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Nutrient Database Improvement Project: The influence of USDA Quality and Yield Grade on the separable components and proximate composition of raw and cooked retail cuts from the beef chuck

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ABSTRACT

This study was designed to provide updated information on the separable components, cooking yields, and proximate composition of retail cuts from the beef chuck. Additionally, the impact the United States Department of Agriculture (USDA) Quality and Yield Grade may have on such factors was investigated. Ultimately, these data will be used in the USDA — Nutrient Data Laboratory's (NDL) National Nutrient Database for Standard Reference (SR). To represent the current United States beef supply, seventy-two carcasses were selected from six regions of the country based on USDA Yield Grade, USDA Quality Grade, gender, and genetic type. Whole beef chuck primals from selected carcasses were shipped to three university laboratories for subsequent retail cut fabrication, raw and cooked cut dissection, and proximate analyses. The incorporation of these data into the SR will improve dietary education, product labeling, and other applications both domestically and abroad, thus emphasizing the importance of accurate and relevant beef nutrient data.

1. Introduction

The United States Department of Agriculture (USDA) — Nutrient Data Laboratory's (NDL) National Nutrient Database for Standard Reference (SR) provides data for national nutrition policies, diet therapy, nutrition education programs, guidance for pediatric, obstetric, and geriatric populations, and serves as a source of information for menu calculations for schools, nursing homes, and hospitals (United States Department of Agriculture — Agricultural Research Service, 2012). Data in the SR also are used to provide nutrition information for on-pack labeling of nutrient claims. Because such a large number of people rely on these data, it is imperative that the information be current and accurate. The SR is the prominent source of food composition data in the United States and internationally, and it is accessible on the NDL website (Haytowitz, 1995). Today's SR supersedes food composition table data which were published in hard copy form starting in 1950, and were collectively referred to as "Agriculture Handbook No. 8" (AH-8). Beef data which were published in AH-8 as Section 13, "Composition of Foods: Beef Products; Raw, Processed Prepared," (AH 8-13) have since undergone four revisions (NCBA, 2005). In the early 1980s, AH 8-13 was based on fat trim data from 1963. Research conducted by Cross, Savell, and Francis (1986) and Savell et al. (1989) worked to update much of the information in the database when reports from these authors showed that consumers preferred beef retail cuts that were trimmed to have little or no fat.

At the time of the first National Beef Market Basket Survey (1987–1988), the AH 8-13 was based on a retail fat trim level of 1.27 cm. The National Beef Market Basket Survey (Savell, Harris, Cross, Hale, & Beasley, 1991) concluded that the mean fat trim level on retail cuts was actually 0.31 cm, while over 42% of the cuts surveyed were trimmed free of external fat. Also, ground beef in the retail marketplace contained 10% less fat than reported in the AH 8-13 at that time. Following these reports, the AH 8-13 was updated with data from a series of work that evaluated separable components, fat and moisture content of the separable lean, cooking yields, and fat retentions of beef retail cuts (Jones, Savell, & Cross, 1992a; Jones, Savell, & Cross, 1992b; Jones,

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Savell, & Cross, 1992c). The National Beef Tenderness Survey—1998 revealed that fat trim levels were continuing to decrease (Brooks et al., 2000) and additional research was initiated to address differences in fat trim levels and cooking methods on separable components (Wahrmund-Wyle, Harris, & Savell, 2000a; Wahrmund-Wyle, Harris, & Savell, 2000b); data from these studies also were incorporated in the AH 8-13 (now termed the SR). Additionally, Gerber, Scheeder, and Wenk (2009) reported that cooking and trimming significantly affect the nutrients in meat, and when nutrient information is estimated, this must be taken into account.

In 2005, researchers conducting the National Beef Market Basket Survey collected 1551 retail cuts from eleven cities across the United States to better understand the physical and chemical composition of the retail cuts in the marketplace (Mason et al., 2009). The Executive Summary from this study (NCBA, 2005) brought two issues to the forefront: (1) many of the retail cuts in stores were not represented in the SR, and (2) health professionals and consumers commonly associate the nutritive value of beef as too high in fat. For these reasons, the Nutrient Database Improvement Project was initiated to update the SR with the most current and accurate beef nutrient data available.

2. Materials and methods

2.1. Carcass selection

A total of seventy-two carcasses (36 paired carcasses) of nationally representative USDA Quality Grade, USDA Yield Grade, gender and genetic type were selected from seven packing plants in six different regions of the country (Green Bay, WI; Greeley, CO; Dodge City, KS; Tolleson, AZ; Plainview, TX; Omaha, NE; Corpus Christi, TX). Trained university personnel were responsible for identifying genetic type, gender, maturity (A), and appropriate hot carcass weights (318 to 408 kg for steer and dairy carcass; 295–386 kg for heifer carcasses). Additional factors considered in this study were USDA Quality Grade (upper choice, lower choice, and select), USDA Yield Grade (Yield Grade (YG) 2 and YG 3), gender (steers and heifers) and genetics (non-dairy and dairy). In order to obtain sufficient sample quantities and to appropriately represent all retail cuts, carcasses were selected in pairs (within a pair, carcasses had the same design factors and approximately the same marbling score).

2.2. Beef chuck collection

Following the selection of carcasses based on the sampling matrix for this study, left and right sides were identified for cooking/raw designation as stipulated by the study design. Beef chucks were procured from these sides, placed in combos, and shipped via refrigerated truck to one of three universities (Colorado State University, Texas Tech University, or Texas A&M University). Temperatures were verified prior to loading and upon arrival at each laboratory to ensure that product was maintained at 0 to 4 °C. Upon receipt, beef chucks were stored in the absence of light at 0 to 4 °C until fabrication.

2.3. Retail cut fabrication

Beef chucks were fabricated into seven subprimals 4 to 7 d postmortem: Beef Brisket, Deckle-Off, Boneless (IMPS 120; Institutional Meat Purchasing Specifications); Beef Chuck, Chuck Tender (Individual Muscle [IM]) (IMPS 116B); Beef Chuck, Short Ribs, Boneless (IMPS 130A); Beef Chuck, Chuck Eye Roll (IMPS 116D); Beef Chuck, Under Blade Roast (IMPS 116E); Beef Chuck, Shoulder (Clod) Top Blade (IMPS 114D); and Beef Chuck, Shoulder (Clod), Arm Roast (IMPS 114E). In addition to the subprimals listed above, Beef for Stewing (IMPS 135A), lean trimmings, fat, and refuse also were produced. Within 14 to 21 d postmortem, subprimals were fabricated into retail cuts (Table 1) with a 0.00 cm fat trim level.

Table 1
Retail identification and designated cooking method for retail cuts from the beef chuck.

Retail cut	URMIS[a]	IMPS	Cooking method
Beef Brisket, Flat Cut, Boneless[b]	1623	120A	None
Beef Brisket, Point Cut, Boneless[c]	1628	120B	None
Beef Chuck, Mock Tender Steak	1116	116B	Braised
Beef Chuck, Short Ribs, Boneless	1127	130A	Braised
Beef Chuck, Chuck Eye Roll Steak, Boneless	1102	1116D	Grilled
Beef Chuck, Chuck Eye Roll Roast ("America's Beef Roast")	1095	116D	Roasted
Beef Chuck, Chuck Eye, Country-Style Ribs, Boneless	1096	116D	Braised
Beef Chuck, Under Blade Roast, Boneless	1151	116E	Braised
Beef Chuck, Under Blade Steak, Boneless[d]	1158	116E	Braised
Beef Chuck, Under Blade, Center-Cut Steak ("Denver Cut")	1098/1913	1116G	Grilled
Beef Chuck, Shoulder (Clod), Top Blade Steak	1144	1114D	Grilled
Beef Chuck, Shoulder (Clod), Roast	1132	114E	Braised
Beef Chuck, Shoulder (Clod), Steak[d]	1133	114E	Grilled
Beef for Stewing	1727	135A	Braised

[a] URMIS, Uniform Retail Meat Identity Standards.
[b] Nutrient analyses were performed on raw retail cuts only.
[c] Nutrient analyses were not performed on the indicated cut.
[d] Nutrient analyses were performed on cooked retail cuts only. Raw nutrient values of indicated cuts are the same as those recorded for the corresponding roasts.

2.3.1. Beef Brisket, Deckle-Off, Boneless

Beef briskets were evaluated to ensure that all cartilage and deckle were removed. Briskets were separated along a natural seam to produce Beef Brisket, Flat Cut, Boneless (IM) (IMPS 120A) and Beef Brisket, Point Cut, Boneless (IM) (IMPS 120B).

2.3.2. Beef Chuck, Chuck Tender (IM)

Beef Chuck, Chuck Tender (IM) (IMPS 116B) subprimals were portioned into 2.54 cm-thick steaks. For the purpose of this study the resulting portions were termed Mock Tender Steaks.

2.3.3. Beef Chuck, Short Ribs, Boneless

Beef Chuck, Short Ribs, Boneless (IMPS 130A) were trimmed to produce a product 75% free of fat. The short ribs were then cut across the grain to produce 2.54 cm-wide strips.

2.3.4. Beef Chuck, Chuck Eye Roll

Three Chuck Eye Steaks were cut at a thickness of 2.54 cm from the posterior end of the subprimal. Two 5.08 cm-thick Chuck Eye Roasts were removed from the anterior end of the Chuck Eye Roll. These roasts were termed America's Beef Roast throughout the duration of this study. The remainder of the subprimal was used to produce Boneless Country Style Ribs, which were generated by cutting 3.81 cm-thick portions. These portions were then positioned cut surface up, and divided in half.

2.3.5. Beef Chuck, Under Blade Roast

Three retail cuts were procured from the Beef Chuck, Under Blade Roast (IMPS 116E): Under Blade Roasts, Under Blade Steaks, and Under Blade, Center-Cut (IM) (IMPS 116G). The Beef Chuck, Under Blade, Center-Cut portions were referred to as "Denver Cut" throughout this study. Because the three retail cuts listed above share common muscles, carcasses designated as "A" during carcass selection were utilized for Under Blade Roasts and Under Blade Steaks. Denver Cut portions were removed from carcasses designated as "B."

From "A" carcasses, portions termed Under Blade Roasts were produced by squaring up the Beef Chuck, Under Blade Roast and removing one 5.08 cm-thick portion from each end of the subprimal. The remainder of the Beef Chuck, Under Blade Roast was portioned into 2.54 cm-thick Under Blade Steaks. For "B" carcasses, the *M. rhomboideus*, *M. splenius*, surface fat, and connective tissue were removed from the Beef Chuck, Under Blade Roast to produce the "Denver Cut." Beginning

at the posterior end of the remaining *M. serratus ventralis*, 2.54 cm-thick steaks were generated.

2.3.6. Beef Chuck, Shoulder (Clod), Top Blade

The *M. infraspinatus* was cut into 2.54 cm-thick steaks from end-to-end producing portions termed Beef Shoulder, Top Blade Steak.

2.3.7. Beef Chuck, Shoulder (Clod), Arm Roast

Beef Shoulder Steaks, referred to as Clod Steaks for the purpose of this study, were generated by cutting 2.54 cm-thick portions from the anterior end of the subprimal. The number of steaks cut was sufficient to satisfy the sample needs of this study. Clod Roasts were fabricated from the remainder of the subprimal by cutting 2.05 cm-thick portions. The *M. latissimus dorsi* and *M. pectoralis profundus* were reserved for Beef for Stewing (IMPS 135A).

Lean trimmings, fat, and refuse also were weighed during fabrication of subprimals to retail cuts. Retail cuts were individually identified, vacuum-packaged, and placed in −20 °C storage until dissection. Daily temperature logs were maintained to verify that product was held at the proper storage temperature.

2.4. Cooking of retail cuts

Prior to cooking, all retail cuts were tempered in a single layer under refrigerated conditions (0 to 4 °C) for 24 to 48 h. The temperature of thawed retail cuts was taken to ensure that internal product temperature was within a range of 0 to 4 °C. Prior to weighing and cooking, cuts were blotted to remove any accumulated purge. Cooking applications for the retail cuts were selected based on existing data in the USDA Nutrient Database for Standard Reference (SR), some cuts were not analyzed on both cooked and raw basis (Table 1). Clod Roasts, Boneless Country-Style Ribs, Under Blade Roasts, Under Blade Steaks, Mock Tender Steaks, Chuck Short Ribs, and Beef for Stewing were assigned to the braising application. America's Beef Roast was the only retail cut assigned to roasting as a cooking method. Grilling was utilized for Clod Steaks, Denver Cuts, Chuck Eye Steaks, and Top Blade Steaks. Following each of the cooking methods, cuts were cooled, covered, and chilled at 0 to 4 °C for 12 to 24 h.

2.4.1. Braising

Braising was achieved by first pre-heating a non-stick 5.7 L Dutch oven (Calphalon, Toledo, OH) to 177 °C. An infrared thermometer was used to verify Dutch oven temperature prior to placing a cut in the pan. Pre-weighed beef cuts were browned on all sides and pan drippings were collected and recorded. A type J iron thermocouple wire (Omega Engineering Inc., Stamford, CT) was inserted into the geographic center of one cut per pan. The thermocouple wires were used with a type J Digi-sense thermocouple thermometer (Cole Parmer Instrument Co., Vernon Hills, IL) to allow continuous monitoring of product temperature before, during, and after cooking. Distilled, de-ionized water was added at a volume that reached one-third the thickness of the retail cut, and that volume was recorded. The liquid was brought to a boil and the Dutch oven was subsequently placed in a pre-heated (120 °C) conventional oven. Samples simmered until internal product temperature reached 85 °C. The Dutch oven was then removed from the heat, and temperature of the cut was monitored until a peak temperature was recorded. The volume of any remaining cooking liquid also was documented. Following a 30 min rest period at room temperature, cooked cut weights were recorded.

2.4.2. Roasting

Weighed cuts were roasted in a non-stick anodized aluminum roasting pan with a rack (Calphalon, Toledo, OH). A thermocouple wire inserted into the geometric center of each cut, paired with a thermocouple reader was utilized to monitor product temperature prior to and throughout the cooking process, as previously described. A conventional oven was pre-heated to 160 °C prior to placing the roasting pan in the center of the oven. Verification of oven temperature prior to cooking was achieved using an infrared thermometer on a centrally located oven rack. When internal product temperature reached 60 °C, the roasting pan was removed from the oven. The temperature of each retail cut was monitored until a point of decline; this peak temperature was recorded. After a 30 min rest period, final cooked weight of each cut also was recorded.

2.4.3. Grilling

Salton two-sided electric grills (Model GRP99; Salton Inc., Lake Forest, IL) were pre-heated to 195 °C. Grill surface temperatures were verified using an infrared thermometer and recorded prior to placing each group of cuts on a grill. Weighed cuts were evenly spaced on the grill surface, and the lid was closed. As outlined previously, thermocouple wires and a thermocouple reader were used to monitor internal product temperature before and during cooking. Cuts were removed from the grill when an internal temperature of 70 °C was obtained; cooked weight and final peak temperature also were recorded.

2.5. Retail cut dissection

Frozen (raw) retail cuts were tempered in a single layer under refrigerated conditions (0 to 4 °C) for 24 to 48 h prior to dissection into separable components. Cooked samples were maintained under refrigeration as previously described and dissected 12 to 24 h after cooking. The temperature of thawed retail cuts was taken to ensure that the internal product temperature was within the range of 0 to 4 °C. An initial weight of each cut was recorded before dissection began. The manufacturer calibrated scales annually, and test weights were utilized prior to each dissection day to verify scale accuracy. Separable components were identified as: separable lean — included all muscle, intramuscular fat, and edible connective tissue; intermuscular (seam) fat — all fat located between muscles within an individual cut; and refuse (waste) — all bone and heavy connective tissue deemed inedible. These components were divided using a disposable scalpel (Feather Safety Razor Co., Ltd., Osaka, Japan) and stainless steel forceps. The weight of each component was recorded and a recovery percentage was calculated. A range of 97–101% recovery was tolerated for this study. Separable lean portions were placed in sealed plastic bags under refrigerated conditions (0 to 4 °C) for same-day homogenization. Dissected fat was cubed, placed in sealed plastic bags, and frozen at −20 °C for later homogenization to produce three study-wide fat homogenates: raw external fat (from retail cut fabrication), raw intermuscular fat, and cooked intermuscular fat.

2.6. Homogenization

Due to previously existing data in the USDA SR, the raw Clod Steaks and raw Under Blade Steaks were not utilized beyond the point of dissection. All other retail cuts were homogenized for nutrient analyses. Homogenization procedures were conducted in the absence of direct light to maintain nutrient integrity of the samples. Following dissection, lean samples were removed from refrigeration one at a time, cubed, and placed in a stainless steel strainer and submerged in liquid nitrogen until completely frozen. Frozen samples were then transferred into a 6.62 L Robot Coupe (BLIXER 6V; Robot Coupe USA Inc., Ridgeland, MS) batch processor and blended until a fine, homogenous powder was formed. This result was obtained by blending samples at 1500 rpm for approximately 10 s, scraping the bowl, and then blending the sample at 3500 rpm for approximately 30 s. A 60 g aliquot of the homogenate was obtained for proximate analysis and a 100 g aliquot of the homogenate was obtained to provide a back-up/archive sample. The remainder of the homogenate was retained for further analysis and compositing. All homogenate powder aliquots were labeled, double-bagged in sealable plastic bags, and stored at −80 °C until nutrient analyses were conducted.

For homogenization of fat samples, the fat from all cuts within each fat group (raw external fat, raw intermuscular fat, and cooked intermuscular fat) was mixed by group in a model A-80 Koch mixer (Koch Supplies, Inc., Kansas City, MO) for approximately 3 min. After mixing, random cores were taken to create a 2300 g homogenate for each fat type, and were stored at −80 °C for subsequent analyses.

2.7. Nutrient analysis

Homogenized separable lean samples from each individual animal were utilized to formulate individual animal proximate samples for the determination of moisture, protein, total fat, and ash. As previously described, a portion of each individual animal homogenate was designated for future compositing to provide a nationally representative sample for detailed nutrient analyses. Data for nationally representative composite samples will be presented in subsequent studies. Proximate analyses for individual animal homogenate samples were conducted at one of three USDA-approved university laboratories (Colorado State University, Texas Tech University, or Texas A&M University).

2.7.1. Protein

Protein analysis was performed by combustion using the AOAC method 992.15 (AOAC International, 2006). Total nitrogen was determined using a nitrogen determinator (Leco FP-2000 or Leco TruSpec CN; LECO Corporation, St. Joseph, MI and Rapid N cube; Elementar, Hanau, Germany) and percent protein was calculated by multiplying total percentage nitrogen by a factor of 6.25. All analyses were performed in duplicate.

2.7.2. Total fat

Total fat analysis for each sample was performed in duplicate using a variation of the chloroform:methanol method described by Folch, Lees, and Stanley (1957). Percentage of fat was calculated using the formula: % fat = [(total volume of (chloroform / methanol) / 10 × final lipid weight) / sample weight] × 100.

2.7.3. Moisture

Analysis of percent moisture was performed in duplicate using the AOAC oven drying methods 950.46 and 934.01 (AOAC International, 1995). All samples were analyzed in duplicate and percent moisture (% MC) was calculated using the formula: % MC = ((wet weight − dry weight) / wet weight) × 100.

2.7.4. Ash

Percent ash was determined in duplicate using the AOAC ash oven methods 920.153 and 923.03 (1995). Ash analyses were conducted in duplicate and percent ash (%Ash) was calculated using the formula: % ash = (ash weight / wet weight) × 100.

2.8. Quality control

Quality control (QC) throughout nutrient analysis was performed in order to ensure precise and accurate data. For initial university lab validation, beef and chicken baby food control material of known composition, and coming from the same lot of production (Beech Nut, Canajoharie, NY) was obtained from the Food Analysis Laboratory Control Center (FALCC; Virginia Polytechnic Institute and State University,

Table 2
Effect of USDA Quality Grade[1] on the separable components (%) of raw and cooked retail beef cuts from the chuck.

Retail cut	Separable lean (%)[2]				Seam fat (%)[3]				Refuse (%)[4]			
	Choice	SEM	Select	SEM	Choice	SEM	Select	SEM	Choice	SEM	Select	SEM
Raw												
Beef Brisket, Flat Cut, Boneless	90.5	1.0	89.8	1.3	8.3	1.5	8.5	1.8	0.7	1.0	1.1	1.1
Beef Brisket, Point Cut, Boneless	75.7	2.6	74.8	3.0	22.3	2.8	24.1	3.1	1.3	0.9	0.3	1.0
Mock Tender Steak	93.7	0.6	94.4	0.7	1.1	0.3	1.3	0.4	4.4	0.6	3.6	0.7
Chuck Short Ribs, Boneless	74.3	2.7	75.7	2.8	17.4	3.3	17.0	3.5	7.4	1.9	6.3	2.2
Chuck Eye Roll Steak, Boneless	72.5	3.9	72.9	4.0	16.7	2.1	17.1	2.3	9.6	3.5	8.8	3.7
Chuck Eye Roll Roast ("America's Beef Roast")	79.2[b]	2.7	84.2[a]	2.9	11.0	2.8	9.7	3.0	9.0[a]	1.5	5.5[b]	1.6
Country-Style Ribs, Boneless	76.2	3.2	75.2	3.3	14.3	3.0	13.8	3.1	8.5	2.2	10.1	2.3
Under Blade Roast, Boneless	77.3	2.9	80.4	3.2	14.2	1.9	13.3	2.4	7.7	2.2	5.5	2.4
Under Blade Steak, Boneless	80.9	2.3	80.4	2.5	14.3	2.1	12.8	2.3	3.7[b]	1.7	6.2[a]	1.8
Under Blade, Center-Cut Steak ("Denver Cut")	95.5[*]	5.1	93.1[*]	5.1	2.9	2.9	3.8	2.9	1.5	2.1	2.9	2.1
Shoulder (Clod), Top Blade Steak	82.6	0.9	84.1	1.3	1.9[*]	0.4	0.9[*]	0.5	14.3	1.0	13.8	0.8
Shoulder (Clod), Roast	91.6	1.9	92.1	1.9	1.9	0.4	1.4	0.5	5.7	1.9	5.8	2.0
Shoulder (Clod), Steak	92.0	2.6	91.7	2.6	1.2	0.3	1.0	0.4	6.0	2.2	6.4	2.3
Beef for Stewing	97.0[*]	3.5	95.8[*]	3.5	1.1	1.6	2.4	1.7	1.6	1.6	1.7	1.7
Cooked[5]												
Mock Tender Steak	85.5	3.8	85.8	3.9	7.5	6.4	7.5	6.5	6.3	2.4	5.8	2.4
Chuck Short Ribs, Boneless	73.7	3.5	76.5	4.0	19.5	1.5	16.9	2.1	5.8	2.7	5.6	2.8
Chuck Eye Roll Steak, Boneless	75.2	1.9	77.1	2.1	17.9	2.3	17.4	2.5	5.9	2.4	4.4	2.5
Chuck Eye Roll Roast ("America's Beef Roast")	81.2	5.7	78.7	5.8	12.3	2.6	12.9	2.7	5.5	3.4	7.1	3.5
Country-Style Ribs, Boneless	72.1	1.6	74.7	1.9	18.6	3.1	16.7	3.2	8.4	1.6	7.5	1.8
Under Blade Roast, Boneless	75.4	3.2	76.3	3.8	20.4	3.4	18.8	3.9	3.2	2.1	4.0	2.2
Under Blade Steak, Boneless	78.5[*]	2.8	82.3[*]	3.1	16.6[*]	2.3	13.1[*]	2.6	4.0	2.1	3.8	2.3
Under Blade, Center-Cut Steak ("Denver Cut")	96.9	3.1	97.0	3.1	1.9	2.2	1.6	2.3	0.9	0.8	1.4	0.8
Shoulder (Clod), Top Blade Steak	82.3	3.8	80.3	3.9	4.4[a]	1.6	1.5[b]	1.8	12.5[b]	4.2	17.0[a]	4.3
Shoulder (Clod), Roast	90.0	2.7	89.8	2.7	1.8	0.5	2.6	0.6	7.8	1.8	7.0	1.9
Shoulder (Clod), Steak	92.3	3.0	92.5	3.0	1.8	0.6	1.7	0.6	5.3	2.2	5.2	2.2
Beef for Stewing	97.5	2.7	96.6	2.8	1.3[*]	1.4	2.0[*]	1.4	1.0	1.2	1.2	1.3

[a,b]Weighted least squares means within a separable component and raw or cooked cut lacking a common letter differ ($P < 0.05$).

[*] Weighted least squares means noted with an asterisk exhibit tendencies ($0.05 < P < 0.1$) within a separable component and raw or cooked cut.

[1] USDA Choice weighted least squares means represent 24 individual carcasses; USDA Select weighted least squares means represent 12 individual carcasses.

[2] Separable lean, %: [separable lean (g) / pre-dissection cut weight (g)] × 100.

[3] Seam fat, %: [seam fat (g) / pre-dissection cut weight (g)] × 100.

[4] Refuse (including all bone and heavy connective tissue), %: [refuse (g) / pre-dissection cut weight (g)] × 100.

[5] Clod Steaks, Denver Cuts, Chuck Eye Steaks, and Top Blade Steaks were grilled to an internal temperature of 70 °C using a clam-shell grill; Chuck Eye Roll Roasts were roasted in a conventional oven to an internal temperature of 60 °C; all other cuts were placed in a non-stick Dutch oven and braised in a conventional oven until an internal product temperature of 85 °C was reached.

Blacksburg, Virginia). The National Institute of Standards and Technology SRM 1546 Meat Homogenate was used as an additional control for laboratory validation. Throughout the study, these same control materials, beef and chicken baby food and/or SRM 1546, were run with each analysis group to ensure that the sample values were accurate (Montgomery, 2008). Chemical analyses were considered valid by USDA—NDL when the SRM nutrient value was within the uncertainty limits as given on the certificate for the material, or that the baby food control values fell within the expected ranges. Furthermore, a blind duplicate sample was run in each analysis group. If the CV of the study sample and its respective blind duplicate was greater than 5%, the data were considered invalid and reanalyzed. Each sample was also run in duplicate in order to calculate a CV per sample and ensure that all CVs were below 5% before accepting the sample's analysis value. No CV was greater than 5% in this study.

2.9. Statistical methods

2.9.1. Experimental design

The design factors considered in this study were USDA Quality Grade (upper choice, lower choice, and select), USDA Yield Grade (Yield Grade (YG) 2 and YG 3), gender (steers and heifers) and genetics (non-dairy and dairy). Animals were numbered from 1 to 36, and were assigned to a combination of each of the above design factors to provide a nationally representative sample set. In order to ensure adequate amounts of sample and to represent all retail cuts, two carcasses were selected for each animal number represented. The two carcasses were termed "A" and "B" for each animal number within the sampling matrix, resulting in 36 pairs of animals ($n = 72$ individual animals). To reduce variation, the paired A and B carcasses were required to be in the same marbling score category (not crossing grade line) and have all other characteristics within the prescribed sampling criteria. Additionally, left and right sides were identified for cooking/raw designation as stipulated by the study design. The design is an incomplete block design with each university processing an incomplete replicate of the factor combinations. The replicates are incomplete because there were only 16 combinations of design factors used in the study and each university was assigned 10 unique combinations. There were 12 non-dairy heifers (6 factor combinations × 2 animals), 4 dairy steers (4 combinations × 1 animal) and 20 non-dairy steers (4 combinations × 3 + 2 combinations × 4) resulting in 36 animal pairs. The 36 animals were randomly assigned to plants for procurement with the restriction that the number of animals in each USDA Quality Grade and in each USDA Yield Grade be as equal as possible, and that there be approximately twice as many steers as heifers. Because dairy steers were available at only two plants, two dairy steers were selected at each of those plants.

2.9.2. Statistical analysis

For individual animal data, a mean for each of the 36 pairs of animals was computed for analysis. Depending on the variable, these means were calculated across A/B animals, multiple steaks/roast and/or multiple analytical values. The genetic-type and gender factors were combined into a single factor, called GeneticsGender, with three possible groups (non-dairy, steer; non-dairy, heifer; and dairy steer). The mixed model analysis of variance included the following fixed factors: USDA Quality Grade (QG), GeneticsGender, QG * GeneticsGender and

Table 3
The effect of USDA Yield Grade[1] (YG) on the separable components (%) of raw and cooked retail beef cuts from the chuck.

Retail cut	Separable lean (%)[2]				Seam fat (%)[3]				Refuse (%)[4]			
	YG 2	SEM	YG 3	SEM	YG 2	SEM	YG 3	SEM	YG 2	SEM	YG 3	SEM
Raw												
Beef Brisket, Flat Cut, Boneless	90.5	1.1	90.0	1.2	7.6	1.6	9.2	1.6	1.4	1.0	0.4	1.0
Beef Brisket, Point Cut, Boneless	77.1	2.7	73.7	2.8	21.8	2.9	24.2	3.0	0.3*	0.9	1.5*	1.0
Mock Tender Steak	93.9	0.7	94.0	0.7	1.0	0.3	1.3	0.3	4.3	0.6	3.9	0.6
Chuck Short Ribs, Boneless	74.9	2.7	74.7	2.8	16.7	3.4	17.8	3.4	7.6	2.0	6.4	2.1
Chuck Eye Roll Steak, Boneless	73.6	4.0	71.8	4.0	16.9	2.2	16.9	2.2	8.3	3.6	10.2	3.6
Chuck Eye Roll Roast ("America's Beef Roast")	81.5	2.7	80.9	2.8	10.0	2.8	11.0	2.9	7.8	1.5	7.4	1.6
Country-Style Ribs, Boneless	76.1	3.2	75.5	3.2	13.9	3.1	14.3	3.1	8.8	2.2	9.4	2.3
Under Blade Roast, Boneless	80.0	3.0	77.1	3.1	13.5	2.1	14.2	2.2	5.8	2.2	7.8	2.3
Under Blade Steak, Boneless	83.1[a]	2.4	78.4[b]	2.4	11.9[b]	2.1	15.6[a]	2.2	4.3	1.7	5.1	1.7
Under Blade, Center-Cut Steak ("Denver Cut")	94.7	5.1	94.3	5.1	2.9	2.9	3.6	2.9	2.1	2.1	2.0	2.1
Shoulder (Clod), Top Blade Steak	83.5	1.1	82.8	1.1	0.7[b]	0.4	2.2[a]	0.5	14.4	1.1	13.8	1.1
Shoulder (Clod), Roast	90.8[b]	1.9	92.8[a]	1.9	1.6	0.4	1.8	0.5	6.8[a]	1.9	4.6[b]	2.0
Shoulder (Clod), Steak	91.4	2.6	92.4	2.6	1.3	0.3	0.9	0.3	6.4	2.2	5.8	2.2
Beef for Stewing	95.8[b]	3.5	97.2[a]	3.5	1.8	1.7	1.5	1.7	2.1	1.7	1.1	1.7
Cooked[5]												
Mock Tender Steak	84 .9	3.8	86.3	3.8	8.4*	6.5	6.7*	6.5	6.0	2.4	6.2	2.4
Chuck Short Ribs, Boneless	76.4	3.7	73.2	3.7	18.0	1.7	18.9	1.7	4.5*	2.7	7.0*	2.7
Chuck Eye Roll Steak, Boneless	75.3	2.0	76.6	2.0	18.3	2.3	17.2	2.4	5.4	2.4	5.2	2.4
Chuck Eye Roll Roast ("America's Beef Roast")	81.4	5.7	79.0	5.8	12.1	2.6	13.0	2.7	5.4	3.5	6.9	3.5
Country-Style Ribs, Boneless	74.3	1.7	72.0	1.7	16.9	3.1	18.8	3.2	7.8	1.7	8.3	1.7
Under Blade Roast, Boneless	77.3	3.3	74.3	3.6	17.1	3.4	22.5	3.7	4.8*	2.1	2.2*	2.1
Under Blade Steak, Boneless	81.0	2.9	79.1	2.9	14.2	2.4	16.2	2.4	4.2	2.2	3.7	2.2
Under Blade, Center-Cut Steak ("Denver Cut")	97.7[a]	3.1	96.1[b]	3.1	1.0*	2.2	2.5*	2.3	1.2	0.8	1.1	0.8
Shoulder (Clod), Top Blade Steak	82.6	3.8	80.4	3.9	3.4	1.7	3.0	1.7	12.9*	4.2	15.8*	4.2
Shoulder (Clod), Roast	90.1	2.7	89.7	2.7	2.1	0.5	2.1	0.5	7.2	1.9	7.7	1.9
Shoulder (Clod), Steak	92.9	3.0	92.9	3.0	1.2*	0.6	2.3*	0.6	5.3	2.2	5.2	2.2
Beef for Stewing	97.1	2.7	97.2	2.7	1.6	1.4	1.6	1.4	1.1	1.2	1.0	1.2

[a,b]Weighted least squares means within a separable component and raw or cooked cut lacking a common letter differ ($P < 0.05$).

* Weighted least squares means noted with an asterisk exhibit tendencies ($0.05 < P < 0.1$) within a separable component and raw or cooked cut.

[1] USDA Yield Grade 2 weighted least squares means represent 19 individual carcasses; USDA Yield Grade 3 weighted least squares means represent 17 individual carcasses.

[2] Separable lean, %: [separable lean (g) / pre-dissection cut weight (g)] × 100.

[3] Seam fat, %: [seam fat (g) / pre-dissection cut weight (g)] × 100.

[4] Refuse (including all bone and heavy connective tissue), %: [refuse (g) / pre-dissection cut weight (g)] × 100.

[5] Clod Steaks, Denver Cuts, Chuck Eye Steaks, and Top Blade Steaks were grilled to an internal temperature of 70 °C using a clam-shell grill; Chuck Eye Roll Roasts were roasted in a conventional oven to an internal temperature of 60 °C; all other cuts were placed in a non-stick Dutch oven and braised in a conventional oven until an internal product temperature of 85 °C was reached.

Table 4
The effect of USDA Quality Grade[1] and Yield Grade[2] (YG) on the cooking[3] yield percentage[4] (%) of retail beef cuts from the chuck.

Retail cut	USDA Quality Grade				USDA Yield Grade			
	Choice	SEM	Select	SEM	YG 2	SEM	YG 3	SEM
Mock Tender Steak	70.9	9.6	72.0	9.7	70.8	9.7	71.9	9.7
Chuck Short Ribs, Boneless	62.6[b]	3.7	71.3[a]	4.2	66.3	3.9	65.9	4.1
Chuck Eye Roll Steak, Boneless	80.2	2.0	80.1	2.0	80.8	2.0	79.5	2.0
Chuck Eye Roll Roast ("America's Beef Roast")	83.9	1.6	84.7	1.8	84.6	1.6	83.9	1.7
Country-Style Ribs, Boneless	68.5	2.4	67.9	2.4	68.7	2.4	67.9	2.4
Under Blade Roast, Boneless	68.2	1.2	64.5	1.5	64.5[b]	1.2	68.8[a]	1.4
Under Blade Steak, Boneless	65.2	1.3	64.5	1.4	64.7	1.3	65.2	1.4
Under Blade, Center-Cut Steak ("Denver Cut")	73.0[b]	0.9	76.9[a]	1.2	73.9	1.0	75.3	1.1
Shoulder (Clod), Top Blade Steak	76.7	3.5	79.0	3.6	77.7	3.5	77.6	3.6
Shoulder (Clod), Roast	66.3	2.2	66.2	2.3	65.9	2.2	66.7	2.3
Shoulder (Clod), Steak	77.5	1.6	78.0	1.7	78.2	1.7	77.3	1.7
Beef for Stewing	63.1	0.8	63.2	1.0	63.5	0.9	62.7	0.9

[a,b]Weighted least squares means within a USDA Quality Grade or Yield Grade lacking a common letter differ ($P < 0.05$).
[1] USDA Choice weighted least squares means represent 24 individual carcasses; USDA Select weighted least squares means represent 12 individual carcasses.
[2] USDA Yield Grade 2 weighted least squares means represent 19 individual carcasses; USDA Yield Grade 3 weighted least squares means represent 17 individual carcasses.
[3] Clod Steaks, Denver Cuts, Chuck Eye Steaks, and Top Blade Steaks were grilled to an internal temperature of 70 °C using a clam-shell grill; Chuck Eye Roll Roasts were roasted in a conventional oven to an internal temperature of 60 °C; all other cuts were placed in a non-stick Dutch oven and braised in a conventional oven until an internal product temperature of 85 °C was reached.
[4] Cooking yield, %: [hot cooked weight (g) / pre-cooked raw weight (g)] × 100.

USDA Yield Grade. Differences among universities and the residual variation were defined as random effects. Weighted least squares means were computed so that designated percentages for USDA Quality Grades (20% upper choice; 40% lower choice; 40% select), USDA Yield Grades (50% YG 2; 50% YG 3), genders (66.7% steers; 33.3% heifers), and genetics (88.9% non-dairy; 11.1% dairy) were achieved.

3. Results and discussion

3.1. Separable components

The effect of USDA Quality Grade on separable components dissected from raw and cooked retail cuts from the beef chuck can be seen in

Table 5
The effect of USDA Quality Grade on the protein content (g/100 g) of the separable lean from beef chuck retail cuts.

	Comparison within USDA Choice Quality Grade				Comparison between USDA Quality Grades			
Retail cut	Upper[1]	SEM	Lower[2]	SEM	Choice[3]	SEM	Select[4]	SEM
Raw								
Beef Brisket, Flat Cut, Boneless	21.3	0.3	21.3	0.3	21.3	0.3	21.7	0.3
Mock Tender Steak	21.3	0.4	21.4	0.4	21.4	0.3	21.2	0.4
Chuck Short Ribs, Boneless	19.0	0.3	19.6	0.3	19.4	0.3	20.1	0.3
Chuck Eye Roll Steak, Boneless	21.1	0.5	21.4	0.5	21.3	0.5	21.3	0.5
Chuck Eye Roll Roast ("America's Beef Roast")	20.7	0.5	20.7	0.5	20.7	0.4	20.5	0.4
Country-Style Ribs, Boneless	20.8	0.6	20.9	0.6	20.9	0.6	21.1	0.6
Under Blade Roast, Boneless[5]	20.6	0.3	21.5	0.3	21.2	0.3	21.0	0.3
Under Blade Steak, Boneless[5]	20.6	0.3	21.5	0.3	21.2	0.3	21.0	0.3
Under Blade, Center-Cut Steak ("Denver Cut")	18.6[b]	0.4	19.6[a]	0.4	19.2	0.3	19.7	0.4
Shoulder (Clod), Top Blade Steak	20.1	0.5	20.4	0.5	20.3	0.4	20.4	0.5
Shoulder (Clod), Roast[6]	21.3	0.2	21.5	0.2	21.4	0.2	21.9	0.2
Shoulder (Clod), Steak[6]	21.3	0.2	21.5	0.2	21.4	0.2	21.9	0.2
Beef for Stewing	21.4	0.6	21.8	0.6	21.6	0.6	21.9	0.6
Cooked[7]								
Mock Tender Steak	33.5	1.2	33.6	1.2	33.5	1.2	33.0	1.2
Chuck Short Ribs, Boneless	27.4[b]	0.6	29.6[a]	0.6	28.8	0.4	28.8	0.6
Chuck Eye Roll Steak, Boneless	28.2	1.4	27.9	1.4	28.0	1.4	27.9	1.4
Chuck Eye Roll Roast ("America's Beef Roast")	25.6	1.1	26.8	1.1	26.4	1.1	27.0	1.1
Country-Style Ribs, Boneless	30.7	1.2	31.1	1.2	30.9[b]	1.2	32.1[a]	1.2
Under Blade Roast, Boneless	30.3	1.0	30.5	1.0	30.5	0.9	30.7	1.0
Under Blade Steak, Boneless	29.8[b]	0.6	31.5[a]	0.6	30.9	0.5	32.0	0.6
Under Blade, Center-Cut Steak ("Denver Cut")	26.7	0.8	26.4	0.8	26.5	0.7	26.5	0.8
Shoulder (Clod), Top Blade Steak	27.6	1.4	28.6	1.4	28.3	1.3	28.0	1.4
Shoulder (Clod), Roast	30.7	0.4	31.6	0.4	31.3	0.3	31.7	0.4
Shoulder (Clod), Steak	28.1	0.4	28.7	0.4	28.5	0.3	28.7	0.4
Beef for Stewing	32.5	0.6	32.5	0.6	32.5	0.6	32.3	0.6

[a,b]Weighted least squares means within a USDA Quality Grade comparison and raw or cooked cut lacking a common letter differ ($P < 0.05$).
[1] USDA Upper Choice weighted least squares means represent 12 individual carcasses.
[2] USDA Lower Choice weighted least squares means represent 12 individual carcasses.
[3] USDA Choice weighted least squares means represent 24 individual carcasses (both Upper and Lower Choice).
[4] USDA Select weighted least squares means represent 12 individual carcasses.
[5] Weighted least squares means generated for raw, Boneless Under Blade roasts were used to represent values for raw, Boneless Under Blade steaks.
[6] Weighted least squares means generated for raw, Shoulder (Clod) roasts were used to represent values for raw, Shoulder (Clod) steaks.
[7] Clod Steaks, Denver Cuts, Chuck Eye Steaks, and Top Blade Steaks were grilled to an internal temperature of 70 °C using a clam-shell grill; Chuck Eye Roll Roasts were roasted in a conventional oven to an internal temperature of 60 °C; all other cuts were placed in a non-stick Dutch oven and braised in a conventional oven until an internal product temperature of 85 °C was reached.

Table 2. For most raw and cooked retail cuts, USDA Quality Grade had no impact ($P > 0.05$) on percent separable lean, seam fat, and refuse. However, raw USDA Select Chuck Eye Roll Roasts had a notably higher ($P < 0.05$) percentage separable lean, and lower ($P < 0.05$) percentage refuse when compared to the USDA Choice counterpart. Further, raw USDA Select Under Blade Steaks had significantly higher percent refuse ($P < 0.05$) than the same type of steak carrying the USDA Choice designation. When compared to cooked USDA Select Top Blade steaks, cooked USDA Choice Top Blade steaks presented a higher ($P < 0.05$) and a lower ($P < 0.05$) percentage of seam fat and refuse, respectively. Both raw Beef for Stewing and "Denver Cut" Steaks tended ($0.05 < P < 0.1$) to have a lower percent separable lean for retail cuts from USDA Select beef chucks when compared to those cuts from USDA Choice beef chucks. This finding differs from results of previous studies, which cite an inverse relationship between carcass grades and separable lean percentage (Jones et al., 1992a; Paterson & Parrish, 1986; Ramsey, Cole, & Hobbs, 1962).

While not significant ($P > 0.05$) for all retail cuts, USDA Yield Grade did influence percent dissectible components as expected (Table 3). Generally, USDA Yield Grade 2 carcasses presented a higher percentage separable lean, and a lower percentage separable fat for both raw and cooked cuts when compared to cuts from USDA Yield Grade 3 carcasses. This relationship was found to be significant ($P < 0.05$) for the separable lean component of raw Under Blade Steaks and cooked "Denver Cut" Steaks. Conversely, raw Shoulder (Clod) Roasts and Beef for Stewing had a higher ($P < 0.05$) percentage separable lean when fabricated from USDA Yield Grade 3 carcasses. Only the raw Under Blade and Top Blade Steaks fabricated from USDA Yield Grade 2 carcasses possessed a lower ($P < 0.05$) percent separable fat as compared to the same cuts from USDA Yield Grade 3 carcasses. Overall, these findings are in agreement with studies conducted by other researchers that have documented an increase in intermuscular fat (Jones, Savell, & Cross, 1990), and a decrease in separable lean as USDA Yield Grade increases (Paterson & Parrish, 1986; Ramsey et al., 1962). It should be noted that these data were not stratified by sex-class, as this was not an objective of this study. However, some instances of products from USDA Yield Grade 2 carcasses presenting a higher percentage of refuse or seam fat, as compared to their USDA Yield Grade 3 counterparts, may be attributable to sex-related seam fat deposition. This phenomenon was reported by Jones et al. (1990), in which primals from Yield Grade 2.5 heifers had less seam fat than yield grade 3.5 steers. Data from the same study also showed primals from Yield Grade 3.5 heifers to have more seam fat than primals from Yield Grade 4.5 steers (Jones et al., 1990).

Previous studies that investigated the influence of USDA Quality Grade and Yield Grades on separable components limited the number of cuts from the beef chuck to the Arm Roast, Blade Roast, and Brisket (Jones et al., 1992a; Wahrmund-Wyle et al., 2000a). In a study by Jones et al. (1992a), two levels of external fat trim were evaluated (0.0 and 0.6 cm), and the importance of trimming external fat was noted. In an effort to reduce seam fat in retail cuts, Jones et al. (1992a) recommended the fabrication of Shoulder (Clod) Roasts and roasts from the Chuck Roll in place of Arm Roasts and Blade Roasts, respectively. With these recommended cuts, among other innovative cuts from the beef chuck (i.e. "Denver Cut") being commonplace in our retail market today, the constant evolution of retail beef cuts, to provide the consumer with leaner choices, is evident.

Table 6
The effect of USDA Quality Grade on the fat content (g/100 g) of the separable lean from beef chuck retail cuts.

	Comparison within USDA Choice Quality Grade				Comparison between USDA Quality Grades			
Retail cut	Upper[1]	SEM	Lower[2]	SEM	Choice[3]	SEM	Select[4]	SEM
Raw								
Beef Brisket, Flat Cut, Boneless	6.3[a]	0.6	5.5[b]	0.6	5.7[a]	0.6	4.1[b]	0.6
Mock Tender Steak	4.7	0.3	4.5	0.3	4.6[a]	0.3	3.5[b]	0.3
Chuck Short Ribs, Boneless	12.2[a]	1.1	9.9[b]	1.1	10.7[a]	1.0	9.0[b]	1.1
Chuck Eye Roll Steak, Boneless	9.4[a]	0.5	7.9[b]	0.5	8.3[a]	0.5	6.5[b]	0.5
Chuck Eye Roll Roast ("America's Beef Roast")	7.0[a]	0.6	5.8[b]	0.6	6.2	0.5	2.7	0.6
Country-Style Ribs, Boneless	8.2[a]	0.3	7.4[b]	0.3	7.7[a]	0.2	5.9[b]	0.3
Under Blade Roast, Boneless[5]	7.1	0.4	6.2	0.4	6.5	0.3	5.4	0.4
Under Blade Steak, Boneless[5]	7.1	0.4	6.2	0.4	6.5	0.3	5.4	0.4
Under Blade, Center-Cut Steak ("Denver Cut")	11.9	2.4	10.5	2.4	11.0[a]	2.3	8.5[b]	2.4
Shoulder (Clod), Top Blade Steak	8.2[a]	0.4	6.2[b]	0.4	6.9[a]	0.4	5.7[b]	0.4
Shoulder (Clod), Roast[6]	4.9[a]	0.3	4.1[b]	0.3	4.4[a]	0.3	3.7[b]	0.3
Shoulder (Clod), Steak[6]	4.9[a]	0.3	4.1[b]	0.3	4.4[a]	0.3	3.7[b]	0.3
Beef for Stewing	5.3[a]	0.9	4.6[b]	0.9	4.8[a]	0.9	4.0[b]	0.9
Cooked[7]								
Mock Tender Steak	7.4	0.4	6.7	0.4	6.9[a]	0.4	5.4[b]	0.4
Chuck Short Ribs, Boneless	17.7[a]	2.5	13.6[b]	1.5	14.9[a]	2.4	12.1[b]	2.5
Chuck Eye Roll Steak, Boneless	12.3	0.8	11.1	0.8	11.5[a]	0.8	9.8[b]	0.8
Chuck Eye Roll Roast ("America's Beef Roast")	10.2[a]	0.5	8.9[b]	0.5	9.4[a]	0.4	7.1[b]	0.5
Country-Style Ribs, Boneless	12.6	0.7	12.0	0.7	12.2[a]	0.6	10.2[b]	0.7
Under Blade Roast, Boneless	11.5	1.4	11.0	1.3	11.1	1.3	9.4	1.3
Under Blade Steak, Boneless	11.5	1.3	10.6	1.3	10.9	1.3	9.7	1.3
Under Blade, Center-Cut Steak ("Denver Cut")	15.0[a]	2.1	12.6[b]	2.1	13.4[a]	2.0	11.5[b]	2.1
Shoulder (Clod), Top Blade Steak	11.4[a]	1.1	9.1[b]	1.1	9.8	1.1	8.3	1.1
Shoulder (Clod), Roast	9.4[a]	0.6	7.7[b]	0.6	8.3[a]	0.5	7.0[b]	0.6
Shoulder (Clod), Steak	7.1[a]	0.6	5.8[b]	0.6	6.3[a]	0.5	5.2[b]	0.6
Beef for Stewing	7.6	1.0	6.9	1.0	7.1	0.9	6.3	0.9

[a,b]Weighted least squares means within a USDA Quality Grade comparison and raw or cooked cut lacking a common letter differ ($P < 0.05$).

[1] USDA Upper Choice weighted least squares means represent 12 individual carcasses.

[2] USDA Lower Choice weighted least squares means represent 12 individual carcasses.

[3] USDA Choice weighted least squares means represent 24 individual carcasses (both Upper and Lower Choice).

[4] USDA Select weighted least squares means represent 12 individual carcasses.

[5] Weighted least squares means generated for raw, Boneless Under Blade roasts were used to represent values for raw, Boneless Under Blade steaks.

[6] Weighted least squares means generated for raw, Shoulder (Clod) roasts were used to represent values for raw, Shoulder (Clod) steaks.

[7] Clod Steaks, Denver Cuts, Chuck Eye Steaks, and Top Blade Steaks were grilled to an internal temperature of 70 °C using a clam-shell grill; Chuck Eye Roll Roasts were roasted in a conventional oven to an internal temperature of 60 °C; all other cuts were placed in a non-stick Dutch oven and braised in a conventional oven until an internal product temperature of 85 °C was reached.

3.2. Cooking yield

USDA Quality and Yield Grades had little impact on the cooking yield percentage of retail cuts from the chuck, regardless of the cooking method used (Table 4). Only two differences resulted from the effect of USDA Quality Grade on cooking yield percentages. USDA Select Chuck Short Ribs and "Denver Cut" Steaks exhibited a higher ($P < 0.05$) cooking yield (%) than their USDA Choice counterparts. The lack of impact by USDA Quality Grade on cooking yield of retail cuts also has been documented by Jones et al. (1992c), Luchak et al. (1998), and Wahrmund-Wyle et al. (2000a). USDA Yield Grade also had minimal effect on cooking yield (%). A single cut, Under Blade Roast, presented a higher ($P < 0.05$) cooking yield percentage when derived from USDA Yield Grade 3 carcasses, as compared to the same cut from USDA Yield Grade 2 carcasses.

Although data from the current study were not analyzed for significant differences in cooking yield (%) among cooking methods, a trend among these data should be noted. For those cuts assigned to the grilling and roasting cooking methods, a higher cooking yield can be seen when compared to those cuts that were braised. Due to the higher endpoint internal temperature of braised cuts (85 °C), increased cooking loss would be expected when compared to roasted and grilled cuts which had endpoint temperatures of 60 and 70 °C, respectively. This relationship was also noted in previous studies that investigated the influence of cooking method or final internal product temperature on cooking yield percentages of various beef retail cuts (Akinwunmi, Thompson, & Ramsey, 1993; Jones et al., 1992c; Luchak et al., 1998; Smith, Harris, Haneklaus, & Savell, 2011; Wahrmund-Wyle et al., 2000a).

3.3. Proximate composition

3.3.1. Protein

The effects of USDA Quality Grade on the least squares means for protein content (g/100 g) of the separable lean from raw and cooked beef retail cuts from the chuck are presented in Table 5. USDA Quality Grade was responsible for a single difference ($P < 0.05$) in the protein content of raw retail chuck cuts. "Denver Cut" Steaks carrying the USDA Upper Choice designation contained less ($P < 0.05$) protein (g/100 g) than USDA Lower Choice "Denver Cuts." For cooked cuts, both the Chuck Short Rib and Under Blade Steak presented a higher ($P < 0.05$) protein content in USDA Lower Choice cuts as compared to USDA Upper Choice cuts. Likewise, cooked USDA Select Country-Style Ribs contained more ($P < 0.05$) protein than their USDA Choice counterparts. The relationship between USDA Quality Grade and the protein content of beef cuts (raw and cooked) has been well documented in previous studies, with the protein content of beef cuts decreasing as USDA Quality Grade (intramuscular fat) increases (Akinwunmi et al., 1993; Brackebusch, McKeith, Carr, & McLaren, 1991; Garrett & Hinman, 1971; Smith et al., 2011; Wahrmund-Wyle et al., 2000b). Additionally, data from the current study display a greater protein content in cooked cuts versus raw cuts, and braised cuts versus cuts assigned to cooking methods with lower degrees of doneness. Both of these trends are in agreement with Smith et al. (2011) and Wahrmund-Wyle et al. (2000b) who noted the concentration of nutrients in cooked lean tissue, leading to greater protein content in cuts cooked to advancing degrees of doneness.

Table 7
The effect of USDA Quality Grade on the moisture content (g/100 g) of the separable lean from beef chuck retail cuts.

	Comparison within USDA Choice Quality Grade				Comparison between USDA Quality Grades			
Retail cut	Upper[1]	SEM	Lower[2]	SEM	Choice[3]	SEM	Select[4]	SEM
Raw								
Beef Brisket, Flat Cut, Boneless	71.7[b]	0.5	72.5[a]	0.5	72.2[b]	0.5	73.4[a]	0.5
Mock Tender Steak	73.0	0.6	73.3	0.6	73.2[b]	0.6	74.5[a]	0.6
Chuck Short Ribs, Boneless	67.2[b]	0.6	69.5[a]	0.6	68.7[b]	0.5	70.2[a]	0.6
Chuck Eye Roll Steak, Boneless	68.7[b]	0.3	69.9[a]	0.3	69.5[b]	0.2	71.4[a]	0.3
Chuck Eye Roll Roast ("America's Beef Roast")	71.5	0.7	72.5	0.7	72.2	0.6	73.0	0.7
Country-Style Ribs, Boneless	69.9[b]	0.4	70.9[a]	0.4	70.6[b]	0.3	72.1[a]	0.4
Under Blade Roast, Boneless[5]	70.7	0.8	70.9	0.8	70.8[b]	0.8	72.3[a]	0.8
Under Blade Steak, Boneless[5]	70.7	0.8	70.9	0.8	70.8[b]	0.8	72.3[a]	0.8
Under Blade, Center-Cut Steak ("Denver Cut")	67.5	1.8	68.6	1.8	68.2[b]	1.8	70.6[a]	1.8
Shoulder (Clod), Top Blade Steak	70.7[b]	0.5	72.4[a]	0.5	71.8[b]	0.4	73.4[a]	0.5
Shoulder (Clod), Roast[6]	72.4[b]	0.4	73.2[a]	0.4	72.9	0.4	73.5	0.4
Shoulder (Clod), Steak[6]	72.4[b]	0.4	73.2[a]	0.4	72.9	0.4	73.5	0.4
Beef for Stewing	71.9	1.2	72.5	1.2	72.3	1.1	72.8	1.2
Cooked[7]								
Mock Tender Steak	58.6	1.4	59.5	1.4	59.2[b]	1.4	60.8[a]	1.4
Chuck Short Ribs, Boneless	54.6	2.4	56.6	2.4	55.9[b]	2.3	58.7[a]	2.4
Chuck Eye Roll Steak, Boneless	59.1[b]	1.2	61.0[a]	1.2	60.4[b]	1.2	61.4[a]	1.2
Chuck Eye Roll Roast ("America's Beef Roast")	63.4	1.4	64.1	1.4	63.9[b]	1.4	66.2[a]	1.4
Country-Style Ribs, Boneless	56.6	0.9	56.7	0.9	56.6	0.9	57.5	0.9
Under Blade Roast, Boneless	58.1	1.3	57.7	1.3	57.8	1.2	58.8	1.3
Under Blade Steak, Boneless	58.1	1.4	57.3	1.4	57.6	1.4	58.9	1.4
Under Blade, Center-Cut Steak ("Denver Cut")	58.1	1.1	59.2	1.1	58.8[b]	1.0	61.1[a]	1.1
Shoulder (Clod), Top Blade Steak	60.7	1.8	62.3	1.8	61.7	1.7	62.7	1.8
Shoulder (Clod), Roast	59.5	0.6	60.3	0.6	60.1	0.6	61.0	0.6
Shoulder (Clod), Steak	63.5	0.6	64.6	0.6	64.2[b]	0.5	65.2[a]	0.6
Beef for Stewing	59.3	0.7	59.6	0.7	59.5[b]	0.7	61.0[a]	0.7

[a,b]Weighted least squares means within a USDA Quality Grade comparison and raw or cooked cut lacking a common letter differ ($P < 0.05$).

[1] USDA Upper Choice weighted least squares means represent 12 individual carcasses.

[2] USDA Lower Choice weighted least squares means represent 12 individual carcasses.

[3] USDA Choice weighted least squares means represent 24 individual carcasses (both Upper and Lower Choice).

[4] USDA Select weighted least squares means represent 12 individual carcasses.

[5] Weighted least squares means generated for raw, Boneless Under Blade Roasts were used to represent values for raw, Boneless Under Blade steaks.

[6] Weighted least squares means generated for raw, Shoulder (Clod) roasts were used to represent values for raw, Shoulder (Clod) steaks.

[7] Clod Steaks, Denver Cuts, Chuck Eye Steaks, and Top Blade Steaks were grilled to an internal temperature of 70 °C using a clam-shell grill; Chuck Eye Roll Roasts were roasted in a conventional oven to an internal temperature of 60 °C; all other cuts were placed in a non-stick Dutch oven and braised in a conventional oven until an internal product temperature of 85 °C was reached.

USDA Yield Grade had minimal effect on the protein content of cooked and raw cuts (data not shown in tabular form). A single difference was noted in raw Chuck Eye Steaks, with cuts from USDA Yield Grade 2 carcasses containing more ($P < 0.05$) protein than those from USDA Yield Grade 3 carcasses. Most previous studies were not specifically designed to analyze the impact of USDA Yield Grade on the nutrient content of beef cuts; however, Garrett and Hinman (1971) found no influence of USDA Yield Grade on beef nutrients.

3.3.2. Total fat

Although significant ($P < 0.05$) differences were not observed for all cuts, a positive correlation between fat content (g/100 g) and USDA Quality Grade was seen overall (Table 6). When compared to USDA Lower Choice, a higher ($P < 0.05$) fat content was noted for raw, USDA Upper Choice Flat Cut Briskets, Chuck Short Ribs, Chuck Eye Steaks, America's Beef Roasts, Boneless Country-Style Ribs, Top Blade Steaks, Clod Roasts, Clod Steaks, and Beef for Stewing. When comparing USDA Choice and USDA Select, a higher ($P < 0.05$) fat content was seen in raw, USDA Choice Flat Cut Briskets, Mock Tender Steaks, Chuck Short Ribs, Chuck Eye Steaks, Boneless Country-Style Ribs, "Denver Cut" Steaks, Top Blade Steaks, Clod Roasts, Clod Steaks, and Beef for Stewing. Similar differences were seen in the cooked cuts, with Chuck Short Ribs, America's Beef Roasts, "Denver Cut" Steaks, Top Blade Steaks, Clod Roasts, Clod Steaks, and Beef for Stewing having a greater ($P < 0.05$) fat content in USDA Upper Choice as compared to USDA Lower Choice. Cooked USDA Select Mock Tender Steaks, Chuck Short Ribs, Chuck Eye Steaks, America's Beef Roasts, Boneless Country-Style Ribs, "Denver Cut" Steaks, Clod Roasts, and Clod Steaks, also contained less fat ($P < 0.05$) than their USDA Choice counterparts. Previous studies did not differentiate between USDA Upper and Lower Choice; however, the relationship between the fat content of USDA Choice and Select beef cuts documented in the current study is in agreement with prior work (Akinwunmi et al., 1993; Brackebusch et al., 1991; Garrett & Hinman, 1971; Smith et al., 2011; Wahrmund-Wyle et al., 2000b). In general, the fat content of cooked cuts was higher than the same cuts analyzed raw. Beef cuts are known to lose both fat and moisture during the cooking process; however, moisture loss exceeds that of the fat, causing cooked cuts to have an increased fat percentage (Garrett & Hinman, 1971).

Similar to protein content, USDA Yield Grade had little impact on the fat content of either cooked or raw beef retail cuts from the chuck (data not shown in tabular form). USDA Yield Grade 3 cuts that exhibited a higher ($P < 0.05$) fat content than the same cuts procured from USDA Yield Grade 2 carcasses were raw Mock Tender Steaks, cooked Chuck Eye Steaks, and cooked Clod Roasts.

3.3.3. Moisture

The influence of USDA Quality Grade on moisture content (g/100 g) of retail beef chuck cuts was more apparent when comparing USDA Choice and Select than USDA Upper and Lower Choice (Table 7), especially on a cooked basis. Overall, cuts obtained from USDA Select carcasses contained more moisture than cuts from USDA Choice carcasses. Within the USDA Choice grade, raw USDA Upper Choice Flat Cut Briskets, Chuck Short Ribs, Chuck Eye Steaks, Boneless Country-Style Ribs, Top Blade Steaks, Clod Roasts, and Clod Steaks had a lower ($P < 0.05$) moisture content than the same cuts identified as USDA

Table 8
The effect of USDA Quality Grade on the ash content (g/100 g) of the separable lean from beef chuck retail cuts.

	Comparison within USDA Choice Quality Grade				Comparison between USDA Quality Grades			
Retail cut	Upper[1]	SEM	Lower[2]	SEM	Choice[3]	SEM	Select[4]	SEM
Raw								
Beef Brisket, Flat Cut, Boneless	1.0	0.1	1.0	0.1	1.0	0.1	1.1	0.1
Mock Tender Steak	1.1[b]	0.2	1.3[a]	0.2	1.2	0.2	1.1	0.2
Chuck Short Ribs, Boneless	0.9	0.1	0.9	0.1	0.9	0.1	0.9	0.1
Chuck Eye Roll Steak, Boneless	1.0	0.1	0.9	0.1	0.9[b]	0.1	1.0[a]	0.1
Chuck Eye Roll Roast ("America's Beef Roast")	1.0	0.1	1.1	0.1	1.0	0.1	1.0	0.1
Country-Style Ribs, Boneless	1.0	0.1	0.9	0.1	0.9	0.1	1.0	0.1
Under Blade Roast, Boneless[5]	1.0	0.1	1.1	0.1	1.1	0.1	1.1	0.1
Under Blade Steak, Boneless[5]	1.0	0.1	1.1	0.1	1.1	0.1	1.1	0.1
Under Blade, Center-Cut Steak ("Denver Cut")	0.8[b]	0.1	1.0[a]	0.8	0.9	0.1	0.9	0.1
Shoulder (Clod), Top Blade Steak	1.0	0.2	1.0	0.2	1.0[b]	0.2	1.2[a]	0.2
Shoulder (Clod), Roast[6]	1.1	0.2	1.2	0.2	1.1	0.2	1.1	0.2
Shoulder (Clod), Steak[6]	1.1	0.2	1.2	0.2	1.1	0.2	1.1	0.2
Beef for Stewing	1.1	0.1	1.1	0.1	1.1	0.1	1.1	0.1
Cooked[7]								
Mock Tender Steak	1.5	0.4	1.7	0.4	1.3	0.3	1.7	0.4
Chuck Short Ribs, Boneless	0.9	0.1	0.9	0.1	0.9	0.1	0.9	0.1
Chuck Eye Roll Steak, Boneless	1.0	0.1	1.0	0.1	1.0	0.1	1.0	0.1
Chuck Eye Roll Roast ("America's Beef Roast")	1.0	0.1	1.0	0.1	1.0	0.1	1.0	0.1
Country-Style Ribs, Boneless	1.0	0.1	1.1	0.1	1.1	0.1	1.1	0.1
Under Blade Roast, Boneless	1.1	0.3	1.3	0.3	1.3[b]	0.3	1.6[a]	0.3
Under Blade Steak, Boneless	1.4	0.3	1.6	0.3	1.6	0.2	1.2	0.3
Under Blade, Center-Cut Steak ("Denver Cut")	1.0	0.1	1.0	0.1	1.0	0.1	1.0	0.1
Shoulder (Clod), Top Blade Steak	1.0	0.1	1.0	0.1	1.0[b]	0.1	1.3[a]	0.1
Shoulder (Clod), Roast	1.6	0.3	1.3	0.3	1.4	0.3	1.4	0.3
Shoulder (Clod), Steak	1.2	0.1	1.2	0.1	1.2	0.1	1.2	0.1
Beef for Stewing	1.2[b]	0.2	1.4[a]	0.2	1.3[a]	0.2	1.2[b]	0.2

[a,b]Weighted least squares means within a USDA Quality Grade comparison and raw or cooked cut lacking a common letter differ ($P < 0.05$).

[1] USDA Upper Choice weighted least squares means represent 12 individual carcasses.

[2] USDA Lower Choice weighted least squares means represent 12 individual carcasses.

[3] USDA Choice weighted least squares means represent 24 individual carcasses (both Upper and Lower Choice).

[4] USDA Select weighted least squares means represent 12 individual carcasses.

[5] Weighted least squares means generated for raw, Boneless Under Blade roasts were used to represent values for raw, Boneless Under Blade steaks.

[6] Weighted least squares means generated for raw, Shoulder (Clod) roasts were used to represent values for raw, Shoulder (Clod) steaks.

[7] Clod Steaks, Denver Cuts, Chuck Eye Steaks, and Top Blade Steaks were grilled to an internal temperature of 70 °C using a clam-shell grill; Chuck Eye Roll Roasts were roasted in a conventional oven to an internal temperature of 60 °C; all other cuts were placed in a non-stick Dutch oven and braised in a conventional oven until an internal product temperature of 85 °C was reached.

Lower Choice. When comparing raw USDA Choice cuts to USDA Select, the inverse relationship is again seen between USDA Quality Grade and moisture content. On a raw basis, USDA Choice Flat Cut Briskets, Mock Tender Steaks, Chuck Short Ribs, Chuck Eye Steaks, Boneless Country-Style Ribs, Under Blade Roasts, Under Blade Steaks, "Denver Cut" Steaks, and Top Blade Steaks all contained less ($P < 0.05$) moisture than their USDA Select cohorts. These findings agree with the work of previous researchers that identified a reduction in moisture content as fat content (USDA Quality Grade) increased (Akinwunmi et al., 1993; Brackebusch et al., 1991; Garrett & Hinman, 1971; Jones et al., 1992b; Wahrmund-Wyle et al., 2000b). Although moisture content of cooked cuts was lower overall as compared to cuts analyzed on a raw basis, the same correlation between USDA Quality Grade and moisture content was noted. This correlation was associated with significantly less ($P < 0.05$) moisture in USDA Upper Choice Chuck Eye Steaks when compared to USDA Lower Choice Chuck Eye Steaks. In addition to Chuck Eye Steaks, these results were also seen for Mock Tender Steaks, Chuck Short Ribs, America's Beef Roasts, "Denver Cut" Steaks, Clod Steaks, and Beef for Stewing when comparing USDA Choice and Select. In previous studies, researchers also have identified progressively decreasing moisture content in beef cuts as they are exposed to increasing degrees of doneness (Jones et al., 1992b; Smith et al., 2011; Wahrmund-Wyle et al., 2000b). Although distinct differences are not visible in all cases, data from the current study exhibit a similar trend, with braised cuts presenting slightly lower moisture content than the roasted or grilled cuts.

Few notable differences were seen in moisture content as influenced by USDA Yield Grade (data not shown in tabular form). Only raw Clod Steaks, Clod Roasts, Country-Style Ribs, and cooked Chuck Eye Steaks from USDA Yield Grade 2 carcasses were found to have more ($P < 0.05$) moisture than the same cuts from USDA Yield Grade 3 carcasses.

3.3.4. Ash

As expected, USDA Quality Grade (Table 8) and USDA Yield Grade (data not shown in tabular form) had limited impact on the ash content (g/100 g) of raw and cooked beef retail cuts from the chuck. Ash content was found to be higher ($P < 0.05$) in USDA Lower Choice raw Mock Tender Steaks, raw "Denver Cut" Steaks, and cooked Beef for Stewing when compared to the same cuts graded USDA Upper Choice. Following this trend, USDA Select raw Chuck Eye Steaks, raw and cooked Top Blade Steaks, cooked Under Blade Roasts, and cooked Beef for Stewing each contains more ($P < 0.05$) ash than their USDA Choice counterparts. Overall, these data are in agreement with previous studies, in which ash content (g/100 g) tended to hold constant regardless of USDA Quality Grade (Akinwunmi et al., 1993; Smith et al., 2011; Wahrmund-Wyle et al., 2000b).

4. Conclusions

The findings documented in this study will provide relevant nutrient data on retail beef chuck cuts that are both new and currently represented in the National Nutrient Database for Standard Reference (SR). The domestic and international use of this database highlights the need for current data on beef composition, cooking yields, and separable components. Improved beef nutrient data will provide support for the current production of lean healthful beef products, allow enhanced dietary education of consumers, and improve the accuracy of product labeling.

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