

**NATIONAL BEEF QUALITY AUDIT–2011: IN-PLANT SURVEY OF
TARGETED CARCASS CHARACTERISTICS RELATED TO QUALITY,
QUANTITY, VALUE, AND MARKETING OF FED STEERS AND HEIFERS**

A Thesis

by

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

MASTER OF SCIENCE

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December 2012

Major Subject: Animal Science

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ABSTRACT

The National Beef Quality Audit – 2011 assessed the current status of quality and consistency of fed steers and heifers. Beef carcasses (n = 9,802), representing approximately 10 percent of each production lot in 28 beef processing facilities, were selected randomly for the survey. Carcass evaluation for the cooler assessment of this study revealed these traits and frequencies: steer (63.5%), heifer (36.4%), cow (0.1%), and bullock (0.03%) sex classes; dark-cutters (3.2%); blood splash (0.3%); yellow fat (0.1%); calloused ribeye (0.05%); A (92.8%), B (6.0%), and C or greater (1.2%) overall maturities; native (88.3%), dairy-type (9.9%), and *Bos indicus* (1.8%) estimated breed types; and United States (97.7%), Mexico (1.8%), and Canada (0.5%) country of origin. Certified or marketing program frequencies were age and source verified (10.7%), $\leq A^{40}$ (10.0%), Certified Angus Beef (9.3%), top Choice (4.1%), natural (0.6%), and Non-Hormone Treated Cattle (0.5%), and there were no organic programs observed. Mean USDA YG traits were USDA YG (2.9), HCW (374.0 kg), AFT (1.3 cm), LM area (88.8 cm²), and KPH (2.3%); Frequencies of USDA YG distributions were YG 1 (12.4%), YG 2 (41.0%), YG 3 (36.3%), YG 4 (8.6%), and YG 5 (1.6%). Mean USDA QG traits were USDA QG (Select⁹³), marbling score (Small⁴⁰), overall maturity (A⁵⁹), lean maturity (A⁵⁴), skeletal maturity (A⁶²). Frequencies of USDA QG distributions were Prime (2.1%), Choice (58.9%), Select (32.6%), and Standard or less (6.3%). Marbling score distribution was Slightly Abundant or greater (2.3%), Moderate (5.0%), Modest (17.3%), Small (39.7%), Slight (34.6%), and Traces or less (1.1%). Carcasses with QG

of Select or greater and YG of 3 or numerically less represented 85.1% of the sample. This is the fifth benchmark study measuring targeted carcass characteristics, and information from this survey will continue to help drive progress in the beef industry. Results will be used in extension and educational programs as teaching tools to inform beef producers and industry professionals of the current state of the U.S. beef industry.

DEDICATION

I dedicate this thesis and the work done for it to my family and friends. Without the love and constant support of my family, this could not have been achieved. They have been there for me through thick and thin and were always there when I needed them most. To my friends, this work also could not have been completed without you. You all were the glue that held me together through graduate school, up to the completion of my thesis work, and even today.

ACKNOWLEDGEMENTS

I thank my committee co-chairs, Dr. Jeffrey W. Savell and Dr. Kerri B. Harris and committee member, Dr. Davey B. Griffin, for their guidance and support throughout the course of this research and my time here at Texas A&M University, especially during these last two years of graduate school. Because of you all, I have been inspired to learn and study about an industry that intrigues me. You all have helped me in developing my abilities and myself as a well-rounded individual. Thank you for teaching me and sharing your wisdom and expertise in not only Meat Science and Food Safety but also life in general.

Many thanks also go to my friends and colleagues and the Meat Science Section faculty and staff for making my time at Texas A&M University a great experience. Dr. Kerth, thank you very much for taking the time to help me with writing Excel formulas and equations used in analyzing my data. Also, thank you for your statistics expertise and unending guidance whenever I needed it. Dr. Hale, thank you for always being there and available if I ever had a question regarding anything or needed advice.

Words cannot begin to describe how thankful I am for my fellow graduate students. You have all been there for me on countless occasions and have always been more than willing to lend a helping hand no matter what. To Gatlan Gray and Leslie Frenzel, thank you both for traveling with me to do the majority of the cooler assessments at numerous different plants. I know traveling and being on the road for a research project can be stressful, but you both were very helpful. I could not have asked

for better colleagues to travel with, and I know for a fact that the trips would not have been as fun as they were if the two of you were not there with me. To Kayla Nelson, Haley Grimes, Carson Ulbrich and Russell McKeith, thank you for your time and efforts in traveling and conducting cooler assessments as well. Without your help, this project would not have gone as smoothly as it did. To Meagan Igo, Cody Labus, Lindsey Mehall, Ashley Haneklaus, Amanda Smith, Jacob Lemmons, and to the rest of the graduate students, thank you all for any help that you have ever given me during my time here as a graduate student. Whether it included help with entering and checking data, covering my labs for me while I was traveling, taking notes for me in class, or just simply being there for me whenever I needed help and guidance, I greatly appreciate it all. Also, a big thank you to the Meat Science student workers, Julianne Riley, Jenny Bohac, Julie Lockhart, Rachel Glascock, and Jessica Stegar, who graciously made data books, mailed packages, and checked and entered data for countless hours. I would not have been able to complete this project in the time span I did if I did not have such a wonder team of professors, graduate students, colleagues, and student workers to graciously assist me.

I extend my gratitude to The Beef Checkoff for funding this project. Also, my sincere appreciation goes out to all the institutions that collaborated with Texas A&M University and that served a part in this research. To the professors, graduate students, and industry leaders at The Pennsylvania University, Colorado State University, Oklahoma State University, West Texas A&M University, California Polytechnic State University, USDA-ARS, and USDA-AMS, thank you all for taking part in this research.

Thank you all for your time and effort put forth to complete this project. This work could not have been done without the collaboration of all these great institutions.

Finally, thanks to my parents for their encouragement and love. They have always pushed me to be the best I could and were one of the driving forces that lead me to complete my master's degree. They have always been there to celebrate my accomplishments during good times and to offer heartening words for when I was down during the bad. I would not be able to do the things I do if I did not have them backing me one hundred percent. Also, thank you to my sisters, Lacey and Sydney, for their continuous love and support. They were always there for me to lend a hand when I needed anything and to lend an ear for when I just needed someone to talk to. I would not have been able to accomplish anything without the love and support of my family. Thank you all for your undeniable inspiration and encouragement.

NOMENCLATURE

AFT	Adjusted fat thickness
AMS	Agricultural Marketing Service
CME	Chicago Mercantile Exchange
HCW	Hot carcass weight
KPH	Kidney, pelvic, and heart fat
LM	Loin muscle
NBQA	National Beef Quality Audit
NBQA-1991	National Beef Quality Audit – 1991
NBQA-1995	National Beef Quality Audit – 1995
NBQA-2000	National Beef Quality Audit – 2000
NBQA-2005	National Beef Quality Audit – 2005
NBQA-2011	National Beef Quality Audit – 2011
QG	Quality grade
USDA	United States Department of Agriculture
YG	Yield grade

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CHAPTER I

INTRODUCTION

The NBQA began in the early 1990's and was the first benchmark study conducted to measure economically important characteristics of the U.S. fed beef supply since the USDA Market Consist Report (Abraham, 1977). Smith et al. (1992) suggested that audits be conducted every 4 to 5 years, so changes in the fed beef supply could be documented over time. Published results of the 4 previous audits include those of the NBQA-1991 (Lorenzen et al., 1993), NBQA-1995 (Boleman et al., 1998), NBQA-2000 (McKenna et al., 2002), and NBQA-2005 (Garcia et al., 2008). The NBQA provides valuable snapshots of the industry, and its quality challenges at specific points in time and findings are used to develop numerous producer-related extension workshops and industry research objectives.

The NBQA-2011 was conducted to assess the current status of consistency and quality of the U.S. fed beef population. This study also allowed measurement of the progress that has been made since the previous audit and identified needs for improvement. During the past twenty years, new policies and marketing practices, such as age and source verification, country of origin labeling (USDA, 2009), and development of certification programs, have impacted beef marketing. Fluctuations in the U.S. economy, weather trends, improvement in cattle genetics, and varying cattle numbers could cause changes in the beef industry. For instance, the U.S. cattle population is currently at an all time low since 1973 totaling at 97.8 million head (CME

Group, 2012). The NBQA-2011 was conducted to report the current quality and consistency of beef and identify issues that have developed since the last audit. Issues include those discussed at the NBQA-2011 Strategy Workshop such as inconsistent carcass weights, LM area, and fat thickness as well as the remaining existence of non-conforming carcasses (National Cattlemen's Beef Association, 2012).

CHAPTER II

REVIEW OF LITERATURE

Over the years, the NBQA has been one of the most vital studies funded by The Beef Checkoff. Since 1991, these benchmark studies have been providing the beef industry with data identifying areas of non-conformity and quality shortfalls in products. There have been 4 studies in the United States which include the NBQA-1991 (Lorenzen et al., 1993), NBQA-1995 (Boleman et al., 1998), NBQA-2000 (McKenna et al., 2002), and NBQA-2005 (Garcia et al., 2008). Similar research studies were also conducted in Canada. They include the Canadian Beef Quality Audit-1995-96 (Van Donkersgood et al., 1997) and the Canadian Beef Quality Audit-1998-99 (Van Donkersgood et al., 2001).

History of Beef Grading

Grades for dressed beef were seen in the beef industry as early as 1916 as tentative grades. The following year, in early 1917, grades were instated as a national service. Grades were established as a way to “sort” beef into similar groups making them more suitable for marketing. The first publication to consist of beef grades came out in August of 1924 and was the USDA Department Bulletin No. 1246 “Market Classes and Grades of Dressed Beef.” Revised grade descriptions were then published in 1926 to provide the basis for beef grading when the voluntary grading and stamping service began in May 1927.

Over the years, there have been many revisions made to the official standards through amendments with some of the most major changes being listed here. The first being in 1939 was to provide a single standard for grading steer, heifer, and cow beef according to similar quality characteristics. This amendment also changed grade terms for steer, heifer, and cow beef from “Medium” to “Commercial,” “Common” to “Utility,” and “Low Cutter” to “Canner.” In November 1941, another amendment established grade terms for all beef to include the following grades: Prime, Choice, Good, Commercial, Utility, Cutter, and Canner. Later in October of 1949, all reference to fat color in quality grade determination was eliminated. In June 1965, official standards for grades of steer, heifer, and cow beef were changed to reflect less emphasis on maturity for in Prime, Choice, Good, and Standard grades. In July 1973, official standards were changed once again to provide a separate grading system for beef from young bulls or “bullocks.” Quality grade standards for bullocks would essentially be the same as steer, heifer, and cow beef. However, there would only be five quality grades for the carcasses designated as bullocks. These grades were Prime, Choice, Good, Standard, and Utility. In November of 1987, official grade standards were revised to change the quality grade name U.S. Good to U.S. Select for steer, heifer, and cow beef. No grade requirements were change, just the grade name. Then in April 1989, an amendment changed grade standards to allow official grades of carcasses to include only quality grade, only yield grade, or a combination of both. The last amendment to the official grade standards occurred in 1997, and those changes still stand today as the United States Standards for Grades of Carcass Beef (USDA, 1997).

Grades of Fed Beef Carcasses: November 1973-October 1974

Abraham et al. (1977) reported in the USDA Market Consist Report the distribution of quality and yield grades of the fed beef production. This report served as the first benchmark for determining changes in the US fed beef supply. Information found was used to assess the amount of beef in each grade. Knowledge of quality and yield grade consist and the factors that influence those grades was used to understand changes in beef productions and pinpoint areas of improvement. Data in this report also served as a database that future research could be compared to. Factors evaluated during this study were quality and yield grade factors, and they included the following: conformation, maturity, marbling, final quality grade, carcass weight, actual and adjusted fat over the ribeye, ribeye area, and estimated percentage kidney, pelvic, and heart fat, and final yield grade. The class of the carcass also was evaluated (steer, heifer, or bullock). Any other comments were also noted such as dark cutters, unusual conditions, or any other factors that would affect final quality grade.

Results from this study showed consist of quality and yield grades during at that point and time in the beef industry. Mean USDA YG was 3.4 with mean YG factors being the following: HCW was 307.9 kg; fat thickness over ribeye, actual was 1.47 cm; fat thickness over the ribeye, adjusted was 1.57 cm; ribeye area was 75.7 cm²; estimated percentage kidney, pelvic, and heart fat was 3.0%. Quality grade percentages were Prime (4.5%), Choice (54.1%), Good (39.9%), and Standard (1.4%). Yield grade percentages were YG 1 (4.1%), YG 2 (25.7%), YG 3 (43.9%), YG 4 (20.5%), and YG 5 (5.8%). The frequency of dark cutters in this study was 1.4%.

National Beef Quality Audit – 1991

The first of the NBQAs began in 1991. The number one goal of the NBQA-1991 was “to conduct a quality audit of slaughter steers/heifers – their carcasses, cuts and dress-off/offal items – for the U.S. beef industry in 1991, establishing baselines for present quality shortfalls and identifying targets for desired quality levels by the year 2001” (National Cattlemen's Beef Association, 1992). The NBQA-1991 aimed to obtain quality and quantity attributes of beef during the cooler stage of the beef marketing sequence. This was done to serve as a benchmark for the beef industry to have to measure what was being produced. Results from this audit showed the following USDA YG means: USDA YG, 3.2; HCW, 345.0 kg; AFT, 1.5 cm; LM area, 83.4 cm²; and KPH percentage, 2.2 (Lorenzen et al., 1993). Mean USDA QG were the following: USDA QG, Select⁸⁶; marbling score, Small²⁴; lean maturity, A⁶³; skeletal maturity, A⁷⁵; and overall maturity, A⁶⁹ (Lorenzen et al., 1993). When compared to the USDA Market Consist Report of 1974 (Abraham, 1977) the NBQA-1991 showed a numerical decrease ($P < 0.05$) of 0.3 in USDA YG, 0.08 cm less AFT, and 0.8% less KPH percentage as well as an increase in LM area of 7.1 cm² and HCW increased by 36.8 kg (Lorenzen et al., 1993). This quality audit showed the beef feeding industry that cattle were being fed to heavier weights with approximately the same amount of subcutaneous fat and with less marbling with fewer high quality grades when compared to the USDA Market Consist Report (Abraham, 1977). The genetic change in cattle at that time lead to an increase in lean production and a reduction in total fat produced (Lorenzen et al., 1993).

National Beef Quality Audit – 1995

Four years after the completion of the NBQA-1991, the second NBQA was conducted. The NBQA-1991 showed the beef industry that it was losing money through challenges it was facing, such as excess fat, lack of marbling, inconsistencies, and other carcass defects (Lorenzen et al., 1993). The NBQA-1995 aimed to assess whether or not progress had been made in correcting deficiencies and reducing quality concerns when comparing its results to those of the NBQA-1991 (National Cattlemen's Beef Association, 1995). The results from the NBQA-1995 showed a mixture of continued product deficiencies and successes in correcting those product quality shortfalls. Mean USDA YG and QG traits were the following: USDA YG, 2.8; HCW, 339.2 kg; AFT, 1.2 cm; LM area, 82.6 cm²; KPH percentage, 2.1; USDA QG, Select⁷⁹; marbling score, Small⁰⁶; overall maturity, A⁶⁰; skeletal maturity, A⁶³; and lean maturity, A⁵⁴ (Boleman et al., 1998). When compared with data from the NBQA-1991 (Lorenzen et al., 1993) carcasses in the NBQA-1995 were lower ($P < 0.05$) in USDA YG, AFT, HCW, KPH percentage, marbling score, and USDA QG. This quality audit proved the beef industry was moving in the right direction as far as producing a lean product. USDA YG 1 frequencies improved from 44% in 1991 to 58% in 1995, and mean USDA YG improved from 3.16 in 1991 to 2.82 in 1995. Fat thickness also decreased from 1991 (1.50 cm) to 1995 (1.19 cm). However, percentage of Prime and Choice USDA QG carcasses decreased 7% since the NBQA-1991 (Lorenzen et al., 1993). NBQA-1995 data indicate that overall, marbling scores have decreased. However, there were fewer carcasses with marbling scores that corresponded with USDA Standard (Boleman et al.,

1998). The NBQA-1995 provided cattle producers and the beef industry with information of the quality shortfalls of their product and provided them with some solutions for overcoming those problems (National Cattlemen's Beef Association, 1995).

National Beef Quality Audit – 2000

The NBQA-2000 was the third in a series of national audits that began in 1991. It continued to demonstrate the effort and progress the beef industry was making to improve the quality of its products. Mean USDA YG and QG traits were the following: USDA YG, 3.0; USDA QG, Select⁸⁵; AFT, 1.2 cm; HCW, 356.9 kg; LM area, 84.5 cm²; KPH percentage, 2.4; marbling score, Small²³; overall maturity, A⁶⁶; skeletal maturity, A⁶⁷; lean maturity, A⁶⁵ (McKenna et al., 2002). The NBQA-2000 revealed a numerically greater mean YG of 3.0 when compared to the NBQA-1995. However, the AFT mean (1.27 cm) was numerically less than the mean found in the NBQA-1991 (1.50 cm). This audit also showed that HCW were increasing as well. In the NBQA-2000, HCW averaged 354 kg, which were 18 kg heavier than in 1995 and 12 kg heavier than in 1991. In addition, an increase in the percentage of Choice carcasses and a decrease in Select carcasses over the 1995 levels were noted (National Cattlemen's Beef Association, 2000). This audit suggested that producers had made measurable efforts in managing genetics for reduction of fat in beef products.

National Beef Quality Audit – 2005

The NBQA-2005 was the fourth of previous and similar audits. Its intention, again, was to establish a new benchmark for shortfalls in beef cattle quality and identify new targets for the preferred quality of beef. In addition, this benchmark would be used as a tool in creating Beef Quality Assurance education efforts (National Cattlemen's Beef Association, 2005). Mean USDA YG and QG traits were the following: USDA YG, 2.9; USDA QG, Select⁹⁰; AFT, 1.3 cm; HCW, 359.9 kg; LM area, 86.4 cm²; KPH percentage, 2.3; marbling score, Small³²; overall maturity, A⁶⁴; skeletal maturity, A⁶⁸; lean maturity, A⁵⁷ (Garcia et al., 2008). This audit showed the continued increase in HCW, which lead to one of the conclusions of the NBQA-2005 of focusing on target weights that optimize profitability without creating productivity or product desirability problems (National Cattlemen's Beef Association, 2005).

National Beef Quality Audit – 2011

The NBQAs do not provide the final word on beef quality through their extensive research efforts. They offer valuable snapshots of the beef industry along with its strengths and weaknesses at that given point in time. In order for the beef industry to be able to correct the areas it continues to struggle in, the NBQA must be conducted to determine exactly what those shortcomings are. Having the information the NBQAs contribute to the beef industry is key because it gives direction to producers, and the industry as a whole, as they search for methods to address and correct certain challenges.

The NBQA-2011 will be the new benchmark for the beef industry, and it will help producers to improve the consistency and competitiveness of U.S. fed beef.

CHAPTER III

MATERIALS AND METHODS

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

General Overview

In-plant cooler audits were conducted in 28 federally inspected beef processing facilities throughout the United States selected to represent the major fed beef plants (Table 1). A correlation session was conducted with the collaborating institutions before the beginning of this study to ensure consistency of measurements and observations during data collection. These audits were conducted from May 2011 through February 2012 by personnel from 7 collaborating institutions. Beef processors were surveyed to obtain data representing the equivalent of one day's production, and both shifts were surveyed in those packing plants that process cattle during 2 shifts per day. Data were collected between Monday and Friday of a given week.

Carcass Assessment

Beef carcasses ($n = 9,802$), representing approximately 10 percent of each production lot, were selected randomly for the survey. Trained personnel evaluated beef carcasses to determine sex class (steer, heifer, cow or bullock), estimated breed type (native, dairy or *Bos indicus*), LM area (measured by either dot grid, blotting paper or

video image analysis camera), HCW, carcass discounts (dark cutter, blood splash, calloused ribeye, yellow fat, etc.), certified or other marketing program, country of origin (USDA, 2009), and whether the carcass was from an animal 30 months of age or older. The sex class of surveyed carcasses was determined by USDA (1997) AMS standards. Estimated breed types were classified using the protocol established by Lorenzen et al. (1993): dairy type carcasses were those in which the conformation and overall muscling were angular and thin in relation to carcass size, *Bos indicus* type carcasses had dorsal thoracic humps (*M. rhomboideus*, overlying muscles, and subcutaneous fat) greater than 10.2 cm, and carcasses with no readily distinguishable characteristics that would classify them as dairy or *Bos indicus* type were considered native. Carcasses qualifying for certified or other marketing programs were noted. United States Department of Agriculture, AMS, Meat Grading and Certification Branch personnel evaluated beef carcasses for lean maturity, skeletal maturity, marbling score, AFT, and KPH percentage (USDA, 1997).

Grade Determination

Factors collected using data sheets (Figure 1) during cooler assessment were entered and checked into Microsoft Excel for Mac 2011. A final quality grade was determined using quality grade factors that were evaluated and collected. Quality grades reported were based on the United States Standards for Grades of Carcass Beef (USDA, 1997). Maturity and marbling scores were combined using the Relationship Between Marbling, Maturity, and Carcass Quality Grade chart (USDA, 1997) depicted in Figure 2

to determine quality grades. Yield grades reported were formulated from yield grade factors such as AFT, HCW, LM area, and KPH percentage. The equation used to determine yield grade is the same that is described in the official standards (USDA, 1997). The yield grade equation was the following: Yield grade = $2.50 + (2.50 \times \text{adjusted fat thickness, inches}) + (0.20 \times \text{percent kidney, pelvic, and heart fat}) + (0.0038 \times \text{hot carcass weight, pounds}) - (0.32 \times \text{ribeye area, square inches})$.

Statistical Analysis

All analyses were performed by using JMP Software (JMP Pro, Version 9.0.0, SAS Institute Inc., Cary, NC 1989-2010) and Microsoft Excel for Mac 2011. The Fit Y by X function was used for analysis of variance, and least squares means comparisons were performed using Student's t test. Frequency distributions, means, standard deviations, minimum, and maximum values were determined using the distribution function. Tables with n values that do not add up to n = 9,802 represent samples with missing data points.

CHAPTER IV

RESULTS AND DISCUSSION

The mean USDA QG for the current study was Select⁹³, whereas the mean USDA YG was 2.9 (Table 2). Means for USDA QG and YG (Table 3) were Select⁸⁶ and 3.2 for NBQA-1991 (Lorenzen et al., 1993), Select⁷⁹ and 2.8 for NBQA-1995 (Boleman et al., 1998), Select⁸⁵ and 3.0 for NBQA-2000 (McKenna et al., 2002), and Select⁹⁰ and 2.9 for NBQA-2005 (Garcia et al., 2008). Frequency distributions of carcasses by one-half yield grade increments are shown in Figure 3. The USDA YG distributions were YG 1 (12.4%), YG 2 (41.0%), YG 3 (36.3%), YG 4 (8.6%), and YG 5 (1.6%). USDA YG distributions from NBQA-2005 (Garcia et al., 2008) were YG 1 (15.3%), YG 2 (38.8%), YG 3 (32.9%), YG 4 (10.8%), and YG 5 (2.2%). The USDA QG distributions were Prime (2.1%), Choice (58.9%), Select (32.6%), Standard (5.1%), Commercial (0.9%), and Utility (0.3%). The USDA QG distributions from NBQA-2005 (Garcia et al., 2008) were Prime (2.6%), Choice (51.9%), Select (40.2%), Standard (4.4%), Commercial (0.7%), and Utility (0.3%). When data were compared from previous audits to the NBQA-2011 data, HCW and LM area both increased numerically, whereas AFT generally stayed constant. This indicates that cattle may be fed to a specific fat thickness endpoint even though carcass sizes and weights have increased. Since the last audit, β -adrenergic agonists that have become more widely used in the beef feeding industry (Delmore et al., 2010; Scramlin et al., 2010). An increase in HCW and LM area could also be from cattle genetics and management. One such example

would be the use of Continental European breeds, which are known for being larger framed, leaner, and more muscular resulting in heavier HCW (Wheeler et al., 2005).

Marbling scores across and within USDA QG are shown in Table 4. The majority of marbling scores are in the low parts of the grades (e.g., low Prime = 78.05%, low Choice = 62.71%, etc.). Occurrence of marbling score percentages within Moderate, Modest, and Small all increased numerically since NBQA-2005 (Garcia et al., 2008). McKenna et al. (2002) reported the need to determine the number of carcasses that were graded greater than or equal to Small⁵⁰ because of the growing number of certified beef programs that include such carcasses. Current data shows that 41.2% of the carcasses surveyed had marbling scores greater than or equal to Small⁵⁰, which was numerically greater than that reported (36.6%) by McKenna et al. (2002) and (23.6%) by Garcia et al. (2008). This increase could be related to the growing number of USDA Certified Beef Programs. Currently, there are 77 program or brand names among 44 companies that are certified by USDA. Thirty-nine of those programs have initial release dates after 2005 (USDA, 2012). Therefore, they were effective after the NBQA-2005. Marbling score requirements of these programs vary, but the majority of the programs have a minimum of Small⁰⁰. However, some also have minimum requirements of Small⁵⁰. The number of marketing programs focusing on cattle that produce Choice or greater continues to increase and may be the cause of numerical increases in greater marbling scores in this audit. Table 4 also shows 46.7% of the Standard grade had Small marbling scores. This was due to carcasses having advanced

maturities. Even though those carcasses had the marbling requirement to grade Choice, the overall maturity of those carcasses downgraded their quality grade to Standard.

Distributions of carcasses represented in the USDA QG by YG matrix are reported in Table 5. Carcasses that were Choice and Select, YG 2 and 3 comprised 72.0% of the sample; comparable percentages were 67.2% for NBQA-1991 (Lorenzen et al., 1993), 75.0% for NBQA-1995 (Boleman et al., 1998), 70.5% for NBQA-2000 (McKenna et al., 2002), and 67.2% for NBQA-2005 (Garcia et al., 2008).

Nonconforming carcasses—QG of Standard and lower and (or) YG 4 and 5—represented 15.6% of the sample. Garcia et al. (2008) reported 18.3% of the carcasses in NBQA-2005 to be nonconforming.

Carcasses that were A-maturity comprised 92.8% of the carcasses sampled (Table 6). The Beef Export Verification program for Japan (USDA, 2005) requires that beef carcasses from cattle of unknown chronological ages must be A⁴⁰ or more youthful in overall maturity. Of all carcasses evaluated, 23.2% were A⁴⁰ or younger; within all A-maturity carcasses, 25.0% met this qualification. A numerical increase also was seen in the percentage of B maturity carcasses. The percentage of B maturity carcasses in NBQA-2011 was 6.0% as compared to 1.7% in the NBQA-2005.

In data not reported in tabular form, 3.2% of the carcasses were dark cutters. The discounts for dark cutters were one-third grade (1.07%), one-half grade (0.77%), two-thirds grade (0.66%), and full grade (0.69%). McKenna et al. (2002) reported 2.3% dark cutters with these discount distributions: one-third grade (1.0%), one-half grade (0.6%), two-thirds grade (0.4%), and full grade (0.3%). Data from the NBQA-2005 (Garcia et

al., 2008) showed 1.9% of carcasses sampled were dark cutters with discounts of one-third grade (0.7%), one-half grade (0.3%), two-thirds grade (0.3%), and full grade (0.5%). Data from the NBQA-2011 showed an increase in percentage of dark cutters from previous audits: of those carcasses that qualified as dark cutters, 57.5% occurred during the fall and winter months of September through February. Other carcass defects included blood splash (0.3%), yellow fat (0.1%), and calloused ribeye (0.05%).

Least squares means for carcass traits within each USDA QG are shown in Table 7. As QG increased from Standard to Prime, numerical YG, AFT, and KPH percentage increased ($P < 0.05$). This is to be expected because carcasses with higher quality grades tend to be fatter. Higher AFT and KPH percentage both cause YG to become numerically larger. In contrast, LM area decreased as QG increased from Standard to Prime. Carcasses that were Standard had greater ($P < 0.05$) marbling scores than those that graded Select. Those carcasses had marbling scores qualifying them for Choice or Prime quality grades. However, they were downgraded to the Standard grade because their overall maturity was B or older or they were discounted for being dark cutters. Carcasses qualifying for higher USDA QG had numerically larger HCW and smaller LM area, which is a trend that has been consistent throughout all the NBQAs.

Carcass trait means within each USDA YG are displayed in Table 8. As USDA YG increased (from YG 1 to YG 5), marbling, QG, AFT, HCW, and KPH percentage also increased, whereas LM area decreased ($P < 0.05$). This is to be expected because of how AFT, HCW, KPH, and LM area affect YG due to the USDA yield grade equation (USDA, 1997). Carcasses with greater yield grades are fatter and also tend to have

greater marbling scores and QG. These relationships between carcass traits and USDA YG are similar to those reported by Lorenzen et al. (1993), Boleman et al. (1998), McKenna et al. (2002), and Garcia et al. (2008).

Carcass traits within HCW groups are displayed in Table 9. As HCW increased, numerical YG, AFT, marbling score, QG, and LM area increased ($P < 0.05$). These findings are comparable to those reported in the NBQA-2000 (McKenna et al., 2002) and the NBQA-2005 (Garcia et al., 2008). Frequency distribution of carcasses by weight group is reported in Figure 4. McKenna et al. (2002) discussed discounts for carcasses weighing 431 kg and reported 4.6% of carcasses in the NBQA-2000 exceeded this weight. Garcia et al. (2008) reported that 5.1% of the carcasses in the NBQA-2005 weighed more than 431 kg. Current data showed that 11.1% of the carcasses sampled exceed 431 kg. However, in the beef industry today, it is more common to see major discounts for carcasses exceeding 454 kg. In this study, 3.7% of the carcasses sampled weighed greater than 454 kg. HCW have gradually increased since the first NBQA-1991 (Lorenzen et al., 1993). As previously mentioned, the prevalence of Continental European breeds in American breeding systems and the popularity in use of growth promotants and β -adrenergic agonists could have led to this increase in HCW. LM area numerically increased with each carcass weight group ($P < 0.05$). The trend of HWC and LM area increasing with each NBQA ties into one of the top priorities of reducing extremes in ribeye area and carcass weight discussed at the NBQA-2011 Strategy Workshop (National Cattlemen's Beef Association, 2012).

Least squares means for carcass traits within fat thickness categories are reported in Table 10. As fat thickness increased, numerical YG, QG, HCW, and KPH percentage also increased ($P < 0.05$). The increase in marbling and KPH percentage as fat thickness increased was to be expected because the growth rates of these fat depots are related (Kempster, 1981). These relationships between carcass traits and USDA YG are similar to those reported by Lorenzen et al. (1993), Boleman et al. (1998), McKenna et al. (2002), and Garcia et al. (2008). Furthermore, Garcia et al. (2008) reported that QG increased ($P < 0.05$) with increasing fat thickness up to 1.51 cm, but did not increase after that point. The same trend was seen in the data from the NBQA-2011. This shows that increasing fat thickness in cattle beyond a specific point does not ensure increased marbling or QG. In addition, the correlation coefficient between AFT and marbling was 0.3354, which shows that an increase in AFT does not necessarily mean that there will be an increase in marbling score.

The sex-class distribution of carcasses was: steers (63.47%), heifers (36.37%), cows (0.13%), and bullocks (0.03%). The percentages were similar to those reported in the NBQA-2005 (Garcia et al., 2008), which included steers (63.7%), heifers (36.2%), cows (0.05%), and bullocks (0.05%). Carcass traits stratified by sex class are displayed in Table 11. Carcasses from steers and heifers had more youthful ($P < 0.05$) overall maturity scores than carcasses from bullocks and cows. Bullock carcasses are younger than cows in chronological age and skeletal maturity. However, they tend to have more advanced lean maturities because bullock carcasses have ribeyes that are dark red in color and more coarse textured (USDA, 1997). Heifer carcasses had older overall

maturity scores (A^{63}) than steer carcasses (A^{56}) in this study ($P < 0.05$). Steer carcasses had significantly ($P < 0.05$) heavier HCW and larger LM area than heifer carcasses. However, heifer carcasses had greater AFT, KPH, and marbling scores than steer carcasses. Bullock carcasses had ($P < 0.05$) smaller numerical YG, QG, and marbling scores than those of steer, heifer, and cow carcasses.

Current data showed that carcass estimated breed types were native type (88.3%), dairy type (9.9%), and *Bos indicus* (1.8%). The trend for breed type seen over time in these surveys was an increasing number of carcasses classified as dairy type. Corresponding percentages of dairy carcasses from previous audits were 6.9% for NBQA-2000 (McKenna et al., 2002) and 8.3% for NBQA-2005 (Garcia et al., 2008). Carcass traits stratified by estimated breed type are reported in Table 12. Among breed types, marbling score, HCW, KPH, and LM area differed significantly. Native-type carcasses had the greatest ($P < 0.05$) AFT, heaviest HCW, and the largest LM area. Dairy-type carcasses had greater ($P < 0.05$) marbling scores than the other two breed types.

The frequency distribution of carcasses from different countries of origin (USDA, 2009) were United States (97.7%), Mexico (1.8%), and Canada (0.5%). Figure 5 displays the frequency distribution of carcasses identified as eligible for certain certified or marketing programs (USDA, 2012). Frequencies were as follows: age and source verified (10.7%), $\leq A^{40}$ (10.0%), Certified Angus Beef (9.3%), top Choice (4.1%), natural (0.6%), and Non-Hormone Treated Cattle (0.5%). There were no organic

programs observed. This is the first time in the history of the National Beef Quality Audits that this information has been obtained.

CHAPTER V

CONCLUSIONS

The NBQA serves as a benchmark study to measure and report certain producer-related cattle and carcass traits in the US beef industry. Some of the trends observed in the NBQA-2011 included an increase in USDA Prime and Choice carcasses, increased HCW, increased LM area, and more dairy-type carcasses compared with previous audits. Also, the percentage of nonconforming carcasses—QG of Standard and lower and (or) YG 4 and 5—has decreased when compared to the last NBQA. This indicates that the beef industry is improving at providing a more uniform, consistent product. Information from this audit adds to the existing knowledge base of the beef industry regarding quality related attributes. Findings will be used to mark the progress that has been made in the industry and pinpoint the areas of improvement for the future.

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APPENDIX A

Table 1. Company and location of surveyed plants

Company	Location
AB Foods	Toppenish, WA
Cargill Meat Solutions	Fort Morgan, CO
Cargill Meat Solutions	Schuyler, NE
Cargill Meat Solutions	Dodge City, KS
Cargill Meat Solutions	Plainview, TX
Cargill Meat Solutions	Friona, TX
Creekstone Farms	Arkansas City, KS
Greater Omaha Packing Company	Omaha, NE
Harris Ranch Beef Company	Selma, CA
JBS Green Bay	Green Bay, WI
JBS Plainwell	Plainwell, MI
JBS Souderton	Souderton, PA
JBS Swift Cactus	Cactus, TX
JBS Swift Grand Island	Grand Island, NE
JBS Swift Greeley	Greeley, CO
JBS Swift Hyrum	Hyrum, UT
JBS Tolleson	Tolleson, AZ
National Beef	Brawley, CA
National Beef	Dodge City, KS
National Beef	Liberal, KS
Nebraska Beef	Omaha, NE
Sam Kane Beef Processors	Corpus Christi, TX
Tyson Fresh Meats	Joslin, IL
Tyson Fresh Meats	Finney County, KS
Tyson Fresh Meats	Dakota City, NE
Tyson Fresh Meats	Lexington, NE
Tyson Fresh Meats	Amarillo, TX
Tyson Fresh Meats	Pasco, WA

Table 2. Means, standard deviations, and minimum and maximum values for USDA carcass grade traits

Trait	Mean	SD	Minimum	Maximum
USDA yield grade	2.9	0.9	-0.2	7.1
USDA quality grade ¹	693	61	220	887
Adjusted fat thickness, cm	1.30	0.52	-1.02 ⁴	3.96
HCW, kg	374.0	46.5	140.4	545.7
LM area, cm ²	88.8	11.7	50.3	148.4
KPH, %	2.3	0.8	0.0	5.0
Marbling score ²	440	98	100	960
Lean maturity ³	154	28	110	550
Skeletal maturity ³	162	34	100	600
Overall maturity ³	159	29	110	585

¹100 = Canner⁰⁰, 400 = Commercial⁰⁰, 600 = Select⁰⁰, and 800 = Prime⁰⁰.

²100 = Practically devoid⁰⁰, 300 = Slight⁰⁰, 500 = Modest⁰⁰, 700 = Slightly Abundant⁰⁰, and 900 = Abundant⁰⁰.

³100 = A⁰⁰ and 500 = E⁰⁰.

⁴Minimum value is less than 0 because of data conversion from a preliminary YG of less than 2.0.

Table 3. Means for USDA carcass grade traits from NBQA-1991, NBQA-1995, NBQA-2000, NBQA-2005, and NBQA-2011

Trait	NBQA-1991	NBQA-1995	NBQA-2000	NBQA-2005	NBQA-2011
USDA yield grade	3.2	2.8	3.0	2.9	2.9
USDA quality grade ¹	686	679	685	690	693
Adjusted fat thickness, cm	1.5	1.2	1.2	1.3	1.3
HCW, kg	345.0	339.2	356.9	359.9	374.0
LM area, cm ²	83.4	82.6	84.5	86.4	88.8
KPH, %	2.2	2.1	2.4	2.3	2.3
Marbling score ²	424	406	423	432	440
Lean maturity ³	163	154	165	157	154
Skeletal maturity ³	175	163	167	168	162
Overall maturity ³	169	160	166	164	159

¹100 = Canner⁰⁰, 400 = Commercial⁰⁰, 600 = Select⁰⁰, and 800 = Prime⁰⁰.

²100 = Practically devoid⁰⁰, 300 = Slight⁰⁰, 500 = Modest⁰⁰, 700 = Slightly Abundant⁰⁰, and 900 = Abundant⁰⁰.

³100 = A⁰⁰ and 500 = E⁰⁰.

Table 4. Occurrence¹ of marbling scores within USDA quality grades²

Marbling score, %	Overall ³	Prime	Choice	Select	Standard
Abundant	0.03	1.46			
Moderately Abundant	0.44	20.49			
Slightly Abundant	1.78	78.05	0.09		
Moderate	4.99		8.27		
Modest	17.41		28.93	0.06	
Small	39.89		62.71	0.38	46.73
Slight+	19.51			56.20	20.61
Slight-	14.85			43.35	11.63
Traces	1.02				19.59
Practically Devoid	0.08				1.43

¹Rounding error prevents all categories from adding to 100.0.

²USDA quality grade was affected by maturity and dark cutting.

³Overall category represents USDA quality grades of Prime, Choice, Select, Standard, Commercial, Utility, and Cutter.

Table 5. Percentage distribution¹ of carcasses stratified by USDA quality² and yield grades

USDA yield grade	USDA quality grade, %						
	Prime	Choice	Select	Standard	Commercial	Utility	Cutter
1	0.00	3.56	7.33	1.21	0.08	0.05	0.01
2	0.37	22.77	15.34	2.02	0.26	0.14	0.01
3	1.81	25.86	8.02	1.17	0.29	0.05	0.00
4	0.53	6.32	1.37	0.26	0.14	0.04	0.00
5	0.14	1.26	0.13	0.04	0.04	0.01	0.00

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

²USDA quality grade was affected by maturity and dark-cutting beef, and there were no Canner carcasses observed in the audit.

Table 6. Characteristics of overall maturity¹

Overall maturity	n	Percentage of sample	Mean	SD	Minimum	Maximum
A	8,901	92.80	153	14	110	195
B	578	6.03	218	21	200	295
C	102	1.06	307	16	300	370
D	6	0.06	444	28	410	485
E	5	0.05	531	39	500	585

¹100 = A⁰⁰, 200 = B⁰⁰, 300 = C⁰⁰, 400 = D⁰⁰, and 500 = E⁰⁰.

Table 7. Least squares means for carcass traits (SEM¹) within USDA quality grades

Trait	USDA quality grade			
	Prime (n = 205)	Choice (n = 5,634)	Select (n = 3,121)	Standard (n = 490)
USDA yield grade	3.7 ^a (0.06)	3.1 ^b (0.01)	2.6 ^c (0.02)	2.6 ^c (0.04)
USDA quality grade ²	819 ^a (1.59)	727 ^b (0.30)	650 ^c (0.41)	582 ^d (1.03)
Adjusted fat thickness, cm	1.68 ^a (0.03)	1.40 ^b (0.008)	1.14 ^c (0.009)	1.11 ^c (0.02)
HCW, kg	385.4 ^a (3.22)	377.9 ^b (0.62)	366.9 ^d (0.83)	373.4 ^c (2.12)
LM area, cm ²	83.8 ^c (0.81)	87.5 ^b (0.15)	91.1 ^a (0.21)	90.9 ^a (0.52)
KPH, %	2.4 ^a (0.06)	2.4 ^a (0.01)	2.2 ^b (0.01)	1.8 ^c (0.04)
Marbling score ³	759 ^a (4.0)	484 ^b (0.8)	351 ^d (1.0)	377 ^c (2.6)
Lean maturity ⁴	151 ^b (1.5)	151 ^b (0.3)	151 ^b (0.4)	201 ^a (1.0)
Skeletal maturity ⁴	160 ^b (1.6)	159 ^b (0.3)	154 ^c (0.4)	206 ^a (1.0)
Overall maturity ⁴	157 ^b (1.3)	155 ^b (0.2)	153 ^c (0.3)	204 ^a (0.8)

^{a-d}Means within a row lacking a common superscript letter differ ($P < 0.05$).

¹SEM is the SE of the least squares means.

²100 = Canner⁰⁰, 400 = Commercial⁰⁰, 600 = Select⁰⁰, and 800 = Prime⁰⁰.

³100 = Practically devoid⁰⁰, 300 = Slight⁰⁰, 500 = Modest⁰⁰, and 700 = Slightly Abundant⁰⁰.

⁴100 = A⁰⁰ and 500 = E⁰⁰.

Table 8. Least squares means for carcass traits (SEM¹) within USDA yield grades

Trait	USDA yield grade				
	1 (n = 1,012)	2 (n = 3,338)	3 (n = 2,955)	4 (n = 700)	5 (n = 131)
USDA yield grade	1.6 ^e (0.009)	2.6 ^d (0.005)	3.4 ^c (0.005)	4.4 ^b (0.01)	5.5 ^a (0.03)
USDA quality grade ²	653 ^e (2.30)	684 ^d (1.26)	706 ^c (1.33)	713 ^b (2.73)	729 ^a (6.34)
Adjusted fat thickness, cm	0.72 ^e (0.01)	1.08 ^d (0.006)	1.45 ^c (0.006)	2.05 ^b (0.01)	2.64 ^a (0.03)
HCW, kg	351.8 ^e (1.36)	368.7 ^d (0.75)	383.3 ^c (0.80)	399.8 ^b (1.64)	411.1 ^a (3.79)
LM area, cm ²	100.3 ^a (0.32)	91.4 ^b (0.17)	84.8 ^c (0.18)	81.1 ^d (0.38)	75.2 ^e (0.88)
KPH, %	1.96 ^e (0.02)	2.19 ^d (0.01)	2.39 ^c (0.01)	2.62 ^b (0.03)	3.30 ^a (0.06)
Marbling score ³	373 ^e (2.9)	422 ^d (1.6)	466 ^c (1.7)	497 ^b (3.4)	543 ^a (7.9)
Lean maturity ⁴	157 ^a (0.9)	155 ^b (0.5)	152 ^c (0.5)	153 ^{bc} (1.1)	151 ^{bc} (2.5)
Skeletal maturity ⁴	161 ^b (1.1)	160 ^b (0.6)	160 ^b (0.6)	166 ^a (1.3)	164 ^{ab} (2.9)
Overall maturity ⁴	159 ^a (0.9)	158 ^{ab} (0.5)	157 ^b (0.5)	160 ^a (1.1)	159 ^{ab} (2.1)

^{a-d}Means within a row lacking a common superscript letter differ ($P < 0.05$).

¹SEM is the SE of the least squares means.

²100 = Canner⁰⁰, 400 = Commercial⁰⁰, 600 = Select⁰⁰, and 800 = Prime⁰⁰.

³100 = Practically devoid⁰⁰, 300 = Slight⁰⁰, 500 = Modest⁰⁰, and 700 = Slightly Abundant⁰⁰.

⁴100 = A⁰⁰ and 500 = E⁰⁰.

Table 9. Least squares means for carcass traits (SEM¹) within carcass weight groups

Trait	Carcass weight group, kg						
	<226.8 (n = 14)	226.8 to 272.1 (n = 136)	272.2 to 317.5 (n = 933)	317.5 to 362.8 (n = 2,780)	362.9 to 408.2 (n = 3,524)	408.2 to 453.5 (n = 1,901)	>453.5 (n = 359)
USDA yield grade	1.6 ^g (0.24)	2.1 ^f (0.08)	2.5 ^e (0.03)	2.8 ^d (0.02)	3.0 ^c (0.01)	3.2 ^b (0.02)	3.6 ^a (0.05)
USDA quality grade ²	621 ^d (19.85)	654 ^d (6.44)	680 ^c (2.47)	690 ^b (1.43)	692 ^b (1.26)	694 ^{ab} (1.72)	702 ^a (3.93)
Adjusted fat thickness, cm	0.59 ^f (0.13)	0.85 ^f (0.04)	1.09 ^e (0.02)	1.23 ^d (0.01)	1.33 ^c (0.008)	1.40 ^b (0.01)	1.61 ^a (0.03)
HCW, kg	197.4 ^g (3.44)	257.1 ^f (1.10)	300.6 ^e (0.42)	342.6 ^d (0.24)	384.9 ^c (0.22)	426.9 ^b (0.30)	472.0 ^a (0.68)
LM area, cm ²	68.2 ^g (2.84)	74.4 ^f (0.91)	80.4 ^e (0.35)	85.3 ^d (0.20)	90.1 ^c (0.18)	94.5 ^b (0.24)	97.8 ^a (0.56)
KPH, %	1.8 ^{cd} (0.22)	2.1 ^{bcd} (0.08)	2.3 ^{ab} (0.03)	2.3 ^a (0.02)	2.3 ^a (0.01)	2.2 ^{bc} (0.02)	2.1 ^d (0.04)
Marbling score ³	360 ^e (25.9)	378 ^e (8.3)	416 ^d (3.2)	433 ^c (1.8)	447 ^b (1.6)	451 ^b (2.2)	481 ^a (5.1)
Lean maturity ⁴	191 ^a (7.2)	158 ^{bc} (2.4)	151 ^d (0.9)	152 ^d (0.5)	154 ^c (0.5)	156 ^{bc} (0.6)	158 ^b (1.4)
Skeletal maturity ⁴	185 ^a (9.0)	158 ^{cd} (2.9)	157 ^d (1.1)	159 ^d (0.6)	162 ^c (0.6)	166 ^b (0.8)	175 ^a (1.8)
Overall maturity ⁴	188 ^a (7.5)	158 ^{cde} (2.4)	154 ^e (0.9)	156 ^e (0.5)	159 ^d (0.5)	162 ^c (0.7)	168 ^b (1.5)

^{a-d}Means within a row lacking a common superscript letter differ ($P < 0.05$).

¹SEM is the SE of the least squares means.

²100 = Canner⁰⁰, 400 = Commercial⁰⁰, 600 = Select⁰⁰, and 800 = Prime⁰⁰.

³100 = Practically devoid⁰⁰, 300 = Slight⁰⁰, 500 = Modest⁰⁰, and 700 = Slightly Abundant⁰⁰.

⁴100 = A⁰⁰ and 500 = E⁰⁰.

Table 10. Least squares means for carcass traits (SEM¹) within fat thickness groups

Trait	Fat thickness, cm									
	<0.51 (n = 347)	0.51 to 0.74 (n = 1,026)	0.76 to 0.99 (n = 1,164)	1.02 to 1.25 (n = 2,372)	1.27 to 1.50 (n = 1,535)	1.52 to 1.75 (n = 1,832)	1.78 to 2.01 (n = 543)	2.03 to 2.26 (n = 499)	2.29 to 2.52 (n = 200)	>2.52 (n = 208)
USDA yield grade	1.8 ^l (0.03)	2.1 ⁱ (0.02)	2.4 ^h (0.02)	2.7 ^g (0.01)	3.0 ^f (0.02)	3.4 ^e (0.01)	3.7 ^d (0.03)	4.1 ^c (0.03)	4.3 ^b (0.04)	5.0 ^a (0.04)
USDA quality grade ²	640 ^g (3.96)	664 ^f (2.30)	676 ^e (2.14)	688 ^d (1.49)	699 ^c (1.85)	702 ^c (1.69)	710 ^b (3.10)	713 ^{ab} (3.24)	706 ^{bc} (5.13)	723 ^a (5.02)
Adjusted fat thickness, cm	0.29 ⁱ (0.005)	0.63 ⁱ (0.003)	0.87 ^h (0.003)	1.11 ^g (0.002)	1.37 ^f (0.002)	1.60 ^e (0.002)	1.86 ^d (0.004)	2.12 ^c (0.004)	2.38 ^b (0.006)	2.81 ^a (0.006)
HCW, kg	341.2 ^g (2.25)	355.7 ^f (1.42)	365.7 ^e (1.33)	373.0 ^d (0.93)	378.6 ^c (1.16)	380.9 ^c (1.06)	386.5 ^b (1.94)	390.9 ^a (2.03)	392.4 ^a (3.18)	395.7 ^a (3.15)
LM area, cm ²	86.3 ^{de} (0.62)	89.1 ^b (0.36)	90.6 ^a (0.34)	89.6 ^b (0.24)	89.6 ^b (0.30)	88.1 ^c (0.27)	87.2 ^{cd} (0.50)	86.2 ^d (0.52)	85.8 ^{de} (0.82)	84.3 ^e (0.81)
KPH, %	2.05 ^f (0.04)	2.11 ^f (0.02)	2.24 ^e (0.02)	2.27 ^e (0.02)	2.28 ^{de} (0.02)	2.36 ^c (0.02)	2.40 ^{bc} (0.04)	2.35 ^{cd} (0.04)	2.51 ^b (0.06)	2.77 ^a (0.05)
Marbling score ³	369 ⁱ (5.0)	394 ^h (2.9)	409 ^g (2.7)	432 ^f (1.9)	448 ^e (2.4)	462 ^d (2.2)	478 ^c (4.0)	495 ^b (4.1)	501 ^b (6.6)	521 ^a (6.4)
Lean maturity ⁴	169 ^a (1.5)	159 ^b (0.9)	154 ^c (0.8)	154 ^c (0.6)	153 ^c (0.7)	153 ^c (0.7)	152 ^c (1.2)	154 ^c (1.2)	154 ^c (2.0)	151 ^c (1.9)
Skeletal maturity ⁴	164 ^{bcd} (1.8)	160 ^{de} (1.1)	158 ^e (1.0)	159 ^e (0.7)	162 ^{cd} (0.9)	165 ^b (0.8)	165 ^{bc} (1.5)	173 ^a (1.5)	169 ^{ab} (2.4)	171 ^a (2.4)
Overall maturity ⁴	167 ^a (1.6)	160 ^{bc} (0.9)	156 ^e (0.9)	157 ^{de} (0.6)	158 ^{cde} (0.7)	160 ^{bc} (0.7)	159 ^{bcd} (1.2)	165 ^a (1.3)	162 ^{ab} (2.0)	163 ^{ab} (2.0)

^{a-d}Means within a row lacking a common superscript letter differ ($P < 0.05$).

¹SEM is the SE of the least square means.

²100 = Canner⁰⁰, 400 = Commercial⁰⁰, 600 = Select⁰⁰, and 800 = Prime⁰⁰.

³100 = Practically devoid⁰⁰, 300 = Slight⁰⁰, 500 = Modest⁰⁰, and 700 = Slightly Abundant⁰⁰.

⁴100 = A⁰⁰ and 500 = E⁰⁰.

Table 11. Least squares means for carcass traits (SEM¹) within sex class

Trait	Sex class			
	Steer (n = 6,171)	Heifer (n = 3,536)	Cow (n = 13)	Bullock (n = 3)
USDA yield grade	3.0 ^a (0.01)	2.9 ^a (0.02)	2.6 ^a (0.26)	1.4 ^b (0.50)
USDA quality grade ²	690 ^a (0.97)	691 ^a (1.28)	562 ^b (20.97)	380.7 ^c (43.66)
Adjusted fat thickness, cm	1.23 ^b (0.006)	1.41 ^a (0.009)	0.73 ^c (0.14)	0.51 ^c (0.29)
HCW, kg	386.8 ^a (0.56)	352.1 ^b (0.73)	359.7 ^b (13.08)	399.4 ^{ab} (25.05)
LM area, cm ²	89.2 ^a (0.15)	88.0 ^b (0.20)	77.9 ^c (3.24)	101.9 ^a (6.74)
KPH, %	2.2 ^b (0.01)	2.4 ^a (0.01)	1.5 ^c (0.21)	0.7 ^c (0.43)
Marbling score ³	436 ^b (1.3)	448 ^a (1.7)	488 ^{ab} (27.1)	280 ^c (56.5)
Lean maturity ⁴	154 ^d (0.4)	155 ^c (0.5)	232 ^b (7.6)	400 ^a (19.3)
Skeletal maturity ⁴	158 ^c (0.4)	169 ^b (0.6)	302 ^a (9.2)	177 ^{bc} (19.2)
Overall maturity ⁴	156 ^c (0.4)	163 ^b (0.5)	276 ^a (7.8)	275 ^a (19.8)

^{a-d}Means within a row lacking a common superscript letter differ ($P < 0.05$).

¹SEM is the SE of the least squares means.

²100 = Canner⁰⁰, 400 = Commercial⁰⁰, 600 = Select⁰⁰, and 800 = Prime⁰⁰.

³100 = Practically devoid⁰⁰, 300 = Slight⁰⁰, 500 = Modest⁰⁰, and 700 = Slightly Abundant⁰⁰.

⁴100 = A⁰⁰ and 500 = E⁰⁰.

Table 12. Least squares means for carcass traits (SEM¹) within estimated breed types

Trait	Estimated breed type		
	Native (n = 7,776)	Dairy (n = 876)	<i>Bos indicus</i> (n = 159)
USDA yield grade	2.9 ^a (0.01)	2.9 ^a (0.03)	2.7 ^b (0.07)
USDA quality grade ²	689 ^a (0.88)	695 ^a (2.66)	689 ^a (6.13)
Adjusted fat thickness, cm	1.34 ^a (0.005)	0.80 ^c (0.02)	0.99 ^b (0.04)
HCW, kg	375.2 ^a (0.53)	367.7 ^b (1.57)	335.2 ^c (3.77)
LM area, cm ²	89.6 ^a (0.13)	79.4 ^c (0.38)	82.4 ^b (0.89)
KPH, %	2.2 ^c (0.009)	2.3 ^b (0.03)	2.5 ^a (0.06)
Marbling score ³	440 ^b (1.1)	451 ^a (3.3)	424 ^c (7.7)
Lean maturity ⁴	155 ^a (0.3)	154 ^a (1.0)	152 ^a (2.3)
Skeletal maturity ⁴	163 ^a (0.4)	157 ^b (1.2)	154 ^b (2.7)
Overall maturity ⁴	160 ^a (0.3)	156 ^b (1.0)	154 ^b (2.3)

^{a-d}Means within a row lacking a common superscript letter differ ($P < 0.05$).

¹SEM is the SE of the least squares means.

²100 = Canner⁰⁰, 400 = Commercial⁰⁰, 600 = Select⁰⁰, and 800 = Prime⁰⁰.

³100 = Practically devoid⁰⁰, 300 = Slight⁰⁰, 500 = Modest⁰⁰, and 700 = Slightly Abundant⁰⁰.

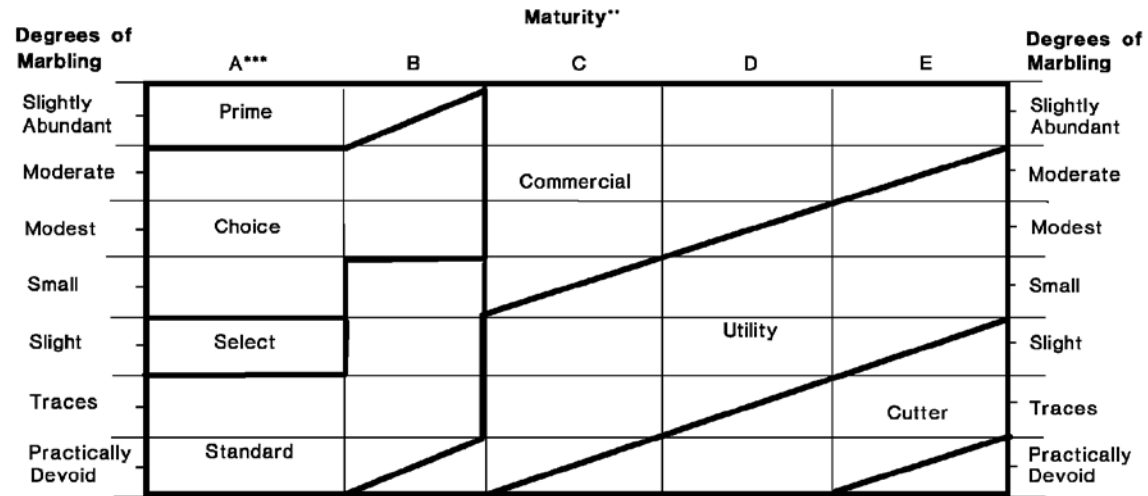
⁴100 = A⁰⁰ and 500 = E⁰⁰.

APPENDIX B

Car. ID/Sequence # _____	L. MAT.	A	B	C	D	E		
Car. Wt. (lbs.) _____	S. MAT.	A	B	C	D	E		
REA (in²) _____	PYG	1	2	3	4	5		
Sex: S H B C	% KPH	0	1	2	3	4	5	
Native	MARB	PD	TR	SL	SM	MT	MD	SA MA
Brahman	DARK C.	1/3	1/2	2/3	FULL	B. Spl.	Call.	Yellow Fat
Dairy	PROGRAM	CAB	Top Ch.	NHTC	A40	G_____	In-House_____	
USA CAN MEX		Angus Stamp	Organic	Natural	ASV	30 Month	Other_____	

Figure 1. Example of data sheet used during data collection.

Relationship Between Marbling, Maturity, and Carcass Quality Grade*



* Assumes that firmness of lean is comparably developed with the degree of marbling and that the carcass is not a "dark cutter."

** Maturity increases from left to right (A through E).

*** The A maturity portion of the Figure is the only portion applicable to bullock carcasses.

Figure 2. Relationship between marbling, maturity, and carcass quality grade chart (USDA, 1997).

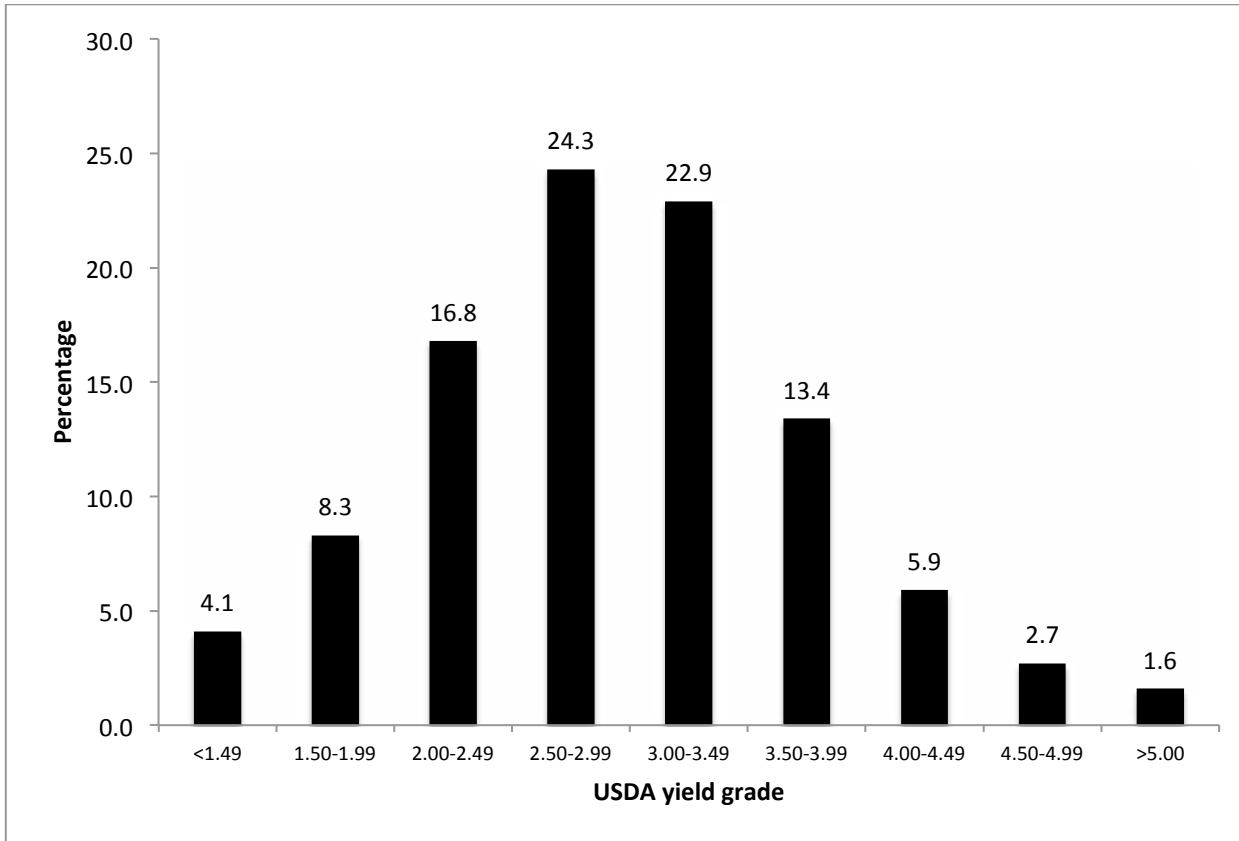


Figure 3. Frequency distribution of carcass by one-half yield grade increments.

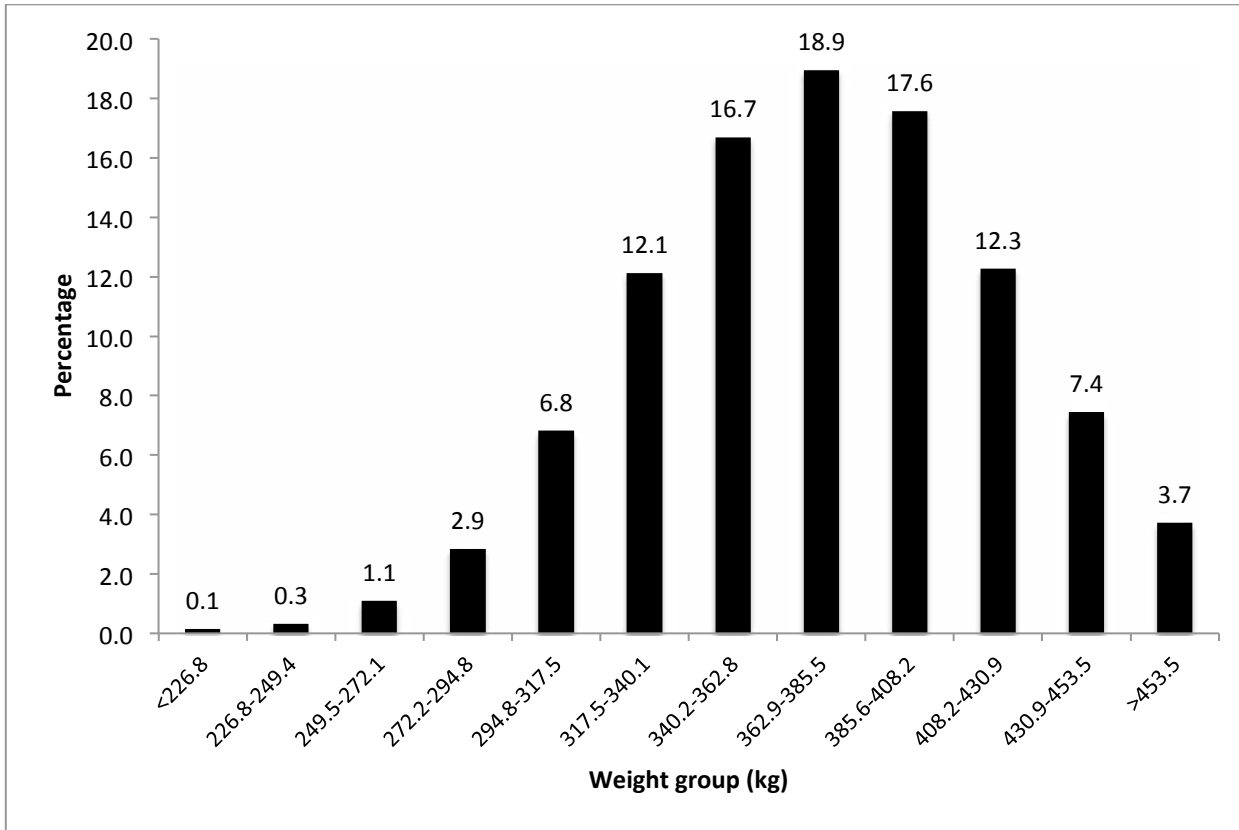


Figure 4. Frequency distribution of carcasses by weight groups.

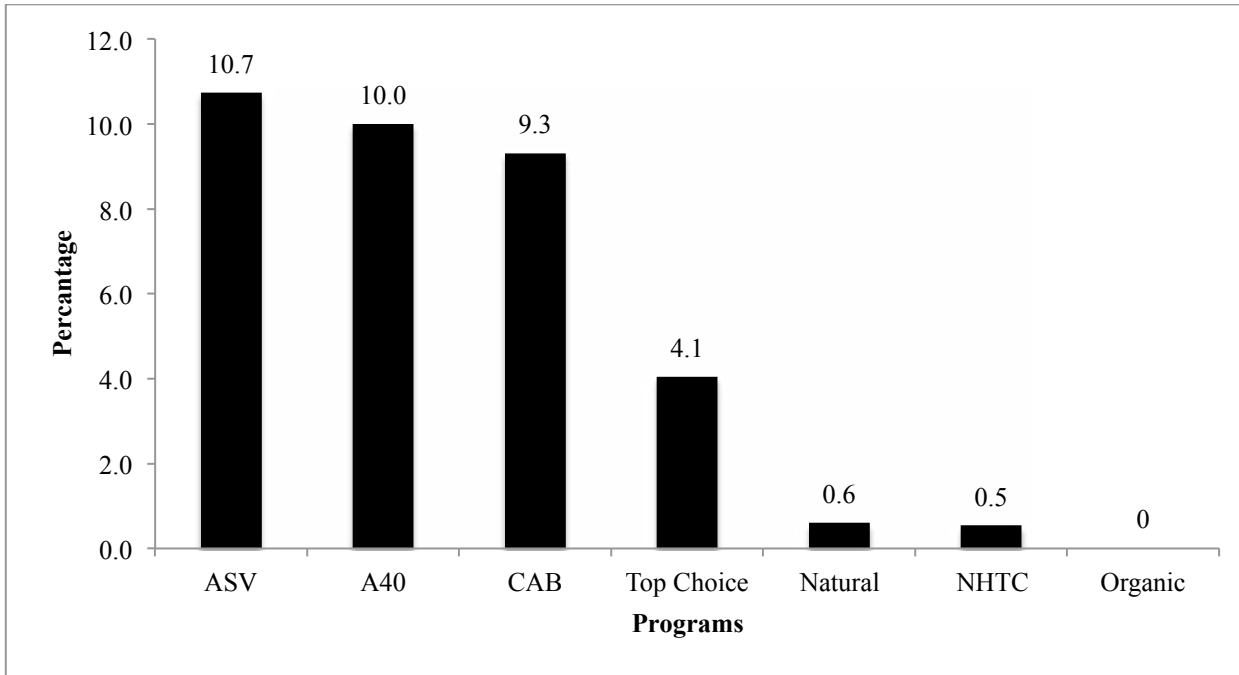


Figure 5. Frequency distribution of different certified and marketing programs. ASV is age and source verified; A40 is for carcasses that meet the carcass maturity requirements for exporting to Japan; CAB is Certified Angus Beef; Top Choice is all other top Choice programs other than CAB; Natural is for carcasses qualifying for natural programs; NHTC is Non-Hormone Treated Cattle; and Organic is for carcasses qualify for organic programs.