National Beef Quality Audit–2011: In-plant survey of targeted carcass characteristics related to quality, quantity, value, and marketing of fed steers and heifers[1,2]

M. C. Moore,* G. D. Gray,* D. S. Hale,* C. R. Kerth,* D. B. Griffin,* J. W. Savell,*[3] 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 Jr.,‖ L. M. Christensen,‖ S. D. Shackelford,¶ D. A. King,¶ T. L. Wheeler,¶ L. R. Meadows, and M. E. O'Connor††**

*Department of Animal Science, Texas A&M AgriLife Research, Texas A&M University, College Station 77843-2471; †Department of Dairy and Animal Science, The Pennsylvania State University, University Park 16082; ‡Department of Animal Sciences, Colorado State University, Fort Collins 80523-1171; §Department of Animal Science, Oklahoma State University, Stillwater 74078; #Department of Agricultural Sciences, West Texas A&M University, Canyon 79016; ‖Department of Animal Science, California Polytechnic State University, San Luis Obispo 93407; ¶Roman L. Hruska US Meat Animal Research Center, ARS-USDA, Clay Center, NE 68933-0166; **Agricultural Marketing Service-USDA, 13952 Denver West Parkway, Building 53, Suite 350, Golden, CO 80402; ††Agricultural Marketing Service-USDA, 1400 Independence Avenue, SW, Stop 0249, Washington, DC 20250-0249

ABSTRACT: The 2011 National Beef Quality Audit (NBQA-2011) assessed the current status of quality and consistency of fed steers and heifers. Beef carcasses (n = 9,802), representing approximately 10% 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 the following traits and frequencies: sex classes of steer (63.5%), heifer (36.4%), cow (0.1%), and bullock (0.03%); dark cutters (3.2%); blood splash (0.3%); yellow fat (0.1%); calloused rib eye (0.05%); overall maturities of A (92.8%), B (6.0%), and C or greater (1.2%); estimated breed types of native (88.3%), dairy type (9.9%), and *Bos indicus* (1.8%); and country of origin of United States (97.7%), Mexico (1.8%), and Canada (0.5%). 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%); no organic programs were observed. Mean USDA yield grade (YG) traits were USDA YG (2.9), HCW (374.0 kg), adjusted fat thickness (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 quality grade (QG) traits were USDA quality grade ($Select^{93}$), marbling score ($Small^{40}$), overall maturity (A^{59}), lean maturity (A^{54}), and skeletal maturity (A^{62}). 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 3 or 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.

Key words: beef quality, carcass, market survey, meat grade

J. Anim. Sci. 2012.90:5143–5151
doi:10.2527/jas2012-5550

INTRODUCTION

The National Beef Quality Audit (**NBQA**) began in the early 1990s 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 should be conducted every 4 to 5 yr, so changes in the fed beef supply could

[1]This project was funded in part by the Beef Checkoff, Cattlemen's Beef Board, Centennial, CO.

[2]USDA is an equal opportunity employer. Mention of trade names, proprietary products, or specified equipment does not constitute a guarantee or warranty by the USDA and does not imply approval to the exclusion of other products that may be suitable.

[3]Corresponding author: j-savell@tamu.edu.

Received June 11, 2012.
Accepted August 2, 2012.

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 2011 National Beef Quality Audit (**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 20 yr, new policies and marketing practices, such as age and source verification, country of origin labeling (USDA, 2005), and development of certification programs, have affected beef marketing. Fluctuations in the economy, weather trends, improvement in cattle genetics, and varying cattle numbers could cause changes in the beef industry. For instance, the cattle population in the United States is currently at an all-time low since 1973, totaling 97.8 million animals (CME Group, 2012). The NBQA-2011 was conducted to report the current quality and consistency of beef and to 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 nonconforming carcasses (National Cattlemen's Beef Association, 2012).

MATERIALS AND METHODS

Institutional Animal Care and Use Committee approval was not required 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 1 d of 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.

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

Carcass Assessment

Beef carcasses (n = 9,802), representing approximately 10% 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 (e.g., dark cutter, blood splash, calloused rib eye, yellow fat), certified or other marketing program, country of origin (USDA, 2005), and whether the carcass was from an animal 30 mo of age or older. The sex class of surveyed carcasses was determined by USDA (1997) Agricultural Marketing Service (**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* types were considered native. Carcasses qualifying for certified or other marketing

Table 2. Means, standard deviations, and minimum and maximum values for USDA carcass grade traits (n = 9,802)

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[2]	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[3]	440	98	100	960
Lean maturity[4]	154	28	110	550
Skeletal maturity[4]	162	34	100	600
Overall maturity[4]	159	29	110	585

[1]Scores are as follows: 100 = Canner^{00}, 400 = Commercial00, 600 = Select^{00}, and 800 = Prime^{00}.

[2]Minimum value is less than zero because of data conversion from a preliminary yield grade of less than 2.0.

[3]Scores are as follows: 100 = Practically devoid^{00}, 300 = Slight^{00}, 500 = Modest^{00}, 700 = Slightly Abundant^{00}, and 900 = Abundant^{00}.

[4]Scores are as follows: 100 = A^{00} and 500 = E^{00}.

programs were noted. Personnel of the Meat Grading and Certification Branch, AMS, USDA, evaluated beef carcasses for lean maturity, skeletal maturity, marbling score, adjusted fat thickness (**AFT**), and percentage of KPH (USDA, 1997).

Statistical Analyses

All analyses were performed by using JMP Software (JMP Pro, SAS Inst. Inc., Cary, NC) 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, and minimum and maximum values were determined using the distribution function.

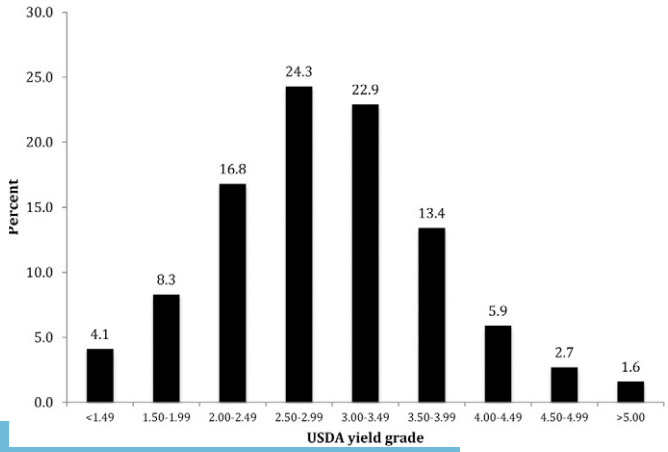

Figure 1. Frequency distribution of carcass by 1/2 yield grade increments.

Table 3. Means for USDA carcass grade traits from the 1991 National Beef Quality Audit (NBQA-1991), NBQA-1995, NBQA-2000, NBQA-2005, and NBQA-2011

Trait	NBQA-1991 (n = 7,375)	NBQA-1995 (n = 11,799)	NBQA-2000 (n = 9,396)	NBQA-2005 (n = 9,475)	NBQA-2011 (n = 9,802)
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

[1]Scores are as follows: 100 = Canner^{00}, 400 = Commercial^{00}, 600 = Select^{00}, and 800 = Prime^{00}.

[2]Scores are as follows: 100 = Practically Devoid^{00}, 300 = Slight^{00}, 500 = Modest00, 700 = Slightly Abundant^{00}, and 900 = Abundant^{00}.

[3]Scores are as follows: 100 = A^{00} and 500 = E^{00}.

RESULTS AND DISCUSSION

Carcass Assessment

The mean USDA quality grade (**QG**) for the current study was Select^{93}, whereas the mean USDA yield grade (**YG**) was 2.9 (Table 2). Means for USDA QG and YG (Table 3) were Select^{86} and 3.2 for NBQA-1991 (Lorenzen et al., 1993), Select79 and 2.8 for NBQA-1995 (Boleman et al., 1998), Select^{85} 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 YG increments are shown in Figure 1. The USDA YG distributions were 12.4% for YG 1, 41.0% for YG 2, 36.3% for YG 3, 8.6% for YG

Table 4. Occurrence (%) of marbling scores within USDA quality grades[1,2] (n = 9,564)

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

[1]Rounding error prevents all categories from adding to 100.0.

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

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

Table 5. Distribution (%) of carcasses stratified by USDA quality and yield grades[1,2] (n = 7,941)

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

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

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

4, and 1.6% for YG 5. The USDA YG distributions from NBQA-2005 (Garcia et al., 2008) were 15.3% for YG 1, 38.8% for YG 2 , 32.9% for YG 3, 10.8% for YG 4, and 2.2% for YG 5. The USDA QG distributions were 2.1% for Prime, 58.9% for Choice, 32.6% for Select, 5.1% for Standard, 0.9% for Commercial, and 0.3% for Utility. The USDA QG distributions from NBQA-2005 (Garcia et al., 2008) were 2.6% for Prime, 51.9% for Choice, 40.2% for Select, 4.4% for Standard, 0.7% for Commercial, and 0.3% for Utility. When data read from previous audits were compared with the NBQA-2011 data, HCW and LM area both increased numerically, whereas AFT generally stayed constant. This finding indicates that even though carcass sizes and weights have increased, cattle might be fed to a specific fat thickness end point. Since the last audit, β-adrenergic agonists 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 a result of changes in cattle genetics and management. One such example would be

Table 6. Characteristics of overall maturity[1]

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

[1]Scores are as follows: 100 = A^{00}, 200 = B^{00}, 300 = C^{00}, 400 = D^{00}, and 500 = E^{00}.

Table 7. Least squares means for carcass traits (SEM) 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}	3.1^{b}	2.6^{c}	2.6^{c}
	(0.06)	(0.01)	(0.02)	(0.04)
USDA quality grade[1]	819^{a}	727^{b}	650^{c}	582^{d}
	(1.59)	(0.30)	(0.41)	(1.03)
Adjusted fat thickness, cm	1.68^{a}	1.40^{b}	1.14^{c}	1.11^{c}
	(0.03)	(0.008)	(0.009)	(0.02)
HCW, kg	385.4^{a}	377.9^{b}	366.9^{d}	373.4^{c}
	(3.22)	(0.62)	(0.83)	(2.12)
LM area, cm^2	83.8^{c}	87.5^{b}	91.1^{a}	90.9^{a}
	(0.81)	(0.15)	(0.21)	(0.52)
KPH, %	2.4^{a}	2.4^{a}	2.2^{b}	1.8^{c}
	(0.06)	(0.01)	(0.01)	(0.04)
Marbling score[2]	759^{a}	484^{b}	351^{d}	377^{c}
	(4.0)	(0.8)	(1.0)	(2.6)
Lean maturity[3]	151^{b}	151^{b}	151^{b}	201^{a}
	(1.5)	(0.3)	(0.4)	(1.0)
Skeletal maturity[3]	160^{b}	159^{b}	154^{c}	206^{a}
	(1.6)	(0.3)	(0.4)	(1.0)
Overall maturity[3]	157^{b}	155^{b}	153^{c}	204^{a}
	(1.3)	(0.2)	(0.3)	(0.8)

[a–d]Means within a row that do not have a common superscript letter differ ($P < 0.05$).

[1]Scores are as follows: 100 = $Canner^{00}$, 400 = $Commercial^{00}$, 600 = $Select^{00}$, and 800 = $Prime^{00}$.

[2]Scores are as follows: 100 = $Practically\ Devoid^{00}$, 300 = $Slight^{00}$, 500 = $Modest^{00}$, and 700 = $Slightly\ Abundant^{00}$.

[3]Scores are as follows: 100 = A^{00} and 500 = E^{00}.

Table 8. Least squares means for carcass traits (SEM) 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}	2.6^{d}	3.4^{c}	4.4^{b}	5.5^{a}
	(0.009)	(0.005)	(0.005)	(0.01)	(0.03)
USDA quality grade[1]	653^{e}	684^{d}	706^{c}	713^{b}	729^{a}
	(2.30)	(1.26)	(1.33)	(2.73)	(6.34)
Adjusted fat thickness, cm	0.72^{e}	1.08^{d}	1.45^{c}	2.05^{b}	2.64^{a}
	(0.01)	(0.006)	(0.006)	(0.01)	(0.03)
HCW, kg	351.8^{e}	368.7^{d}	383.3^{c}	399.8^{b}	411.1^{a}
	(1.36)	(0.75)	(0.80)	(1.64)	(3.79)
LM area, cm^2	100.3^{a}	91.4^{b}	84.8^{c}	81.1^{d}	75.2^{e}
	(0.32)	(0.17)	(0.18)	(0.38)	(0.88)
KPH, %	1.96^{e}	2.19^{d}	2.39^{c}	2.62^{b}	3.30^{a}
	(0.02)	(0.01)	(0.01)	(0.03)	(0.06)
Marbling score[2]	373^{e}	422^{d}	466^{c}	497^{b}	543^{a}
	(2.9)	(1.6)	(1.7)	(3.4)	(7.9)
Lean maturity[3]	157^{a}	155^{b}	152^{c}	153^{bc}	151^{bc}
	(0.9)	(0.5)	(0.5)	(1.1)	(2.5)
Skeletal maturity[3]	161^{b}	160^{b}	160^{b}	166^{a}	164^{ab}
	(1.1)	(0.6)	(0.6)	(1.3)	(2.9)
Overall maturity[3]	159^{a}	158^{ab}	157^{b}	160^{a}	159^{ab}
	(0.9)	(0.5)	(0.5)	(1.1)	(2.1)

[a–e]Means within a row that do not have a common superscript letter differ ($P < 0.05$).

[1]Scores are as follows: 100 = $Canner^{00}$, 400 = $Commercial^{00}$, 600 = $Select^{00}$, and 800 = $Prime^{00}$.

[2]Scores are as follows: 100 = $Practically\ Devoid^{00}$, 300 = $Slight^{00}$, 500 = $Modest^{00}$, and 700 = $Slightly\ Abundant^{00}$.

[3]Scores are as follows: 100 = A^{00} and 500 = E^{00}.

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

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

$^{a–g}$Means within a row that do not have a common superscript letter differ ($P < 0.05$).

[1]Scores are as follows: 100 = Canner^{00}, 400 = Commercial^{00}, 600 = Select^{00}, and 800 = Prime^{00}.

[2]Scores are as follows: 100 = Practically Devoid^{00}, 300 = Slight^{00}, 500 = Modest^{00}, and 700 = Slightly Abundant^{00}.

[3]Scores are as follows: 100 = A^{00} and 500 = E^{00}.

the use of continental European breeds. European cattle are larger-framed, leaner, and more muscular. This results in European breeds having heavier HCW than British breeds. (Wheeler et al., 2005).

Marbling scores across and within USDA QG are shown in Table 4. The majority of marbling scores were in the low parts of the grades (e.g., low Prime = 78.05%, low Choice = 62.71%, etc.). Percentages of marbling scores 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 Small^{50} because of the growing number of certified beef programs that include such carcasses. Current data show that 41.2% of the carcasses surveyed had marbling scores greater than or equal to Small^{50}, which was numerically greater than that reported by McKenna et al. (2002; 36.6%) and by Garcia et al. (2008; 23.6%). 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 the 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 Small^{00}; however, some also have minimum requirements of Small^{50}. The number of marketing programs focusing on cattle that produce Choice or greater continues to increase and could be the cause of numerical increases in greater marbling scores in the 2011 audit.

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, were 72.0% of the sample; comparable values 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 less, or YG 4 and 5, represented 15.6% of the sample. Garcia et al. (2008) reported that 18.3% of the carcasses in NBQA-2005 were 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 A^{40} or more youthful in overall maturity. Of all carcasses evaluated, 23.2% were A^{40} or younger; within all A-maturity carcasses, 25.0% met this qualification.

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%),

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

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

$^{a-j}$Means within a row that do not have a common superscript letter differ ($P < 0.05$).

[1]Scores are as follows: 100 = Canner^{00}, 400 = Commercial^{00}, 600 = Select^{00}, and 800 = Prime^{00}.

[2]Scores are as follows: 100 = Practically Devoid^{00}, 300 = Slight^{00}, 500 = Modest^{00}, and 700 = Slightly Abundant^{00}.

[3]Scores are as follows: 100 = A^{00} and 500 = E^{00}.

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 rib eye (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 percentage of KPH increased ($P < 0.05$). This finding is to be expected because carcasses with higher-quality grades tend to be fatter. Greater AFT and KPH both cause YG to be-

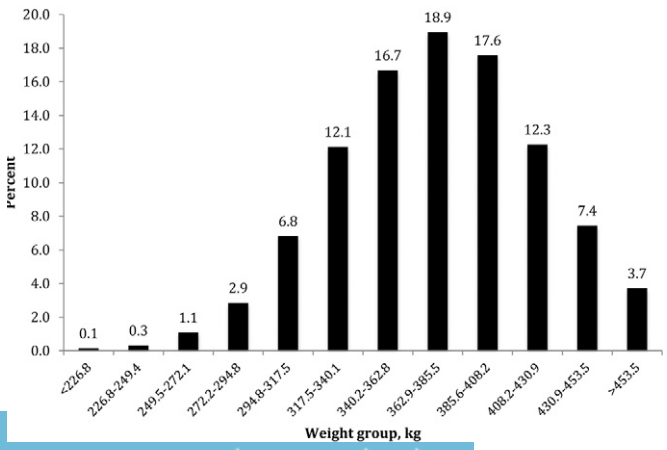

Figure 2. Frequency distribution of carcasses by weight groups.

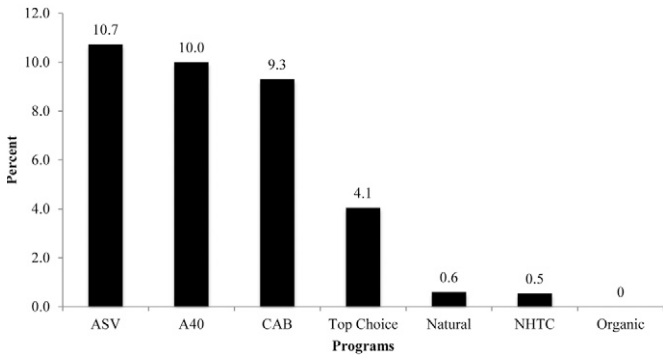

Figure 3. Frequency distribution of different certified and marketing programs. ASV = age and source verified, A40 = carcasses that meet the carcass maturity requirements for exporting to Japan, CAB = Certified Angus Beef, Top Choice = all other Top Choice programs other than CAB, Natural = carcasses qualifying for natural programs, NHTC = Non-Hormone-Treated Cattle, and Organic = carcasses qualify for organic programs.

come numerically greater. 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 were 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.

Carcass trait means within each USDA YG are displayed in Table 8. As USDA YG increased (from YG 1 to 5), marbling, QG, AFT, HCW, and percentage of KPH also increased, whereas LM area decreased ($P < 0.05$). This finding is to be expected because of how AFT, HCW, KPH, and LM area affect YG via 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 with those reported in NBQA-2000 (McKenna et al., 2002) and NBQA-2005 (Garcia et al., 2008). Frequency distribution of carcasses by weight group is shown in Figure 2. McKenna et al. (2002) discussed discounts for carcasses weighing 431 kg and reported 4.6% of carcasses in NBQA-2000 exceeded this weight. Garcia et al. (2008) reported that 5.1% of the carcasses in 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 observe major discounts for carcasses exceeding 454 kg. In the 2011 audit, 3.7% of the carcasses sampled weighed greater than 454 kg. Hot carcass weights have gradually increased since the first NBQA in 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 contributed to this increase in HCW.

Least squares means for carcass traits within fat thickness categories are reported in Table 10. As fat thickness increased, numerical YG, QG, HCW, and percentage of KPH also increased ($P < 0.05$). The increase in mar-

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

	Sex class			
Trait	Steer (n = 6,171)	Heifer (n = 3,536)	Cow (n = 13)	Bullock (n = 3)
USDA yield grade	3.0[a]	2.9[a]	2.6[a]	1.4[b]
	(0.01)	(0.02)	(0.26)	(0.50)
USDA quality grade[1]	690[a]	691[a]	562[b]	380.7[c]
	(0.97)	(1.28)	(20.97)	(43.66)
Adjusted fat thickness, cm	1.23[b]	1.41[a]	0.73[c]	0.51[c]
	(0.006)	(0.009)	(0.14)	(0.29)
HCW, kg	386.8[a]	352.1[b]	359.7[b]	399.4[ab]
	(0.56)	(0.73)	(13.08)	(25.05)
LM area, cm^2	89.2[a]	88.0[b]	77.9[c]	101.9[a]
	(0.15)	(0.20)	(3.24)	(6.74)
KPH, %	2.2[b]	2.4[a]	1.5[c]	0.7[c]
	(0.01)	(0.01)	(0.21)	(0.43)
Marbling score[2]	436[b]	448[a]	488[ab]	280[c]
	(1.3)	(1.7)	(27.1)	(56.5)
Lean maturity[3]	154[d]	155[c]	232[b]	400[a]
	(0.4)	(0.5)	(7.6)	(19.3)
Skeletal maturity[3]	158[c]	169[b]	302[a]	177[bc]
	(0.4)	(0.6)	(9.2)	(19.2)
Overall maturity[3]	156[c]	163[b]	276[a]	275[a]
	(0.4)	(0.5)	(7.8)	(19.8)

[a–d]Means within a row that do not have a common superscript letter differ ($P < 0.05$).

[2]Scores are as follows: 100 = Canner[00], 400 = Commercial[00], 600 = Select[00], and 800 = Prime[00].

[3]Scores are as follows: 100 = Practically Devoid[00], 300 = Slight[00], 500 = Modest[00], and 700 = Slightly Abundant[00].

[4]Scores are as follows: 100 = A[00] and 500 = E[00].

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

	Estimated breed type		
Trait	Native (n = 7,776)	Dairy (n = 876)	*Bos indicus* (n = 159)
USDA yield grade	2.9[a]	2.9[a]	2.7[b]
	(0.01)	(0.03)	(0.07)
USDA quality grade[1]	689[a]	695[a]	689[a]
	(0.88)	(2.66)	(6.13)
Adjusted fat thickness, cm	1.34[a]	0.80[c]	0.99[b]
	(0.005)	(0.02)	(0.04)
HCW, kg	375.2[a]	367.7[b]	335.2[c]
	(0.53)	(1.57)	(3.77)
LM area, cm^2	89.6[a]	79.4[c]	82.4[b]
	(0.13)	(0.38)	(0.89)
KPH, %	2.2[c]	2.3[b]	2.5[a]
	(0.009)	(0.03)	(0.06)
Marbling score[2]	440[b]	451[a]	424[c]
	(1.1)	(3.3)	(7.7)
Lean maturity[3]	155[a]	154[a]	152[a]
	(0.3)	(1.0)	(2.3)
Skeletal maturity[3]	163[a]	157[b]	154[b]
	(0.4)	(1.2)	(2.7)
Overall maturity[3]	160[a]	156[b]	154[b]
	(0.3)	(1.0)	(2.3)

[a–c]Means within a row that do not have a common superscript letter differ ($P < 0.05$).

[1]Scores are as follows: 100 = Canner[00], 400 = Commercial[00], 600 = Select[00], and 800 = Prime[00].

[2]Scores are as follows: 100 = Practically Devoid[00], 300 = Slight[00], 500 = Modest[00], and 700 = Slightly Abundant[00].

[3]Scores are as follows: 100 = A[00] and 500 = E[00].

bling and KPH as fat thickness increased is 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 evident in the present data, which 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 suggests 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 63.47% for steers, 36.37% for heifers, 0.13% for cows, and 0.03% for bullocks. These values were similar to those reported in the NBQA-2005 (Garcia et al., 2008), which included 63.7% for steers, 36.2% for heifers, 0.05% for cows, and 0.05% for bullocks. Carcass traits stratified by sex class are depicted 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 rib eyes 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 the NBQA-2011 ($P < 0.05$), and steer carcasses had significantly ($P < 0.05$) heavier HCW and larger LM area than heifer carcasses. Nonetheless, 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.

Carcass estimated breed types in the NBQA-2011 were native type (88.3%), dairy type (9.9%), and *Bos indicus* (1.8%). The trend for breed type observed 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 2 breed types.

The frequency distribution of carcasses from different countries of origin (USDA, 2005) were 97.7% for United States, 1.8% for Mexico, and 0.5% for Canada. Figure 3 shows the frequency distribution of carcasses identified as eligible for certain certified or marketing programs (USDA, 2012). Frequencies were as follows: 10.7% for age and source verified, 10.0% for $\leq A^{40}$, 9.3% for Certified Angus Beef, 4.1% for Top Choice, 0.6% for natural, and 0.5% for Non-Hormone-Treated Cattle. There were no organic programs observed. This is the first time in the history of the NBQA that this information has been obtained.

Conclusions

The NBQA serves as a benchmark study to measure and report certain producer-related cattle and carcass traits in the U.S. 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. In addition, the percentage of nonconforming carcasses, QG of Standard and less, or YG 4 and 5, has decreased compared to the 2005 NBQA, suggesting 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. The findings will be used to mark the progress that has been made in the industry and pinpoint the areas of improvement for the future.

LITERATURE CITED

Abraham, H. C. 1977. Grades of fed beef carcasses: November 1973-October 1974. Marketing Res. Rep. No. 1073. Agric. Marketing Serv., USDA, Washington, DC.

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.

CME Group. 2012. Daily livestock report. Accessed Aug. 1, 2012. http://www.dailylivestockreport.com/documents/dlr 07-23-2012.pdf.

Delmore, R. J., J. M. Hodgen, and B. J. Johnson. 2010. Perspectives on the application of zilpaterol hydrochloride in the United States beef industry. J. Anim. Sci. 88:2825–2828.

Garcia, L. G., K. L. Nicholson, T. W. Hoffman, T. E. Lawrence, D. S. Hale, D. B. Griffin, J. W. Savell, D. L. VanOverbeke, J. B. Morgan, K. E. Belk, T. G. Field, J. A. Scanga, J. D. Tatum, and G. C. Smith. 2008. National Beef Quality Audit–2005: Survey of targeted cattle and carcass characteristics related to quality, quantity, and value of fed steers and heifers. J. Anim. Sci. 86:3533–3543.

Kempster, A. J. 1981. Fat partition and distribution in the carcasses of cattle, sheep and pigs: A review. Meat Sci. 5:83–98.

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. 71:1495–1502.

McKenna, D. R., D. L. Roeber, P. K. Bates, T. B. Schmidt, D. S. Hale, D. B. Griffin, J. W. Savell, J. C. Brooks, J. B. Morgan, T. H. Montgomery, K. E. Belk, and G. C. Smith. 2002. National Beef Quality Audit–2000: Survey of targeted cattle and car-

cass characteristics related to quality, quantity, and value of fed steers and heifers. J. Anim. Sci. 80:1212–1222.

National Cattlemen's Beef Association. 2012. Pillars of beef chain success–Executive summary: The 2011 National Beef Quality Audit. Accessed Aug. 1 2012. http://www.bqa.org/CMDocs/bqa/NBQA.pdf.

Scramlin, S. M., W. J. Platter, R. A. Gomez, W. T. Choat, F. K. McKeith, and J. Killefer. 2010. Comparative effects of ractopamine hydrochloride and zilpaterol hydrochloride on growth performance, carcass traits, and longissimus tenderness of finishing steers. J. Anim. Sci. 88:1823–1829.

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 Quality Audit–1991. Natl. Cattlemen's Beef Assoc., Englewood, CO.

USDA. 1997. United States standards for grades of carcass beef. Agric. Marketing Serv., USDA, Washington, DC. Accessed Mar. 26, 2012. http://www.ams.usda.gov/AMSv1.0/getfile?dDocName=STELDEV3002979.

USDA. 2005. USDA Export Verification (EV) Program specified product requirements for beef—Japan. Agric. Marketing Serv., USDA, Washington, DC. Accessed May 15, 2012. http://www.ams.usda.gov/AMSv1.0/getfile?dDocName=STELDEV3103526.USDA. 2009. 7 CFR Parts 60 and 65: Mandatory Country of Origin Labeling of Beef, Pork, Lamb, Chicken, Goat Meat, Wild and Farm-Raised Fish and Shellfish, Perishable Agricultural Commodities, Peanuts, Pecans, Ginseng, and Macadamia Nuts; Final Rule. Accessed May 15, 2012. http://www.ams.usda.gov/AMSv1.0/getfile?dDocName=STELPRDC5074925.

USDA. 2012. USDA Certified Beef Programs. Agric. Marketing Serv., USDA, Washington, DC. Accessed June 4, 2012. http://www.ams.usda.gov/AMSv1.0/getfile?dDocName=STELDEV3025674.

Wheeler, T. L., L. V. Cundiff, S. D. Shackelford, and M. Koohmaraie. 2005. Characterization of biological types of cattle (Cycle VII): Carcass, yield, and longissimus palatability traits. J. Anim. Sci. 83:196–207.