THE EFFECT OF CARCASS WEIGHT AND RIBEYE SIZE ON BEEF CARCASS

COMPOSITION AND RETAIL CUTTING YIELDS

A Thesis

by

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ABSTRACT

According to the NBQA, average HCW and REA of beef carcasses have increased from the first audit in 1995 to the most recent in 2016 by 51.9 kg and 7.6 cm^2, respectively. These factors have been correlated to the relative size of other muscles in the body, which effect the overall cut size consistency for foodservice professionals, retailers and consumers alike. The objectives of this study were to collect weights, dimensional measurements, and retail yield data from specified muscles and subprimals to determine the impact of varying HCW and REA sizes on carcass composition. Beef carcasses (n = 36) were selected to fill a 3 X 3 treatment structure of HCW categories of 340.6 to 385.6 kg, 386.0 to 430.9 kg and 431.4 to 476.3 kg as well as REA categories of 83.9 to 89.8 cm^2, 90.3 to 96.1 cm^2 and 96.7 to 102.6 cm^2 with four carcasses in each of the nine treatment groups. One hindquarter from each carcass (n = 18) was randomly selected to undergo a dissection while the remaining side (n = 18) was subjected to conventional fabrication at a collaborating beef packer. Dissected muscles and subprimals were cut into retail steaks at a commercial case-ready facility to be cut into retail to derive a true percentage of boneless, closely trimmed retail cuts. Muscles grow largely in concert to one another, with statistical differences in dimensional properties, especially muscle weight occurring between carcasses in the lightest HCW category and the heaviest HCW category. HCW accounted for a greater number of significant differences than did REA, suggesting that HCW could be a more accurate predictor of muscle size. Retail yield from this study showed differences in the number of steaks produced between weight categories with the lightest HCW category producing fewer steaks and roasts than heavier HCW categories. Compositional data were also analyzed to determine the percentage changes in muscle weight as REA and HCW increased. HCW

produced the greatest effect on the *M. longissimus lumborum* as the muscles from the lightest weight category made up 1.9% more of their respective hindquarter weights than those muscles in the 386.0 to 430.9 kg category and 0.8% more than the heaviest HCW category. These findings will prove useful in developing new marketing strategies and predictive methods to satisfy foodservice and retailers demanding a more consistent subprimal size.

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This work was supervised by a thesis committee consisting of Dr. Jeffrey W. Savell (chair) and Dr. Davey B. Griffin of the Department of Animal Science and Dr. Kerri B. Gehring (co-chair) of the Department of Food Science and Technology. Researchers involved in data collection were Dr. Davey Griffin and Morgan Foster from Texas A&M University as well as Dr. Dave McKenna, Dr. Heather Rode, and Dr. Devin Gredell from Tyson Foods, Incorporated. All other work for this thesis was completed by the author.

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NOMENCLATURE

NBQA	National Beef Quality Audit
HCW	Hot Carcass Weight
REA	Ribeye Area
LMA	Loin Muscle Area
USDA	United States Department of Agriculture
SL	Strip Loin
TSB	Top Sirloin Butt
IR	Inside Round
BRF	Bottom Round Flat
EOR	Eye of Round
Coulotte	Top Sirloin Butt, Cap

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CHAPTER I

INTRODUCTION

According to the National Beef Quality Audits (NBQA) of 2000, 2005, 2010, and 2015, hot carcass weights (HCW) and ribeye area (REA) have increased (Boykin et al., 2017a; Garcia et al., 2008; Gray et al., 2012; McKenna et al., 2002). Beef cattle have historically been marketed and sold on a weight basis with heavier cattle bringing a greater dollar amount than lighter-weight cattle. This marketing system ultimately led to heavier carcasses, larger muscle groups, and discounts if carcasses exceed a 454 kg weight threshold (Garcia et al., 2008). Foodservice cuts from these large carcasses result in an inadequate plate presentation and thus less desired by the foodservice professionals that prepare them and the customers that consume them (Clark, 2019; Maples, Lusk, & Peel, 2018).

There have been studies conducted on beef carcass composition, in terms of predictive methods, and composition's impact on palatability and consumer acceptance (Geary et al., 2003; Griffin, Savell, Morgan, Garrett, & Cross, 1992; Griffin, Savell, Recio, Garrett, & Cross, 1999; Lunt et al., 1985). However, with recent innovations in beef cattle feeding and marketing techniques, minimal literature on present-day beef carcass composition in relation to relative muscle size exists. The objectives of this study were to collect weights, dimensional measurements, and retail yield data from specified muscles and subprimals to determine the impact of varying HCW and REA sizes on carcass composition.

CHAPTER II

REVIEW OF LITERATURE

2.1 Beef carcass composition overview

Carcass composition has time and time again proven itself to be a foremost topic of discussion, as mankind endlessly attempts to achieve production animal perfection by studying the lean, fat, and bone contents of the livestock we produce. In 1965, the USDA announced the release of standardized beef carcass yield grades that were to be utilized in order to predict a percentage of boneless, closely trimmed retail cuts (BCTRC) in the form of a whole, numerical number of 1 through 5 (USDA, 1996).Yield grades are a combination of adjusted fat thickness of the entire length of the carcass as well as a measure of the REA. As the level of fat increases on the external surface of the carcass, the percentage of BCTRC decreases resulting in a numerically higher yield grade, with every 0.254 cm change in fat thickness opposite the ribeye affecting the yield grade by 25 percent of a grade (USDA, 2017). Additionally, an evaluation of the efficacy of the USDA yield grades conducted by Abraham, Murphey, Cross, Smith, and Franks (1980) concluded that fat opposite the ribeye, kidney, pelvic, and heart fat and loin muscle area (LMA) were the three most important factors as well as HCW being a significant contributor when determining percentages of BCTRC and consequently, yield grades. Carcass composition can be predicted using an objective measurement such as conformation scores of thin, average and thick, such as in May et al. (1992) where findings indicated that carcasses exhibiting thick muscle conformation scores produced higher cutability chuck rolls, ribeye rolls and strip loins. Composition has been known to differ greatly between carcasses of varying trim levels, breed types, sex classes, and especially between yield grades (Griffin, 1989; Griffin et al., 1992; Griffin et al., 1999). In a study conducted by Griffin et al. (1992), breed types of *Bos indicus* and *Bos taurus*, sex classes of steers and heifers and carcass types of beef and dairy were evaluated for percentage of BCTRC. In their findings, Griffin et al. (1992) concluded that heifer carcasses possessed a greater amount of external fat than did steers, further supporting past research by Lunt et al. (1985) and Murphey, Johnson, Smith, Abraham, and Cross (1985) and more current research Boykin et al. (2017b). In regards to breed type, Continental breeds of cattle such as Charolais and Limousin produced higher cutability carcasses with more usable retail yield than English bred cattle such as Angus and Hereford (Koch, Dikeman, Allen, May, Crouse, & Campion, 1976).

Carcass composition determination has been revolutionized by the utilization of various non-terminal technologies such as ultrasound, that allows for gathering compositional information on an animal without slaughtering it. Ultrasound technology was originally used in human medicine and in muscular rehabilitation (Hides, Richardson, & Jull, 1998) by giving medical professionals the ability to pulse ultrasound into a living entity around a muscular structure and measuring the speed of return, intensity and attenuation to create a real-time image of the muscle structure (Hides et al., 1998; Kremkau, 1983). This has obvious implications for the medical industry, but has also proved useful in the determination of carcass composition. Griffin et al. (1999) investigated the possible application of rapid ultrasound technology in harvest operations. In this study, results showed that actual fat thickness and ultrasound fat thickness were highly correlated and ultrasound REA and actual REA were not correlated but were significant (Griffin et al., 1999), meaning that REA measured in the cooler after a 24 hour chill were more accurate than ultrasound measurements. This proves that ultrasound technology could be accurately used to predict subcutaneous fat levels in live animals, and although the REA prediction proved not to be as accurate, it still stands as a valuable non-invasive asset for seedstock producers for use in genetic selection tools such as expected progeny difference (EPD) charts for animals that would otherwise be counterintuitive to slaughter.

The prediction and determination of percentage BCTRC in beef carcasses remains essential in determining the ultimate value of the beef carcass itself for future merchandising. Of the factors that affect carcass cutout value, HCW and REA are two factors that can be linked to each other (Radunz, 2010), and contribute to the relative muscle size of valuable commercial beef cuts. Although, according to Bass, Scanga, Chapman, Smith, and Belk (2009), LM area alone did not prove to be an accurate predictor of retail portion size or steak crossectional area of other commercially relevant muscles other than the *longissimus thoracis et. lumborum*.

2.2 Carcass weight dilemma and ribeye size

Overly large carcass weights are not necessarily a new concern, but rather one that has been facing the beef industry since the rise of boxed beef in the 1970's. Originally, this issue garnered attention due to challenges associated with increasingly large cuts and standardized box sizes for transport (Drake, 2004). Presently, products derived from large carcasses represent a growing concern for maintaining an attractive plate presentation (Clark, 2019) rather than fitting in to a box (Drake, 2004). The source of the carcass weight dilemma rests on the shoulders of producers, cattle feeders and packers and the marketing methods utilized to trade cattle between them. According to the NBQA of 1995, the average HCW observed weighed 338.4 kg (Boleman et al., 1998). However, the most recent NBQA in 2016 reported an average HCW of 390.3 kg (Boykin et al., 2017a), an increase of 51.9 kg. These data contributed to the cited complaints of "Overall Uniformity" from the NBQAs of 1995 (Boleman et al., 1998), 2000 (McKenna et al., 2002), and 2005 (Garcia et al., 2008). Although, the issue of "Weight and size" has progressed more to the forefront of the quality challenges to address in NBQAs of 2011 and 2016 (Boykin et al., 2017a; Moore et al., 2012). These issues of increased carcass weight and REA exist as problems created by producers and feeders fetching higher live prices as live cattle are marketed on a weight basis (Feuz, 1998). Such practices serve as a means to feed an ever-growing human population and the added pressure to grow more beef cattle more efficiently on less and less land. Live cattle value determination rests upon the live weights of the respective cattle. So much so that 71 to 95% of the difference in live cattle valuation is driven by live weight when sold on a grid basis from a pen (Feuz, 1998). With such a large incentive for cattle producers to continue growing beef cattle to heavier weights in pursuit of a better return on investment, it has become vital to determine the effect of these increased carcass weights on carcass composition and relative muscle size. In tandem with increasing carcass weights, increasing ribeye sizes present unique challenges as well. According to Radunz (2010), "the average ribeye size is relatively dependent on animal weight. On average an increase of 45.36 kg of live weight results in approximately 6.45 to 7.74 cm^2 increase of REA in beef cattle." In regard to ribeye sizes, it should also be noted that according to the NBQA of 1995 the reported mean LMA measured 81.9 cm^2 (Boleman et al., 1998) while the NBQA of 2016 reported a mean LMA of 89.5 cm^2 (Boykin et al., 2017b), an increase of 7.6 cm^2 over a 20-year period.

2.3 Muscle to muscle variation in beef carcasses

Muscles exist as biological entities of an animal that do not necessarily grow in concert of one another, but rather accrete tissue as needed for the development of the animal as it grows throughout its life strongly rooted in a genetically pre-determined evolutionary pattern (Berg & Butterfield, 1976). Butterfield and Berg (1966a) placed individual muscles (*n*= 95) from selected calves and steers (*n*= 92) into groups of similar growth speeds across 5 different phases of development. Phase 1 included specimens from 0 to 84 days of age, phase 2 from 85 days to 365 days of age, phase 3 from 366 to 730 days of age, phase 4 from 731 to 1460 days of age and phase 5, 1461 days and older. Allometric growth coefficients derived from the equation from Huxley (1932) then were assigned to each muscle individually. In this study, muscles were assigned growth coefficients and then separated into groups that experienced monophasic and diphasic or multi-phasic growth. Muscles exhibiting characteristics of multi-phasic growth were identified by larger standard error from different growth phase groups, and growth speeds of "high impetus," "average impetus," and "low impetus" were assigned to the muscles. Those muscles exhibiting a single monophasic growth pattern of any speed were given a single speed designation while a diphasic growth muscle received scores of "high-average," "average-high," or "low-average." Butterfield and Berg (1966a) later explained that this diphasic ranking system does not distinguish between points that change in growth occurs, but does note that the change typically occurred between the first and second phase of growth in most muscles. Relevant individual muscles from this study classified into these categories include the *M. longissimus, M. semimembranosus, M. gluteus medius,* and *M. semitendinosus*. All of these muscles were classified as diphasic with a "high-average" relative growth impetus (Butterfield & Berg, 1966a).

Concurrently, Butterfield and Berg (1966b) sought to utilize the information gleaned from Butterfield and Berg (1966a) to classify meat industry relevant muscles into generalized muscle groups in order to better apply it to classical beef production. In this study, findings indicated that the distal muscles of the pelvic limb exhibited "low impetus" and "early" maturing time, muscles surrounding the spinal column revealed "average" impetus and "average" maturing time and muscles connecting the thorax and thoracic limb possessed "high" impetus and "very late" maturing time. This proved as a contradictory statement from their previous work

(Butterfield & Berg, 1966a), however, Butterfield and Berg (1966b) does speculate that the difference in growth periods could be due to the presence of other muscles such as the *M. spinalis dorsi* that exhibited "low-average" impetus, thus driving down the "high-average" growth period of the *M. longissimus* to a simple "average" impetus rating. In addition, a differentiation in growth period existed between the proximal pelvic limb (high-average and low) and the distal pelvic limb (low). Butterfield and Berg (1966a) made light of this difference and further elaborated in this study to describe that muscles that perform much of their growth in the early phases of life should not necessarily be classified as "very late" maturing despite their similar growth patterns with late maturing muscles, but that much of their growth comes in earlier life stages (Butterfield & Berg, 1966b). In short, the maturity of an animal does not necessarily dictate muscle size, as much of this growth happens early in life as seen in Butterfield, Griffiths, Thompson, Zamora, and James (1983). This becomes increasingly important when investigating the optimal cut sizing for muscle groups in animals of differing sizes and growth phases.

2.4 Cut size optimization

Foodservice cuts from these large carcasses ultimately lead to an inadequate plate presentation and thus less desired by the foodservice professionals that prepare them. Optimum *longissimus* size for foodservice offerings reported by Dunn, Williams, Tatum, Bertrand, and Pringle (2000) fell between 77.4 and 96.6 cm^2 to optimize both product tenderness and cook time. The REA as described by Dunn et al. (2000) falls well within the range of 64.5 to 103.2 cm^2 adopted by most branded beef programs such as Certified Angus Beef (Bass, 2016). Branded beef programs stand to provide a highly desirable and uniform eating experience for their customers by creating restrictions on certain carcass characteristics such as REA and HCW, thereby limiting the relative muscle size of more valuable middle meats (Bass, 2016). Branded beef programs provide an incentive for cattle producers to raise and feed cattle to qualify for these value-based programs in order to control carcass weight and REA. However, the carcasses that do not meet branded beef specifications may be larger and thus may be more difficult to merchandise. According to the 2016 NBQA, more further processors would rather see an increase in size consistency than an increase in total muscle size, with 66% saying that they would even be willing to pay a premium in order to receive a guarantee of muscle weight and size (Boykin et al., 2017b). Inconsistencies in muscle size materialize on the retail and foodservice sectors of the beef industry. Steaks are sold on a weight basis in a retail setting, and generally, a consumer’s willingness to pay (WTP) decreases with an increase in price (Maples et al., 2018). Steaks from carcasses with heavier HCW and larger REA will ultimately lead to larger cuts sold at the retail level resulting in a higher price per package than cuts from lighter weight carcasses. To combat this, retailers attempt to hit a target sticker price in order to ensure an empty case at the end of the day, but are forced to cut larger diameter cuts thinner to meet this target price (Maples et al., 2018). On the other hand, in the foodservice sector, the issue of plate presentation arises, as well as cook time variations. Thicker cut steaks require a greater amount of time in order to reach their desired endpoint internal temperature and also experienced a greater amount of microbial reduction than similar steaks cut more thinly (Shen, Adler, Geornaras, Belk, Smith, & Sofos, 2010). Large variations in steak thickness and general muscle size will undoubtedly lead to variations in cook time as it simply takes longer to reach a designated endpoint temperature especially in orders with varying degrees of doneness. This is a common problem with individuals within the foodservice industry as high levels of variation in muscle sizes reported in (Boykin et al., 2017a; Clark, 2019; Moore et al., 2012) ultimately leads to these cook time variation issues. These large sizes will contribute to inconsistencies in plate presentation. As stated before, consumers will generally prefer a thicker cut steak as compared to a thinner one (Maples et al., 2018), and expect a large amount of plate coverage (Clark, 2019). Cut size and uniformity becomes an issue in the retail sector when cuts become ununiform in appearance in a retail case; altering product presentation, final price tag and ultimately consumer WTP (Maples et al., 2018).

2.5 Consumer perceptions of cut size

Tenderness is a well-documented driver for beef palatability (Egan, Ferguson, & Thompson, 2001; Miller, Carr, Ramsey, Crockett, & Hoover, 2001; Savell et al., 1987; Savell et al., 1989), and can fluctuate in cuts of varying thickness (Dunn et al., 2000). In a world where consumers generally prefer thicker cut steaks (Maples et al., 2018), it would be in the best interest of the beef industry to address the issue of thin-cut steaks, as consumers will typically be more willing to pay for a cut as long as their standards of quality for the cut are met (Lyford et al., 2010). Contrastingly, Behrends, Leick, Schilling, Yoder, and Schmidt (2009) found that when ribeye steaks were cut to a constant weight, male consumers and those making less than $20,000 per year would tend to select thinner cut steaks, suggesting that a steak with a larger surface, and therefore more plate coverage or one that appeared to have a heavier weight, was of greater importance than cut thickness while female participants did not have a thickness or surface area preference in ribeye steaks. A potential solution to the problem of plate presentation of beef steaks resides in the utilization of dairy breeds such as Holstein steers, despite the historically negative connotations of *M. longissimus thoracis et lumborum* elongated triangular appearance (Howard et al., 2014; Lawrence et al., 2011). Based on research regarding the efficacy of beta-agonists in increasing LM size (Arp et al., 2014; Elam et al., 2009; Montgomery et al., 2009; Scramlin, Platter, Gomez, Choat, McKeith, & Killefer, 2010; Vasconcelos et al.,

2008) and specifically in attempting to correct the LM conformation issue (Lawrence et al., 2011), Holstein beef could potentially capture a greater level of center-of-the-plate. Of course, with an increase in carcass weight, there also will be an increase in total product other than middle meats. For example, cut thickness and plate presentation remain irrelevant for ground beef, and could possibly help offset some of the $8.6 billion loss from the increase in carcass weights (Maples et al., 2018).

These problems plague the beef industry today, and stand as a function of the issue of increased HCW and REA. This study serves to determine the effect of varying HCW and REA on carcass composition and evaluate their effect on the retail cutting yield of select hindquarter muscles and subprimals in order to assist in determining the impact these carcass characteristics have on relative muscle size.

CHAPTER III

MATERIALS AND METHODS

3.1 Product procurement

USDA Choice beef carcasses (*n* = 36) were selected from commercial beef processing facility that utilized Video Image Analysis grading technology. Essential quality and yield factors of carcasses were displayed on nearby monitors. This technology allowed for on-line carcass selection at the grading and sorting station within the sales cooler. Carcasses were selected to fill a 3 X 3 treatment structure of carcass weight and ribeye area size categories (Table 1). Two separate runs of product collection were performed in order to facilitate reasonable work schedules. One side from each selected carcass was identified for individual muscle dissection, whereas the remaining side of each carcass was designated for conventional fabrication. For beef sides designated for dissection (*n* = 18), the *M. gluteobiceps, M. gluteus medius, M. longissimus lumborum, M. semitendinosus,* and *M. semimembranosus* were individually removed from each hindquarter following natural seams (Figure 1). Individual muscles were trimmed practically free of fat, weighed, and measured. In total, twelve dimensional measurements and one weight measurement were taken from each muscle. Specifically, length of each dorsal, medial, and ventral surface, in addition to, width, height, and circumference at the anterior, median, and posterior locations of each muscle was obtained before being individually labeled and vacuum packaged (Figure 2). The remaining side of each carcass (*n* = 18) designated for conventional fabrication was broken down as specified by the collaborating packer. Collected subprimals generated from conventional fabrication were similar to Institutional Meat Purchase Specifications (IMPS) 180 PSO 2, Beef Loin, Strip loin, Boneless

(SL); IMPS 184, Beef Loin, Top sirloin butt, Boneless; IMPS 170, Beef Round, Bottom (Gooseneck); IMPS 168, Beef Round, Top (Inside), Untrimmed (NAMI, 2014). Additional cuts that were derived from the previously mentioned subprimals were: IMPS 169A Beef Round, Top (Inside), Cap Off (IR), IMPS 171B Beef Round, Outside Round (Flat) (BRF); IMPS 171C Beef Round, Eye of Round (EOR); Beef Loin, Top Sirloin Butt, Center-Cut, Cap Off, Boneless, 184B; Beef Loin, Top Sirloin Butt, Cap (Coulotte), IMPS 184D (NAMI, 2014). Bones were removed and cuts were trimmed practically free of fat before collection of weights and dimensional measurements. EOR and Coulotte subprimals were not sent to the case-ready facility and were returned to normal production after data collection. All whole muscle and conventionally-fabricated subprimals were individually tagged, vacuum packaged, and shipped to a case-ready facility.

3.2 Preparation of individual muscles for steak cutting

Weights from all individual muscles and conventionally fabricated subprimals were obtained before and after unpackaging. As previously mentioned, whole muscles and subprimals were trimmed free of fat and connective tissue before being sliced into retail steaks of uniform thickness. From the *M. longissimus lumborum*, any periosteum, *ligamentum nuchae,* or epimysium were removed, and a face cut taken on the loin-end to create an even cut surface for ease of slicing. A second cut was made on the sirloin end to remove any *M. gluteus medius* (on SL subjected to conventional fabrication treatment) for the same purpose. *M. gluteobiceps* was trimmed of external fat and connective tissue using a knife, and then hand-separated into the coulotte and flat portions for slicing; the wing and tail portions were denoted as stew, while the nose tip was denoted as trim (Figure 3). *M. gluteus medius* was trimmed of any connective tissue and split into the "baseball cut" resembling IMPS 184F: Beef Loin, Top Sirloin Butt, Center-Cut, Seamed, Dorsal Side, Boneless and center-cut portions similar to IMPS 184B, PSO 1 (NAMI, 2014) for slicing (Figure 4).

3.3 Steak cutting

A Grasselli slicer (NSL400, Albinea, Italy) was utilized to slice each *M. semimembranosus* with 1.27-cm face cuts on either side of the muscle, and 1.91-cm center cut steaks (Figure 5). Defects were trimmed from each resulting steak, then weighed, and recorded. Each *M. longissimus lumborum* was portioned into 2.54-cm steaks using the Grasselli slicer. Any steaks from the *M. longissimus lumborum* that were deemed too thin, such as end pieces, were denoted as stew meat, and any “vein steaks” were identified and weighed separately.

Coulotte portions were separated from the *M. gluteobiceps* dissected muscle and sliced into 2.54-cm steaks (Figure 6) using a Marel portioner (I-Cut 11 PortionCutter, Boxmeer, Netherlands). Steaks from the *M. gluteus medius* were obtained using the Marel portioner by slicing the “baseball cut” posterior end first generating 2.9-cm steaks IMPS 1184F (Figure 7), with smaller slices on either end of the muscle denoted as “face cuts.” Using the Marel portioner, center-cut portions derived from each *M. gluteus medius* were sliced, sciatic nerve entering first, to generate 1.9-cm thick face cuts and 2.9-cm thick steaks from the remainder of each muscle portion (Figure 7). Finally, the flat portion of each *M. gluteobiceps* was sliced anterior end first using a Marelec intelligent portion cutter (Portio3D, Nieuwpoort, Belgium) to generate roasts. All steaks, roasts, trim, and stew meat derived from muscle preparation and slicing were weighed, recorded, and returned to normal case-ready production following data collection.

Yields of each muscle and subprimal were classified into a type of retail cut and total number of merchandisable cuts number produced. Data were used to determine the mean retail cut weight of each cut as well as the primary yield (weight of total retail cuts), saleable yield (sum of weight of total retail cuts and lean trim) and percentage of waste.

3.4 Statistical analysis

Data collected from carcass dissection and retail cutting yield tests were analyzed using JMP® Pro, Version 14.0.0 on a 3 x 3 statistical analysis format with main effects denoted as REA (cm^2) and Carcass weight (kg). Significant differences in least squares means of individual muscle weight, dimensional measurements, steak type produced, total steak number produced, mean steak weight, primary yield, saleable yield and waste across REA and carcass weight were differentiated with an α of 0.05. Steak yield (or Roast yield depending on the cut) was derived by the following equation (weight of all merchandisable cuts (kg)/initial unbagged weight of muscle or subprimal x 100) in order to achieve a percentage of retail-ready products. Saleable yield was used to describe the amount of total saleable product ((steak or roast yield + trim)/initial unbagged weight of muscle x 100) on a percentage basis and waste described the amount of any product loss such as any remaining perimysium, connective tissue, or in the case of the *M. gluteus medius* and the TSB, the removal of the sciatic nerve (Product loss/initial unbagged product weight x 100).

CHAPTER IV

RESULTS

4.1 Results from dissected whole muscles

Least squares means of muscle weights (kg) as well as dimensional measurements for the dissected *M. longissimus lumborum* (n = 36) are displayed in Table 2. Thirteen total measurements were obtained and recorded, and the main effects of HCW and REA produced a significant difference in muscle weight. REA influenced the weight of *M. longissimus lumborum* (P = 0.01), with the lightest muscles originating from the smallest ribeye size of 83.9 to 89.8 cm^2 and the heaviest muscle from the largest ribeye size of 96.7 to 102.6 cm ($P < 0.05$). Analysis of HCW generated similar results ($P < 0.01$), with the heaviest weight category producing the heaviest *M. longissimus lumborum* ($P < 0.05$). Moreover, another significant result obtained from the anterior depth measurement when stratified by REA with the 96.7 to 102.6 cm^2 category measuring deeper than the smallest ribeye category: 83.9 to 89.8 cm^2 ($P < 0.05$).

For the *M. gluteobiceps* obtained from the dissected carcass treatment, the lone value influenced by REA main effect was the posterior depth measurement (Table 3). The carcasses in the 96.7 to 102.6 cm^2 REA main effect category possessed deeper *M. gluteobiceps* than carcasses in the 83.9 to 89.8 cm^2 REA category (P = 0.01). On the other hand, HCW influenced muscle weight dramatically with the lightest carcass weight main effect producing significantly lighter *M. gluteobiceps* than its heavier counterparts ($P < 0.01$). In addition, muscles obtained from the 340.6 to 385.6-kg HCW category were smaller in posterior circumference ($P < 0.01$) and shorter in ventral length measurements ($P < 0.01$) than the two heavier weight categories. Interestingly, however, the 431.4 to 476.3-kg HCW category produced numerically shorter ventral length measurements than the 386.0 to 430.9-kg group, but was not statistically significant ($P > 0.05$).

When examining dissected *M. gluteus medius* ($n = 36$), HCW was the driving force behind differences in muscle weight ($P < 0.01$) as shown in Table 4, with the 340.6 to 385.6-kg carcasses weighing less than muscles from the two heavier carcass weight main effect categories. Interestingly, however, the *M. gluteus medius* from the 340.6 to 385.6-kg category weighed numerically heavier than those in the 431.4 to 476.3-kg category, although not significantly ($P > 0.05$). Moreover, carcasses qualifying for the 340.6 to 385.6-kg weight category were smaller in anterior ($P = 0.01$) and median circumference ($P < 0.01$).

Dissected *M. semimembranosus* ($n = 36$) dimensional and weight measurements are displayed in Table 5. When stratified by REA as a main effect, the only significant result was detected in muscle weight as the 83.9 to 89.8 cm^2 category produced smaller muscles than the 96.7 to 102.6 cm^2 category ($P < 0.05$). Similarly, the HCW main effect also impacted muscle weight, however, the muscles dissected from the 340.6 to 385.6-kg category were lighter than its two heavier counterparts ($P < 0.01$). Furthermore, 340.6 to 385.6-kg carcasses possessed longer dorsal ($P = 0.01$) and medial length ($P = 0.01$) measurements and wider anterior ($P < 0.01$) and posterior width measurements ($P < 0.01$) as well as greater anterior and median circumference ($P < 0.05$ and $P < 0.05$, respectively) than the 386.0 to 430.9-kg and 431.4 to 476.3-kg categories.

In Table 6, the *M. semitendinosus* ($n = 36$) HCW stratification identified muscles from the 340.6 to 385.6-kg category that were lighter ($P <0.01$) in muscle weight and smaller median circumference measurements ($P = 0.01$) than the 386.0 to 430.9-kg and 431.4 to 476.3-kg weight counterparts. Additionally, the 386.0 to 430.9-kg carcass category produced a larger anterior circumference than the carcasses in the 340.6 to 385.6-kg category ($P = 0.01$).

4.2 Results from fabricated subprimals

Table 7 displays BRF subprimal ($n = 34$) dimensional and weight measurements. Differences in dorsal length were affected by a REA x HCW interaction ($P < 0.05$; data not shown in tabular form). With the exception of anterior width measurements ($P < 0.05$), REA did not drive any other dimensional factors for the BRF ($P > 0.05$). Notably, factors of muscle weight, dorsal and medial length, median width, and anterior, median and posterior circumference measurements were all affected in a similar fashion in that the muscles from the 340.6 to 385.6-kg category were lighter and smaller ($P < 0.05$) than those collected from muscles in the 386.0 to 430.9-kg and 431.4 to 476.3-kg HCW categories. Differences between weight and dimensional measurements of 386.0 to 430.9-kg and 431.4 to 476.3-kg HCW categories were noticed, although these differences did not prove significant ($P > 0.05$). Posterior width measurements were realized, with the BRF from the 431.4 to 476.3-kg categories being wider ($P < 0.05$) than the two lighter HCW categories. Carcasses from the 386.0 to 430.9-kg HCW category were also numerically wider in posterior width measurements, however these were not significant ($P > 0.05$).

Dimensional analysis of fabricated EOR muscles ($n = 34$) are exhibited in Table 8. REA did not drive any significant variations in this muscle across any of the 13 dimensional factors measured in this study ($P > 0.05$). However, carcasses within the 340.6 to 385.6-kg HCW category possessed lighter muscle weights ($P < 0.01$), and larger anterior circumference ($P < 0.05$), median circumference ($P < 0.05$) and posterior circumference ($P = 0.01$) than its contemporaries in the 386.0 to 430.9-kg and 431.4 to 476.3-kg HCW categories, whereas variations in the previously listed points of measurement between the two heaviest HCW categories were not significant ($P > 0.05$). Carcasses in the 340.6 to 385.6-kg HCW category were shorter in medial and ventral length ($P < 0.05$ and $P < 0.01$, respectively) and narrower in anterior ($P < 0.01$) and median width measurements ($P < 0.01$). Interestingly, muscles from the 431.4 to 476.3-kg HCW category were numerically shorter in medial and ventral length and narrower in anterior and median width measurements, although not significantly ($P > 0.05$).

Least squares means of weight and dimensional measurements from the fabricated IR ($n = 34$) subprimal stratified by REA and HCW are displayed in Table 9. Similar to data collected from the dissected *M. semimembranosus* muscles, REA contributed to variations in multiple recorded measurements. Notably, a REA x HCW interaction existed at anterior depth ($P = 0.01$) and median depth ($P = 0.01$) measures. Moreover, carcasses in the 96.7 to 102.6 cm^2 REA category experienced heavier muscle weights ($P < 0.01$) and wider anterior width ($P < 0.01$) than the 90.3 to 96.1 cm^2 and 83.9 to 89.8 cm^2 REA categories. Also, ventral length measurements in the 90.3 to 96.1 cm^2 category were shorter ($P < 0.05$) than those in the 96.7 to 102.6 cm^2 category, but not different ($P > 0.05$) from those in the 83.9 to 89.8 cm^2 category. Moreover, a stepwise difference occurred in the median width measurements with carcasses in the 83.9 to 89.8 cm^2 category being narrower ($P < 0.05$) than carcasses in the 96.7 to 102.6 cm^2 category. Additionally, HCW impacted several measurements as well. Muscles from 340.6 to 385.6-kg carcasses were much lighter ($P < 0.01$) and possessed narrower ($P < 0.05$) median width measurements than those from the 386.0 to 430.9-kg and the 431.4 to 476.3-kg HCW categories. Interestingly, carcasses in the 386.0 to 430.9-kg carcasses category were wider in anterior width measurements than those 430.91 to 476.27-kg and 340.6 to 385.6-kg HCW categories ($P < 0.01$), while those in the 340.6 to 385.6-kg category were significantly narrower ($P < 0.01$) than those in the 386.0 to 430.9-kg and 431.4 to 476.3-kg categories. Finally, muscles belonging to the 340.6 to 385.6-kg HCW category were smaller in anterior circumference ($P < 0.01$) than heavier carcass weight categories, and larger ($P < 0.05$) in median circumference measures when comparing carcasses in the 431.4 to 476.3-kg HCW category with those in the 340.6 to 385.6-kg category.

Table 10 displays least squares means for weight and dimensional measurements for fabricated coulotte muscles ($n = 33$). The REA main effect revealed carcasses within the 96.7 to 102.6 cm^2 category to be deeper in anterior depth measurements ($P < 0.01$) as well as a stepwise interaction within median depth measures, as the 96.7 to 102.6 cm^2 category was deeper ($P = 0.01$) than the 83.9 to 89.8 cm^2 category, but not different than the 90.3 to 96.1 cm^2 category ($P > 0.05$). The HCW main effect also impacted various dimensional factors of the coulotte, as carcasses in the 340.6 to 385.6-kg category were lighter ($P < 0.01$), and narrower in anterior ($P < 0.01$), median ($P < 0.01$) and posterior ($P < 0.05$) width measurements than those in the 386.0 to 430.9-kg and 431.4 to 476.3-kg categories. Moreover, carcasses in the 431.4 to 476.3-kg HCW category were deeper in anterior ($P < 0.01$) and median ($P < 0.01$) depth measurements. Stepwise differences in circumference were detected with carcasses in the 340.6 to 385.6-kg HCW category were smaller in anterior ($P < 0.05$) and median ($P < 0.05$) circumference than those in the 431.4 to 476.3-kg category.

Excluding a REA x HCW interaction ($P < 0.05$) in anterior circumference measurements for the fabricated TSB subprimal ($n = 33$), REA did not impact any of the other 12 dimensional measurements (Table 11). When stratified by the HCW main effect, muscle weights of TSB subprimals derived from carcasses in the 340.6 to 385.6-kg category were lighter ($P < 0.01$) than contemporaries in the 386.0 to 430.9-kg and 431.4 to 476.3-kg HCW categories. Additionally, width measurements taken at the anterior measurement point were narrower ($P < 0.05$) within the 340.6 to 385.6-kg HCW category compared to the 386.0 to 430.9-kg category, and narrower in median ($P = 0.01$) and posterior ($P < 0.05$) width measurements when compared to 386.0 to 430.9-kg and 431.4 to 476.3-kg HCW categories.

Table 12 illustrates the least squares means of weight and dimensional measurements for the fabricated SL ($n = 34$) subprimal. As expected, the muscle weight of SL from carcasses belonging to the 96.7 to 102.6 cm^2 REA category were heavier ($P = 0.01$) than those from the 90.3 to 96.1 and 83.9 to 89.8 cm^2 categories. There also existed a REA x HCW interaction for median depth measurements ($P < 0.05$). HCW also had an effect on muscle weights as those from the lightest HCW category produced lighter ($P < 0.01$) SL than those from the 386.0 to 430.9-kg and 431.4 to 476.3-kg HCW categories. Furthermore, SL from the 340.6 to 385.6-kg HCW category were shorter in dorsal ($P = 0.01$) and medial ($P < 0.05$) length measurements compared to those in the 431.4 to 476.3-kg category, and shorter ($P = 0.01$) in ventral length measurements compared to both heavier HCW categories.

4.3 Retail Cutting Results

As shown in Table 13, REA and HCW both impacted the average steak weight of *M. longissimus lumborum* as expected, with the largest REA category producing the heaviest mean steak weight and the lightest HCW category the lightest mean steak weight. 340.6 to 385.6-kg carcasses also produced the least amount of strip steaks ($P < 0.05$) and the greatest amount of waste percentage ($P < 0.01$).

M. gluteobiceps data displayed in Table 14 exhibited REA x HCW interactions for primary yield ($P < 0.05$) and waste ($P < 0.05$). Interestingly, the smallest REA category produced significantly more coulotte steaks ($P < 0.01$) as well as lighter roast weights than carcasses with 90.3 to 96.1 and 96.7 to 102.6 cm^2 ribeye sizes as well as a greater number of total steaks and roasts ($P < 0.01$) than those from the 90.3 to 96.1 cm^2. Moreover, the 386.0 to

430.9-kg HCW category produced a significantly greater number of total steaks and roasts compared to the 340.6 to 385.6-kg category, but similar to those from the 431.4 to 476.3-kg HCW category. Likewise, 340.6 to 385.6-kg carcasses produced a lighter mean roast weight ($P < 0.01$) as well as fewer roasts per subprimal ($P < 0.01$) than 386.0 to 430.9-kg and 431.4 to 476.3-kg carcasses.

HCW solely impacted the retail measurements of the *M. gluteus medius* (Table 15). Carcasses from the 340.6 to 385.6-kg carcasses produced significantly fewer center-cut steaks ($P < 0.05$) as well as the least amount of total steaks and the lightest mean steak weight when compared to the two heavier HCW categories. While not significantly, carcasses from the 340.6 to 385.6-kg HCW category tended to produce the greatest amount of saleable yield ($P > 0.05$).

The REA main effect impacted the total steak numbers produced ($P = 0.02$) from the *M. semimembranosus* such that the smallest REA category produced the least amount of retail steaks (Table 16). The HCW main effect also influenced this similarly, as the 340.6 to 385.6-kg HCW category produced the least amount of steaks ($P < 0.01$) and the lightest mean steak weight ($P < 0.01$).

In retail cutting analysis of BRF subprimals (Table 17), REA did not appear to influence any of the measurable factors. However, primary and saleable yield percentages tended to be higher for carcasses from the 90.3 to 96.1 cm^2 REA category, although not significant ($P > 0.05$). When stratified by HCW, the lightest weight category produced the least number of total retail-ready roasts ($P < .01$) and the lightest roast weight on average ($P < 0.01$).

Table 18 explains the retail yields of inside round subprimals. Carcasses in the 90.3 to 96.1 cm^2 REA category produced fewer retail steaks than the 96.7 to 102.6 cm^2 category, however the 83.9 to 89.8 cm^2 category produced a similar number of steaks to both larger REA categories ($P > 0.05$). The largest REA category also produced the heaviest steak weight on average ($P < 0.01$) compared to the two smaller REA categories. Moreover, when stratified by HCW, the 340.65-385.55-kg category tended to produce the least number of retail steaks ($P > 0.05$) although not significantly, but did produce the lightest steak weight on average ($P < 0.01$).

In TSB subprimals, the 340.6 to 385.6-kg HCW category possessed lighter average steak weights ($P < 0.01$) than either of the heavier HCW category counterparts. Interestingly though, the 431.4 to 476.3-kg HCW category tended to yield the least number of baseball and center-cut steaks, although not significantly ($P > 0.05$)

Results from strip loin yield data in Table 20 showed that carcasses possessing 96.7 to 102.6 cm^2 REA produced more vein steaks ($P < 0.05$) than those with 90.3 to 96.1 cm^2 REA. This proved interesting as carcasses qualifying for the lightest weight category yielded similar numbers of vein steaks to both the 90.3 to 96.1 cm^2 and 96.7 to 102.6 cm^2 REA categories. Carcasses in the 96.7 to 102.6 cm^2 REA category also produced heavier steak weights on average than the two smaller REA categories ($P < 0.01$), and the 340.6 to 385.6- kg HCW category produced the lightest average steak weights ($P < 0.01$).

CHAPTER V

DISCUSSION

5.1 Discussion of dissected muscle dimensional analysis

HCW appeared to be the primary driver for differences in muscle weight and dimensional measurements ($P < 0.05$), significantly affecting 3 times as many factors than the REA main effect. Muscle weight was the most commonly affected point of measurement across both main effect stratifications. The REA main effect impacted the weight of *M. longissimus lumborum* as well as the *M. semimembranosus* as the largest REA category produced the heaviest muscles. HCW impacted muscle weight in all 5 dissected muscles ($P < 0.05$) with the lightest HCW category producing the lightest muscle weights ($P < 0.05$). The next most common difference noted the impact of HCW on circumference measures ($P < 0.05$), as significant differences were detected in 4 out of 5 muscles (*M. gluteobiceps*, *M. semimembranosus*, *M. semitendinosus*) with 3 out of 5 possessing at least 2 differences (*M. gluteus medius*, *M. semimembranosus*, *M. semitendinosus*) ($P < 0.05$) in circumference. Circumference of muscles is a noteworthy factor as it could potentially relate to surface area of foodservice and retail cuts impacting adequate or inadequate plate coverage. With this postulation in mind, findings in this study disagree with Bass et al. (2009) with respect to the *M. gluteus medius* muscle who found that LMA posed a significant difference in steak and portion size as well as merchandiser acceptability. Contrarily, the *M. gluteus medius* examined in this study was greatly more affected by HCW, notably in muscle weight and anterior and median circumference measures ($P < 0.05$). Dimensional data from the *M. gluteus medius* (Table 4) in this analysis only yielded a single significant difference in anterior circumference measures when stratified by REA. *M. semimembranosus* muscles

(Table 5) produced the greatest number of variations within the dissected muscle treatment as muscle weight, and all 3 length, width, and circumference measures from the 340.6 to 385.6-kg carcass category were significantly lighter, narrower and smaller ($P < 0.05$) in circumference than carcasses from the 386.0 to 430.9-kg and 430.91 to 476.27-kg HCW categories. Considering that REA only significantly affected muscle weight and no other dimensional factors for *M. semimembranosus*, these findings somewhat agree with Bass et al. (2009) that found that REA was not a significant contributor to *M. semimembranosus* portion sizing.

Table 21 describes the dissected muscle compositional percentage for the hindquarter sourced from the three REA and HCW categories and how these relative percentages fluctuate with increases in the respective main effects. With the exception of the *M. longissimus lumborum*, generally, the compositional percentages of the dissected muscles numerically increase as HCW increases. The *M. longissimus lumborum* compositional percentages varied, however, as muscles from the lightest HCW category made up 1.9% more of the weight of their respective hindquarters compared to the 386.0 to 430.9 kg category and 0.8% more of the weight compared to the heaviest HCW category despite being significantly lighter in weight than the heaviest HCW category. However, other dissected muscles do not reveal such differences, as the compositional percentages of the remaining dissected muscles varied less than 1%. When stratified by REA largest compositional difference, a 0.66% decrease, existed between the *M. gluteus medius* of the smallest REA category and the median REA size category. The remaining differences in hindquarter muscle composition percentages were less than 0.5% as REA size increased. This illustrates again that HCW proved to be a greater contributor to changes in muscle size, particularly for the *M. longissimus lumborum*.

5.2 Discussion of fabricated muscle dimensional analysis

Similar to the results of the dissected muscles, the HCW main effect was the primary driver of muscle weight and dimensional measurement ($P < 0.05$), as it impacted almost 4 times as many factors ($P < 0.05$) as the REA main effect. As a whole, there was a greater number of detectable variations in muscles subjected to the fabrication treatment than the dissection treatment. This could be attributed to the increase in the number of personnel removing subprimals from the carcass compared to the single person dissecting muscles from the hindquarter individually. The instance of variation could also increase with the removal of subprimals from the carcass at approximate regions, leaving behind portions of the individual muscle on other subprimals and not remaining on the portion utilized in this study. Muscle weight was significantly impacted ($P < 0.05$) by HCW in all 6 subprimals utilized in the fabrication treatment. Additionally, 5 of the 6 subprimals (BRF, EOR, IR, Coulotte, TSB) possessed significant differences in both circumference and width, with 5 of the 6 subprimals (as listed above) producing at least 2 differences in width, and 4 subprimals (BRF, EOR, IR, Coulotte) having at least 2 difference in circumference. In the case of BRF and EOR, all 3 circumference measurements possessed detectable variations ($P < 0.05$). For Coulotte and TSB subprimals, all 3 width measurements also produced detectable differences ($P < 0.05$). The REA main effect also produced a significant difference in anterior, median and posterior measurements width measurements ($P < 0.05$) within IR, which disagrees with similar studies that indicated LMA did not have an effect on IR portion sizing (Bass et al., 2009). This same study, however, found that LMA had an effect on SL portion sizing, which is supported by differences in muscle weight ($P = 0.0130$) in this study. Although, a greater number of differences in SL were observed for the HCW main effect in muscle weight ($P = 0.0018$) as well as dorsal, medial, and ventral length measurements ($P < 0.05$). The question still rises however that the SL should be similar in size to the REA, given that the ribeye and loin eye exist as two halves of the same 12th and 13th rib interface. This is supported to an extent, as carcasses from the 96.7 to 102.6 cm^2 REA category possessed a greater anterior circumference to those from the 90.3 to 96.1 cm^2 and the 83.9 to 89.8 cm^2 categories. However, these differences fade and become less apparent in median ($P > 0.05$) and posterior circumference ($P > 0.05$) as the farther posterior measurements were obtained, the more similar the SL became in size in regards to circumference. This difference was not consistent on the *M. longissimus lumborum* when stratified by REA as there were no differences ($P > 0.05$) in any circumference measures.

Concurring with Griffin et al. (1999) as well as Bass et al. (2009), REA did not prove to be an accurate predictor of other hindquarter muscles in beef carcasses. Rather, agreeing with Greiner, Rouse, Wilson, and Cundiff (1997) and Greiner, Rouse, Wilson, Cundiff, and Wheeler (2003), HCW proved to be a better predictor of muscle size and could explain a greater number of variations than the REA main effect. A large number of differences in circumference of muscles and subprimals could possibly affect the relative plate coverage of some cuts.

5.3 Discussion of retail cutting yields

Much like the dimensional analysis of dissected and fabricated muscles, HCW seemed to explain a greater level of variation in retail cutting yields than did REA. The most common difference appearing in all 8 muscles and subprimals was that the lightest weight carcass category produced the lightest mean steak weights ($P < 0.05$). This statistic closely follows the total number of retail-ready products generated when stratified by HCW which appeared in 4 of the 8 muscles and subprimals analyzed (dissected *M. gluteobiceps*, *M. gluteus medius*, *M. semimembranosus*, and fabricated bottom round flat).

Similar to the dimensional analysis of the *M. longissimus lumborum* (Table 2) where the lightest HCW category produced the lightest muscle weight ($P < 0.01$), the 340.6 to 385.6-kg HCW category yielded the lightest average steak weight ($P = 0.03$), which was to be expected. A similar occurrence was observed in the REA main effect where the 83.9 to 89.8 cm^2 REA category produced lighter muscles and lighter average steak weights than the 96.7 to 102.6 cm^2 REA category, but remained similar to the 90.3 to 96.1 cm^2 category. The 340.6 to 385.6-kg HCW category also produced the fewest strip steaks ($P < 0.05$), and while there was no significant difference, heavier carcasses tended to produce longer *M. longissimus lumborum*. Dissimilar, however, were the retail yield results from the SL subprimal (Table 20). Significant differences were observed in all length measurements for fabricated SL muscles when stratified by HCW with 340.6 to 385.6-kg carcasses producing the shortest subprimals and the 431.4 to 476.3-kg carcasses producing the longest subprimals. Yet, there were no significant differences in number of strip steaks, vein steaks or total number of steaks produced ($P > 0.05$). Mean steak weights of SL were affected by REA similar to how REA affected subprimal weights in that carcasses with 96.7 to 102.6 cm^2 REA produced heavier subprimals and heavier mean steak weights than either of the smaller REA categories.

Much like the *M. longissimus lumborum*, the HCW main effect for length measurements in dissected *M. gluteobiceps muscles* (Table 14) and number of merchandisable products produced were affected similarly as the 386.0 to 430.9-kg HCW category yielded a greater number of merchandisable steaks and roasts ($P < 0.05$) than carcasses from the 340.6 to 385.6-kg category, but produced a similar amount to the 431.4 to 476.3-kg category. The smallest REA category also produced the greatest number of coulotte steaks ($P < 0.01$) that could have occurred due to the relatively small number of samples in this study. There was a REA x HCW interaction at the primary yield and waste percentage calculations ($P = 0.02$ and $P = 0.04$, respectively; tabular data not shown), indicating that REA and HCW acted in conjunction to influence their outcomes. Bottom round flat subprimal retail yield analysis results in Table 17 more closely follow the expected outcome of the lightest HCW category producing the lightest muscle weights ($P < 0.01$) and the lightest mean roast weight ($P < 0.01$). Moreover, dimensional analysis revealed the lightest HCW category possessed the shortest medial and ventral length measurements ($P = 0.01$ and $P < 0.01$, respectively) as well as the least number of retail-ready roasts ($P < 0.01$).

Once again, the same effect of HCW on muscle weight of *M. gluteus medius* (Table 4) was observed in mean steak weight as the 340.6 to 385.6-kg carcasses produced the lightest muscle weights ($P < 0.01$) and the lightest mean steak weights ($P < 0.01$). Moreover, this same weight category also produced the least number of center-cut steaks ($P = 0.03$) and the least amount of total steaks overall ($P = 0.02$). While there was a difference in the average weight and number of steaks produced, it should also be noted there was no significant difference in primary or saleable yield ($P > 0.05$) from either the REA or HCW main effects. Due to fabrication differences between runs, trimming of waste material was inconsistent for the dissected *M. gluteus medius,* therefore analysis of percentage waste was not performed. In data gathered from TSB steak fabrication (Table 19), fabrication of product for slicing was not consistent between trips. Therefore, analysis of saleable yield and waste were not conducted. 431.4 to 476.3-kg carcasses possessed significantly longer ventral length measurements ($P < 0.05$), as well as non-significant differences in dorsal and medial length that tended to be longer for carcasses in the 431.37-476.27-kg HCW category (Table 11). However, no differences or tendencies in the total number of steaks produced were observed for TSB subprimals ($P > 0.05$) across either HCW or

REA main effects. Although, primary yield for 431.4 to 476.3-kg carcasses was numerically higher than the two lighter HCW categories, the difference was not significant ($P > 0.05$).

A similar phenomenon was also observed in analysis of the *M. semimembranosus* retail cutting yields (Table 16) in that the lightest HCW category produced the least number of retail ready steaks and the lightest average steak weight ($P < 0.01$), but did not realize a difference in primary yield ($P > 0.05$). Also similar to dimensional analysis for dissected and fabricated treatments, REA and HCW both impacted muscle weight and steak weight of *M. semimembranosus*. In this instance, shorter dorsal and medial length measurements of carcasses in the 340.6 to 385.6-kg HCW category seemed to be related in that this category also produced the least amount of retail steaks ($P < 0.01$). This produced the least number of total steaks ($P < 0.05$). Fabrication differences between runs for the IR subprimal were not consistent. Therefore, analysis of saleable yield and waste was not conducted. Evaluation of retail yields from IR subprimals appeared to hold some similarities to collected dimensional data in Table 9. When stratified by the REA main effect, the largest REA category in Table 18 produced the greatest number of total steaks ($P < 0.05$) as well as the heaviest mean steak weight ($P < 0.01$). Numerically, the number of total steaks produced was higher for the 83.9 to 89.8 cm^2 category compared to the 90.3 to 96.1 cm^2 category, although not significant ($P > 0.05$) which was consistent with the ventral length measurements from Table 9. Mean steak weight was influenced by both the REA and HCW main effect as the largest REA category produced the heaviest mean steak weight and the lightest HCW category produced the lightest mean steak weight ($P < 0.01$).

CHAPTER VI

CONCLUSION

In summary, as HCW increased, muscle and subprimal weight, and subsequent mean steak weights increased as well. In this study, the length of traditionally fabricated SL subprimals did not have a significant effect on the number of steaks produced from the subprimal. However, the difference in all length least squares mean ranged from approximately 2 to 3 cm (Table 12). Given that each steak was cut to a thickness of 2.54 cm, the possibility remains that this difference in length would not allow for an additional steak to be cut from each subprimal consistently. This issue was not observed for other muscles and subprimals such as the dissected *M. gluteobiceps*, *M. semimembranosus*, or fabricated bottom round flat and inside round as the significant differences in length were large enough to show that the 340.6 to 385.6-kg HCW category produced measurably fewer steaks and roasts that either subsequent heavier HCW categories. Variations in the results of this study could be a result of the lack of standardization of sex class or yield grades, which have been shown to affect the composition of beef carcasses (Griffin, 1989). The issue of yield grade was somewhat controlled by the use of carcasses qualifying for a top choice angus program, which eliminate the use of carcasses with backfat thicknesses of 3.81 cm or greater. This selection method, however, did not standardize the use of carcasses qualifying for any yield grades lower than 4, thus opening the possibility of variation between carcasses of varying fat thicknesses that would otherwise contribute to variations in carcass weight. Results garnered from this study will prove useful in attempting to target the size of certain muscles to a given consumer preference, as lighter weight carcasses produced smaller muscles and subprimals and lighter mean steak weights.

While these data could prove useful in attempting to solve a dilemma of portion sizing and thickness and consumer acceptability within the foodservice and retail sectors, it was postulated in Sweeter, Wulf, and Maddock (2005), that there appeared to exist a consumer of every cut size: large and small, thick and thin. As discussed in Butterfield and Berg (1966a), muscles grow in phases largely determined by the genetic background of that animal. If a consumer exists for every cut and portion size, then premiums could be applied to cattle producers utilizing progressive genetic selection tools to create lighter weight cattle in order to compensate for the decreased revenue that could be potentially realized by producing heavier weight cattle in the current United States cattle marketing system. Results gleaned from this study show that when stratified by REA, large differences in dimensional measurements from the smallest REA category to the largest seem to indicate that muscles grow in concert with each other. Similar results are seen when stratified by HCW, however, the most obvious differences are observed when comparing carcasses from the lightest HCW category to those from the two heavier HCW categories. Carcasses from the lightest HCW category produced muscles that were lighter weight and smaller in dimensional measurement points than carcasses from the 386.0 to 430.9 kg and 431.4 to 476.3 kg HCW categories. These results point to a similar conclusion garnered from the analysis of the REA main effect in that the muscles and subprimals seem to have increased in size as the live animal increased in weight. However, the HCW main effect shows that at a point between the light and medium HCW treatments, growth seems to have been optimized. With this in mind, HCW could serve as a greater sorting tool for packers experiencing issues with customers complaining of unacceptable cut sizes in certain subprimals.

In this study as well as in Bass et al. (2009), REA accounted for a fewer number of variations in muscle dimension and retail cutting yields compared to HCW. Looking forward, there exists a need to conduct more current research on the true impact of REA on the percentage of boneless closely trimmed retail cuts of beef carcasses and to evaluate if a larger emphasis should be placed on HCW in yield grade calculations and decrease the role REA currently plays in this calculation. In addition, further exploration into the optimization of muscle growth as it compares to animal maturity, live weight, and carcass weight could be beneficial in the quest for more sustainable protein production. As discussed in Butterfield et al. (1983), changes in muscle sizes occurred early in life while fat deposition occurred late in life. From this perspective, genetically selecting for cattle with lighter live weights and thus lighter carcass weights could potentially increase the acceptability of retail and foodservice cuts. Alterations in live cattle marketing, such as added premiums for producers genetically selecting for cattle of lighter carcass weights or beef certification programs demanding lighter carcass weights could be a possible solution to this cut size consistency dilemma. When analyzed from a compositional standpoint, HCW had the greatest effect on *M. longissimus lumborum* muscle weight, as the muscles from the smallest REA category made up 1.9% more of their respective hindquarter weights than those from the 386.0 to 430.9 kg category and 0.8% more than the heaviest HCW category. However, the majority of other compositional differences across REA and HCW main effects produced less than 0.5% change in muscle weight as REA and HCW increased. The responsibility of beef industry improvement not only rests on the shoulders of producers, but on that of packers as well to provide greater incentives for cattle producers to create a more acceptable product in order to satisfy the needs of today’s consumer. If the industry as a whole is to succeed, a greater level of collaboration on both ends of production remains vital in order to ensure prosperity for all.

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APPENDIX A

Table 1. Carcass allocation across treatment structure

	Ribeye size category		
Carcass weight category	83.9 to 89.8 cm^2	90.3 to 96.1 cm^2	96.7 to 102.6 cm^2
340.6 to 385.6 kg	4 carcasses	4 carcasses	4 carcasses
386.0 to 430.9 kg	4 carcasses	4 carcasses	4 carcasses
431.4 to 476.3 kg	4 carcasses	4 carcasses	4 carcasses

Table 2. Least squares means for measurements of the *M. longissimus lumborum* stratified by ribeye area and carcass weight category main effects

Measurement	*Ribeye area category, cm².*					*Carcass weight category, kg*				
	83.87 to 89.68	90.32 to 96.13	96.77 to 102.58	SEM	*P*-value	340.65 to 385.55	386.0 to 430.91	431.37 to 476.27	SEM	*P*-value
Muscle weight, kg	3.68[b]	3.83[ab]	4.04[a]	0.08	0.01	3.63[b]	3.92[a]	3.99[a]	0.08	0.01
Length, cm										
Dorsal	41.30	43.13	42.38	1.34	0.63	40.09	42.49	44.23	1.34	0.11
Medial	40.48	42.43	41.93	1.31	0.55	39.46	41.48	43.90	1.31	0.07
Ventral	39.62	40.33	40.12	1.11	0.90	38.60	39.30	42.16	1.11	0.07
Width, cm										
Anterior	20.28	16.95	16.91	2.28	0.50	16.57	20.39	17.18	2.28	0.46
Median	21.79	18.24	18.28	2.32	0.47	17.99	21.76	18.56	2.32	0.47
Posterior	25.64	21.82	21.38	2.44	0.41	20.88	25.83	22.13	2.44	0.34
Depth, cm										
Anterior	6.46[b]	6.76[ab]	7.13[a]	0.16	0.02	7.00	6.79	6.55	0.16	0.16
Median	6.96	6.53	7.21	0.27	0.22	6.96	7.29	6.44	0.28	0.11
Posterior	4.75	4.50	4.13	0.30	0.35	4.46	4.37	4.55	0.30	0.91
Circumference, cm										
Anterior	37.99	39.20	39.21	0.63	0.31	38.79	38.78	38.83	0.63	0.99
Median	40.47	39.78	41.20	0.80	0.47	40.26	40.29	40.90	0.80	0.82
Posterior	44.53	44.26	44.81	0.82	0.89	43.99	45.32	44.29	0.82	0.50

[a-b]Least squares means within a row and main effect lacking common superscript letters differ ($P < 0.05$).
n = 36 subprimals; dissection

Table 3. Least squares means for measurements of the *M. gluteobiceps* stratified by ribeye area and carcass weight category main effects

Measurement	*Ribeye area category, cm²*					*Carcass weight category, kg*				
	83.87 to 89.68	90.32 to 96.13	96.77 to 102.58	SEM	*P*-value	340.65 to 385.55	386.0 to 430.91	431.37 to 476.27	SEM	*P*-value
Muscle weight, kg	7.29 ± 0.15	7.26 ± 0.15	7.62 ± 0.16		0.20	6.56^{b} ± 0.15	7.79^{a} ± 0.16	7.81^{a} ± 0.15		< 0.01
Length, cm										
Dorsal	19.76	18.35	18.95	1.25	0.73	17.41	20.83	18.83	1.25	0.17
Medial	24.66	21.87	21.06	1.15	0.09	20.75	24.39	22.44	1.15	0.10
Ventral	27.68	25.93	26.46	1.16	0.56	23.98^{b}	29.52^{a}	26.56^{ab}	1.61	< 0.01
Width, cm										
Anterior	59.43	61.20	66.82	2.66	0.14	61.38	61.73	64.35	2.66	0.69
Median	60.90	64.37	65.33	2.45	0.42	63.40	61.36	65.85	2.45	0.44
Posterior	60.06	62.53	63.15	2.33	0.62	61.48	60.14	64.12	2.33	0.48
Depth, cm										
Anterior	5.58	6.21	6.48	0.37	0.22	5.79	6.67	5.82	0.37	0.17
Median	10.04	11.08	10.92	0.44	0.22	10.63	10.71	10.71	0.44	0.99
Posterior	8.67^{b}	9.75^{ab}	10.67^{a}	0.44	0.01	9.00	9.75	10.33	0.44	0.12
Circumference, cm										
Anterior	40.46	40.68	43.2	0.94	0.09	39.68	41.68	42.97	0.94	0.06
Median	49.22	48.33	50.04	1.13	0.57	47.42	50.16	50.01	1.13	0.18
Posterior	54.38	55.90	56.66	1.17	0.39	52.11^{b}	57.65^{a}	57.18^{a}	1.17	< 0.01

[a-b]Least squares means within a row and main effect lacking common superscript letters differ ($P < 0.05$).
n = 36 subprimals; dissection

Table 4. Least squares means for measurements of the *M. gluteus medius* stratified by ribeye area and carcass weight category main effects

Measurement	*Ribeye area category, cm²*					*Carcass weight category, kg*				
	83.87 to 89.68	90.32 to 96.13	96.77 to 102.58	SEM	*P*-value	340.65 to 385.55	386.0 to 430.91	431.37 to 476.27	SEM	*P*-value
Muscle weight, kg	3.71	3.59	3.80	0.09	0.26	3.35[b]	3.90[a]	3.85[a]	0.09	< 0.01
Length, cm										
Dorsal	24.12	22.14	22.53	0.99	0.34	21.18[b]	24.98[ab]	22.63[a]	0.99	0.04
Medial	26.56	28.45	28.68	1.16	0.38	27.16	29.47	27.06	1.16	0.27
Ventral	43.83	43.93	46.06	1.59	0.54	44.72	44.46	44.63	1.59	0.99
Width, cm										
Anterior	23.46	23.65	23.16	0.57	0.83	22.19[b]	23.87[a]	24.21[a]	0.57	0.04
Median	26.21	26.50	26.58	0.63	0.91	25.45	26.98	26.86	0.63	0.18
Posterior	23.90	21.71	24.96	0.99	0.08	22.83	23.18	24.57	0.99	0.43
Depth, cm										
Anterior	7.67	6.89	7.67	0.28	0.10	7.08	7.42	7.73	0.28	0.29
Median	8.00	7.94	8.13	0.22	0.83	7.83[b]	7.67[b]	8.57[a]	0.22	0.06
Posterior	7.92	7.48	8.25	0.43	0.46	7.96	7.83	7.86	0.43	0.98
Circumference, cm										
Anterior	51.08[b] ± 1.33	52.88[ab] ± 1.33	56.52[a] ± 1.40		0.03	50.08[b] ± 1.33	54.33[a] ± 1.33	56.08[a] ± 1.40		0.01
Median	59.12 ± 0.75	58.90 ± 0.75	60.17 ± 0.79		0.47	56.53[b] ± 0.75	60.63[a] ± 0.75	61.03[a] ± 0.79		< 0.01
Posterior	53.05 ± 2.16	49.86 ± 2.16	53.13 ± 2.27		0.49	48.45 ± 2.16	54.02 ± 2.16	53.57 ± 2.27		0.15

[a-b]Least squares means within a row and main effect lacking common superscript letters differ ($P < 0.05$).
n = 36 subprimals; dissection

Table 5. Least squares means for measurements of the *M. semimembranosus* stratified by ribeye area and carcass weight category main effects

Measurement	*Ribeye area category, cm^2*					*Carcass weight category, kg*				
	83.87 to 89.68	90.32 to 96.13	96.77 to 102.58	SEM	*P*-value	340.65 to 385.55	386.0 to 430.91	431.37 to 476.27	SEM	*P*-value
Muscle weight, kg	6.53[b]	6.66[ab]	6.94[a]	0.11	0.05	6.12[b]	7.01[a]	7.01[a]	0.11	< 0.01
Length, cm										
Dorsal	29.35	27.43	28.47	0.91	0.34	26.04[b]	29.63[a]	29.58[a]	0.91	0.01
Medial	32.07	32.85	31.94	0.58	0.50	30.78[b]	32.90[a]	33.18[a]	0.58	0.01
Ventral	29.14	28.83	28.91	0.73	0.95	28.03	30.33	28.53	0.73	0.08
Width, cm										
Anterior	31.43	30.78	31.40	0.47	0.55	29.85[b]	32.55[a]	31.21[a]	0.47	< 0.01
Median	32.62	33.52	33.26	0.52	0.46	31.65[b]	34.26[a]	33.48[a]	0.52	< 0.01
Posterior	28.19	26.60	28.70	0.69	0.10	26.74	28.13	28.62	0.69	0.16
Depth, cm										
Anterior	11.29	11.92	11.96	0.33	0.30	11.54	11.71	11.92	0.33	0.73
Median	10.63	11.63	10.71	0.35	0.10	10.63	10.75	11.58	0.35	0.12
Posterior	9.00	9.13	9.00	0.33	0.95	8.71	8.79	9.63	0.33	0.10
Circumference, cm										
Anterior	72.38	71.16	73.80	0.99	0.19	69.95[b]	73.80[a]	73.61[a]	0.99	0.02
Median	71.89	71.83	72.80	0.82	0.65	70.06[b]	73.10[a]	73.36[a]	0.82	0.01
Posterior	60.91	60.66	59.56	1.53	0.80	60.53	58.84	61.75	1.53	0.41

[a-b]Least squares means within a row and main effect lacking common superscript letters differ ($P < 0.05$).
n = 36 subprimals; dissection

Table 6. Least squares means for measurements of the *M. semitendinosus* stratified by ribeye area and carcass weight category main effects

Measurement	*Ribeye area category, cm²*					*Carcass weight category, kg*				
	83.87 to 89.68	90.32 to 96.13	96.77 to 102.58	SEM	*P*-value	340.65 to 385.55	386.0 to 430.91	431.37 to 476.27	SEM	*P*-value
Muscle weight, kg	2.53	2.64	2.77	0.08	0.14	2.35[b]	2.83[a]	2.76[a]	0.08	< 0.01
Length, cm										
Dorsal	12.98	16.65	12.87	1.72	0.23	12.49	14.72	15.29	1.72	0.49
Medial	12.74	17.34	12.94	1.98	0.20	12.37	15.00	15.66	1.98	0.47
Ventral	13.49	17.31	13.77	1.81	0.27	12.75	15.62	16.20	1.81	0.37
Width, cm										
Anterior	35.77	32.37	37.17	1.86	0.19	33.81	35.13	36.37	1.86	0.63
Median	39.13	34.78	39.92	1.84	0.13	37.47	38.21	38.16	1.84	0.95
Posterior	35.46	32.76	36.52	1.75	0.31	34.20	34.96	35.58	1.75	0.86
Depth, cm										
Anterior	6.13	6.71	6.25	0.31	0.40	6.21	6.67	6.21	0.31	0.50
Median	8.13[b]	8.63[ab]	9.04[a]	0.21	0.02	8.08[b]	8.88[a]	8.83[a]	0.21	0.02
Posterior	9.46	9.38	9.83	0.38	0.67	9.46	9.46	9.75	0.38	0.82
Circumference, cm										
Anterior	31.39	31.60	32.26	0.67	0.63	30.20[b]	33.01[a]	32.04[ab]	0.67	0.02
Median	33.08	33.38	33.94	0.62	0.61	31.85[b]	34.63[a]	33.91[a]	0.62	0.01
Posterior	34.49[b]	33.79[b]	36.83[a]	0.59	< 0.01	34.22	35.51	35.39	0.59	0.25

[a-b]Least squares means within a row and main effect lacking common superscript letters differ ($P < 0.05$).
n = 36 subprimals; dissection

Table 7. Least squares means ± SEM for measurements of the bottom round flat subprimal stratified by ribeye area and carcass weight category main

Measurement	Ribeye area category, cm^2				Carcass weight category, kg			
	83.87 to 89.68	90.32 to 96.13	96.77 to 102.58	*P*-value	340.65 to 385.55	386.0 to 430.91	431.37 to 476.27	*P*-value
Muscle weight, kg	6.03 ± 0.13	6.10 ± 0.14	6.26 ± 0.13	0.46	5.45^{b} ± 0.13	6.46^{a} ± 0.14	6.49^{a} ± 0.14	< 0.01
Length, cm								
Dorsal								
Medial	21.04 ± 0.54	21.89 ± 0.60	21.55 ± 0.54	0.57	20.11^{b} ± 0.54	21.76^{a} ± 0.57	22.62^{a} ± 0.57	0.01
Ventral	25.53 ± 0.51	26.62 ± 0.57	26.92 ± 0.51	0.16	24.40^{b} ± 0.51	27.75^{a} ± 0.54	26.91^{a} ± 0.54	< 0.01
Width, cm								
Anterior	46.70^{ab} ± 2.09	42.18^{b} ± 2.31	50.31^{a} ± 2.09	0.05	43.81 ± 2.09	49.85 ± 2.21	45.53 ± 2.21	0.15
Median	49.20 ± 1.71	43.82 ± 1.90	49.75 ± 1.71	0.06	43.28^{b} ± 1.71	49.24^{a} ± 1.81	50.25^{a} ± 1.81	0.019
Posterior	47.92 ± 1.23	45.64 ± 1.36	44.90 ± 1.23	0.22	44.42^{b} ± 1.23	45.00^{b} ± 1.30	49.04^{a} ± 1.30	0.03
Depth, cm								
Anterior	7.58 ± 0.32	7.69 ± 0.36	8.08 ± 0.32	0.53	7.38 ± 0.32	7.65 ± 0.34	8.33 ± 0.34	0.13
Median	10.71 ± 0.36	10.58 ± 0.39	10.88 ± 0.36	0.86	10.71 ± 0.36	10.31 ± 0.37	11.15 ± 0.37	0.30
Posterior	8.71 ± 0.43	9.29 ± 0.47	8.42 ± 0.43	0.40	8.33 ± 0.43	9.36 ± 0.45	8.72 ± 0.45	0.27
Circumference, cm								
Anterior	47.65 ± 0.52	49.19 ± 0.58	49.00 ± 0.52	0.11	45.98^{b} ± 0.52	50.08^{a} ± 0.55	49.78^{a} ± 0.55	< 0.01
Median	50.95 ± 0.55	51.73 ± 0.61	52.63 ± 0.55	0.11	49.25^{b} ± 0.55	53.43^{a} ± 0.58	52.63^{a} ± 0.58	< 0.01
Posterior	56.84 ± 0.68	55.42 ± 0.76	57.30 ± 0.68	0.18	53.71^{b} ± 0.68	57.28^{a} ± 0.72	58.58^{a} ± 0.72	< 0.01

[a-b]Least squares means within a row and main effect lacking common superscript letters differ ($P < 0.05$).
n = 34 subprimals "normal fabrication" (2 sides were missing compared to the n = 36 for dissection)
Note: Dorsal Length, cm — REA*CW interaction (P = 0.0251)

Table 8. Least squares means ± SEM for measurements of the eye of round subprimal stratified by ribeye area and carcass weight category main effects

Measurement	*Ribeye area category, cm²*				*Carcass weight category, kg*			
	83.87 to 89.68	90.32 to 96.13	96.77 to 102.58	*P*-value	340.65 to 385.55	386.0 to 430.91	431.37 to 476.27	*P*-value
Muscle weight, kg	2.51 ± 0.08	2.63 ± 0.09	2.74 ± 0.08	0.16	2.32^{b} ± 0.08	2.78^{a} ± 0.09	2.78^{a} ± 0.09	< 0.01
Length, cm								
Dorsal	12.25 ± 0.24	12.62 ± 0.27	12.78 ± 0.24	0.31	12.08 ± 0.24	12.82 ± 0.26	12.75 ± 0.26	0.08
Medial	12.48 ± 0.29	12.94 ± 0.32	12.99 ± 0.29	0.40	12.19^{b} ± 0.29	13.20^{a} ± 0.30	13.03^{ab} ± 0.30	0.05
Ventral	13.07 ± 0.36	13.75 ± 0.39	14.27 ± 0.36	0.08	12.62^{b} ± 0.36	14.44^{a} ± 0.38	14.03^{a} ± 0.38	< 0.01
Width, cm								
Anterior	37.03 ± 0.62	37.67 ± 0.69	37.14 ± 0.62	0.77	34.58^{b} ± 0.62	39.18^{a} ± 0.65	38.09^{a} ± 0.65	< 0.01
Median	39.54 ± 0.72	40.33 ± 0.79	41.29 ± 0.72	0.24	37.78^{b} ± 0.72	41.76^{a} ± 0.76	41.61^{a} ± 0.76	< 0.01
Posterior	36.28 ± 0.90	36.66 ± 0.99	37.58 ± 0.90	0.58	35.13 ± 0.90	37.68 ± 0.94	37.73 ± 0.94	0.09
Depth, cm								
Anterior	6.46 ± 0.19	6.25 ± 0.21	6.17 ± 0.19	0.56	6.29 ± 0.19	6.34 ± 0.20	6.24 ± 0.20	0.93
Median	8.08 ± 0.33	8.28 ± 0.36	7.79 ± 0.33	0.60	8.00 ± 0.33	7.86 ± 0.34	8.29 ± 0.34	0.67
Posterior	8.67 ± 0.22	9.19 ± 0.24	9.04 ± 0.22	0.26	8.63 ± 0.22	9.06 ± 0.23	9.22 ± 0.23	0.17
Circumference, cm								
Anterior	30.73 ± 0.48	31.25 ± 0.53	31.62 ± 0.48	0.43	29.95^{b} ± 0.48	31.99^{a} ± 0.50	31.64^{a} ± 0.50	0.01
Median	32.75 ± 0.60	32.89 ± 0.66	33.88 ± 0.60	0.37	31.81^{b} ± 0.60	33.88^{a} ± 0.63	33.83^{a} ± 0.63	0.04
Posterior	34.38 ± 0.59	35.56 ± 0.66	36.35 ± 0.59	0.08	33.80^{b} ± 0.59	36.20^{a} ± 0.63	36.28^{a} ± 0.63	0.01

[a-b]Least squares means within a row and main effect lacking common superscript letters differ ($P < 0.05$).
n = 34 subprimals "normal fabrication" (2 sides were missing compared to the *n* = 36 for dissection)

Table 9. Least squares means ± SEM for measurements of the inside round subprimal stratified by ribeye area and carcass weight category main effects

Measurement	*Ribeye area category, cm²*				*Carcass weight category, kg*			
	83.87 to 89.68	90.32 to 96.13	96.77 to 102.58	*P*-value	340.65 to 385.55	386.0 to 430.91	431.37 to 476.27	*P*-value
Muscle weight, kg	$6.28^{b} \pm 0.11$	$6.50^{b} \pm 0.12$	$6.86^{a} \pm 0.11$	< 0.01	$6.04^{b} \pm 0.11$	$6.84^{a} \pm 0.11$	$6.76^{a} \pm 0.11$	< 0.01
Length, cm								
Dorsal	29.85 ± 0.74	29.11 ± 0.81	28.54 ± 0.74	0.46	28.00 ± 0.74	30.19 ± 0.78	29.31 ± 0.78	0.14
Medial	32.00 ± 0.63	31.23 ± 0.69	32.17 ± 0.63	0.58	30.60 ± 0.63	32.96 ± 0.66	31.83 ± 0.66	0.05
Ventral	$30.91^{ab} \pm 0.55$	$29.68^{b} \pm 0.61$	$31.87^{a} \pm 0.55$	0.04	29.73 ± 0.55	31.47 ± 0.58	31.26 ± 0.58	0.07
Width, cm								
Anterior	$31.64^{b} \pm 0.51$	$30.63^{b} \pm 0.57$	$33.43^{a} \pm 0.51$	< 0.01	$30.07^{c} \pm 0.51$	$33.71^{a} \pm 0.54$	$31.93^{b} \pm 0.54$	< 0.01
Median	$32.12^{b} \pm 0.55$	$32.58^{ab} \pm 0.61$	$34.18^{a} \pm 0.55$	0.04	$31.70^{b} \pm 0.55$	$33.46^{a} \pm 0.58$	$33.72^{a} \pm 0.58$	0.04
Posterior	28.18 ± 0.76	27.73 ± 0.85	28.52 ± 0.76	0.79	27.31 ± 0.76	29.31 ± 0.81	27.81 ± 0.81	0.20
Depth, cm								
Anterior								
Median								
Posterior	8.92 ± 0.30	9.35 ± 0.34	8.96 ± 0.30	0.59	8.96 ± 0.30	9.25 ± 0.32	9.01 ± 0.32	0.79
Circumference, cm								
Anterior	$72.66^{b} \pm 0.68$	$72.57^{b} \pm 0.75$	$74.92^{a} \pm 0.68$	0.04	$69.80^{b} \pm 0.68$	$75.16^{a} \pm 0.72$	$75.19^{a} \pm 0.72$	< 0.01
Median	72.70 ± 0.86	71.50 ± 0.95	73.57 ± 0.86	0.29	$70.53^{b} \pm 0.86$	$73.06^{ab} \pm 0.90$	$74.17^{a} \pm 0.90$	0.02
Posterior	63.28 ± 1.17	61.73 ± 1.29	62.61 ± 1.17	0.66	62.10 ± 1.17	62.63 ± 1.23	62.49 ± 1.23	0.95

[a-c]Least squares means within a row and main effect lacking common superscript letters differ ($P < 0.05$).
$n = 34$ subprimals "normal fabrication" (2 sides were missing compared to the $n = 36$ for dissection)
Note: Anterior and Median Depth, cm — REA*CW interaction ($P = 0.0103$ and 0.0185, respectively)

Table 10. Least squares means ± SEM for measurements of the Top sirloin butt, cap stratified by ribeye area and carcass weight category main effects

	Ribeye area category, cm^2				Carcass weight category, kg			
Measurement	83.87 to 89.68	90.32 to 96.13	96.77 to 102.58	*P*-value	340.65 to 385.55	386.0 to 430.91	431.37 to 476.27	*P*-value
Muscle weight, kg	1.21 ± 0.05	1.22 ± 0.06	1.26 ± 0.05	0.74	1.03^b ± 0.05	1.26^a ± 0.05	1.40^a ± 0.06	< 0.01
Length, cm								
Dorsal	21.94 ± 0.62	19.78 ± 0.68	21.70 ± 0.65	0.06	20.28 ± 0.62	21.28 ± 0.65	21.86 ± 0.68	0.24
Medial	19.38^a ± 0.68	16.85^b ± 0.75	19.37^a ± 0.71	0.03	18.22 ± 0.68	18.27 ± 0.71	19.12 ± 0.75	0.62
Ventral	15.88 ± 0.83	12.85 ± 0.92	13.61 ± 0.88	0.05	13.01 ± 0.83	14.87 ± 0.88	14.46 ± 0.92	0.29
Width, cm								
Anterior	23.23 ± 0.57	23.02 ± 0.63	22.94 ± 0.60	0.94	21.00^b ± 0.57	24.90^a ± 0.60	23.29^a ± 0.63	< 0.01
Median	21.48 ± 0.96	23.49 ± 1.06	22.01 ± 1.01	0.37	19.45^b ± 0.96	23.74^a ± 1.01	23.79^a ± 1.06	< 0.01
Posterior	16.93 ± 1.22	20.61 ± 1.35	18.42 ± 1.29	0.15	15.59^b ± 1.22	19.81^a ± 1.29	20.56^a ± 1.35	0.02
Depth, cm								
Anterior	4.96^b ± 0.16	5.32^b ± 0.18	5.90^a ± 0.17	< 0.01	5.29^b ± 0.16	4.94^b ± 0.17	5.94^a ± 0.18	< 0.01
Median	5.08^b ± 0.17	5.38^{ab} ± 0.19	5.86^a ± 0.18	0.01	5.29^b ± 0.17	5.08^b ± 0.18	5.94^a ± 0.19	< 0.01
Posterior	4.21 ± 0.19	4.42 ± 0.21	4.39 ± 0.20	0.72	4.21 ± 0.19	4.24 ± 0.20	4.57 ± 0.21	0.40
Circumference, cm								
Anterior	41.16 ± 1.26	40.64 ± 1.40	43.66 ± 1.33	0.26	39.08^b ± 1.26	42.53^{ab} ± 1.33	43.85^a ± 1.40	0.05
Median	37.79 ± 1.57	37.76 ± 1.73	40.27 ± 1.65	0.48	35.11^b ± 1.57	39.06^{ab} ± 1.65	41.65^a ± 1.73	0.03
Posterior	29.74 ± 2.02	29.34 ± 2.24	35.85 ± 2.13	0.07	27.68 ± 2.02	32.89 ± 2.13	34.38 ± 2.24	0.08

[a-b]Least squares means within a row and main effect lacking common superscript letters differ ($P < 0.05$).
$n = 33$ subprimals "normal fabrication" (2 sides and one Coulotte were missing compared to the $n = 36$ for dissection)

Table 11. Least squares means ± SEM for measurements of the top sirloin butt subprimal stratified by ribeye area and carcass weight category main effects

Measurement	*Ribeye area category, cm²*				*Carcass weight category, kg*			
	83.87 to 89.68	90.32 to 96.13	96.77 to 102.58	*P*-value	340.65 to 385.55	386.0 to 430.91	431.37 to 476.27	*P*-value
Muscle weight, kg	3.20 ± 0.07	3.15 ± 0.08	3.35 ± 0.08	0.21	2.83^{b} ± 0.07	3.43^{a} ± 0.08	3.44^{a} ± 0.08	< 0.01
Length, cm								
Dorsal	22.35 ± 0.43	22.23 ± 0.48	22.78 ± 0.46	0.69	22.17 ± 0.43	22.59 ± 0.46	22.60 ± 0.48	0.74
Medial	22.82 ± 0.46	23.26 ± 0.51	23.59 ± 0.48	0.71	22.68 ± 0.46	24.14 ± 0.48	23.84 ± 0.51	0.09
Ventral	22.49 ± 0.36	22.94 ± 0.39	22.85 ± 0.38	0.67	21.98^{b} ± 0.36	23.04^{ab} ± 0.38	23.26^{a} ± 0.39	< 0.05
Width, cm								
Anterior	24.24 ± 0.47	24.09 ± 0.52	24.33 ± 0.50	0.95	23.23^{b} ± 0.47	25.10^{a} ± 0.50	24.34^{ab} ± 0.52	0.04
Median	26.68 ± 0.45	25.98 ± 0.50	26.42 ± 0.48	0.58	25.22^{b} ± 0.45	27.14^{a} ± 0.48	26.73^{a} ± 0.50	0.02
Posterior	25.96 ± 0.46	24.79 ± 0.51	25.66 ± 0.49	0.24	24.38^{b} ± 0.46	25.98^{a} ± 0.49	26.04^{a} ± 0.51	0.03
Depth, cm								
Anterior	6.63 ± 0.45	7.04 ± 0.50	6.81 ± 0.48	0.83	6.42 ± 0.45	6.99 ± 0.48	7.07 ± 0.50	0.57
Median	7.79 ± 0.28	7.81 ± 0.31	8.10 ± 0.29	0.71	7.58 ± 0.28	7.88 ± 0.29	8.24 ± 0.31	0.31
Posterior	6.29 ± 0.42	6.04 ± 0.46	7.07 ± 0.44	0.25	6.08 ± 0.41	6.04 ± 0.44	7.28 ± 0.46	0.11
Circumference, cm								
Anterior								
Median	58.21 ± 0.96	55.25 ± 1.07	58.83 ± 1.02	< 0.05	55.50 ± 0.96	58.14 ± 1.02	58.64 ± 1.07	0.08
Posterior	55.27 ± 0.66	55.59 ± 0.72	57.49 ± 0.69	0.06	53.87^{b} ± 0.66	56.97^{a} ± 0.69	57.51^{a} ± 0.72	< 0.01

$^{a-b}$Least squares means within a row and main effect lacking common superscript letters differ ($P < 0.05$).

$n = 33$ subprimals "normal fabrication" (2 sides and one top sirloin butt were missing compared to the $n = 36$ for dissection)

Note: Anterior circumference, cm — REA*CW interaction ($P = 0.0392$)

Table 12. Least squares means ± SEM for measurements of the strip loin subprimal stratified by ribeye area and carcass weight category main effects

Measurement	Ribeye area category, cm^2				Carcass weight category, kg			
	83.87 to 89.68	90.32 to 96.13	96.77 to 102.58	*P*-value	340.65 to 385.55	386.0 to 430.91	431.37 to 476.27	*P*-value
Muscle weight, kg	$4.75^b \pm 0.10$	$4.76^b \pm 0.11$	5.14a ± 0.10	0.01	$4.56^b \pm 0.10$	$4.98^a \pm 0.10$	$5.10^a \pm 0.10$	< 0.01
Length, cm								
Dorsal	45.81 ± 0.63	44.49 ± 0.69	44.93 ± 0.63	0.36	$43.74^b \pm 0.63$	$44.98^{ab} \pm 0.66$	$46.50^a \pm 0.66$	0.02
Medial	45.29 ± 0.64	43.92 ± 0.71	44.07 ± 0.64	0.29	$43.00^b \pm 0.64$	$44.59^{ab} \pm 0.68$	$45.69^a \pm 0.68$	0.03
Ventral	40.95 ± 0.49	40.11 ± 0.54	40.33 ± 0.49	0.49	$39.18^b \pm 0.49$	$40.80^a \pm 0.52$	$41.41^a \pm 0.52$	0.01
Width, cm								
Anterior	19.14 ± 0.96	18.08 ± 1.06	18.58 ± 0.96	0.76	19.38 ± 0.96	17.87 ± 1.01	18.55 ± 1.01	0.56
Median	20.39 ± 0.99	18.78 ± 1.10	19.23 ± 0.99	0.53	20.39 ± 0.99	18.65 ± 1.05	19.36 ± 1.05	0.49
Posterior	21.74 ± 0.34	20.98 ± 0.38	21.97 ± 0.34	0.15	21.52 ± 0.34	21.31 ± 0.36	21.86 ± 0.36	0.55
Depth, cm								
Anterior	6.42 ± 0.12	6.24 ± 0.13	6.67 ± 0.12	0.07	6.42 ± 0.12	6.56 ± 0.13	6.35 ± 0.13	0.50
Median								
Posterior	7.17 ± 0.27	7.67 ± 0.30	7.83 ± 0.27	0.22	7.29 ± 0.27	7.95 ± 0.29	7.42 ± 0.29	0.23
Circumference, cm								
Anterior	$40.91^b \pm 0.43$	$41.59^b \pm 0.48$	$43.58^a \pm 0.43$	< 0.01	41.28 ± 0.43	41.95 ± 0.45	42.84 ± 0.45	0.06
Median	43.78 ± 0.50	43.96 ± 0.55	44.57 ± 0.50	0.52	44.38 ± 0.50	43.27 ± 0.53	44.66 ± 0.53	0.16
Posterior	47.90 ± 0.66	46.75 ± 0.73	48.84 ± 0.66	0.13	47.43 ± 0.66	47.70 ± 0.70	48.36 ± 0.70	0.62

[a-b]Least squares means within a row and main effect lacking common superscript letters differ ($P < 0.05$).

n = 34 subprimals "normal fabrication" (2 sides were missing compared to the n = 36 for dissection)

Note: Median depth, cm — REA*CW interaction (P = 0.0478)

Table 13. Least squares means for steak measurements of the *M. longissimus lumborum* stratified by ribeye area and carcass weight category main effects

Measurement	*Ribeye area category, cm²* 83.87 to 89.68	90.32 to 96.13	96.77 to 102.58	*P*-value	*Carcass weight category, kg* 340.65 to 385.55	386.0 to 430.91	431.37 to 476.27	*P*-value
Strip steak number	10.28 ± 0.25	10.58 ± 0.23	10.08 ± 0.23	0.34	9.78^{b} ± 0.25	10.67^{a} ± 0.23	10.50^{a} ± 0.23	0.04
Vein steak number	4.56 ± 0.32	4.17 ± 0.31	4.42 ± 0.31	0.68	4.39 ± 0.32	4.42 ± 0.31	4.33 ± 0.31	0.98
Total steak number	14.83 ± 0.37	14.75 ± 0.35	14.50 ± 0.35	0.79	14.17 ± 0.37	15.08 ± 0.35	14.83 ± 0.35	0.20
Mean steak weight, kg	0.18^{a} ± < 0.01	0.18^{ab} ± < 0.01	0.20^{b} ± < 0.01	0.04	0.18^{b} ± < 0.01	0.19^{a} ± < 0.01	0.19^{a} ± < 0.01	0.03
Steak yield, %	94.27 ± 0.80	94.85 ± 0.76	95.22 ± 0.76	0.69	94.54 ± 0.80	95.11 ± 0.76	94.69 ± 0.80	0.86
Saleable yield, %	97.27 ± 0.83	97.53 ± 0.79	97.11 ± 0.79	0.93	96.74 ± 0.83	97.25 ± 0.79	97.91 ± 0.79	0.59
Waste, %	2.23 ± 0.19	2.09 ± 0.18	2.03 ± 0.19	0.72	2.67^{a} ± 0.19	1.98^{b} ± 0.18	1.68^{b} ± 0.19	<0.01

[a-b]Least squares means within a row and main effect lacking common superscript letters differ ($P < 0.05$).
n = 36 subprimals; dissection

Table 14. Least squares means for steak measurements of the *M. gluteobiceps* stratified by ribeye area and carcass weight category main effects

Measurement	*Ribeye area category, cm²*					*Carcass weight category, kg*				
	83.87 to 89.68	90.32 to 96.13	96.77 to 102.58	SEM	*P*-value	340.65 to 385.55	386.0 to 430.91	431.37 to 476.27	SEM	*P*-value
Coulotte steak number	11.75[a]	10.25[b]	10.75[b]	0.26	< 0.01	10.75	11.08	10.92	0.26	0.68
Roast number	3.67	3.91	4.00	0.12	0.15	3.42[b]	4.25[a]	3.92[a]	0.12	< 0.01
Total steak number	15.41[a]	14.17[b]	14.75[ab]	0.27	< 0.01	14.17[b]	15.33[a]	14.83[ab]	0.27	0.02
Mean coulotte steak weight, kg	0.12	0.11	0.11	0.01	0.06	0.10	0.11	0.12	0.01	0.07
Mean roast weight, kg	0.79[b]	0.83[ab]	0.89[a]	0.02	0.02	0.72[b]	0.91[a]	0.88[a]	0.02	<0.01
Steak and Roast yield, %										
Saleable yield, %	89.75	88.17	90.40	0.87	0.19	88.54	90.73	89.05	0.87	0.19
Waste, %										

[a-b]Least squares means within a row and main effect lacking common superscript letters differ ($P < 0.05$).
n = 36 subprimals; dissection
Note: REA X HCW interaction for Steak and Roast yield % ($P = 0.0248$) and Waste ($P = 0.0433$)

Table 15. Least squares means for steak measurements of the *M. gluteus medius* stratified by ribeye area and carcass weight category main effects

Measurement	Ribeye area category, cm^2					Carcass weight category, kg				
	83.87 to 89.68	90.32 to 96.13	96.77 to 102.58	SEM	*P*-value	340.65 to 385.55	386.0 to 430.91	431.37 to 476.27	SEM	*P*-value
Baseball steak number	12.75	12.00	12.66	0.34	0.25	11.91	12.75	12.75	0.34	0.16
Center-cut steak number	9.33	9.75	9.33	0.23	0.36	8.92^{b}	9.75^{a}	9.75^{a}	0.23	0.03
Total steak number	22.08	21.75	22.00	0.44	0.86	20.83^{b}	22.50^{a}	22.50^{a}	0.44	0.02
Mean steak weight, kg	0.13	0.12	0.13	0.01	0.37	0.11^{b}	0.13^{a}	0.13^{a}	0.01	<0.01
Steak yield, %	97.42	97.50	97.02	0.33	0.55	97.37	97.11	97.46	0.33	0.75
Saleable yield, %	99.76	99.88	99.34	0.29	0.47	99.89	99.39	99.74	0.29	0.47

$^{a-b}$Least squares means within a row and main effect lacking common superscript letters differ ($P < 0.05$).

n = 36 subprimals; dissection

Table 16. Least squares means for steak measurements of the *M. semimembranosus* stratified by ribeye area and carcass weight category main effects

Measurement	*Ribeye area category, cm²*					*Carcass weight category, kg*				
	83.87 to 89.68	90.32 to 96.13	96.77 to 102.58	SEM	*P*-value	340.65 to 385.55	386.0 to 430.91	431.37 to 476.27	SEM	*P*-value
Total steak number	14.00[b]	14.67[a]	14.83[a]	0.20	0.02	13.83[b]	14.83[a]	14.83[a]	0.20	< 0.01
Mean steak weight, kg	0.39	0.40	0.41	0.01	0.09	0.37[b]	0.42a	0.42[a]	0.01	< 0.01
Steak yield, %	99.46	99.62	98.98	0.33	0.37	99.46	99.56	99.04	0.33	0.51

[a-b]Least squares means within a row and main effect lacking common superscript letters differ ($P < 0.05$).
n = 36 subprimals; dissection

Table 17. Least squares means for steak measurements of the bottom round flat subprimal stratified by ribeye area and carcass weight category main effects

Measurement	*Ribeye area category, cm^2* 83.87 to 89.68	90.32 to 96.13	96.77 to 102.58	SEM	*P*-value	*Carcass weight category, kg* 340.65 to 385.55	386.0 to 430.91	431.37 to 476.27	SEM	*P*-value
Total roast number	4.42	4.58	4.67	0.12	0.33	4.00[b]	4.75[a]	4.92[a]	0.12	<0.01
Mean roast weight, kg	0.80	0.82	0.84	0.02	0.36	0.72[b]	0.87[a]	0.87[a]	0.02	<0.01
Roast yield, %	82.13	83.17	82.16	0.49	0.25	81.96	82.63	82.87	0.49	0.41
Saleable yield, %	91.89	92.33	92.05	0.37	0.70	92.04	92.14	92.08	0.37	0.98
Waste, %	8.10	8.01	7.67	0.27	0.50	8.30	7.55	7.94	0.27	0.17

[a-b]Least squares means within a row and main effect lacking common superscript letters differ ($P < 0.05$).
n = 34 subprimals; "normal fabrication"

Table 18. Least squares means for steak measurements of the inside round subprimal stratified by ribeye area and carcass weight category main effects

Measurement	*Ribeye area category, cm²*					*Carcass weight category, kg*				
	83.87 to 89.68	90.32 to 96.13	96.77 to 102.58	SEM	*P*-value	340.65 to 385.55	386.0 to 430.91	431.37 to 476.27	SEM	*P*-value
Total steak number	13.67[ab]	13.17[b]	14.17[a]	0.25	0.03	13.17	13.92	13.92	0.25	0.07
Mean steak weight, kg	0.38[b]	0.40[b]	0.42[a]	0.01	< 0.01	0.37[b]	0.42[a]	0.42[a]	0.01	<0.01
Steak yield, %	99.82	99.53	99.86	0.44	0.85	99.50	100.12	99.59	0.44	0.56

[a-b]Least squares means within a row and main effect lacking common superscript letters differ ($P < 0.05$).
n = 34 subprimals; “normal fabrication

Table 19. Least squares means for steak measurements of the top sirloin butt subprimal stratified by ribeye area and carcass weight category main effects

Measurement	*Ribeye area category, cm²*					*Carcass weight category, kg*				
	83.87 to 89.68	90.32 to 96.13	96.77 to 102.58	SEM	*P*-value	340.65 to 385.55	386.0 to 430.91	431.37 to 476.27	SEM	*P*-value
Baseball steak number	8.00	8.25	7.00	0.41	0.09	7.83	8.00	7.42	0.41	0.59
Center-cut steak number	8.42	8.50	7.75	0.42	0.40	8.17	8.75	7.75	0.42	0.26
Total steak number	16.41	16.75	14.75	0.80	0.19	16.00	16.75	15.17	0.80	0.39
Mean steak weight, kg	0.16	0.16	0.17	0.01	0.22	0.14^{b}	0.18^{a}	0.18^{a}	0.01	<0.01
Steak yield, %	99.68	99.60	99.67	0.17	0.94	99.56	99.57	99.82	0.17	0.51

$^{a-b}$Least squares means within a row and main effect lacking common superscript letters differ ($P < 0.05$).
n = 33 subprimals; “normal fabrication”

Table 20. Least squares means for steak measurements of the strip loin subprimal stratified by ribeye area and carcass weight category main effects

Measurement	*Ribeye area category, cm²*					*Carcass weight category, kg*				
	83.87 to 89.68	90.32 to 96.13	96.77 to 102.58	SEM	*P*-value	340.65 to 385.55	386.0 to 430.91	431.37 to 476.27	SEM	*P*-value
Strip steak number	11.17	11.00	10.58	0.28	0.34	10.75	10.92	11.08	0.28	0.71
Vein steak number	4.75^{ab}	4.58^{b}	5.33^{a}	0.20	0.04	4.58	5.17	4.92	0.20	0.15
Total steak number	15.92	15.58	15.92	0.27	0.61	15.33	16.08	16.00	0.27	0.12
Mean steak weight, kg	0.21^{b}	0.22^{b}	0.23^{a}	0.01	< 0.01	0.20^{b}	0.23^{a}	0.23^{a}	0.01	< 0.01
Steak yield, %	92.38	93.46	94.02	0.72	0.28	92.73	93.63	93.51	0.72	0.63
Saleable yield, %	97.18	97.29	97.11	0.58	0.98	96.54	97.43	97.61	0.58	0.39
Waste, %	1.92	2.56	2.26	0.26	0.23	2.33	2.45	1.97	0.26	0.41

$^{a\text{-}b}$Least squares means within a row and main effect lacking common superscript letters differ ($P < 0.05$).
n = 34 subprimals; “normal fabrication”

Table 21. Least squares means and relative hindquarter composition percentages for dissected muscle weights stratified by ribeye area and carcass weight category main effects

	Ribeye area category, cm²						*Carcass weight category, kg*					
Muscle name	83.87 to 89.68	%	90.32 to 96.13	%	96.77 to 102.58	%	340.65 to 385.55	%	386.0 to 430.91	%	431.37 to 476.27	%
M. longissimus lumborum	3.68	15.50	3.83	15.97	4.04	16.05	3.63	16.49	3.92	15.40	3.99	15.69
M. gluteobiceps	7.29	30.71	7.26	30.28	7.62	30.27	6.56	29.80	7.79	30.68	7.81	30.72
M. gluteus medius	3.71	15.63	3.59	14.97	3.80	15.10	3.35	15.22	3.90	15.32	3.85	15.42
M. semimembranosus	6.53	27.51	6.66	27.77	6.94	27.57	6.12	27.81	7.01	27.54	7.01	27.58
M. semitendinosus	2.53	10.66	2.64	11.01	2.77	11.01	2.35	10.68	2.83	11.12	2.76	10.85

[a-b]Least squares means within a row and main effect lacking common superscript letters differ ($P < 0.05$).
n = 36 subprimals; dissection

Figure 1. Selected hindquarter muscles removed at the natural seams

Figure 2. *M. longissimus lumborum* being measured for length

Figure 3. *M. Gluteobiceps* cut separation and trim denotation

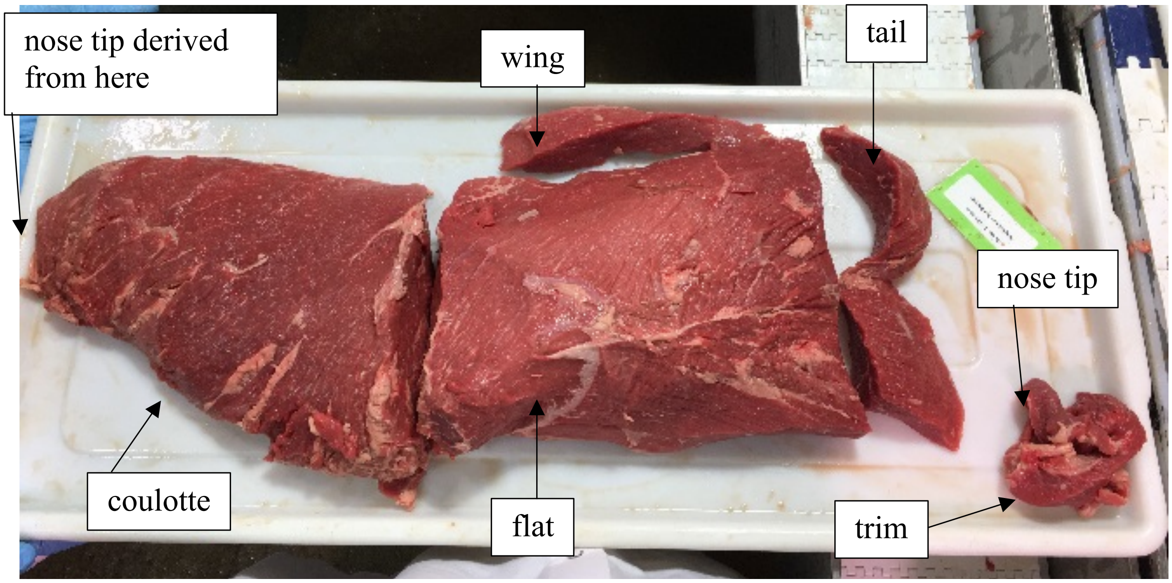

Figure 4. *M. gluteus medius* cut separation denotation

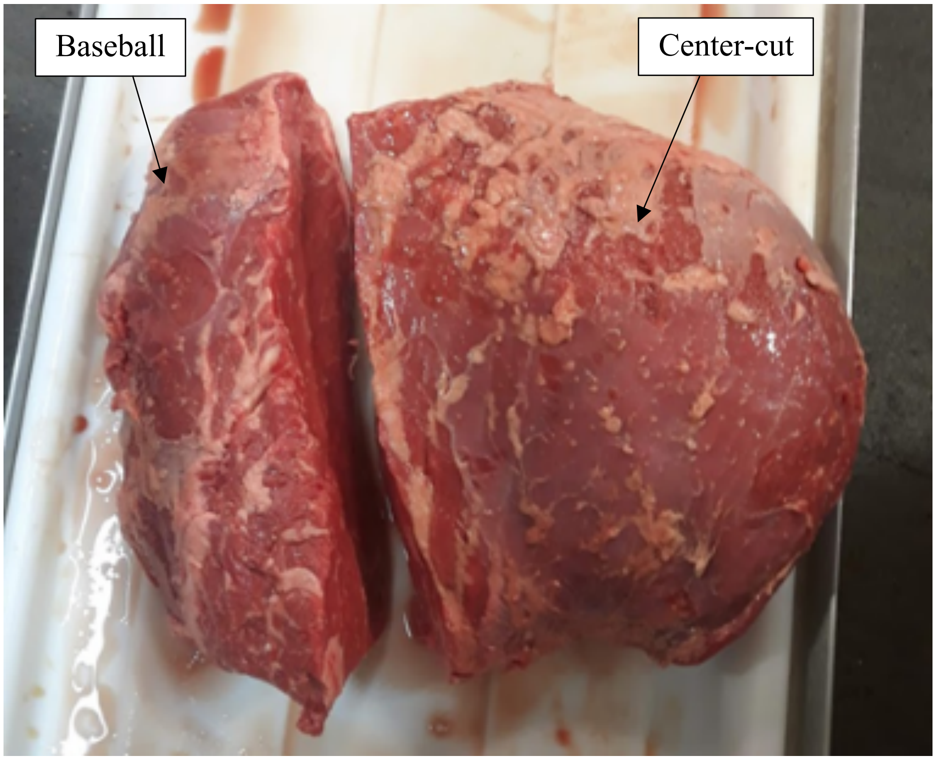

Figure 5. *M. Semimembranosus* steak slicing pattern

Figure 6. Top sirloin butt, cap steak slicing pattern

Figure 7. *M. gluteus medius* steak slicing pattern