EVALUATING THE IMPACTS OF GENDER, FATNESS, MUSCLING, AND WEIGHT ON YIELD GRADE 4 BEEF CARCASSES

A Thesis

by

JAMES THOMAS DILLON

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

MASTER OF SCIENCE

August 2009

Major Subject: Animal Science

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Approved by:

Chair of Committee,	Jeffrey W. Savell
Committee Members,	Davey B. Griffin
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ABSTRACT

Evaluating the Impacts of Gender, Fatness, Muscling, and Weight on Yield Grade 4 Beef Carcasses.

(August 2009)

James Thomas Dillon, B.S., Texas A&M University

Chair of Advisory Committee: Dr. Jeffrey W. Savell

This study was conducted to assess cutout and value differences in Yield Grade 4 beef carcasses by evaluating impacts of gender, fatness, muscling, and weight. USDA Choice, Yield Grade 4 carcasses (n = 60) were selected according to gender: heifers (n = 20) and steers (n = 40), and weight groups: lightweight heifers (315.5 – 362.9 kg) and steers (362.9 – 408.2 kg), and heavy weight heifers (362.9 – 408.2 kg) steers (408.2 – 453.6 kg). Within weight classes, carcasses were separated according to ribeye area per 45.36 kg of HCW ratio ($REAcm^2$:100 kg): heifers (>21.76) and ($\leq$ 21.76); steers (>20.07) and ($\leq$ 20.07) based on analysis from NBQA-2005 (National Beef Quality Audit – 2005). Data in this study showed that within yield grade 4 carcasses, there are both conformational and value differences associated with different types of yield grade 4's, particularly when sex-class is considered due to the biological differences associated with fat and muscle deposition between genders. As expected, carcasses from heifers had more trimmable fat than steers, and steers had higher yields of certain cuts from the chuck and in bone differences than did heifers. In this demonstration, applied estimated

discounts out-weighted the value differences found in cutout values. There were no clear associations in carcass traits that could be used to more accurately sort value differences in Yield Grade 4 carcasses with exception to sex-class. However, the present data suggests a need to establish a prediction equation that predicts carcass value in addition to the current Yield Grade equation. In conclusion, further research is needed incorporating all yield grade carcass types. Standard carcass fabrication styles and fat trim levels consistent with industry are needed to further assign current subprimal and minor cut prices. Additional premium and discount prices are needed for a current industry representation to obtain if premiums and discounts are being applied according to potential profits or losses incurred because of cutability differences found between the different yield grades.

DEDICATION

This thesis is dedicated to the love of my life, Kristin Leni Dillon, who is my wife, best friend, and the driving force behind my success. Additionally, I would like to extend this dedication to my father, Robert Crawford Dillon, Jr., the greatest influence on my life, who taught me the that the best kind of knowledge to have is that which is learned because of genuine interest.

Thank you all for the guidance and impacts you have had on my life. Without your presence and example none of this would have been possible. You have been the source of my motivation and inspiration.

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CHAPTER I

INTRODUCTION

According to the National Beef Quality Audit-2005 (NBQA-2005) Garcia et al. (2008), USDA Yield Grade 4 (YG 4) carcasses are one of the top ten problems facing the beef industry today (NCBA, 2006). In 2007, USDA beef carcass grading data showed that 9.5% of carcasses that were graded YG 4 (USDA, 2008a). Additionally, USDA-AMS reported that, on average, YG 4 carcasses receive approximately a $15/45.36 kg (per hundred weight) discount. These carcasses are heavily discounted due to their low red-meat yield percentages and high percentages of fat and bone. However, should all USDA Yield Grade 4 carcasses be valued equally? Past research has shown that there are breedtype differences in fat deposition, and that the current yield grade system, implemented in the 1960's, over-estimates and under-estimates different cattle types (Crouse et al., 1975; Griffin et al., 1992; Koch et al., 1976).

Within the population of YG 4 carcasses, there are carcasses classified as Yield Grade 4 because of below average muscling, excessive fat thickness, heavy carcass weight, or a combination of these factors. USDA Yield Grades are a numerical representation estimated percentage of boneless, closely trimmed retail cuts from the round, loin, rib, and chuck of a carcass. USDA yield grades are assigned to carcasses

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This thesis follows the style of Journal of Animal Science.

based on an equation that incorporates fat thickness, ribeye area, hot carcass weight, and percentage of kidney, pelvic, and heart fat (USDA, 1997). Data from the National Beef Quality Audit-2005 indicated that YG 4 heifer carcasses often assigned that grade because of fat thickness, whereas steer carcasses were assigned a YG 4 designation due to a variety of reasons. It appears that in addition to steer carcasses becoming YG 4's for the reason of excess fat, a significant portion of this population received the YG 4 grade due to a small ribeye area in relation to heavy carcass weights. In the NBQA 2005 results, the data showed that 315 of the 422 (74.64%) USDA Yield Grade 4 heifer carcasses had a fat thickness greater than 2.03 cm. Among steer carcasses, a substantial percentage of YG 4 carcasses had fat thickness levels of 1.52 to 2.03 cm, indicating that these carcasses became USDA Yield Grade 4's as they displayed below-average muscling.

A current assessment of the composition of Yield Grade 4 carcasses from steers and heifers is needed to further examine this issue. Historically, the cutability for YG 4 carcasses would have been lower than the cutability from YG 3's or better. Excessive fat due to a change of one yield grade unit represents a 2.3% change in boneless, closely trimmed retail cuts from the round, loin, rib, and chuck (Murphey et al., 1960) or a 3.4% change in total retail product from the whole carcass (Dikeman et al., 1998). However, increasing carcass weights may be driven by increased muscle and frame size rather than by excessive fatness. This rationale may be contributing to the higher number of carcasses being identified as Yield Grade 4. Cutability of these carcasses may not be as negatively impacted as the Yield grade equation suggests. Current cutability information

is needed to determine the economic impact of Yield Grade 4 carcasses. Essentially, a fresh approach to evaluating composition of Yield Grade 4 carcasses is needed. Particularly carcasses placed in this category due to heavy weights and less muscle and not primarily excessive fatness. Upon completion of this project, our objective is to assess the variability in Yield Grade 4 beef carcass composition, and as a result increase the values of these commonly discounted carcasses for packers, and in turn adding value to these cattle.

The goals of this study are to:

1) To assess the cutout and value differences among carcasses within the USDA Yield Grade 4 category.

2) To provide packers and cattle producers up-to-date information for determining the optimum utilization of Yield Grade 4 carcasses.

CHAPTER II

REVIEW OF LITERATURE

The National Cattlemen's Beef Association (NCBA) and its predecessor organizations have continuously sought after a means to improve grading to better suggest purchasing desires in order to assemble recommendations to the USDA concerning possible modifications in beef quality and yield grading. The USDA yield grades were established to predict the yield of boneless, closely trimmed retail cuts from a beef carcass (1997). Although grades were established for marketing purposes, a price spread developed between yield grades. In practice the largest price break is between Yield Grade 3 or better carcasses and those from Yield Grade 4 or 5 carcasses (Griffin et al., 1992). The growing interest in marketing fed cattle on a value or grid basis, where prices are based on individual carcass merit, highlights the USDA's responsibility to revise its grade standards when revision will increase the accuracy, precision, and usefulness.

The first real reported attempt to determine whole-body composition of animals was by Lawes and Gilbert (1859). In this study physical dissection and chemical analyses were performed on three bovines through the separate analysis of individual organs and tissues. This work was to be followed by Trowbridge in 1919, Lotka (1925). These studies served as a basis for the development of methods to predict carcass composition.

One of the first standardized methods of evaluating composition of a beef carcass was the physical separation of the 9-10-11-rib cut (Hankins and Howe, 1946). These studies indicated the most effective means of establishing the composition of beef carcasses is the use of chemical analysis in an entire carcass. Furthermore, they also reported that heifers contained a larger quantity of trimmable fat from the 9-10-11-rib section than found in steer carcasses. However, this method is found to be time intense, costly, and results in non-usable carcasses, resulting in less wasteful methods for estimating carcass composition.

A report by Murphey et al. (1960) became the basis for the USDA yield grading standards for beef, later to be adopted in 1965. Since 1965, numerous researchers have evaluated the USDA yield grade equation and its relevance. A considerable amount of research has been performed relating to the composition of beef carcasses. The greater parts of such studies are comprised of data used to classify the total composition of the carcass when segregated by diet, breed, gender, or additional easily obtainable measures.

Consequently, techniques that would calculate beef carcass composition without rendering the carcass unusable were employed. Murphey et al. (1960) established that a regression equation utilizing four independent variables (fat thickness over the rib eye, percent kidney, pelvic, and heart fat; area of rib eye; carcass weight) could be utilized to predict the percentage of boneless, closely trimmed retail cuts from the round, loin, rib, and chuck. Carcasses (n=162) of varying weights and quality grades were incorporated in this study with carcasses fabricated in accordance with recognized research

procedures. The following equation was recommended for use by USDA to predict carcass cutability:

Percent boneless retail cuts from the round, loin, rib, and chuck

= 51.34 - 5.78 (single fat thickness over the rib eye, in.)

- .462 (percent kidney fat)

+ .740 (area of rib eye, sq. in.)

- .0093 (carcass weight, lbs.)

A numerical scale of one to ten indicated the predicted range in the yield of retail cuts. These scale numbers, each representing a range of 2.3% are referred to as yield grades. The simple correlation coefficient between estimated yields by this regression equation and actual cuts was 0.906. From this work a beef yield grading system was developed.

Many other studies have been conducted to predict the composition of beef both on the live animal, as well as, the carcass. Powell and Huffman (1973), and Cross et al. (1973), compared the yield grades with other available methods of estimating beef carcass cutability and concluded that the current yield grade system is the best method for predicting cutability in addition to maintaining practical application in the present grading program. However, certain researchers have argued that there are deficiencies in the current yield grade system or have recommended modifications, which they believe, would expand the accuracy of the yield grades. Outcomes reported by Tyler et al. (1964), indicated that composition of carcasses with identical yield grades were not affected by differences in carcass conformation. Although, they reported carcasses with the equivalent fat depth had higher muscle to bone ratios as carcass conformation grades

increased. Powell and Huffman (1973), established that fat thickness was the most significant aspect in determining USDA yield grades as well as predicting desirable carcass composition as determined by chemical analysis. Kauffman et al. (1975), in an attempt to predict extractable fat and fat-free muscle, found the combination of adjusted fat thickness, longissimus muscle area, and marbling score accounted for 73% of the variability in percent fat-free muscle as a percentage of carcass weight. Crouse et al. (1975) evaluated the USDA yield grade equation as it applied to finding value-determining differences in beef. Due to the introduction of faster growing, more muscular, later maturing types of beef cattle breeds, findings demonstrate that the independent variable most associated with proportion of cutability is that of fat thickness at the 12^{th} rib. Further, the use of a single prediction equation to predict cutability for all breeds is only slightly more accurate within a breed, and only a single percent less precise between breeds. Crouse and Dikeman (1976) established that adjusted fat thickness, longissimus muscle area, estimated kidney, pelvic and heart fat, hot carcass weight, and marbling score singularly, or in conjunction with partial retail cutout of the rib or round will, by the use of regression, produce reasonable estimates of percentage retail product.

Common practice in the majority of packing plants is the slaughter of both steer and heifer carcasses. Nevertheless, in many cases, different prices are assigned for carcasses of different genders with steers receiving higher prices than heifers. Garrett et al. (1971) reported subprimals from heifer carcasses averaged .5 to 1% higher in total fat than those subprimals obtained from steer carcasses. Equations for predicting the

cutability of individual beef wholesale cuts were presented by Cross et al. (1973). These equations were calculated using easily available measurements from the round, loin, rib, chuck, or flank, and accounted for 63 to 80% of the differences in yields of bone-in and boneless retail cuts from the major wholesale cuts. It was also observed that when bone was removed from the primal cuts, the incorporated measures of muscle improved in comparative significance. Additionally, Stiffler et al. (1985) evaluated the cutability characteristics of beef cattle from Continental crossbreds, *Bos indicus* crossbreds, Dairy crossbreds, and *Bos taurus* crossbreds. Stiffler reported the *Bos taurus* influenced cattle had the highest percentage of fat trim, while the Dairy influenced cattle had the highest percentage yield of bone. Continental crossbred cattle had the highest percentage yield of major subprimals with the *Bos taurus* having the lowest. Even though, the Dairy influenced cattle had the lowest fat trim, the higher percentage in subprimal yield over the *Bos indicus* and Continental was offset by the higher percentage of bone.

CHAPTER III

MATERIALS AND METHODS

Carcass Selection

USDA Choice, Yield Grade 4 beef carcasses (n = 60) were selected from two commercial packing facilities located in different regions of Texas, and one side of each carcass was purchased. A USDA Agricultural Marketing Service (AMS) Meat Grading Supervisor evaluated carcasses for preliminary yield grade, adjusted preliminary yield grade, ribeye area, percentage of kidney, pelvic, and heart fat, hot carcass weight, final yield grade, maturity (skeletal and lean), marbling score, and quality grades according to USDA (1997) standards. Texas A&M University and West Texas A&M University personnel recorded additional information including lot number, hot carcass weight, ribeye area to hot carcass weight ratio, hump height, and sex. Hump height measurements were obtained by extending a line along the top of the back. The height of the hump was the distance from the line to the top of the lean muscle (excluding the external layer of fat) and is measured perpendicular to the extension of the top-line at the peak of the hump laid at the top of the animals' shoulders, consisting of the *M. rhomboideus* (AMSA, 2001). Marbling scores were assigned as follows: 300 to 399 = Slight; 400 to 499 = small; 500 to 599 = Modest. Bodywall thickness was measured 12.7 cm from the *M. longissimus lumborum* at the 12^{th} and 13^{th} rib split.

The 60 carcasses selected for this project were selected on parameters that segregated them into eight different groups (Table 1). Initially, the carcasses were

selected by sex class into heifer (n=20) and steer (n=40) carcasses. Heifer carcasses were selected (n = 5 per group) by weight groups: lighter weight (317.5 - 362.9 kgs) and heavier weight (362.9 - 408.2 kgs). Steer carcasses were selected to fit two weight groups (n = 20 per group): lighter weight (362.9 - 408.2 kgs) and heavier weight (408.2 - 453.6 kgs). Carcasses were further divided within weight class according to ribeye area per 100 pounds of hot carcass weight ratio (REA: 100 kg). The two groups within the heifer hot carcass weight groups were those carcasses with a REA: 100 kg ratio of less than 21.76 9.3 cm^2/45.4kg and those equal to or above 21.76 9.3 cm^2/45.4kg. The two groups within steer hot carcass weight groups were those carcasses with a REA: 100 kg ratio of less than 20.07 9.3 cm^2/45.4kg and those equal to or above 20.07 9.3 cm^2/45.4kg. Selection stratifications were developed based on analysis of the population of Yield Grade 4 carcasses from NBQA-2005 (NCBA, 2006), which revealed a natural break between the carcasses having a REA: 100 kg ratios within the parameters previously listed.

Table 1.
Carcass selection parameters

Heifers (n=20)		
	REA / HCW	Warm carcass
n	Ratio	Weight, kg
5	(< 21.76)	317.5 – 362.9
5	(≥ 21.76)	317.5 – 362.9
5	(< 21.76)	363.3 – 408.2
5	(≥ 21.76)	363.3 – 408.2
Steers (n=40)		
	REA / HCW	Warm carcass
n	Ratio	Weight, kg
10	(< 20.07)	362.9 – 408.2
10	(≥ 20.07)	362.9 – 408.2
10	(< 20.07)	408.7 – 453.6
10	(≥ 20.07)	408.7 – 453.6

After carcasses were evaluated and selected, each side was assessed for slaughter and dressing defects and the side practically free of defects (i.e., miss-splits, trimming, etc) was selected. Inside skirt muscles (*M. transversus abdominis*) were released from the hindquarter preceding ribbing of the carcass at the packing facility. Carcasses were divided into quarters and shipped via refrigerated trucks to the Rosenthal Meat Science and Technology Center, Texas A&M University, College Station, Texas for subsequent fabrication.

Carcass Fabrication

Upon receiving the carcasses, each side was weighed, sprayed with lactic acid as a microbial intervention, and reweighed. Carcasses were held until they were fabricated into boneless subprimals, and minor cuts. Throughout fabrication, each subprimal and corresponding lean trimmings, fat trimmings, and bone components were weighed and recorded to the nearest 0.0045 kg. All components were summed to ensure a 99% recovery of each subprimal weight. The briskets were trimmed to 1.905 cm subcutaneous fat to represent "packer trimmed" briskets, while all other subprimals were trimmed to no greater than 0.635 cm. When lean trimmings were produced, the targeted visual lean proportion was 80% lean to 20% fat. However, specific carcass components were identified as 50%, or 90% lean, respectively as traditionally identified by the meat industry. Where appropriate, Institutional Meat Purchase Specification numbers (IMPS #), as defined by USDA (1997) and NAMP (2008), were used to manufacture fabricated subprimals.

Forequarter Fabrication

Forequarters (IMPS #102) were weighed; heart fat was removed flush with the body cavity surface and reweighed prior to further fabrication. The inside (*M. transversus abdominis*) and the outside (*M. diaphragma pars costalis et sternalis*) skirt muscles were loosened at their most anterior attachment in preparation for the rib/chuck separation. A saw-cut between the fifth and sixth ribs was made to separate the rib and plate from the chuck.

The brisket was separated from the remaining arm chuck by a saw-cut perpendicular to the chuck/plate separation approximately 2.54 cm from the dorsal end of the *M. pectoralis profundus* through the cartilaginous juncture of the first rib and sternum. The removal of this portion was completed by following the natural seam found on the medial segment of the foreshank. All bones and cartilage were removed, and deckle fat was trimmed to expose the lean surface of the *M. Pectoralis profundus,* without scoring the lean. The hard fat along the ventral edge of the brisket was trimmed flush with the lean surface and external fat was trimmed to 1.91 cm to create a Beef Brisket, Deckle Off, Boneless (IMPS #120). The remaining arm chuck portion was then suspended by the foreshank and the Beef Chuck, Outside Shoulder (Clod) (IMPS #114) was removed. The shoulder clod further was broken down by removing the *M. Teres major* through the natural seam and denuded to create a Beef Chuck, Shoulder Tender (IM) (IMPS #114F). The *M. Infraspinatus* was removed through the natural seam as a whole muscle and was trimmed practically free of fat, generating a Beef Chuck, Outside Shoulder (Clod) (IMPS #114D), Top Blade, Roast. The *M. latissimus dorsi* was removed and trimmed of any excess fat and labeled as special trim, while the *M. tensor fascia antebrachii* was removed from the *M. triceps brachii* creating the Beef Chuck, Shoulder Clod, Arm Roast (IMPS #114E). The scapula, including the *M. supraspinatus* and the *M. subscapularis,* was removed from the chuck. The Beef Chuck, Chuck (Mock) Tender (IMPS #116B) was fabricated by separating the *M. supraspinatus* from the scapula and trimming. The *M. subscapularis* also was removed from the scapula and recorded as lean trimmings. The dorsal segment of the *M. pectoralis profundus,*

remaining on the chuck after the brisket separation, was detached and denuded, making the Beef Chuck, Square Cut, Pectoral Meat (IMPS #115D). The remainder of the chuck was separated from the foreshank through natural seams. A dorsal/ventral saw-cut separated the neck from the chuck between the fifth and sixth cervical vertebra. The chuck short ribs were cut along the ventral edge of the vertebral column and perpendicular to the rib end of the chuck roll. Beef Chuck, Short Ribs (IMPS #130) were prepared by removing the first rib and overlying tissue leaving the remaining ribs (2 through 5), intercostal and *M. serratus ventralis* practically free of fat. The Beef Chuck, Chuck Roll (IMPS #116A) was fabricated by removing the vertebrae, dorsal spinous processes, ligamentum nuchae, *M. trapezius,* and associated fat. In addition, the ventral edge of the chuck roll was cut to include a 2.54 cm tail (from the ventral edge of the *M. longissimus thoracis*). The remaining foreshank and neck were separated into lean trimmings, trimmable fat, and bone components.

A saw-cut, 10.16 cm ventral to the *M. longissimus thoracis* on the caudal end and 7.62 cm ventral to the *M. longissimus* on the cranial end, identified the rib/plate separation. The resulting Beef Plate, Short Plate (IMPS #121) consisted of seven remaining ribs (and overlying tissue), in addition to, the *M. diaphragma* and the *M. transversus abdominis* muscles. Following Short Plate (IMPS #121) fabrication, we completed the Beef Plate, Short Plate, Boneless (IMPS #121A), which was utilized as 50% (50% lean to 50% fat) lean trimmings. Prior to fabrication of the IMPS #121A, the Beef Plate, the Inside Skirt (IMPS #121D) and the Outside Skirt (IMPS #121C) were

removed, the peritoneum was removed, and the surface was trimmed practically free of fat.

The remaining beef rib was first fabricated by separating the cap and wedge meat (*M. rhomboideus thoracis, M. trapezius pars thoracia,* and *M. latissimus dorsi*) from the rib to produce Beef Rib, Blade Meat (IMPS #109B) by separating each individual muscle and trimming it practically free of fat. The Beef Rib, Back Ribs (IMPS #124) also were removed from the rib. Beef Rib, Ribeye, Lip-On (IMPS #112A) additionally was fabricated by removing the ligamentum nuchae and reducing the tail to 5.08 cm ventral to the *M. longissimus thoracis* on both ends of the subprimal.

Hindquarter Fabrication

Fabrication of the Beef Hindquarter (IMPS #155) was conducted after recording the initial weight. Before the separation of the round and loin, practically all kidney and pelvic fat was removed. The *M. rectus abdominis* and associated fat were removed from the *M. transversus abdominis, M. obliquus abdominis internus*, and the *M. obliquus abdominis externus* through the natural seams producing the Beef Flank, Flank Steak (IMPS #193). The Beef Loin, Bottom Sirloin Butt, Flap, Boneless (IMPS #185A) consisting of only the *M. obliquus abdominis internus* was removed from the bottom sirloin by a separation from the ball tip (*M. rectus femoris, M. vastus lateralis and M. vastus medialis*) and the tri tip (*M. tensor fasciae latae*) through the natural seams. The round/loin division was made by a saw cut 2.54 cm anterior to the aitch bone (split surface of the pelvis) and between the juncture of the forth and fifth sacral vertebrae.

The Beef Loin, Tenderloin, Full, Side Muscle On, Defatted (IMPS #189A) was derived by removal of the *M. psoas major, M. psoas minor,* and *M. iliacus* complex. After removal from the loin, all remaining areas of fat were trimmed from the surface of the subprimal. The *M. cutaneous trunci,* commonly referred by the meat industry as the "elephant ear," was removed from the surface of the loin and flank.

The sirloin was separated from the shell loin (post tenderloin removal) immediately anterior to the tuber coxae of the ilium, and parallel to the cut exterior of the round/loin separation. The top and bottom sirloin were separated by a straight cut along the natural seam at the ventral edge of the *M. gluteus medius*. The top sirloin was fabricated into a Beef Loin, Top Sirloin Butt, Boneless (IMPS #184), with all bones, cartilage, and sacrosciatic ligament, as well as lean and fat covering the ligament removed. The bottom sirloin was separated into the Beef Loin, Bottom Sirloin Butt, Ball Tip, Boneless (IMPS #185B) and the Beef Loin, Bottom Sirloin Butt, Tri-Tip, Boneless, Defatted (IMPS #185D). Both cuts were trimmed virtually free of fat.

The cod/udder fat was removed from the flank area and weighed separately. The flank was separated from the remaining portion of the loin by a straight cut 7.62 cm from the ventral edge of the *M. longissimus thoracis* and 5.08 cm from the ventral edge of the *M. longissimus lumborum*. The *M. obliquus externus abdominis* (special trim flank muscle) was isolated and trimmed free of fat.

The bodies of the thoracic and lumbar vertebrae of the remaining portion of the shell loin were detached and all remaining bones were removed. The tail was reduced to 2.54 cm on the anterior end and 0.00 cm on the posterior end to prepare the Beef Loin,

Strip Loin, Boneless (IMPS #180 [0 × 1]). Subcutaneous fat also was trimmed to 0.635 cm over the external surface of the strip loin.

The aitch bone was removed before hanging the remaining portion of the round on the rail by the Achilles tendon for further fabrication. Commencing at the patella, the round tip was removed by following the natural seams, and the Beef Round, Tip (Knuckle) Peeled (IMPS #167A) was further readied by removing the patella, the distal tip of the *M. tensor fasciae latae,* and the layer of heavy connective tissue with any connected fat. The Beef Round, Top (Inside) (IMPS #168) was removed from the round through the natural seam, and the medial side was trimmed free of remaining fat. The remaining portion of the round was removed from the hindshank and subsequently fabricated into a Beef Round, Outside Round (Flat) (IMPS #171B) and the Beef Round, Eye of Round (IM) (IMPS #171C). Both cuts were trimmed free of fat on the medial surface, and the heavy connective tissue ("silver skin") was removed from the outside round (flat). The Beef Round, Bottom Round, Heel (IMPS #171F), consisting of the *M. gastrocnemius* and *M. superficial digital flexor* muscles located adjacent to the femur, was removed from the lower portion of the outside round and recorded as 90% lean trimmings. The remaining hindshank was separated into lean trimmings, trimmable fat, and bone components.

Price Allocation

Subprimal prices (Table 2) were obtained from the Agricultural Marketing Service of USDA. Prices were collected from USDA archives from the weekly average of the first and last week of the first and last month of each quarter for 2007 and for the first half of 2008. These prices then were averaged to determine a price to be used to compare total value of the different carcass types.

Table 2. Average prices used in value determinations

	IMPS # [a]	Prices / 45.36 kg U.S. $
Beef rib		
Blade meat	109B	180.39
Ribeye roll	112A	549.99
Back ribs	124	101.55
Beef chuck		
Shoulder, top blade	114D	217.32
Shoulder, arm roast	114E	216.16
Shoulder tender (IM)	114F	295.70
Square cut, pectoral meat	115D	207.84
Chuck roll	116A	168.31
Chuck tender	116B	168.54
Short ribs	130	147.76
Beef brisket, deckle off, bnls	120	130.69
Beef plate		
Inside skirt (IM)	121C	272.44
Outside skirt (IM)	121D	301.09
Beef round		
Knuckle (tip), peeled	167A	177.03
Top (inside)	168	173.68
Outside round (flat)	171B	166.68
Eye of round (IM)	171C	194.24
Beef loin		
Strip loin, bnls (0 x 1)	180A	541.57
Top sirloin butt, bnls	184	255.05
Bottom sirloin butt, flap, bnls	185A	316.71
Bottom sirloin butt, ball tip, bnls	185B	193.02
Bottom sirloin butt, tri-tip, bnls, defatted	185D	351.22
Tenderloin, full	189A	883.95
Beef flank, flank steak (IM)	193	392.11
Special trim		180.39
Lean trim (90%)		168.12
Lean trim (81%)		124.09
Lean trim (50%)		57.89
Bone		5.13
Fat		20.57

[a] Institutional Meat Purchase Specifications

Statistical Analysis

Analysis of variance was performed by PROC GLM of SAS (SAS Institute, Cary, NC), and contrasts were evaluated between predetermined populations as follows:

- Heifers and steers (Heifers vs. Steers)
- Light-muscled (REA: 100 KG < 21.76) heifers compared to heavy-muscled (REA: 100 KG $\geq$ 21.76) heifers. (Light vs. heavy muscled heifers)
- Light-weight (317.51 - 362.87 kg) heifers compared to the heavy weight (363.33 - 362.87 kg) heifers. (Light vs. heavy weight heifers)
- Light muscled (REA: 100 KG < 20.07) steers compared to large muscled (REA: 100 KG $\geq$ 20.07) steers. (Light vs. heavy muscled steers)
- Light-weight (362.87 - 408.23 kg) steers compared to heavy-weight (408.69 - 453.59 kg) steers. (Light vs. heavy weight steers)
- Heavy-weight (363.33 - 408.23 kg) heifers compared to the light weight (362.87 - 408.23 kg) steers. (Heavy heifers vs. light steers)

Microsoft Excel also was used to formulate simple means. The initial data analysis was performed on the total group of 60 carcasses. Simple linear correlations involving FT (fat thickness, cm); PYG (preliminary yield grade); REA (*M. longissimus* area, cm^2); KPH (kidney, pelvic, and heart fat, percent), HCW (warm carcass weight, kg); YG

(USDA YG); REA: HCW (*M. longissimus* area, cm^2 / warm carcass weight, kg), HH (hump height); BW (body wall thickness, cm^2) were calculated using the correlations procedure (PROC CORR) of SAS 9.0. Before regressions were performed, Variance Inflation Factors (VIF) were analyzed in (Fit Model) of JMP 8.0 (SAS Institute, Cary, NC) to determine the degree of multicollinearity between the dependent and independent variables. A VIF of greater than 12 was used to indicate multicollinearity. According to the results, if multicollinearity was found those variables were not used.

Mallows Cp statistic, R-square values, and logistics of the models were used to select the best model to predict the carcass value per 100 kg. The number of independent variables in each model ranged from 1 to 7. Once each model containing data from the complete population, or data separated by gender, was chosen, verification of the models were run by averaging the difference with regard to the predicted, and actual values, as well as, least squares means for the difference between the predicted and actual values.

CHAPTER IV

RESULTS AND DISCUSSION

Simple Statistics

Simple statistics for variables analyzed for the populations are presented in Table 3, separated by gender; reporting the mean, standard deviation, minimum, and maximum values for USDA Yield Grade and for the yield grade factors concurrently with additional measurements from the carcasses selected for this study. The mean USDA Yield Grade for both the steers and heifers was 4.48. While having similar mean yield grades, heifers had greater 12^{th} rib fat thickness (single fat thickness over the *M. longissimus* perpendicular to the outside fat surface at a point three-fourths of the length of the *M. longissimus*), larger ribeye area per 100 kg, and lighter carcass weights than steers. Within steers, carcasses with larger ribeye area per 100 kg had more 12^{th} rib fat thickness, a larger ribeye, and a lower numerical yield grade than steer carcasses with lower ribeye area per 100 kg. The selection criteria used in this study were chosen for the purpose of obtaining a sample of carcasses that represented a variation in gender, weight, fat, and ribeye that are typically found in the fed beef population, this was accomplished based on the information corresponded in Table 3.

Table 3.
Simple means, standard deviations (SD), minimum and maximum values of carcass traits stratified by sex class

Variable	Carcass type	Mean	SD	Min	Max
Fat thickness, cm					
	Heifers	2.34	0.30	1.73	2.79
	Steers	2.22	0.33	1.42	2.84
	Combined	2.26	0.33	1.42	2.84
Preliminary yield grade					
	Heifers	4.19	0.32	3.50	4.80
	Steers	4.14	0.39	3.20	5.00
	Combined	4.15	0.37	3.20	5.00
Longissimus muscle area, cm^2					
	Heifers	78.19	7.14	67.10	92.90
	Steers	82.47	8.38	63.23	101.94
	Combined	81.04	8.18	63.23	101.94
Kidney, pelvic, and heart fat, %					
	Heifers	2.45	0.65	1.50	4.00
	Steers	2.33	0.53	1.50	4.50
	Combined	2.37	0.57	1.50	4.50
Warm carcass weight, kg					
	Heifers	365.40	25.65	322.96	401.88
	Steers	407.90	22.65	363.78	449.96
	Combined	393.74	30.97	322.96	449.96
USDA yield grade					
	Heifers	4.48	0.20	4.00	4.75
	Steers	4.48	0.23	4.03	4.92
	Combined	4.48	0.22	4.00	4.92
REA:HCW [a]					
	Heifers	21.43	1.61	17.61	23.91
	Steers	20.23	1.84	16.25	25.43
	Combined	20.63	1.84	16.25	25.43
Marbling score [b]					
	Heifers	456.50	52.94	400.00	580.00
	Steers	442.75	47.55	400.00	560.00
	Combined	447.33	49.40	400.00	580.00
Hump height, measurement [d]					
	Heifers	1.26	0.62	0.00	2.54
	Steers	2.50	1.45	0.51	7.62
	Combined	2.09	1.37	0.00	7.62
Bodywall thickness, cm [c]					
	Heifers	5.78	1.13	4.32	7.62
	Steers	5.94	1.28	3.56	8.64
	Combined	5.89	1.22	3.56	8.64

[a] Ribeye area (cm^2) and hot carcass weight kg ratio.
[b] Marbling score: 300 to 399 = Slight; 400 to 499 = small; 500 to 599 = Modest.
[c] Bodywall thickness measured 12.7 cm from the vertebra at the 12^{th} rib.
[d] Distance from the line to the top of the lean muscle (excluding the external layer of fat),measured perpendicular to the extension of the top-line at the peak of the hump laid at the top of the shoulders.

Heifer Population

Table 4 illustrates simple carcass data from only the heifer population. USDA Yield Grades varied from 4.00 to 4.75 but with no significant differences as reported in the tables on p. 26 and p. 29 through least squares means separation and contrasts by designated populations. Carcass weights ranged from 322.96 kg to 401.88 kg. Table 4 reports ribeye area (area of the *M. Longissimus* cm^2) ranged from 67.10 cm^2 to 92.90 cm^2. Ribeye area per 100 kg ranged from 17.61 to 23.91 as was in accordance with the experimental design previously listed. Within the heifer population fat thickness, cm varied from 1.73 cm to 2.79 cm. These carcasses also had a large variation in bodywall thickness, cm ranging from 4.32 cm to 7.62 cm and hump height averages ranging from 0.86 cm to 1.57 cm. From this population similar variations averages for marbling scores ranged from 434.00 to 478.00, and kidney, pelvic, and heart fat percent varied from 3.92 percent to 4.48 percent.

Table 4.
Simple means, standard deviations (SD), minimum and maximum values of heifer carcass traits stratified by weight (kg), and ribeye area per hundred weight

	Heifers					
Variable	Hot carcass weights, kg	REA:HCW[a] ratio	Mean	SD	Min	Max
Fat thickness, cm						
	317.5-362.9	(< 21.76)	2.32	0.24	2.03	2.64
	317.5-362.9	(≥ 21.76)	2.34	0.29	2.03	2.64
	362.9-408.2	(< 21.76)	2.15	0.32	1.73	2.54
	362.9-408.2	(≥ 21.76)	2.57	0.25	2.13	2.79
Preliminary yield grade						
	317.5-362.9	(< 21.76)	4.06	0.26	3.70	4.40
	317.5-362.9	(≥ 21.76)	4.28	0.27	4.00	4.60
	362.9-408.2	(< 21.76)	3.92	0.28	3.50	4.20
	362.9-408.2	(≥ 21.76)	4.48	0.24	4.20	4.80
Longissimus muscle area, cm^2						
	317.5-362.9	(< 21.76)	73.16	4.15	67.10	78.06
	317.5-362.9	(≥ 21.76)	76.13	4.00	71.61	82.58
	362.9-408.2	(< 21.76)	75.61	4.62	69.03	80.65
	362.9-408.2	(≥ 21.76)	87.87	5.01	81.29	92.90
Kidney, pelvic, and heart fat, %						
	317.5-362.9	(< 21.76)	2.50	0.50	2.00	3.00
	317.5-362.9	(≥ 21.76)	2.40	0.96	1.50	4.00
	362.9-408.2	(< 21.76)	2.20	0.57	1.50	3.00
	362.9-408.2	(≥ 21.76)	2.70	0.57	2.00	3.50
Warm carcass weight, kg						
	317.5-362.9	(< 21.76)	348.04	10.35	335.66	362.87
	317.5-362.9	(≥ 21.76)	337.61	10.26	322.96	345.64
	362.9-408.2	(< 21.76)	388.18	7.99	376.48	398.25
	362.9-408.2	(≥ 21.76)	387.78	15.24	365.14	401.88
USDA yield grade						
	317.5-362.9	(< 21.76)	4.57	0.09	4.46	4.67
	317.5-362.9	(≥ 21.76)	4.33	0.24	4.00	4.56
	362.9-408.2	(< 21.76)	4.56	0.18	4.32	4.75
	362.9-408.2	(≥ 21.76)	4.46	0.22	4.13	4.67
REA:HCW [a]						
	317.5-362.9	(< 21.76)	21.01	0.79	19.63	21.51
	317.5-362.9	(≥ 21.76)	22.55	0.91	21.80	23.91
	362.9-408.2	(< 21.76)	19.50	1.53	17.61	21.42
	362.9-408.2	(≥ 21.76)	22.65	0.46	22.08	23.12
Marbling score [b]						
	317.5-362.9	(< 21.76)	434.00	45.61	400.00	510.00
	317.5-362.9	(≥ 21.76)	478.00	66.11	400.00	580.00
	362.9-408.2	(< 21.76)	470.00	51.48	420.00	550.00
	362.9-408.2	(≥ 21.76)	444.00	50.79	410.00	530.00
Hump height, measurement [d]						
	317.5-362.9	(< 21.76)	0.86	0.61	0.00	1.52
	317.5-362.9	(≥ 21.76)	1.17	0.46	0.76	1.78
	362.9-408.2	(< 21.76)	1.42	0.73	0.51	2.54
	362.9-408.2	(≥ 21.76)	1.57	0.61	1.02	2.54
Bodywall thickness, cm [c]						
	317.5-362.9	(< 21.76)	5.08	0.48	4.57	5.59
	317.5-362.9	(≥ 21.76)	5.31	1.35	4.32	7.62
	362.9-408.2	(< 21.76)	5.82	1.16	4.32	7.37
	362.9-408.2	(≥ 21.76)	6.91	0.49	6.10	7.37

[a] Ribeye area (cm^2) and hot carcass weight kg ratio.
[b] Marbling score: 300 to 399 = Slight; 400 to 499 = small; 500 to 599 = Modest.
[c] Bodywall thickness measured 12.7 cm from the vertebra at the 12^{th} rib.
[d] Distance from the line to the top of the lean muscle (excluding the external layer of fat),measured perpendicular to the extension of the top-line at the peak of the hump laid at the top of the shoulders.

Steer Population

Table 5 presents simple carcass data from the steer populations. USDA Yield Grades varied from 4.03 to 4.92. Carcass weights ranged from 363.78 kg to 449.96 kg, ribeye area (area of the *M. Longissimus* cm^2) ranged from 63.23 cm^2 to 101.94 cm^2, and ribeye area per 100 kg 16.25 to 25.43. Within the steer population fat thickness, cm varied from 1.42 cm to 2.84 cm. Additionally, these carcasses also had a large variation in bodywall thickness, cm ranging from 3.56 cm to 8.64 cm and hump height averages ranging from 1.85 cm to 3.00 cm. From this population similar variations averages for marbling scores ranged from 435.00 to 449.00, and kidney, pelvic, and heart fat percent varied from 2.20 percent to 2.50 percent. Additional tables for all carcass characteristics of the Yield Grade 4 population regarding least squares mean separation and contrasts by designated populations can be found in tables 1 through 18 Appendix A.

Carcass Composition Percents

Least squares means of beef carcass components as cutout weights stratified by sex class, hot carcass weight, and ribeye area per 100 kg ratio of the population coupled with contrasts by designated populations can be found in tables 19 through 30, Appendix A.

Table 5.
Simple means, standard deviations (SD), minimum and maximum values of steer carcass traits stratified by weight (kg), and ribeye area per hundredweight

	Steers					
Variable	Hot carcass weights, kg	REA:HCW ratio [a]	Mean	SD	Min	Max
Fat thickness, cm						
	362.9 – 408.2	(< 20.07)	2.01	0.21	1.73	2.34
	362.9 – 408.2	(> 20.07)	2.37	0.34	1.83	2.84
	408.7 – 453.6	(< 20.07)	2.05	0.33	1.42	2.44
	408.7 – 453.6	(> 20.07)	2.46	0.21	2.13	2.84
Preliminary yield grade						
	362.9 – 408.2	(< 20.07)	3.94	0.43	3.40	5.00
	362.9 – 408.2	(> 20.07)	4.21	0.37	3.40	4.70
	408.7 – 453.6	(< 20.07)	4.07	0.37	3.20	4.70
	408.7 – 453.6	(> 20.07)	4.33	0.31	4.00	5.00
Longissimus muscle area, cm^2						
	362.9 – 408.2	(< 20.07)	74.06	4.91	63.23	81.29
	362.9 – 408.2	(> 20.07)	84.77	6.59	77.42	98.06
	408.7 – 453.6	(< 20.07)	80.32	6.03	69.03	86.45
	408.7 – 453.6	(> 20.07)	90.71	5.94	83.87	101.94
Kidney, pelvic, and heart fat, %						
	362.9 – 408.2	(< 20.07)	2.35	0.34	2.00	3.00
	362.9 – 408.2	(> 20.07)	2.20	0.35	1.50	2.50
	408.7 – 453.6	(< 20.07)	2.50	0.82	1.50	4.50
	408.7 – 453.6	(> 20.07)	2.25	0.48	1.50	3.00
Warm carcass weight, kg						
	362.9 – 408.2	(< 20.07)	389.41	14.64	369.22	408.23
	362.9 – 408.2	(> 20.07)	390.02	13.19	363.78	407.78
	408.7 – 453.6	(< 20.07)	428.21	14.08	411.86	449.96
	408.7 – 453.6	(> 20.07)	423.97	12.48	409.14	445.43
USDA yield grade						
	362.9 – 408.2	(< 20.07)	4.54	0.18	4.32	4.92
	362.9 – 408.2	(> 20.07)	4.33	0.23	4.03	4.70
	408.7 – 453.6	(< 20.07)	4.62	0.16	4.24	4.11
	408.7 – 453.6	(> 20.07)	4.42	0.23	4.11	4.83
REA:HCW [a]						
	362.9 – 408.2	(< 20.07)	19.01	0.91	17.12	19.91
	362.9 – 408.2	(> 20.07)	21.75	1.80	20.07	25.43
	408.7 – 453.6	(< 20.07)	18.75	1.24	16.25	20.04
	408.7 – 453.6	(> 20.07)	21.38	0.94	20.14	23.10
Marbling score [b]						
	362.9 – 408.2	(< 20.07)	435.00	57.10	400.00	560.00
	362.9 – 408.2	(> 20.07)	449.00	49.54	400.00	540.00
	408.7 – 453.6	(< 20.07)	448.00	44.17	400.00	510.00
	408.7 – 453.6	(> 20.07)	439.00	44.58	400.00	540.00
Hump height, measurement [d]						
	362.9 – 408.2	(< 20.07)	1.85	0.93	0.76	3.81
	362.9 – 408.2	(> 20.07)	3.00	2.21	0.76	7.62
	408.7 – 453.6	(< 20.07)	2.57	1.07	0.76	3.81
	408.7 – 453.6	(> 20.07)	2.59	1.23	0.51	4.57
Bodywall thickness, cm [c]						
	362.9 – 408.2	(< 20.07)	5.61	0.97	4.45	7.24
	362.9 – 408.2	(> 20.07)	5.99	1.35	3.81	7.87
	408.7 – 453.6	(< 20.07)	5.91	1.62	3.56	8.51
	408.7 – 453.6	(> 20.07)	6.26	1.21	4.32	8.64

[a] Ribeye area (cm^2) and warm carcass weight kg ratio.
[b] Marbling score: 300 to 399 = Slight; 400 to 499 = small; 500 to 599 = Modest.
[c] Bodywall thickness measured 12.7 cm from the vertebra at the 12^{th} rib.
[d] Distance from the line to the top of the lean muscle (excluding the external layer of fat),measured perpendicular to the extension of the top-line at the peak of the hump laid at the top of the shoulders.

Tables 6 through 17 illustrate least squares percentage means of beef carcass components as a percentage of side weight stratified by sex class, hot carcass weight, and ribeye area per 100 kg ratio. Tables are separated by primal followed the contrasts for that particular primal. There were no major observable trends or differences between defined heifer/steer groups; however, some carcass cutout components did differ when contrasted between defined groups.

Overall, steer carcasses had a higher percentage of arm roast, chuck roll, chuck tender and percentage bone than heifers ($P < 0.05$) reported in tables 8 and 9, whereas heifer carcasses reported a higher percentage of trimmable fat ($P < 0.05$) (tables 16 and 17). When heavy heifer carcass (362.9-408.2) cutouts were compared to the same (362.9-408.2 weight steer carcasses (tables 8 – 9 and tables 10 – 11), steers sustained a higher percentage of chuck roll, chuck tender, and tenderloin, ($P < 0.05$) whereas the heifers yielded a higher percentage of trimmable fat than steer carcasses ($P < 0.05$). Other comparisons between light-weight and heavy-weight steer carcasses, light-weight and heavy-weight heifer carcasses and light-muscled and heavy-muscled steer carcasses showed little or no consequential differences. In general, cuts from the forequarters of steer carcasses tended to have higher numerical percentage than heifer carcasses and heifer carcasses had a higher percentage of trimmed fat than their steer counterparts.

In reference to table 17, the steer population proved to occupy a significantly ($P < 0.05$) higher percentage of bone; while the heifer population demonstrates a significantly ($P < 0.001$) higher percentage of trimmable fat waste. This implies that within yield grade 4 carcasses there are differences found between genders. These differences may not be due solely to conformational differences, but rather the lack of muscling found in heifers may be driven by the additional fat deposition, specifically in the forequarter. Furthermore, the contrasts taking into account sex-class, the heifer population reported a significantly ($P < 0.01$) less percentage of subprimals and minor cuts as did by the steer population. Continuing with weight held within the equivalent weight range taking into account sex-class there was still a significant ($P < 0.05$) difference between the percentage of subprimals and minor cuts, specifically between lighter muscled heifers and the heavier muscled steers weighing within 362.9-408.2 kg.

Table 6.
Least squares means of beef rib and plate subprimal components (%) stratified by sex class, weight (kg), and ribeye area per 100 kg ratio

		Heifers					Steers					
Subprimal	IMPS # [a]	317.5-362.9 (< 21.76)	317.5-362.9 (≥ 21.76)	362.9-408.2 (< 21.76)	362.9-408.2 (≥ 21.76)	SEM [b]	362.9-408.2 (< 20.07)	362.9-408.2 (≥ 20.07)	408.2-453.6 (< 20.07)	408.2-453.6 (≥ 20.07)	SEM [b]	*P* > F
Beef rib												
Blade meat												
	109B	0.80	0.80	0.84	1.00	0.10	0.91	0.98	0.91	0.88	0.07	0.6594
Ribeye roll												
	112A	2.86	3.12	3.10	3.12	0.11	2.98	3.23	3.08	3.10	0.08	0.2509
Back ribs												
	124	0.86	0.84	0.84	0.81	0.05	0.87	0.82	0.88	0.89	0.04	0.8618
Beef plate												
Inside skirt (IM)												
	121C	0.64	0.55	0.58	0.51	0.06	0.53	0.49	0.52	0.53	0.04	0.5851
Outside skirt (IM)												
	121D	0.29	0.36	0.39	0.39	0.03	0.33	0.34	0.35	0.36	0.02	0.4693

Within a row, means lacking a common letter (j-l) differ ($P < 0.05$)
[a] Institutional Meat Purchase Specifications
[b] Standard error of the least squares mean

Table 7.
Beef rib and plate subprimal components (%) contrasts by designated populations

Contrast	Blade meat	Ribeye roll	Back ribs	Inside skirt	Outside skirt
IMPS # [a]	109b	112A	124	121C	121D
	P > F	*P* > F	*P* > F	*P* > F	*P* > F
Heifers vs. Steers	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]
Heifers (REA:HCW < 21.76) vs. heifers (REA:HCW > 21.76)	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]
Heifers (317.5–362.9, kg) vs. heifer (317.5–362.10, kg)	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]
Steers (REA:HCW < 20.07) vs. steers (REA:HCW ≥ 20.07)	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]
Steers (362.9–408.2, kg) vs .steers (408.2–453.6, kg)	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]
Heifers (362.9–408.2, kg) vs. steers (362.9 – 408.2, kg)	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]

[a] Institutional Meat Purchase Specifications
[c] Non significant (P > 0.05)

Table 8.
Least squares means of beef chuck and brisket subprimal components (%) stratified by sex class. weight (kg), and ribeye area per 100 kg ratio

		Heifers					Steers					
Subprimal	IMPS # [a]	317.5-362.9 (< 21.76)	317.5-362.9 (≥ 21.76)	362.9-408.2 (< 21.76)	362.9-408.2 (≥ 21.76)	SEM [b]	362.9-408.2 (< 20.07)	362.9-408.2 (≥ 20.07)	408.2-453.6 (< 20.07)	408.2-453.6 (≥ 20.07)	SEM [b]	*P* > F
Beef chuck												
Shoulder, top blade												
	114D	1.05	1.27	1.11	1.16	0.08	1.17	1.20	1.29	1.17	0.06	0.3666
Shoulder, arm roast												
	114E	1.86	1.68	1.72	1.89	0.15	2.14	1.87	1.93	1.98	0.11	0.2974
Shoulder tender (IM)												
	114F	0.36	0.23	0.28	0.31	0.05	0.35	0.34	0.43	0.30	0.04	0.0961
Square cut, pectoral meat												
	115D	0.45	0.42	0.31	0.40	0.06	0.44	0.32	0.44	0.35	0.04	0.2641
Chuck roll												
	116A	3.95	3.92	4.09	3.68	0.23	4.38	4.43	4.12	4.50	0.16	0.0524
Chuck tender												
	116B	0.70	0.72	0.73	0.71	0.04	0.80	0.77	0.75	0.75	0.03	0.3469
Short ribs												
	130	1.01	0.96	0.84	0.85	0.08	0.97	0.84	0.95	0.90	0.06	0.5237
Beef brisket, deckle off, bnls												
	120	3.43	3.23	3.68	3.35	0.21	3.41	3.49	3.30	3.69	0.15	0.5174

Within a row, means lacking a common letter (j-l) differ ($P < 0.05$)
[a] Institutional Meat Purchase Specifications
[b] Standard error of the least squares mean

Table 9.
Beef chuck components (%) contrasts by designated populations

Contrast	Shoulder, top blade	Shoulder, arm roast	Shoulder tender	Square cut, pectoral meat	Chuck roll	Chuck tender	Short ribs	Beef brisket, deckle off, bnls
IMPS # [a]	114D	114E	114E	115D	116A	116B	130	120
	P > F	*P* > F	*P* > F	*P* > F	*P* > F	*P* > F	*P* > F	*P* > F
Heifers vs. Steers	n.s. [c]	< 0.05	n.s. [c]	n.s. [c]	< 0.01	< 0.05	n.s. [c]	n.s. [c]
Heifers (REA:HCW < 21.76) vs. heifers (REA:HCW > 21.76)	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]
Heifers (317.5–362.9, kg) vs. heifer (317.5–362.10, kg)	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]
Steers (REA:HCW < 20.07) vs. steers (REA:HCW $\underline{>}$ 20.07)	n.s. [c]	n.s. [c]	n.s. [c]	< 0.05	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]
Steers (362.9–408.2, kg) vs. steers (408.2–453.6, kg)	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]
Heifers (362.9–408.2, kg) vs. steers (362.9 – 408.2, kg)	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]	< 0.01	< 0.05	n.s. [c]	n.s. [c]

[a] Institutional Meat Purchase Specifications
[c] Non significant (P > 0.05)

Table 10.
Least squares means of beef loin subprimal components (%) stratified by sex class. weight (kg), and ribeye area per 100 kg ratio

		Heifers					Steers					
Subprimal	IMPS # [a]	317.5-362.9 (< 21.76)	317.5-362.9 (≥ 21.76)	362.9-408.2 (< 21.76)	362.9-408.2 (≥ 21.76)	SEM [b]	362.9-408.2 (< 20.07)	362.9-408.2 (≥ 20.07)	408.2-453.6 (< 20.07)	408.2-453.6 (≥ 20.07)	SEM [b]	*P* > F
Beef loin												
Strip loin, bnls (0 x 1)	180A	2.79	2.66	2.62	3.03	0.13	2.72	2.91	2.61	2.77	0.09	0.1355
Top sirloin butt, bnls	184	2.80	2.97	2.73	3.23	2.80	3.01	2.83	2.95	2.79	0.10	0.2018
Bottom sirloin butt, flap, bnls	185A	0.92	0.89	0.86	0.93	0.05	0.90	0.81	0.98	0.92	0.03	0.0954
Bottom sirloin butt, ball tip, bnls	185B	0.81	0.89	0.89	0.91	0.16	0.82	0.88	0.79	0.91	0.11	0.9944
Bottom sirloin butt, tri-tip, bnls, defatted	185D	0.66	0.64	0.57	0.70	0.04	0.65	0.67	0.64	0.68	0.03	0.4533
Tenderloin, full	189A	1.60	1.50	1.28	1.45	0.07	1.49	1.49	1.44	1.49	0.05	0.0923
Beef flank, flank steak (IM)	193	0.46	0.48	0.46	0.47	0.03	0.45	0.42	0.50	0.50	0.02	0.1403

Within a row, means lacking a common letter (j-l) differ ($P < 0.05$)
[a] Institutional Meat Purchase Specifications
[b] Standard error of the least squares mean

Table 11 Beef loin subprimal component (%) contrasts by designated populations

Contrast	Strip loin, bnls (0 x 1)	Top sirloin butt, bnls	Bottom sirloin butt, flap, bnls	Bottom sirloin butt, ball tip, bnls	Bottom sirloin butt, tri-tip, bnls, defatted	Tenderloin, full	Beef flank, flank steak
IMPS # [a]	180A	184	185A	185B	185D	189A	193
	P > F	*P* > F	*P* > F	*P* > F	*P* > F	*P* > F	*P* > F
Heifers vs. Steers	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]	< 0.01
Heifers (REA:HCW < 21.76) vs. heifers (REA:HCW > 21.76)	n.s. [c]	< 0.05	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]
Heifers (317.5–362.9, kg) vs. heifer (317.5–362.10, kg)	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]	< 0.01	n.s. [c]
Steers (REA:HCW < 20.07) vs. steers (REA:HCW ≥ 20.07)	n.s. [c]	n.s. [c]	< 0.05	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]
Steers (362.9–408.2, kg) vs. .steers (408.2–453.6, kg)	n.s. [c]	n.s. [c]	< 0.01	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]
Heifers (362.9–408.2, kg) vs. steers (362.9 – 408.2, kg)	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]	< 0.05	n.s. [c]

[a] Institutional Meat Purchase Specifications
[c] Non significant (P > 0.05)

Table 12.
Least squares means of round subprimal components (%) stratified by sex class. weight (kg), and ribeye area per 100 kg ratio

		Heifers					Steers					
Subprimal	IMPS # [a]	317.5-362.9 (< 21.76)	317.5-362.9 (≥ 21.76)	362.9-408.2 (< 21.76)	362.9-408.2 (≥ 21.76)	SEM [b]	362.9-408.2 (< 20.07)	362.9-408.2 (≥ 20.07)	408.2-453.6 (< 20.07)	408.2-453.6 (≥ 20.07)	SEM [b]	*P* > F
Beef round												
Knuckle (tip), peeled	167A	2.10	2.06	1.96	2.01	0.15	2.21	1.97	2.02	1.82	0.10	0.3744
Top (inside)	168	4.83	5.09	4.85	5.21	0.16	5.05	5.11	4.95	4.99	0.12	0.6749
Outside round (flat)	171B	3.74	3.74	3.37	3.83	0.13	3.65	3.77	3.61	3.57	0.09	0.1850
Eye of round (IM)	171C	1.43	1.39	1.27	1.41	0.05	1.44	1.39	1.36	1.40	0.04	0.3817

[a] Institutional Meat Purchase Specifications
[b] Standard error of the least squares mean

Table 13.
Beef round subprimal component (%) contrasts by designated populations

Contrast	Knuckle (tip), peeled	Top (inside)	Outside round (flat)	Eye of round
IMPS # [a]	167A	168	171B	171C
	P > F	*P* > F	*P* > F	*P* > F
Heifers vs. Steers	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]
Heifers (REA:HCW < 21.76) vs. heifers (REA:HCW > 21.76)	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]
Heifers (317.5–362.9, kg) vs. heifer (317.5–362.10, kg)	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]
Steers (REA:HCW < 20.07) vs. steers (REA:HCW ≥ 20.07)	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]
Steers (362.9–408.2, kg) vs. steers (408.2–453.6, kg)	< 0.05	n.s. [c]	n.s. [c]	n.s. [c]
Heifers (362.9–408.2, kg) vs. steers (362.9 – 408.2, kg)	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]

[a] Institutional Meat Purchase Specifications
[c] Non significant (P > 0.05)

Table 14.
Least squares means of beef lean trim from subprimal components (%) stratified by sex class. weight (kg), and ribeye area per 100 kg ratio

		Heifers					Steers					
Subprimal	Percent lean	317.5-362.9 (< 21.76)	317.5-362.9 (≥ 21.76)	362.9-408.2 (< 21.76)	362.9-408.2 (≥ 21.76)	SEM [b]	362.9-408.2 (< 20.07)	362.9-408.2 (≥ 20.07)	408.2-453.6 (< 20.07)	408.2-453.6 (≥ 20.07)	SEM [b]	*P* > F
Lean trim	Special	0.33	0.43	0.31	0.39	0.05	0.37	0.36	0.34	0.39	0.03	0.6536
Lean trim	(90%)	3.24	3.03	3.12	3.14	0.14	3.20	3.05	3.14	3.15	0.10	0.9461
Lean trim	(80%)	11.21	12.02	12.05	11.36	0.62	12.23	11.65	12.31	12.96	0.44	0.2979
Lean trim	(50%)	8.81	7.65	9.21	8.77	0.47	8.49	8.76	8.72	8.35	0.33	0.4437

Within a row, means lacking a common letter (j-l) differ (*P* < 0.05)
[b] Standard error of the least squares mean

Table 15.
Beef lean trim (%) contrasts by designated populations

Contrast	Lean trim	Lean trim	Lean trim	Lean trim
Percent Lean	Special trim	(90%)	(80%)	(50%)
	P > F	*P* > F	*P* > F	*P* > F
Heifers vs. Steers	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]
Heifers (REA:HCW < 21.76) vs. heifers (REA:HCW > 21.76)	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]
Heifers (317.5–362.9, kg) vs. heifer (317.5–362.10, kg)	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]
Steers (REA:HCW < 20.07) vs. steers (REA:HCW ≥ 20.07)	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]
Steers (362.9–408.2, kg) vs. steers (408.2–453.6, kg)	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]
Heifers (362.9–408.2, kg) vs. steers (362.9 – 408.2, kg)	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]

[c] Non significant (P > 0.05)

Table 16.
Least squares means of bone and fat waste trim (%) stratified by sex class, weight (kg), and ribeye area per 100 kg ratio

	Heifers					Steers					
	317.5-362.9 (< 21.76)	317.5-362.9 (≥ 21.76)	362.9-408.2 (< 21.76)	362.9-408.2 (≥ 21.76)	SEM [b]	362.9-408.2 (< 20.07)	362.9-408.2 (≥ 20.07)	408.2-453.6 (< 20.07)	408.2-453.6 (≥ 20.07)	SEM [b]	*P* > F
Bone	14.20	14.01	14.55	13.57	0.45	15.09	14.53	14.57	14.69	0.32	0.2377
Fat	21.39	21.84	21.01	21.10	0.89	18.59	19.93	19.72	18.88	0.63	0.0246

Within a row, means lacking a common letter (j-l) differ (*P* < 0.05)
[b] Standard error of the least squares mean

Table 17.
Bone and fat waste trim (%) contrasts by designated populations

Contrast	Bone	Fat
	P > F	*P* > F
Heifers vs. Steers	< 0.05	< 0.001
Heifers (REA:HCW < 21.76) vs. heifers (REA:HCW > 21.76)	n.s. [c]	n.s. [c]
Heifers (317.5–362.9, kg) vs. heifer (317.5–362.10, kg)	n.s. [c]	n.s. [c]
Steers (REA:HCW < 20.07) vs. steers (REA:HCW ≥ 20.07)	n.s. [c]	n.s. [c]
Steers (362.9–408.2, kg) vs. .steers (408.2–453.6, kg)	n.s. [c]	n.s. [c]
Heifers (362.9–408.2, kg) vs. steers (362.9 – 408.2, kg)	n.s. [c]	< 0.05

[c] Non significant (P > 0.05)

Carcass Values

As described in Materials and Methods, wholesale prices of carcass components were obtained from USDA Market News reports. Prices were applied to weights of each carcass component and the values for each subprimal and trim off product as well as an overall carcass value and value per 45.36 kg are reported in Tables 18 through 29. Comparisons of carcass component values were readily evident between the defined groups of carcasses; however, essentially all differences can be attributed to differences in component/carcass weight differences rather than substantial differences in carcass composition. In evaluating heifer versus steer carcasses, steer carcasses had significantly ($P < 0.05$) higher values for 21 of the 30 carcass component values as well as total carcass value found in tables 18 through 29. Same weight (362.9-408.2 kg) heifer and steer carcasses only differed in four carcass components. Steers had higher ($P < 0.05$) values for chuck roll, chuck tender, and tenderloin, whereas heifers had a higher value for trimmable fat. The comparison of light- and heavy-weight steer carcasses revealed much the same differences as those for heifers versus steers. Heavyweight steers had higher ($P < 0.05$) values for 14 of 30 carcass components. Once more, this

can primarily be attributed to the increased weight of cuts as carcass weight increased. Analysis of lightweight versus heavy-weight heifer carcasses indicated much the same results with heavy-weight heifer carcass components having higher values in 12 of the 30 comparisons.

Tables 30 and 31 reinforce that carcass weights play a considerable role in overall carcass value than carcass composition concerning different Yield Grade 4 carcasses as represented by forequarter, hindquarter, and total values. Although differences in previous individual carcass components were prominent, when total carcass value was divided by carcass weight per hundred kg, differences between genders only proved to be statistically different ($P < 0.05$) as represented by total value per 45.36 kg in tables 32 and 33. To further determine where the differences in value per 45.36 kg exist, we find that the differences occur between genders. This difference is found more notably in the forequarter. This is consistent with findings in carcass cutouts represented as percentages previously discussed.

Table 18.
Least squares means of beef rib and plate subprimal components ($) stratified by sex class, weight (kg), and ribeye area per 100 kg ratio

		Heifers					Steers					
Subprimal	IMPS#[a]	317.5-362.9 (< 21.76)	317.5-362.9 (≥ 21.76)	362.9-408.2 (< 21.76)	362.9-408.2 (≥ 21.76)	SEM[b]	362.9-408.2 (< 20.07)	362.9-408.2 (≥ 20.07)	408.2-453.6 (< 20.07)	408.2-453.6 (≥ 20.07)	SEM[b]	*P* > F
Beef rib												
Blade meat												
	109B	5.40	5.29	6.33	7.45	0.76	6.82	7.47	7.56	7.28	0.54	0.1049
Ribeye roll												
	112A	59.04[j]	62.83[j, k]	71.18[j, k]	70.66[j, k]	2.88	67.6[j, k, l]	74.54[j]	77.29[j]	78.02[j]	2.03	< 0.0001
Back ribs												
	124	3.27[j, k]	3.13[k]	3.61[k, l]	3.42[k, l]	0.25	3.65[j, k, l]	3.50[l]	4.10[l]	4.16[l]	0.18	0.0076
Beef plate												
Inside skirt (IM)												
	121C	6.52	5.57	6.70	5.76	0.70	5.98	5.63	6.49	6.71	0.49	0.6747
Outside skirt (IM)												
	121D	3.33	4.01	4.99	4.83	0.44	4.10	4.37	4.86	5.02	0.31	0.0427

Within a row, means lacking a common letter (j-l) differ ($P < 0.05$)
[a] Institutional Meat Purchase Specifications
[b] Standard error of the least squares mean

Table 19.
Beef rib and plate subprimal component ($) contrasts by designated populations

Contrast	Blade meat	Ribeye roll	Back ribs	Inside skirt	Outside skirt
IMPS #[a]	109b	112A	124	121C	121D
	P > F	*P* > F	*P* > F	*P* > F	*P* > F
Heifers vs. Steers	< 0.01	< 0.0001	< 0.01	n.s.[c]	n.s.[c]
Heifers (REA:HCW < 21.76) vs. heifers (REA:HCW > 21.76)	n.s.[c]	n.s.[c]	n.s.[c]	n.s.[c]	n.s.[c]
Heifers (317.5–362.9, kg) vs. heifer (317.5–362.10, kg)	< 0.05	< 0.001	n.s.[c]	n.s.[c]	< 0.01
Steers (REA:HCW < 20.07) vs. steers (REA:HCW ≥ 20.07)	n.s.[c]	n.s.[c]	n.s.[c]	n.s.[c]	n.s.[c]
Steers (362.9–408.2, kg) vs. steers (408.2–453.6, kg)	n.s.[c]	< 0.001	< 0.01	n.s.[c]	< 0.05
Heifers (362.9–408.2, kg) vs. steers (362.9 – 408.2, kg)	n.s.[c]	n.s.[c]	n.s.[c]	n.s.[c]	n.s.[c]

[a] Institutional Meat Purchase Specifications
[c] Non significant (P > 0.05)

Table 20.
Least squares means of beef chuck and brisket subprimal components ($) stratified by sex class, weight (kg), and ribeye area per 100 kg ratio

		Heifers					Steers					
Subprimal	IMPS#[a]	317.5-362.9 (< 21.76)	317.5-362.9 (≥ 21.76)	362.9-408.2 (< 21.76)	362.9-408.2 (≥ 21.76)	SEM[b]	362.9-408.2 (< 20.07)	362.9-408.2 (≥ 20.07)	408.2-453.6 (< 20.07)	408.2-453.6 (≥ 20.07)	SEM[b]	*P* > F
Beef chuck												
Shoulder, top blade												
	114D	8.61[j]	10.14[j, k]	10.08[j, k]	10.42[j, k]	0.79	10.53[j, k]	11.05[j, k]	12.76[k]	11.66[k]	0.56	0.0041
Shoulder, arm roast												
	114E	15.02[j, k]	13.32[j]	15.6[j, k]	16.81[j, k]	1.51	19.13[j, k]	17.07[j, k]	19.17[k]	19.65[k]	1.07	0.0003
Shoulder tender (IM)												
	114F	3.99[j, k]	2.54[k]	3.51[j, k]	3.78[j, k]	0.68	4.28[j, k]	4.22[j, k]	5.83[k]	4.06[j, k]	0.48	0.0084
Square cut, pectoral meat												
	115D	3.52	3.17	2.70	3.41	0.53	3.78	2.83	4.20	3.35	0.38	0.2344
Chuck roll												
	116A	25.00[j, k]	24.32[j]	28.97[j, k, l]	25.49[j, k]	1.91	30.54[j, k, l]	31.49[k, l]	31.82[k, l]	34.88[l]	1.35	0.0001
Chuck tender												
	116B	4.45[j]	4.47[j]	5.16[j, k]	4.94[j, k]	0.27	5.60[k]	5.46[j, k]	5.78[k]	5.77[k]	0.19	0.0001
Short ribs												
	130	5.61	5.17	5.23	5.19	0.48	5.95	5.24	6.41	6.13	0.34	0.1472
Beef brisket, deckle off, bnls												
	120	16.87[j]	15.57[j]	20.19[j, k]	18.13[j, k]	1.31	18.43[j, k]	19.26[j, k]	19.71[j, k]	22.17[k]	0.92	0.0052

Within a row, means lacking a common letter (j-l) differ ($P < 0.05$)
[a] Institutional Meat Purchase Specifications
[b] Standard error of the least squares mean

Table 21.
Beef chuck and brisket subprimal component ($) contrasts by designated populations

Contrast	Shoulder, top blade	Shoulder, arm roast	Shoulder tender	Square cut, pectoral meat	Chuck roll	Chuck tender	Short ribs	Beef brisket, deckle off, bnls
IMPS # [a]	114D	114E	114E	115D	116A	116B	130	120
	P > F	*P* > F	*P* > F	*P* > F	*P* > F	*P* > F	*P* > F	*P* > F
Heifers vs. Steers	< 0.001	< 0.001	< 0.01	n.s. [c]	< 0.001	< 0.0001	< 0.05	< 0.01
Heifers (REA:HCW < 21.76) vs. heifers (REA:HCW > 21.76)	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]
Heifers (317.5–362.9, kg) vs. heifer (317.5–362.10, kg)	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]	< 0.05	n.s. [c]	< 0.05
Steers (REA:HCW < 20.07) vs. steers (REA:HCW ≥ 20.07)	n.s. [c]	n.s. [c]	n.s. [c]	< 0.05	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]
Steers (362.9–408.2, kg) vs. steers (408.2–453.6, kg)	< 0.01	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]	< 0.05	< 0.05
Heifers (362.9–408.2, kg) vs. steers (362.9 – 408.2, kg)	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]	< 0.05	< 0.05	n.s. [c]	n.s. [c]

[a] Institutional Meat Purchase Specifications
[c] Non significant (P > 0.05)

Table 22.
Least squares means of beef loin subprimal components ($) stratified by sex class. weight (kg), and ribeye area per 100 kg ratio

		Heifers					Steers					
Subprimal	IMPS#[a]	317.5-362.9 (< 21.76)	317.5-362.9 (≥ 21.76)	362.9-408.2 (< 21.76)	362.9-408.2 (≥ 21.76)	SEM[b]	362.9-408.2 (< 20.07)	362.9-408.2 (≥ 20.07)	408.2-453.6 (< 20.07)	408.2-453.6 (≥ 20.07)	SEM[b]	*P* > F
Beef loin												
Strip loin, bnls (0 x 1)	180A	56.83 [j, k]	52.82 [j]	59.55 [j, k, l]	67.65 [k, l]	2.98	61.03 [j, k, l]	66.45 [k, l]	64.71 [k, l]	68.98 [l]	2.11	0.0005
Top sirloin butt, bnls	184	26.80 [j]	27.84 [j]	29.18 [j, k]	33.96 [j, k]	1.54	31.72 [k]	30.35 [j, k]	34.48 [k]	32.64 [j, k]	1.09	0.001
Bottom sirloin butt, flap, bnls	185A	11.00 [j, k]	10.37 [j]	11.50 [j, k, l]	12.17 [j, k, l]	0.73	11.78 [j, k, l]	10.83 [j, k]	14.23 [k, l]	13.41 [l]	0.52	< 0.0001
Bottom sirloin butt, ball tip, bnls	185B	5.81	6.31	7.16	7.34	1.29	6.56	7.14	7.02	8.07	0.91	0.8943
Bottom sirloin butt, tri-tip, bnls, defatted	185D	8.68 [j]	8.23 [j]	8.50 [j]	10.14 [j, k]	0.57	9.48 [j, k]	9.96 [j, k]	10.29 [j, k]	11.02 [k]	0.40	0.0014
Tenderloin, full	189A	52.79 [j, k]	48.62 [j]	47.54 [j]	53.02 [j, k]	2.24	54.52 [j, k]	55.37 [j, k]	58.00 [k]	60.47 [k]	1.58	0.0001
Beef flank, flank steak (IM)	193	6.74 [j]	6.95 [j]	7.69 [j, k]	7.61 [j, k]	0.54	7.36 [j, k]	7.00 [j, k]	9.06 [k]	9.05 [k]	0.38	0.0003

Within a row, means lacking a common letter (j-l) differ (*P* < 0.05)
[a] Institutional Meat Purchase Specifications
[b] Standard error of the least squares mean

Table 23.
Beef loin subprimal component ($) contrasts by designated populations

Contrast	Strip loin, bnls (0 x 1)	Top sirloin butt, bnls	Bottom sirloin butt, flap, bnls	Bottom sirloin butt, ball tip, bnls	Bottom sirloin butt, tri-tip, bnls, defatted	Tenderloin, full	Beef flank, flank steak
IMPS # [a]	180A	184	185A	185B	185D	189A	193
	P > F	*P* > F	*P* > F	*P* > F	*P* > F	*P* > F	*P* > F
Heifers vs. Steers	< 0.001	< 0.01	< 0.01	n.s. [c]	< 0.001	< 0.0001	< 0.01
Heifers (REA:HCW < 21.76) vs. heifers (REA:HCW > 21.76)	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]
Heifers (317.5–362.9, kg) vs. heifer (317.5–362.10, kg)	< 0.01	< 0.01	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]
Steers (REA:HCW < 20.07) vs. steers (REA:HCW ≥ 20.07)	< 0.05	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]
Steers (362.9–408.2, kg) vs. steers (408.2–453.6, kg)	n.s. [c]	< 0.05	< 0.0001	n.s. [c]	< 0.05	< 0.01	< 0.0001
Heifers (362.9–408.2, kg) vs. steers (362.9 – 408.2, kg)	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]	< 0.01	n.s. [c]

[a] Institutional Meat Purchase Specifications
[c] Non significant (P > 0.05)

Table 24.
Least squares means of round subprimal components ($) stratified by sex class. weight (kg), and ribeye area per 100 kg ratio

		Heifers					Steers					
Subprimal	IMPS#[a]	317.5-362.9 (< 21.76)	317.5-362.9 (≥ 21.76)	362.9-408.2 (< 21.76)	362.9-408.2 (≥ 21.76)	SEM[b]	362.9-408.2 (< 20.07)	362.9-408.2 (≥ 20.07)	408.2-453.6 (< 20.07)	408.2-453.6 (≥ 20.07)	SEM[b]	*P* > F
Beef round												
Knuckle (tip), peeled	167A	13.99	13.43	14.59	14.60	1.12	16.16	14.64	16.38	14.79	0.79	0.315
Top (inside)	168	31.50[j]	32.58[j, k]	35.38[j, k, l]	37.41	1.47	36.33[j, k, l]	37.37[k, l]	39.33[l]	39.74[l]	1.04	0.0001
Outside round (flat)	171B	23.42[j, k]	22.93[j]	23.63[j, k, l]	26.39[j, k, l]	1.02	25.22[j, k, l]	26.48[j, k, l]	27.52[l]	27.33[k, l]	0.72	0.0009
Eye of round (IM)	171C	10.43[j, k]	9.93[j]	10.41[j, k]	11.38[j, k, l]	0.52	11.61[j, k, l]	11.44[j, k, l]	12.11[k, l]	12.53[l]	0.37	0.0014

Within a row, means lacking a common letter (j-l) differ (*P* < 0.05)
[a] Institutional Meat Purchase Specifications
[b] Standard error of the least squares mean

Table 25.
Beef round subprimal component ($) contrasts by designated populations

Contrast	Knuckle (tip), peeled	Top (inside)	Outside round (flat)	Eye of round
IMPS # [a]	167A	168	171B	171C
	P > F	*P* > F	*P* > F	*P* > F
Heifers vs. Steers	< 0.05	< 0.0001	< 0.001	< 0.0001
Heifers (REA:HCW < 21.76) vs. heifers (REA:HCW > 21.76)	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]
Heifers (317.5–362.9, kg) vs. heifer (317.5–362.10, kg)	n.s. [c]	< 0.01	n.s. [c]	n.s. [c]
Steers (REA:HCW < 20.07) vs. steers (REA:HCW ≥ 20.07)	< 0.05	n.s. [c]	n.s. [c]	n.s. [c]
Steers (362.9–408.2, kg) vs. steers (408.2–453.6, kg)	n.s. [c]	< 0.01	n.s. [c]	n.s. [c]
Heifers (362.9–408.2, kg) vs. steers (362.9 – 408.2, kg)	n.s. [c]	n.s. [c]	< 0.05	n.s. [c]

[a] Institutional Meat Purchase Specifications
[c] Non significant (P > 0.05)

Table 26.
Least squares means of beef lean trim from subprimal components ($) stratified by sex class. weight (kg), and ribeye area per 100 kg ratio

		Heifers					Steers					
	Percent lean	317.5-362.9 (< 21.76)	317.5-362.9 (≥ 21.76)	362.9-408.2 (< 21.76)	362.9-408.2 (≥ 21.76)	SEM [b]	362.9-408.2 (< 20.07)	362.9-408.2 (≥ 20.07)	408.2-453.6 (< 20.07)	408.2-453.6 (≥ 20.07)	SEM [b]	*P* > F
Lean trim	Special	2.29	2.88	2.36	2.92	0.38	2.80	2.76	2.81	3.30	0.27	0.465
Lean trim	(90%)	20.42 [j, k]	18.70 [j]	22.01 [j, k]	21.89 [j, k]	1.06	22.23 [j, k]	21.62 [j, k]	24.15 [k]	24.24 [k]	0.75	0.0013
Lean trim	(80%)	52.09	54.82	62.69	58.63	3.19	62.58	60.97	69.70	73.72	2.26	< 0.0001
Lean trim	(50%)	19.39	16.35	22.61	21.19	1.34	20.53	21.57	23.30	22.41	0.95	0.0055

Within a row, means lacking a common letter (j-l) differ (*P* < 0.05)
[b] Standard error of the least squares mean

Table 27
Beef lean trim from subprimal component ($) contrasts by designated populations

Contrast	Lean trim	Lean trim	Lean trim	Lean trim
Percent Lean	Special trim	(90%)	(80%)	(50%)
	P > F	*P* > F	*P* > F	*P* > F
Heifers vs. Steers	n.s. [c]	< 0.001	< 0.0001	< 0.01
Heifers (REA:HCW < 21.76) vs. heifers (REA:HCW > 21.76)	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]
Heifers (317.5–362.9, kg) vs. heifer (317.5–362.10, kg)	n.s. [c]	< 0.05	< 0.05	< 0.01
Steers (REA:HCW < 20.07) vs. steers (REA:HCW ≥ 20.07)	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]
Steers (362.9–408.2, kg) vs. steers (408.2–453.6, kg)	n.s. [c]	< 0.01	< 0.0001	n.s. [c]
Heifers (362.9–408.2, kg) vs. steers (362.9 – 408.2, kg)	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]

[c] Non significant (P > 0.05)

Table 28.
Least squares means of bone and fat waste trim from subprimal components ($) stratified by sex class, weight (kg), and ribeye area per 100 kg ratio

	Heifers					Steers					
	317.5-362.9 (< 21.76)	317.5-362.9 (≥ 21.76)	362.9-408.2 (< 21.76)	362.9-408.2 (≥ 21.76)	SEM [b]	362.9-408.2 (< 20.07)	362.9-408.2 (≥ 20.07)	408.2-453.6 (< 20.07)	408.2-453.6 (≥ 20.07)	SEM [b]	*P* > F
Bone	2.73 [j]	2.64 [j]	3.14 [k, l]	2.87 [j, k]	0.10	3.20 [k, l]	3.14 [k, l]	3.42 [l]	3.45 [l]	0.07	<0.0001
Fat	16.54	16.53	18.11	17.91	0.84	15.85	17.27	18.54	17.83	0.60	0.0708

Within a row, means lacking a common letter (j-l) differ (*P* < 0.05)
[b] Standard error of the least squares mean

Table 29.
Bone and waste trim ($) contrasts by designated populations

Contrast	Bone	Fat
	P > F	*P* > F
Heifers vs. Steers	n.s. [c]	n.s. [c]
Heifers (REA:HCW < 21.76) vs. heifers (REA:HCW > 21.76)	< 0.0001	n.s. [c]
Heifers (317.5–362.9, kg) vs. heifer (317.5–362.10, kg)	n.s. [c]	n.s. [c]
Steers (REA:HCW < 20.07) vs. steers (REA:HCW ≥ 20.07)	< 0.01	n.s. [c]
Steers (362.9–408.2, kg) vs. steers (408.2–453.6, kg)	n.s. [c]	< 0.01
Heifers (362.9–408.2, kg) vs. steers (362.9 – 408.2, kg)	< 0.001	n.s. [c]

[c] Non significant (P > 0.05)

Table 30.
Least squares means of beef carcass value ($) stratified by sex, weight (kg), and ribeye area per 100 kg ratio

	Heifers					Steers					
	317.5-362.9 (< 21.76)	317.5-362.9 (> 21.76)	362.9-408.2 (< 21.76)	362.9-408.2 (> 21.76)	SEM[b]	362.9-408.2 (< 20.07)	362.9-408.2 (> 20.07)	408.2-453.6 (< 20.07)	408.2-453.6 (> 20.07)	SEM[b]	P > F
Forequarter values											
Subprimal	160.65 [j]	159.55 [j]	184.24 [k]	180.29 [k]	5.06	186.41 [k]	192.15 [k, l]	206.01 [l]	208.88 [l]	3.58	<.0001
Total	235.96 [j]	235.47 [j]	272.00 [k]	263.55 [k]	6.16	271.53 [k]	276.87 [k, l]	300.07 [l, m]	305.99 [m]	4.36	<.0001
Hindquarter values											
Subprimal	247.99 [j, k]	240.02 [j]	255.14 [j, k, l]	281.67 [l, m]	7.10	271.79 [k, l, m]	277.06 [l, m]	293.14 [m]	298.04 [m]	5.02	<.0001
Total	286.14 [j, k]	276.03 [j]	298.39 [j, k, l]	323.84 [l, m, n]	7.68	313.87 [k, l, m]	319.66 [l, m, n]	340.99 [m, n]	345.90 [m]	5.43	<.0001
Carcass values											
Subprimals	408.64 [j, k]	399.57 [j]	439.38 [k, l]	461.96 [m, n]	10.17	458.20 [m]	469.20 [m, n, o]	499.14 [n, o]	506.92 [o]	7.19	<.0001
Total	522.10 [j]	511.49 [j]	570.39 [k]	587.38 [k]	11.71	585.40 [k]	596.53 [k, l]	641.07 [l, m]	651.89 [m]	8.28	<.0001

Within a row, means lacking a common letter (j-o) differ (*P* < 0.05)
[b] Standard error of the least squares mean

Table 31.
Carcass value ($) contrasts by designated populations

Contrast	Forequarter values		Hindquarter Values		Total side value	
	Subprimal values	Total value	Subprimal values	Total value	Subprimal values	Total value
	P > F	*P* > F	*P* > F	*P* > F	*P* > F	*P* > F
Heifers vs. Steers	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Heifers (REA:HCW < 21.76) vs. heifers (REA:HCW > 21.76)	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]
Heifers (317.5–362.9, kg) vs. heifer (317.5–362.10, kg)	< 0.0001	< 0.0001	< 0.01	< 0.001	< 0.0001	< 0.0001
Steers (REA:HCW < 20.07) vs. steers (REA:HCW ≥ 20.07)	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]
Steers (362.9–408.2, kg) vs. steers (408.2–453.6, kg)	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Heifers (362.9–408.2, kg) vs. steers (362.9 – 408.2, kg)	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]

[c] Non significant (P > 0.05)

Table 32.
Least squares means carcass value per 45.36 kg ($) stratified by sex class, weight (kg), and ribeye area per 100 kg ratio

	Heifers					Steers					
	317.5-362.9 (< 21.76)	317.5-362.9 (> 21.76)	362.9-408.2 (< 21.76)	362.9-408.2 (> 21.76)	SEM[b]	362.9-408.2 (< 20.07)	362.9-408.2 (> 20.07)	408.2-453.6 (< 20.07)	408.2-453.6 (> 20.07)	SEM[b]	P > F
Values / 45.36 kg											
Forequarter	117.80 [j]	119.91 [j, k]	119.20 [j, k]	121.35 [j, k]	1.46	122.59 [j, k]	123.30 [j, k]	123.01 [j, k]	124.66 [k]	1.03	0.0050
Hindquarter	163.59	161.65	156.11	165.29	3.08	163.40	162.58	159.89	162.25	2.17	0.4910
Carcass	139.14	139.22	135.92	142.12	1.73	141.54	141.60	140.19	142.12	1.22	0.1155

Within a row, means lacking a common letter (j-l) differ (*P* < 0.05)
[b] Standard error of the least squares mean

Table 33.
Beef carcass value per 45.36 kg ($) contrasts by designated populations

Contrast	Values / 45.36 kg		
	Forequarter Values / 45.36 kg	Hindquarter value / 45.36 kg	Side value / 45.36 kg
	P > F	*P* > F	*P* > F
Heifers vs. Steers	< 0.0001	n.s. [c]	< 0.05
Heifers (REA:HCW < 21.76) vs. heifers (REA:HCW > 21.76)	n.s. [c]	n.s. [c]	n.s. [c]
Heifers (317.5–362.9, kg) vs. heifer (317.5–362.10, kg)	n.s. [c]	n.s. [c]	n.s. [c]
Steers (REA:HCW < 20.07) vs. steers (REA:HCW ≥ 20.07)	n.s. [c]	n.s. [c]	n.s. [c]
Steers (362.9–408.2, kg) vs. steers (408.2–453.6, kg)	n.s. [c]	n.s. [c]	< 0.01
Heifers (362.9–408.2, kg) vs. steers (362.9 – 408.2, kg)	< 0.05	n.s. [c]	n.s. [c]

[b] Standard error of the least squares mean

Reported in tables 34-45 are carcass characteristics means grouped by different yield grade carcasses. Table 35, intermuscular fat contrasts showed that the heifer population maintained a significantly ($P > 0.05$) higher percent of intermuscular fat specifically in the forequarter than did the steer population. This gives a basis for the differences previously found in the value differences coupled with carcass conformation differences previously found. Table 37 shows the percentage of subcutaneous fat to be significantly ($P > 0.01$) higher in the heifer population and continuing difference found in forequarters ($P > 0.01$) as well as in the hindquarter ($P > 0.05$). This suggests that not only is there a difference in intermuscular but there is also a difference in subcutaneous fat deposition between genders.

In addition, table 39 suggests a significant ($P > 0.05$) difference in perinephric fat deposition between sex-classes. Within equivalent weight ranges there continues to be a significant ($P > 0.05$) difference in perinephric fat deposition. This proposes a continuing biological difference found between steers and heifers, which may be a basis for value difference. Table 41 represents carcass fat (subcutaneous and intermuscular) as a percentage of side weight without the influence of kidney, pelvic, and heart fat. The data suggests a significant difference ($P > 0.001$) in carcass fat, heifers having the higher percentage. More specifically, this implies that heifer carcasses maintain a significantly ($P > 0.001$) higher percent of fat deposition in the carcass forequarter. This is most significant ($P > 0.05$) influence on total fat deposition within carcasses of an equivalent range.

Tables 42-43 represent carcass bone characteristics found between sex-classes. The differences found in percentage bone were constant through the forequarter, hindquarter, and the whole carcass. However, within the same weight range, the heifer population showed to incorporate a significantly ($P > 0.05$) lower percentage of bone than did the steer population. This suggests that in unison with differences in fat deposition, additional biological differences between heifer and steer populations are driven by differences in bone deposition, more specifically in the carcass forequarter.

Tables 44 – 45 illustrate differences found in percent total red meat yield between heifer and steer population with a significance level of ($P > 0.01$). More specifically the driver of this difference was found in the forequarter with the heifer population producing significantly ($P > 0.05$) less percent red meat yield than the steer population. This finding is consistent with the previous findings of heifers maintaining a higher percentage of fat deposition, particularly in the forequarter. However, it is interesting to note that within the same weight range no significant differences were found. This brings up the question of, “Even though heifers tend to deposit more fat than steers, does the addition amount of bone deposited by steers compensate this when considering the amount of red meat yield produced?”

Table 34.
Least squares means of intermuscular fat characteristics (%) stratified by sex class, weight (kg), and ribeye area per 100 kg ratio

	Heifers					Steers					
Intermuscular Fat	362.9–408.2 (< 20.07)	362.9–408.2 (≥ 20.07)	408.2–453.6 (< 20.07)	408.2–453.6 (≥ 20.07)	SEM [a]	317.5–362.9 (< 21.76)	317.5–362.9 (≥ 21.76)	362.9–408.2 (< 21.76)	362.9–408.2 (≥ 21.76)	SEM [a]	*P* > F
Forequarter	4.48	4.87	5.20	4.19	0.49	3.85	4.18	4.47	3.66	0.34	0.1904
Hindquarter	3.26	3.14	3.26	3.05	0.49	3.20	3.78	3.50	3.66	0.35	0.8680
Total	7.74	8.01	8.47	7.24	0.80	7.05	7.96	7.97	7.32	0.57	0.8234

Within a column, means lacking a common letter (j-k) differ ($P < 0.05$)
[a] Standard error of the least squares mean

Table 35
Intermuscular fat contrasts by designated populations

	Intermuscular Fat		
Contrast	Forequarter	Hindquarter	Total
	P > F	*P* > F	*P* > F
Heifers vs. Steers	< 0.05	n.s. [c]	n.s. [c]
Heifers (REA:HCW < 21.76) vs. heifers (REA:HCW > 21.76)	n.s. [c]	n.s. [c]	n.s. [c]
Heifers (317.5–362.9, kg) vs. heifer (317.5–362.10, kg)	n.s. [c]	n.s. [c]	n.s. [c]
Steers (REA:HCW < 20.07) vs. steers (REA:HCW ≥ 20.07)	n.s. [c]	n.s. [c]	n.s. [c]
Steers (362.9–408.2, kg) vs. steers (408.2–453.6, kg)	n.s. [c]	n.s. [c]	n.s. [c]
Heifers (362.9–408.2, kg) vs. steers (362.9 – 408.2, kg)	n.s. [c]	n.s. [c]	n.s. [c]

[c] Non significant (P > 0.05)

Table 36
Least squares means of subcutaneous fat characteristics (%) stratified by sex class, weight (kg), and ribeye area per 100 kg ratio

	Heifers					Steers					
Subcutaneous Fat	362.9–408.2 (< 20.07)	362.9–408.2 (≥ 20.07)	408.2–453.6 (< 20.07)	408.2–453.6 (≥ 20.07)	SEM [a]	317.5–362.9 (< 21.76)	317.5–362.9 (≥ 21.76)	362.9–408.2 (< 21.76)	362.9–408.2 (≥ 21.76)	SEM [a]	*P* > F
Forequarter	3.89	3.38	2.98	3.60	0.33	2.88	3.18	2.78	2.87	0.24	0.1164
Hindquarter	6.02	5.74	5.41	5.54	0.48	5.33	4.96	5.01	5.06	0.34	0.6043
Total	9.91	9.12	8.40	9.14	0.63	8.22	8.14	7.79	7.94	0.45	0.1325

Within a column, means lacking a common letter (j-k) differ ($P < 0.05$)
[a] Standard error of the least squares mean

Table 37
Subcutaneous fat contrasts by designated populations

	Subcutaneous Fat		
Contrast	Forequarter	Hindquarter	Total
	P > F	*P* > F	*P* > F
Heifers vs. Steers	< 0.01	< 0.05	< 0.01
Heifers (REA:HCW < 21.76) vs. heifers (REA:HCW > 21.76)	n.s. [c]	n.s. [c]	n.s. [c]
Heifers (317.5–362.9, kg) vs. heifer (317.5–362.10, kg)	n.s. [c]	n.s. [c]	n.s. [c]
Steers (REA:HCW < 20.07) vs. steers (REA:HCW ≥ 20.07)	n.s. [c]	n.s. [c]	n.s. [c]
Steers (362.9–408.2, kg) vs. steers (408.2–453.6, kg)	n.s. [c]	n.s. [c]	n.s. [c]
Heifers (362.9–408.2, kg) vs. steers (362.9 – 408.2, kg)	n.s. [c]	n.s. [c]	n.s. [c]

[c] Non significant (P > 0.05)

Table 38.
Least squares means of kidney, pelvic, and heart fat characteristics (%) stratified by sex class, weight (kg), and ribeye area per 100 kg ratio

	Heifers					Steers					
	362.9–408.2 (< 20.07)	362.9–408.2 (≥ 20.07)	408.2–453.6 (< 20.07)	408.2–453.6 (≥ 20.07)	SEM [a]	317.5–362.9 (< 21.76)	317.5–362.9 (≥ 21.76)	362.9–408.2 (< 21.76)	362.9–408.2 (≥ 21.76)	SEM [a]	*P* > F
Kidney, pelvic, heart fat	3.73	4.70	4.15	4.72	0.49	3.32	3.83	3.96	3.61	0.34	0.2369

Within a column, means lacking a common letter (j-k) differ ($P < 0.05$)
[a] Standard error of the least squares mean

Table 39
Kidney, pelvic, and heart fat contrasts by designated populations

Contrast	**Kidney, pelvic, heart fat**
	P > F
Heifers vs. Steers	< 0.05
Heifers (REA:HCW < 21.76) vs. heifers (REA:HCW > 21.76)	n.s. [c]
Heifers (317.5–362.9, kg) vs. heifer (317.5–362.10, kg)	n.s. [c]
Steers (REA:HCW < 20.07) vs. steers (REA:HCW ≥ 20.07)	n.s. [c]
Steers (362.9–408.2, kg) vs. steers (408.2–453.6, kg)	n.s. [c]
Heifers (362.9–408.2, kg) vs. steers (362.9 – 408.2, kg)	< 0.05

[c] Non significant (P > 0.05)

Table 40.
Least squares means of carcass fat characteristics (%) stratified by sex class, weight (kg), and ribeye area per 100 kg ratio

	Heifers					Steers					
	362.9–408.2 (< 20.07)	362.9–408.2 (≥ 20.07)	408.2–453.6 (< 20.07)	408.2–453.6 (≥ 20.07)	SEM [a]	317.5–362.9 (< 21.76)	317.5–362.9 (≥ 21.76)	362.9–408.2 (< 21.76)	362.9–408.2 (≥ 21.76)	SEM [a]	*P* > F
Total Fat											
Forequarter Fat	8.37	8.25	8.19	7.79	0.48	6.73	7.36	7.25	6.53	0.34	0.0109
Hindquarter Fat	9.28	8.88	8.68	8.58	0.59	8.53	8.74	8.51	8.73	0.42	0.9818
Carcass Fat	21.39	21.84	21.01	21.10	0.89	18.59	19.93	19.72	18.88	0.63	0.0246

Within a column, means lacking a common letter (j-k) differ ($P < 0.05$)
[a] Standard error of the least squares mean

Table 41.
Carcass fat (%) contrasts by designated populations

	Combination Side Fat		
Contrast	Forequarter	Hindquarter	Total
	P > F	*P* > F	*P* > F
Heifers vs. Steers	< 0.001	n.s. [c]	< 0.001
Heifers (REA:HCW < 21.76) vs. heifers (REA:HCW > 21.76)	n.s. [c]	n.s. [c]	n.s. [c]
Heifers (317.5–362.9, kg) vs. heifer (317.5–362.10, kg)	n.s. [c]	n.s. [c]	n.s. [c]
Steers (REA:HCW < 20.07) vs. steers (REA:HCW ≥ 20.07)	n.s. [c]	n.s. [c]	n.s. [c]
Steers (362.9–408.2, kg) vs. steers (408.2–453.6, kg)	n.s. [c]	n.s. [c]	n.s. [c]
Heifers (362.9–408.2, kg) vs. steers (362.9 – 408.2, kg)	< 0.05	n.s. [c]	< 0.05

[c] Non significant (P > 0.05)

Table 42.
Least squares means of carcass bone characteristics (%) stratified by sex class, weight (kg), and ribeye area per 100 kg ratio

	Heifers					Steers					
	362.9–408.2 (< 20.07)	362.9–408.2 (≥ 20.07)	408.2–453.6 (< 20.07)	408.2–453.6 (≥ 20.07)	SEM [a]	317.5–362.9 (< 21.76)	317.5–362.9 (≥ 21.76)	362.9–408.2 (< 21.76)	362.9–408.2 (≥ 21.76)	SEM [a]	*P* > F
Bone											
Forequarter	8.68	8.33	8.40	8.24	0.20	8.25	8.03	8.29	7.69	0.28	0.2294
Hindquarter	6.40	6.20	6.18	6.44	0.16	5.95	5.98	6.26	5.88	0.23	0.3543
Total	15.09	14.53	14.57	14.69	0.32	14.20	14.01	14.55	13.57	0.45	0.2377

Within a column, means lacking a common letter (j-k) differ ($P < 0.05$)
[a] Standard error of the least squares mean

Table 43.
Carcass bone (%) contrasts by designated populations

	Bone		
Contrast	Forequarter	Hindquarter	Total
	P > F	*P* > F	*P* > F
Heifers vs. Steers	< 0.05	< 0.05	< 0.05
Heifers (REA:HCW < 21.76) vs. heifers (REA:HCW > 21.76)	n.s. [c]	n.s. [c]	n.s. [c]
Heifers (317.5–362.9, kg) vs. heifer (317.5–362.10, kg)	n.s. [c]	n.s. [c]	n.s. [c]
Steers (REA:HCW < 20.07) vs. steers (REA:HCW ≥ 20.07)	n.s. [c]	n.s. [c]	n.s. [c]
Steers (362.9–408.2, kg) vs. steers (408.2–453.6, kg)	n.s. [c]	n.s. [c]	n.s. [c]
Heifers (362.9–408.2, kg) vs. steers (362.9 – 408.2, kg)	< 0.05	n.s. [c]	n.s. [c]

[c] Non significant (P > 0.05)

Table 44.
Least squares means of carcass red meat yield (%) stratified by sex class, weight (kg), and ribeye area per 100 kg ratio

	Heifers					Steers					
	362.9–408.2 (< 20.07)	362.9–408.2 (≥ 20.07)	408.2–453.6 (< 20.07)	408.2–453.6 (≥ 20.07)	SEM [a]	317.5–362.9 (< 21.76)	317.5–362.9 (≥ 21.76)	362.9–408.2 (< 21.76)	362.9–408.2 (≥ 21.76)	SEM [a]	*P* > F
Red Meat Yield											
Forequarter	37.92	37.47	37.50	38.43	0.43	36.48	36.21	37.52	36.28	0.61	0.0353
Hindquarter	29.05 [j, k]	28.64 [j, k]	28.92 [j]	28.81 [k]	0.37	28.47 [j, k]	28.37 [j, k]	27.44 [j, k]	29.65 [j, k]	0.53	0.1762
Total	66.00	65.22	65.35	66.16	0.59	64.03	63.56	64.09	65.03	0.84	0.1236

Within a column, means lacking a common letter (j-k) differ ($P < 0.05$)
[a] Standard error of the least squares mean

Table 45
Percent red meat yield (%) contrasts by designated populations

	Red meat yield		
Contrast	Forequarter	Hindquarter	Total
	P > F	*P* > F	*P* > F
Heifers vs. Steers	< 0.01	n.s. [c]	< 0.01
Heifers (REA:HCW < 21.76) vs. heifers (REA:HCW > 21.76)	n.s. [c]	< 0.05	n.s. [c]
Heifers (317.5–362.9, kg) vs. heifer (317.5–362.10, kg)	n.s. [c]	n.s. [c]	n.s. [c]
Steers (REA:HCW < 20.07) vs. steers (REA:HCW ≥ 20.07)	n.s. [c]	n.s. [c]	n.s. [c]
Steers (362.9–408.2, kg) vs. steers (408.2–453.6, kg)	n.s. [c]	n.s. [c]	n.s. [c]
Heifers (362.9–408.2, kg) vs. steers (362.9 – 408.2, kg)	n.s. [c]	n.s. [c]	n.s. [c]

[c] Non significant (P > 0.05)

Presented in table 46 is the simple means, standard deviations, minimum, and maximum assessment of carcass values separated according to sex-class. The yield grade 4 side values were compiled from data based on previously obtained carcass values per 45.36 kg of carcass weight multiplied by side weight; while the same values multiplied by hot carcass weight were used to obtain carcass values. The Weekly National Carlot Meat Report, choice, 600-900, carcass value was collected from the USDA archives for the average of 600-900, Choice, weekly cutout value summary from the equivalent dates as the corresponding subprimal and minor cut prices used for yield grade 4 price allocation. This data is used as a rough estimate for the comparison for the compiled Yield Grade 4 carcass data. The Weekly National Carlot Meat Report, choice, 600-900, carcass value with $13.46 discount is the same rough estimate used including the National average discounts applied for Yield Grade 4 carcasses.

Table 47 represents the simple means, standard deviations, minimum, and maximum assessment of differences found between carcass values separated according to sex-class. The data suggests that within the heifer population the average discount that theoretically should be applied is $9.71 per 45.36 kg of carcass weight, while steers

Table 46.
Simple means, standard deviations (SD), minimum and maximum values of carcass values stratified by gender

	Carcass type	Mean	SD	Min	Max
Yield grade 4 side value	Heifers	537.62	39.39	476.46	611.17
	Steers	606.76	37.82	533.35	683.52
	Combined	583.72	50.25	476.46	683.52
Weekly National, Carlot Report, choice, 600-900, side value	Heifers	586.29	41.65	512.85	648.19
	Steers	651.45	38.98	578.05	729.68
	Combined	629.73	50.22	512.85	729.68
Weekly National, Carlot Report, choice, 600-900, side value with $13.46 discount	Heifers	533.26	39.89	466.46	589.56
	Steers	533.26	37.89	466.46	589.56
	Combined	572.77	45.68	466.46	663.68
Yield grade 4 carcass value	Heifers	1120.44	84.86	1000.13	1265.09
	Steers	1271.08	75.25	1133.91	1439.27
	Combined	1220.87	105.79	1000.13	1439.27
Weekly National, Carlot Report, choice, 600-900, carcass value	Heifers	1198.78	84.15	1059.53	1318.46
	Steers	1338.22	74.31	1193.46	1476.20
	Combined	1291.74	101.61	1059.53	1476.20
Weekly National, Carlot Report, choice, 600-900, carcass value with $13.46 discount	Heifers	1090.35	76.54	963.69	1199.20
	Steers	1217.17	67.59	1085.51	1342.68
	Combined	1174.90	92.42	963.69	1342.68

should be receiving a $7.45 discount per 45.36 kg, and the population as a whole should receive a roughly estimated $8.20 discount to compensate for the potential value lost due to carcass composition being that of a Yield Grade 4. However, when a rough estimate discount of $13.46 per 45.36 kg is applied we find that Yield grade 4 carcasses are overly discounted on average of $5.26 per 45.36 kg as a whole population. It is interesting to not that within the steer population they discount is over applied by a rough estimate of $6.01 while heifers is overly discounted by a rough estimate of only $3.75. This finding is consistent with previous findings with value and compositional differences found between heifer and steer populations. The remaining data represented

in table 47 shows how the application of the overly compensated discounts when applied to carcass sides and whole carcasses is substantial and how it will impact values lost in the industry.

Tables 48 and 49 present the least squares means and contrasts of differences found in beef carcass value per 45.36 kg between the estimated Weekly National Carlot Meat Report, choice, 600-900, carcass values and the Weekly National Carlot Meat Report, choice, 600-900, carcass value with $13.46 discount applied. Specifically, in table 48, shows a significant ($P > 0.05$) difference with contrasts between sex-class. This implies that Yield Grade 4 steer carcasses are excessively discounted when compared to heifer carcasses. It is interesting to note how the value differences vary concerning carcasses within the same weight group. The carcass type most consistent with the current applied discounts is for a lighter muscled 362.9 – 408.2 kg carcass. On the other hand, the most non-deserving kind is a heavy muscled, 408.2 – 453.6 kg steer carcasses.

Table 47.
Simple means, standard deviations (SD), minimum and maximum values of differences in values stratified by gender

	Carcass type	Mean	SD	Min	Max
Difference in beef carcass value per 100 kg between:					
Weekly National Carlot Report and yield grade 4	Heifers	9.71	4.35	4.29	19.13
	Steers	7.45	3.71	-0.70	18.02
	Combined	8.20	4.04	-0.70	19.13
Weekly National Carlot Report with $13.46 discount, and yield grade 4	Heifers	-3.75	4.35	-9.17	5.67
	Steers	-6.01	3.71	-14.16	4.56
	Combined	-5.26	4.04	-14.16	5.67
Difference in beef carcass side value between:					
Weekly National Carlot Report and yield grade 4	Heifers	38.45	18.33	15.31	81.50
	Steers	32.73	16.35	-2.82	76.58
	Combined	34.63	17.09	-2.82	81.50
Weekly National Carlot Report with $13.46 discount, and yield grade 4	Heifers	-14.58	17.55	-36.49	24.16
	Steers	-26.20	15.85	-57.24	18.98
	Combined	-22.32	17.20	-57.24	24.16
Difference in beef carcass value between:					
Weekly National Carlot Report and yield grade 4	Heifers	78.34	36.80	32.30	165.31
	Steers	67.13	33.75	-6.04	161.45
	Combined	70.87	34.89	-6.04	165.31
Weekly National Carlot Report with $13.46 discount, and yield grade 4	Heifers	-30.09	36.07	-75.59	49.01
	Steers	-53.91	33.07	-122.33	39.57
	Combined	-45.97	35.64	-122.33	49.01

Table 48.
Least squares means of differences in beef carcass value per 45.36 kg ($) stratified by sex, weight (kg), and ribeye area per 100 kg ratio

	Heifers					Steers					
	317.5-362.9 (< 21.76)	317.5-362.9 (> 21.76)	362.9-408.2 (< 21.76)	362.9-408.2 (> 21.76)	SEM[b]	362.9-408.2 (< 20.07)	362.9-408.2 (> 20.07)	408.2-453.6 (< 20.07)	408.2-453.6 (> 20.07)	SEM[b]	P > F
Difference in beef carcass value per 100 kg between:											
Weekly National Carlot Report and yield grade 4	9.67	9.59	12.88	6.68	1.73	7.27	7.21	8.62	6.69	1.22	0.1154
Weekly National Carlot Report with $13.46 discount, and yield grade 4	-3.79	-3.86	-0.57	-6.77	1.73	-6.19	-6.25	-4.84	-6.77	1.22	0.1155

Within a row, means lacking a common letter (j-l) differ ($P < 0.05$)
[b] Standard error of the least squares mean

Table 49.
Beef carcass value per 45.36 kg ($) contrasts by designated populations

Contrast	**Difference between yield grade 4 carcass value per 100 kg:**	
	Weekly National Carlot Report value per 45.36 kg	**Weekly National Carlot Report value per 45.36 kg with $13.46 discount**
	P > F	*P* > F
Heifers vs. Steers	< 0.05	< 0.05
Heifers (REA:HCW < 21.76) vs. heifers (REA:HCW > 21.76)	n.s. [c]	n.s. [c]
Heifers (317.5–362.9, kg) vs. heifer (317.5–362.10, kg)	n.s. [c]	n.s. [c]
Steers (REA:HCW < 20.07) vs. steers (REA:HCW ≥ 20.07)	n.s. [c]	n.s. [c]
Steers (362.9–408.2, kg) vs. steers (408.2–453.6, kg)	n.s. [c]	n.s. [c]
Heifers (362.9–408.2, kg) vs. steers (362.9 – 408.2, kg)	n.s. [c]	n.s. [c]

[c] Non significant (P > 0.05)

Correlation Coefficients

Measurements taken during carcass selection included preliminary yield grade; adjusted preliminary yield grade; ribeye area; percentage of kidney, pelvic, and heart fat; warm carcass weight; final yield grade; marbling score; ribeye area to hot carcass weight ratio, as well as hump height.

Within the USDA Yield Grade 4 carcasses examined in this study, USDA Yield Grade and the four factors used in the USDA Yield Grade equation had low and non-significant ($P > 0.05$) correlations with final carcass value per 45.36 kg as reported in table 50, with the exception of ribeye area (r = 0.28775; $P < 0.05$), which was still a low but significant correlation. This indicates that the majority of these variables may not possess value when segmenting carcasses according to final carcass value per 45.36 kg, based on the cutting tests done in this study. Furthermore, marbling number (r = -0.30743; $P < 0.05$), was to some extent, negatively correlated. However, within the USDA Yield Grade 4 carcasses segregated by gender, within the heifers preliminary yield grade (r = 0.48632; $P < 0.05$), ribeye area to hot carcass weight ratio (r = 0.47365; $P < 0.05$), adjusted preliminary yield grade (r = 0.50567; $P < 0.05$) were all moderately significantly correlated.

Table 50.
Pearson correlation coefficients for carcass value per 45.36 kg between yield grade factors overall and by sex class

	Carcass value / 45.36 kg $
Hot carcass weight, kg	
All animals	0.12
Heifers	-0.05
Steers	-0.09
Fat thickness, cm	
All animals	0.19
Heifers	0.50*
Steers	0.13
Longissimus muscle area, 12th rib, cm2	
All animals	0.29*
Heifers	0.39
Steers	0.17
PYG	
All animals	0.12
Heifers	0.49*
Steers	-0.02
Internal fat percent	
All animals	-0.02
Heifers	0.07
Steers	-0.04
Yield grade	
All animals	-0.13
Heifers	0.04
Steers	-0.22
REA/HCW [a]	
All animals	0.21
Heifers	0.47*
Steers	0.24
Bodywall [b]	
All animals	0.04
Heifers	0.12
Steers	-0.03
Hump height, measurement [c]	
All animals	0.17
Heifers	-0.03
Steers	0.09
Marbling score [d]	
All animals	-0.31*
Heifers	-0.49*
Steers	-0.15
Adjusted preliminary yield grade	
All animals	0.19
Heifers	0.50*
Steers	0.13

* $P < 0.05$
** $P < 0.01$
*** $P < 0.001$
[a] Ribeye area (cm^2) and hot carcass weight kg ratio.
[b] Bodywall thickness measured 12.7 cm from the vertebra at the 12th rib.
[c] Distance from the line to the top of the lean muscle (excluding the external layer of fat),measured perpendicular to the extension of the top-line at the peak of the hump laid at the top of the shoulders.
[d] Marbling score: 300 to 399 = Slight; 400 to 499 = small; 500 to 599 = Modest.

Table 51 shows a breakdown of how different fat percentages are correlated to carcass value per 45.36 kg. All measures of carcass end values are primarily influenced by weight increments therefore the correlation coefficients between all end values were reported as percentages. Percentage of forequarter subcutaneous fat (r = -0.09109; $P < 0.4888$), percent hindquarter subcutaneous fat (r = -0.04638; $P < 0.7249$) and percent total subcutaneous fat (r = -0.08224; $P < 0.5322$) had a low and non-significant correlation to carcass value per 45.36 kg. In spite of this, percent forequarter seam fat (r = -0.25810; $P < 0.05$), percent hindquarter seam fat (r = -0.43039; $P < 0.0006$) and percent seam fat (r = -0.47159; $P < 0.0001$) had up to a moderate and significant ($P < 0.05$) simple correlation with final carcass value per 45.36 kg. This is consistent with the findings of Jones et al. (1990) whose studies presented that intermuscular fat tended to be greater in carcasses from heifers than steers; as amounts of intermuscular fat increased as USDA yield grade and marbling score increased. When grouping fats by quarters we find percent forequarter fat (r = -0.22900; $P < 0.0784$), and percent hindquarter fat (r = -0.40334; $P < 0.0014$) while percent total fat (r = -0.53993; $P < 0.0001$) correlation with carcass value per 45.36 kg. This may indicate that intermuscular fat is a bigger driver in the resulting final carcass value per 45.36 kg than the other fat depots when examined within USDA Yield Grade 4 carcasses. Furthermore, the percentage of total fat consisting of subcutaneous and intermuscular fat from the forequarter and hindquarter proved to be the highest negative correlation in relation to carcass value per 45.36 kg. With regards to percent to fat and percent red meat yield (r = -0.88359; $P < 0.0001$) are significantly, highly correlated for the entire

population, further separating the population by gender we find that correlations are all significantly, highly correlated heifers (r = -0.84063; $P < 0.0001$), and steers (r = -0.87708; $P < 0.0001$). This is most likely due too, as fat increases the amount of red meat yield decreases, in turn decreasing carcass value per 45.36 kg. Estimates of correlation and regression coefficients are affected by the variation in the data upon which they are based. This may explain some of the high correlation values reported. Such inflation of the correlation coefficient does not indicate any greater absolute precision in the estimation of whole carcass composition. Moreover, table 52; correlations observed for the heifer population in regards to percent carcass bone (r = -0.44572; $P < 0.0489$), we find only to be moderately correlated with carcass value per 45.36 kg.

Table 51.
Pearson correlation coefficients for (%) carcass fat components and value per 45.36 kg stratified by gender

	Forequarter seam fat %	Forequarter subcutaneous fat %	Forequarter fat %	Hindquarter seam fat %	Hindquarter Subcutaneous fat %	Hindquarter fat %	Seam fat %	Subcutaneous fat %	Carcass fat %
Percent carcass subprimal									
All animals	-0.31**	-0.09	-0.26*	-0.31**	-0.17	-0.41**	-0.40**	-0.17	-0.50***
Heifers	-0.43	0.12	-0.12	-0.35	0.01	-0.34	-0.44*	0.07	-0.37
Steers	-0.13	-0.08	-0.17	-0.41**	-0.17	-0.45**	-0.40**	-0.18	-0.46**
Percent red meat yield									
All animals	-0.40**	-0.32*	-0.50***	-0.31*	-0.27*	-0.49***	-0.43***	-0.36**	-0.88***
Heifers	-0.15	-0.30	-0.32	-0.12	-0.22	-0.35	-0.15	-0.31	-0.84***
Steers	-0.41**	-0.19	-0.47**	-0.54***	-0.18	-0.55***	-0.63***	-0.24	-0.88***
Carcass value / 45.36 kg									
All animals	-0.26*	-0.09	-0.23	-0.43***	-0.05	-0.40**	-0.47***	-0.08	-0.54***
Heifers	-0.12	0.00	-0.06	-0.24	0.09	-0.15	-0.24	0.06	-0.40
Steers	-0.23	-0.01	-0.18	-0.65***	-0.01	-0.52***	-0.65***	-0.02	-0.54***

* $P < 0.05$
** $P < 0.01$
*** $P < 0.001$

Table 52.
Pearson correlation coefficients for carcass percents and value per 45.36 kg and bone influence stratified by gender

	Forequarter bone, %	Hindquarter bone %	Carcass bone %
Percent carcass subprimal			
All animals	-0.00	-0.03	-0.02
Heifers	-0.23	-0.31	-0.28
Steers	0.01	-0.02	-0.00
Percent red meat yield			
All animals	-0.00	-0.02	-0.01
Heifers	-0.10	-0.27	-0.18
Steers	-0.11	-0.06	-0.10
Carcass value / 45.36 kg			
All animals	-0.23	-0.15	-0.22
Heifers	-0.41	-0.43	-0.44*
Steers	-0.27	-0.14	-0.24

* $P < 0.05$
** $P < 0.01$
*** $P < 0.001$

Prediction Equation Analysis

Prediction equations should be used that have been derived from populations that are representative of the carcasses being marketed within given specifications. The selection criteria for the most desirable method of estimating carcass composition should include (1) the difficulty and cost of taking the measurements, (2) the proven accuracy of the method and (3) the reliability of a measurement when used in a prediction equation to estimate composition of carcasses that differ in breed and sex (Hedrick, 1983).

The objective in selecting a prediction equation was to select an equation that would maximize R-square, which is the proportion of the total, corrected sums of squares of the dependent variable accounted for in the equation, thus accounting or a greater percentage of the total variation than other models yielding a smaller R-square value calculated from the same data set. For the purpose of this study the focus is on carcass value per 45.36 kg. Independent variables identified to be used in the regression

models were fat thickness, preliminary yield grade, ribeye area, kidney, pelvic, and heart fat, percent, warm carcass weight, marbling score, hump height, and bodywall thickness. These variables were established to account for as much of the variation as possible resulting from sex class (steers vs. heifers), carcass weights, and ribeye area per 100 kg ratio interaction. All predicted values were calculated from regression equations using the same number of independent variables in order to standardize the analysis, and to utilize only easily obtainable measurements, as they would be applicable to the industry. This method of analysis, furthermore, will allow for the maximization of R-square to warrant minimizing the residual variance and influencing the standard error of the estimate. In addition to recording regression equations for the dependent variable, the R-square and the residual standard deviations are reported for each equation in order to explain the amount of variation in the dependent variable being explained by the model, and to describe how well the actual and observed values correspond. Additionally, Mallows (Cp) statistic was used when selecting the equation of best fit due to its' power in recognizing the relative involvement with the squared true error and the squared lack of fit associated with selecting independent variables or models.

Stepwise regression was used to specify the significance of variables to a model when estimating the carcass value per 45.36 kg from the population of carcasses and subpopulations divided by gender. Variables used included those regularly obtained from carcasses following twenty four hours post harvest which included: actual fat thickness, warm carcass weight, ribeye area, percentage of kidney, pelvic and heart fat, marbling score, hump height as well as body wall thickness.

When analyzing table 53, the complete population of USDA Yield Grade 4 carcasses ribeye area increased R-square and decreased the residual mean square error (RMSE) in model than when only marbling number. Although the R-square does not explain vary much of the variation in the model used when adding more variables it does not increase the value of R-square. However, with the heifer population coupled with the addition of the variables warm carcass weight, adjusted preliminary yield grade, marbling number, and body wall thickness, R-square is maximized and a minimized root mean square error, explaining approximately 58% of the variation in the equation. From the information available in table 54, it appears carcass value per 45.36 kg can be most appropriately predicted from model 4. Regrettably, when selecting a prediction equation for the steer population in table 55, we see a severe decline in R-square values ($r^2 = 0.11$) when selecting the model containing variables warm carcass weight, ribeye area, preliminary yield grade, and marbling number. The estimates of correlation and regression coefficients reported may be affected by the variation in the data upon which they are based. Thus, a given technique is likely to show a higher correlation as the carcasses or animals being examined become more variable. This may explain some of the high correlation values reported. However, such inflation of the correlation coefficients may not indicate any greater absolute precision in the estimation.

Table 56 reports the applied prediction equations for the entire population along with the equations taking into account sex class differences. The applied equations are as follows:

Entire population predicted carcass value per 45.36 kg

= 140.3530 + (0.1411 * Longissimus muscle area, cm^2)
- (0.0250 * Marbling number)

Heifer population predicted carcass value per 45.36 kg

= 161.2304 - (0.0522 * warm carcass weight)
+ (5.1418 * fat thickness)
- (0.0553 * marbling number)
+ (1.7606 * bodywall thickness)

Steer population predicted carcass value per 45.36 kg

= 154.2442 - (0.0350 * warm carcass weight)
+ (0.1563 * fat thickness)
- (1.4702 * preliminary yield grade)
- (0.0122 * marbling number)

Table 53.
Models to predict carcass value per 45.36 kg as listed by stepwise analysis for entire population

	Entire Population			
Models	Independent Variables	R-Square	Cp	RMSE
1	Marbling number	0.09	2.00	3.88
2	Ribeye area, Marbling number	0.18	-1.22	3.73
3	Ribeye area, Internal fat percent, Marbling number	0.18	0.63	3.76
4	Warm carcass weight, Ribeye area, Hump Height, Marbling number	0.18	2.44	3.79
5	Warm carcass weight, Ribeye area, Internal fat percent, Hump Height, Marbling number	0.18	4.21	3.81
6	Warm carcass weight, Ribeye area, Internal fat percent, Hump Height, Marbling number, Bodywall	0.19	6.02	3.84
7	Warm carcass weight, Ribeye area, Adjusted preliminary yield grade, Internal fat percent, Hump Height, Marbling number, Bodywall	0.19	8.00	3.88

Table 54.
Models to predict carcass value per 45.36 kg as listed by stepwise analysis for heifer population

	Heifer Population			
Models	Independent Variables	R-Square	Cp	RMSE
1	Adjusted preliminary yield grade	0.25	5.91	3.86
2	Adjusted preliminary yield grade, Marbling number	0.46	1.87	3.38
3	Adjusted preliminary yield grade, Marbling number, Bodywall	0.51	2.34	3.31
4	Warm carcass weight, Adjusted preliminary yield grade, Marbling number, Bodywall	0.58	2.30	3.16
5	Warm carcass weight, Ribeye area, Adjusted preliminary yield grade, Marbling number, Bodywall	0.59	4.08	3.25
6	Warm carcass weight, Ribeye area, Marbling number, Bodywall, Internal fat percent	0.59	6.03	3.36
7	Warm carcass weight, Ribeye area, Adjusted preliminary yield grade, Hump height, Marbling number, Bodywall, Internal fat percent	0.59	8.00	3.49

Table 55.
Models to predict carcass value per 45.36 kg as listed by stepwise analysis for steer population

	Steer Data			
Models	Independent Variables	R-Square	Cp	RMSE
1	Ribeye area	0.03	-0.66	3.70
2	Warm carcass weight, Ribeye area	0.07	-0.04	3.68
3	Warm carcass weight, Ribeye area, Marbling number	0.09	1.17	3.69
4	Warm carcass weight, Ribeye area, Preliminary yield grade, Marbling number	0.11	2.49	3.70
5	Warm carcass weight, Ribeye area, Preliminary yield grade, Marbling number, Bodywall	0.12	4.09	3.73
6	Warm carcass weight, Ribeye area, Preliminary yield grade, Hump height, Marbling number, Bodywall	0.12	6.02	3.78
7	Warm carcass weight, Actual fat thickness, Ribeye area, Preliminary yield grade, Hump height, Marbling number, Bodywall	0.12	8.00	3.84

Table 56.
Prediction equations generated to predict carcass value per 45.36 kg stratified by sex class

	Carcass Value / 45.36 kg								
	Intercept	Warm carcass weight, kg	Adjusted preliminary yield grade	Longissimus muscle area, cm2	Preliminary yield grade	Marbling number	Bodywall thickness	R^2	Residual standard deviation
All Data	140.3530			0.1411		-0.0250		0.18	1.93
Heifer Data	150.7823	-0.0522	5.2240			-0.0553	1.7606	0.58	1.78
Steer Data	154.2442	-0.0350	0.1563		-1.4702	-0.0122		0.11	1.92

Verification

Table 57 reports the average of differences between the predicted and actual values for carcass value per 45.36 kg. The overall population and heifer prediction equations were the more accurate without surprise. This can be justified by the R-square values reported in tables 49 - 51.

When prediction equations are applied to different populations, their accuracy may be reduced due to differences in deposition of fat or muscle due to breed (Butterfield, 1965; Abraham et al., 1968; Kempster and Evans, 1981), sex of animal (Carpenter et al., 1969) different populations (Abraham et al., 1980, Hedrick et al., 1983). The recommended approach for use of a prediction equation to estimated carcass composition is to compare the intended accuracy of the equation on the population of carcasses being evaluated and when changes occur in characteristics of animals and carcasses due to production and management practices, revise the prediction equation to more accurately estimate composition (Hedrick, 1983).

Table 57.
Average differences between actual variable and predicted variables for carcasses stratified sex class

	Average differences (predicted minus actual)											
	Whole population				Heifers				Steers			
Dependent variables	Mean	S.D.	Min.	Max.	Mean	S.D.	Min.	Max.	Mean	S.D.	Min.	Max.
Value/45.36 kg	-2.68	3.66	-13.71	5.84	-2.64	2.71	-6.10	2.96	9.80	3.84	-1.74	16.39
USDA yield grade	-0.27	1.29	-2.85	2.85	-0.02	1.52	-2.76	2.85	-0.33	1.39	-2.85	2.85

CHAPTER V

SUMMARY AND CONCLUSIONS

The National Beef Quality Audit – 2005 found that Yield Grade 4 carcasses were in the top ten problems facing the beef industry today. There were 9.5% of the steer and heifer carcasses in the survey that were graded as Yield Grade 4 carcasses, and the discounts applied to these carcasses in the marketplace place a substantial burden on the beef industry. A study to investigate the yields and value of Yield Grade 4 carcasses was undertaken. The priority of this research was to asses the conformational and value differences within USDA Yield Grade 4 carcasses. Data presented in this study showed that within yield grade 4 carcasses, there are both conformational and value differences associated with different types of yield grade 4's, particularly when sex-class is considered due to the biological differences associated with fat and muscle deposition between genders. As expected, carcasses from heifers had more trimmable fat than carcasses than steers, and carcasses from steers had higher yields of certain cuts from the chuck and in bone differences than did carcasses from heifers. In this demonstration, applied discounts out-weighted the value differences found in cutout values.

This study is the most exhaustive to be conducted on Yield Grade 4 carcasses in recent time, and unfortunately, there were no clear relationships in carcass traits that could be used to more accurately sort value differences in Yield Grade 4 carcasses other than differences between steer and heifer carcasses. However, the present data suggest a

need to establish a prediction equation that predicts carcass value in addition to the current Yield Grade equation and its proven ability to predict the percent of boneless, closely trimmed retail cuts from the round, loin, rib, and chuck. In general, there are conformational differences within the overall yield grade population. These findings imply discounts associated with yield grade 4 carcasses may be due to the preconceived bias established with different cattle types used in establishing the original yield grade prediction equation.

In conclusion, further research is needed incorporating all yield grade carcass types. Standard carcass fabrication styles and fat trim levels consistent with industry are needed to further assign current subprimal and minor cut prices. Additional premium and discount prices are needed for a current industry representation to obtain if premiums and discounts are being applied according to potential profits or losses incurred because of cutability differences found between the different yield grades.

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APPENDIX A

Table A1.
Least squares means of fat thickness, cm stratified by weight (kg), and ribeye area per 100 kg ratio

	Heifers			Steers		
Variable	Hot carcass weights, kg	REA:HCW ratio [a]	Means	Hot carcass weights, kg	REA:HCW ratio [a]	Means
Fat thickness, cm						
	317.5-362.9	(< 21.76)	2.01 [j, k]	362.9-408.2	(< 20.07)	2.32 [j]
	317.5-362.9	(≥ 21.76)	2.37 [j, k]	362.9-408.2	(≥ 20.07)	2.34 [j, k]
	362.9-408.2	(< 21.76)	2.05 [j, k]	408.7-453.6	(< 20.07)	2.15 [j]
	362.9-408.2	(≥ 21.76)	2.46 [k]	408.7-453.6	(≥ 20.07)	2.57 [j, k]
SEM [b]			0.09			0.12
P > F			0.0018			0.0018

Within a row, means lacking a common letter (j-k) differ ($P < 0.05$)
[a] Ribeye area (cm^2) and warm carcass weight kg ratio
[b] Standard error of the least squares mean

Table A2.
Actual fat thickness contrasts by designated populations

Contrast	Fat thickness, cm
	P > F
Heifers vs. Steers	n.s. [c]
Heifers (REA:HCW < 21.76) vs. heifers (REA:HCW > 21.76)	n.s. [c]
Heifers (317.5–362.9, kg) vs. heifer (317.5–362.10, kg)	n.s. [c]
Steers (REA:HCW < 20.07) vs. steers (REA:HCW ≥ 20.07)	< 0.0001
Steers (362.9–408.2, kg) vs. steers (408.2–453.6, kg)	n.s. [c]
Heifers (362.9–408.2, kg) vs. steers (362.9 – 408.2, kg)	n.s. [c]

[c] Non significant (P > 0.05)

Table A3.
Least squares means of preliminary yield grade stratified by weight (kg), and ribeye area per 100 kg ratio

	Heifers			Steers		
Variable	Hot carcass weights, kg	REA:HCW ratio [a]	Means	Hot carcass weights, kg	REA:HCW ratio [a]	Means
Preliminary yield grade						
	317.5-362.9	(< 21.76)	3.94	362.9-408.2	(< 20.07)	4.06
	317.5-362.9	(≥ 21.76)	4.21	362.9-408.2	(≥ 20.07)	4.28
	362.9-408.2	(< 21.76)	4.07	408.7-453.6	(< 20.07)	3.92
	362.9-408.2	(≥ 21.76)	4.33	408.7-453.6	(≥ 20.07)	4.48
SEM [b]			0.11			0.15
P > F			0.0018			0.0018

Within a row, means lacking a common letter (j-k) differ ($P < 0.05$)
[a] Ribeye area (cm^2) and warm carcass weight kg ratio
[b] Standard error of the least squares mean

Table A4.
Preliminary yield grade contrasts by designated populations

Contrast	Preliminary yield grade
	P > F
Heifers vs. Steers	n.s. [c]
Heifers (REA:HCW < 21.76) vs. heifers (REA:HCW > 21.76)	< 0.05
Heifers (317.5–362.9, kg) vs. heifer (317.5–362.10, kg)	n.s. [c]
Steers (REA:HCW < 20.07) vs. steers (REA:HCW ≥ 20.07)	< 0.05
Steers (362.9–408.2, kg) vs. steers (408.2–453.6, kg)	n.s. [c]
Heifers (362.9–408.2, kg) vs. steers (362.9 – 408.2, kg)	n.s. [c]

[c] Non significant (P > 0.05)

Table A5.
Least squares means of longissimus muscle area, cm^2 stratified by weight (kg), and ribeye area per 100 kg ratio

	Heifers			Steers		
Variable	Hot carcass weights, kg	REA:HCW ratio [a]	Means	Hot carcass weights, kg	REA:HCW ratio [a]	Means
Longissimus muscle area, cm^2						
	317.5-362.9	(< 21.76)	74.06 [j]	362.9-408.2	(< 20.07)	73.16 [j]
	317.5-362.9	(≥ 21.76)	84.77 [j, k]	362.9-408.2	(≥ 20.07)	76.13 [k, l, m]
	362.9-408.2	(< 21.76)	80.32 [j, k]	408.7-453.6	(< 20.07)	75.61 [j, k, l]
	362.9-408.2	(≥ 21.76)	90.71 [l, m]	408.7-453.6	(≥ 20.07)	87.87 [m]
SEM [b]			1.74			2.46
P > F			< 0.0001			< 0.0001

Within a row, means lacking a common letter (j-m) differ ($P < 0.05$)
[a] Ribeye area (cm^2) and warm carcass weight kg ratio
[b] Standard error of the least squares mean

Table A6.
Longissimus muscle area, cm^2 contrasts by designated populations

Contrast	Longissimus muscle area, cm^2
	P > F
Heifers vs. Steers	< 0.01
Heifers (REA:HCW < 21.76) vs. heifers (REA:HCW > 21.76)	< 0.01
Heifers (317.5–362.9, kg) vs. heifer (317.5–362.10, kg)	< 0.01
Steers (REA:HCW < 20.07) vs. steers (REA:HCW ≥ 20.07)	< 0.0001
Steers (362.9–408.2, kg) vs. steers (408.2–453.6, kg)	< 0.001
Heifers (362.9–408.2, kg) vs. steers (362.9 – 408.2, kg)	n.s. [c]

[c] Non significant (P > 0.05)

Table A7.
Least squares means of kidney, pelvic, and heart fat, %, stratified by weight (kg), and ribeye area per 100 kg ratio

	Heifers			Steers		
Variable	Hot carcass weights, kg	REA:HCW ratio [a]	Means	Hot carcass weights, kg	REA:HCW ratio [a]	Means
Kidney, pelvic, and heart fat, %						
	317.5-362.9	(< 21.76)	2.35	362.9-408.2	(< 20.07)	2.50
	317.5-362.9	(≥ 21.76)	2.20	362.9-408.2	(≥ 20.07)	2.40
	362.9-408.2	(< 21.76)	2.50	408.7-453.6	(< 20.07)	2.20
	362.9-408.2	(≥ 21.76)	2.25	408.7-453.6	(≥ 20.07)	2.70
SEM [b]			0.18			0.26
P > F			0.7646			0.7646

Within a row, means lacking a common letter (j-k) differ ($P < 0.05$)
[a] Ribeye area (cm^2) and warm carcass weight kg ratio
[b] Standard error of the least squares mean

Table A8.
Kidney, pelvic, and heart fat, %, contrasts by designated populations

Contrast	Kidney, pelvic, and heart fat, %
	P > F
Heifers vs. Steers	n.s. [c]
Heifers (REA:HCW < 21.76) vs. heifers (REA:HCW > 21.76)	n.s. [c]
Heifers (317.5–362.9, kg) vs. heifer (317.5–362.10, kg)	n.s. [c]
Steers (REA:HCW < 20.07) vs. steers (REA:HCW ≥ 20.07)	n.s. [c]
Steers (362.9–408.2, kg) vs. steers (408.2–453.6, kg)	n.s. [c]
Heifers (362.9–408.2, kg) vs. steers (362.9 – 408.2, kg)	n.s. [c]

[c] Non significant (P > 0.05)

Table A9.
Least squares means of hot carcass weight, kg, stratified by weight (kg), and ribeye area per 100 kg ratio

	Heifers			Steers		
Variable	Hot carcass weights, kg	REA:HCW ratio [a]	Means	Hot carcass weights, kg	REA:HCW ratio [a]	Means
Hot carcass weight, kg						
	317.5-362.9	(< 21.76)	389.41 [j]	362.9-408.2	(< 20.07)	348.04 [k]
	317.5-362.9	(≥ 21.76)	390.02 [j]	362.9-408.2	(≥ 20.07)	337.61 [k]
	362.9-408.2	(< 21.76)	428.21 [k]	408.7-453.6	(< 20.07)	388.18 [l]
	362.9-408.2	(≥ 21.76)	423.97 [k]	408.7-453.6	(≥ 20.07)	387.78 [l]
SEM [b]			4.09			5.79
P > F			< 0.0001			< 0.0001

Within a row, means lacking a common letter (j-l) differ ($P < 0.05$)
[a] Ribeye area (cm^2) and warm carcass weight kg ratio
[b] Standard error of the least squares mean

Table A10.
Hot carcass weight (kg) contrasts by designated populations

Contrast	Hot carcass weight, kg
	P > F
Heifers vs. Steers	< 0.0001
Heifers (REA:HCW < 21.76) vs. heifers (REA:HCW > 21.76)	n.s. [c]
Heifers (317.5–362.9, kg) vs. heifer (317.5–362.10, kg)	< 0.0001
Steers (REA:HCW < 20.07) vs. steers (REA:HCW ≥ 20.07)	n.s. [c]
Steers (362.9–408.2, kg) vs. steers (408.2–453.6, kg)	< 0.0001
Heifers (362.9–408.2, kg) vs. steers (362.9 – 408.2, kg)	n.s. [c]

[c] Non significant (P > 0.05)

Table A11.
Least squares means of USDA yield grade, stratified by weight (kg), and ribeye area per 100 kg ratio

	Heifers			Steers		
Variable	Hot carcass weights, kg	REA:HCW ratio [a]	Means	Hot carcass weights, kg	REA:HCW ratio [a]	Means
USDA yield grade						
	317.5-362.9	(< 21.76)	4.54	362.9-408.2	(< 20.07)	4.57
	317.5-362.9	(≥ 21.76)	4.33	362.9-408.2	(≥ 20.07)	4.33
	362.9-408.2	(< 21.76)	4.62	408.7-453.6	(< 20.07)	4.56
	362.9-408.2	(≥ 21.76)	4.42	408.7-453.6	(≥ 20.07)	4.46
SEM [b]			0.06			0.09
P > F			0.0329			0.0329

Within a row, means lacking a common letter (j-l) differ ($P < 0.05$)
[a] Ribeye area (cm^2) and warm carcass weight kg ratio
[b] Standard error of the least squares mean

Table A12.
USDA yield grade, contrasts by designated populations

Contrast	USDA yield grade
	P > F
Heifers vs. Steers	n.s. [c]
Heifers (REA:HCW < 21.76) vs. heifers (REA:HCW > 21.76)	n.s. [c]
Heifers (317.5–362.9, kg) vs. heifer (317.5–362.10, kg)	n.s. [c]
Steers (REA:HCW < 20.07) vs. steers (REA:HCW ≥ 20.07)	< 0.05
Steers (362.9–408.2, kg) vs. steers (408.2–453.6, kg)	n.s. [c]
Heifers (362.9–408.2, kg) vs. steers (362.9 – 408.2, kg)	n.s. [c]

[c] Non significant (P > 0.05)

Table A13.
Least squares means of marbling score [d], stratified by weight (kg), and ribeye area per 100 kg ratio

	Heifers			Steers		
Variable	Hot carcass weights, kg	REA:HCW ratio [a]	Means	Hot carcass weights, kg	REA:HCW ratio [a]	Means
Marbling score [d]						
	317.5-362.9	(< 21.76)	435.00	362.9-408.2	(< 20.07)	434.00
	317.5-362.9	(≥ 21.76)	449.00	362.9-408.2	(≥ 20.07)	478.00
	362.9-408.2	(< 21.76)	448.00	408.7-453.6	(< 20.07)	470.00
	362.9-408.2	(≥ 21.76)	439.00	408.7-453.6	(≥ 20.07)	444.00
SEM [b]			16.02			22.66
P > F			0.7672			0.7672

Within a row, means lacking a common letter (j-l) differ ($P < 0.05$)
[a] Ribeye area (cm^2) and warm carcass weight kg ratio
[b] Standard error of the least squares mean
[d] Marbling score: 300 to 399 = Slight; 400 to 499 = small; 500 to 599 = Modest

Table A14.
Marbling score [d] contrasts by designated populations

Contrast	Marbling score [d]
	P > F
Heifers vs. Steers	n.s. [c]
Heifers (REA:HCW < 21.76) vs. heifers (REA:HCW > 21.76)	n.s. [c]
Heifers (317.5–362.9, kg) vs. heifer (317.5–362.10, kg)	n.s. [c]
Steers (REA:HCW < 20.07) vs. steers (REA:HCW ≥ 20.07)	n.s. [c]
Steers (362.9–408.2, kg) vs. steers (408.2–453.6, kg)	n.s. [c]
Heifers (362.9–408.2, kg) vs. steers (362.9 – 408.2, kg)	n.s. [c]

[c] Non significant (P > 0.05)
[d] Marbling score: 300 to 399 = Slight; 400 to 499 = small; 500 to 599 = Modest

Table A15.
Least squares means of hump height [c] stratified by weight (kg), and ribeye area per 100 kg ratio

	Heifers			Steers		
Variable	Hot carcass weights, kg	REA:HCW ratio [a]	Means	Hot carcass weights, kg	REA:HCW ratio [a]	Means
Hump height [c]						
	317.5-362.9	(< 21.76)	1.85	362.9-408.2	(< 20.07)	0.86
	317.5-362.9	(≥ 21.76)	3.00	362.9-408.2	(≥ 20.07)	1.17
	362.9-408.2	(< 21.76)	2.56	408.7-453.6	(< 20.07)	1.42
	362.9-408.2	(≥ 21.76)	2.59	408.7-453.6	(≥ 20.07)	1.57
SEM [b]			0.39			0.56
P > F			0.0209			0.0209

Within a row, means lacking a common letter (j-k) differ ($P < 0.05$)
[a] Ribeye area (cm^2) and warm carcass weight kg ratio
[b] Standard error of the least squares mean
[c] Distance from the line to the top of the lean muscle (excluding the external layer of fat),measured perpendicular to the extension of the top-line at the peak of the hump laid at the top of the shoulders.

Table A16
Hump height [c] contrasts by designated populations

Contrast	Hump height
	P > F
Heifers vs. Steers	n.s. [c]
Heifers (REA:HCW < 21.76) vs. heifers (REA:HCW > 21.76)	n.s. [c]
Heifers (317.5–362.9, kg) vs. heifer (317.5–362.10, kg)	< 0.05
Steers (REA:HCW < 20.07) vs. steers (REA:HCW ≥ 20.07)	n.s. [c]
Steers (362.9–408.2, kg) vs. steers (408.2–453.6, kg)	n.s. [c]
Heifers (362.9–408.2, kg) vs. steers (362.9 – 408.2, kg)	n.s. [c]

[c] Non significant (P > 0.05)
[b] Marbling score: 300 to 399 = Slight; 400 to 499 = small; 500 to 599 = Modest
[c] Distance from the line to the top of the lean muscle (excluding the external layer of fat),measured perpendicular to the extension of the top-line at the peak of the hump laid at the top of the shoulders.

Table A17
Least squares means of bodywall thickness, cm [e], stratified by weight (kg), and ribeye area per 100 kg ratio

Variable	Heifers Hot carcass weights, kg	Heifers REA:HCW ratio [a]	Heifers Means	Steers Hot carcass weights, kg	Steers REA:HCW ratio [a]	Steers Means
Bodywall thickness, cm [e]						
	317.5-362.9	(< 21.76)	5.08	362.9-408.2	(< 20.07)	5.31
	317.5-362.9	(≥ 21.76)	5.31	362.9-408.2	(≥ 20.07)	5.99
	362.9-408.2	(< 21.76)	5.82	408.7-453.6	(< 20.07)	5.90
	362.9-408.2	(≥ 21.76)	6.91	408.7-453.6	(≥ 20.07)	6.26
SEM [b]			0.54			0.38
P > F			0.3112			0.3112

Within a row, means lacking a common letter (j-l) differ ($P < 0.05$)
[a] Ribeye area (cm^2) and warm carcass weight kg ratio
[b] Standard error of the least squares mean
[e] Bodywall thickness measured 12.7 cm from the vertebra at the 12th rib

Table A18
Bodywall thickness, cm [e] contrasts by designated populations

Contrast	Bodywall thickness, cm [e]
	P > F
Heifers vs. Steers	n.s. [c]
Heifers (REA:HCW < 21.76) vs. heifers (REA:HCW > 21.76)	n.s. [c]
Heifers (317.5–362.9, kg) vs. heifer (317.5–362.10, kg)	n.s. [c]
Steers (REA:HCW < 20.07) vs. steers (REA:HCW ≥ 20.07)	< 0.05
Steers (362.9–408.2, kg) vs. steers (408.2–453.6, kg)	n.s. [c]
Heifers (362.9–408.2, kg) vs. steers (362.9 – 408.2, kg)	n.s. [c]

[c] Non significant (P > 0.05)
[e] Bodywall thickness measured 12.7 cm from the vertebra at the 12th rib

Table A19.
Least squares means of beef rib and plate subprimal components (kg) stratified by sex class, weight (kg), and ribeye area per 100 kg ratio

		Heifers					Steers					
Subprimal	IMPS#[a]	317.5-362.9 (< 21.76)	317.5-362.9 (≥ 21.76)	362.9-408.2 (< 21.76)	362.9-408.2 (≥ 21.76)	SEM[b]	362.9-408.2 (< 20.07)	362.9-408.2 (≥ 20.07)	408.2-453.6 (< 20.07)	408.2-453.6 (≥ 20.07)	SEM[b]	*P* > F
Beef rib												
Blade meat												
	109B	1.36	1.33	1.59	1.87	0.19	1.71	1.88	1.90	1.83	0.13	0.1049
Ribeye roll												
	112A	4.89[j]	5.20[j, k]	5.89[k, l]	5.85[j, k, l]	0.24	5.60[j, k, l]	6.17[l]	6.40[l]	6.46[l]	0.17	<.0001
Back ribs												
	124	1.46[j, k]	1.40[j]	1.61[j, k]	1.53[j, k]	0.11	1.63[j, k]	1.56[j, k]	1.83[j, k]	1.86[k]	0.08	0.0076
Beef plate												
Inside skirt (IM)												
	121C	1.08	0.93	1.11	0.96	0.11	0.99	0.94	1.08	1.12	0.08	0.6747
Outside skirt (IM)												
	121D	0.50	0.60	0.75	0.73	0.07	0.62	0.66	0.73	0.76	0.05	0.0427

Within a row, means lacking a common letter (j-l) differ ($P < 0.05$)
[a] Institutional Meat Purchase Specifications
[b] Standard error of the least squares mean

Table A20.
Beef rib and plate subprimal components (kg) contrasts by designated populations

Contrast	Blade meat	Ribeye roll	Back ribs	Inside skirt	Outside skirt
IMPS #[a]	109b	112A	124	121C	121D
	P > F	*P* > F	*P* > F	*P* > F	*P* > F
Heifers vs. Steers	< 0.01	< 0.0001	< 0.01	n.s.[c]	n.s.[c]
Heifers (REA:HCW < 21.76) vs. heifers (REA:HCW > 21.76)	n.s.[c]	n.s.[c]	n.s.[c]	n.s.[c]	n.s.[c]
Heifers (317.5–362.9, kg) vs. heifer (317.5–362.10, kg)	< 0.05	< 0.001	n.s.[c]	n.s.[c]	< 0.01
Steers (REA:HCW < 20.07) vs. steers (REA:HCW ≥ 20.07)	n.s.[c]	n.s.[c]	n.s.[c]	n.s.[c]	n.s.[c]
Steers (362.9–408.2, kg) vs. steers (408.2–453.6, kg)	n.s.[c]	< 0.01	< 0.01	n.s.[c]	< 0.05
Heifers (362.9–408.2, kg) vs. steers (362.9 – 408.2, kg)	n.s.[c]	n.s.[c]	n.s.[c]	n.s.[c]	n.s.[c]

[a] Institutional Meat Purchase Specifications
[c] Non significant (P > 0.05)

Table A21.
Least squares means of beef chuck and brisket subprimal components (kg) stratified by sex class, weight (kg), and ribeye area per 100 kg ratio

		Heifers					Steers					
Subprimal	IMPS#[a]	317.5-362.9 (< 21.76)	317.5-362.9 (≥ 21.76)	362.9-408.2 (< 21.76)	362.9-408.2 (≥ 21.76)	SEM[b]	362.9-408.2 (< 20.07)	362.9-408.2 (≥ 20.07)	408.2-453.6 (< 20.07)	408.2-453.6 (≥ 20.07)	SEM[b]	*P* > F
Beef chuck												
Shoulder, top blade												
	114D	1.80[j]	2.12[j, k]	2.10[j, k]	2.17[j, k]	0.16	2.20[j, k]	2.31[j, k]	2.66[k]	2.43[k]	0.12	0.0041
Shoulder, arm roast												
	114E	3.15[j, k]	2.79[j]	3.27[j, k]	3.53[j, k]	0.32	4.01[j, k]	3.58[j, k]	4.02[k]	4.12[k]	0.22	0.0098
Shoulder tender (IM)												
	114F	0.61[j, k]	0.39[j]	0.54[j, k]	0.58[j, k]	0.10	0.66[j, k]	0.65[j, k]	0.89[k]	0.62[j, k]	0.07	0.018
Square cut, pectoral meat												
	115D	0.77	0.69	0.59	0.74	0.12	0.82	0.62	0.92	0.73	0.08	0.2344
Chuck roll												
	116A	6.74[j, k]	6.55[k]	7.81[j, k, l]	6.87[j, k]	0.51	8.23[j, k, l]	8.48[j, k, l]	8.58[k, l]	9.40[l]	0.36	0.0001
Chuck tender												
	116B	1.20[j]	1.20[j]	1.39[j, k]	1.33[j, k]	0.07	1.51[k]	1.47[j, k]	1.56[k]	1.55[k]	0.05	0.0001
Short ribs												
	130	1.72	1.59	1.61	1.59	0.15	1.83	1.61	1.97	1.88	0.10	0.1472
Beef brisket, deckle off, bnls												
	120	5.86[j]	5.40[j]	7.01[j, k]	6.29[j, k]	0.45	6.40[j, k]	6.85[j, k]	6.84[j, k]	7.69[k]	0.32	0.0052

Within a row, means lacking a common letter (j-l) differ ($P < 0.05$)
[a] Institutional Meat Purchase Specifications
[b] Standard error of the least squares mean

Table A22.
Beef rib and plate subprimal components (kg) contrasts by designated populations

Contrast	Shoulder, top blade	Shoulder, arm roast	Shoulder tender	Square cut, pectoral meat	Chuck roll	Chuck tender	Short ribs	Beef brisket, deckle off, bnls
IMPS # [a]	114D	114E	114E	115D	116A	116B	130	120
	P > F	*P* > F	*P* > F	*P* > F	*P* > F	*P* > F	*P* > F	*P* > F
Heifers vs. Steers	< 0.001	< 0.001	< 0.01	n.s. [c]	< 0.0001	< 0.0001	< 0.05	< 0.01
Heifers (REA:HCW < 21.76) vs. heifers (REA:HCW > 21.76)	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]
Heifers (317.5–362.9, kg) vs. heifer (317.5–362.10, kg)	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]	< 0.05	n.s. [c]	< 0.05
Steers (REA:HCW < 20.07) vs. steers (REA:HCW $\geq$ 20.07)	n.s. [c]	n.s. [c]	n.s. [c]	< 0.05	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]
Steers (362.9–408.2, kg) vs. steers (408.2–453.6, kg)	< 0.01	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]	< 0.05	< 0.05
Heifers (362.9–408.2, kg) vs. steers (362.9 – 408.2, kg)	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]	< 0.05	< 0.05	n.s. [c]	n.s. [c]

[a] Institutional Meat Purchase Specifications
[c] Non significant (P > 0.05)

Table A23.
Least squares means of beef loin subprimal components (kg) stratified by sex class, weight (kg), and ribeye area per 100 kg ratio

		Heifers					Steers					
Subprimal	IMPS#[a]	317.5-362.9 (< 21.76)	317.5-362.9 (≥ 21.76)	362.9-408.2 (< 21.76)	362.9-408.2 (≥ 21.76)	SEM[b]	362.9-408.2 (< 20.07)	362.9-408.2 (≥ 20.07)	408.2-453.6 (< 20.07)	408.2-453.6 (≥ 20.07)	SEM[b]	*P* > F
Beef loin												
Strip loin, bnls (0 x 1)	180A	4.76$^{j, k}$	4.42^{j}	4.99$^{j, k, l}$	5.67$^{k, l}$	0.25	5.11$^{k, l}$	5.56$^{k, l}$	5.42$^{k, l}$	5.78^{l}	0.18	0.0005
Top sirloin butt, bnls	184	4.76^{j}	4.95^{j}	5.19$^{j, k}$	6.04^{k}	0.27	5.64$^{j, k}$	5.40$^{j, k}$	6.13^{k}	5.80$^{j, k}$	0.19	0.001
Bottom sirloin butt, flap, bnls	185A	1.57$^{j, k}$	1.48^{j}	1.65$^{j, k, l}$	1.74$^{j, k, l}$	0.10	1.69$^{j, k, l}$	1.55$^{j, k}$	2.04^{l}	1.92$^{k, l}$	0.07	0.0053
Bottom sirloin butt, ball tip, bnls	185B	1.36	1.48	1.68	1.72	0.30	1.54	1.68	1.56	1.90	0.21	0.8943
Bottom sirloin butt, tri-tip, bnls, defatted	185D	1.12^{j}	1.06^{j}	1.10^{j}	1.31$^{j, k}$	0.07	1.22$^{j, k}$	1.29$^{j, k}$	1.33$^{j, k}$	1.42^{k}	0.05	0.0014
Tenderloin, full	189A	2.71$^{j, k}$	2.49^{j}	2.44^{j}	2.72$^{j, k}$	0.11	2.80$^{j, k}$	2.84$^{j, k}$	2.98^{k}	3.10^{k}	0.08	0.0001
Beef flank, flank steak (IM)	193	0.78^{j}	0.80^{j}	0.89$^{j, k}$	0.88$^{j, k}$	0.06	0.85$^{j, k}$	0.81$^{j, k}$	1.05^{k}	1.05^{k}	0.04	0.0003

Within a row, means lacking a common letter (j-k) differ ($P < 0.05$)
[a] Institutional Meat Purchase Specifications
[b] Standard error of the least squares mean

Table A24.
Beef loin subprimal components (kg) contrasts by designated populations

Contrast	Strip loin, bnls (0 x 1)	Top sirloin butt, bnls	Bottom sirloin butt, flap, bnls	Bottom sirloin butt, ball tip, bnls	Bottom sirloin butt, tri-tip, bnls, defatted	Tenderloin, full	Beef flank, flank steak
IMPS # [a]	180A	184	185A	185B	185D	189A	193
	P > F	*P* > F	*P* > F	*P* > F	*P* > F	*P* > F	*P* > F
Heifers vs. Steers	< 0.001	< 0.01	< 0.01	n.s. [c]	< 0.001	< 0.0001	< 0.01
Heifers (REA:HCW < 21.76) vs. heifers (REA:HCW > 21.76)	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]
Heifers (317.5–362.9, kg) vs. heifer (317.5–362.10, kg)	< 0.01	< 0.01	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]
Steers (REA:HCW < 20.07) vs. steers (REA:HCW ≥ 20.07)	< 0.05	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]
Steers (362.9–408.2, kg) vs. steers (408.2–453.6, kg)	n.s. [c]	< 0.05	< 0.0001	n.s. [c]	< 0.05	< 0.01	< 0.0001
Heifers (362.9–408.2, kg) vs. steers (362.9 – 408.2, kg)	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]	< 0.05	n.s. [c]

[a] Institutional Meat Purchase Specifications
[c] Non significant (P > 0.05)

Table A25.
Least squares means of round subprimal components (kg) stratified by sex class. weight (kg), and ribeye area per 100 kg ratio

		Heifers					Steers					
Subprimal	IMPS#[a]	317.5-362.9 (< 21.76)	317.5-362.9 (≥ 21.76)	362.9-408.2 (< 21.76)	362.9-408.2 (≥ 21.76)	SEM[b]	362.9-408.2 (< 20.07)	362.9-408.2 (≥ 20.07)	408.2-453.6 (< 20.07)	408.2-453.6 (≥ 20.07)	SEM[b]	*P* > F
Beef round												
Knuckle (tip), peeled	167A	3.58	3.44	3.74	3.74	0.29	4.14	3.75	4.20	3.79	0.20	0.3150
Top (inside)	168	8.23[j]	8.51[j, k]	9.24[j, k, l]	9.77[k, l]	0.38	9.49[j, k, l]	9.76[k, l]	10.27[l]	10.38[l]	0.27	0.0001
Outside round (flat)	171B	6.37[j, k]	6.24[j]	6.43[j, k, l]	7.18[j, k, l]	0.28	6.86[j, k, l]	7.21[j, k, l]	7.49[l]	7.44[k, l]	0.20	0.0009
Eye of round (IM)	171C	2.43[j, k]	2.31[j]	2.42[j, k]	2.65[j, k, l]	0.12	2.70[j, k, l]	2.67[j, k, l]	2.82[k, l]	2.92[l]	0.08	0.0014

Within a row, means lacking a common letter (j-l) differ (*P* < 0.05)
[a] Institutional Meat Purchase Specifications
[b] Standard error of the least squares mean

Table A26.
Beef round subprimal components (kg) contrasts by designated populations

Contrast	Knuckle (tip), peeled	Top (inside)	Outside round (flat)	Eye of round
IMPS # [a]	167A	168	171B	171C
	P > F	*P* > F	*P* > F	*P* > F
Heifers vs. Steers	< 0.05	< 0.0001	< 0.001	< 0.0001
Heifers (REA:HCW < 21.76) vs. heifers (REA:HCW > 21.76)	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]
Heifers (317.5–362.9, kg) vs. heifer (317.5–362.10, kg)	n.s. [c]	< 0.01	n.s. [c]	n.s. [c]
Steers (REA:HCW < 20.07) vs. steers (REA:HCW ≥ 20.07)	< 0.05	n.s. [c]	n.s. [c]	n.s. [c]
Steers (362.9–408.2, kg) vs. steers (408.2–453.6, kg)	n.s. [c]	< 0.01	< 0.05	< 0.05
Heifers (362.9–408.2, kg) vs. steers (362.9 – 408.2, kg)	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]

[a] Institutional Meat Purchase Specifications
[c] Non significant (P > 0.05)

Table A27.
Least squares means of beef lean trim from subprimal components (kg) stratified by sex class, weight (kg), and ribeye area per 100 kg ratio

		Heifers					Steers					
	Percent lean	317.5-362.9 (< 21.76)	317.5-362.9 (≥ 21.76)	362.9-408.2 (< 21.76)	362.9-408.2 (≥ 21.76)	SEM [b]	362.9-408.2 (< 20.07)	362.9-408.2 (≥ 20.07)	408.2-453.6 (< 20.07)	408.2-453.6 (≥ 20.07)	SEM [b]	*P* > F
Lean trim	Special	0.57	0.72	0.59	0.73	0.09	0.70	0.69	0.70	0.82	0.07	0.465
Lean trim	(90%)	5.51 [j, k]	5.04 [j]	5.96 [j, k]	5.91 [j, k]	0.29	6.00 [j, k]	5.83 [j, k]	6.51 [k]	6.54 [k]	0.20	0.0013
Lean trim	(80%)	19.04 [j]	20.04 [j]	22.91 [j, k, l]	21.43 [j, k]	1.17	22.87 [j, k, l]	22.29 [j, k]	25.48 [k, l]	26.95 [l]	0.82	<.0001
Lean trim	(50%)	15.06 [j, k]	12.70 [j]	17.56 [k]	16.46 [j, k]	1.04	15.95 [j, k]	16.75 [k]	18.11 [k]	17.41 [k]	0.74	0.0055

Within a row, means lacking a common letter (j-l) differ (*P* < 0.05)
[b] Standard error of the least squares mean

Table A28.
Beef round subprimal components (kg) contrasts by designated populations

Contrast	Lean trim	Lean trim	Lean trim	Lean trim
Percent Lean	Special trim	(90%)	(80%)	(50%)
	P > F	*P* > F	*P* > F	*P* > F
Heifers vs. Steers	n.s. [c]	< 0.001	< 0.0001	< 0.01
Heifers (REA:HCW < 21.76) vs. heifers (REA:HCW > 21.76)	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]
Heifers (317.5–362.9, kg) vs. heifer (317.5–362.10, kg)	n.s. [c]	< 0.05	< 0.05	< 0.01
Steers (REA:HCW < 20.07) vs. steers (REA:HCW ≥ 20.07)	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]
Steers (362.9–408.2, kg) vs. steers (408.2–453.6, kg)	n.s. [c]	< 0.01	< 0.0001	n.s. [c]
Heifers (362.9–408.2, kg) vs. steers (362.9 – 408.2, kg)	n.s. [c]	n.s. [c]	n.s. [c]	n.s. [c]

[c] Non significant (P > 0.05)

Table A29.
Least squares means of bone and waste trim from subprimal components (kg) stratified by sex class, weight (kg), and ribeye area per 100 kg ratio

	Heifers					Steers					
	317.5-362.9 (< 21.76)	317.5-362.9 (≥ 21.76)	362.9-408.2 (< 21.76)	362.9-408.2 (≥ 21.76)	SEM [b]	362.9-408.2 (< 20.07)	362.9-408.2 (≥ 20.07)	408.2-453.6 (< 20.07)	408.2-453.6 (≥ 20.07)	SEM [b]	*P* > F
Bone	24.15 [j]	23.34 [j]	27.74 [k, l]	25.40 [j, k]	0.89	28.31 [k, l]	27.76 [k, l]	30.21 [l]	30.54 [l]	0.63	<.0001
Fat	36.48	36.46	39.95	39.49	1.86	34.95	38.08	40.89	39.32	1.32	0.0708

Within a row, means lacking a common letter (j-l) differ (*P* < 0.05)
[b] Standard error of the least squares mean

Table A30.
Bone and waste trim (kg) contrasts by designated populations

Contrast	Bone	Fat
	P > F	*P* > F
Heifers vs. Steers	< 0.0001	n.s. [c]
Heifers (REA:HCW < 21.76) vs. heifers (REA:HCW > 21.76)	n.s. [c]	n.s. [c]
Heifers (317.5–362.9, kg) vs. heifer (317.5–362.10, kg)	< 0.01	n.s. [c]
Steers (REA:HCW < 20.07) vs. steers (REA:HCW $\underline{>}$ 20.07)	n.s. [c]	n.s. [c]
Steers (362.9–408.2, kg) vs. steers (408.2–453.6, kg)	< 0.001	< 0.01
Heifers (362.9–408.2, kg) vs. steers (362.9 – 408.2, kg)	n.s. [c]	< 0.05

[c] Non significant (P > 0.05)

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