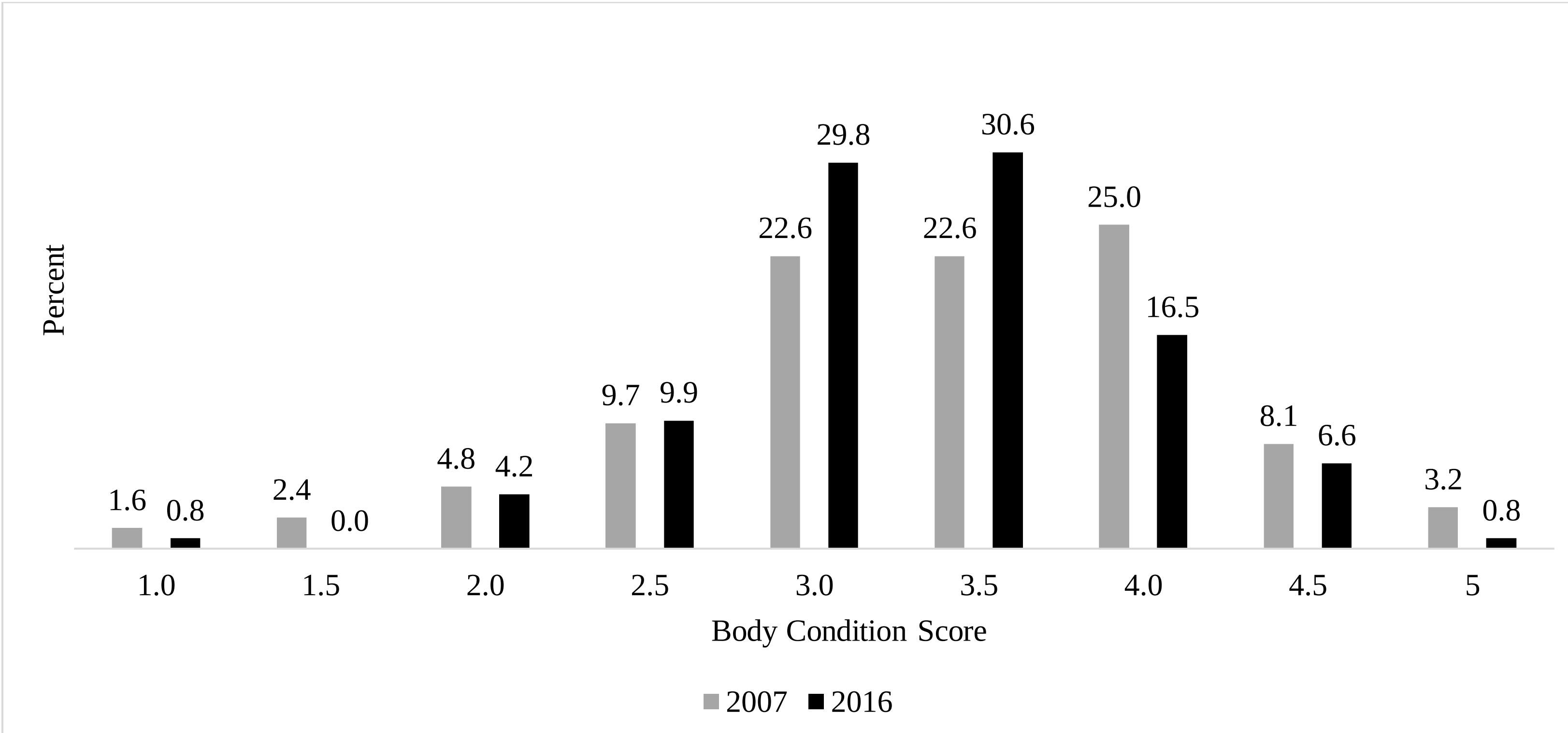

Figure 8. National Beef Quality Audit (NBQA): Distribution of body condition score for dairy bulls in 2007 (*n* = 124) and 2016 (*n* = 121) (Nicholson, 2008).

Originally said by Mike Smith, but reported by Roeber et al. (2000), 3.5% of beef cattle and 4.6% of dairy cattle were too thin (score 1 and 2 on a 9-point scale) during the first audit conducted (not in figure form). In 1999, Roeber et al. (2000) used the same definition for determining cattle that were too thin and reported 2.3%, 5.4%, 1.2% and 1.3% of beef cows, dairy cows, beef bulls, and dairy bulls, respectively fell into this category (Fig. 9). In 1999, the same condition score was used for both beef and dairy cattle. However, in 2007, two distinct score systems were utilized to more accurately depict differences between condition evaluation in beef and dairy animals. Nicholson (2008) reported frequencies for condition scores (Fig. 5 through 8). If the same criteria were used to categorize cattle as “too thin” (score 1 and 2) as was done in the NMCBBQA-1999, then 10.0%, 22.2%, 2.1%, and 4.0% of beef cows, dairy cows, beef bulls, dairy bulls, respectively, were too thin. After comparing to the current audit year, there has been a decline in the percentage of beef cows, dairy cows, and dairy bulls that are too thin, yet an increase in the percentage of beef bulls that are too thin (Fig. 9).

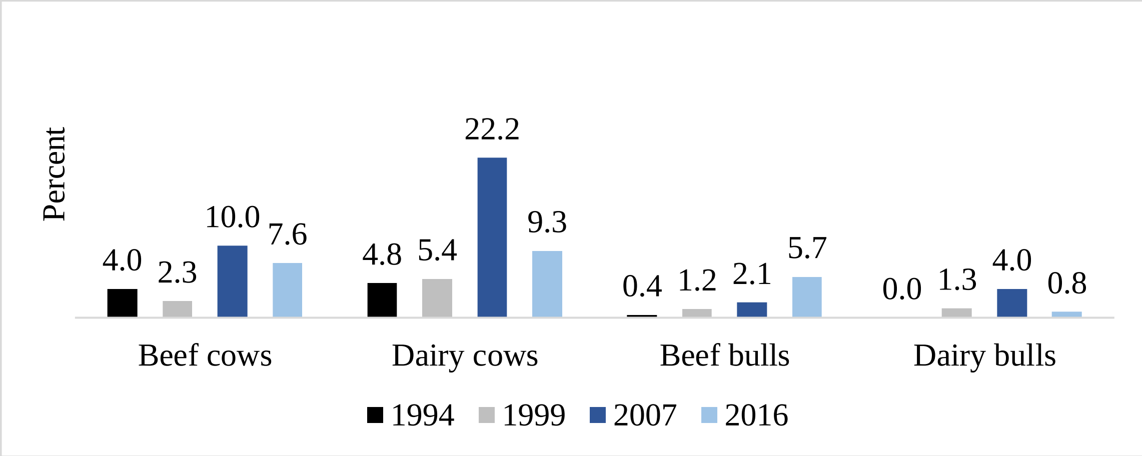

Figure 9. National Beef Quality Audit (NBQA): Comparison of cattle that are "too thin" over the last 17 years. Total number of observations were National Non-Fed Beef Quality Audit – 1994: beef cows (*n* = 1,548), dairy cows (*n* = 1,013), beef bulls (*n* = 254), dairy bulls (*n* = 38); National Market Cow and Bull Beef Quality Audit – 1999: beef cows (*n* = 2,237), dairy cows (*n* = 1,108), beef bulls (*n* = 419), dairy bulls (*n* = 79); NMCBBQA – 2007: beef cows (*n* = 2,800), dairy cows (*n* = 2,103), beef bulls (*n* = 431), dairy bulls (*n* = 124); NBQA-2016: beef cows (*n* = 1,910), dairy cows (*n* = 2,878), beef bulls (*n* = 406), dairy bulls (*n* = 121).

The same comparison over the last 22 years can be made for cattle that are over conditioned (Fig. 10). In 1994, 9.7% of beef cows, 3.1% of dairy cows, 1.6% of beef bulls, and 0.0% of dairy bulls were over conditioned (score 8 or 9 on a 9-point scale) (Smith et al., 1994). In 1999, 4.5%, 1.0%, 0.2%, and 0% of beef cows, dairy cows, beef bulls, and dairy bulls, respectively, were over conditioned, meaning they were assigned a condition score 8 or 9 on the 9-point scale (Roeber et al., 2000). If the same criteria were used for data collected in the 2007 audit, 4.2%, 2.6%, 3.3%, and 11.3% of beef cows, dairy cows, beef bulls, and dairy bulls, respectively, were over conditioned (Nicholson, 2008). When compared to 2016 frequencies, where 3.6%, 0.2%, 2.0% and 5.0% of beef cows, dairy cows, beef bulls, and dairy bulls, respectively, were over conditioned, it appears there are fewer incidences of cattle being fed too long or too much before being marketed.

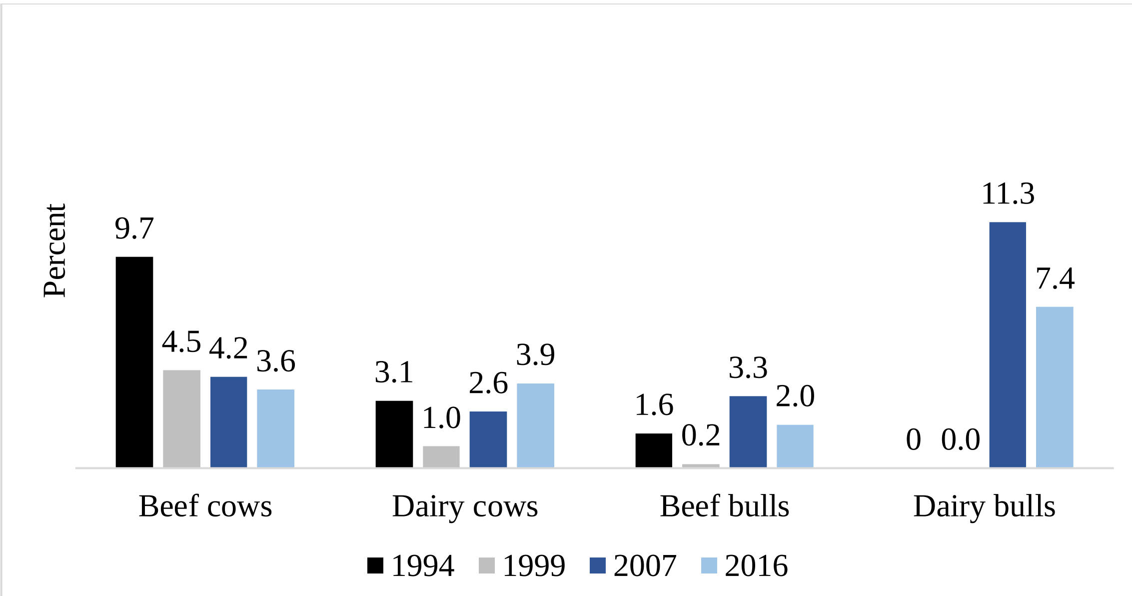

Figure 10. National Beef Quality Audit (NBQA): Comparison of cattle that are "over conditioned" over the last 17 years. Total number of observations were National Non-Fed Beef Quality Audit – 1994: beef cows (*n* = 1,548), dairy cows (*n* = 1,013), beef bulls (*n* = 254), dairy bulls (*n* = 38); National Market Cow and Bull Beef Quality Audit-1999: beef cows (*n* = 2,237), dairy cows (*n* = 1,108), beef bulls (*n* = 419), dairy bulls (*n* = 79); NMCBBQA-2007: beef cows (*n* = 2,800), dairy cows (*n* = 2,103), beef bulls (*n* = 431), dairy bulls (*n* = 124); NBQA-2016: beef cows (*n* = 1,910), dairy cows (*n* = 2,878), beef bulls (*n* = 406), dairy bulls (*n* = 121).

These data on muscle and body condition score of the live animals evaluated in the NBQA-2016 are interesting findings when thought about from the perspective of the energy metabolism of cattle. Too thin of cattle, especially dairy cattle, are most often in a negative energy balance and must then begin metabolizing muscle tissue. Therefore, it would seem there should be a parallel relationship between the frequency changes associated with too thin cattle and too light muscled cattle across audits. However, there seems to be the opposite phenomenon occurring as dairy cattle have trended towards being lighter muscled, yet fatter since 2007. Looking even prior to 2007, in the time between the 1999 audit and the 2007 audit, all cattle showed improvements in muscle. But, there were consistently higher frequencies of cattle that were too thin. It is unclear what may be causing this pattern; this may be a research area of interest for the market cow and bull beef industry.

Beyond condition of an animal, there are multiple other reasons to market cows and bulls. Physical defects which impair reproductive efficiency, or defects that cause economic losses are all important for producers in determining market readiness of animals.

A large majority of cattle surveyed had no defects present when evaluated at the processing facilities (Fig. 11). This may indicate animals were culled for less visible reasons, not recorded by researchers, which may include behavior, reproductive inability, or replacement of the genetic pool. Nonetheless, it was observed that 27.9%, 44.1%, 32.1%, and 24.2% of beef cows, dairy cows, beef bulls, and dairy bulls, respectively, had at least one visible defect present. Dairy cows (44.1% vs. 37.0%), beef bulls (32.1% vs. 23.9%), and dairy bulls (24.2% vs. 19.7%) all reported increased frequencies of at least one defect since 2007. When analyzed on single versus multiple defect presence basis, frequencies indicate producers were more likely to cull animals after visualizing a single defect rather than holding that animal until other conditions occur.

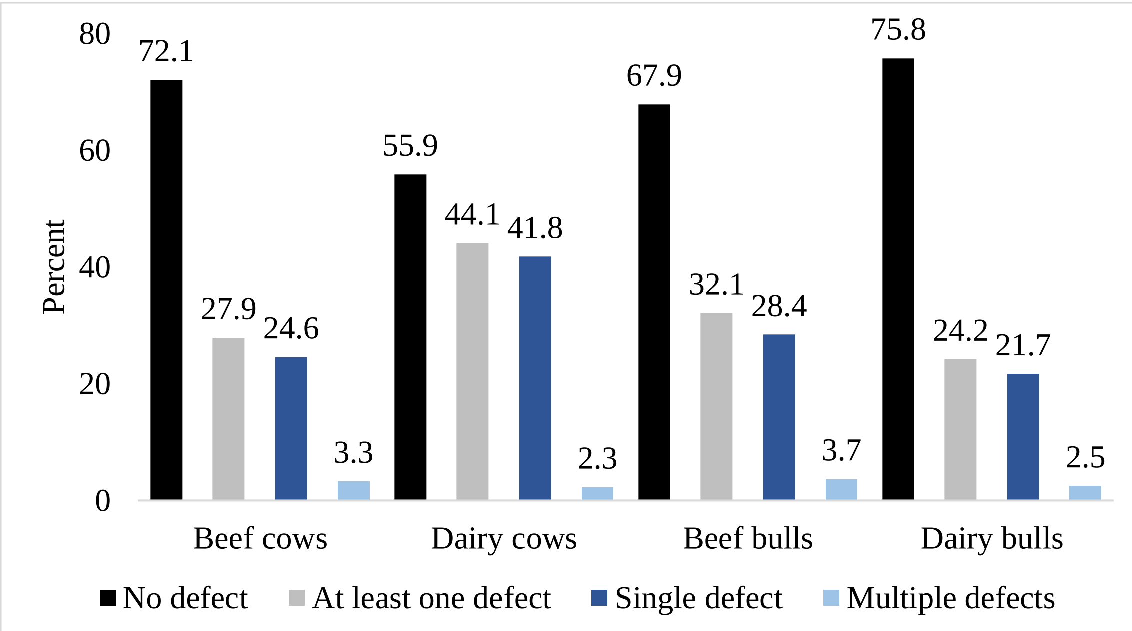

Figure 11. National Beef Quality Audit (NBQA): Distribution of the number of defects observed on cattle surveyed. Total number of observations were beef cows (*n* = 1,912), dairy cows (*n* = 2,855), beef bulls (*n* = 402), dairy bulls (*n* = 120).

Once identified to be a cosmetic and public perception concern, bovine ocular neoplasia (cancer eye) was not identified in 99.0% of all cattle surveyed. Other defects not associated with reproductive soundness, and their frequency of observance, are shown in Fig. 12. Foot abnormalities in beef bulls were much more prevalent than in cows and dairy bulls, as well as being at a higher frequency than when compared to 2007 (12.7% vs. 6.3%) (Nicholson, 2008). This trend was not observed nine years prior as dairy cows had the highest percentage of foot abnormalities compared against other cattle. Since the NMCBBQA-2007, percent of dairy cattle characterized with a foot abnormality fell from 7.2% to 2.2% (Nicholson, 2008). While only a small percentage of cattle possessed some form of abscess, it is telling to understand where those abscesses were located. Of the abscesses observed in beef cows (*n* = 36), 55.6% were located on the face, 8.3% were located on the knee or hock, and 16.7% were located on the hooks or pins. Dairy cattle abscesses (*n* = 85) were more frequently located on the knee or hock (50.6%) and only 20.0%, 17.6%, and 11.8% were located on the hooks and pins, face, or "other" area, respectively. Nearly 82% of the abscesses in beef bulls (*n* = 11) were on the face. There was a higher incidence of lumpy jaw observed in beef cows during 2016 than 2007 (1.2% vs. 0.78%) (Nicholson, 2008). The opposite was seen in beef bulls as 0.8% fewer beef bulls showed signs of lumpy jaw in 2016 than in 2007 (Nicholson, 2008). The hide damage observed in cattle was primarily due to latent hide damage. It seems evident warts were not a major concern observed during audits.

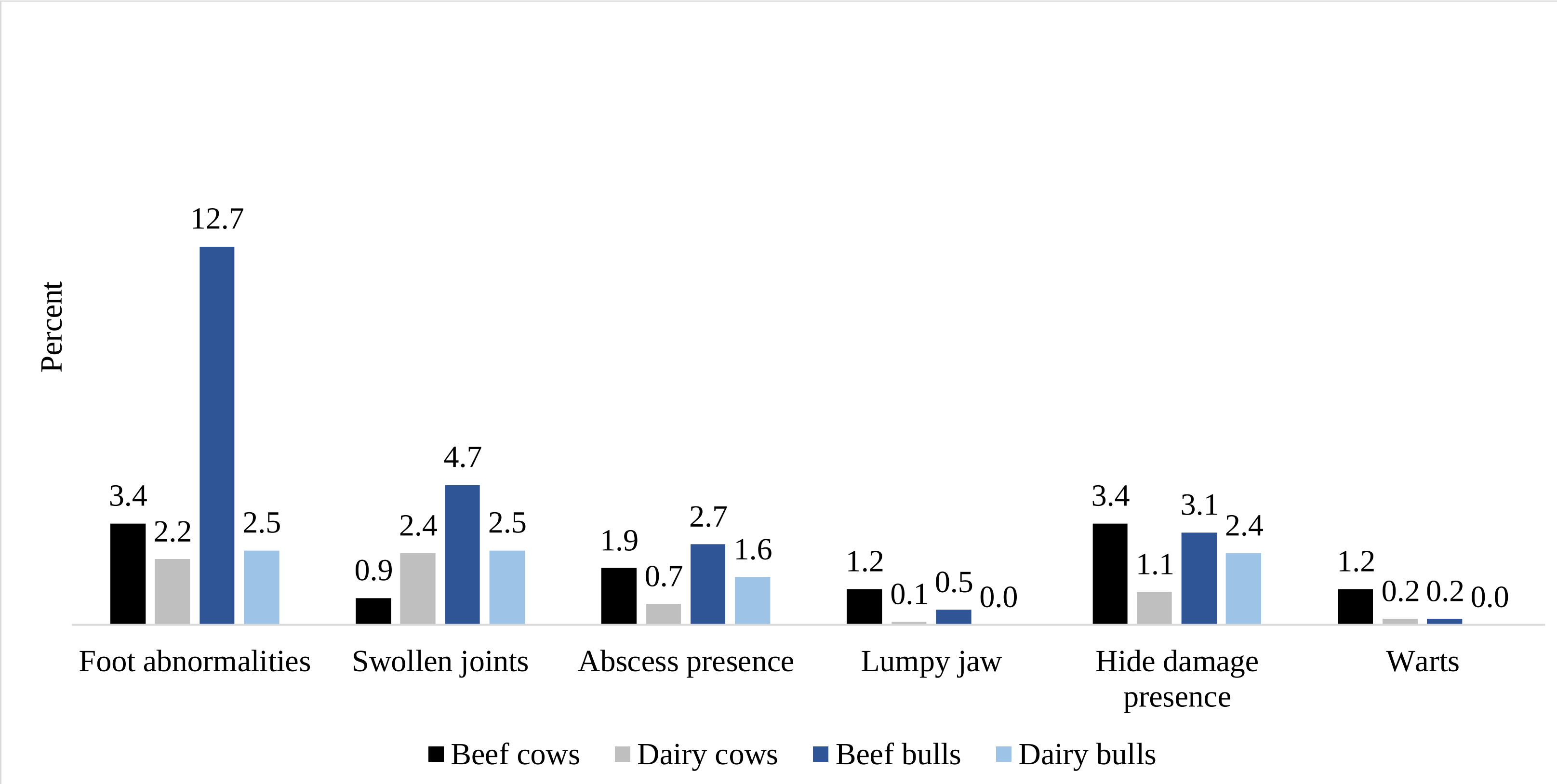

Figure 12. National Beef Quality Audit (NBQA): Distribution of live animal defects pertinent to all surveyed cattle. Total number of observations were beef cows (*n* = 1,913), dairy cows (*n* = 2,856), beef bulls (*n* = 402), dairy bulls (*n* = 120).

Reproductive soundness is often compromised in cows that show signs of failed suspensory ligaments, mastitis, udder problems, and retained placentas. These reproductive defects were observed in surveyed cattle at frequencies outlined in Fig. 13. Dairy cattle showcased the highest incidence of reproductive defects, excluding bottle teats; beef cows showed a higher frequency of bottle teats than dairy cows. Bottle teats, were found to be cause of higher calf mortality and inadequate milk production by the cow to support the calf (Riley et al., 2001). This gives support for the validity in culling a cow with this condition. In comparison to the NMCBBQA-2007 where only 3.6% of cows had failed suspensory ligaments, in the current audit dairy cows had a much higher (14.7%) frequency of failed suspensory ligaments (Nicholson, 2008). Inverse of this, dairy cows in 2016 had a lower frequency (3.8% vs. 9.9%) of multiple udder defects than in 2007 (Nicholson, 2008). Beef cows had a higher rate of mastitis in 2016 than 2007 (2.1% vs. 0.4%) (Nicholson, 2008).

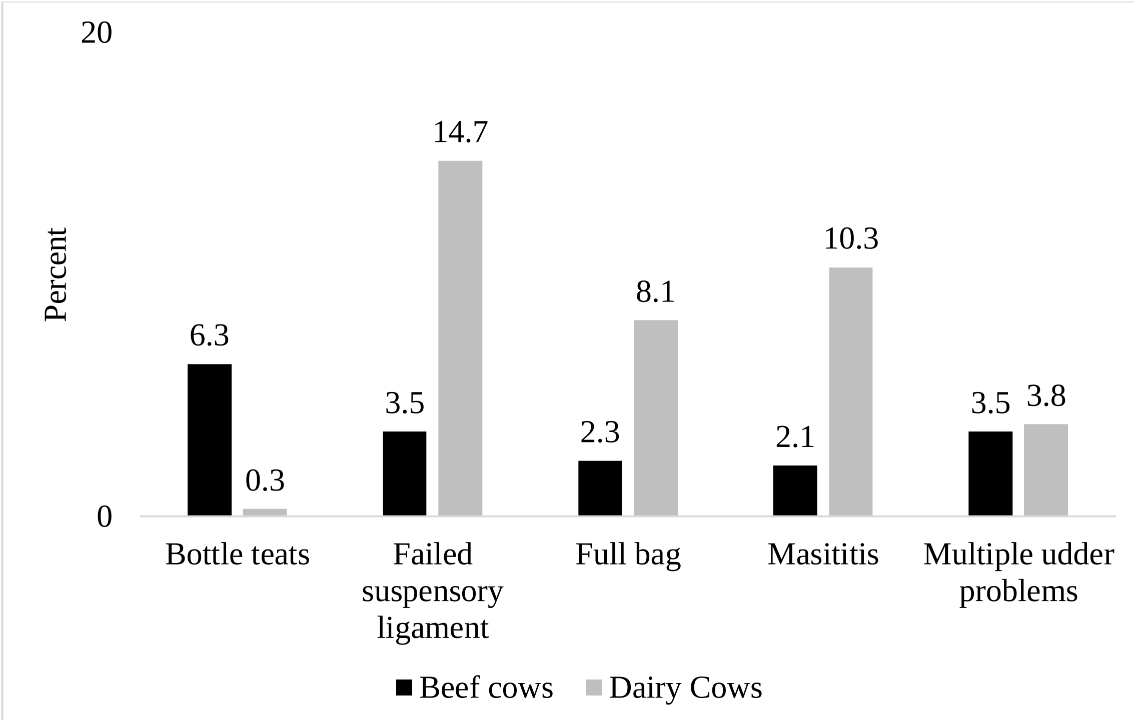

Figure 13. National Market Cow and Bull Beef Quality Audit (NBQA): Distribution of defects associated with reproductive soundness in cows. Total number of observations were beef cows (*n* = 1,913) and dairy cows (*n* = 2,856).

Bulls are often culled for inability to breed cows. This could be caused by sperm infertility, a broken penis, or loss of libido. Observations determined 6.7% of beef bulls (*n* = 402) and 0.0% of dairy bulls (*n* = 120) had broken penises. There was higher incidence (3.8%) of broken penises in dairy bulls during 2007 (Nicholson, 2008).

Horn presence can be a cause of carcass bruising. Cattle with horns comingled with other cattle can elicit carcass damage through force or trauma. Therefore, the presence and length of horns were evaluated in surveyed cattle to determine if horns could be a likely cause for quality defects (Table 11). Of the cattle surveyed, 90.3%, 87.9%, 82.7%, and 69.0% of beef cows, dairy cows, beef bulls, and dairy bulls, respectively, did not have horns. The greatest frequency of horned beef cattle possessed horns greater than 12.7 cm in length. In contrast, the greatest frequency of horned dairy cows possessed horns shorter than 2.54 cm. This may indicate dairy producers are more effectively tipping horned cattle to alleviate undue carcass bruising.

Table 11. National Beef Quality Audit (NBQA): Percentage of horn presence and size in surveyed cattle

Horn size	All cattle (*n* = 5,212)	Beef cows (*n* = 2,094)	Dairy cows (*n* = 2,584)	Beef bulls (*n* = 398)	Dairy bulls (*n* = 84)
No horns	88.0	90.3	87.9	82.7	69.0
<2.54 cm	4.8	1.9	7.0	2.5	16.7
2.54 cm to 12.7 cm	4.3	3.4	4.6	4.8	13.1
>12.7 cm	2.9	4.5	0.5	10.1	1.2

A knot, generally defined as a swelling resulting from an intramuscular or subcutaneous injection of animal health products, poses a potential quality concern in the beef and dairy industry (Roeber et al., 2000). If animal health products are not administered subcutaneously in the neck region and instead administered in the muscle, there can be increased incidence of injection-site lesions visible in high-valued primals and subprimals during fabrication. This causes significant loss in meat quality, yet is something very controllable early in the production scheme. Of the cattle surveyed (*n* = 5,160), 97.9% displayed no visible sign of a knot. Of the knots visible (*n* = 109), 45.0% were observed in the neck. This does not pose a quality defect concern, as the Beef Quality Assurance program advocates animal health injections be administered subcutaneously in the neck (Beef Quality Assurance Advisory Board, n.d.). Of the 109 knots observed, 14.7% were in the shoulder, 14.7% were in the top butt, 6.4% were seen in the round, and 19.3% were observed elsewhere not specified. In 2007, 2.6% of all cattle (n = 5,520) had a knot in the neck, 4.6% had one in the shoulder, 0.2% had one in the top butt, and 0.5% had a knot in the round (Nicholson, 2008). Compared to the 2016 survey results, where 0.9%, 0.3%, 0.3%, and 0.1% of all cattle (n = 5,160) had a knot in the neck, shoulder, top butt, and round, respectively, it appears there have been efforts to reduce injection site lesions through Beef Quality Assurance training and producer education.

Ear tags specifying individual animal identification were most commonly observed in all cattle surveyed; however, dairy cows had a much higher frequency of electronic tag identification than other cattle (Table 12). The Holstein Association USA initiated a national tag registration system in 2015 that required registered dairy Holsteins to be tagged once at birth and once again at six months of age using official USDA identification with an 840 number (USDA-APHIS, 2013; Holstein Association USA, n.d.). The 840 ear tags can be either a visible identification with numbers, or may include a radio frequency identification (RFID) to be used for electronic scanning. The required tagging procedures likely contribute to why dairy cows were more frequently observed to have two forms of identification and were most tagged with an electronic identification tag. Because the 840 ear tags come in both electronic and non-electronic in addition to being shaped like standard-type ear tags, the determination of the frequency of individual identification may have been overestimated, whereas the determination of the frequency of electronic identification may have been underestimated.

Electronic tag utilization in the dairy industry is practical because cows are handled once, if not twice, daily for milking. Tracking a cow for milk yield by way of scanning an electronic tag while she is in the milking parlor each day allows for sophisticated livestock management and increased producer awareness to the productivity of their cow herd (Eradus and Jansen, 1999). This type of sophisticated technology is less pertinent, yet still useful if efficiently implemented, in beef operations. This is most likely another reason for the higher incidence of electronic tags observed in dairy versus beef cows and bulls.

Table 12. National Beef Quality Audit (NBQA): Percentage of identification types[1] in surveyed cattle

Identification	All Cattle (*n* = 5,242)	Beef Cows (*n* = 2,088)	Dairy Cows (*n* = 2,621)	Beef Bulls (*n* = 397)	Dairy Bulls (*n* = 84)
No ID	8.3	11.9	3.2	20.2	17.9
Single ID	38.6	48.3	29.0	50.1	56.0
Multiple ID	53.0	39.8	67.9	29.7	26.2
Identification Type					
Ankle	0.7	0.0	1.4	0.0	0.0
Barcode	1.5	0.9	2.3	0.5	0.0
Electronic	13.2	4.0	22.1	3.0	9.5
Ear tag	69.0	54.9	82.9	54.9	61.9
Metal Clip	30.0	38.1	26.7	16.1	8.3
Lot Tag	23.0	20.3	27.1	16.1	7.1
Waddles	0.2	0.5	0.0	0.3	0.0
Other	26.9	17.8	34.0	23.4	28.6

[1] Percentages exceed 100% due to animals having multiple forms of identification.

Hide evaluation

As seen in Table 13, 68.0% and 67.2% of beef cows and beef bulls, respectively, had a black-colored hide. Red-hided beef animals were the second most prevalent; 20.8% and 18.7% of beef bulls and beef cows, respectively. Overall, 80.1% of beef bulls and 74.0% of beef cows were solid colored (Table 14). Baldy-patterned hides were identified on 18.4% and 12.8% of beef cows and beef bulls, respectively. Predominant hide pattern and color for dairy cows (94.2%) and bulls (91.0%) resembled the Holstein breed.

In 2007, Nicholson (2008) reported 44.2% black-hided beef cows and 52.3% black-hided beef bulls. There has been a dramatic increase in the number of black-hided beef cows and bulls marketed over the last nine years. With the increase in black-hided beef cows and bulls being marketed, it would be logical to conclude there may be a decrease in the number of black-hided steers and heifers being harvested. In the steer and heifer NBQA-2016, there were 3.3% fewer black-hided cattle harvested than the previous NBQA-2011 (Eastwood et al., 2017). Studies have shown that a premium price is awarded to black-hided feeder cattle (Bulut and Lawrence, 2007; Schulz et al., 2010). In addition, black-hided beef cows received a premium of $1.69/45.5 kg body weight compared to their red-hided counterparts (Ahola et al., 2011). So, whether a producer is utilizing cows that are black to produce premium calves, or he/she is culling black-hided cattle, there is opportunity for increased financial returns. This information should not be the primary reason for making culling decisions, but breeding decisions to increase the percentage of black-hided calves should be considered.

Table 13. National Beef Quality Audit (NBQA): Percentage[1] of each primary hide color observed in cattle surveyed

Hide Color	All cattle (*n* = 5,232)	Beef cows (*n* = 2,086)	Dairy cows (*n* = 2,621)	Beef bulls (*n* = 399)	Dairy bulls (*n* = 82)
Patterned animal[2]	51.7	0.1	99.3	0.0	98.8
Black	32.5	68.0	0.3	67.2	1.2
White	1.7	3.0	0.1	4.5	0.0
Yellow	0.9	1.8	0.1	1.0	0.0
Red	9.5	18.7	0.5	20.8	0.0
Brown	3.8	5.0	2.8	3.5	3.7
Gray	1.1	1.7	0.2	2.8	0.0
Tan	1.1	1.7	0.6	0.8	3.7

[1] Percentages exceed 100% due to animals being classified as both patterned and having a primary color.
[2] Includes: Holstein cattle, non-Holstein dairy cattle, and cattle with a hide that did not have a primary color covering 51% or more of the hide.

Table 14. National Beef Quality Audit (NBQA): Percentage[1] of each hide pattern observed in cattle surveyed

Pattern	All cattle (*n* = 5,106)	Beef cows (*n* = 2,033)	Dairy cows (*n* = 2,554)	Beef bulls (*n* = 391)	Dairy bulls (*n* = 78)
None	38.6	74.0	5.1	80.1	9.0
Baldy	8.5	18.4	0.0	12.8	0.0
Roan	0.7	0.9	0.1	0.8	0.0
Brindle	1.3	2.7	0.1	1.8	0.0
Spots	2.7	5.5	0.3	4.6	0.0
Holstein	48.8	nd[2]	94.2	nd	91.0
Other	0.4	0.2	0.2	2.3	0.0

[1] Percentages exceed 100% due to animals being classified by multiple pattern types.
[2] nd = not determined.

Data show 44.0% of all cattle were observed to have some evidence of mud on the hide (not in tabular form). When broken by gender and type, 54.9% of beef cows, 57.8% of dairy cows, 52.8% of beef bulls, and 48.8% of dairy bulls had mud contamination on their hide. The hide of cattle is known to harbor pathogens capable of causing food-borne illnesses (Reid et al., 2002). It is the producer's, transporter's, and packing facility's responsibility to reduce the prevalence of mud by way of housing animals in dry lots, cleaning trailers, and removing any excess mud on the hide before the animal is dressed. The NBQA-2016 classified the mud present on cattle into categories representing small, moderate, large and extreme amounts (Table 15). While the highest frequency of mud seen was in none or small amounts, presence is still potential for cross-contamination of food products when the skinning and hide-removal process is done on the harvest floor.

Table 15. National Beef Quality Audit (NBQA): Percentage of mud observed in cattle surveyed

Amount	All cattle (*n* = 5,239)	Beef cows (*n* = 2,094)	Dairy cows (*n* = 2,612)	Beef bulls (*n* = 400)	Dairy bulls (*n* = 82)
None	56.0	54.9	57.8	52.8	48.8
Small	34.1	35.0	32.0	39.0	42.7
Moderate	8.1	8.1	8.5	6.8	6.1
Large	1.1	0.8	1.4	0.8	1.2
Extreme	0.7	1.2	0.2	0.8	1.2

The number of cattle without mud present is numerically higher than seen in the NMCBBQA-2007. In 2007, only 42.7% of all cattle had no evidence of mud on their hide vs. 56.0% observed most recently. This shows improvement in the industry's initiatives to remove mud from hides before dressing begins and prevent mud contamination in transport and lairage environments.

Reid et al. (2002) found the most contaminated area of the hide was the brisket; one in five animals sampled tested positive for *Eschericia coli* O1:57H7 and one in ten animals tested positive for *Salmonella* spp on this hide location. The brisket, located in the undercarriage of cattle, may also be a good representative of the belly and legs due to the inherent movement used when cattle lay down and rise again. The legs and belly were areas found to have the highest prevalence of mud in cattle surveyed during the NBQA-2016 (Table 16). In 2007, 20.7%, 20.6%, 22.8% and 18.8% of beef cows, dairy cows, beef bulls, and dairy bulls, respectively, had mud present on the legs (Nicholson, 2008). There has been a numerical increase in the frequency of mud on these locations since then, something surprising since fewer cattle have mud present.

Table 16. National Beef Quality Audit (NBQA): Percentage of cattle with mud on various locations of surveyed cattle[1,2]

Location	All cattle (n = 2,304)	Beef cows (n = 944)	Dairy cows (n = 1,101)	Beef bulls (n = 189)	Dairy bulls (n = 42)
Legs	82.2	81.9	81.7	83.6	90.5
Belly	54.1	46.1	64.3	36.5	59.5
Side	11.4	10.4	12.9	8.5	9.5
Top line	12.1	9.0	14.7	12.2	14.3
Tail region	7.5	5.8	9.0	8.5	4.8

[1] Sample size is only a representation of cattle with mud present.
[2] Percentages do not add to 100 percent because multiple responses may have been recorded per animal surveyed.

Explained best by Roeber et al. (2000), identifying quality shortfalls in the NBQA series allows researchers to identify not only quality defects, but also management practices that contribute to the progress of improving quality within the industry. One very traditional management practice, stemming back to 2700 B.C. (Stamp, 2013), is that of branding cattle as a form of identification. Although hot-iron branding is the most permanent form of identification, it also provides a means for devaluation of the hide. At $3.08 USD/cwt (USDA-AMS, 2017), cow hides are valued at three times that of other offal by-products making it the most valuable item in the drop credit. In the NNFBQA-1994, branded hides were identified as being the cause for an industry loss of $16.6 million USD annually. The combination of hides and latent defects garnered a value loss of $6.92 in 1994, $6.27 in 1999 and $7.47 in 2007(National Cattlemen's Beef Association, 2017). Therefore, it is imperative that producers make attempts at preserving its depreciation value.

Of the cattle surveyed, 22.7% had at least one brand visible on the hide. This is a slightly lower numerical value to the 23.6% of branded hides reported in 2007 (Nicholson, 2008). When stratified across beef and dairy type animals, the percentage of brand occurrence becomes more telling. Beef cattle (35.7%) showed a higher frequency of brand presence compared to dairy cattle (10.7%). Therefore, branding and the loss of hide value is a greater quality concern in beef cattle. This makes sense as traditional beef cattle management involves the branding of calves following the calving season, a management practice that is not utilized heavily in the dairy industry.

Figure 14 shows the percentage of cattle with no brand, one brand, or multiple brands. Nine years ago, 68.7% and 90.1% of beef cows and dairy cows, respectively, had native hides (no brands) (Nicholson, 2008). Even though the presence of brands on cows has increased, the presence of brands on bulls has decreased since 2007.

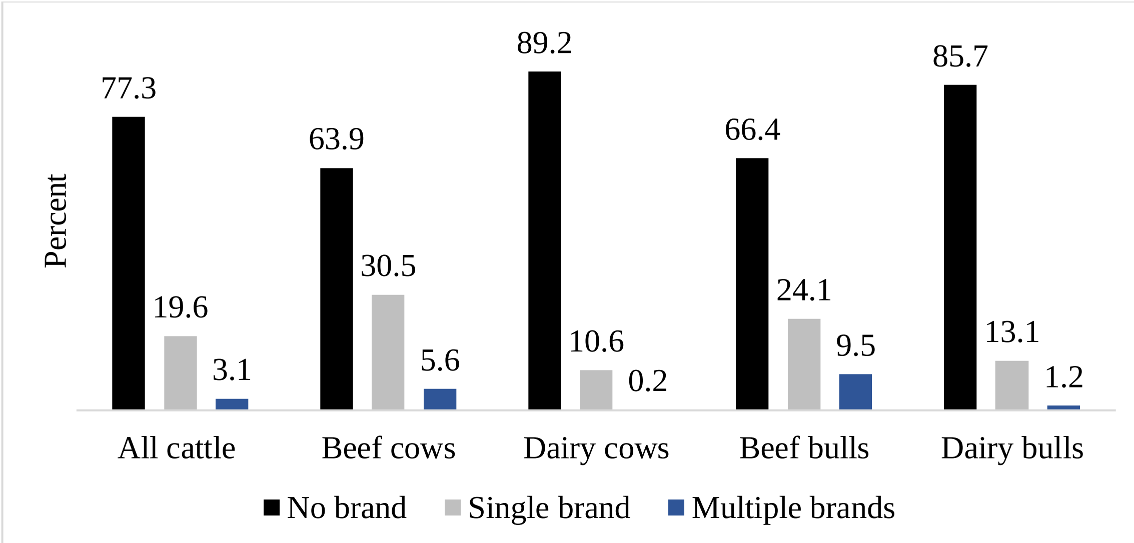

Figure 14. National Beef Quality Audit (NBQA): Percentage of cattle with no brands, single brands and multiple brands. Total number of observations were all cattle (*n* = 5,262), beef cows (*n* = 2,106), dairy cows (*n* = 2,618), beef bulls (*n* = 403), dairy bulls (*n* = 84).

Even though branding is still traditional practice in maintaining the heritage of cattle ranching, producers can minimize the value loss due to branding by recognizing there is less value lost in the drop credit when cattle are branded on the butt or shoulder rather than the side. Table 17 indicates the frequency of brands in each location for all cattle surveyed in 2016. Cattle exhibited butt brands at a higher rate than either side or shoulder brands. This was a similar trend to that seen in 2007 for cows surveyed (Nicholson, 2008). Twenty percent of dairy bulls and 25.5% of beef cows displayed a butt brand in 2007, numerically higher values than observed in the current audit. In contrast, dairy cows and beef bulls were seen to have a higher frequency of butt brands in the current audit than in 2007. Dairy animals as a whole saw a decrease in the frequency of side brands over the past nine years, while beef animals saw an increase.

The only type of cattle to see an increase in the frequency of shoulder brands between the two audits were beef cows. Notably, dairy bulls dropped to 0.0% shoulder brands when there once were 5.2% observed nine years prior (Nicholson, 2008). Brand location is most imperative to producers registering a new brand through their state or county brand law program. Existing brands already have specified locations, but new brands being registered should be placed either on the butt or shoulder to help mitigate the value loss to hides.

Table 17. National Beef Quality Audit (NBQA): Percentage of cattle with a brand located on the butt, side, and shoulder

	n	Percentage (%)
Butt brands		
Beef cows	2,106	25.5
Dairy cows	2,618	9.5
Beef bulls	42	27.4
Dairy bulls	84	14.3
Side brands		
Beef cows	2,107	11.8
Dairy cows	2,619	0.9
Beef bulls	402	9.7
Dairy bulls	84	0.0
Shoulder brands		
Beef cows	2,107	2.8
Dairy cows	2,619	0.4
Beef bulls	402	0.4
Dairy bulls	84	0.0

[1] Percentages do not add to 100% because *n* also includes cattle that were unbranded.

Not only is location of a brand important for minimizing hide devaluation, but size of the brand also plays an important role. Large brands spanning a significant portion of the hide, especially over the midsection of an animal, decrease hide value as the usable surface area of that byproduct is significantly diminished (Gugelmeyer, 2010). Mean brand size of the cattle branded is reported in Table 18. The greatest mean area occupied by a brand was found on the sides of beef cows. There was large variation in the size of side brands on beef cows.

Table 18. National Beef Quality Audit (NBQA): Mean size (cm²) of brands located on the butt and side of all branded cattle surveyed

	n[1]	Mean	Std. Dev.	Min	Max
Beef cows					
Butt	534	191.5	216.88	12.9	1548.4
Side	248	623.2	1048.45	19.4	8361.3
Dairy cows					
Butt	231	502.3	342.64	25.8	2090.3
Side	20	303.2	311.50	25.8	1451.6
Beef bulls					
Butt	110	201.8	203.96	25.8	1161.3
Side	39	435.1	403.97	19.4	1858.06
Dairy bulls[2]					
Butt	12	324.2	194.97	64.5	645.2

[1] Sample size is a reflection of branded cattle. Cattle with native hides were excluded.

[2] Dairy bulls had no incidence of side brands.

Hide-off carcass evaluation

Percentages of carcasses with no bruising, minor bruising, major bruising, and extreme bruising are presented in Table 19. For all cow carcasses evaluated, 35.9% did not have a bruise. This is similar to the frequency of carcasses (37.1%) which did not have a bruise in 2007 (Nicholson, 2008). A large majority of bruises on cow carcasses during the current audit were the lowest severity, meaning less than 0.45 kg of surface trim would be removed due to the bruise damage. A lesser percentage of cattle when compared to 2007 gave evidence of critical bruising, continuing the decline in frequency of bruises causing 4.99 kg to 18.14 kg of surface trim since 1994. Not in table form, 24.0% and 41.3% of beef cows and dairy cows, respectively, had multiple bruises found on the carcass. In comparison, 13.5% and 29.0% of beef bulls and dairy bulls, respectively, had multiple bruises.

Table 19. National Beef Quality Audit (NBQA): Carcass bruise severity over the past twenty-two years in cows and bulls surveyed[1,2,3]

Bruise severity	1994	1999	2007	2016
Cows				
n	Unknown	4,848	5,092	4,262
No bruise	20.3%	11.8%	36.6%	35.9%
Minimal[4]	51.5%	77.2%	36.7%	67.3%
Major[4]	53.9%	41.7%	30.9%	45.1%
Critical[4]	30.7%	21.6%	12.4%	4.9%
Extreme[4]	nd[5]	2.4%	5.4%	1.4%
Bulls				
n	Unknown	831	477	389
No bruise	63.8%	47.1%	46.8%	57.1%
Minimal	25.3%	44.4%	31.5%	42.4%
Major	19.5%	16.7%	20.1%	21.9%
Critical	7.4%	6.9%	11.5%	1.5%
Extreme	nd	1.0%	7.6%	0.3%

[1] National Non-Fed Beef Quality Audit - 1994 (Smith et al., 1994); National Market Cow and Bull Beef Quality Audit - 1999 (Roeber et al., 2000); National Market Cow and Bull Beef Quality Audit - 2007 (Nicholson, 2008).

[2] Total number of observations for cow carcass bruises were: unknown (NNFBQA – 1994); 4,848 (NMCBBQA – 1999); 5,092 (NMCBBQA – 2007); 4,262 (NBQA – 2016). Total number of observations for bull carcass bruises were: unknown (NNFBQA – 1994); 831 (NMCBBQA – 1999); 477 (NMCBBQA – 2007); 389 (NBQA – 2016).

[3] Percentages do not add to 100% because some animals possessed multiple bruises, some of varying severity.

[4] Minimal (<0.45 kg carcass trim); major (0.45 kg to 4.54 kg carcass trim); critical (5.0 kg to 18.14 kg carcass trim); extreme (entire primal was trimmed).

[5] nd = not determined.

The drastic increase in 2007 from 1999 in cows exhibiting no bruises was most probably in part due to the conclusions made by Roeber et al. (2000) that carcass bruising should be of great concern to the market cow and bull industry. Being identified as the sixth cause of whole carcass condemnation in 1999, carcass bruising was a front-runner in improving quality in the industry. In 2007, following interviews with packers, producers, and retailers, bruising was listed as a top-five improvement in beef cattle since the previous 1999 audit (Nicholson, 2008). Even so, carcass bruising was still included in the list of top quality challenges in 2007 (National Cattlemen's Beef Association Beef Quality Assurance Program, 2007). Today, there is still room for improvement for decreasing the prevalence of carcass bruising.

In order to further understand the current state of carcass bruising, researchers analyzed severity of bruises across bruise presence (Table 20). Of the bruises observed in beef cows, dairy cows, beef bulls, and dairy bulls, the greatest frequency were minimal. This is telling in that very little carcass trim would be generated from a large percentage of the bruises reported on the carcasses. In fact, according to Roeber et al. (2000), an average of 0.30 kg of trim would be lost in this instance, having minimal effect on primal marketability.

Table 20. National Beef Quality Audit (NBQA): Frequency (%) of bruise severity

Severity[1]	Beef cows	Dairy cows	Beef bulls	Dairy bulls
Minimal	53.6	57.5	57.2	74.3
Major	39.7	37.6	38.8	24.8
Critical	5.6	3.7	3.9	0.0
Extreme	1.0	1.2	0.0	1.0

[1] Minimal (<0.45 kg carcass trim); major (0.45 kg to 4.54 kg carcass trim); critical (5.0 kg to 18.14 kg carcass trim); extreme (entire primal was trimmed).

Of the bruises reported in cows, the greatest percentage were located on the round and sirloin (Fig. 15 & 16).

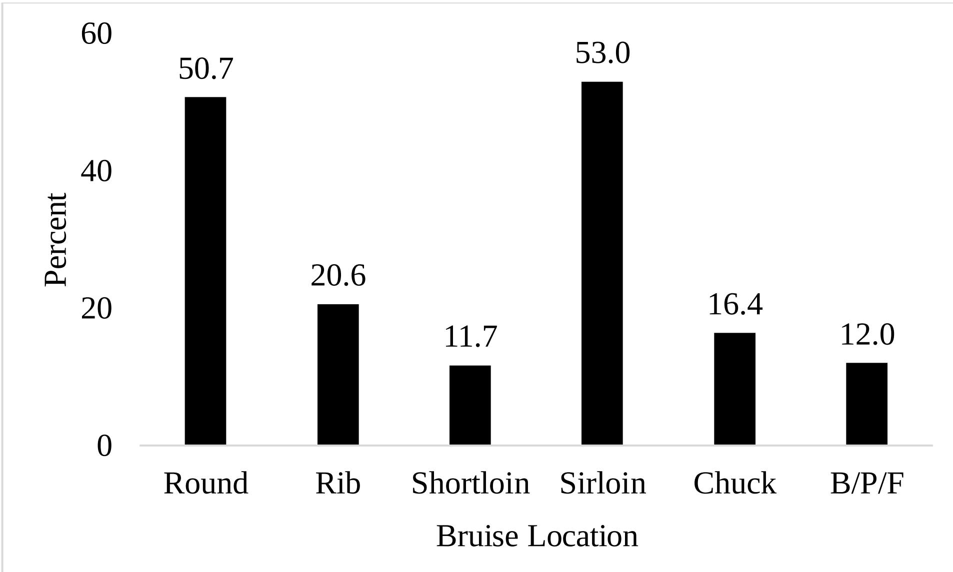

Figure 15. National Beef Quality Audit (NBQA): Frequency of bruising on each primal in beef cows. Total number of observations were *n* = 651.

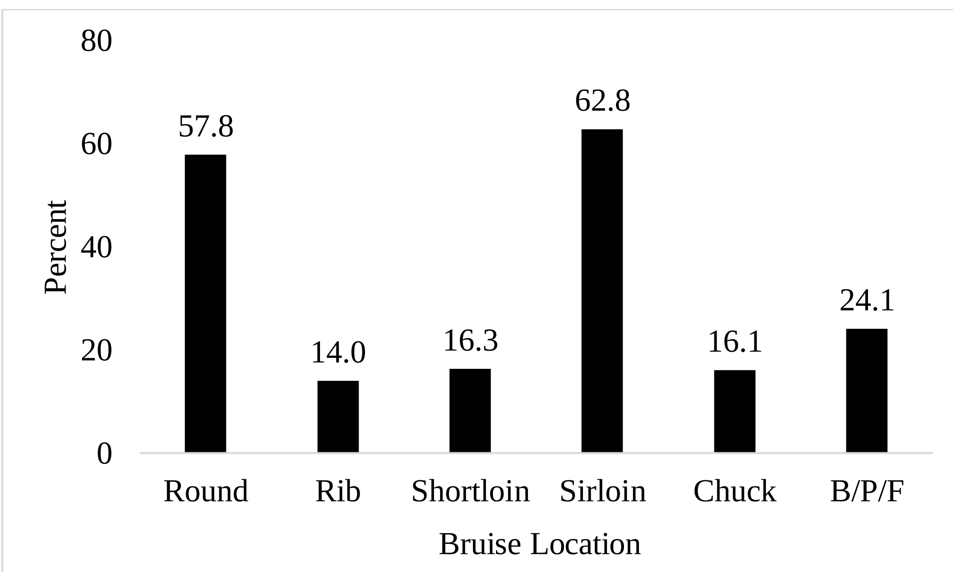

Figure 16. National Beef Quality Audit (NBQA): Frequency of bruising on each primal in dairy cows. Total number of observations were *n* = 2,083.

Bulls (Fig. 17 & 18) tended to have a higher frequency of bruises found on the brisket/plate/flank (B/P/F) region when compared to cows. Bruise location is often a direct result of handling practices and facility design that cattle are worked though 24 h prior to harvest. A Chilean study conducted to compare bruise prevalence and severity between cows sourced from markets and farms found bruises to be present most frequently on the pins, followed by the back, and least frequently on the butt of cattle (Strappini et al., 2012). Cattle sourced from the market had a higher incidence of carcass bruising, and when narrowed to specific locations, cows sourced from a market had a higher rate of rib bruises, while cows from farms saw higher rates of back bruises. Most often cattle bought and sold through markets have increased exposure to transport, handling, and pen systems. This is a likely cause for the higher likelihood of acquiring a carcass bruise when compared to farm sourced cattle. In comparison, Hoffman et al. (1998) determined there was a strong association between bruise prevalence and increased animal handling. Further, in the Recommended Animal Handling Guidelines, Grandin (2013) verifies collisions with protruding equipment on trucks and in holding facilities, as well as contact with sharp objects, and rough, quick handling by cattle haulers and managers are all likely causes of bruises in cattle. As outlined in previous audits, carcass bruising costs the industry each year. The National Cattlemen's Beef Association (1994) outlined $11.47 USD was being lost per animal due to the influence of carcass bruising. Likewise, Boleman et al. (1998) found carcass bruising cost the steer and heifer beef industry $14,452,000 USD annually. Therefore, there needs to be continued emphasis on proper cattle handling for the purpose of reducing bruising among cattle.

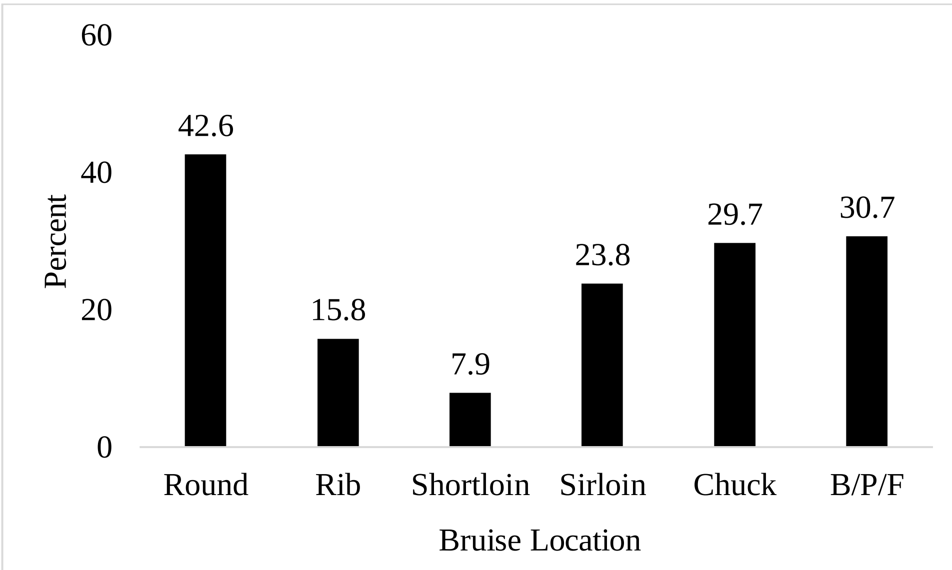

Figure 17. National Beef Quality Audit (NBQA): Frequency of bruising on each primal in beef bulls. Total number of observations were *n* = 101.

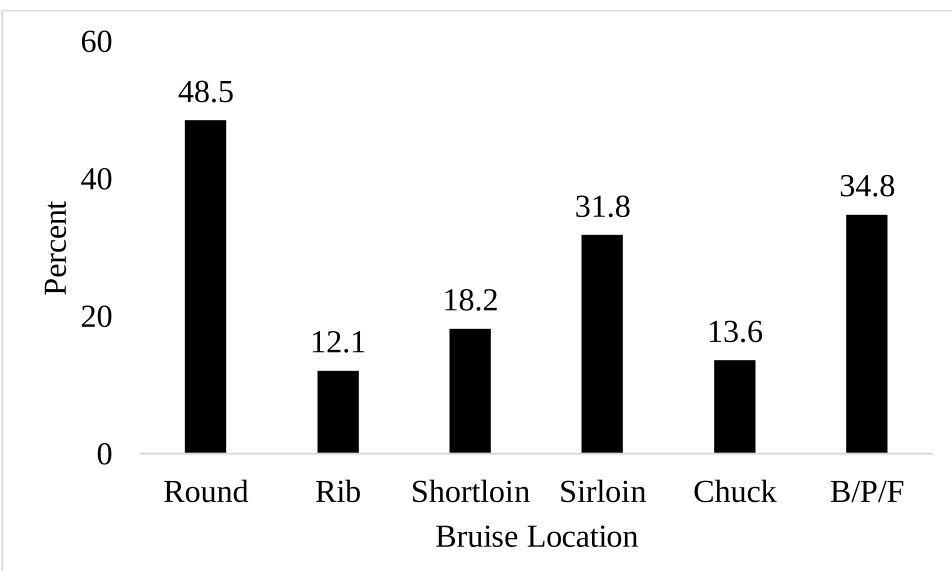

Figure 18. National Beef Quality Audit (NBQA): Frequency of bruising on each primal in dairy bulls. Total number of observations were *n* = 66.

In past audits, injection-site lesions have been a great concern and have led to additional studies to investigate the occurrence in both fed cattle and mature cattle. At its inception, the NNFBQA-1994 audit realized 13.4% of all dairy cattle had an abscess and chronicled 25.0% of all rounds at an audited processing facility possessed an injection-site lesion visible on the exterior of the carcass (National Cattlemen's Beef Association, 1994). Following information gathered in the NMCBBQA-1999, Roeber et al. (2002) more intimately investigated the occurrence of injection-site lesions not simply on the exterior of the carcass, but within muscle. They reported 31.0% of beef rounds and 60.0% of dairy rounds had an injection-site lesion within the round muscle. Although this decreased 6% and 9% for beef and dairy cows, respectively, over the three-year time period of the study, injection-site lesions were still outlined as a priority in producer education initiatives as a result.

In his research, Nicholson (2008) found 93.5% of all cattle surveyed were free of injection-site lesions visible on the exterior of the carcass. Even still, 11.2% of the dairy cows surveyed had a visible injection-site lesion (Nicholson, 2008). In comparison, 98.4% of all cattle in the current audit were observed to have no evidence of an injection-site lesion. Not only is this a percentage increase of nearly five points, but there were also only 1.7% of dairy cows in the current year to show signs of injection-site lesions on the carcass surface. This is a vast improvement over the last nine years.

Harvest floor condemnations

The NBQA-2016 surveyed 4,800 viscera during the course of the audit year. Of those surveyed, 44.6% of livers were condemned. In an effort to understand the reason behind these condemnations, it is useful to know that of the livers condemned (n = 2,142), 46.3% of them had some form of abscess causing failure to pass USDA inspection. Brink et al. (1990) found liver abscess prevalence in feedlot cattle to be 12% to 32%, a range encompassing the frequency (20.1%) of abscessed livers when calculated from all cattle observed in the NBQA-2016. Although cows and bulls are not generally managed in a feedlot setting, there are profit benefits to feeding breeding stock to achieve carcass merits for a White Fat Cow market before selling (Strohbehn et al., 2004). Cows worked through this type of system before being harvested may have the chance to develop liver abscesses; research has shown it takes only 3 to 10 d for abscesses to develop (Nagaraja and Chengappa, 1998). Rezac et al. (2014) observed liver abscesses in 32.2% of the cull dairy and beef cow population they studied. They concluded liver abscesses in dairy cows in particular, are a result of rapid changes in diet when transitioning from gestation to lactation and the high energy diets that are necessary for maximum milk production (Rezac et al., 2014). A high incidence of liver abscesses may also be seen in cows and bulls because of the increased opportunity for the development of "hardware disease" (Rezac et al., 2014). Increased incidence of liver abscesses may be seen in dairy cows due to the non-use of antibiotic feed additives, specifically those containing Tylosin phosphate; this feed additive is only approved for use in beef cattle (Elanco Animal Health, n.d.). Producers who elect to feed beef cows prior to harvest to achieve carcass merits eligible for White Fat programs should work with their veterinarian to incorporate Tylosin to help mitigate the development of liver abscesses, which in turn will preserve the value of the liver as a by-product.

It is interesting that the frequency of liver abscesses (30.8%) reported in the steer and heifer NBQA-2016 (Eastwood et al., 2017) is lower than that reported in the NBQA-2016 for cows and bulls. Being traditionally managed in a feedyard, it would seem steers and heifers have greater exposure to liver abscess development while consuming a high-energy ration. However, the use of antimicrobial feed additives at feedyards under a Veterinary Feed Directive would be reason why a lower rate of abscesses was observed in the steer and heifer population.

A far fewer percentage of livers were condemned for other pathologies such as telangiesctasis (14.5%), flukes (7.1%), and contamination (17.6%). There were some instances when livers (14.5%) could not be classified to one of the prior reasons mentioned, and it was thus recorded as being condemned for “other” reasons. As noted among collaborating universities, the greatest frequency for “other” to be denoted was due to plant personnel failing to present the liver to the USDA inspector in an appropriate manner. The 9 CFR Part 307 states that inspected establishments must ensure organs of livestock must be displayed in a specified order, agreed upon by the inspector and establishment, so that the inspector does not have to spend time locating them before he or she performs inspection procedures (United States Department of Agriculture Food Safety Inspection Services, 2015).

The viscera associated with the aforementioned livers were evaluated for condemnation. It was found that 20.0% of whole viscera audited were condemned. Of the viscera condemned, the greatest percentage (50.3%) were due to contamination. This contamination may have been due directly from the viscera in question, or contamination by viscera ahead or behind on the production line. Furthermore, 25.4% of viscera displayed an abscess concern giving reason to condemn. Ulcers played only a minor role in visceral condemnations (1.5%). Finally, 22.9% of viscera were condemned due to "other" reasons, most likely due to improper presentation as was the case in liver condemnations. To finalize visceral condemnation profiles, 10.5% of the kidneys associated with the 4,800 viscera surveyed were condemned. Reason for kidney condemnation was not recorded.

Upon observance of lung condemnations by USDA-FSIS personnel, 23.1% were condemned. Of the 4,586 lungs sampled, 33.1% were condemned due to pneumonia damage to the lung. Mild pneumonia was evident in 54.6% of the surveyed lungs, moderate pneumonia was seen in 30.3% of the surveyed lungs, and severe pneumonia was only seen in 15.1% of lungs observed. Contamination of the lungs was the reason behind 50.7% of lung condemnations on the production floor. For other unspecified reasons lungs (16.2%) were condemned.

Of the beef hearts, condemnation occurred for 22.3% surveyed. The primary reason for condemnation was contamination of the heart. Pericarditis, a pathology associated with inflammation of the heart sac, was the cause for 23.9% of hearts condemned.

Of the 5,720 heads surveyed, 8.2% were condemned by USDA-FSIS personnel. Table 21 represents the percentage of heads condemned for various reasons. The highest frequency of condemnation occurred due to contamination, a similar finding in the NMCBBQA-2007 (Nicholson, 2008). Not all heads are condemned for the presence of contaminants or for showing lymph node pathology, but rather, heads may have been trimmed before being passed at inspection. There was a frequency of 1.1% of heads trimmed in the current audit. While heads were still condemned for contamination, a far greater percentage were simply trimmed by USDA-FSIS or plant personnel in order to pass inspection.

Table 21. National Beef Quality Audit (NBQA): Head condemnation and trimming rates observed in 2007[1] and 2016

Reason for head condemnation	2016 (*n* = 5,720)	2007 (*n* = 5,260)
Lymph	1.8	1.0
Abscess	0.9	2.0
Contamination	3.3	4.7
Other	2.2	2.5
Reason for head trimming		
Lymph	0.3	0.8
Abscess	0.0	0.2
Contamination	0.5	2.5
Other	0.2	0.7

[1] Nicholson (2008).

Eight permanent incisors were observed in 60.4% of cattle. The survey of more mature cows and bulls still yielded a small percentage (4.3%) of cattle classified as less than 30 months by dentition (<3 permanent incisors). Table 22 represents the incidence of dental defects observed in all cattle surveyed. A broken mouth or lack of incisors utilized to masticate are very likely causes for culling breeding animals because that animal no longer has the ability to maintain condition and therefore be of use for breeding and functionality of the operation.

Table 22. National Beef Quality Audit (NBQA): Dental defects observed in all cattle

Dental defect	All cattle (*n* = 5,670)
Broken mouth	8.5
Gummer	6.2

In association with the head, tongues were evaluated for condemnation due to lymph node concerns, hair sore, cactus tongue, contamination or other unspecified reasons (Table 23). Of the tongues surveyed, 16.9% of them were trimmed while 5.9% were condemned. Tongues were condemned for lymph node concerns (1.4%), contamination (2.3%), hair sore (0.2%), cactus tongue (0.2%), and other reasons (1.8%). Tongues were trimmed for hair sore (9.0%), lymph node concerns (4.1%), contamination (2.3%), cactus tongue (1.4%), and other reasons (0.6%).

Since NMCBBQA-2007, both head and tongue condemnations have declined. Specifically, tongue condemnations have decreased by 4.1% points. At the same time, the rate at which tongues were trimmed has increased by 8.5% points. There was a percentage point decrease in the tongues condemned due to cactus tongue (-2.0%) and hair sore (-1.6%) since 2007, yet a percentage point increase in the tongues trimmed due to cactus tongue (+1.4%) and hair sore (+4.6%) (Nicholson, 2008). When evaluated together, these trends may be a reflection of changes in USDA-FSIS inspection protocol. Trimming tongues rather than condemning them for hair sore and cactus tongue appeared to be more common for USDA-FSIS inspectors in 2016.

Table 23. National Beef Quality Audit (NBQA): Tongue condemnation and trimming rates observed in 2007[1] and 2016

	2016 (*n* = 5,720)	2007 (*n* = 5,260)
Reason for tongue condemnation		
Lymph	1.4	1.0
Hair sore	0.2	1.8
Cactus tongue	0.2	2.2
Contamination	2.3	2.6
Other	1.8	2.5
Reason for tongue trimming		
Lymph	4.1	0.8
Hair sore	9.0	4.4
Cactus tongue	1.4	0.0
Contamination	2.3	1.9
Other	0.6	1.3

[1] Nicholson (2008).

In an effort to document the incidence of bred cows being harvested, the NBQA-2016 detailed the presence of fetuses in surveyed cattle. Of the cows surveyed (*n* = 4,692), 17.4% carried a fetus at the time of harvest. This has numerically increased from 2007, where only 10.6% of cows were pregnant at time of harvest (Nicholson, 2008).

During the 2016 survey year, researchers depicted 47.1% of the fetuses present were over 150 days old (determined by fetal size). On day 38 of pregnancy, the fetus has attached to the uterine wall making pregnancy detection by palpation, ultrasound or blood test very effective. Pregnancy detection by any means is a useful tool for the decision to keep or cull cows based on reproductive performance (Carpenter and Sprott, 2008). Unfortunately, a study conducted by the National Animal Health Monitoring System indicated that less than 20% of cattlemen check for pregnancy in their cowherd (Bridges et al., 2008). For the beef producers who do utilize pregnancy diagnosis in their herd, it must be understood it is possible for cattlemen to cull pregnant cows that have been checked. Consequently, this may be the reason why some bred cows are being harvested. Even so, the fetuses observed in the NMCBBQA-2016 were large enough to be visually observed on the harvest floor, indicating that producers should have been able to detect pregnancy through palpation, ultrasound or blood test. Cattlemen should realize there is opportunity to capitalize on increased calf crop dollar returns by more rigorously checking for pregnancy in their cowherd.

Carcass grading

Established in 1916, the United States Standards for the Grades of dressed beef were designed to provide a basis for the uniform reporting of beef according to specific grade classes intended to represent the beef market (USDA, 2016). These standards, although amended throughout the years to represent changes in market and support research findings, are still available today. However, a majority of market cow and bull packers do not utilize these grade standards, but rather enlist characteristics found to assist them in sorting carcasses based on the market style of the packer. Nonetheless, carcasses surveyed in the NBQA-2016 were classed based on both quality and yield grade factors outlined by the USDA. In some instances, obtaining official USDA quality and yield grades was not plausible due to facility handling of carcasses (i.e. most carcasses were not ribbed). Nonetheless, a representation of all contributing factors for yield and quality determination were collected.

The mean lean, skeletal, and overall maturity, as well as the mean marbling scores of carcasses surveyed are provided in Table 24. The average lean maturity score was C maturity among all classes and types of cattle surveyed. Cows and bulls, more mature in age, have a higher concentration of myoglobin in their muscle make-up and increased prominence of perimysial connective tissue due to muscle fiber degeneration, therefore causing a darker, coarser textured lean observed in the LM area than a less mature, fed-beef animal (Aberle et al., 2012). Average lean maturity in cattle surveyed in 2007 was reported as D^{18}, C^{39}, C^{78}, and C^{54} for beef cows, dairy cows, beef bulls and dairy bulls, respectively (Nicholson, 2008). The most notable change over the nine-year period was the shift from D to C maturity observed in beef cows.

Of the cattle surveyed, the dairy bulls yielded a younger mean skeletal maturity classification (C maturity) than the beef and dairy cows and the beef bulls surveyed (Table 24). Beef Cows tended to be more advanced in skeletal maturity with the mean approaching the E maturity category. Overall maturity determination showed beef cows were the most mature to be surveyed.

Amount of marbling, the second quality characteristic utilized to determine quality grade of United States beef, was variable between cows and bulls (Table 24). Both beef and dairy cows averaged a greater amount of marbling (Slight) than beef and dairy bulls (Traces).

Table 24. National Beef Quality Audit (NBQA): Mean values for USDA quality grade factors in surveyed cattle

	n	Mean	Std. Dev. (°)	Min	Max
All cattle					
Lean maturity	2,420	C^{38}	132	A^{10}	E^{100}
Skeletal maturity	4,272	D^{64}	146	A^{00}	E^{100}
Overall maturity	2,420	D^{13}	123	A^{45}	E^{100}
Marbling score	1,957	SL^{64}	137	PD^{00}	AB^{70}
Beef cows					
Lean maturity	1,109	C^{57}	131	A^{10}	E^{100}
Skeletal maturity	1,734	D^{97}	126	A^{00}	E^{100}
Overall maturity	1,109	D^{43}	110	A^{50}	E^{100}
Marbling score	905	SL^{62}	128	PD^{00}	AB^{70}
Dairy cows					
Lean maturity	1,117	C^{15}	128	A^{20}	E^{100}
Skeletal maturity	1,713	D^{13}	151	A^{10}	E^{100}
Overall maturity	1,117	C^{87}	127	A^{45}	E^{100}
Marbling score	897	SL^{78}	147	PD^{00}	AB^{50}
Beef bulls					
Lean maturity	137	C^{80}	142	A^{60}	E^{100}
Skeletal maturity	213	D^{22}	154	A^{40}	E^{100}
Overall maturity	137	C^{99}	137	A^{60}	E^{100}
Marbling score	103	TR^{76}	78	PD^{00}	SM^{90}
Dairy bulls					
Lean maturity	26	C^{60}	141	A^{40}	E^{100}
Skeletal maturity	59	C^{19}	152	A^{20}	E^{100}
Overall maturity	26	C^{60}	129	A^{60}	E^{100}

Table 24. Continued

Marbling score	25	TR^{80}	84	PD^{00}	SM^{40}

Tables 25, 26, and 27 show the distribution of skeletal, lean, and overall maturity, respectively, for all cattle surveyed. Even though this was a survey of market cows and bulls, all sex classes and types of animals surveyed had at least one representative in the youngest skeletal maturity group (Table 25). It was sometimes the case that the processing facilities visited were market outlets for all cull animals, including young calves or realizer animals that could fall into the young maturity standards. Not surprisingly though, the largest frequency of categorization for cows and bulls was E skeletal maturity (Table 25). This is similar to the overall maturity frequencies outlined with the exception of dairy bulls, which saw the greatest frequency for C overall maturity (Table 27).

Table 25. National Beef Quality Audit (NBQA): Frequencies of skeletal maturity reported in carcasses surveyed

Skeletal maturity	All cattle (*n* = 4,272)	Beef cows (*n* = 1,734)	Dairy cows (*n* = 1,713)	Beef bulls (*n* = 213)	Dairy bulls (*n* = 59)
A	9.4	4.3	15.3	15.0	37.3
B	8.9	7.3	11.7	12.2	18.6
C	10.9	8.7	15.2	11.7	10.2
D	15.0	13.4	19.7	18.8	11.9
E	55.8	66.3	38.1	42.3	22.0

Table 26. National Beef Quality Audit (NBQA): Frequencies of lean maturity reported in carcasses surveyed

Lean maturity	All cattle (*n* = 2,420)	Beef cows (*n* = 1,109)	Dairy cows (*n* = 1,117)	Beef bulls (*n* = 137)	Dairy bulls (*n* = 26)
A	17.9	13.8	23.1	11.7	7.7
B	26.0	22.9	29.3	23.4	30.8
C	19.1	21.6	16.9	15.3	15.4
D	18.7	20.3	17.3	17.5	19.2
E	18.3	21.4	13.4	32.1	26.9

Table 27. National Beef Quality Audit (NBQA): Frequencies of overall maturity reported in carcasses surveyed

Overall maturity	All cattle (*n* = 2,420)	Beef cows (*n* = 1,109)	Dairy cows (*n* = 1,117)	Beef bulls (*n* = 137)	Dairy bulls (*n* = 26)
A	6.2	2.6	9.9	5.8	7.7
B	12.6	9.2	14.5	19.7	23.1
C	20.2	16.3	24.0	21.2	26.9
D	26.8	30.7	24.3	19.0	23.1
E	34.2	41.2	27.3	34.3	19.2

For a comparison over the past nine years, Figures 19 and 20 depict the marbling score distribution in beef cows and dairy cows, respectively, for 2016 alongside that reported in 2007. In the larger population of cows surveyed, all categories of marbling scores were reported. It appears that at 36.7%, beef cows had a higher frequency of Slight marbling in the current audit, shifting the distribution towards increased levels of intramuscular fat. Dairy cattle also had the highest frequency of Slight marbling versus either degrees above or below it, but the overall distribution across marbling scores is similarly represented in both audit years.

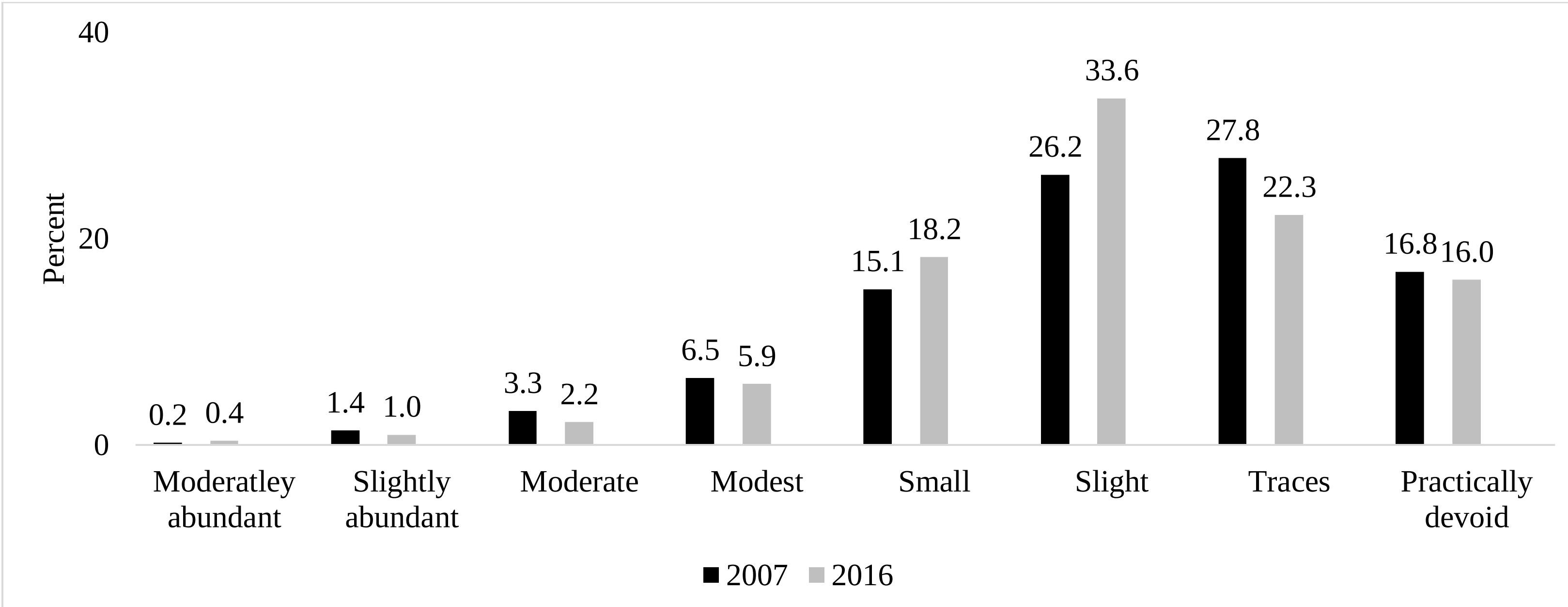

Figure 19. National Beef Quality Audit (NBQA): Marbling distribution for beef cows surveyed in 2007 and 2016. Total number of observations were National Market Cow and Bull Beef Quality Audit-2007 (*n* = 1,057) and NBQA-2016 (*n* = 905) (Nicholson, 2008).

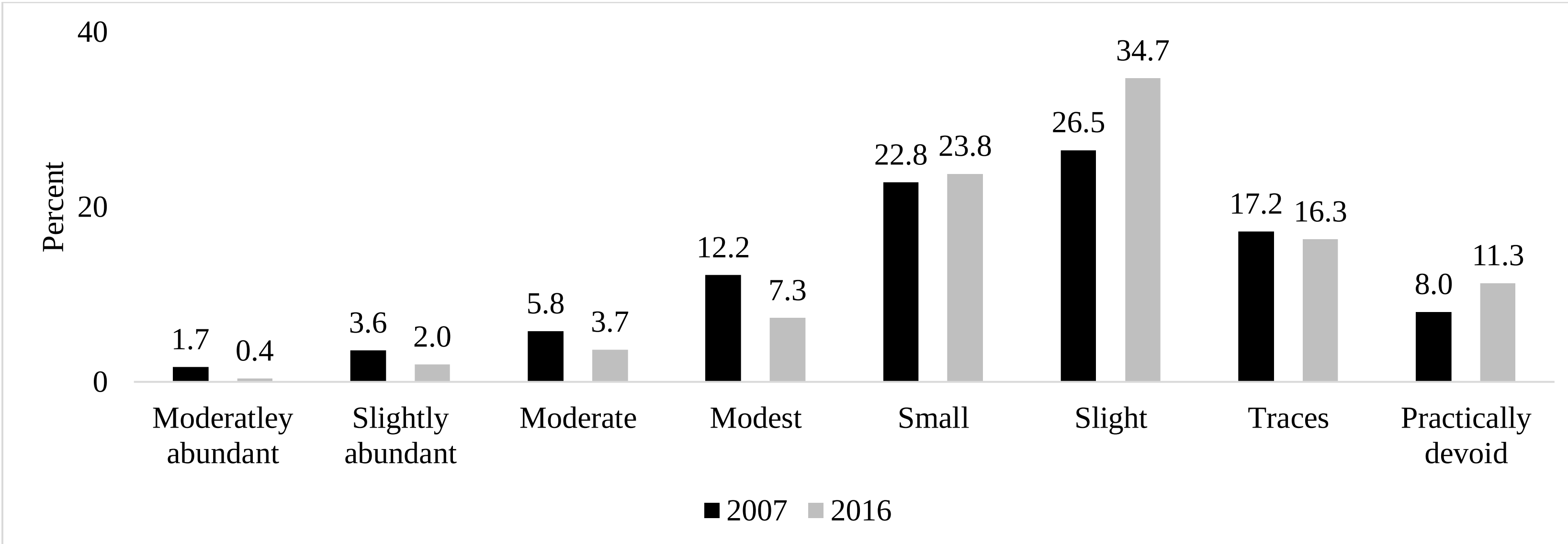

Figure 20. National Beef Quality Audit (NBQA): Marbling distribution for dairy cows in 2007 and 2016. Total number of observations were National Market Cow and Bull Beef Quality Audit-2007 (*n* = 538) and NBQA-2016 (*n* = 897) (Nicholson, 2008).

Figures 21 and 22 represent the marbling score distribution for beef bulls and dairy bulls. Mostly likely due to fewer numbers surveyed, bull carcass marbling scores only ranged from Practically Devoid to Small. In the current audit, nearly 12% more beef bulls achieved Slight marbling while about 10% fewer achieved Practically Devoid marbling. This is a substantial quality improvement over the past nine years. Even further, dairy bulls, although having fewer being assigned to the Moderate and Modest classification, saw an increased percentage identified to have Slight marbling versus Traces, a transition in frequency from 2007.

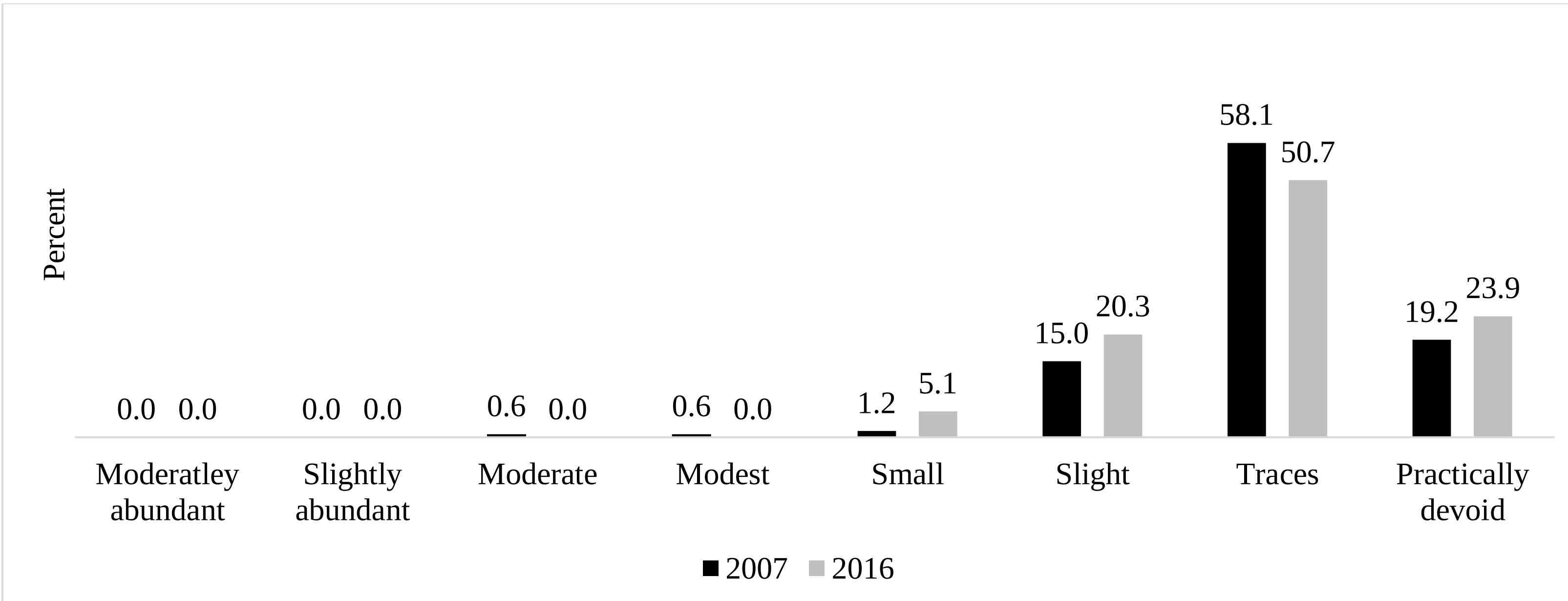

Figure 21. National Beef Quality Audit (NBQA): Marbling distribution for beef bulls in 2007 and 2016. Total number of observations were National Market Cow and Bull Beef Quality Audit-2007 (n = 168) and NBQA-2016 (n = 103) (Nicholson, 2008).

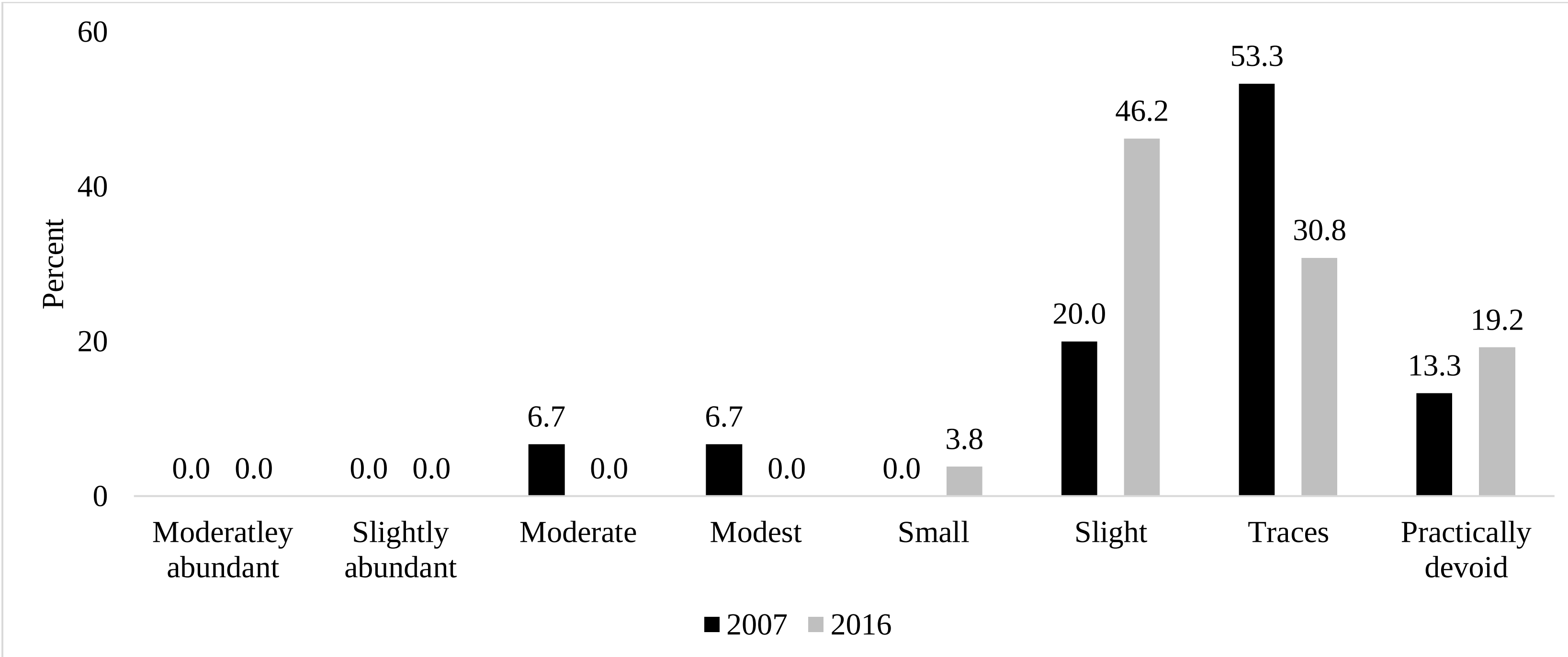

Figure 22. National Beef Quality Audit (NBQA): Marbling distribution for dairy bulls in 2007 and 2016. Total number of observations were National Market Cow and Bull Beef Quality Audit-2007 (n = 15) and NBQA-2016 (n = 25) (Nicholson, 2008).

Figures 23 and 24 show the quality grade distributions for beef cows and dairy cows, respectively, in 2016. The cows surveyed were represented by all U.S. quality grades because there were carcasses of young maturity and high marbling surveyed. Both beef and dairy cows had the highest incidence of Utility carcasses, followed by Cutter carcasses. The data reported in 2007 show similar trends as beef cows primarily graded as Utility or Cutter carcasses (Nicholson, 2008). Even so, a greater percentage of beef cows graded Utility (52.6% vs. 25.4%), and a lesser percentage (25.4% vs. 33.2%) of beef cow carcasses graded Cutter in 2016 compared to 2007.

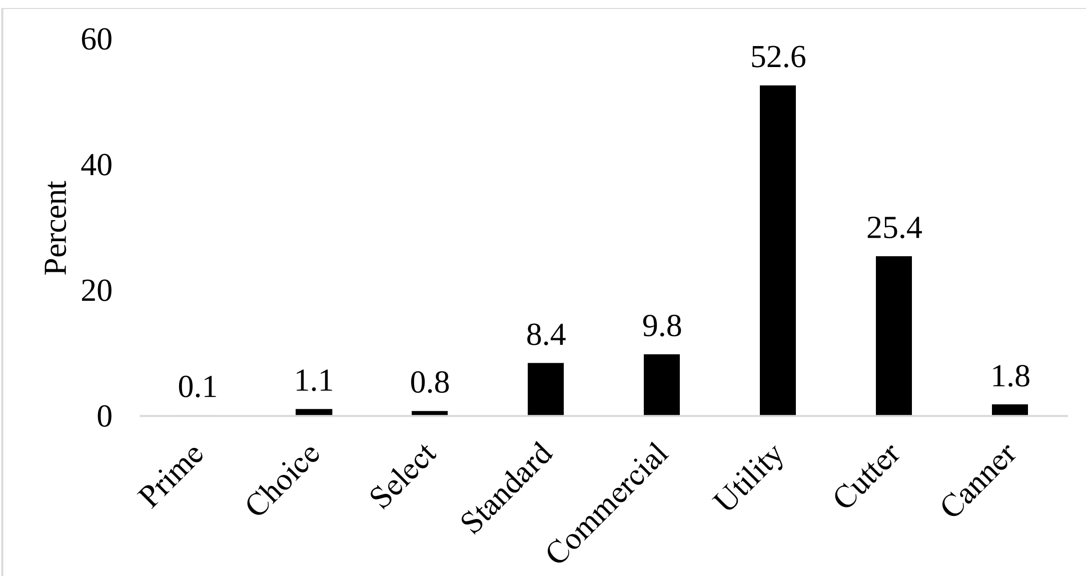

Figure 23. National Beef Quality Audit (NBQA): Distribution of USDA Quality Grades in beef cows. Total number of observations were *n* = 881.

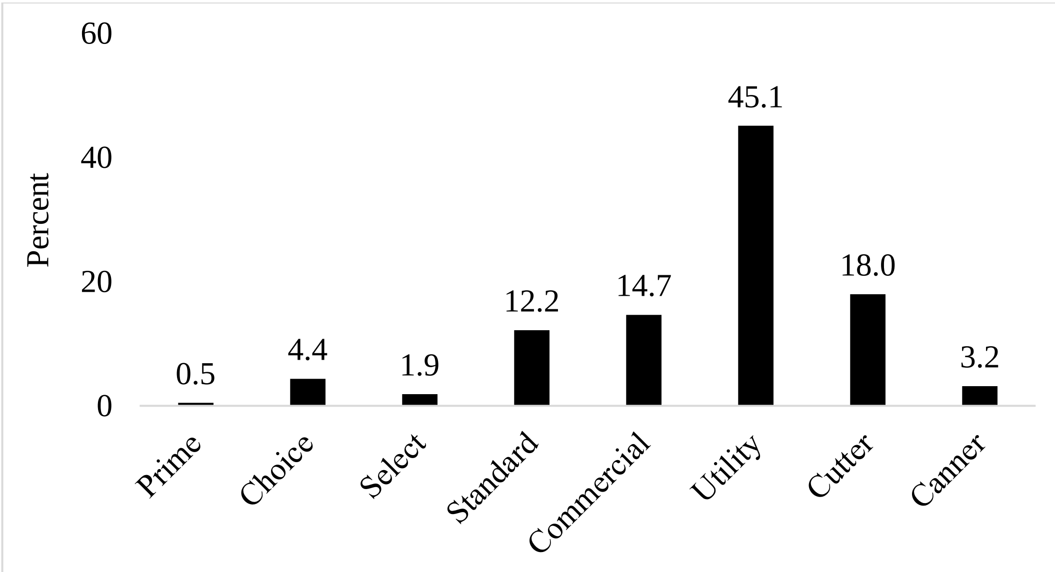

Figure 24. National Beef Quality Audit (NBQA): Distribution of USDA Quality Grades in dairy cows. Total number of observations were *n* = 883.

The mean values for all factors necessary for USDA yield grade determination are reported in Table 28. The preliminary yield grade (PYG) varied little amongst all sex classes and types of carcasses, however beef cows tended to be slightly fatter approaching 3.0 PYG. Bull carcasses tended to be heavier than cow carcasses. Likewise, bull carcasses had LM areas that tended to be larger than the cow carcasses surveyed. Cows finished at higher USDA yield grades when compared to bulls.

Table 28. National Beef Quality Audit (NBQA): Mean values for yield grade factors in surveyed cattle

Trait	*n*	Mean	Std. Dev.	Min	Max
All cattle					
Preliminary yield grade	3,744	2.5	0.63	1.2	6.5
Adjusted fat thickness, cm	3,747	0.6	0.62	0.0	4.6
HCW, kg	4,274	311.5	87.43	25.5	803.8
LM area, cm^2	2,471	65.4	17.22	19.35	123.84
KPH, %	1,399	1.7	1.26	0.0	7.5
USDA yield grade	1,224	2.9	0.95	0.0	7.4
Beef cows					
Preliminary yield grade	1,718	2.7	0.75	1.2	6.5
Adjusted fat thickness, cm	1,718	0.7	0.74	0.0	4.6
HCW, kg	1,728	311.1	86.83	25.5	585.0
LM area, cm^2	1,132	64.2	17.96	19.35	123.8
KPH, %	628	1.5	1.06	0.0	4.5
USDA yield grade	529	3.1	1.04	0.0	7.4
Dairy cows					
Preliminary yield grade	1,708	2.4	0.43	1.6	5.0
Adjusted fat thickness, cm	1,708	0.4	0.43	0.0	3.0
HCW, kg	1,714	303.2	74.00	90.5	549.1
LM area, cm^2	1,133	64.6	15.75	20.0	107.1

Table 28. Continued

KPH, %	696	1.8	1.40	0.0	7.5
USDA yield grade	633	2.8	0.84	0.2	5.8
Beef bulls					
Preliminary yield grade	208	2.3	0.50	1.6	5.5
Adjusted fat thickness, cm	208	0.4	0.49	0.0	3.6
HCW, kg	210	396.6	94.31	42.3	782.3
LM area, cm^2	141	78.8	16.03	28.38	114.2
KPH, %	33	1.1	0.79	0.0	3.0
USDA yield grade	28	2.4	0.98	0.9	4.8
Dairy bulls					
Preliminary yield grade	58	2.2	0.31	1.8	3.9
Adjusted fat thickness, cm	58	0.3	0.30	0.0	1.9
HCW, kg	59	373.0	101.68	155.5	665.0
LM area, cm^2	26	77.5	18.28	36.1	109.7
KPH, %	16	1.2	0.82	0.0	2.5
USDA yield grade	14	2.0	0.7	0.6	2.9

When comparing data across both the NMCBBQA-2007 (Nicholson, 2008) and NBQA-2016, LM area for beef bulls was numerically lower (78.8 cm^2 vs. 90.3 cm^2) in 2016 than in 2007. All other carcass classes reported similar LM areas amongst the two audits. Beef cows in 2007 had a mean carcass weight of 257.6 kg, numerically lower than that seen in 2016. Conversely, dairy bulls in 2007 (420.9 kg) were heavier than in 2016. A comparison of fat thickness can not be appropriately made because data were obtained on an adjusted fat thickness basis in 2007 versus a preliminary yield grade basis in 2016. Nonetheless, if the mathematical relationship ((PYG-2) × 0.4) between these two measures is used to compute adjusted fat thickness, the dairy cow carcasses surveyed in 2016 had numerically less fat (0.4 cm vs. 0.6 cm) than the carcasses in 2007. In contrast, the dairy bulls surveyed in 2016 had numerically more fat (0.3 in vs 0.2 cm) than those surveyed in 2007.

The distribution of preliminary yield grades for cattle surveyed are reported in Fig. 25 (beef cows) and 26 (dairy cows). Beef cows represented the lowest frequency of a preliminary yield grade of a low two, meaning they tended to have a thicker subcutaneous fat layer than other carcasses surveyed. Because unlike dairy cows, beef cows are not intensely selected for high milk yield, a phenotype that requires substantial nutritional energy inputs, they have increased opportunity to deposit exterior fat than dairy cattle are afforded, pending adequate nutrition is supplied.

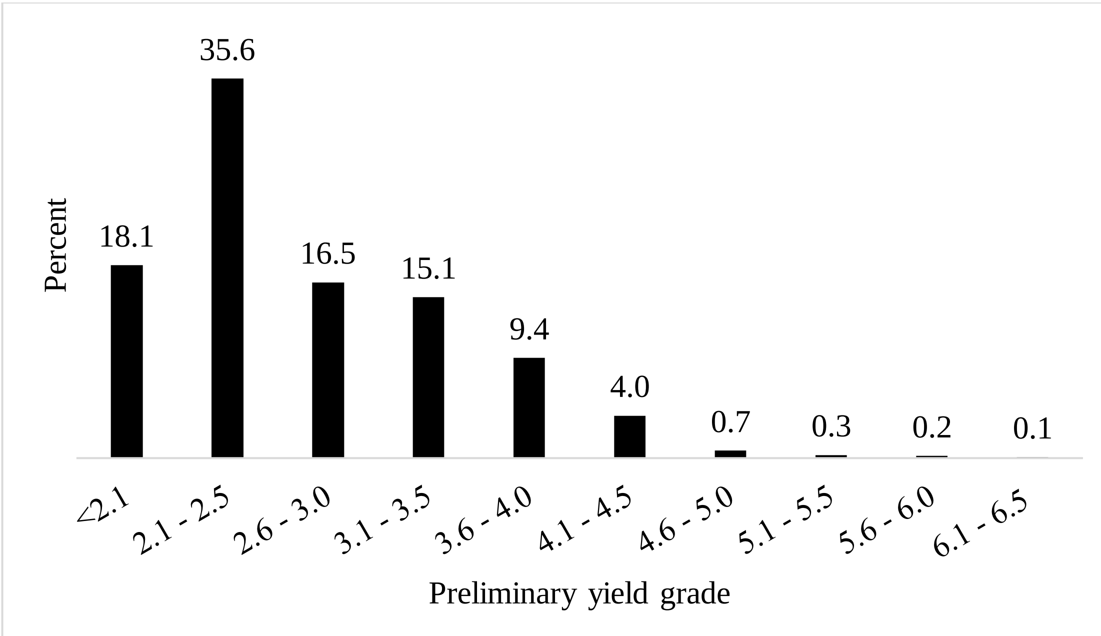

Figure 25. National Beef Quality Audit (NBQA): Distribution of PYG in beef cows. Total number of observations were *n* = 1,718.

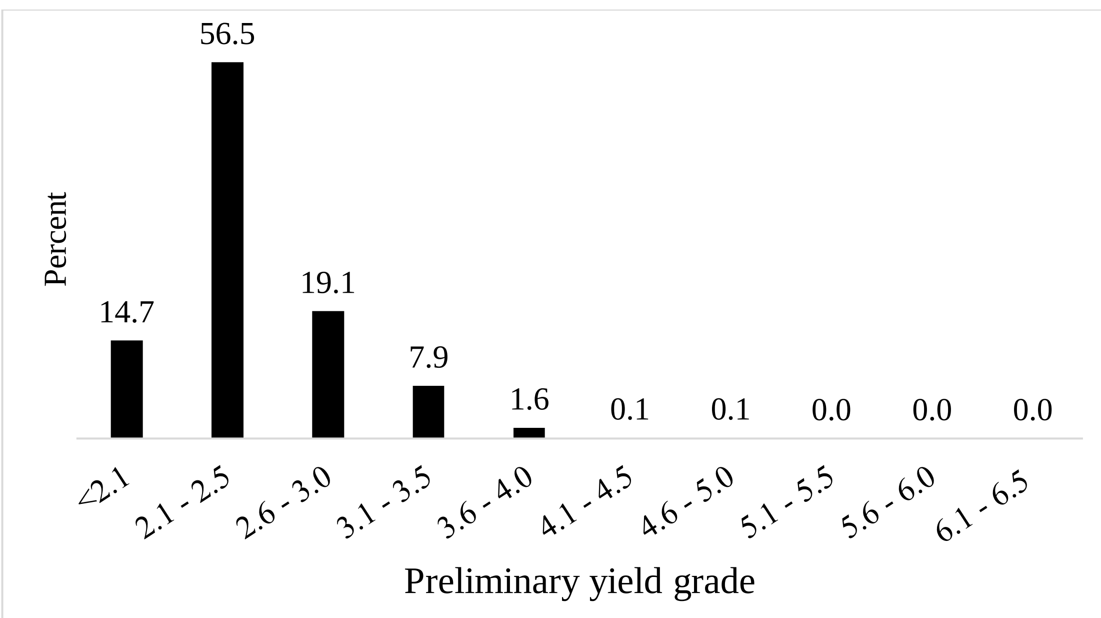

Figure 26. National Beef Quality Audit (NBQA): Distribution of PYG in dairy cows. Total number of observations were *n* = 1,705.

Figures 27 (beef bulls) and 28 (dairy bulls) report the distribution of PYG in the bull carcasses sampled. The distribution of PYGs for bull carcasses in this audit show bulls may be culled because they may be unable to maintain body condition.

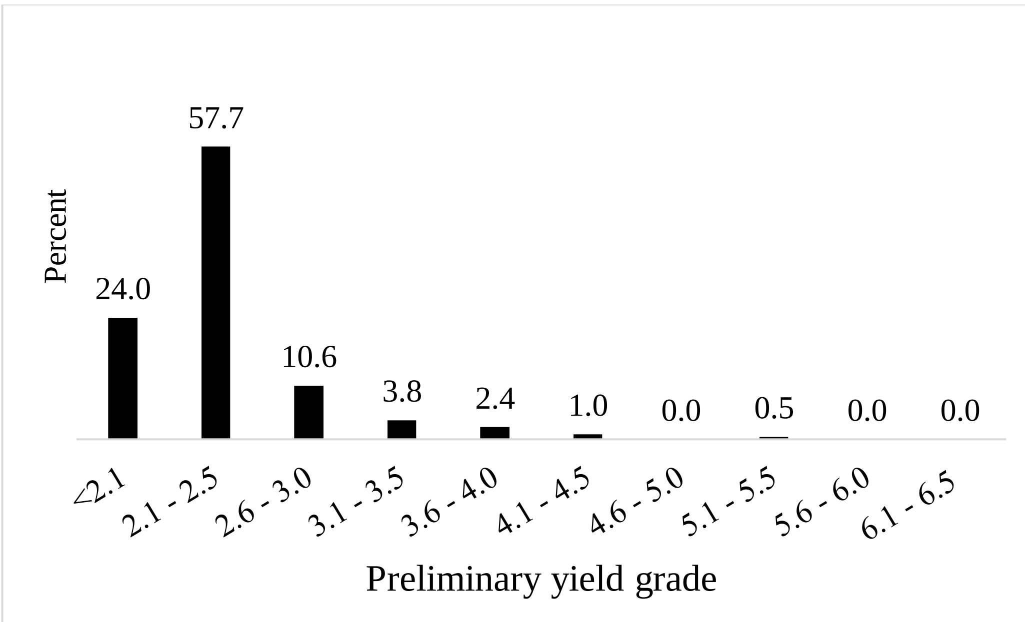

Figure 27. National Market Cow and Bull Beef Quality Audit (2016): Distribution of PYG in beef bulls. Total number of observations were n = 208.

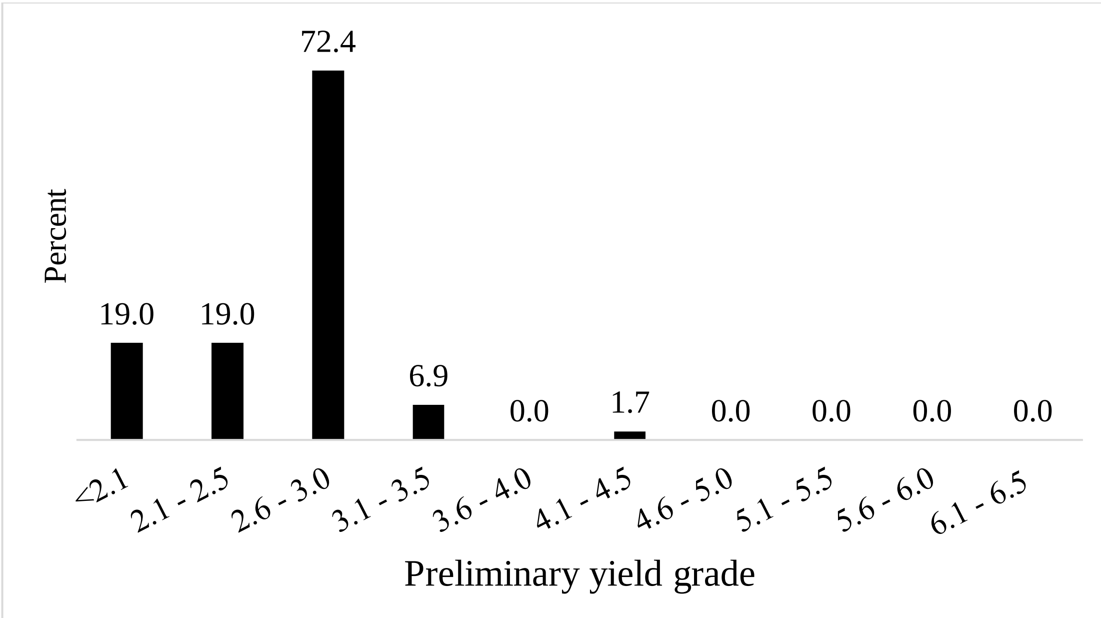

Figure 28. National Beef Quality Audit (NBQA): Distribution of PYG in dairy bulls. Total number of observations were *n* = 58.

In the NNFBQA-1994, researchers identified 26.4% of cows and 8.2% of bulls had fat thicknesses that were too high (Smith et al., 1994; Roeber et al., 2000). Criteria for this determination was a finish score of 4 to 9 on a 9-point scale (1 = no external fat; 9 = excessive external fat) (Smith et al., 1994; Roeber et al., 2000). A similar determination was made in the NMCBBQA-1999; 14.5% of cows and 6.9% of bulls were identified to have fat thicknesses too high (Roeber et al., 2000). Today, preliminary yield grade represents the amount of fat, rather than a Finish Score, so a direct comparison cannot be made. Even so, it may be that there is a greater concern for carcasses with too little fat rather than too much fat. Too little subcutaneous fat can lead to cold shortening, a process by which the sarcomeres within a muscle fiber shorten due to a rapid decrease in muscle temperature prior to the onset of rigor mortis (Aberle et al., 2012). In his review, Savell et al. (2005) stated cold shortening can be prevented with a subcutaneous fat depth of at least 0.62 cm at the 12th rib. Based on adjusted fat thickness reported above, only beef cow carcasses were determined to have an average adjusted back fat that exceeds this threshold. Therefore, all other types of carcass types may be more prone to experience cold shortening during the carcass chilling process.

Figure 29 depicts the representation of carcass weights observed in beef cows. Dairy cow carcass weights are represented in Fig. 30. In 2007, the highest frequency of dairy cow carcasses were between 272.2 kg and 317.1 kg body weight, similar to that seen in 2016 (Nicholson, 2008).

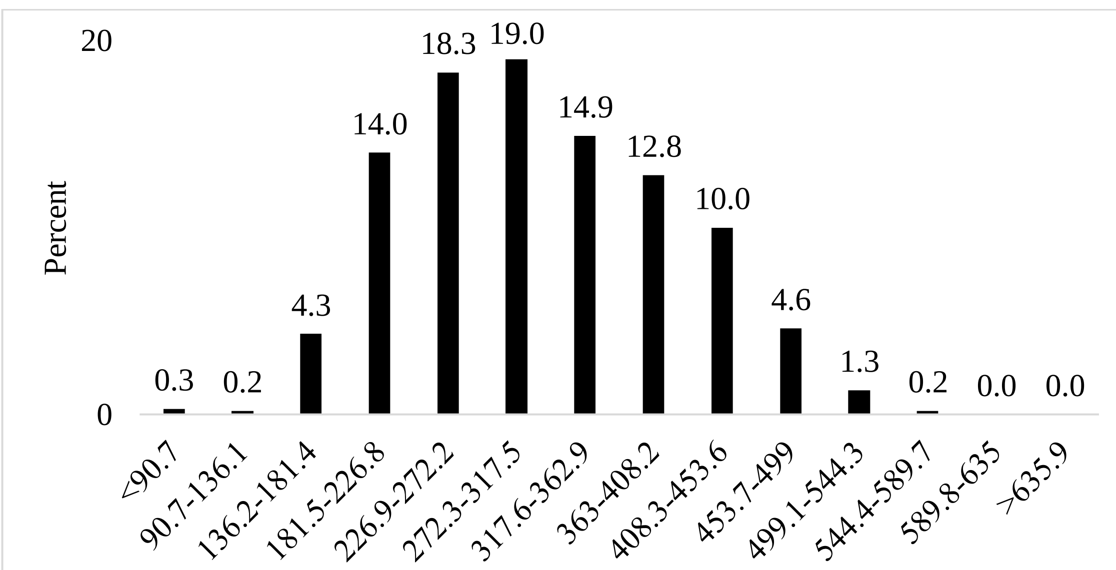

Figure 29. National Beef Quality Audit (NBQA): Distribution of carcass weight (kg) in beef cows. Total number of observations were *n* = 1,728.

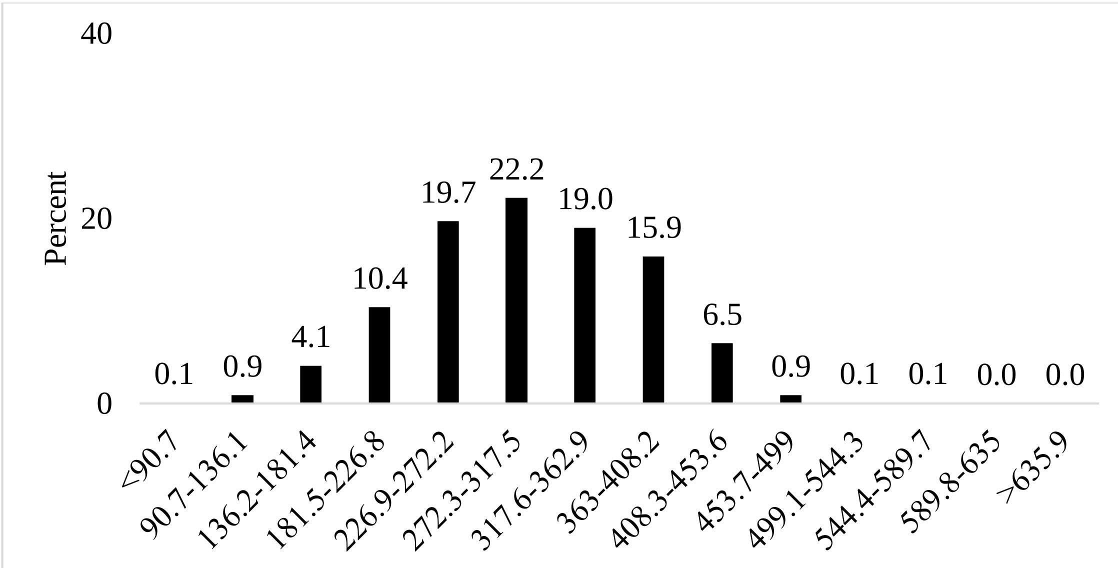

Figure 30. National Beef Quality Audit (NBQA): Distribution of carcass weight (kg) in dairy cows. Total number of observations were *n* = 1,714.

The carcass weight distribution for beef bull and dairy bull carcasses are reported in Fig. 31 and Fig. 32, respectively. Beef bull (Fig. 31) carcass weights had the highest frequency between 408.3 and 453.6 kg, which is what was observed in 2007 (Nicholson, 2008). In 2007, 18.5% of dairy bulls weighed between 362.9 kg and 407.8 kg as well as 499.0 kg and 543.9 kg, creating an uneven distribution of carcass weights observed (Fig. 32) (Nicholson, 2008).

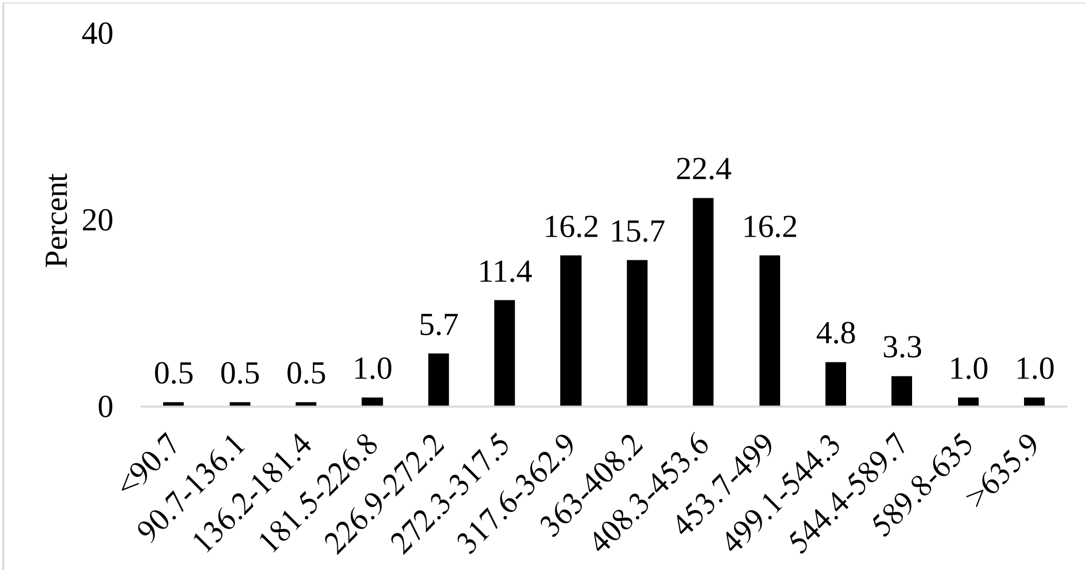

Figure 31. National Beef Quality Audit (NBQA): Distribution of carcass weight (kg) in beef bulls. Total number of observations were n = 210.

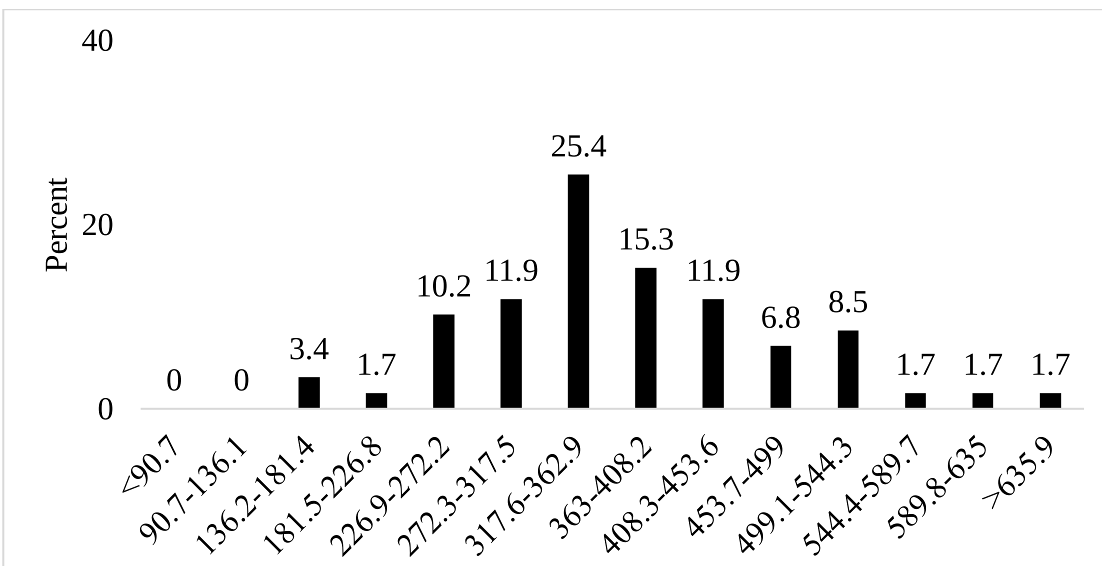

Figure 32. National Beef Quality Audit (NBQA): Distribution of carcass weight (kg) in dairy bulls. Total number of observations were n = 59.

It was determined that 14.4% of cows and no bulls had carcass weights that were too light (<181.4 kg) during the NNFBQA-1994 (Roeber et al., 2000). Five years later there was an increase in the percentage of both cows (16.5%) and bulls (0.7%) that were too light weight (<181.4 kg) (Roeber et al., 2000). This shows cattle with either too little fat or too little muscle were being marketed. It does not seem sufficient to evaluate muscle of cows and bulls without accounting for breed (beef vs. dairy) class. Therefore, sufficient data from 2007 allowed for the distinction between "too light" weight dairy animals and "too light" weight beef animals. In the NMCBBQA-2007, 4.8%, 5.1%, 1.5%, and 3.4% of beef cow carcasses, dairy cow carcasses, beef bull carcasses, and dairy bull carcasses, respectively, were considered "too light" weight (<181.4 kg) (Nicholson, 2008). A comparison of cattle that are too light weight in the NBQA–2016 is made in Fig. 33. A lower percentage of beef cow carcasses, but a greater percentage of dairy cow carcasses, beef bull carcasses, and dairy bull carcasses were "too light" weight in the current audit year when compared to past audits.

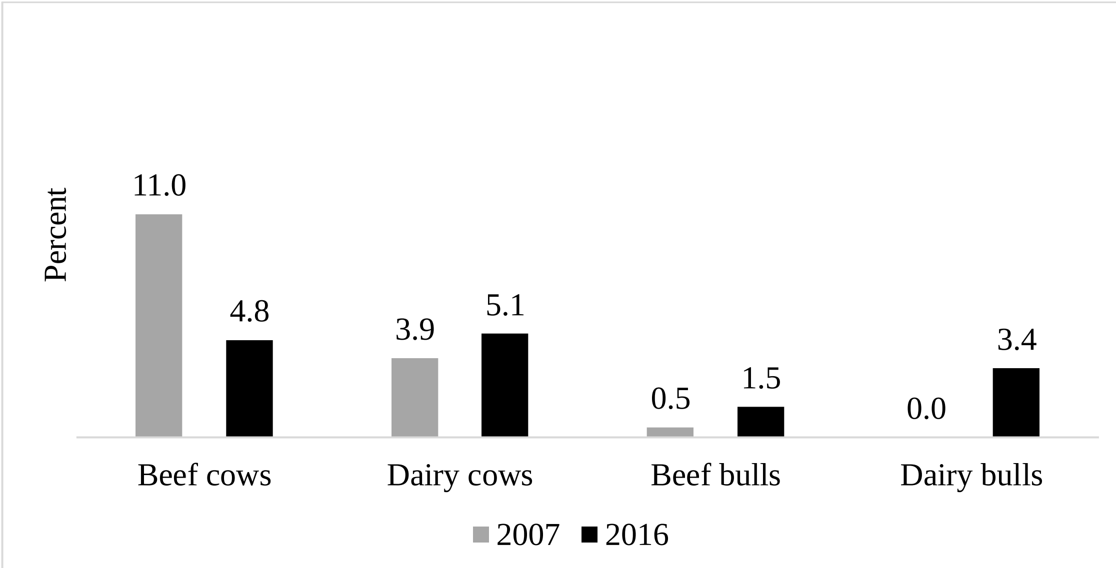

Figure 33. National Beef Quality Audit (NBQA): A comparison of cattle determined to have carcass weights that are too light (<181.4 kg) between the 2007 and 2016 Market Cow and Bull Beef Quality Audits. Total number of observations were National Market Cow and Bull Beef Quality Audit-2007: beef cows (*n* = 1,315), dairy cows (*n* = 1,320), beef bulls (*n* = 245), dairy bulls (*n* = 95); NBQA-2016: beef cows (*n* = 1,728), dairy cows (*n* = 1,714), beef bulls (*n* = 210), dairy bulls (*n* = 59) (Nicholson, 2008).

Just as carcasses were said to be "too light" weight, researchers in the NNFBQA-1994 determined carcasses were also too heavy; 1.7% of cow carcasses and 54.1% of bull carcasses (>407.8 kg) (Roeber et al., 2000). In the NMCBBQA-1999, 1.6% of cow carcasses and 42.5% of bull carcasses were too heavy (>407.8 kg) (Roeber et al., 2000). In the NMCBBQA-2007, 17.6%, 7.7%, 48.2%, and 32.2% of beef cow carcasses, dairy cow carcasses, beef bull carcasses, and dairy bull carcasses, respectively, were too heavy (>407.8 kg) (Nicholson, 2008). Figure 34 shows a comparison of carcasses that were too heavy in the current audit versus those in the previous NBQA- 2007. It is a positive trend being seen that an increased percentage of cow carcasses tended to be too heavy. At the same time, a decreased percentage of bull carcasses tended to be too heavy. In today's beef industry, a threshold of 407.8 kg may be too conservative (Moore et al., 2012). If the threshold is pushed to define carcasses to be too heavy over 453.6 kg, 7.5%, 1.1%, 24.9%, and 20.4% of beef cow carcasses, dairy cow carcasses, beef bull carcasses, and dairy bull carcasses, respectively, in the current audit would be considered too heavy.

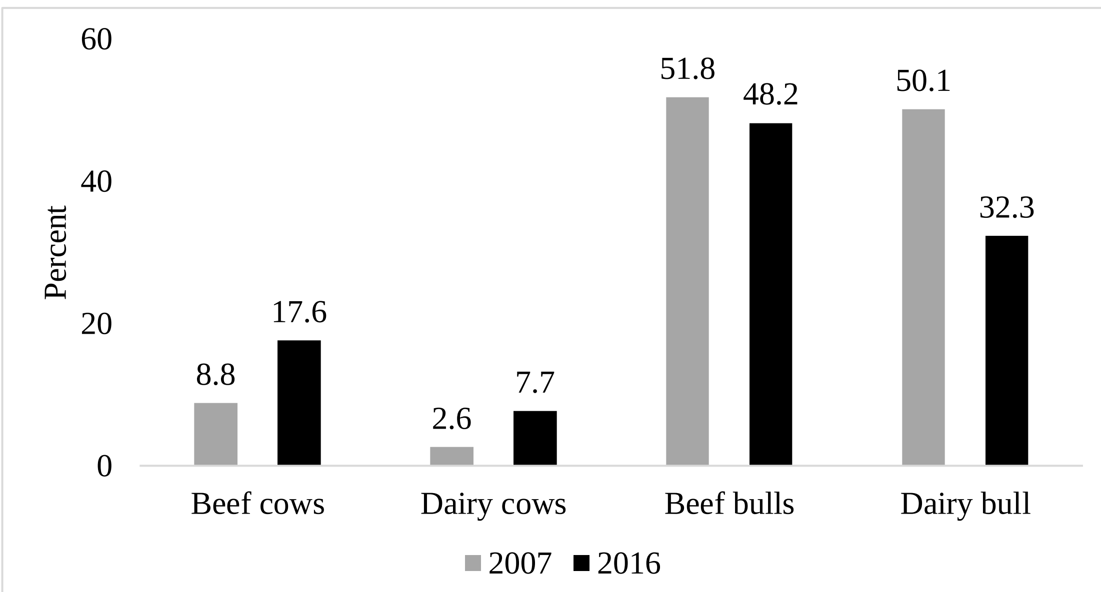

Figure 34. National Beef Quality Audit (NBQA): A comparison of cattle determined to have carcass weights that are too heavy (>407.8 kg) in 2007 and 2016. Total number of observations were National Market Cow and Bull Beef Quality Audit-2007: beef cows (*n* = 1,315), dairy cows (*n* = 1,320), beef bulls (*n* = 245), dairy bulls (*n* = 95); NBQA-2016: beef cows (*n* = 1,728), dairy cows (*n* = 1,714), beef bulls (*n* = 210), dairy bulls (*n* = 59) (Nicholson, 2008).

Figures 35 and 36 show the LM areas observed in cow carcasses throughout the current audit. There were a fewer percentage (3.0% vs. 6.8%) of beef cow carcasses with LM areas less than 32.0 cm^2 than what was observed in 2007 (Nicholson, 2008). The opposite is true for dairy cows as 1.9% had LM area less than 32.0 cm^2 compared to only 0.6% in 2007 (Nicholson, 2008).

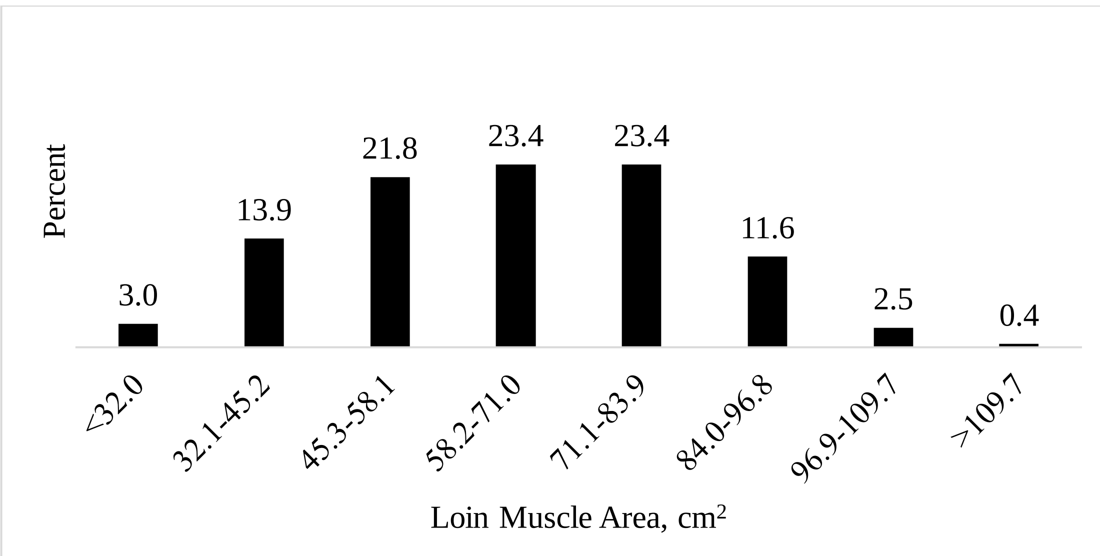

Figure 35. National Beef Quality Audit (NBQA): Distribution of LM area (cm^2) in beef cows.

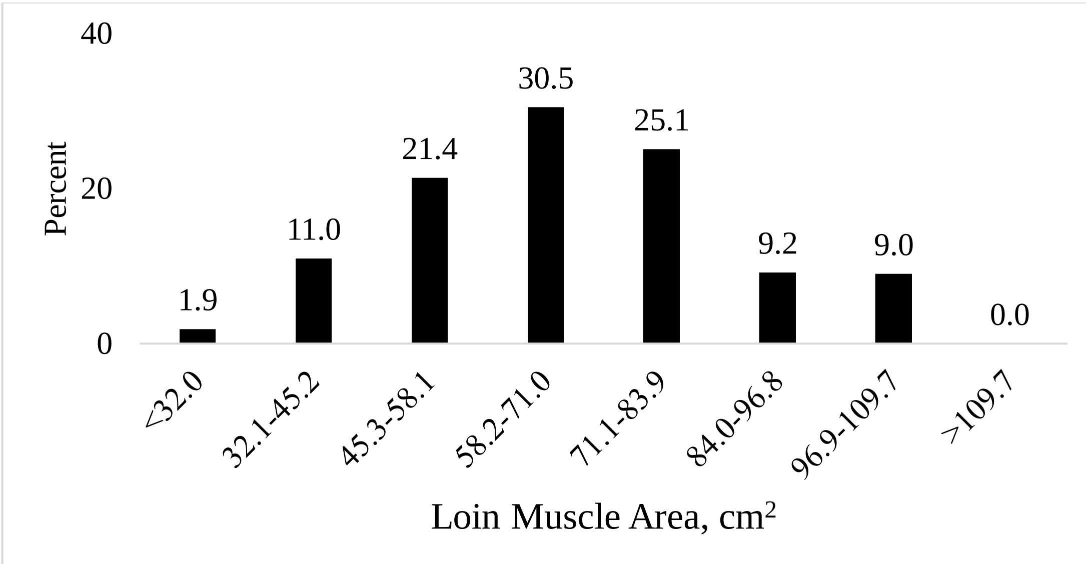

Figure 36. National Beef Quality Audit (NBQA): Distribution of LM area (cm^2) in dairy cows.

Figures 37 and 38 show the frequency distribution of LM areas in bull carcasses surveyed. A greater percentage of beef bull carcasses had LM areas less than 32.0 cm^2, while at the same time beef bull carcasses with LM areas over 109 cm^2 were less frequently observed in the current audit than they were in the previous audit.

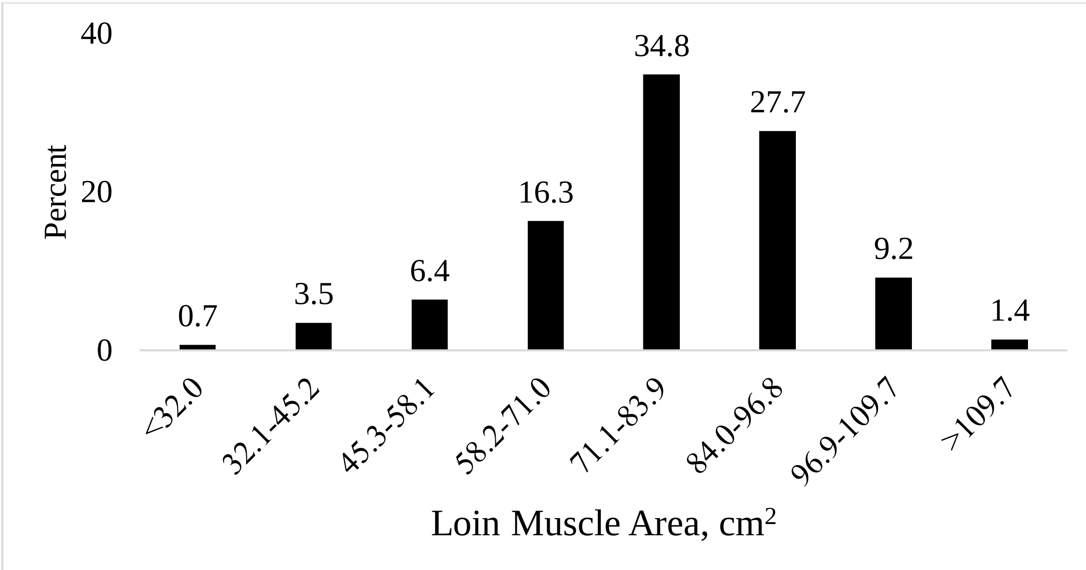

Figure 37. National Beef Quality Audit (NBQA): Distribution of LM area (cm^2) in beef bulls.

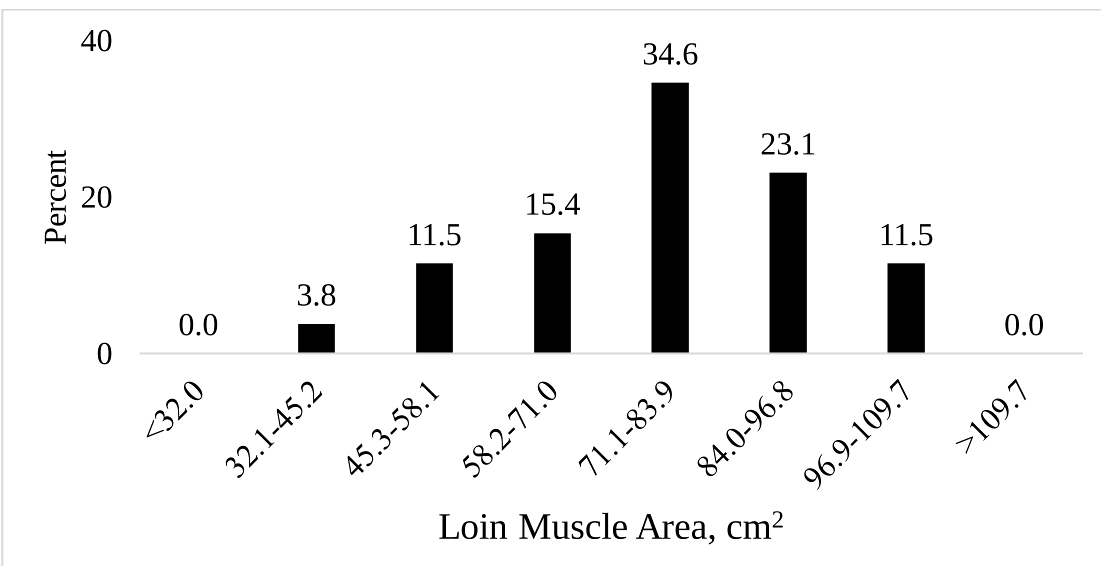

Figure 38. National Beef Quality Audit (NBQA): Distribution of LM area (cm^2) in dairy bulls.

In 1994, 31.1% of cow carcasses and 1.7% of bull carcasses were identified to have LM areas that were too small (<51.6 cm^2) (Roeber et al., 2000). Conversely, 0.5% of cow carcasses and 39.9% of bull carcasses were identified to have LM areas that were too large (>103.2 cm^2) (Roeber et al., 2000). In 1999, congruent information was not provided, however the mean LM area for cow carcasses was 11.96 cm^2 (Roeber et al., 2000). Carcass size has evolved with the industry becoming larger, particularly for the steer and heifer sector (Moore et al., 2012). While cows and bulls can not be equally compared to their steer and heifer counterparts, determination of LM areas that are too small and too large is very subjective to what the rib and loin's end-use will be and who is determining the desirability of size. Therefore, no distinction between "too small" and "too large" LM areas will be provided.

A comparison of final yield grade for cow carcasses for the current and previous audit year is made in Fig. 39 and 40. Since the NBQA-2007 (Nicholson, 2008), there was an upward shift to higher USDA yield grades in beef cows. A slightly higher percentage of dairy cows graded as USDA yield grade 3 in 2016 than in 2007 (Nicholson, 2008).

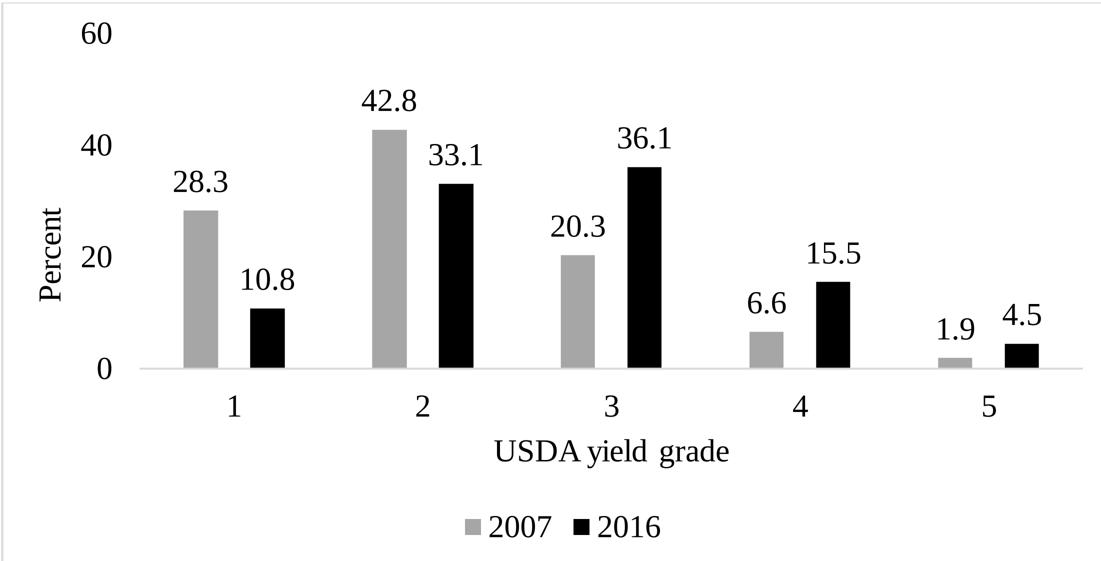

Figure 39. National Beef Quality Audit (NBQA): Distribution of USDA yield grades in beef cows in 2007 and 2016. Total number of observations were National Market Cow and Bull Beef Quality Audit-2007 (*n* = 1,057) and NBQA-2016 (*n* = 529) (Nicholson, 2008).

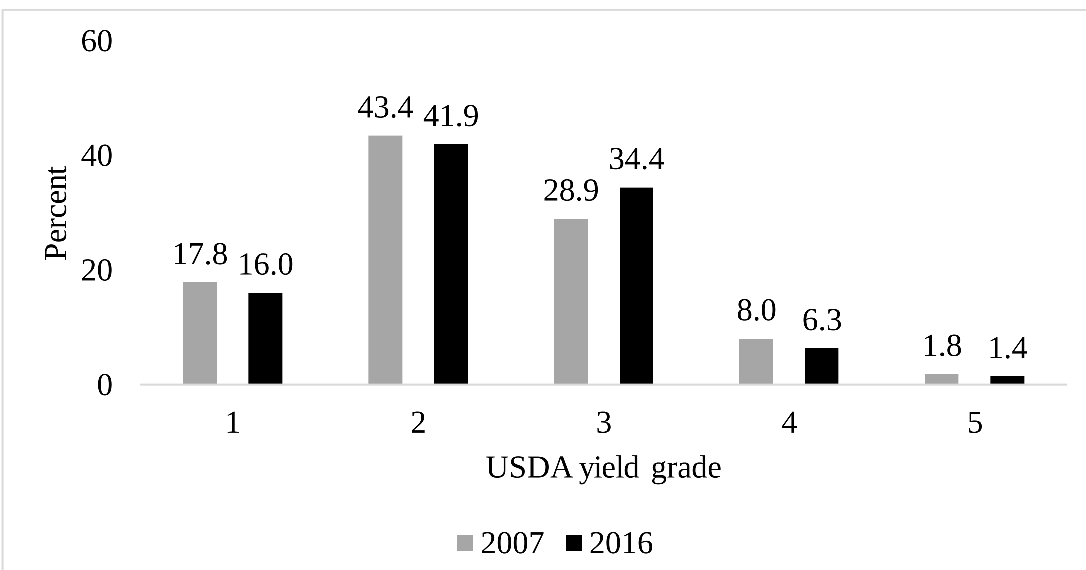

Figure 40. National Beef Quality Audit (NBQA): Distribution of USDA yield grades in dairy cows in 2007 and 2016. Total number of observations were National Market Cow and Bull Beef Quality Audit-2007 (*n* = 538) and NBQA-2016 (*n* = 633) (Nicholson, 2008).

Similarly, a comparison of USDA yield grade for bull carcasses surveyed is provided in Fig. 41 and 42. The same upward shift as seen in beef cow carcasses occurred in beef bull carcasses, however it was a shift from USDA yield grade 1 to 2 rather than 2 to 3 like that seen in beef cows.

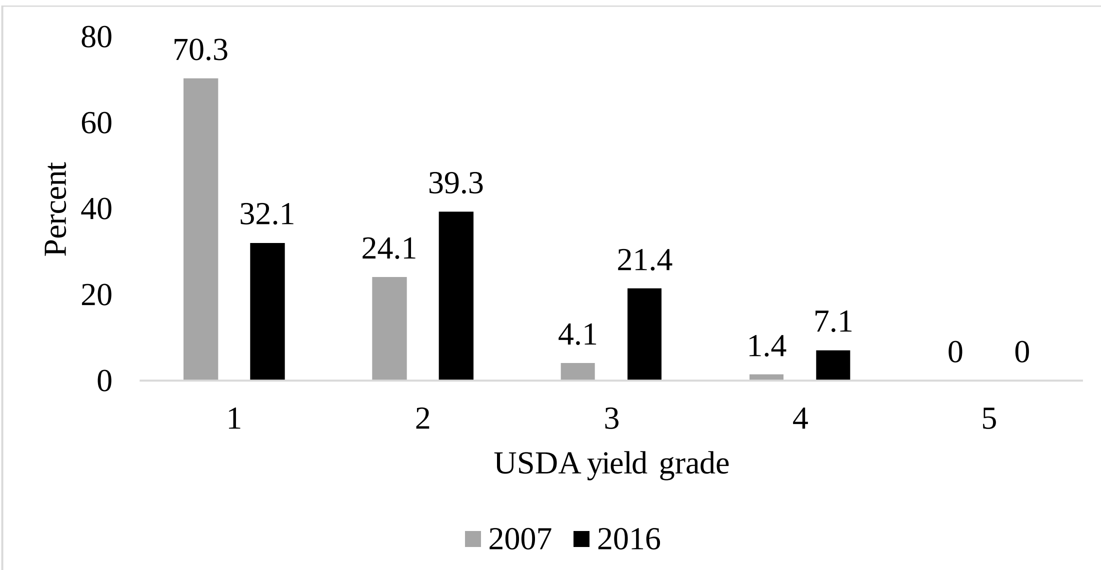

Figure 41. National Beef Quality Audit (NBQA): Distribution of USDA yield grades in beef bulls in 2007 and 2016. Total number of observations were National Market Cow and Bull Beef Quality Audit-2007 (*n* = 168) and NBQA-2016 (*n* = 18) (Nicholson, 2008).

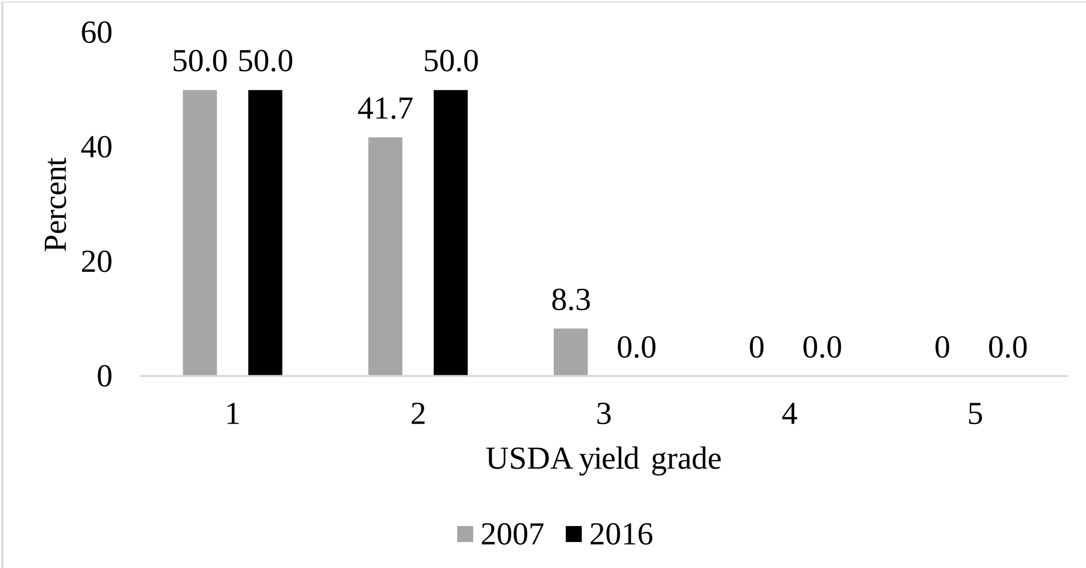

Figure 42. National Beef Quality Audit (NBQA): Distribution of USDA yield grades in dairy bulls in 2007 and 2016. Total number of observations were National Market Cow and Bull Beef Quality Audit-2007 (*n* = 15) and NBQA-2016 (*n* = 14) (Nicholson, 2008).

It is important to note that a higher final yield grade could be in part due to two scenarios:

1) A carcass is covered in increased thickness of subcutaneous fat. This outcome may be more favorable for combatting the quality concern of cows being marketed that are too thin. Figure 43 offers a comparison of back fat thickness from the NMCBBQA-2007 and NBQA-2016. There was an increased percentage of cattle with less than 0.25 cm of back fat, a decreased percentage of cattle with back fat from 0.25 cm to 0.99 cm, and an increased percentage of cattle with back fat equaling 1.27 cm to 2.01 cm. There was no overwhelming trend indicating cattle are becoming fatter than those observed in 2007.

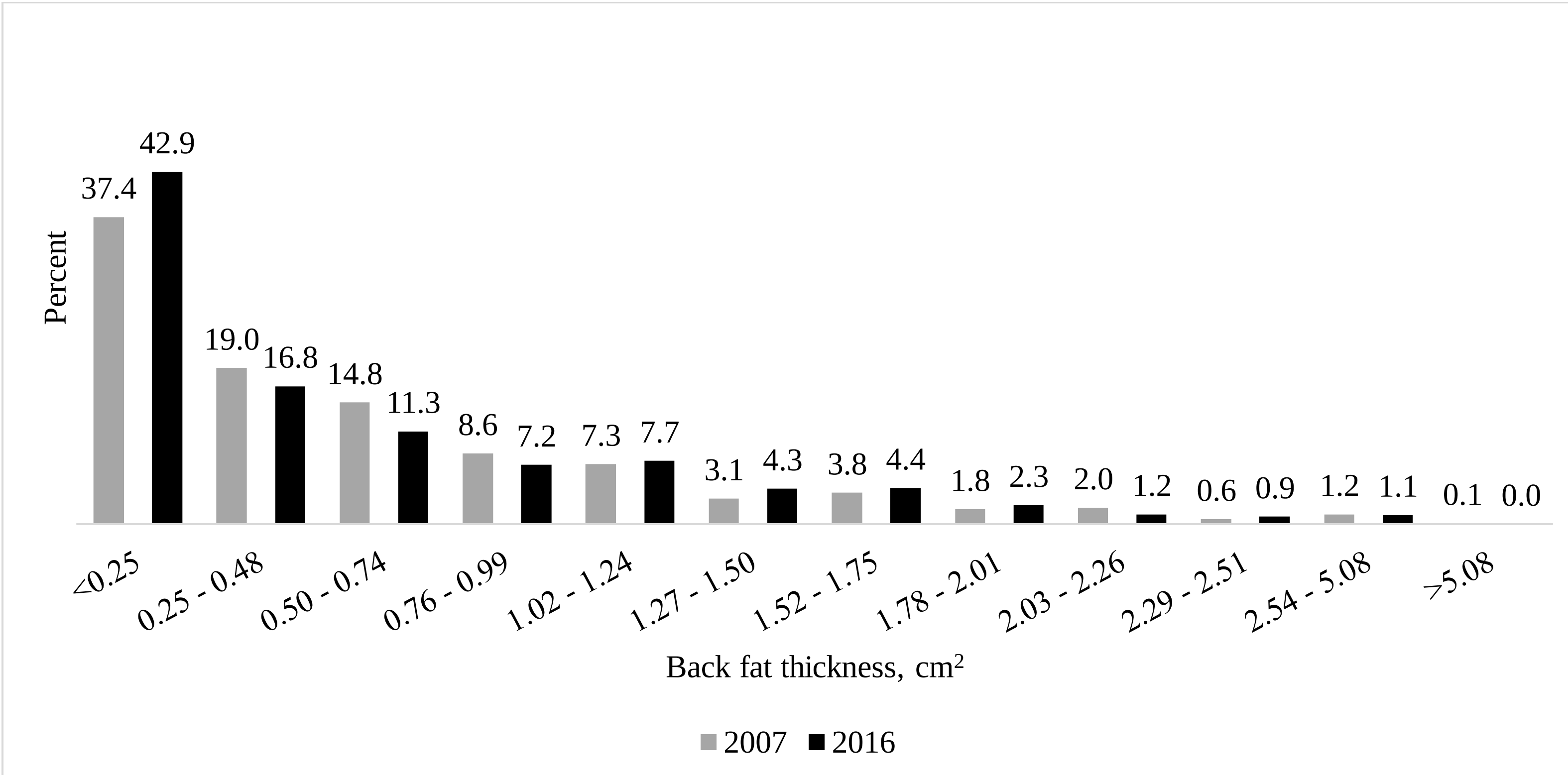

Figure 43. National Beef Quality Audit (NBQA): Comparison of back fat thickness (cm^2) in all cattle surveyed in 2007 and 2016. Total number of observations were National Market Cow and Bull Beef Quality Audit-2007 (n = 1,801) and NBQA-2016 (n = 3,747) (Nicholson, 2008).

2) A carcass is lighter muscled with a smaller LM area contributing to the calculation of the increased yield grade. This scenario is less favorable as carcasses complying with this are often considered “too light” muscled. In the NMCBBQA-1999, Roeber et al. (2000) reported 88.9% of all cow carcasses and 18.9% of bull carcasses garnered “too low” of a muscle score. If the same criteria were used to determine the percentage of cows and bulls that have too low of a muscle score, 55.0%, 89.3%, 31.9%, and 46.5% of beef cow carcasses, dairy cow carcasses, beef bull carcasses, and dairy bull carcasses, respectively, in the current audit would be too light muscled. This can not directly indicate the increase in USDA yield grades is due to decreased muscle in the cattle population surveyed, but it does allow for evidence that muscle may play a role. Nonetheless, the story of a shift to a higher final yield grade for cow carcasses is two-fold and must be understood through multiple scenarios.

The mean fat color score for beef cows and dairy cows was 3.2 and 2.3, respectively. The mean fat color score for beef and dairy bulls was 2.4 and 2.1, respectively. Figures 44 and 45 report the distribution of fat color scores observed in cow carcasses surveyed.

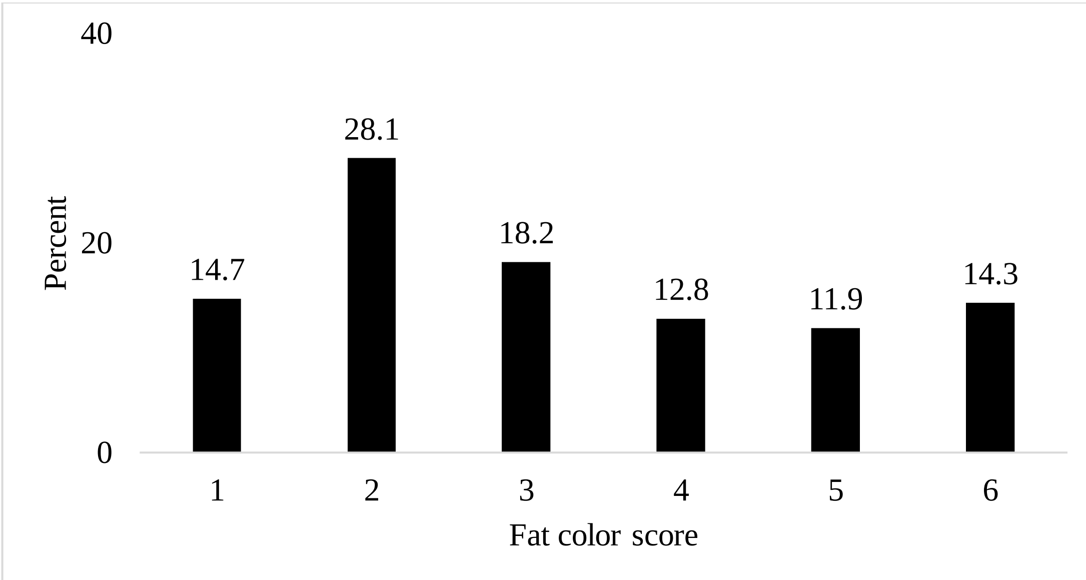

Figure 44. National Beef Quality Audit (NBQA): Distribution of fat color score in beef cows. Total number of observations were (*n* = 1,675). Fat color was scored on a 6-point scale - 1 = whitest fat; 6 = yellowest fat (Nicholson, 2008).

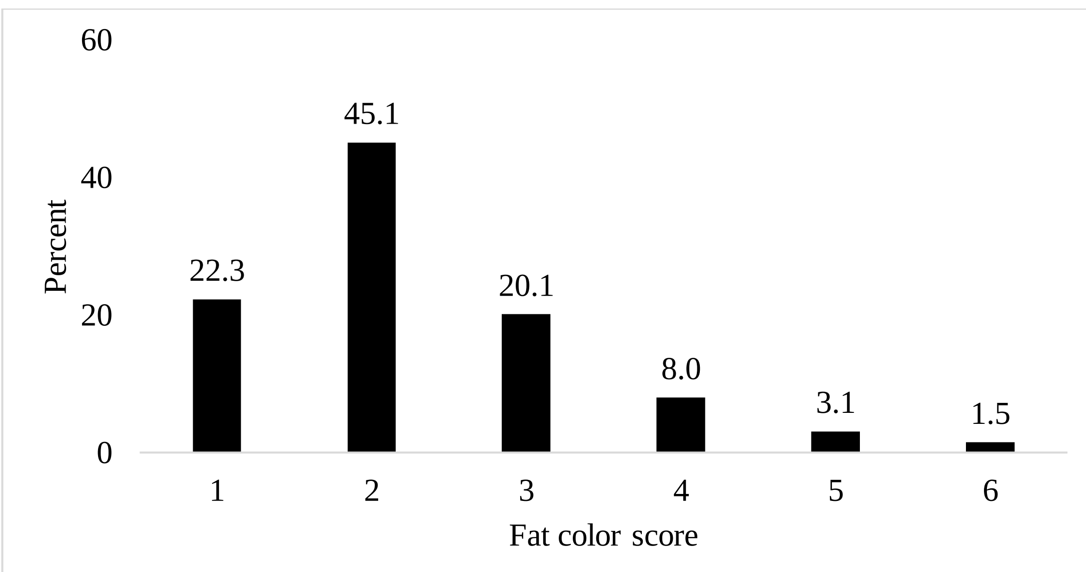

Figure 45. National Beef Quality Audit (NBQA): Distribution of fat color score in dairy cows. Total number of observations were (*n* = 1,684). Fat color was scored on a 6-point scale - 1 = whitest fat; 6 = yellowest fat (Nicholson, 2008).

Figures 46 and 47 report the distribution of fat color scores assigned to surveyed beef bulls and dairy bulls, respectively. All carcasses showcased some level of yellow fat (color score 2) at the highest frequency. Beyond dairy bulls, all other carcasses sampled encompassed all six fat color scores. Beef carcasses tended to have a higher frequency of yellower fat being more evenly distributed over the higher scores. This would support the trend of beef cows and bulls being more often managed in range conditions rather than being fed grain-based diets like that utilized more regularly in the dairy industry.

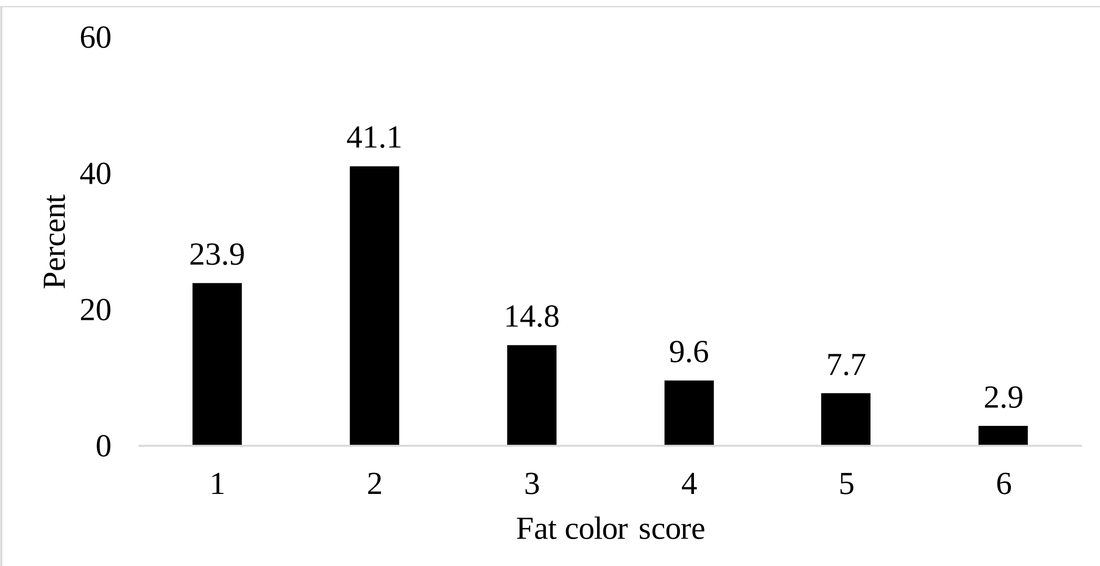

Figure 46. National Beef Quality Audit (NBQA): Distribution of fat color scores in beef bulls. Total number of observations were (*n* = 209). Fat color was scored on a 6-point scale - 1 = whitest fat; 6 = yellowest fat (Nicholson, 2008).

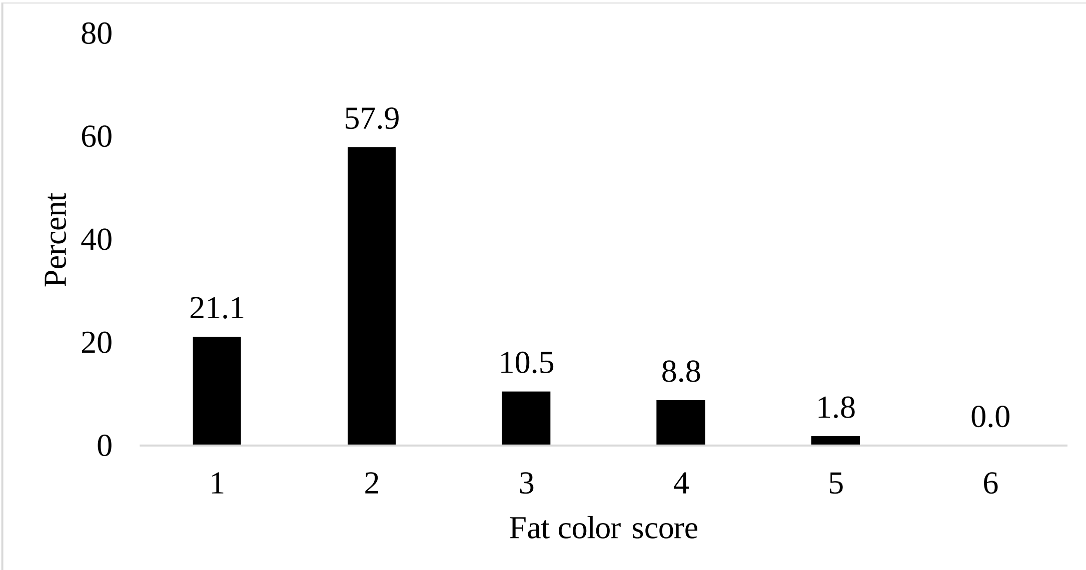

Figure 47. National Beef Quality Audit (NBQA): Distribution of fat color scores in dairy bulls. Total number of observations were (*n* = 57). Fat color was scored on a 6-point scale - 1 = whitest fat; 6 = yellowest fat (Nicholson, 2008).

The distribution of muscles scores for beef and dairy cow carcasses is reported in Fig. 48. Beef cow carcasses were more evenly distributed over all muscle scores. The mean muscle score for beef cows was 2.4, a numerically higher value than the mean muscle score for dairy cows (1.8).

The distribution of muscle scores for beef and dairy bulls is shown in Fig. 49. Just as with cows, dairy bulls have a higher frequency of lower muscle scores than beef bulls. The average muscle score for dairy bulls was 2.7 versus 3.0 for beef bulls.

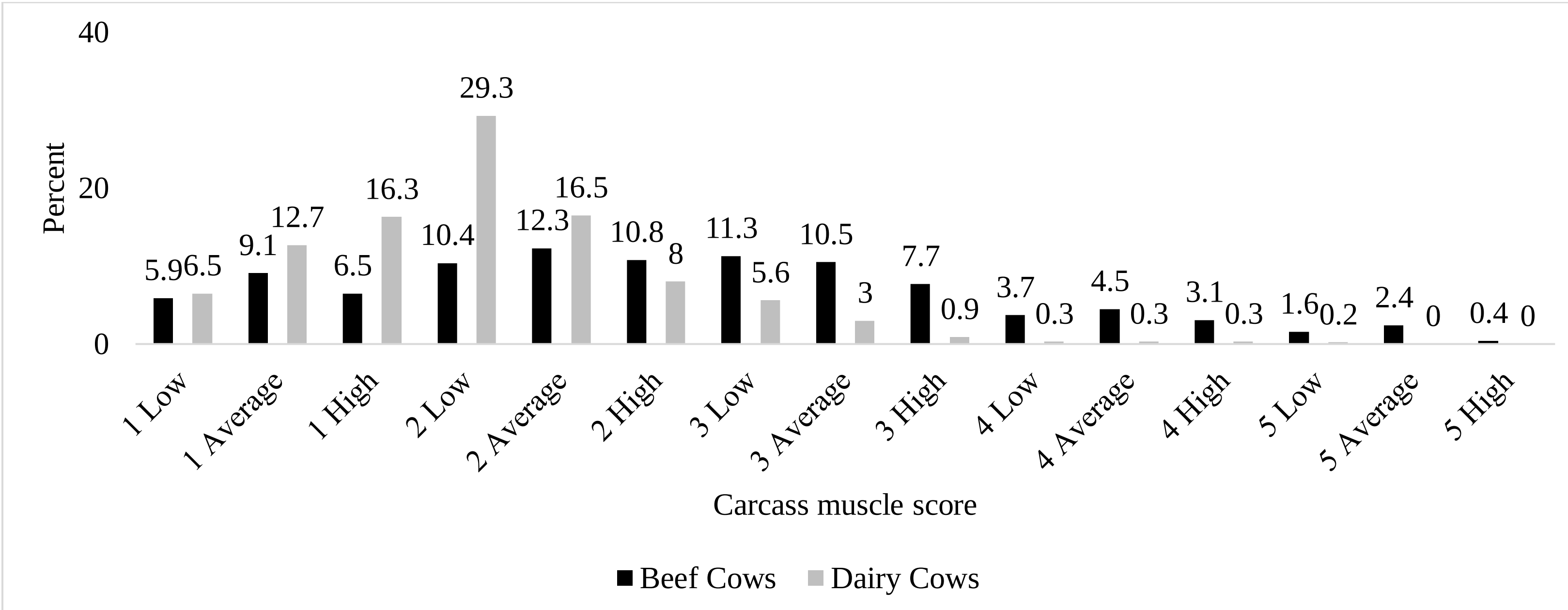

Figure 48. National Beef Quality Audit (NBQA): Distribution of muscle scores in beef and dairy cows. Total number of observations were National Market Cow and Bull Beef Quality Audit-2007 (*n* = 1,689) and NBQA-2016 (*n* = 1,688) (Nicholson, 2008). Muscle scores were assigned on a 5-point scale and each whole number category was further divided into low, average and high – 1 = light muscled; 5 = heavy muscled

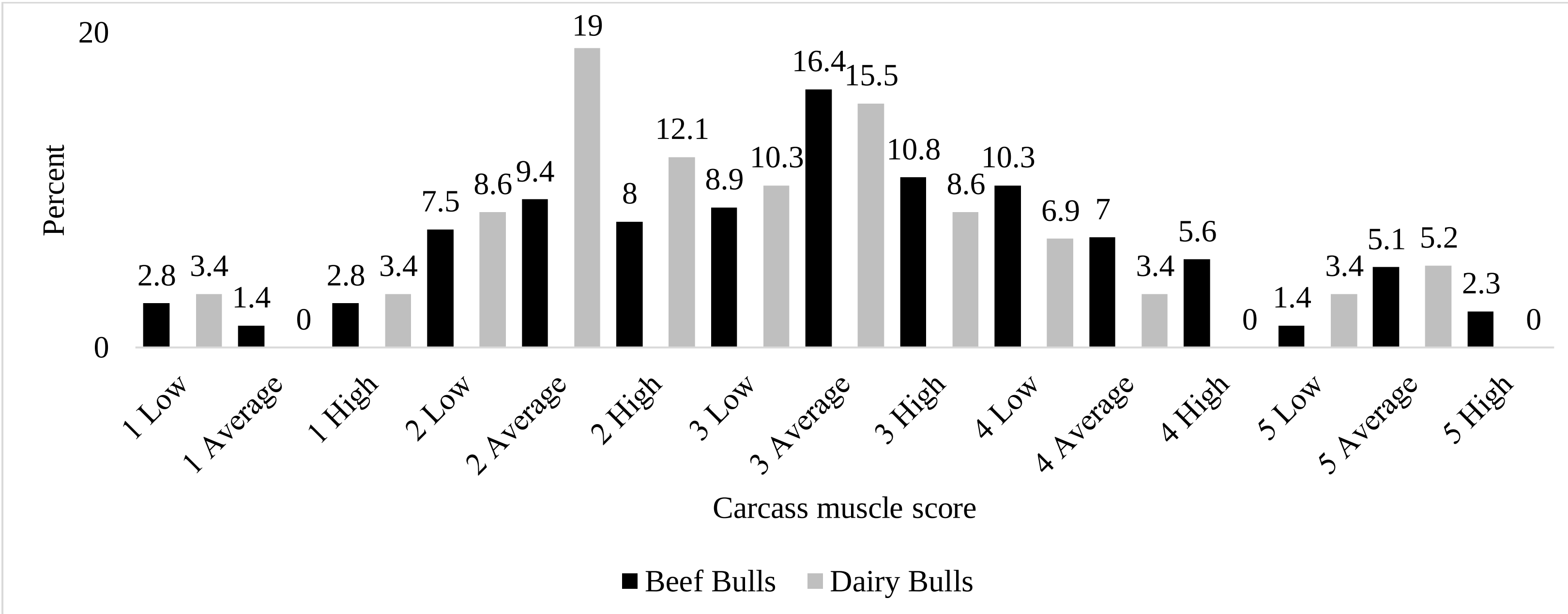

Figure 49. National Beef Quality Audit (NBQA): Distribution of muscles scores for beef and dairy bulls. Total number of observations were National Market Cow and Bull Beef Quality Audit-2007 (*n* = 213) and NBQA-2016 (*n* = 58) (Nicholson, 2008). Muscle scores were assigned on a 5-point scale and each whole number category was further divided into low, average and high – 1 = light muscled; 5 = heavy muscled.

The comparison of muscle score frequencies between the NMCBBQA-2007 and the NBQA-2016 is shown in Table 29. There was a shift toward increased muscle scores in beef cows and dairy cows. Most notably, dairy cows in 2007 were more frequently reported in the lightest muscled (score 1) subcategory than they were to be shown approaching average muscling (score 3). There was a decline in the percentage of beef bulls that were categorized as heavy muscled (score 5) over the last nine years. The same held true for dairy bulls; there was an increase in the percentage of light muscled and a decrease in the percentage of heavy muscled dairy bulls.

Table 29. National Beef Quality Audit (NBQA): Muscle score[1] frequencies (%) compared across the 2007[2] and 2016[3] surveys

Muscle score	2007	2016
Beef cows		
1	32.0	21.4
2	31.5	33.5
3	25.3	29.5
4	8.3	11.3
5	2.9	4.3
Dairy cows		
1	53.0	35.3
2	36.8	54.0
3	9.4	9.6
4	0.8	0.9
5	0.0	0.2
Beef bulls		
1	4.9	7.0
2	13.1	24.9
3	30.7	36.2
4	23.4	23.0
5	27.9	8.9
Dairy bulls		
1	11.7	6.9
2	27.7	39.7

Table 29. Continued

3	28.7	34.5
4	19.2	10.3
5	12.8	8.6

[1] 1 = light muscled, 5 = heavy muscled

[2] National Market Cow and Bull Beef Quality Audit – 2007 (Nicholson, 2008).Total number of observations were: beef cows (*n* = 1,315), dairy cows (*n* = 1,320), beef bulls (*n* = 245), dairy bulls (*n* = 95).

[3] Total number of observations were: beef cows (*n* = 1,691), dairy cows (*n* = 1,701), beef bulls (*n* = 213), dairy bulls (*n* = 58).

If the comparison is made based on the criteria outlined by Roeber et al. (2000) where a muscle score 1 and muscle score 2 are “too low,” then 55.0%, 89.3%, 31.9%, and 46.5% of the beef cow carcasses, dairy cow carcasses, beef bull carcasses, and dairy bull carcasses in 2016 were “too low.” Figure 50 offers a comparison to the carcasses classified as having too low a muscle score in the NMCBBQA-2007. Beef cows saw a decrease in the frequency of too light muscled carcasses, whereas both dairy and beef bulls had greater incidence of producing carcasses that are too light muscled.

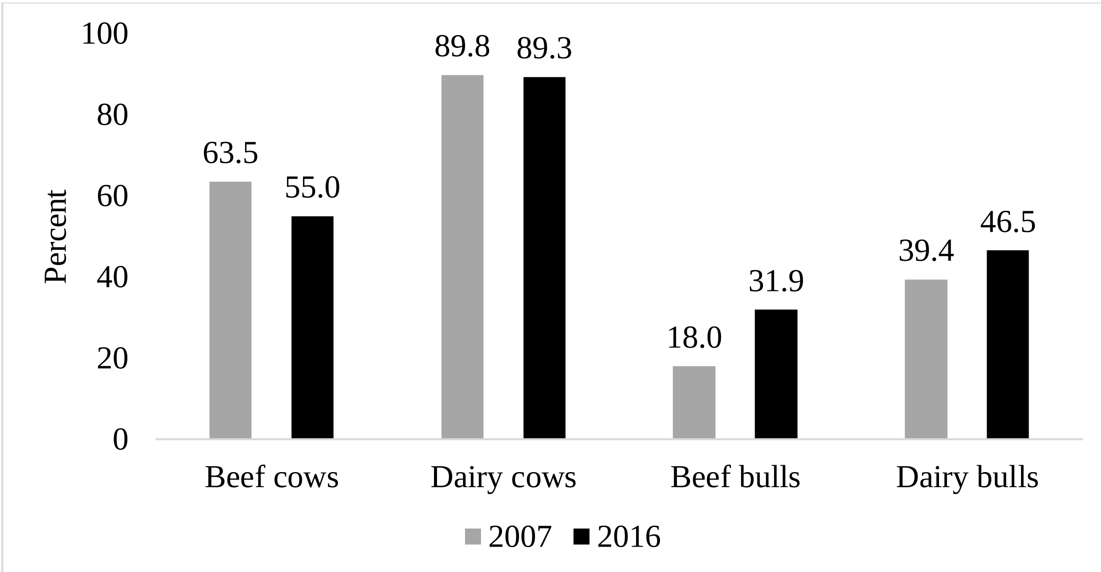

Figure 50. National Beef Quality Audit (2NBQA): Comparison of muscle scores that are "too low" (score 1 and 2 on a 5-point scale where 1 is light muscled and 5 is heavy muscled) in all cattle surveyed in 2007 and 2016. Total number of observations were National Market Cow and Bull Beef Quality Audit-2007: beef cows (*n* = 1,315), dairy cows (*n* = 1,320), beef bulls (*n* = 245), dairy bulls (*n* = 95); NBQA-2016: beef cows (*n* = 1,689), dairy cows (*n* = 1,688), beef bulls (*n* = 213), dairy bulls (*n* = 58) (Nicholson, 2008).

Arthritic joints are another cause of value loss when processing market cows and bulls. Arthritic joints were once determined to contribute to a $9.72 USD per carcass value loss in the NBQA-1999; the loss is now only $1.89 USD per carcass (National Cattlemen's Beef Association, 2017). Once being a significant concern to the industry, arthritic joints have decreased to frequency of only 1.3%. This is a great improvement from the 11.4% that was observed in the NBQA-1999 (Roeber et al., 2000) and 6.2% in the NBQA-2007 (Nicholson, 2008).

Antemortem and postmortem condemnations

Cattle and carcasses unfit for human consumption are removed from the beef supply chain following inspection by the USDA-FSIS. Reason for condemnation by USDA-FSIS personnel is often derived from historical knowledge of ownership and geographic region, and then confirmed through examination and diagnosis of observed pathologies in live animals and carcasses. A more recent evaluation of live animal and carcass condemnations between the years of 2003 and 2007, found 0.49% of cows were condemned during antemortem inspection and 2.01% of cow carcasses were condemned during postmortem inspection (White and Moore, 2009). While the study surveyed both fed cattle and market cows, White and Moore (2009) explained cull beef and dairy cows represented a substantial portion of the total number of cattle slaughtered and constituted the majority of cattle condemned.

The NBQA-2016 collected data regarding the reasons for antemortem and postmortem condemnations for the cattle or carcasses that were condemned during the day of production the audit was conducted (Table 30). Most often, plant records did not identify both breed and sex of cattle condemned, thus the reason for researchers to stratify condemnations between cows and bulls and then beef animals and dairy animals. Data show 65.7%, 50%, 100% and 87.9% of condemned cows, bulls, beef animals, and dairy animals, respectively, were condemned for being non-ambulatory. Following most closely for cows, malignant lymphoma was the cause for 22.4% of the condemnations. In contrast, 12.1% of dairy animals condemned were dead on arrival, providing the second highest frequency of antemortem condemnations.

Table 30. National Beef Quality Audit (NBQA): Reasons identified for antemortem condemnation in live animals surveyed at all packing facilities audited during 2016.

Reason	Cows (*n* = 67)	Bulls (*n* = 2)	Beef Animals (*n* = 7)	Dairy Animals (*n* = 33)
Nonambulatory	65.7	50.0	100.0	87.9
Malignant Lymphoma	22.4	0.0	0.0	0.0
Deceased	6.0	0.0	0.0	12.1
Septicemia	3.0	0.0	14.3	0.0
Dropsy	3.0	0.0	0.0	0.0
Icterus	1.5	0.0	0.0	0.0
Emaciation	0.0	50.0	0.0	0.0

Table 31 identifies the reasons for postmortem condemnations. Cow carcasses were most often condemned for displaying pathological signs associated with malignant lymphoma. This was similar to that found by White and Moore (2009) who reported the top reason for postmortem condemnation (22.3%) between 2003 and 2007 was also malignant lymphoma. Malignant lymphoma is a malignant cancer in the body's lymphatic system. Roeber et al. (2000) found malignant lymphoma to be the top reason for cow condemnations in the NMCBBQA-1999. Even though the NMCBBQA-2007 audit did not stratify carcass condemnations by sex class, conclusions report that malignant lymphoma was the top reason for dairy carcasses being condemned and tied for the top reason beef carcasses were condemned (Nicholson, 2008). This is a similar finding in the current audit when carcasses are stratified based on breed type as dairy animals were most frequently condemned due to malignant lymphoma.

Table 31. National Beef Quality Audit (NBQA): Reasons identified for postmortem condemnation in live animals surveyed at all packing facilities audited during 2016.

	Sex			Breed type		
Reason	Cows (n = 101)	Bulls (n = 8)	Unknown (n = 88)	Beef animals (n = 27)	Dairy animals (n = 60)	Unknown (n = 110)
Malignant lymphoma	36.6	12.5	9.1	11.1	28.3	22.7
Non-ambulatory	5.0	12.5	0.0	3.7	8.3	0.0
Cancer eye	10.9	0.0	1.1	29.6	5.0	0.9
Pyemia	8.9	37.5	1.1	22.2	10.0	0.9
Peritonitis	8.9	0.0	0.0	0.0	15.0	0.0
Toxemia	3.0	12.5	0.0	3.7	5.0	0.0
Emaciation	0.0	25.0	1.1	0.0	1.7	1.8
Pneumonia	5.0	0.0	2.3	11.1	5.0	1.8
Icterus	1.0	0.0	2.3	0.0	0.0	2.7
Pericarditis	2.0	0.0	1.1	3.7	1.7	0.9
Pathology of the kidney	2.0	0.0	1.1	3.7	1.7	0.9
Endocarditis	3.0	0.0	0.0	0.0	5.0	0.0
Measles	2.0	0.0	0.0	3.7	1.7	0.0
TB Test	1.0	0.0	0.0	3.7	0.0	0.0
Metritis/Uterine infection	1.0	0.0	0.0	0.0	1.7	0.0
Dropsy	5.0	0.0	1.1	3.7	3.3	2.7
Septicemia	5.0	0.0	2.3	0.0	6.7	2.7
Mastitis	0.0	0.0	1.1	0.0	0.0	0.9
Neoplasma	0.0	0.0	1.1	0.0	0.0	0.9
Reason not listed	0.0	0.0	75.0	0.0	0.0	60.0

Product fabrication

Historically, cows and bulls were thought to primarily be a source of lean trimmings (Woerner, 2010). Overtime, the industry has realized cow and bull carcasses vary in quality, and certain carcasses may receive premiums for increased quality traits, fat cover, and muscle size (Woerner, 2010) and therefore, be fabricated into primal and subprimals for foodservice use. Table 32 shows the percentage of the ten plants that fabricated common primals, subprimals, and lean trim (only ten of the eighteen plants audited provided fabrication data). All plants produced lean trim and ribeye rolls. The chuck roll was the least frequently produced subprimal across all plants. These data indicate cow and bull carcasses are used for more than lean trimmings.

Table 32. National Beef Quality Audit (NBQA): Frequency of primal/subprimal and lean trim production in plants[1] that provided fabrication information

Primal/Subprimal	Percentage[2] (%)
Brisket	50
Chuck Roll	40
Ribeye Roll	100
Striploin	80
Tenderloin	90
Top Sirloin Butt	60
Whole Muscle Round Pieces	90
Lean Trim	100

[1]Ten plants provided fabrication data.
[2] Percentages do not add to 100 because multiple products were fabricated at a single plant.

Plant characterization

The average chain speed at the 14 plants that provided information was 152 head per hour. The slowest processing plant harvested 24 head an hour, while the fastest harvested 256 head an hour. Pre-harvest washes (prior to stunning) included water washes applied by high-pressure wash boxes and/or handheld hoses in the pens. One plant utilized an antimicrobial wash sprayed from the ground to eliminate pathogens from the underside of animals going to the stun box. Most every plant audited utilized some sort of post-harvest (after stunning) wash. Eleven of the 13 plants that provided this information used an organic acid spray at some point on the line after stunning and before fabrication. The organic acids used included paracetic acid (PAA), lactic acid, chlorine, bromine, and acidified sodium chlorite. Water washes and steam were also utilized in post-harvest intervention strategies. Six facilities of the 14 that provided this information utilized electrical stimulation to improve tenderness of the beef they processed.

CHAPTER IV

SUMMARY

The results from the NBQA-2016 show there have been improvements made in the quality of market cows and bulls and their beef since 2007. Cattle in observed loads were allotted sufficient space as outlined by the current Animal Handling Guidelines most popularly used in the beef industry today. This gives confidence that animals coming to harvest are being managed properly, risk of carcass bruising is being minimized, animal welfare practices are being upheld, and value is being preserved. There was an increase in the percentage of cattle determined to be sound, especially dairy cattle. The current audit saw a decrease in the percentage of beef cows, beef bulls, and dairy bulls that were assigned a muscle score that is too low. Dairy cattle body condition scores have transitioned from thinner to more moderate since 2007. This has led to a decrease in the percentage of dairy cattle considered "too thin." A substantial percentage of cattle surveyed were polled or dehorned. The dairy animals that were horned, most often had horns of length less than 2.54 cm indicating producers are tipping horned cattle to minimize undue carcass bruising. A very large majority (97.9%) of carcasses had no knots visible, indicating great achievements in producer education on injection administration. A lesser percentage of all cattle in the current audit had mud contamination on the hide, and when evaluated for severity of mud contamination, all cattle had less severe contamination since that observed in 2007. This gives evidence producers and packers are attempting to do a more efficient job of removing mud before it becomes a contaminant concern on the harvest floor. A large majority of cattle had native hides, leaving more value to the drop credit. Evaluation of carcass bruising showed there were higher frequencies of minimal bruises, than critical or extreme bruises. Smaller areas of bruising allow for less trim loss and therefore increases quantity, and subsequently value, of cow and bull beef. Far fewer carcasses showcased evidence of arthritic joints in 2016 than in previous audits, thus impacting the value earnings of processors and packers.

In parallel to improvements being made in the market cow and bull beef industry, there are also still areas needing attention. Today, the industry is still seeing over half (64.4%) of the mixed-gender loads not separating cows and bulls, leading to increased risk for animal harm and carcass bruising. Dairy cattle muscle scores have transitioned from more moderate to lighter muscled. Although dairy cattle are generally lighter muscled than beef cattle, there was too high of a frequency of dairy cattle assigned a muscle score 1. There is opportunity for dairy producers to manage cull dairy cows on a feeding schedule to ensure adequate muscle and fat cover are achieved before harvest. Although a large percentage of cattle were identified to have no defect present, a greater percentage of dairy cows, beef bulls, and dairy bulls had some sort of defect present than that which was observed in 2007. Although carcass bruising has trended to be less severe over the last nine years, bruise damage is still leading to carcass trimming. Finding ways to eliminate bruising should be a priority for the industry. Nearly half of the livers surveyed were condemned and nearly half of those condemned were due to abscess presence. This may mean the nutritional management of cows and bulls, if fed concentrate diets, needs to be managed more appropriately to mitigate abscess prevalence. Cows, of which 17.4% were carrying a fetus at the time of harvest, should be checked for pregnancy before being harvested or culled prior to breeding to ensure breeding inputs do not exceed returns due to that cow not calving. There was an upward shift in the distribution of USDA yield grades for beef cows, beef bulls, and dairy bulls indicating carcasses were either fatter or lighter muscled.

Emphasis for extension education, beef quality assurance programs, and future research investigation should be focused toward appropriate management of cull cows and bulls to increase muscle and condition before harvest, culling animals before physical defects are too severe and cause animal welfare concerns or carcass condemnation, and ways to eliminate carcass bruising on the farm, in transport, and at the processing facility.

LITERATURE CITED

Aberle, E. D., J. C. Forrest, D. E. Gerrard, and E. W. Mills. 2012. Principles of meat science. Fifth ed. Kendall Hunt Publishing Company, Dubuque, Iowa.

Ahola, J. K., H. A. Foster, D. L. VanOverbeke, K. S. Jensen, R. L. Wilson, J. B. Glaze, T. E. Fife, C. W. Gray, S. A. Nash, and R. R. Panting. 2011. Quality defects in market beef and dairy cows and bulls sold through livestock auction markets in the western United States: II. Relative effects on selling price. J. Anim. Sci. 89: 1484-1495. doi:10.2527/jas.2010-3171

Beef Quality Assurance. n.d. Master cattle transporter guide. National Cattlemen's Beef Association Beef Quality Assurance Program,, http://www.bqa.org/Media/BQA/Docs/master_cattle_transporter_guide-digital.pdf (Accessed February 13, 2017.)

Beef Quality Assurance Advisory Board. n.d. Beef quality assurance national manual. Centennial, Colorado. http://www.bqa.org/Media/BQA/Docs/nationalmanual.pdf (Accessed 28 February 2017.)

Boleman, S. L., S. J. Boleman, W. W. Morgan, D. S. Hale, D. B. Griffin, J. W. Savell, R. P. Ames, M. T. Smith, J. D. Tatum, T. G. Field, G. C. Smith, B. A. Gardner, J. B. Morgan, S. L. Northcutt, H. G. Dolezal, D. R. Gill, and F. K. Ray. 1998. National Beef Quality Audit-1995: Survey of producer-related defects and carcass quality and quantity attributes. J. Anim. Sci. 76: 96-103. doi:10.2527/1998.76196x

Bridges, A., S. Lake, R. Lemenager, and M. Claeys. 2008. Non-pregnant cows are non-productive cows. Purdue University Cooperative Extension Service, West Lafayett, IN. https://www.extension.purdue.edu/extmedia/AS/AS_586_W.pdf (Accessed 5 February 2017.)

Brink, D. R., S. R. Lowry, R. A. Stock, and J. C. Parrott. 1990. Severity of liver abscesses and efficiency of feed utilization of feedlot cattle. J. Anim. Sci. 68: 1201-1207. doi:10.2527/1990.6851201x

Bulut, H., and J. D. Lawrence. 2007. The value of third-party certification of preconditioning claims at Iowa feeder cattle auctions. J. Agri. Appl. Econ. 39: 625-640.

Carpenter, B. B., and L. R. Sprott. 2008. Determining pregnancy in cattle. AgriLife Communications, The Texas A&M System, College Station, TX. http://animalscience.tamu.edu/wp-content/uploads/sites/14/2012/04/beef-determining-pregnancy.pdf (Accessed 5 February 2017.)

Collick, D. W., W. R. Ward, and H. Dobson. 1989. Associations between types of lameness and fertility. Vet. Rec. 125: 103-106. doi:10.1136/vr.125.5.103

Cook, N. B., and K. V. Nordlund. 2009. The influence of the environment on dairy cow behavior, claw health and herd lameness dynamics. Vet. J. 179: 360-369. doi:10.1016/j.tvjl.2007.09.016

Eastwood, L. C., C. A. Boykin, M. K. Harris, A. N. Arnold, D. S. Hale, C. R. Kerth, D. B. Griffin, J. W. Savell, K. E. Belk, D. R. Woerner, J. D. Hasty, R. J. Delmore, Jr. , J. N. Martin, T. E. Lawrence, T. J. McEvers, D. L. VanOverbeke, G. G. Mafi, M. M. Pfeiffer, T. B. Schmidt, R. J. Maddock, D. D. Johnson, C. C. Carr, J. M. Scheffler, T. D. Pringle, and A. M. Stelzleni. 2017. National Beef Quality Audit-2016: Transportation, mobility, and harvest-floor assessments of targeted characteristics that affect quality and value of cattle, carcasses, and by-products. Transl. Anim. Sci. 1: 229-238. doi:10.2527/tas2017.0029

Elanco Animal Health. 2009. The 5-point body condition scoring system. https://www.elanco.us/pdfs/ai10752-body-condition-score-insert.pdf (Accessed 2 January 2017.)

Elanco Animal Health. n.d. Tylan 40. https://www.elanco.us/labels/Swine/Tylan_40.pdf (Accessed 26 September 2017.)

Eradus, W. J., and M. B. Jansen. 1999. Animal identification and monitoring. Comput. Electron. Agric. 24: 91-98. doi:10.1016/S0168-1699(99)00039-3

Gill, D. R., R. J. Panciera, and R. A. Smith. 1996. Tongue lesions: Incidence and effects on performance of feedlot cattle. http://www.beefextension.com/research_reports/1996rr/33.pdf (Accessed 4 February 2017.)

Grandin, T. 2013. Recommended animal handling guidelines & audit guide: a systematic approach to animal welfare. AMI Foundation, Washington, DC.

http://animalhandling.org/ht/a/GetDocumentAction/i/93003 (Accessed 20 December 2016.)

Green, L. E., V. J. Hedges, Y. H. Schukken, R. W. Blowey, and A. J. Packington. 2002. The impact of clinical lameness on the milk yield of dairy cows. J. Dairy Sci. 85: 2250-2256. doi:10.3168/jds.S0022-0302(02)74304-X

Gugelmeyer, S. 2010. Brands can mean a major discount in the value of hides. http://www.hereford.org/static/files/1010_HidingValue.pdf (Accessed 27 February 2017.)

Hoffman, D. E., M. F. Spire, J. R. Schwenke, and J. A. Unruh. 1998. Effect of source of cattle and distance transported to a commercial slaughter facility on carcass bruises in mature beef cows. J Am Vet Med Assoc 212: 668-672.

Holstein Association USA. n.d. Identification method options. http://www.holsteinusa.com/animal_id/register.html (Accessed 26 September 2017.)

Kahn, C. M., and S. Line. 2010. The merck veterinary manual. 10th ed. ed. Merck & Co., Whitehouse Station, New Jersey.

Lambert, C. 1991. Lost opportunities in beef production. National Cattlemen's Association, Denver, Colorado. http://www.beefusa.org/CMDocs/BeefUSA/Producer%20Ed/Beef%20Cattle%20Information/Lost%20Opportunities.pdf (Accessed March 11, 2017.)

Lorenzen, C. L., D. S. Hale, D. B. Griffin, J. W. Savell, K. E. Belk, T. L. Frederick, M. F. Miller, T. H. Montgomery, and G. C. Smith. 1993. National Beef Quality

Audit: Survey of producer-related defects and carcass quality and quantity attributes. J. Anim. Sci. 71: 1495. doi:10.2527/1993.7161495x

Lucey, S., G. J. Rowlands, and A. M. Russell. 1986. The association between lameness and fertility in dairy cows. Vet. Rec. 118: 628-631. doi:10.1136/vr.118.23.628

Matulis, R. J., F. K. McKeith, D. B. Faulkner, L. L. Berger, and P. George. 1987. Growth and carcass characteristics of cull cows after different times-on-feed. J. Anim. Sci. 65: 669-674. doi:10.2527/jas1987.653669x

Moore, M. C., G. D. Gray, D. S. Hale, C. R. Kerth, D. B. Griffin, J. W. Savell, C. R. Raines, K. E. Belk, D. R. Woerner, J. D. Tatum, J. L. Igo, D. L. VanOverbeke, G. G. Mafi, T. E. Lawrence, R. J. Delmore, L. M. Christensen, S. D. Shackelford, D. A. King, T. L. Wheeler, L. R. Meadows, and M. E. O'Connor. 2012. National beef quality audit-2011: In-plant survey of targeted carcass characteristics related to quality, quantity, value, and marketing of fed steers and heifers. J. Anim. Sci. 90: 5143-5151. doi:10.2527/jas.2012-5550

Nagaraja, T. G., and M. M. Chengappa. 1998. Liver abscesses in feedlot cattle: A review. J. Anim. Sci. 76: 287-298. doi:10.2527/1998.761287x

National Cattlemen's Beef Association. 1994. The National Non-Fed Beef Quality Audit. National Cattlemen's Beef Association, Englewood, Colorado.

National Cattlemen's Beef Association. 2017. National Beef Quality Audit-2017: Market cows and bulls, Executive summary. National Cattlemen's Beef Association, Centennial, Colorado.

National Cattlemen's Beef Association Beef Quality Assurance Program. 2007. Executive summary of the 2007 National Market Cow and Bull Beef Quality Audit. National Cattlemen's Beef Association, Centennial, Colorado.

National Milk Producer's Federation. 2017. National Dairy Farmers Assuring Responsible Management (FARM) Program. Arlington, Virginia. http://www.nationaldairyfarm.com/about-farm#whatisfarm (Accessed 29 August, 2017.)

Nicholson, J. D. W. 2008. National Market Cow and Bull Beef Quality Audit-2007: A survey of producer-related defects. M.S. Thesis, Texas A&M University, College Station.

Nicholson, J. D. W., K. L. Nicholson, L. L. Frenzel, R. J. Maddock, R. J. Delmore, Jr., T. E. Lawrence, W. R. Henning, T. D. Pringle, D. D. Johnson, J. C. Paschal, R. J. Gill, J. J. Cleere, B. B. Carpenter, B. V. Machen, J. P. Banta, D. S. Hale, D. B. Griffin, and J. W. Savell. 2013. Survey of transportation procedures, management practices, and health assessment related to quality, quantity, and value for market beef and dairy cows and bulls. J. Anim. Sci. 91: 5026-5036. doi:10.2527/jas.2013-6283

North American Meat Institute Animal Welfare Committee. 2015. Mobility scoring for cattle. https://www.youtube.com/watch?v=QIslfHCvkpg (Accessed 22 February 2017.)

Rasby, R. n.d. A guide to udder and teat scoring beef cows. University of Nebraska-Lincoln, Lincoln, NE. http://beef.unl.edu/learning/udder_score.shtml (Accessed February 2, 2017.)

Reid, C.-A., A. Small, S. M. Avery, and S. Buncic. 2002. Presence of food-borne pathogens on cattle hides. Food. Control. 13: 411-415. doi:10.1016/S0956-7135(01)00050-0

Rezac, D. J., D. U. Thomson, M. G. Siemens, F. L. Prouty, C. D. Reinhardt, and S. J. Bartle. 2014. A survey of gross pathologic conditions in cull cows at slaughter in the Great Lakes region of the United States. J. Dairy Sci. 97: 4227-4235. doi:10.3168/jds.2013-7636

Riley, D. G., J. O. Sanders, R. E. Knutson, and D. K. Lunt. 2001. Comparison of F1 bos indicus x hereford cows in central texas: II. udder, mouth, longevity, and lifetime productivity. J. Anim. Sci. 79: 1439-1449. doi:10.2527/2001.7961439x

Roeber, D. L., K. E. Belk, G. C. Smith, J. D. Tatum, T. G. Field, J. A. Scanga, C. D. Smith, P. D. Mies, H. A. Foster, T. K. Kennedy, B. R. Moore, and S. G. Hodge. 2000. Improving the consistency and competitiveness of market cow and bull beef; and, improving the value of market cows and bulls: The final report of the National Market Cow and Bull Beef Quality Audit-1999. Colorado State University, Fort Collins.

Roeber, D. L., R. C. Cannell, W. R. Wailes, K. E. Belk, J. A. Scanga, J. N. Sofos, G. L. Cowman, and G. C. Smith. 2002. Frequencies of injection-site lesions in muscles from rounds of dairy and beef cow carcasses. J. Dairy Sci. 85: 532-536. doi:10.3168/jds.S0022-0302(02)74105-2

Roeber, D. L., P. D. Mies, C. D. Smith, K. E. Belk, T. G. Field, J. D. Tatum, J. A. Scanga, and G. C. Smith. 2001. National Market Cow and Bull Beef Quality Audit-1999: A survey of producer-related defects in market cows and bulls. J. Anim. Sci. 79: 658 - 665. doi:10.2527/2001.793658x

Savell, J. W., S. L. Mueller, and B. E. Baird. 2005. The chilling of carcasses. Meat. Sci. 70: 449-459. doi:10.1016/j.meatsci.2004.06.027

Schulz, L., K. C. Dhuyvetter, K. Harborth, and J. Waggoner. 2010. Factors affecting feeder cattle prices in Kansas and Missouri. Kansas State University, Manhattan, Kansas.

Smith, G. C. 1991. A quality audit of the beef industry. In: Range Beef Cow Symposium, Lincoln, Nebraska. p 9.

Smith, G. C., J. B. Morgan, J. D. Tatum, C. C. Kukay, M. T. Smith, T. D. Schnell, and G. G. Hilton. 1994. Improving the consistency and competitiveness of non-fed beef; and, improving the salvage value of cull cows and bulls; The final report of the National Non-Fed Beef Quality Audit-1994. Colorado State University, Fort Collins, Colorado.

Smith, G. C., J. W. Savell, R. P. Clayton, T. G. Field, D. B. Griffin, D. S. Hale, M. F. Miller, T. H. Montgomery, J. B. Morgan, J. D. Tatum, and J. W. Wise. 1992. The final report of the National Beef Qality Audit - 1991. Colorado State University, Fort Collins, Colorado.

Sorensen, A. M. 1979. Animal reproduction: principles and practices. McGraw Hill, New York, New York.

Stamp, J. 2013. Decoding the range: The secret language of cattle branding. http://www.smithsonianmag.com/arts-culture/decoding-the-range-the-secret-language-of-cattle-branding-45246620/ (Accessed 22 February 2017.)

Strappini, A. C., K. Frankena, J. H. M. Metz, C. Gallo, and B. Kemp. 2012. Characteristics of bruises in carcasses of cows sourced from farms or from livestock markets. Animal 6: 502-509. doi:10.1017/S1751731111001698

Strohbehn, D. R., W. D. Busby, D. D. DeWitt, and P. Beedle III. 2004. A summary of feeding market cows for the white fat cow market. Iowa State University, http://lib.dr.iastate.edu/cgi/viewcontent.cgi?article=1047&context=ans_air (Accessed 5 February 2017.)

Texas A&M AgriLife Research & Extension Center. n.d. Overview of body condition scoring system. Texas A&M AgriLife Research & Extension Center, Vernon, Texas. http://vernon.tamu.edu/center-programs/range-animal-nutrition-program/decision-aids-for-cattle-producers/body-condition-scoring-photo-guide/overview-of-body-condition-scoring-system/ (Accessed 20 December 2016.)

United States Department of Agriculture Food Safety Inspection Services. 2015. Postmortem inspection. https://www.fsis.usda.gov/wps/wcm/connect/ad2cab87-9bf9-4ead-969a-cec2d4753c30/LSIT_PostMortem.pdf?MOD=AJPERES (Accessed 5 February 2017.)

USDA. 2016. United States standards for grades of carcass beef. Agricultural Marketing Service, United States Department of Agriculture, Washington, DC. https://www.ams.usda.gov/sites/default/files/media/Carcass%20Beef%20Standard.pdf (Accessed 2 January 2016.)

USDA-AMS. 2017. Weekly USDA by-product drop value (cow). United States Department of Agricultural Market News Des Moines, Iowa. https://www.ams.usda.gov/mnreports/nw_ls444.txt (Accessed 27 February 2017.)

USDA-APHIS. 2013. Animal disease traceability framework: Official eartags - criteria and options. Washington, D.C. https://www.aphis.usda.gov/traceability/downloads/ADT_eartags_criteria.pdf

USDA-APHIS Veterinary Services National Animal Health Monitoring System. 2016. Dairy 2014: Dairy cattle management practices in the United States, 2014. United States Department of Agriculture, Fort Collins, Colorado. https://www.aphis.usda.gov/animal_health/nahms/dairy/downloads/dairy14/Dairy14_dr_PartI.pdf (Accessed 1 March 2017.)

White, T. L., and D. A. Moore. 2009. Reasons for whole carcass condemnations of cattle in the United States and implications for producer education and veterinary intervention. J Am Vet Med Assoc 235: 937-941. doi:10.2460/javma.235.8.937

Woerner, D. R. 2010. Beef from market cows. In: National Cattlemen's Beef Association (ed.), Centennial, Colorado.

APPENDIX A

Table A-1. National Beef Quality Audit (NBQA): Name, location and date of audit for plants surveyed in the 2016 National Beef Quality Audit for market cows and bulls

Plant name	Location	Date audited
ABF Packing	Stephenville, TX	September 15, 2016
American Beef Packers	Chino, CA	May 5, 2016
American Foods Group – Cimpls Inc.	Yankton, SD	September 29, 2016
American Foods Group – Gibbon Packing	Gibbon, NE	September 20, 2016
American Foods Group – Green Bay Dressed Beef	Green Bay, WI	July 12, 2016
American Foods Group – Long Prairie Packing	Long Prairie, MN	November 16, 2016
Cargill Beef Packers	Fresno, CA	May 9, 2016
Cargill Taylor Beef	Wyalusing, PA	March 16, 2016
Caviness Packing	Hereford, TX	November 19, 2016
Central Valley Meat Company	Hanford, CA	May 10, 2016
FPL Foods LLC	Augusta, GA	December 13, 2016
H&B Packing	Waco, TX	October 5, 2016
JBS Green Bay	Green Bay, WI	July 11, 2016
JBS Omaha	Omaha, NE	May 12, 2016
JBS Plainwell	Plainwell, MI	July 18, 2016
JBS Souderton	Souderton, PA	March 18, 2016
JBS Tolleson	Tolleson, AZ	May 3, 2016
Lone Star Beef	San Angelo, TX	March 11, 2016

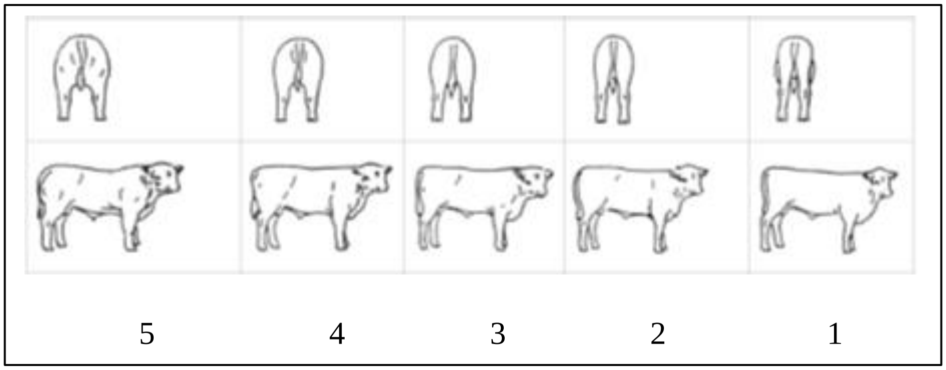

Figure A-1. National Beef Quality Audit (NBQA): Live animal muscle score standard.

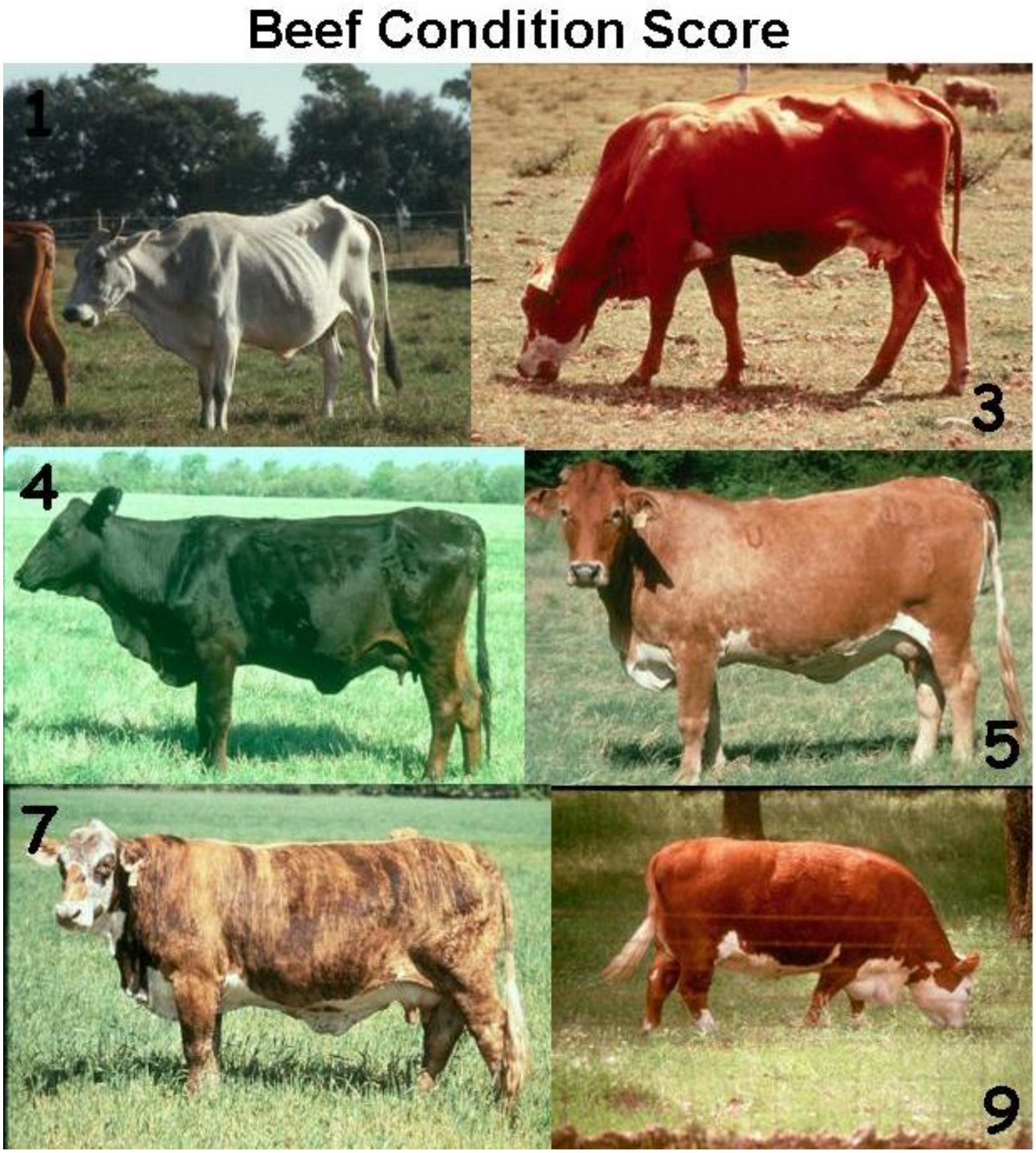

Figure A-2. National Beef Quality Audit (NBQA): Beef animal body condition score standard reference.

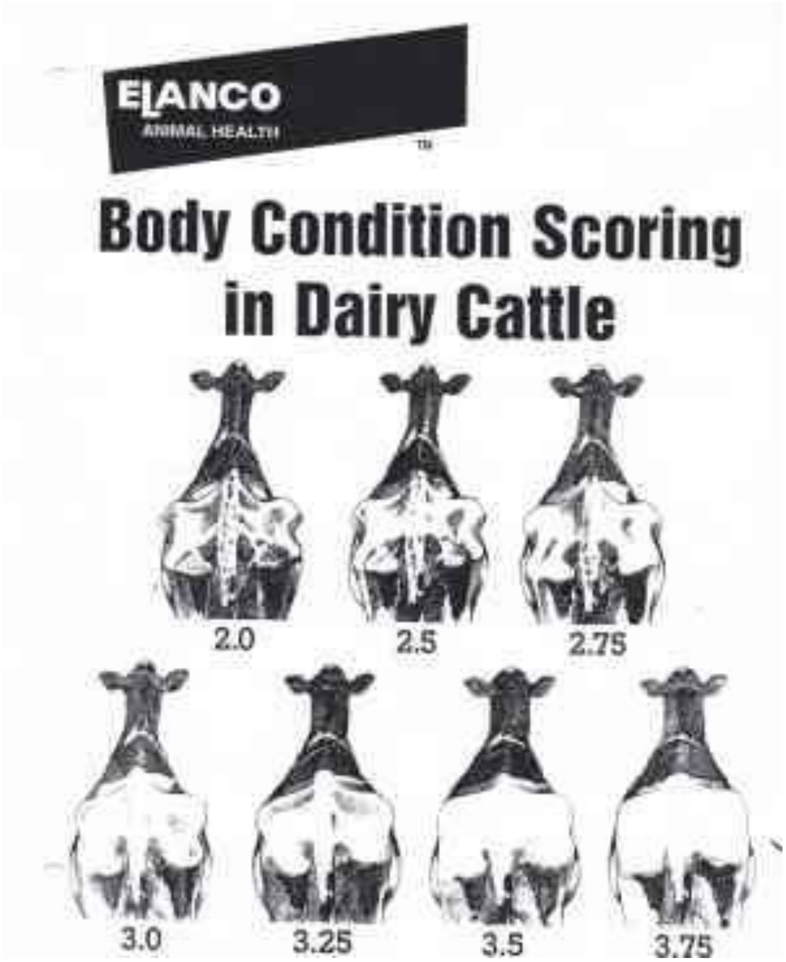

Figure A-3. National Beef Quality Audit (NBQA): Dairy animal body condition score standard reference (Elanco Animal Health, 2009).

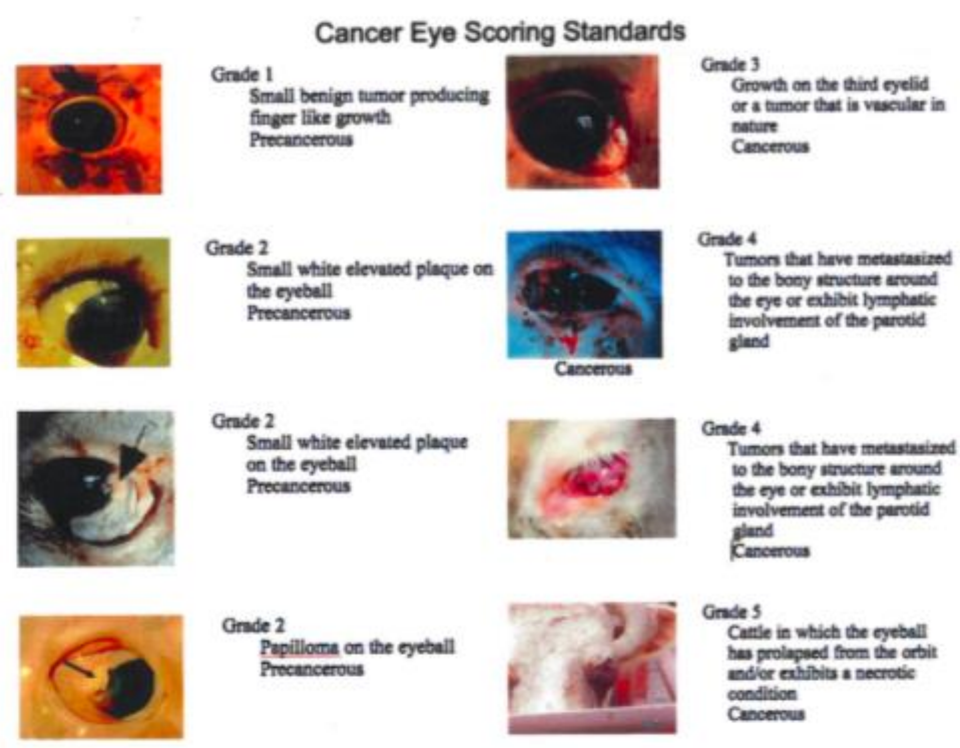

Figure A-4. National Beef Quality Audit (NBQA): Cancer eye scoring system.


Figure A-5. National Beef Quality Audit (NBQA): Standard reference for no mud present on the hide.

Figure A-6. National Beef Quality Audit (NBQA): Standard reference for small amounts of mud present on the hide.


Figure A-7. National Beef Quality Audit (NBQA): Standard reference for moderate amounts of mud present on the hide.

Figure A-8. National Beef Quality Audit (NBQA): Standard reference for large amounts of mud present on the hide.

Figure A-9. National Beef Quality Audit (NBQA): Standard reference for extreme amounts of mud present on the hide.

Table A-2. National Beef Quality Audit (NBQA): Bruise size reference chart.

Bruise Size Key:			
Minimal (<1 lb-surface)	1= quarter size	2= silver dollar	3= deck of cards
Major (1-10 lbs)	4= 1-3 lbs	5= 4-7 lbs	6= 8-10 lbs
Critical (>10 lbs)	7= 11-20 lbs	8= 21-30 lbs	9= 31-40 lbs
Extreme	10= Entire primal		

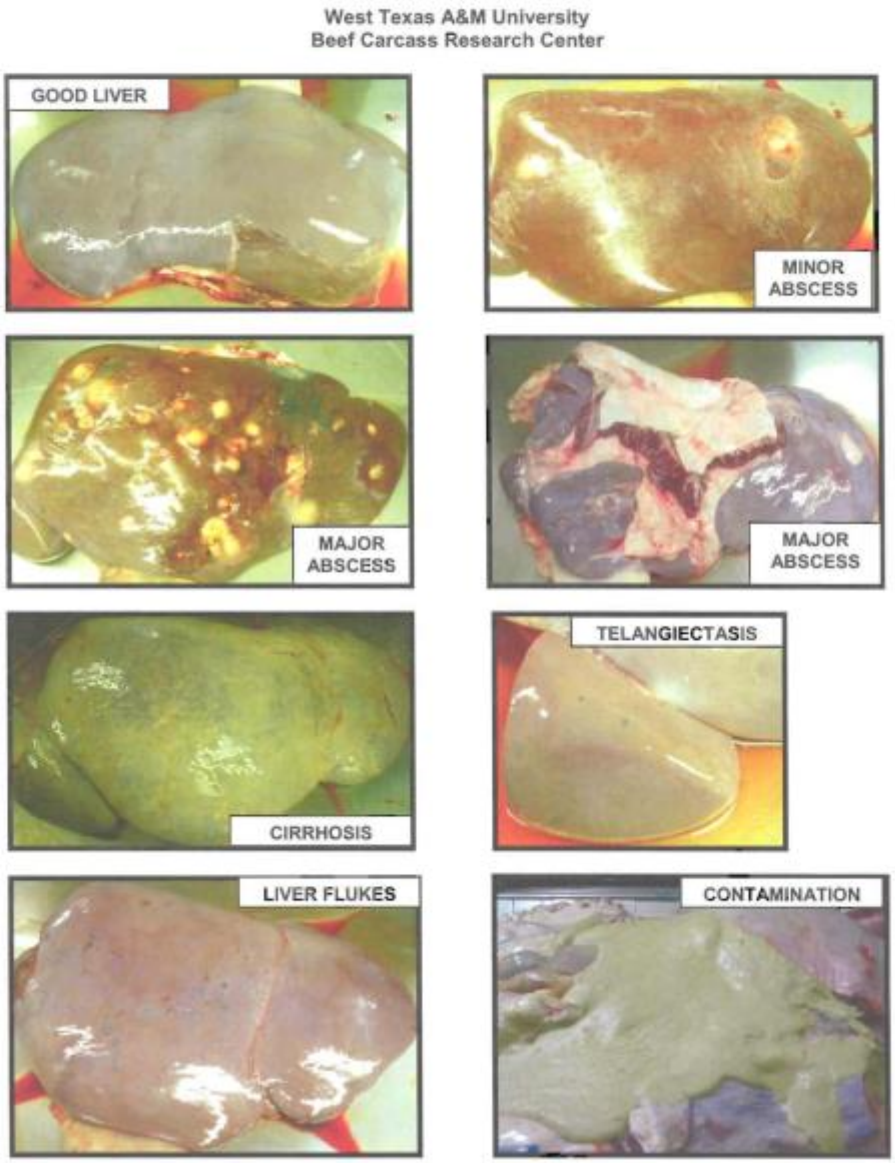

Figure A-10. National Beef Quality Audit (NBQA): Liver pathology reference.

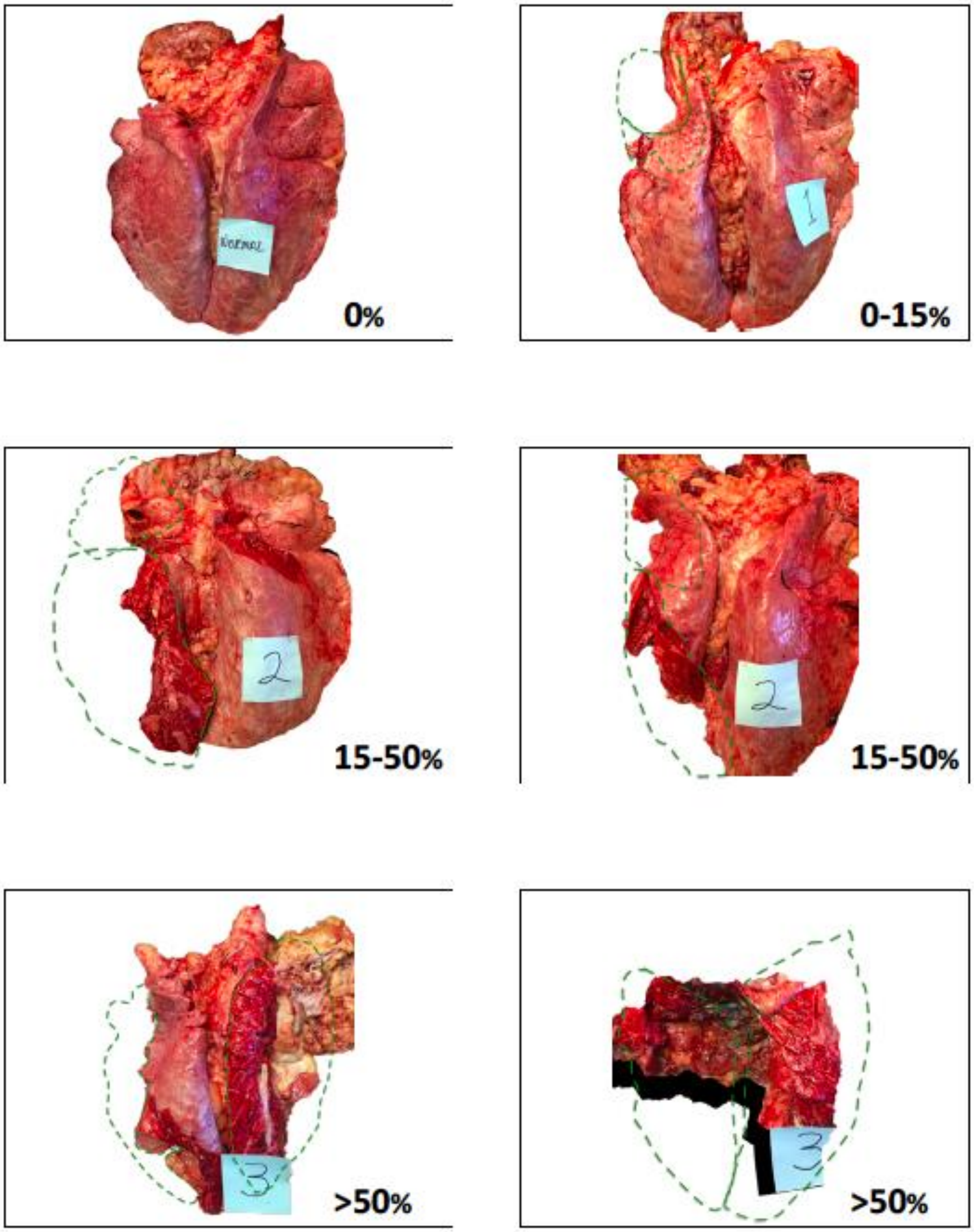

Figure A-11. National Beef Quality Audit (NBQA): Lung pneumonia reference.

Figure A-12. National Beef Quality Audit (NBQA): Hair sore reference.

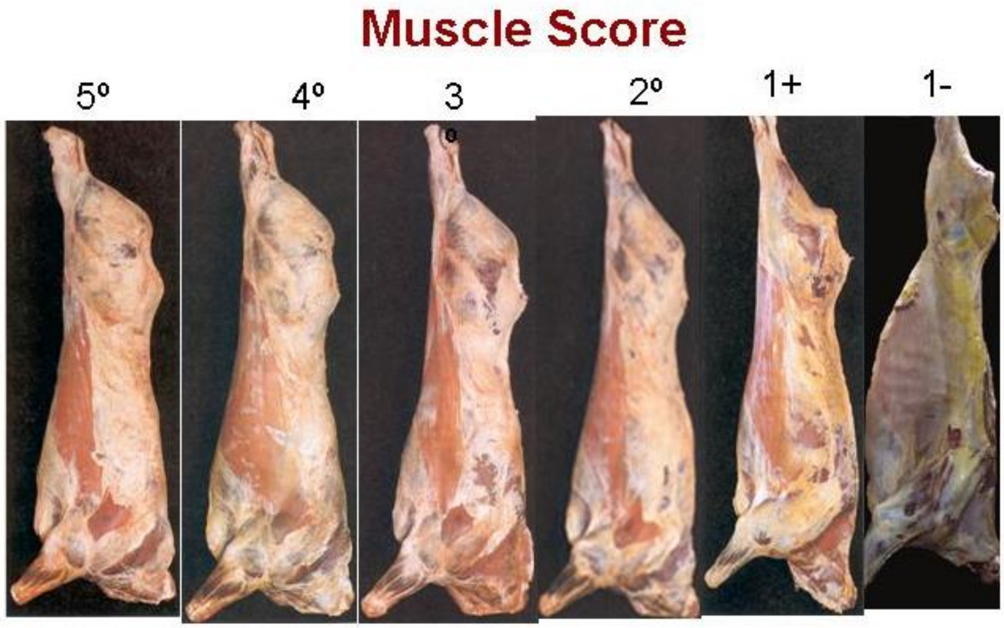

Figure A-13. National Beef Quality Audit (NBQA): Carcass muscle score standard reference.

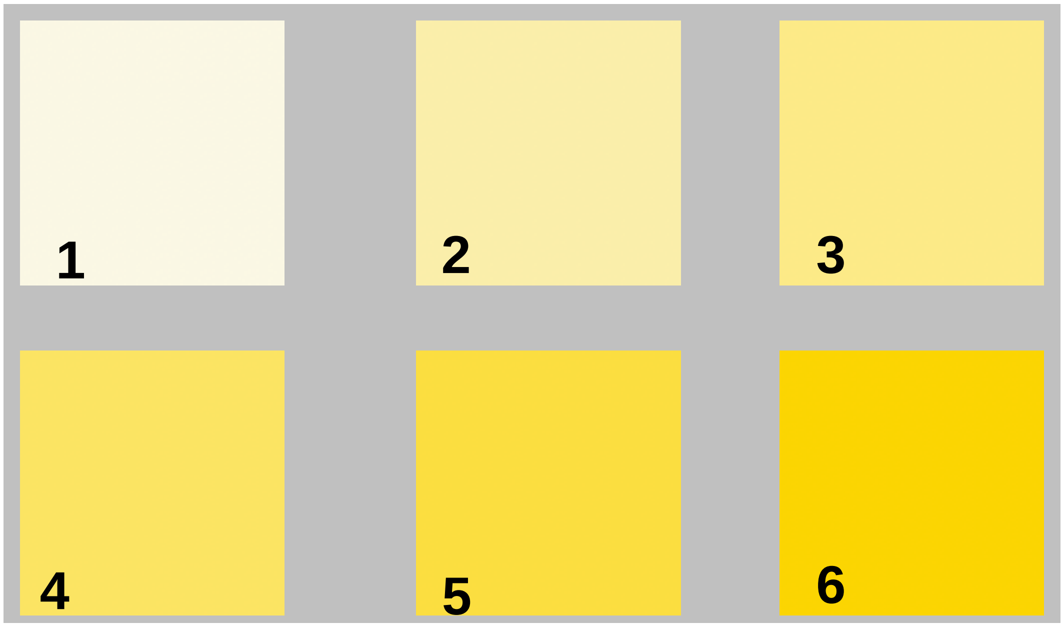

Figure A-14. National Beef Quality Audit (NBQA): Carcass fat color score reference standard.

Table B-1. National Beef Quality Audit (NBQA): Transportation and mobility data collection sheet

Trailer Information								
Trailer Type	Bumper Pull	Gooseneck		Single Deck		Pot Belly	Other:	
Trailer Dimensions	W:__________ (ft.)			L:__________ (ft.)				
Number of Compartments Used	One	Two	Three	Four	Five	Six	Seven	Eight
Use of Front Upper: Y or N		Use of Rear Upper: Y or N			Use of Center Gate: Y or N			
Origin of Cattle (City, State):					Cattle Unloaded in Route: Y or N			
Date Loaded:		Time Loaded:		Distance Traveled:		Time Traveled:		
		Time Zone						
Total Number of Cattle in Load:								
Circle one: Beef Cows Dairy Cows Beef Bulls Dairy Bulls					Mixed (Cows and Bulls) Segregated: Y or N			
Number Dead:				Number Downers:				

Mobility Scoring - Tally				
	Beef Cows	Dairy Cows	Beef Bulls	Dairy Bulls
1				
2				
3				
4				
Downers				

Table B-2. National Beef Quality Audit (NBQA): Live animal evaluation data collection

Beef Cow			**Dairy Cow**			**Beef Bull**		**Dairy Bull**	
Muscle Score	1		2		3		4		5
Dairy Condition Score	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
Beef Condition Score	1	2	3	4	5	6	7	8	9
Cancer Eye Score	0		1	2		3	4		5
Prolapse	Rectal		Vaginal		**Hide Damage**		Insect		Latent
Abscess		Facial			Knee/hock			Hooks/Pins	
Bottle Teats	Broken Penis		Calf in Pen	Failed Suspensory ligament		Foot Abnormality	Full Bag		Lumpy Jaw
Mastitis	Multiple Udder Problems		Retained Placenta	Swollen Joints		Warts	No Defect	Other:	

Table B-3. National Beef Quality Audit (NBQA): Hide/mud/brand data collection sheet

BEEF COW	DAIRY COW	BEEF BULL	DAIRY BULL							
Color: Primary	None	Black	White	Yellow	Red	Brown	Gray	Tan	Holstein	Non-Holstein dairy
Pattern	None	Baldy	Roan	Brindle	Spots	Other:				
Mud Location	No Visible	Legs	Belly	Side	Top Line	Tail Region				
Mud Amount	None	Small	Moderate	Large	Extreme					
Brand Location	**None**	**Butt**	**Side**	**Shoulder**						
Size (in)		x	x	x						
Size (in)		x	x	x						
Size (in)		x	x	x						
Knots	None	Neck	Shoulder	Top Butt	Round	Other:				
Individual ID	None	Ankle	Barcode	Electronic	Other:					
	Individual Tag	Metal Clip	Lot Tag	Waddles						
Horns	None	<1”	1-5”	>5”						
Touching floor/equip. Y or N	Other Comments (i.e. cuts):									

Table B-4. National Beef Quality Audit (NBQA): Bruise data collection sheet.

BEEF COW	DAIRY COW	BEEF BULL	DAIRY BULL

# of Bruises	0	1			2			3			4			Injection Site (#, location)
Location of Bruises		Rnd Rb Shortloin Sir Chk B|P|F			Rnd Rb Shortloin Sir Chk B|P|F			Rnd Rb Shortloin Sir Chk B|P|F			Rnd Rb Shortloin Sir Chk B|P|F			0 | 1 | 2 | 3 | 4 Rnd Rb Shortloin Sir Chk B|P|F
Minimal		1	2	3	1	2	3	1	2	3	1	2	3	# of Arthritic Joints: 0 1 2
Major		4	5	6	4	5	6	4	5	6	4	5	6	
Critical		7	8	9	7	8	9	7	8	9	7	8	9	
Extreme			10			10			10			10		**Grubs Present**

Muscle Score	1			2			3			4			5		
	+	O	-	+	O	-	+	O	-	+	O	-	+	O	-

Fat Color Score	1	2	3	4	5	6

Table B-5. National Beef Quality Audit (NBQA): Liver, viscera, and kidney condemnation and fetal presence data collection sheet.

Lot Information	Liver					Viscera				Kidney
Lot #:_______________ # in lot:_____________ # to sample: ___________	Absc	Flukes	Tlang	Cont.	Other	Absc.	Ulcers	Cont.	Other	
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50										

1	2	3	4	5
6	7	8	9	10
11	12	13	14	15
16	17	18	19	20
21	22	23	24	25
26	27	28	29	30
31	32	33	34	35
36	37	38	39	40
41	42	43	44	45
46	47	48	49	50

Fetuses		
Early		# of cows (if mixed lot)
Late		

Table B-6. National Beef Quality Audit (NBQA): Lung and heart condemnation data collection sheet.

Lot Information	Lungs			Hearts	
	Pneumonia	Contamination	Other	Pericarditis	Contamination
Lot #:______________	1				
# in lot:____________					
# to sample: __________					
	2				
	3				

1	2	3	4	5
6	7	8	9	10
11	12	13	14	15
16	17	18	19	20
21	22	23	24	25
26	27	28	29	30
31	32	33	34	35
36	37	38	39	40
41	42	43	44	45
46	47	48	49	50

Table B-7. National Beef Quality Audit (NBQA): Head and tongue condemnation and dentition data collection sheet.

Lot Information	Head								Tongue									
LOT #: _________ # in lot _________ # to sample:_______	Lymph		Abscess		Cont.		Other		Lymph		Hair Sore		Cactus Tongue		Cont.		Other	
	T	C	T	C	T	C	T	C	T	C	T	C	T	C	T	C	T	C

1	2	3	4	5
6	7	8	9	10
11	12	13	14	15
16	17	18	19	20
21	22	23	24	25
26	27	28	29	30
31	32	33	34	35
36	37	38	39	40
41	42	43	44	45
46	47	48	49	50
51	52	53	54	55
56	57	58	59	60
61	62	63	64	65
66	67	68	69	70
71	72	73	74	75
76	77	78	79	80
81	82	83	84	85
86	87	88	89	90
91	92	93	94	95
96	97	98	99	100

Dentition (# of permanent incisors) (tally system)

0: ______________________	6: ______________________
1: ______________________	7: ______________________
2: ______________________	8: ______________________
3: ______________________	Gummer: ______________________
4: ______________________	Broken Mouth______________________
5: ______________________	

Table B-8. National Beef Quality Audit (NBQA): Carcass grade date collection sheet.

Car. ID/Sequence # ______________	**L. MAT**	A	B	C	D	E		# Arthritic Joints 0 1 2	
HCW (lbs.)_____	**S. MAT.**	A	B	C	D	E			
REA (in^2)_______	**PYG**	1.	2.	3.	4.	5.			
	% KPH	0	1.	2.	3.	4.	5.		
Sex: **C** **B**	**MARB**	PD	TR	SL	SM	MT	MD	SA	MA
	DARK C.	1/3	1/2	2/3	Full	Blood splash		Calloused eye	
Type:	**MUSCLE SCORE**	1	2	3	4	5			
Beef **Dairy**		+ o -	+ o -	+ o -	+ o -	+ o -			
	FAT COLOR SCORE	1	2	3	4	5	6		
Plant Cow Grade:				**Plant Bull Grade:**					

Table B-9. National Beef Quality Audit (NBQA): Product fabrication data collection sheet.

IMPS cuts	Cow lbs.	Bull lbs.
112 Rib, ribeye roll, 6-8 lbs.		
112 Rib, ribeye roll, 8-10 lbs.		
112 Rib, ribeye roll, 10-up lbs.		
112A Rib, ribeye roll-lip-on, 8-dn lbs.		
112A Rib, ribeye roll-lip-on, 8-up lbs.		
Chuck, boneless 85%		
120 Chuck, brisket		
168 Round, top inside, 10-dn lbs.		
168 Round, top inside, 10-up lbs.		
169A Round, top inside cap-off, 8-10 lbs.		
169A Round, top inside cap-off, 10-14 lbs.		
169A Round, top inside cap-off, 14-up lbs.		
171B Round, outside round		
171C Round, eye of round		
Loin, Semi-Bnls Short Loin, 13-dn lbs.		
Loin, Semi-Bnls Short Loin, 13-up lbs.		
180 Loin, strip, bnls, 7-9 lbs.		
180 Loin, strip, bnls, 9-up lbs.		
182 Loin, sirloin butt		
184 Loin, top sirloin butt		
191A Loin, butt tender, peeled		
90% Lean		
100% Lean - Inside Round		
100% Lean - Outside Round		
100% Lean - Eye of Round		
100% Lean - Flats and eyes		
100% Lean - Striploin		
100% Lean - S.P.B.		
116B Chuck, chuck tender		
167A Round, knuckle, peeled		
190 Loin, tenderloin, 2-3 lbs.		
190 Loin, tenderloin, 3-4 lbs.		
190 Loin, tenderloin, 4-5 lbs.		
190 Loin, tenderloin, 5-up lbs.		
193 Flank, flank steak		
Flank, rough		
Other:		
Other:		
Defect Checklist:	**Cows**	**Bulls**
Number of Injection Site Lesions Found:		
Number of Abscesses Found:		
Number of Lead/Shot Found:		
Number of alarms by Metal Detector:		
Magnitude of Metal Detector:		