THESIS

NUTRIENT ANALYSIS OF THE BEEF ALTERNATIVE MERCHANDISING CUTS

Submitted by

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ABSTRACT

NUTRIENT ANALYSIS OF THE BEEF ALTERNATIVE MERCHANDISING CUTS

Six carcasses were selected from each of four different beef packing plants. Carcasses were a combination of USDA Yield Grade 2 (n = 12) and USDA Yield Grade 3 (n = 12), US Quality Grade Premium Choice (n = 8), Low Choice (n = 8), and Select (n = 8), and two genders (steer n = 16, heifer n = 8). The four beef packing plants were located in the Midwestern part of the United States: two in Colorado, one in Kansas, and one in Nebraska. Beef Ribeye, Beef Loin, Strip Loin, and Beef Loin, Top Sirloin Butt subprimals were collected from both sides of these carcasses. Subprimals were vacuum packaged and aged for 14 to 21 days at 0 to 4°C. Subprimals were fabricated into the Beef Alternative Merchandising (BAM) cuts, as described by the Beef Innovations Group of the National Cattlemen's Beef Association (NCBA), at Colorado State University Meat Laboratory. Cuts from both sides of the carcass were randomly designated for use in obtaining cooked and raw nutrient data. All cuts were vacuum packaged and stored at -18°C for subsequent cooking and/ or dissection. Raw cuts were thawed at 0 to 4°C for 24 to 48 h and then dissected into separable lean, separable fat, and refuse (connective tissue). Cuts to be cooked were thawed for 24 to 48 h at 0 to 4°C, roasted or grilled, tempered for 24 to 48 h at 0 to 4°C, then dissected into separable lean, separable fat, and refuse. Following dissection,

both raw and cooked samples were homogenized and then stored at -80°C for subsequent nutrient analysis. The BAM cuts were analyzed for moisture, crude protein, percent lipid, and ash. Of the muscles that comprise the BAM cuts, the *Spinalis dorsi* contained the highest percent fat and lowest percent moisture. As fat content increased, moisture content subsequently decreased. The muscles from the Top Sirloin Butt were the leanest of the muscles comprising the BAM cuts. Fatty acid composition and cholesterol content was determined using gas liquid chromatography. Of the fatty acids identified, saturated-, monounsaturated-, and polyunsaturated fatty acids represented 44.92, 46.04, and 3.04%, respectively. The *Gluteus medius* contained the highest percentage of polyunsaturated fats regardless of Quality Grade. Of the fatty acids detected, oleic, palmitic, and stearic acids represented 74.56% of the fatty acid profile of all BAM cuts. *Trans* fats totaled 6.4% of the fatty acids identified for all the BAM cuts. This study identified seven cuts from three Quality Grades that qualify for USDA Lean and one cut from two Quality Grades that qualify for USDA Extra Lean.

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CHAPTER I

OBJECTIVES OF THESIS

The objectives of this thesis were:

(1) To identify, collect, and process Beef Alternative Merchandising (BAM) cuts,

(2) To generate raw and cooked nutrient composition data, and

(3) To determine differences in proximate values.

CHAPTER II

LITERATURE REVIEW

INTRODUCTION

The leading cause of mortality in the world is due to chronic diseases (i.e., heart disease, stroke, cancer, chronic respiratory diseases, and diabetes), which generally progress slowly and have a long duration (WHO, 2005). According to the World Health Organization (WHO) (2005), an increase in body mass index (overweight and obesity) is a major contributor to chronic disease, and in the U.S., prevalence of overweight individuals is expected to continually increase. The WHO (2005) estimated that 80% of premature heart disease, stroke, and type 2 diabetes and 40% of cancer could be prevented through a healthy diet, regular exercise, and avoidance of tobacco products. As consumption of a healthy diet is a modifiable risk factor for chronic disease, many people are being more conscious of what they are consuming.

Human life, including growth, maintenance, and tissue repair, is dependent on chemical substances known as nutrients (Stipanuk, 2000). It is commonly accepted that proteins, fats, carbohydrates, vitamins, minerals, and water are the major nutritional constituents of foods. Proteins, fats, and carbohydrates represent the macronutrients, while vitamins and minerals characterize the micronutrients. Deficiency or excess of

certain essential nutrients are a concern for human health. Table 2.1 lists the essential nutrients for humans.

Health is at the forefront of American lives. The following review briefly examines some of the essential nutrients for humans and the contribution of meat, particularly beef, to the human diet. In addition, this document reviews the newly amended government regulatory requirements for nutritional labeling of single ingredient meat products and introduces the Beef Alternative Merchandising cuts.

PROTEIN IN THE HUMAN DIET

In a living being, protein molecules function in maintaining body structure (e.g. collagen), in facilitating mobility (e.g. actin and myosin for muscle contraction), in transport (e.g. oxygen transport by hemoglobin), in metabolism (e.g. enzymes), in regulation (e.g. transcription factors), and in immune function (e.g. immunoglobulins) (McNurlan and Anthony, 2006). Protein turnover is a process in which body protein, namely amino acids, is continually degraded and synthesized. Protein degradation during digestion results in free amino acids that are available for protein turnover and for various metabolic pathways (McNurlan and Anthony, 2006). There are twenty α-amino (or -imino) α-carboxylic acids (listed in Table 2.2) that are the precursors for protein synthesis or are the products of protein degradation (Romans, 2001; Stipanuk and Watford, 2000). Amino acids are required as intermediates in the various pathways of metabolism and as precursors for the synthesis of numerous non-protein compounds (Stipanuk, 2000). The body is capable of synthesizing nonessential amino acids. However, the diet must provide

eight essential or indispensable amino acids (Table 2.2). Cysteine and tyrosine are sometimes listed as essential amino acids due to their sparing effects on the requirements for methionine and phenylalanine, respectively (Paul and Southgate, 1978).

Amino Acid Requirements

The body's demand for various amino acids depends on the metabolic state of an individual. The metabolic demand for an amino acid may be increased or the capacity to synthesize an amino acid may be decreased in instances of growth, injury, or disease; thus, an individual's dietary demand for a particular amino acid will increase in these scenarios (Stipanuk, 2000).

For protein metabolism, maintenance is the condition in which there is no change in the amino acid content of the body. That is, dietary intake of every amino acid is exactly balanced by losses in digestion, secretion, and metabolism (Stipanuk, 2000). The obligatory loss of amino acids is referred to as the unavoidable losses due to protein modification, loss of proteins through the epithelia, loss of amino acids in the urine, use of amino acids for synthesis of non-protein substances, and oxidation of amino acids as fuels (Stipanuk, 2000 and WHO, 2007). For maintenance, the dietary intake of amino acids must equal the obligatory loss of amino acids (Stipanuk, 2000). The recommended daily allowance (RDA) for dietary protein is 56 and 46 g per day for men and women, respectively (USDA, NAL, 2011). Table 2.3 lists individual essential amino acid requirements.

When protein synthesis is greater than degradation, as during growth, pregnancy, and lactation, amino acids are used for protein accretion (Stipanuk, 2000). As a result, the dietary protein requirements increase (WHO, 2007).

Protein quality is a result of differences in total protein and amino acid composition, which cause variation in their ability to satisfy the body's metabolic demand for amino acids (Stipanuk, 2000). Table 2.4 lists ranges of amounts of protein for various foods. The WHO (2007) defines protein quality as a measure of protein bioavailability. According to Stipanuk (2000), protein quality is dependent on three attributes: its digestibility, the availability of its amino acids, and the pattern of amino acids making up the protein. Digestibility of a protein is important in such that only the part of the protein that is digested can contribute to dietary amino acid requirements (Stipanuk, 2000). Meat has approximately 94% digestibility whereas whole corn and beans have 87% and 78%, respectively (FAO, 1991). Availability refers to the chemical integrity of an amino acid that determines the availability once absorbed into the body (Stipanuk, 2000). The last factor determining the efficiency of protein utilization is the amino acid composition.

Meat Protein

Meat protein, containing adequate quantities of all essential amino acids, is considered to have a high nutritional value (Bodwell and Anderson, 1987; Romans, 2001; Williams, 2007). Table 2.5 indicates the Reference Dietary Intakes (RDI) of the essential amino acids and lists the amount provided by beef (USDA, NAL, 2011; USDA, Release 23).

Free amino acid content in meat is in part determined by the proteolytic degradation of myofibrillar proteins, which occurs during postmortem aging of muscle (Mullen et al., 2000). Feidt et al. (1996) found that the extent of proteolytic degradation and the release of amino acids varied from muscle to muscle. Protein content and free

amino acid composition of meat is influenced by physiological factors; however, production factors such as nutrition and genetics have little influence (Scollan et al., 2006).

Mullen et al. (2000) found that total free amino acids in bovine muscle did not differ significantly within a muscle at various locations, but data suggested that individual amino acid concentration increased over the aging period of 15 days. Hollo et al. (2001) researched the effect of breed, slaughter weight, and gender on the amino acid profile of beef and the nutritional value of beef protein. Their results indicated that the amino acid profile was not influenced by breed or slaughter weight. However, muscles from females were comprised of greater amounts of essential amino acids than were those from males. No difference in nutritional value of beef protein was found between breed, slaughter weight, or gender (Hollo et al., 2001)

Amount of individual amino acids varies between muscles of various carcass locations (Feidt et al., 1996; Ma et al., 1961). Bovine muscles (from the rib and loin) considered as tender were comprised of more leucine and isoleucine than tougher muscles from the round (Ma et al., 1961). On the contrary, Feidt et al. (1996) found differences in isoleucine but no differences in leucine between the *Longissimus dorsi*, *Triceps brachii*, and *Rectus femoris*. Cornet and Bousset (1999) compared differences in amino acid content of muscles comprised mainly of white, glycolytic (fast twitch), red, oxidative (slow twitch), and intermediate muscles of porcine muscle. They found that oxidative muscles contained more aspartic acid, glutamine, and taurine, and glycolytic muscles contained highest concentrations of β-alanine and carnosine. Carnosine helps stabilize pH in anaerobic contraction in glycolytic muscles and β-alanine is a constituent

of carnosine (Cornet and Bouseet, 1999) . Variations in flavor between muscles can, in part, be attributed to variations in amino acid profile (Cornet and Bousset, 1999).

LIPID IN THE HUMAN DIET

In the human diet, fat is an essential nutrient which supplies the body with energy and essential fatty acids and provides transport for fat soluble vitamins (A, D, E, and K and carotenoids) (Martin and Coolidge, 1978; USDA/USD HHS, 2010). In most foods, fat is a mixture of triacylglycerides, phospholipids, sterols, and related compounds (Paul and Southgate, 1978). Triacylglycerides are compounds called esters that form from a reaction of an alcohol and an acid by the removal of water (Martin and Coolidge, 1978). One molecule of glycerol (a 3-carbon alcohol) binds to three molecules of fatty acids to form a triglyceride (Martin and Coolidge, 1978).

Fatty acids constitute greater than 90% of a fat molecule and, therefore, the types of fatty acids present determine certain properties of the fat (Martin and Coolidge, 1978). Properties that fat contributes to food products include (but are not limited to) shelf life stability, physical state (i.e., solid vs. liquid at room temperature), flavor, and aroma. The most common fatty acids found in food are listed in Table 2.6 (Paul and Southgate, 1978). Fatty acids are classified as saturated (SFA), mono-unsaturated (MUFA), and poly-unsaturated fatty acids (PUFA). The Dietary Guidelines for Americans (2010) recommend that adults limit the consumption of total fat to 20 to 35% of their total calories, with the majority of fat coming from MUFA and PUFA, less than 10% coming from SFA, and minimal trans fat consumption

Saturated Fatty Acids

Saturated fatty acids (SFA) derive their name from their chemical structure in which all of the carbon atoms contain a maximum number of hydrogen atoms and are connected by single bonds (Martin and Coolidge, 1978). Saturated fats are solid at room temperature (Martin and Coolidge, 1978). The human body uses SFA for physiological and structural purposes, but these structures can be synthesized endogenously, and therefore, SFA are not essential in the diet (USDA/ USD HHS, 2010). In the average American diet, about 11% of calories come from SFA with cheese, pizza, grain based desserts, dairy based deserts, and chicken contributing 9, 6, 6, 6, and 6%, respectively, whereas processed red meats (sausage, franks, and bacon) and ribs both contribute 5% (Dietary Guidelines for Americans, 2010).

Unsaturated Fatty Acids

As the name implies, unsaturated fatty acids have carbon atoms that are not completely saturated with hydrogen atoms (Martin and Coolidge, 1978). Unsaturated fatty acids are differentiated into mono- (MUFA) and poly-unsaturated (PUFA) fatty acids. The MUFA have one double bond connecting adjacent carbons, while PUFA have more than one double bond. Fats that are liquid at room temperature contain primarily unsaturated fatty acids (Martin and Coolidge, 1978). The American Dietary Guidelines (2010) recommend the majority of fatty acid intake be consumed in the form of MUFA and PUFA. Table 2.7 indicates various unsaturated fatty acids and significant dietary sources (USDA/USD HHS, 2005)

Trans Fatty Acids

Trans fatty acids have at least one double bond in the *trans* configuration (Mozaffarian et al., 2006). The majority of *trans* fat found in food is produced industrially during the partial hydrogenation of vegetable oils and account for 2 to 3% of total calories consumed in the United States (Mozaffarian et al., 2006). Naturally occurring *trans* fats, accounting for about 0.5% of total calories consumed, are found in meats and dairy products produced from a process called biohydrogenation in ruminant animals (Mozaffarian et al., 2006). In 2005, the average American consumed 5.84 grams per day of *trans* fat with 80% of that from industrial processed foods and oils and 20% from naturally occurring *trans* fats in animal derived products (Dietary Guidelines for Americans, 2005). In 2006, labeling of quantity of *trans* fatty acids on the Nutrition Facts label became mandatory and subsequently, American consumption of *trans* fat decreased (Dietary Guidelines for Americans, 2010). Baked goods, such as cakes, pies, cookies crackers and bread, contribute the greatest amount of *trans* fat at 40%, whereas animal products, margarine, fried potatoes, chips, and household shortening contribute 21, 17, 8, 5, and 4%, respectively, of *trans* fat (USDA/USD HHS, 2005). *The Dietary Guidelines for Americans* (2010) recommends consumption of fat-free or low-fat milk and milk products and lean meats and poultry to reduce the intake of synthetic *trans* fatty acids.

Phospholipid

Phospholipids are esters of fatty acids that include phosphoric acid and other constituents (Martin and Coolidge, 1978). Similar to triacylglycerides, phospholipids have a glycerol backbone. However, in phospholipids, the glycerol esterifies only two fatty acids along with a phosphate and an alcohol (Romans, 2001). Phospholipids are

found primarily in the adipocyte cellular membrane and subcellular organelles (McCormick, 1994).

Cholesterol

Cholesterol is the major sterol in the body serving as a precursor for many hormones, an essential constituent of cell membranes, and the precursor for bile salts necessary for digestion of lipids (Godber, 1994; Martin and Coolidge, 1978). The body synthesizes cholesterol in sufficient quantities; therefore, it is not a dietary essential nutrient (USDA/USD HHS 2010). The Dietary Guidelines for Americans (2010) recommend dietary intake of cholesterol to be less than 300 mg per day. The major sources of cholesterol in the diet include eggs (25% of total), chicken (12% of total), beef (6% of total), and beef burgers (5% of total) (USDA/USD HHS, 2010). Dietary cholesterol has a minor effect on blood cholesterol and is secondary to total caloric intake and saturated fatty acid intake (Romans, 2001).

LIPID IN BEEF

The lipid fraction of beef is of particular importance as it primarily contributes to meat quality. U.S. Quality Grades increase as the amount of intramuscular fat in the *Longissimus dorsi* increases. A greater amount of marbling reflects higher amounts of total intramuscular lipid, mainly comprised of triacylglycerides (Miller et al., 1987). Generally speaking, cuts from the hind-quarter are leaner than muscles from the rest of the carcass (Bodwell and Anderson, 1987). This difference in fat composition is attributed to muscle type and function. As total lipid in a muscle decreases, phospholipid

and cholesterol proportions increase (Bodwell and Anderson, 1987). Not only total lipid is of importance. Fatty acid composition of the lipid fraction is of concern regarding human health, flavor profiles of food, and shelf life.

Fatty Acid Composition

Evidence that different fatty acids have varying effects on human health and disease prevention is well documented, and therefore, particular attention should be placed on the fatty acid composition of a food.

Eichhorn et al. (1985) data indicated steer *longissimus* muscle samples to have approximately 47.9% SFA, 46.1% MUFA, and 5.4% PUFA. Approximately 20 years later, published data showed variations in fatty acid concentrations. Leheska et al. (2008) found SFA, MUFA, and PUFA concentrations of 45.1%, 51.6%, and 3.4%, respectively. The fatty acid concentrations reported by Leheska et al. (2008) show a decrease in SFA and PUFA percent and an increase in MUFA percent. Differences seen fatty acid concentrations were likely due to changes in diet or variations in intramuscular fat content. Eichhorn et al. (1985) observed that oleic (C18:1), palmitic (C16:0), and stearic (C18:0) acids comprise approximately 80% of the fatty acids in bovine tissues. Recent research confirm that C18:1, C16:0, and C18:0 represent the majority of the fatty acids in beef (Leheska et al., 2008).

Eichhorn et al. (1985) found that the *semitendinosus* muscle contained about 6% more PUFA than the *longissimus* muscle. These muscles have different functions in the body and therefore have different fat content. The difference in PUFA seen by Eichohorn et al. (1985) was likely due to differences in intramuscular fat content for the two muscles. The major PUFA in beef are linoleate (C18:2) and linolenate (C18:3).

Trans Fat in Ruminant-Derived Products

Meat and milk from ruminant animals provides the only natural source of trans fatty acids. Naturally occurring *trans* fatty acids found in ruminant meat and milk include primarily *trans*-11 18:1 (vaccenic acid) along with smaller amounts of *cis*-9 *trans*-11 18:2 (rumenic acid) (Wanders et al., 2010). The major industrially produced *trans* fatty acids include *trans*-9 18:1 (elaidic acid) and *trans*-10 18:1 (octadecenoic acid) with smaller amounts of *trans*-8 18:1 and *trans*-11 18:1 (vaccenic acid) (Wanders et al., 2010). One *trans fat* of particular dietary interest is conjugated linoleic acid (CLA). Different positional and geometric isomers of C18:2 make up CLA in foods (Scollan et al., 2006).

Substantial research with animal models has been conducted indicating that CLA does not have the same atherogenic effect as industrially produced *trans* fats. LeDoux et al. (2007) found that rumenic acid (*cis*-9, *trans*-11 CLA) reduced plasma concentration of low density lipoprotein (LDL) cholesterol compared to hamsters fed the *cis*-12 *trans*-10 CLA isomer. Valeille et al. (2005) found that butter enriched with rumenic acid reduced the atherogenic processes in hyperlipidemic hamsters. Kritchevsky et al. (2000) concluded that dietary CLA consumed in levels as low as 0.1% inhibited atherosclerosis, while dietary levels of 1% CLA induced regression of atherosclerosis by measure of aortic lesions in rabbits. This study was significant because the levels of dietary CLA were similar to those which humans consume had an affect on atherogenesis in an animal model (McLeod et al., 2004).

Some animal studies do not support the hypothesis that CLA is anti-atherogenic. Munday et al. (1998) found that the addition of CLA to an atherogenic diet increased the development of aortic fatty streaks (an indication of atherogenesis). However, the high

density lipoprotein (HDL) cholesterol to total cholesterol ratio increased which is considered to be less atherogenic.

A three week long dietary control study in humans found that a diet high in CLA concentration (~9% of calories) increased LDL cholesterol levels and the ratio of total to HDL cholesterol, but not to the extent that a diet high in industrial *trans* fatty acids (~7.5% of calories) does (Wanders et al., 2010). Participants in this study had abnormally high percent of total energy from fat in their diets (range 39.7 to 40.1%).

Although extensive research has been conducted on the effect of CLA in the human diet, no clear health effect has been identified. Further research on this topic is needed to determine CLA's effect in the diet.

Effects on Lipid Content

As intramuscular fat is directly related US Quality Grade of beef, and Quality Grade is a major price determination for beef, the research on factors affecting lipid deposition and composition is extensive. Many factors contribute to the total lipid quantity and lipid composition of beef such as USDA Quality Grade, finishing system, sex, breed, external fat trim, and cooking method.

Effect of Quality Grade

Brackebusche et al. (1991) tested the effect of marbling scores on percent protein, moisture, and fat for 15 different muscles. Marbling scores for the *Longissimus dorsi* included traces and slight for the low marbling group, small and modest for the intermediate marbling group, and slightly abundant for the high marbling group. Marbling had an effect on percent fat and percent water for all 15 muscles and had an effect on percent protein on 9 of the 15 muscles (Brackebusche et al., 1991). Substantial

research confirms differences in percent fat for USDA Quality Grade (Choi et al., 1987; Miller et al, 1981). Miller et al. (1981) attributed increased total lipid to an increase in tryacylglyceride content. Brackebusche et al. (1991) found a positive linear relationship between *longissimus* marbling and percent fat and a negative linear relationship between *longissimus* marbling and percent moisture in all muscles studied. Furthermore, Brackebusche et al. (1991) found that the ranking of muscles by percent fat had the same order in the intermediate and high marbling groups and nearly the same for the low marbling group. The ranking of muscles (starting with leanest) are: *semitendinosus, adductor, semimembranosus, supraspinatus,* gluteal group*, Rectus femoris, triceps brachii,* deep pectoral*, Biceps femoris, longissimus, Psoas major, infraspinatus, Rectus abdominis, Serratus ventralis,* and *spinalis* (Brackebushe et al. 1991). Statistical tests of difference for fat content between these muscles were not performed.

Effect of Finishing System

Substantial research has been performed on the effect of finishing diets on beef lipid. Differences in finishing systems result in variations of intramuscular fat deposition and changes of fatty acid composition. The difference between range- or grass-finished beef and concentrate- or feedlot-finished beef has received much attention. Research indicates that grain-finished beef has a higher concentration of total lipid and a lower percent moisture than grass-finished beef (Duckett et al., 2009; Leheska et al., 2008; Miller et al., 1981; Miller et al., 1987; Williams et al., 1983). Leheska et al. (2008) reported that grass-finished beef had less intramuscular fat with a more yellow appearance, which was attributed to forage diets containing greater concentrations of β-carotene. *Longissimus dorsi* from grain-finished cattle had greater amounts of

intramuscular fat as indicated by a higher marbling score (Leheska et al., 2008; Nuernber et al., 2005; Williams et al., 1983). The greater amount of intramuscular fat deposition by grain-finished cattle was attributed to a higher energy diet (Leheska et al., 2008).

Leheska et al. (2008) found that ground beef and strip steaks from grass-finished beef had greater concentrations of SFA and less MUFA than conventionally raised counter parts. They attributed this to greater concentrations of stearic acid (C18:0). Duckett et al. (2009) and Nuernberg et al. (2005) also found higher stearic acid concentrations in grass-finished beef than in grain-finished. The greater concentrations of MUFA found in grain-finished beef was attributed to greater individual concentrations of oleic acid (C18:1) (Leheska et al., 2008). Duckett et al. (2009) attributed increased oleic acid concentration to an upregulation of stearolyl CoA desaturase, the enzyme responsible for the desaturation of stearic acid to oleic acid. Grass-finished beef showed a greater concentration of *trans* vaccenic acid and total CLA than grain-finished beef (Duckett et al., 2009; Leheska et al., 2008). Other studies found a higher PUFA concentration for grass-finished cattle than for grain-finished cattle (Nuernberg et al., 2005).

Studies suggest that cholesterol values are not different between grass-finished or grain-finished beef (Leheska et al. 2008; Miller et al., 1981; Williams et al., 1983). Research has shown that triacylglyceride content was greater and phospholipid content was less in grain-finished than in grass-finished steers (Williams et al., 1983).

Although grass-finished beef has less total fat, consumers need to be aware that 85% lean ground beef from grass-finished beef is not different from grain-finished ground beef containing 85% lean (Leheska et al., 2008). Furthermore, a 100 g steak from

grain-finished beef would contribute only 23 kcal more energy than an equal portion of grass-finished steak (Miller et al., 1981).

Effect of Gender

Brackebusche et al. (1991) found that steers and heifers did not differ in percentage fat or percentage protein for 15 muscles and only 2 of the 15 muscles differed in percentage moisture. Westerling and Hedrick (1979) studied differences in fatty acid composition in beef due to gender and found that heifers had less linoleic (C18:2) and arachidonic (C20:4) acid, but no differences in total saturated or total unsaturated fat.

Eichorn et al. (1985) found that steer *semitendinosus* and *longissimus* muscles had higher percentages of SFA (mainly stearic acid) than those from bulls; however bull muscle samples contained approximately 5% more PUFA as a result of higher individual concentrations of linoleate (C18:2) and linolenate (C18:3). Gillis and Eskin (1979) found crossbred bulls to have higher myristic (C14:0), palmitoleic (C16:1), linoleic (C18:2) acids, but less oleic (C18:1) acid than steers.

Effect of Breed

Breed has an effect on lipid composition of beef. Gillis and Eskin (1979) found that Limousin-sired crossbred cattle contained higher amounts of myristic (C14:0), palmitic (C16:0), and palmitoleic (C16:1) acids in intramuscular fat than Simmental-sired cattle, whereas Simmental-sired crossbreds contained higher amounts of stearic (C18:0) acid in intramuscular fat than Limousin-sired cattle. For intramuscular lipid composition, beef from Angus-cross had more palmitoleic (C16:1) acid than intramuscular fat from Hereford or Shorthorn cattle (Gillis and Eskin, 1979). Breed effect on fatty acid

composition was attributed to the genetic influence on physiological growth rate (Gillis and Eskin, 1979).

Recent research using purebreds found that beef from Angus (*Bos taurus)* cattle had greater percent fat and less moisture, protein, and ash percentages than beef from Brahman (*Bos indicus)* and Romosinuano (Criollo breed) (Dinh et al., 2010). Dinh et al. (2010) also found beef from Angus and Brahman carcasses had a greater saturation index [SFA/(MUFA+PUFA)] than beef from Romosinuano. Beef from Romosinuano cattle had greater concentrations of PUFA than beef from Angus or Brahman cattle. Beef from Angus cattle had greater concentrations myristic (C14:0), palmitic (C16:0), stearic (C18:0), arachidic (C20:0), myristoleic (C14:1 *cis*-9), palmitoleic (C16:1 *cis*-9), oleic (C18:1 *cis*-9), and elaidic (C18:1 *trans*-9) acids than beef from Brahman and Romosinuano cattle (Dinh et al., 2010).

Effect of External Fat Trim

The removal of external fat prior to cooking meat generally results in a decrease in percent fat (Jones et al., 1992). Wahrmund-Wyle et al. (2000) found that external fat levels (0.0, 0.3, and 0.6 cm) did not affect the percent fat of retail beef cuts. Similarly, Harris et al. (1991b) found minimal differences in percent fat for varying fat trim levels. Wahrmund-Wyle et al. (2000) found Choice cuts trimmed to 0.3 and 0.6 cm had lowest moisture content compared to Choice cuts trimmed to 0.0 cm fat and Select cuts trimmed to 0.0, 0.3, and 0.6 cm fat. Jones et al. (1992) found a 7.7 and 12.2% reduction in total fat in all retail cuts investigated from Choice and Select, respectively, when all external fat was removed. They also found that in rib and blade roasts, percent fat was consistent or higher when fat was removed compared to those containing external fat (Jones et al.,

1992). Jones et al. (1992) concluded that large amounts of intermuscular fat could lead to "migration" of fat into the lean during cooking, thereby terminating any advantage to trimming the external fat before cooking. Furthermore, few differences were found in percent protein or fat retention in beef retail cuts due to external fat trim level (Wahrmund-Wyle et al., 2000).

External fat trim has an effect on the fatty acid composition of cuts. Harris et al. (1991a) investigated the effect of a 0.64 and 0.0 cm trim level on Select and Choice retail cuts. They found that fatty acids least affected by Quality Grade were myristoleic (C14:1) and stearic (C18:0), while palmitoleic (C16:1) and oleic (C18:1) acids were affected the most by Quality Grade. Harris et al. (1991a) found that retail cuts from Choice carcasses had more differences in individual fatty acid percent than those from Select carcasses, and most of the differences in fatty acid composition was seen in retail cuts from the rib and loin (Harris et al., 1991a). For steaks from Choice and Select carcasses cooked to 80°C, Harris et al. (1991b) found higher percentages of SFA in cuts without external fat compared to those with 0.64 cm external fat. Harris et al. (1991a) reported that fatty acid composition was most influenced by external fat trim when retail cuts were single muscle instead of multiple muscles due to external fat being the only source of separable fat.

Effect of Cooking

Applying heat to meat results in cooking and causes changes in structure and composition of meat. Changes in nutrient content results from moisture evaporation which alters percentages of protein, fat, and ash of cooked meat (Romans, 2001). Nutrient retention is defined as "the measure of the proportion of the nutrient remaining

in the cooked food in relation to the nutrient originally present in the raw food" (USDA Nutrient Retention Factors, Release 6, 2007). Smith et al. (1989) reported an increase in protein content after cooking for all cuts and cooking methods. Alfaia et al. (2010) found that grilling and broiling of beef resulted in less total lipid than microwaving. Luchak et al. (1997) reported an increase in fat and a decrease in moisture with an increase in cooking time. Similarly, Harris et al. (1991b) found percent fat increased and percent moisture decreased as degree of doneness increased regardless of fat treatment or Quality Grade. Furthermore, Harris et al. (1991b) reported little variations in fatty acid composition among varying degrees of doneness in Top Loin Steaks.

Because the B-vitamins are water soluble, they are especially sensitive to a braising cooking method (Romans, 2001). Thiamin and B6 was retained only 45% in braised beef, whereas they have 70 and 75%, respectively, retention when beef was broiled (USDA Nutrient Retention Factors, Release 6, 2007).

Bonsell, Andersen, and Rule (1993) reported type of cooking oil had an effect on cholesterol content and fatty acid composition of ground beef. Their results indicated that when frying ground beef in oil, cholesterol content decreased from the control (no oil), and when cooked in oil, the ground beef acquired the fatty acid profile of that particular oil. Alfaia et al. (2010) reported no differences between grilling, broiling, or microwaving on total SFA, total MUFA, or total PUFA content.

Effect Fatty Acids on Human Health

Saturated fatty acids (SFA) increase low-density lipoprotein (LDL) cholesterol (bad cholesterol) content of blood while PUFA tend to lower LDL cholesterol concentrations in blood (Katan et al., 1994). The major SFA found in most human diets

include palmitic, stearic, myristic, and lauric acids (Katan et al., 1994). However, these SFA have varying effects on human health. Lauric, myristic and palmitic acids all clearly raise LDL cholesterol (albeit at different levels) compared to PUFA; on the contrary, stearic acid tends to have a neutral effect (Katan et al., 1994; Peitinen et al., 1997; Romans, 2001). Pietinen et al. (1997) found that SFA were not directly associated with an increase risk of coronary heart disease (CHD). However, a high ratio of total cholesterol to high density lipoprotein (HDL) cholesterol is a powerful predictor of risk for myocardial infarction (Stampfer et al., 1991). The Dietary Guidelines for Americans (2005) recommend a therapeutic diet of less than 7% total fat derived from SFA and less than 200 mg cholesterol to lower elevated LDL cholesterol levels in the blood.

Long chain PUFA are widely accepted as having a beneficial impact on human health. Linoleic (C18:2) and linolenic (C18:3) acids are a dietary essential nutrient for humans. These fatty acids are necessary for growth and normal physiological function (Stipanuk, 2000). The long chain PUFA have been reported to have a protective affect against cardiovascular diseases and cancer (Gogus and Smith, 2010; Lavie et al., 2009).

Trans fatty acids have been linked to many health complications. It is generally accepted that the consumption of *trans* fatty acids increases the risk of coronary heart disease (Mozaffarian et al., 2006; Pietinen et al., 1997). The consumption of industrially produced *trans* fatty acids from the partial hydrogenation of vegetable oils raises levels of LDL cholesterol, reduces levels of HDL cholesterol, and increases the ratio of total cholesterol to HDL cholesterol (Katan et al., 1994 and Mozaffarian et al., 2006). From 14,916 men (ages 40 to 84 years) participating in the Physicians' Health Study, Stampfer et al. (1991) found that the ratio of total cholesterol to HDL cholesterol is a powerful

predictor of risk for myocardial infarction, and that a change of one unit in the ratio resulted in a 37% increase in relative risk for heart disease.

The association between dietary *trans* fatty acids and its effects on cholesterol has not been identified with the consumption of *trans* fatty acids from meat and dairy products (Mozaffarian et al., 2006). The predominant *trans* fatty acid in meat and dairy products is CLA. The health affects of CLA were discussed previously.

VITAMINS AND MINERALS IN MEAT

Protein foods including meat, poultry, seafood, eggs, beans and peas, soy products, nuts, and seeds are good sources of B vitamins (niacin, thiamin, riboflavin, and B6), Vitamin E, iron, zinc, and magnesium (USDA/USD HHS, 2010).

Minerals

Minerals are one of the classes of essential nutrients in the human diet. The broad function of minerals is to help build body structure and to help coordinate body function (Martin and Coolidge, 1978). Meat is especially rich in iron, zinc, and phosphorus, however, lacks calcium, iodine, and magnesium in sufficient amounts (Romans, 2001). In meat, more than half of the iron is heme iron, the most readily absorbed form of iron (Romans, 2001). Heme iron primarily functions in transport of and in the binding of oxygen to hemoglobin in the blood. (Martin and Coolidge, 1978). Zinc is involved in numerous enzyme systems and is necessary for normal growth (Martin and Coolidge, 1978). Phosphorus has many functions throughout the body: it has a key role in maintaining the acid/base balance of blood, chemically reacts with macronutrients to

release energy, is a component of ATP (functional form of energy), and is part of nucleoproteins that carry genetic information (Martin and Coolidge, 1978). Animals require molybdenum, nickel, selenium, chromium, copper, fluorine, manganese, cobalt, magnesium, and iodine for cell functions; therefore, these minerals are present in beef muscle, but not in levels necessary for human nutrition (Romans, 2001).

Plant mineral content can be influenced by soil, climate, seasonal conditions, and maturity of the plant, which in turn influences the mineral content of meat (Martin and Coolidge, 1978). Leheska et al. (2008) found that 85 % lean ground beef samples from grain-finished cattle contained lower concentrations of Mg, P, and K, but had greater concentrations of Na, Zn, and Vitamin B-12 than strip steaks of grass-finished animals. Leheska et al. (2008) attributed this difference to the difference in percent fat. Williams et al. (1983) found that tissue from grass-finished steers contained greater amounts of Zn, P, Mg, and K compared to tissue from grain-finished steers. Similarly, Duckett et al. (2009) found greater Ca, Mg, and K contents in grass-finished beef than grain-finished, whereas Na, Zn, and Fe were not different between the two.

Vitamins

Although meat is not a significant dietary source of most fat-soluble vitamins, it is a good source of many of the water soluble vitamins. Vitamins primarily function as cofactors in major metabolic pathways (e.g., TCA cycle, glycolysis, etc).

Thiamin

Thiamin or Vitamin B-1 acts as a coenzyme and is essential for oxidation of glucose and, therefore, normal functioning of the gastrointestinal tract and nervous system (Martin and Coolidge, 1978). Pork, lamb, and beef are good sources of thiamin

providing 55%, 6% and 4%, respectively, of the recommend daily value per serving (85 g) (Godber, 1994; Romans, 2001).

Riboflavin

Riboflavin is involved in energy and protein metabolism and thus is essential for growth and development and mental vitality (Martin and Coolidge, 1978). Pork, veal, lamb, and beef provide 21%, 18%, 15%, and 13%, respectively, of the recommended daily value per serving making them good dietary sources of riboflavin (Godber, 1994; Romans, 2001).

Niacin

Niacin functions with enzymes that are principally involved in glycolysis, tissue respiration, and fat synthesis (Martin and Coolidge, 1978). Meat provides a form of niacin that is more bioavailable than plant sources for humans (Romans, 2001). Chicken, veal, lamb, pork, and beef are good sources of niacin providing 79%, 60%, 36%, 34% and 22% of the recommend daily value per serving (Godber, 1994).

Vitamin B-12

Vitamin B-12 coenzymes are required for DNA synthesis and are necessary for normal function in cells of bone marrow, the nervous system, and the gastrointestinal tract (Martin and Coolidge, 1978). A single serving of beef or lamb will provide more than the recommended dietary requirement for B-12 (115 and 112% respectively) (Godber, 1994). Veal, pork and chicken also are good sources of B-12 providing 50%, 46%, and 15% , respectively, of the recommend daily value per serving (Godber, 1994; Romans, 2001).

Pasture-finished beef had greater α-tocopherol (Vitamin E) and β-carotene (Vitamin A) content than concentrate-finished beef (Duckett et al., 2009). Duckett et al. (2009) also reported higher concentrations of thiamin and riboflavin in grass-finished beef than for concentrate-finished beef.

Romans (2001) suggested that animal tissues contain "unidentified factors" that do not appear to be known vitamins, minerals, amino acids, or fatty acids that are needed for maximum growth, superior reproduction, and proper development.

LEAN MEAT IN THE HUMAN DIET

With Americans concerned about levels of fat intake, the beef industry has recently invested in considerable research efforts to identify lean cuts of beef. The need for recent nutrient analysis is a result of the beef industry producing leaner carcasses over the past twenty years. The USDA defines "lean" as less than 10.0 g total fat, 4.5 g or less saturated fat, and less than 95 mg of cholesterol per 100 g serving and "extra lean" as less than 5.0 g total fat, 2.0 g or less saturated fat, and less than 95 mg cholesterol per 100 g. Beef industry research has identified 29 cuts of beef which meet USDA's definition of lean which are listed in Appendix A. The Dietary Guidelines for Americans (2010) recommends incorporation of lean meat for a healthy diet. In order to assist consumers in making heart healthy food consumption decisions, the American Heart Association (AHA) developed a program called the Heart-Check Mark. The Heart-Check Mark symbol on a food package signifies a product meets the AHA's criteria for saturated fat and cholesterol. In order to meet the AHA's criteria for extra lean and heart healthy, meat

and seafood must contain less than 5.0 g total fat per Reference Amounts Customarily Consumed (RACC) and per 100 g, less than 2.0 g per RACC and per 100 g, less than 0.5 g *trans* fat per RACC and per labeled serving, less than 95 mg cholesterol per RACC and per 100 g, 480 mg or less sodium per RACC and per labeled serving, and contain 10% or more of the Daily Value of one of six nutrients (Vitamin A, Vitamin C, iron, calcium, protein, or dietary fiber per RACC)(AHA, 2011).

Much research has been conducted on the addition of lean beef to the diet and its affects on human health. O'Dea et al. (1990) investigated the affects of a low fat diet containing lean beef on plasma cholesterol and found that plasma cholesterol concentrations fell within one week of starting the lean beef supplemented diet. The lean beef was substituted for a high carbohydrate portion of the diet. This study attributed the decrease in plasma cholesterol to changes in LDL-cholesterol concentrations as HDL was not affected. O'Dea et al. (1990) also observed plasma cholesterol concentrations when beef fat (dripping) was substituted for the carbohydrate fraction of the diet. They found that 10% added beef fat did not affect plasma cholesterol, however 20% supplementation caused plasma cholesterol concentrations to rise. This study concluded that a low fat diet including lean beef was just as effective at lowering plasma cholesterol concentrations as other low fat diets (O'Dea et al., 1990).

Research has also been conducted in order to clarify the relationship between red meat and cancer, specifically colorectal cancer. Alexander et al. (2009) conducted a meta-analysis of animal fat and animal protein intake and risks of colorectal cancer. In this meta-analysis, researchers identified case-control studies that reported results for animal fat intake and combined this data with cohort data and found no statistical

associations linking animal fat or protein with colorectal cancer. Alexander et al. (2010) conducted a similar analysis of 15 studies for red meat intake and prostate cancer and found no association between consumption (high verse low intake) of red meat and total prostate cancer.

Research investigating the effects of meat and ruminant fat on coronary heart disease (CHD) also has been of high interest. Motard-Belanger et al. (2008) published results that suggested that moderate intakes of ruminant *trans* fatty acid, which represented intake levels well above the upper limit of current human consumption, had neutral effects on plasma lipids and other cardiovascular disease risk factors. In an 18-year-follow-up study of 3,686 Danish men and women (age 30-71) with no previous record of CHD, data suggested no association between ruminant derived fatty acid intake and risk of CHD (Jakobsen et al., 2008).

In addition, a meta analysis concluded that the consumption of red meat (not including processed meat) was not associated with CHD (relative risk = 1.00 per serving per day), diabetes mellitus (relative risk = 1.16 per serving per day), nor total ischemic stroke or total stroke mortality (relative risk = 1.17 per serving per day) (Mich et al., 2010).

Trans fats from ruminant derived product fail to induce the risk for CHD that is seen with consumption of industrially produced *trans* fat. Mozaffarian et al. (2006) attributed the lack of risk to 3 different hypothesis: people generally consume less *trans* fats from ruminant products than from industrially produced products; isomers vary from the naturally occurring *trans* fats to the industrially produced *trans* fats; and ruminant

derived products may have “balancing” factors which compensate for the small amounts of *trans* fats.

NUTRITIONAL LABELING OF MEAT

The following is derived from the Department of Agriculture, Food Safety and Inspection Service, Federal Register on 9 CFR Parts 317 and 381: Nutrition Labeling of Single-Ingredient Products and Ground or Chopped Meat and Poultry Products; Final Rule unless stated otherwise.

In an effort to educate U.S. consumers on diet and nutrition, the USDA continues to update regulations on nutrition labeling of products. Every five years the USDA in conjunction with the U.S. Department of Health and Human Services (HHS) develops Dietary Guidelines for Americans. The 2010 Dietary Guideline includes chapters on balancing calories to manage weight, avoiding certain foods and nutrients, increasing certain foods and nutrients, building healthy eating patterns, and making healthy choices (USDA/USD HHS, 2010). By combining Dietary Guidelines for Americans and information on nutrition labels of products, consumers can make educated decisions when purchasing food and developing a healthy diet.

Some beef products can vary from only 5 g of total fat per 100 g of meat (USDA Select Beef, round, outside round, steak) to 13 g of total fat per 100 g of meat (USDA Choice Beef, chuck, Denver Cut, steak) (NDL, Release 23, 2009). Without nutritional labeling of these products, consumers cannot assess precise levels of specific nutrients and thus cannot make educated choices. Because of this, the Food Safety Inspection

Service (FSIS) determined that "major cuts of single-ingredient raw, meat and poultry products that do not bear nutrition information on their labels or on point-of-purchase materials will be misbranded under section 1(n) of the Federal Meat Inspection Act (FMIA)(21 U.S.C. 601(n)(1)) and section 4(h)(1) of the Poultry Products Inspection Act (PPIA)(21 U.S.C. 453(h)(1))." To enforce this, the FSIS has amended the Federal meat and poultry products inspection regulations to require nutrition labeling of the major cuts of single-ingredient, raw meat and poultry products, including ground products, on labels or at point of purchase, effective January 1, 2012.

Major Cuts

The major cuts of single-ingredient, raw meat products, according to 9 CFR 317.344, are listed in Appendix B. Many trade associations feel that the list of "major cuts" is outdated. The list was last amended at 59 FR 45196, Sept. 1, 1994. However, FSIS did not propose to amend this list and did not allow the public to comment on such an amendment. Therefore, FSIS said they are not going to change the list of mandatory major cuts at this time.

Required Labeling

According to Title 21 CFR Part 101, Food Labeling, the headings required for labeling include "Nutrition Facts," "Amount per Serving," and "% Daily Value." Nutrients that must be included under Nutrition Facts (bold and left aligned) include "Calories," "Total Fat," "Cholesterol," "Sodium," "Total Carbohydrate," "Protein," "Dietary Fiber," and "Sugars." "Saturated Fat" and "*Trans* Fat" are required and indented from "Total Fat." "Vitamins and Minerals" are included as a percent of the recommended daily intake (RDI) separated from other nutrients by a solid, horizontal bar and must

include (in order) Vitamin A, Vitamin C, Calcium, and Zinc. Voluntary labeling of MUFA, PUFA, and potassium may be included in the Nutritional Facts table. Calories are determined using Atwater coefficients for protein, carbohydrate, and fat (4, 4, 9 calories/ g, respectively). Carbohydrate content is determined by subtracting the sum of crude protein, total fat, moisture, and ash from the total weight (Title 21 CFR Part 101).

Other mandatory items on the label include the name of the product, a list of ingredients, net quantity of contents, and an official inspection legend and number of official USDA establishment.

Exemptions

Certain products will be exempt from the nutrition labeling of single-ingredient products and ground or chopped meat and poultry products final rule. The products exempt include:

-products intended for further processing bearing no nutritional claim,

-products not intended for consumers bearing no nutritional claim,

-products less than 0.5 oz and individually packaged bearing no nutritional claim,

-products that are custom slaughtered or prepared,

-products intended for export,

-products that are "non-major" cuts of single-ingredient, raw products,

-ground or chopped products that qualify for small business exemption,

-products ground or chopped upon consumer request,

-ground or chopped products in packages of total surface area of 12 square inches or less, and

-ground products produced by small businesses bearing no nutritional claim other than percent fat and percent lean.

Small business exemptions are available only for ground or chopped products, not for major cuts of single-ingredient, raw meat and poultry. The Food and Drug Administration (FDA) defines a small businesses as those retailers who have annual gross sales of not more than $500,000 or have annual gross sales of foods or dietary supplements of not more than $50,000. Businesses that employ fewer than an average of 100 full-time employees and fewer than 100,000 units of that product are sold in the United States in a 12-month period also qualify for the small business exemption.

Enforcement

The final rule of the nutrition labeling of single-ingredient products and ground or chopped meat and poultry products will be effective on January 1, 2012. After implementation of the final rule, FSIS will conduct product sampling and nutrient analysis of ground and chopped products since visual assessment is not possible. Nutrition labeling of the major cuts of single-ingredient, raw products based off of USDA's National Nutrient Data Bank or USDA's National Nutrient Database for Standard Reference will not be sampled since this data is already USDA validated.

BEEF ALTERNATIVE MERCHANDISING CUTS

A combination of genetic selection and management practices in cattle production has contributed to continuous improvements in maximizing beef carcass yield and quality. As a result, carcass weights and the incidence of oversized carcasses have been gradually

increasing (Garcia et al., 2008; McKenna et al., 2002). The 2005 National Beef Quality Audit (NBQA) reported more than 5% of carcasses were oversized (Garcia et al., 2008). As hot carcass weight (HCW) and ribeye area (REA) increase, steak thickness decrease in order to maintain portion size of rib and loin steaks (Dunn et al., 2000; Leick et al., 2011). Bass et al. (2009) found that ribeye area does not accurately predict the size and dimensions (and ultimately portion size) of many muscles in the beef carcass. Furthermore, their results suggest that a wide range of REA would produce acceptable portion sizes from many muscles within the beef carcass (Bass et al., 2009). In an attempt to offer portion sizes for health conscious consumers, research funded by The Beef Checkoff, Cattlemen's Beef Board, and the National Cattlemen's Beef Association resulted in the innovation of the Beef Alternative Merchandising (BAM) cuts.

West et al. (2011) researched innovative retail merchandising strategies to accommodate for the growing trend of heavier carcass weights in the United States. They looked at three subprimals fabricated according to International Meat Purchase Specifications (IMPS)(Beef Rib, Ribeye, Lip-on, Boneless—IMPS 112A; Beef Loin, Strip Loin, Boneless—IMPS 180; and Beef Loin, Top Sirloin Butt, Boneless—IMPS 184), which when further processed, resulted in the BAM cuts. West et al. (2011) found that innovative fabrication of IMPS 112A, 180, 184 resulted in an increase in processing times compared to conventional fabrication and a decrease in total saleable yields for the top sirloin butt and ribeye but not for the strip loin. Furthermore, an estimated increase in retail sale price of 2.6, 11.6 and 26.9% for the strip loins, top sirloin butts and ribeyes, respectively, would be necessary to have an equivalent subprimal value as seen with conventional fabrication methods (West et al., 2011). On the contrary, Pfeiffer et al.

(2005) reported innovative fabrication had a higher yielding top sirloin cap (portion of the top sirloin butt) when compared to conventional fabrication, and no difference in fabrication methods for yield in the center-cut top sirloin (remaining portion of the top sirloin butt).

Dunn et al. (2000) investigated optimum ribeye area for portion cutting of beef steaks for foodservice. This study found that thicker steaks required increased cooking times and ranked more tender (sensory panel and shear force values) with a more intense beef flavor (sensory panel) (Dunn et al., 2000). Dunn et al. (2000) concluded that carcasses with ribeye areas ranging between 77.4 to 96.6 cm^2 had optimal tenderness and cooking times for foodservice-portioned steaks.

In a study designed to find an optimum size of beef *longissimus* muscle for consumers, Sweeter et al. (2005) found that South Dakotan consumers tended to prefer larger *longissimus* muscle sizes over smaller sizes. Furthermore, consumers had a lower willingness to pay for ribeye steaks cut in half (Sweeter et al., 2005). A similar study investigating the optimum consumer acceptance of ribeye, top loin, and sirloin steaks found that consumers preferred thinner ribeye (2.1 cm) and top loin (2.3 cm) steaks, but preferred average thickness of sirloin (3.0 cm) steaks (Leick et al., 2011). Although consumers in this study did not prefer the thickest steaks, the majority of consumers ranked thickness as the most important selection criteria for top loin and sirloin steaks and the second most important criteria for selection of ribeye steaks (Leick et al., 2011). The results from these two studies lack sufficient data indicating an "optimum" steak size for retail consumers, and data suggest that a potential market exists for steaks of all thicknesses and sizes (Leick et al., 2011; Sweeter et al., 2005). Additional research of

various locations and demographics of the U.S. is needed to verify findings of Leick et al. (2011) and Sweeter et al. (2005).

TABLES

Table 2.1: List of Essential Nutrients for Humans

Fatty Acids		
Linoleic		
α-Linoenic		
Minerals		
Calcium	Zinc	Chloride
Phosphorus	Copper	Boron
Magnesium	Manganese	Chromium
Iron	Iodine	
Sodium	Selenium	
Potassium	Molybdenum	
Vitamins		
Vitamin A	Niacin	
Vitamin C	Vitamin B-6	
Vitamin D	Thiamin	
Vitamin E	Pantothenic Acid	
Vitamin K	Folate	
Riboflavin	Biotin	
Vitamin B-12		
Amino Acids		
Histidine	Threonine	
Isoleucine	Tryptophan	
Leucine	Valine	
Lysine		
Methionine		
Phenlalanine		

Table 2.2: Amino Acids

Essential	Nonessential	Less Common, Nonessential
Histidine	Alanine	Cystine
Isoleucine	Arginine	Hydroxyproline
Leucine	Asparagine	Hydroxylysine
Methionine	Aspartic Acid	Citrulline
Phenylalanine	Cysteine	B-Alanine
Threonine	Glutamine	Aminobutyric Acid
Tryptophan	Glutamic Acid	Diaminopimelic Acid
Valine	Glycine	Dihydroxyphenylalanine
	Proline	Ornithine
	Serine	Taurine
	Tyrosine	

Table 2.3: Dietary Reference Intake for Amino Acids

Amino Acid	g/100 g Protein
Histidine	1.8
Isoleucine	2.5
Leucine	5.5
Lysine	5.1
Methionine [& Cysteine]	2.5
Phenylalanine [& Tyrosine]	4.7
Threonine	2.7
Tryptophan	0.7
Valine	3.2

Table adapted from USDA, NAL, 2011

Table 2.4: Food Sources of Protein

Meats
16-26 g per 3 oz Beef
22-26 g per 3 oz Chicken
15-23 g per 3 oz Fish
Cereals and Legumes
2 g per ½ cup cooked White Rice
8 g per oz Peanuts
8 g per ½ cup Black Beans
9 g per ½ cup Tofu
Dairy
8 g per cup Milk
7 g per oz Cheddar Cheese
Eggs
6 g per Egg

Adapted from Stipanuk, 2006

Table 2.5: Comparison of Beef and RDI of Individual Amino Acids[1] (g/100 g)

	His	Ile	Leu	Lys	Met (+Cys)	Phy (+Tyr)	Thr	Trp	Val
RDI[2]	1.8	2.5	5.5	5.1	2.5	4.7	2.7	0.7	3.2
Beef	0.95	1.4	2.4	2.5	1.2	2.1	1.2	0.2	1.5

[1]His = Histidine; Ile = Isoleucine; Leu = Leucine; Lys = Lysine; Met = Methionine; Cys = Cysteine; Phy = Phenylalanine; Tyr = Tyrosine; Thr = Threonine; Trp = Tryptophan; Val = Valine

[2]RDI = Recommended Daily Intake.

Table 2.6: Fatty Acids Commonly Found in Foods

Carbon	:	Double Bonds	Common Name
SFA[1]			
C4	:	0	Butyric
C6	:	0	Caproic
C8	:	0	Caprylic
C10	:	0	Capric
C12	:	0	Lauric
C14	:	0	Myristic
C16	:	0	Palmitic
C18	:	0	Stearic
C20	:	0	Arachidic
C22	:	0	Behenic
C24	:	0	Lignoceric
MUFA[2]			
C16	:	1	Palmitoleic
C18	:	1	Oleic
C20	:	1	Eicosenoic
C22	:	1	Erucic
PUFA[3]			
C18	:	2	Linoleic
C18	:	3	Linolenic
C20	:	4	Arachidonic

[1]SFA = Saturated Fatty Acid

[2]MUFA = Monounsaturated Fatty Acid

[3]PUFA = Polyunsaturated Fatty Acid

Table 2.7: Dietary Sources of Unsaturated Fatty Acids

Fatty Acid	Dietary Source
MUFA[1]	-vegetable oils (liquid at room temperature) -nuts
Omega (α-linolenic)	-soybean oil -canola oil -walnuts -flaxseed
Omega-3 (EPA[2] & DHA[3])	-fish -shellfish
Omega-6	-soy bean oil -corn oil -safflower oil

[1]MUFA = Monounsaturated Fatty Acid
[2]EPA = Eicosapentaenoic Acid
[3]DHA = Docosahexaenoic Acid

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CHAPTER III

NUTRIENT ANALYSIS OF THE BEEF ALTERNATIVE MERCHANDISING CUTS

INTRODUCTION

A combination of genetic selection and management practices in cattle production has contributed to continuous improvements in maximizing beef carcass yield and quality. As a result, carcass weights and the incidence of oversized carcasses have been gradually increasing (Garcia et al., 2008; McKenna et al., 2002). The 2005 National Beef Quality Audit (NBQA) reported more than 5% of carcasses were oversized (Garcia et al., 2008). According to the USDA's National Agricultural Statistics Service, beef carcasses have steadily increased in average dressed weight from 267.41 kg in 1968 to 355.94 kg in 2009 (USDA, National Livestock Slaughter Annual Summary). Increased carcass sizes result in larger primals and sub-primals, especially in oversized carcasses. As hot carcass weight (HCW) and ribeye area (REA) increase, steak thickness decrease in order to maintain portion size of rib and loin steaks (Dunn et al., 2000; Leick et al., 2011). Bass et al. (2009) found that ribeye area does not accurately predict the size and dimensions (and ultimately portion size) of many muscles in the beef carcass. Furthermore, their results suggest that a wide range of ribeye area sizes would produce acceptable portion sizes from many muscles within the beef carcass (Bass et al., 2009). In an attempt to offer portion sizes for health conscious consumers, research funded by The Beef Checkoff,

Cattlemen's Beef Board, and the National Cattlemen's Beef Association resulted in the innovation of the Beef Alternative Merchandising (BAM) cuts.

The USDA National Nutrient Database for Standard Reference (SR) (Release 23) provides food composition information for the National Food Survey and serves as the core data for many commercial and international databases. The Food Safety and Inspection Service (FSIS) has specified the SR as the source of nutrient information for labeling of beef products in its mandatory labeling of single ingredient meats. In addition to labeling, the SR also is used in many other settings including clinical practice, providing clients with nutritional solutions; in food service, offering accurate nutritional information; in research, providing a quickly searchable database; and in everyday life, providing Americans the nutritional information required to make healthy food choices. The current release of the SR provides food and nutrient composition data for over 500 beef items. While the nutrient data for 13 beef cuts, beef organ meats, ground beef, and the newly developed Beef Value Cuts were updated in the last seven years, most of the data in SR dates back to the 1980s. The Nutrient Data Laboratory (NDL) website (http://www.ars.usda.gov/ba/bhnrc/ndl) also provides information on cooking yields and nutrient retention factors for minerals and vitamins, which date back to 1960-1970. Currency of the beef nutrient data is critical to the industry. First, it will allow for the most accurate nutrient data to be on beef nutrient labels in the meat case, which will provide opportunity for on-pack nutrient claims. More specifically, this research will allow for access of the nutrient data for the innovative BAM cuts, and for the BAM cuts to be marketed as Lean or Extra Lean when appropriate.

MATERIALS AND METHODS

The following section describes the materials and methods used for completing the objectives of the Nutrient Analysis of the BAM Cuts.

Carcass Identification and Collection

Before beginning the study, a carcass sampling plan was generated (Table 3.1). Six carcasses were selected from four different beef packing plants. Carcasses were a combination of USDA Yield Grade 2 (n = 12) or 3 (n = 12), U.S. Quality Grade Premium Choice (n = 8), Low Choice (n = 8), or Select (n = 8), and two genders (steer, n = 16, or heifer, n = 8) carcasses. The four beef packing plants were located in Colorado, Nebraska, and Kansas. Trained personnel from Colorado State University (CSU) traveled to the packing plants and selected carcasses based on USDA standards in accordance to the sampling plan and recorded carcass trait information (Tables 3.2 and 3.3). Table 3.2 identifies carcass trait information for carcasses providing Beef Rib and the Beef Loin, Strip Loin subprimals. Table 3.3 identifies carcass trait information for carcasses providing Beef Loin, Top Sirloin Butt information. Subprimals collected included the Beef Rib, the Beef Loin, Strip Loin, and the Beef Loin, Top Sirloin Butt. Subprimals from both sides of the carcass were identified, vacuum packaged, and transported under refrigeration to CSU's Meat Laboratory. Subprimals were aged 14 to 21 days postmortem at 0 to 4° Celsius (C).

Product Fabrication

After aging was complete, subprimals were fabricated into the BAM cuts, as described by the Beef Innovations Group of National Cattlemen's Beef Association

(NCBA). The steaks, filets, and roasts were packaged, frozen, and stored at -18° C. Below is an outline of the fabrication of the BAM cuts from their respective subprimals.

107 Beef Rib, Oven Prepared

The Beef Rib, Oven Prepared (Institutional Meat Purchase Specification (IMPS) 107) was fabricated into the Beef Rib, Ribeye Roll, Lip-on (IMPS 112A) according to the North American Meat Processors guide to fabrication. The 112A then was fabricated into boneless, single muscle cuts (1) *Biceps femoris*: Beef Ribeye, Cap Steak, (2) *Longissimus dorsi*: Beef Ribeye, Petite Roast, and (3) *Longissimus dorsi*: Beef Ribeye, Filet. The fabrication of the ribeye into BAM cuts is outlined in Appendix C.

180 Beef Loin, Strip Loin

The Beef Loin, Strip Loin (IMPS 180) was fabricated so that the *Gluteus medius* (vein roast) was removed, and the external fat was trimmed to a maximum level of 0.32 cm. The remaining *Longissimus dorsi* was cut into boneless single muscle cuts (1) Beef Loin, Top Loin, Petite Roast and (2) Beef Loin, Top Loin, Filet. Cuts from the Strip Loin will be referred to as Top Loin cuts. The fabrication of the strip loin into BAM cuts is outlined in Appendix D.

184 Beef Loin, Top Sirloin Butt

The Beef Loin, Top Sirloin Butt (IMPS 184) was first trimmed to an external fat level of 0.32 cm. The *Biceps femoris* was removed at the natural seam and fabricated into boneless (1) Beef Loin, Top Sirloin, Cap Steak. The *Gluteus accessorius* and the *Gluteus profundus* (mouse meat) was removed from the *Gluteus medius*. The *Gluteus medius* (or Center-Cut) was fabricated into boneless (1) Beef Loin, Top Sirloin, Petite Roast and (2)

Beef Loin, Top Sirloin, Filet. The fabrication of the strip loin into BAM cuts is outlined in Appendix E.

Cooking

Frozen cuts were thawed in original packaging under refrigeration (0 to 4°C) for 24 to 48 hours. Product was cooked according to Grilling Standard Operating Procedure (SOP) (Appendix F) or Roasting SOP (Appendix G). All (1) Beef Ribeye, Cap Steak, (2) Beef Ribeye, Filet, (3) Beef Loin, Top Loin Filet, (4) Beef Loin, Top Sirloin, Cap Steak, and (5) Beef Loin, Top Sirloin, Filet, were grilled. All (1) Beef Ribeye, Petite Roast, (2) Beef Loin, Top Loin, Petite Roast, and (3) Beef Loin, Top Sirloin, Petite Roast, were roasted.

Dissection

Cuts were dissected either after thawing for raw analysis or 24 to 48 hours after cooking for cooked analysis. All cuts were dissected into three components: separable lean, external fat, and refuse. Refuse consisted of heavy connective tissue. No intramuscular fat was dissected. All components were weighed to the nearest 0.1 g. Lean and external fat was homogenized and stored for subsequent nutrient analysis. All refuse was discarded after weighing.

Homogenization

All cuts were homogenized in accordance with Beef Nutrient Data Improvement Study SOP for Homogenization (Appendix H). After homogenization, samples were stored at -80° C. Following homogenization of all cuts, composites were compiled according to a predetermined plan (Table 3.4). All samples were stored at -80°C for subsequent nutrient analyses.

Nutrient Analysis

Moisture Analysis

Moisture analysis was performed using the AOAC (2006a) Official Method 950.46 moisture removal process. Samples (approximately 2.0 g) were weighed out into aluminum tins and allowed to dry for 24 h at 100 °C in an air oven. After drying in the oven, the samples were allowed to cool in a desiccator and then were weighed. Loss in weight was reported as percent moisture.

Percent Ash

Ash was determined using the ash oven method described in the AOAC (2006b) Official Method 920.153. Approximately 1.0 g of sample was placed into a dry, pre-weighed crucible. The samples were then placed into a Thermolyne box furnace at 600°C for 24 hours. Samples were allowed to cool in a desiccator and weighed. Ash was calculated by loss in weight.

Crude Protein Determination

Crude protein was determined using the AOAC (2006c) Official Method 992.15 (TruSpec CN Carbon/Nitrogen Determination Instruction Manual, December 2004, Leco Corp.St. Joseph, MI). Ethylenediaminetetraacetic Acid (EDTA- 9.75% nitrogen) was used as a standard reference for calibration purposes as well as blanks. A standard and blank ran every 25 samples. Samples (approximately 0.1 g) were weighed into aluminum combustion tins and weights were recorded. Crude protein levels were determined by multiplying each protein level by a nitrogen factor of 6.25 after optimizing each sample based on the standard.

Total Lipid and Cholesterol Determination

Total lipid was extracted and quantified from 1 g of homogenized sample using the method of Folch et al., (1957) as modified by Bligh and Dyer (1959). Total cholesterol was determined via gas liquid chromatography using a SPB-1 fused capillary column (30 m x 0.53 mm i.d; Supelco, Bellefonte, PA) with column temperature at 250°C and detector and injector temperatures at 300°C as described by Dinh et al. (2008).

Fatty acid analysis

Fatty acid methyl esters were prepared as described by Parks and Goins (1994) and analyzed via gas chromatography using a Agilent (Avondale, PA) Model 6890 series II gas chromatograph fixed with a series 7683 injector and flame ionization detector. The instrument was equipped with a 100-m x 0.25-mm (id) fused silica capillary column (SP-2560 Supelco Inc. Bellefonte, PA). The carrier, gas ramping temperatures, and flow rates were similar to those described by Duckett et al. (2002). Fatty acids were quantified by incorporating internal standards (C12:0 and C27:0; Nu-Check Prep, Elysian, MN; Matreya, Pleasant Gap, PA; and Supelco, Bellefonte, PA) into each sample prior to methylation.

Selenium

Selenium analysis was performed using the AOAC (2005) Official Method 986.15 hydride generation method. Briefly, the sample was digested using perchloric acid, prior to being reduced with hydrochloric acid (HCl). The sample was reacted with sodium borohydride to produce the volatile selenium hydride, which was measured via atomic absorption spectroscopy with at quantitation limit of 30 ppb.

Vitamin B-12

Sample was accurately weighed in a flask. Forty ml of 50 mM sodium acetate buffer (pH 4.0), 1 mL of sodium cyanide (1%), 0.25 g of α-amylase, and 1 g of pepsin were added under agitation and the solution was incubated at 37 °C for 3 h. The pH value of the solution was adjusted to 4.8 using sodium hydroxide solutions and then heated at 100 °C for 35 min under nitrogen steam reflux and agitation. After cooling to room temperature, the solution was quantitatively transferred in a 50 mL of volumetric flask. Then, 125 μL of internal standard solution was added followed by the addition of deionized water. The resulting solution was shaken fully, centrifuged at 8000 × *g* for 10 min. The supernatant was filtered through a 0.45 μm membrane filter before injection. Vitamin B-12 was analyzed using a Waters HPLC system (Waters Corporation, Milford, MA, USA), equipped with in-line degasser AF and a XTerra™ MS C_{18} column (3.9 mm × 150 mm, 5 μm, Milford, MA, USA, and connected to Micromass ZQ 4000 electrospray mass spectrometer (Manchester, U.K.). Nitrogen was used as both a desolvation gas at a flow rate of 350 L/h and cone gas at a flow rate 50 L/h. The desolvation temperature was set at 350 °C.

STATISTICAL ANALYSIS

Proximate Analysis

The dependent variables fat, protein, moisture and ash for a given muscle were analyzed from individual animal samples. Independent variables included U.S. Quality Grade (QG), gender (G), USDA Yield Grade (YG) and their two factor interactions.

Statistical analysis was performed using the mixed model procedure of SAS (SAS Institute, Inc., Cary, NC). Two possible random portions of the model were considered. The first was the traditional homogeneous variance model with a single residual pooled variance, and the second was a heterogeneous variance model with a separate residual variance for each quality grade. If the heterogeneous variance model was a better (chi-square, $P < 0.05$) fit of the data, then the heterogeneous variance model was selected. Otherwise the simpler homogeneous variance model was selected as the final model.

Weights for least squares means were based on an NCBA slaughter market survey to represent cattle being slaughtered (Garcia et al, 2005). USDA Quality Grades were weighted 1:2:2 for Premium Choice (PC), Low Choice (LC), and Select (SE), respectively. All Choice refers to weights of 1:2 for PC and LC, respectively, and All Grades refers to weights of 1:2:2 for PC, LC, SE, respectively. Genders were weighted 1:2 for heifers and steers, respectively. USDA Yield Grades were equally weighted (1:1) for Yield Grades 2 (YG2) and 3 (YG3). Fixed effects were evaluated at $P = 0.05$. When tests of mean differences resulted in more comparisons than degrees of freedom, the Boniferroni corrected probability was used as the criteria for significance.

Composite Analysis

Composite samples weighted in 1:2 ratio for Gender and a 1:1 ratio for Yield Grade were used for determination of fatty acid composition, Vitamin B-12 content, selenium content, cholesterol content, and differences in cooking method. All Choice refers to weights of 1:2 for PC and LC, respectively, and All Grades refers to weights of 1:2:2 for PC, LC, SE, respectively. Independent variables include USDA Quality Grade, raw vs. cooked, and when more than one cooking method was used for an individual

muscle, cooking method was nested within cooked data. Two-way interactions were included for these factors. The random portion of the model included composite variability within Quality Grade (this includes animal variability), random variation among composites from the same carcass but from different sides of the carcass, and random variation within side among composites from different cuts or cooking method from the same muscle. Three different heterogeneous variance models were considered for these analyses. These were separate residual variances for different Quality Grades, raw vs. cooked samples, or raw and each cooking method. The final model selected had the smallest goodness fit statistic. Differences between least squares means were examined using the Boniferroni correction to determining significance.

RESULTS AND DISCUSSION

Proximate

Spinalis dorsi Raw

Proximate estimate percentages for the raw *Spinalis dorsi* (SD) are shown in Table 3.5. All proximate (fat, protein, moisture, and ash) values had homogeneous variance ($P > 0.05$). The SD from Premium Choice (PC) carcasses expressed higher ($P < 0.0125$) proportions of fat than the SD from carcasses that graded USDA Select (SE). Raw SD from carcasses grading Yield Grade 2 (YG2) had higher fat percent ($P < 0.05$) than SD from carcasses of Yield Grade 3 (YG3). The raw SD from SE carcasses had more ($P < 0.0125$) protein percentage than raw SD from PC carcasses. The raw SD from PC carcasses had less ($P < 0.0125$) percent moisture than the raw SD from SE carcasses.

The weighted fat content from All Choice for the raw SD was less ($P < 0.0125$) than the fat content of raw SD from SE carcasses. Raw *Spinalis dorsi* from YG2 carcasses had less ($P < 0.05$) percent moisture than those from YG3 carcasses.

Spinalis dorsi Grilled

Proximate estimates for grilled *Spinalis dorsi* (SD) are shown in Table 3.6. Null model likelihood ratio test indicated that fat and ash values had heterogeneous variance ($P < 0.05$), while protein and moisture had homogeneous variance ($P > 0.05$). Heterogeneous variance was corrected by using individual residual variance specific for each estimate and standard error. Grilled SD from PC carcasses had higher ($P < 0.0125$) percent fat and lower ($P < 0.0124$) proportions of protein than those from SE carcasses. Grilled SD weighted for All Choice had higher ($P < 0.0125$) fat content than grilled SD from SE carcasses. Grilled SD from steer carcasses had higher ($P < 0.05$) percent of protein than grilled SD from heifer carcasses, and grilled SD from YG2 carcasses had lower ($P < 0.05$) protein content than those from YG3 carcasses.

Ribeye Longissimus dorsi Raw

Proximate estimates for raw Ribeye *longissimus dorsi* (RLD) are shown in Table 3.5. Null model likelihood ratio test indicated that all proximate (fat, protein, moisture, and ash) values had homogeneous variance ($P > 0.05$). Quality Grade influenced ($P < 0.05$) percent fat in the RLD whereas gender, yield grade, and any interactions were insignificant ($P > 0.05$). Raw RLD from PC carcasses had higher ($P < 0.0125$) percentage of total fat than those from LC or SE carcasses. Raw RLD weighted for All Choice had higher ($P < 0.0125$) fat content than those from SE carcasses. Raw RLD from PC carcasses had lower ($P < 0.0125$) percent protein and percent moisture than those from

LC and SE carcasses. Percent moisture from raw RLD weighted for All Choice was lower ($P < 0.0125$) than raw RLD from SE carcasses.

Ribeye Longissimus dorsi Roasted

Proximate estimates for roasted Ribeye *Longissimus dorsi* (RLD) are shown in Table 3.6. Fat and moisture displayed heterogeneous variance ($P < 0.05$). Heterogeneous variance was corrected by using individual residual variance specific for each estimate and standard error. Roasted RLD from SE carcasses had lower ($P < 0.0125$) percent fat than those from PC and LC carcasses and those weighted for All Choice. Roasted RLD from SE carcasses had higher ($P < 0.0125$) percent moisture than those from PC carcasses and those weighted for All Choice. No differences between Quality Grade, Yield Grade, or gender were seen for percent protein or percent ash in the roasted RLD.

Ribeye Longissimus dorsi Grilled

Proximate estimates for grilled Ribeye *longissimus dorsi* (RLD) are shown in Table 3.6. Null model likelihood ratio test indicated that all proximate (fat, protein, moisture, and ash) values had homogeneous variance ($P > 0.05$). Grilled RLD from PC carcasses had higher ($P < 0.0125$) proportions of fat than those from LC and SE carcasses. Grilled RLD from SE carcasses had lower ($P < 0.0125$) percent fat than those weighted for All Choice. Protein percent of grilled RLD was higher ($P < 0.05$) from heifer carcasses than from steer carcasses. Grilled RLD from SE carcasses had lower ($P < 0.0125$) percent fat and higher ($P < 0.0125$) percent moisture than those from PC carcasses and those weighted for All Choice. No differences between Quality Grade, Yield Grade, or gender were seen for percent ash of the grilled RLD.

Top Loin Longissimus dorsi Raw

Proximate estimates for raw Top Loin *Longissimus dorsi* (TLD) are shown in Table 3.7. Null model likelihood ratio test indicated that all proximate (fat, protein, moisture, and ash) values had homogeneous variance ($P > 0.05$). Raw TLD from PC carcasses had higher ($P < 0.0125$) fat percentage than those from SE carcasses. In addition, raw TLD from PC carcass had lower ($P < 0.0125$) percent of protein than those from LC and SE carcasses. However, raw TLD weighted for All Choice did not differ ($P > 0.0125$) from those from SE carcasses for percent fat and percent protein. Raw TLD from SE carcasses had higher ($P < 0.0125$) percent moisture than those from PC carcasses and those weighted for All Choice. No differences between Quality Grade, Yield Grade, or gender were seen for percent ash in the raw TLD.

Top Loin Longissimus dorsi Roasted

Proximate estimates for roasted Top Loin *Longissimus dorsi* (TLD) are shown in Table 3.8. Null model likelihood ratio test indicated that all proximate (fat, protein, moisture, and ash) values had homogeneous variance ($P > 0.05$). Roasted TLD from PC carcasses had higher ($P < 0.0125$) percent total fat than those from either LC or SE carcasses. Fat percent was higher ($P < 0.0125$) for roasted TLD when weighted for All Choice than for those from SE carcasses. Roasted TLD from PC carcasses had lower ($P < 0.0125$) percent protein than those from LC carcasses. Roasted TLD from SE carcasses had higher ($P < 0.0125$) percent moisture than those from PC carcasses or when weighted for All Choice. No Quality Grade, Yield Grade, or gender differences were seen for ash in the roasted TLD.

Top Loin Longissimus dorsi Grilled

Proximate estimates for grilled Top Loin *Longissimus dorsi* (TLD) are shown in Table 3.8. Null model likelihood ratio test indicated that all proximate (fat, protein, moisture, and ash) values had homogeneous variance ($P > 0.05$). Percent Fat estimates for grilled TLD were higher ($P < 0.0125$) for those from PC carcasses than those from LC and SE carcasses. In addition grilled TLD from SE carcasses had lower ($p<0.0125$) fat percentages than those weighted for All Choice. Grilled TLD from SE carcasses had higher ($P < 0.0125$) percent protein than those from PC carcasses and those weighted for All Choice. Grilled TLD from SE carcasses had higher ($P < 0.0125$) percent moisture than those from PC carcasses. No differences between Quality Grade, Yield Grade, or gender were seen for percent ash in the grilled TLD.

Biceps femoris Raw

Proximate estimates for raw *Biceps femoris* (BF) are shown in Table 3.9. Null model likelihood ratio test indicated that all proximate (fat, protein, moisture, and ash) values had homogeneous variance ($P > 0.05$). Raw BF from PC carcasses had higher ($P < 0.0125$) percent fat and lower percent moisture than those from LC and SE carcasses. Furthermore, raw BF from SE carcasses had lower ($P > 0.0125$) percent fat than those weighted for All Choice. Raw BF from steer carcasses had lower ($P < 0.05$) percent fat and higher ($P < 0.0125$) percent moisture than heifer carcasses. No differences between Quality Grade, Yield Grade, or gender were seen for percent ash in the raw BF.

Biceps femoris Grilled

Proximate estimates for grilled *Biceps femoris* (BF) are shown in Table 3.10. Null model likelihood ratio test indicated that all proximate (fat, protein, moisture, and ash)

values had homogeneous variance ($P > 0.05$). Grilled BF from SE carcasses had lower ($P < 0.0125$) percent fat and higher ($P < 0.0125$) percent moisture than those from PC carcasses and those weighted for All Choice. Grilled BF from steer carcasses had lower ($P < 0.05$) percent fat and higher ($P < 0.05$) percent moisture than heifer carcasses. No differences between Quality Grade, Yield Grade, or gender were seen for percentages of protein or ash in the grilled BF.

Gluteus Medius Raw

Proximate estimates for raw *Gluteus medius* (GM) are shown in Table 3.9. Null model likelihood ratio test indicated that percent fat estimates had a heterogeneous ($P < 0.05$) variance, while protein, moisture, and ash means had homogeneous variance ($P > 0.05$). Heterogeneous variance was corrected by using individual residual variances specific for each estimate and standard error. Raw GM from PC carcasses had higher ($P < 0.0125$) percent fat than those from LC and SE carcasses. Raw GM from SE carcasses had lower ($P < 0.0125$) percent fat than those weighted for All Choice, and those from steer carcasses had lower ($P < 0.05$) percent fat than those from heifer carcasses. Raw GM from PC carcasses had lower ($P < 0.0125$) percent moisture than those from LC and SE carcasses, while raw GM from SE carcasses had higher ($P < 0.0125$) percent moisture than those weighted for All Choice. Raw GM from steer carcasses had higher ($P < 0.05$) percent moisture than those from heifer carcasses. No differences between Quality Grade, Yield Grade, or gender were seen for percentages of protein or ash in the raw GM.

Gluteus medius Roasted

Proximate estimates for roasted *Gluteus medius* (GM) are shown in Table 3.10. Null model likelihood ratio test indicated that all proximate (fat, protein, moisture, and

ash) means had homogeneous variance ($P > 0.05$). Roasted GM from PC carcasses had higher ($P < 0.0125$) percent fat than those from SE carcasses. No differences between Quality Grade, Yield Grade, or gender were seen for percentages of protein, moisture, or ash in the roasted GM.

Gluteus Medius Grilled

Proximate estimates for grilled *Gluteus medius* (GM) are shown in Table 3.10. Null model likelihood ratio test indicated that all proximate (fat, protein, moisture, and ash) means had homogeneous variance ($P > 0.05$). Grilled GM from PC carcasses had higher ($P < 0.0125$) percent fat than those from LC and SE carcasses. Grilled GM from SE carcasses had lower ($P < 0.0125$) percent fat than those weighted for All Choice. Grilled GM from PC carcasses had lower ($P < 0.0125$) percent ash than those from LC carcasses. No differences between Quality Grade, Yield Grade, or gender were seen for percentages of protein or moisture in the grilled GM.

All Cuts

Of all the cuts investigated, the *Spinalis dorsi* (SD) had the highest percent fat content and lowest moisture percent. Brackebusch et al. (1991) recorded the SD as being the fattest muscle of those investigated. As percent fat increased, percent moisture subsequently decreased for all cuts investigated. This has been found in many other studies of nutrient content of beef (Duckett et al, 2009; Leheska et al., 2008; Miller et al., 1981; Miller et al., 1987; Williams et al., 1983). The roasted GM and grilled GM were the only two cuts that did not have a difference in percent moisture when a difference was seen in fat. Increased percent fat was seen in higher Quality Grades attributed to greater amounts of *longissimus* intramuscular fat seen with higher Quality Grades. These results

were consistent with other research (Brackebusche et al., 1991; Choi et al., 1987; Miller et al., 1981). Some differences were seen between genders and Yield Grades. These differences were not consistent.

Differences in Cooking Method

Differences in cooking method for the same muscle are shown in Table 3.11. Grilled Ribeye *Longissimus dorsi* (RLD) had lower ($P > 0.05$) percent fat, percent moisture, and cholesterol content than the roasted RLD. The grilled Top Loin *Longissimus dorsi* (TLD) had higher ($P > 0.05$) percent protein and cholesterol content and lower ($P > 0.05$) percent moisture than the roasted TLD. The grilled *Gluteus medius* (GM) had higher ($P > 0.05$) percent protein and moisture than the roasted GM.

Fatty Acid

Fatty acid composition of the cuts are separated into tables by Quality Grade, raw or cooked, and g/100 g or percent weight. Data for raw Premium Choice (PC) recorded as g/100 g is located in Table 3.12, and those recorded as weight percent are located in Table 3.13. Data for cooked PC recorded as g/100 g is located in Table 3.14, and those recorded as weight percent are located in Table 3.15 Data for raw Low Choice (LC) recorded as g/100 g is located in Table 3.16, and those recorded as weight percent are located in Table 3.17. Data for cooked LC recorded as g/100 g is located in Table 3.18, and those recorded as weight percent are located in Table 3.19. Data for raw Select (SE) recorded as g/100 g is located in Table 3.20 and those recorded as weight percent are located in Table 3.21. Data for cooked SE recorded as g/100 g is located in Table 3.22, and those recorded as weight percent are located in Table 3.23.

The Ribeye, LD cook, roast contained 49.78, 44.83, and 1.3 percent SFA, MUFA, and PUFA, respectively, of the fatty acids identified. These results were similar to those reported by Leheska et al. (2008), who reported LD concentrations of 45.1, 51.6, and 3.4 percent for SFA, MUFA, and PUFA, respectively. The differences in PUFA could be due to variations in total fat concentration. The GM muscle tended to have the greatest percent PUFA regardless of Quality Grade. Of the fatty acids identified, Oleic (cis 9 C18:1), palmitic (C16:0), and stearic (C18:0) acids, respectively, collectively comprised 74.56% of total lipid averaged for all the cuts investigated. Leheska et al. (2008) and Eichhorn et al. (1985) found that oleic, palmitic and stearic acids to represent the majority of the fatty acid profile in bovine muscle. Of the fatty acids identified, *trans* fats comprised of 6.4% of total fat of all BAM cuts.

Cholesterol

Data for cholesterol content is located in Table 3.33. Differences in cooking method averaged over Quality Grade are located in Table 3.11. The raw RLD from LC carcasses had higher ($P < 0.0125$) cholesterol content than those from PC carcasses. All cuts investigated had cholesterol values that were less than the required minimum (95 mg/ 100 g) for characterization of USDA Lean. Cooked cuts had higher cholesterol concentrations than did cuts that were raw. Cholesterol content for cuts investigated had slightly higher concentrations of cholesterol than those reported by Rule et al. (1997) and slightly lower concentrations of those reported by Williams et al. (1983).

Lean Cuts

The USDA defines “lean” as less than 10.0 g total fat, 4.5 g or less saturated fat, and less than 95 mg of cholesterol per 100 g serving and “extra lean” as less than 5.0 g

total fat, 2.0 g or less saturated fat, and less than 95 mg cholesterol per 100 g serving. The cuts qualified for USDA Lean include:

Ribeye Petite Roast (*Longissimus dorsi*) from PC, LC, and SE carcasses,

Ribeye Filet (*Longissimus dorsi*) from PC, LC, and SE carcasses,

Top Loin Petite Roast (*Longissimus dorsi*) from PC, LC, and SE carcasses,

Top Loin Filet (*Longissimus dorsi*) from PC, LC, and SE carcasses,

Top Sirloin Cap Steak (*Biceps femoris*) from PC, LC, and SE carcasses,

Top Sirloin Petite Roast (*Gluteus medius*) from PC, LC, and SE carcasses, and

Top Sirloin Filet (*Gluteus medius*) from PC, LC, and SE carcasses.

The Top Sirloin Petite Roast and Top Sirloin Filet from LC and SE carcasses qualified for USDA Extra Lean. USDA Lean and Extra Lean is determined from raw nutrient data.

In order to meet the AHA's criteria for extra lean and heart healthy, meat and seafood must contain less than 5.0 g total fat per Reference Amounts Customarily Consumed (RACC) and 100 g, less than 2.0 g per RACC and 100 g, less than 0.5 g *trans* fat per RACC and labeled serving, less than 95 mg cholesterol per RACC and 100 g, 480 mg or less sodium per RACC and labeled serving, and contain 10% or more of the daily value of one of six nutrients (vitamin A, vitamin C, iron, calcium, protein, or dietary fiber per RACC)(AHA, 2011). The Top Sirloin Petite Roast and Top Sirloin Filet from LC and SE carcasses qualified for the AHA's heart healthy check.

Vitamins and Minerals

Vitamin B12 and selenium were analyzed from composites. Values for B12 (μg/100 g) are located in Table 3.34. Estimates for Vitamin B-12 ranged from 2.52 to

4.88 μg / 100 g. Vitamin B12 content was consistent to that reported in the USDA Nutrient Database for similar cuts of beef. Values for selenium (ppm) are located in Table 3.35. Selenium estimates ranged from 0.23 to 0.39 ppm. These values were similar to those reported in the USDA Nutrient Database for similar cuts of beef.

Labeling

According to 9 CFR part 317, "major cut" single-ingredient meat products and ground or chopped meat products will require mandatory labeling regulation starting January 1, 2012. Nutrient composition of a variety of beef cuts (major and others) is available on the USDA National Nutrient Database (NND) for Standard Reference. In an effort to provide retailers with the most current and accurate nutritional information, the Beef Checkoff has funded extensive research to update the database. The data produced from this research was conducted in accordance to USDA standards and will be available in the National Nutrient Database.

Although the Food Safety Inspection Service (FSIS) mandatory labeling is intended to inform consumers of the actual composition of meat products, it may in fact discourage the consumption of beef. Primarily the sections on fat may be misrepresentative. Labeling of total fat, saturated fat, and *trans* fat will be required on the package in a Nutrition Facts Table (Title 21 CFR part 101). Consumers have been told that SFA and *trans* fatty acids have negative health effects. The Dietary Guidelines for Americans (2010) advises Americans to consume less than 10% of fat calories as SFA and to eat minimal amounts of *trans* fatty acids.

Data from this study indicated that total fat for the cuts investigated ranged from approximately 3% to 20% fat. SFA represented approximately 44.92 ± 4.68 percent or

3.6 g/100 g. This study found that C18:0 (stearic acid) ranged from 31% to 36% of total SFA representing 1.17 ± 0.56 g/100 g. Contrary to most SFA, stearic acid has a neutral affect on human health (Katan et al., 1994; Peitinen et al., 1997; Romans, 2001). Due to stearic acid's profound difference from other SFA, it should be considered separate from other SFA. *Trans* fatty acids also are linked to many health complications, namely heart disease (Katan et al, 1994; Mozaffarian et al., 2006; Pietinen et al., 1997). *Trans* fatty acids represented 6.4% of all fatty acids identified in the cuts investigated with vaccenic acid (trans 11 C18:1) comprising 94.2% of the *trans* fatty acids identified. Many studies have failed to find an association between vaccenic acid and heart disease (Ascherio et al., 1994; Hodgson et al., 1996; Tricon et al., 2006). Because of the negative image of all *trans* fatty acids by most consumers, vaccenic acid should not be coupled with all *trans* fats. Labeling of total SFA and total *trans* fat misrepresents nutritional quality of beef to consumers. In order to educate consumers of actual nutritional quality of beef, changes in labeling needs to occur.

CONCLUSION

The results from this study reinforce the fact that beef is a high quality, nutrient dense food source. Many cuts of beef are considered lean and can be incorporated into a variety of diets, including those designed for therapeutic outcomes such as weight loss and cholesterol management. This study identified seven cuts from three Quality Grades that qualify for USDA Lean and two cuts from two Quality Grades that qualify for USDA Extra Lean and the American Heart Association's Heart Healthy Check.

In order to portray the actual nutrient quality of beef, more specific labeling needs to occur. In addition, consumers need to be further educated on the various components in food, specifically fat. Due to various compositions of the fatty acids found in food, there exists a wide range of human health benefits and consequences. Combining all saturated fatty acids and all *trans* fatty acids is misrepresentative.

The innovation of the BAM cuts resulted from oversized carcasses yielding rib, loin, and sirloin cuts that when cut to typical specifications resulted in an unappealing portion size. The steaks had to be cut much thinner in order to maintain typical weight of the cut. In an attempt to maintain cut thickness, individual muscles were separated and turned into new cuts. These new cuts have a significant opportunity to become popular with consumers. However, one implication of processing the rib and loin into unknown cuts is that cuts from these locations typically yield the highest revenue for retailers. Changing known cutting specifications may alarm consumers and cause them not to want to spend the same cost on an unproven cut. Therefore, the beef industry must educate consumers in order to successfully launch the BAM cuts.

In addition to maintaining portion sizes, the BAM cuts reflect a more ideal size for consumers looking to decrease plate size. These cuts are not oversized and will appeal to those looking to make healthy choices and cut back on consumption

TABLES

Table 3.1: Study Sampling Plan

Plant #	Carcass #	Quality Grade[1]	Yield Grade	Gender[2]
1	1	PC	3	H
1	2	PC	2	S
1	3	LC	3	S
1	4	LC	2	H
1	5	SE	2	S
1	6	SE	3	S
2	7	PC	2	S
2	8	PC	3	H
2	9	LC	2	S
2	10	LC	3	S
2	11	SE	3	S
2	12	SE	2	H
3	13	PC	3	S
3	14	PC	2	S
3	15	LC	3	H
3	16	LC	2	S
3	17	SE	2	H
3	18	SE	3	S
4	19	PC	2	S
4	20	PC	3	S
4	21	LC	3	S
4	22	LC	2	H
4	23	SE	2	S
4	24	SE	3	H

[1]PC = Premium Choice; LC = Low Choice; SE = Select

[2]S = Steer; H = Heifer

Table 3.2: Carcass Data for Beef Ribeye and Beef Loin, Strip Loin Subprimals.

CX ID[1]	SEX[2]	HCW[3]	KPH[4]	SIDE	HCW	REA[7]	Marbling Score[8]	PYG[9]	Fat Thick[10]	adj. PYG[11]	Final YG[12]	Final QG[13]
1	H	388	2.5	left	196	94.8	680	3.3	1.3	3.4	3.1	CH^+
				right	192	95.5	690	3.5	1.5			
2	S	426	2.5	left	214	98.1	560	2.9	0.9	3.3	2.9	CH^0
				right	212	98.7	540	2.8	0.8			
3	S	419	1.5	left	212	94.2	440	3.5	1.5	3.6	3.7	CH^-
				right	207	85.2	410	3.5	1.5			
4	H	370	1.5	left	186	92.3	400	3.0	1.0	2.8	2.4	CH^-
				right	184	87.1	400	2.7	0.7			
5	S	404	1.5	left	204	106.5	380	2.8	0.8	2.9	2.1	SE^+
				right	200	101.9	390	2.7	0.7			
6	S	388	1.5	left	195	84.5	390	3.4	1.4	3.5	3.5	SE^+
				right	194	81.3	390	3.3	1.3			
7	S	371	3.5	left	187	105.8	540	2.9	0.9	3.0	2.1	CH^0
				right	184	103.9	530	3.0	1.0			
8	H	378	1.5	left	190	94.8	590	4.0	2.0	3.8	3.5	CH^0
				right	188	80.0	550	3.6	1.6			
9	S	386	3.5	left	197	100.0	420	3.1	1.1	3.1	2.8	SM^-
				right	188	92.9	480	3.1	1.1			
10	S	389	3.0	left	194	94.2	470	3.3	1.3	3.4	3.2	SM^-
				right	195	91.0	440	3.1	1.1			
11	S	404	2.5	left	205	108.4	320	3.7	1.7	3.7	3.1	SE^-
				right	199	103.2	330	3.5	1.5			
12	H	294	3.5	left	149	86.5	350	3	1.0	3.1	2.5	SE^-
				right	144	84.5	380	3	1.0			

[1]CX ID = Carcass number.

[2]S = Steers; H = Heifers.

[3]HCW = Hot Carcass Weight, kg.

[4]KPH = Kidney, Pelvic, and Heart Fat, % Carcass Weight.

[5]SM = Skeletal Maturity.

[6]LM = Lean Maturity.

[7]REA = Ribeye Area (*Longissimus dorsi*), cm^2.

[8]Marbling Score: 600-699 = Moderate; 500-599 = Modest; 400-499 = Small; 300-399 = Slight.

[9]PYG = Preliminary Yield Grade, cm.

[10]Fat Thick = Fat Thickness at 12th rib, cm.

[11]Adj PYG = Adjusted Preliminary Yield Grade.

[12]Final YG = Final Yield Grade.

[13]Final QG = Final Quality Grade; CH^+ = High Choice; CH^0 = Average Choice; CH^- = Low Choice;

SE+ = High Select; SE- = Low Select; All carcasses graded A skeletal and A lean maturity.

Table 3.2: Carcass Data for Beef Ribeye and Beef Loin, Strip Loin Subprimals, Continued

CX ID[1]	SEX[2]	HCW[3]	KPH[4]	SIDE	HCW	REA[7]	Marbling Score[8]	PYG[9]	Fat Thick[10]	adj. PYG[11]	Final YG[12]	Final QG[13]
13	S	239	2.0	left	187	83.9	510	3.4	1.4	3.5	3.3	CH^0
				right	191	89.0	530	3.6	1.6			
14	S	377	1.5	left	189	89.7	510	3.3	1.3	3.3	2.8	CH^0
				right	188	91.0	500	3.3	1.3			
15	H	433	2.5	left	217	98.1	430	3.5	1.5	3.6	3.5	CH^-
				right	215	92.3	440	3.6	1.6			
16	S	423	3.0	left	212	118.7	460	3.1	1.1	3.5	2.5	CH^-
				right	211	114.2	640	3.7	1.7			
17	H	329	3.0	left	168	89.0	370	3.2	1.2	3.2	2.7	SE^+
				right	161	87.7	350	3.0	1.0			
18	S	430	1.5	left	217	96.8	340	3.9	1.9	3.8	3.5	SE^-
				right	213	92.9	350	3.8	1.8			
19	S	446	2.0	left	228	93.5	680	3.4	1.4	3.6	3.0	CH^+
				right	218	94.2	690	3.5	1.5			
20	S	372	1.5	left	190	91.0	550	3.3	1.3	3.4	2.9	CH^0
				right	183	89.0	540	3.3	1.3			
21	S	444	1.5	left	220	99.4	460	3.4	1.4	3.5	3.2	CH^-
				right	219	94.8	480	3.5	1.5			
22	H	336	2.5	left	165	84.5	450	3.2	1.2	3.4	2.9	CH^-
				right	171	87.7	460	2.8	0.8			
23	S	313	2.0	left	159	89.0	330	3.1	1.1	3.2	2.3	SE^-
				right	154	83.9	340	3.2	1.2			
24	H	352	2.5	left	173	88.4	360	3.2	1.2	3.2	3.0	SE^+
				right	179	86.5	380	3.2	1.2			

[1]CX ID = Carcass number.

[2]S = Steers; H = Heifers.

[3]HCW = Hot Carcass Weight, kg.

[4]KPH = Kidney, Pelvic, and Heart Fat, % Carcass Weight.

[5]SM = Skeletal Maturity.

[6]LM = Lean Maturity.

[7]REA = Ribeye Area (*Longissimus dorsi*), cm^2.

[8]Marbling Score: 600-699 = Moderate; 500-599 = Modest; 400-499 = Small; 300-399 = Slight.

[9]PYG = Preliminary Yield Grade, cm.

[10]Fat Thick = Fat Thickness at 12th rib, cm.

[11]Adj PYG = Adjusted Preliminary Yield Grade.

[12]Final YG = Final Yield Grade.

[13]Final QG = Final Quality Grade; CH^+ = High Choice; CH^0 = Average Choice; CH^- = Low Choice; SE+ = High Select; SE- = Low Select; All carcasses graded A skeletal and A lean maturity.

Table 3.3: Carcass Data for Beef Loin, Top Sirloin Butt Subprimals.

CX ID[1]	SEX[2]	HCW[3]	KPH[4]	SIDE	HCW	REA[7]	Marbling Score[8]	PYG[9]	Fat Thick[10]	adj. PYG[11]	Final YG[12]	Final QG[13]
1	H	350	2.0	left	176	88.3	540	3.7	1.7	3.9	3.5	CH^0
				right	174	85.7	510	3.5	1.5			
2	S	417	2.0	left	209	107.3	530	3.0	1.0	3.3	2.6	CH^0
				right	208	107.9	530	3.5	1.5			
3	S	384	2.0	left	192	85.7	420	3.5	1.5	3.7	3.8	CH^-
				right	192	78.5	410	3.8	1.8			
4	H	324	2.0	left	160	94.9	420	3.4	1.4	3.4	2.5	CH^-
				right	163	90.9	410	2.9	0.9			
5	S	414	2.5	left	207	106.0	320	3.1	1.1	3.3	2.8	SE^-
				right	206	103.4	310	3.3	1.3			
6	S	365	2.5	left	184	96.8	350	3.4	1.4	3.6	3.1	SE^-
				right	182	92.2	340	3.4	1.4			
7	S	389	2.5	left	n/a	98.1	500	2.8	0.8	3.2	2.6	CH^0
				right	n/a	104.0	530	3.0	1.0			
8	H	370	2.5	left	n/a	99.4	590	3.6	1.6	3.8	3.2	CH^0
				right	n/a	96.2	540	3.6	1.6			
9	S	389	2.5	left	n/a	107.9	480	3.6	1.6	3.7	2.8	CH^-
				right	n/a	100.1	430	3.6	1.6			
10	S	467	2.5	left	n/a	106.6	440	3.8	1.8	4.0	3.6	CH^-
				right	n/a	113.2	480	3.8	1.8			
11	S	374	2.5	left	n/a	93.5	350	3.4	1.4	3.5	3.3	SE^+
				right	n/a	96.8	350	3.3	1.3			
12	H	279	2.5	left	n/a	90.9	370	2.7	0.7	2.8	2.0	SE^+
				right	n/a	85.0	350	2.6	0.6			

[1]CX ID = Carcass number.

[2]S = Steers; H = Heifers.

[3]HCW = Hot Carcass Weight, kg.

[4]KPH = Kidney, Pelvic, and Heart Fat, % Carcass Weight.

[5]SM = Skeletal Maturity.

[6]LM = Lean Maturity.

[7]REA = Ribeye Area (*Longissimus dorsi*), cm^2.

[8]Marbling Score: 600-699 = Moderate; 500-599 = Modest; 400-499 = Small; 300-399 = Slight.

[9]PYG = Preliminary Yield Grade, cm.

[10]Fat Thick = Fat Thickness at 12th rib, cm.

[11]Adj PYG = Adjusted Preliminary Yield Grade.

[12]Final YG = Final Yield Grade.

[13]Final QG = Final Quality Grade; CH^+ = High Choice; CH^0 = Average Choice; CH^- = Low Choice; SE+ = High Select; SE- = Low Select; All carcasses graded A skeletal and A lean maturity.

Table 3.3: Carcass Data for Beef Loin, Top Sirloin Butt Subprimals, Continued.

CX ID[1]	SEX[2]	HCW[3]	KPH[4]	SIDE	HCW	REA[7]	Marbling Score[8]	PYG[9]	Fat Thick[10]	adj. PYG[11]	Final YG[12]	Final QG[13]
13	S	439	2.0	left	n/a	103.9	550	3.8	1.8	3.7	3.3	CH^0
				right	n/a	101.3	520	3.6	1.6			
14	S	405	2.0	left	n/a	115.5	590	3.7	1.7	3.6	2.4	CH^0
				right	n/a	107.1	550	3.4	1.4			
15	H	365	2.5	left	n/a	84.5	460	3.5	1.5	3.6	3.3	CH^-
				right	n/a	94.2	440	3.6	1.6			
16	S	444	2.5	left	n/a	116.8	460	3.7	1.7	3.6	2.5	CH^-
				right	n/a	121.9	420	3.2	1.2			
17	H	316	2.5	left	n/a	81.9	360	3.4	1.4	3.2	2.9	SE^+
				right	n/a	79.4	360	3.1	1.1			
18	S	364	2.5	left	n/a	88.4	380	3.7	1.7	3.7	3.4	SE^+
				right	n/a	88.4	370	3.7	1.7			
19	S	443	2.5	left	199	92.9	650	2.7	0.7	3.0	3.1	CH^+
				right	216	94.8	620	2.8	0.8			
20	S	382	2.0	left	196	96.1	530	2.9	0.9	3.0	2.4	CH^0
				right	186	94.2	570	2.9	0.9			
21	S	395	2.5	left	202	89.0	460	3.5	1.5	3.4	3.4	CH^-
				right	192	84.5	440	3.1	1.1			
22	H	393	3.0	left	198	104.5	470	2.8	0.8	2.8	2.1	CH^-
				right	194	101.9	460	2.6	0.6			
23	S	373	2.0	left	190	94.2	390	2.5	0.5	2.7	2.3	SE^+
				right	183	85.8	390	2.6	0.6			
24	H	410	2.5	left	230	93.5	380	3.9	1.9	3.9	3.7	SE^+
				right	180	91.0	370	3.8	1.8			

[1]CX ID = Carcass number.

[2]S = Steers; H = Heifers.

[3]HCW = Hot Carcass Weight, kg.

[4]KPH = Kidney, Pelvic, and Heart Fat, % Carcass Weight.

[5]SM = Skeletal Maturity.

[6]LM = Lean Maturity.

[7]REA = Ribeye Area (*Longissimus dorsi*), cm^2.

[8]Marbling Score: 600-699 = Moderate; 500-599 = Modest; 400-499 = Small; 300-399 = Slight.

[9]PYG = Preliminary Yield Grade, cm.

[10]Fat Thick = Fat Thickness at 12th rib, cm.

[11]Adj PYG = Adjusted Preliminary Yield Grade.

[12]Final YG = Final Yield Grade.

[13]Final QG = Final Quality Grade; CH^+ = High Choice; CH^0 = Average Choice; CH^- = Low Choice; SE+ = High Select; SE- = Low Select; All carcasses graded A skeletal and A lean maturity.

Table 3.4: BAM Composite Plan

Composite	Carcass #	Quality Grade[1]	Yield Grade	Gender[2]
1	1	PC	3	H
	7	PC	2	S
	13	PC	3	S
	19	PC	2	S
2	2	PC	2	S
	8	PC	3	H
	14	PC	2	S
	20	PC	2	S
3	3	LC	3	S
	9	LC	2	S
	15	LC	3	H
	21	LC	3	S
4	4	LC	2	H
	10	LC	3	S
	16	LC	2	S
	22	LC	2	H
5	5	SE	2	S
	11	SE	3	S
	17	SE	2	H
	23	SE	2	S
6	6	SE	3	S
	12	SE	2	H
	18	SE	3	S
	24	SE	3	H

[1]PC = Premium Choice; LC = Low Choice; SE = Select.

[2]H = Heifer; S = Steer.

Table 3.5: Weighted Mean Estimates ± Standard Error for Raw Rib Cuts

Cut	Characteristic[1]	Fat (%)	Protein (%)	Moisture (%)	Ash (%)
Spinalis dorsi: Ribeye Cap Steak	PC	12.92[c] ± 0.63	18.83[c] ± 0.24	65.42[c] ± 0.60	0.91 ± 0.02
	LC	10.66 ± 0.56	19.77 ± 0.21	67.01 ± 0.53	0.89 ± 0.02
	SE	9.42[a] ± 0.56	20.06[a] ± 0.21	68.54[a] ± 0.53	0.87 ± 0.02
	ALL CH	11.41 ± 0.41	19.46 ± 0.16	66.48[c] ± 0.39	0.89 ± 0.02
	ALL GRADES	10.62 ± 0.33	19.70 ± 0.13	67.30 ± 0.31	0.89 ± 0.01
	Heifers	11.35 ± 0.58	19.72 ± 0.22	66.51 ± 0.55	0.90 ± 0.02
	Steers	10.25 ± 0.42	19.69 ± 0.16	67.70 ± 0.40	0.88 ± 0.02
	YG 2	11.39[e] ± 0.49	19.47 ± 0.19	66.56[e] ± 0.46	0.90 ± 0.02
	YG 3	9.84 ± 0.48	19.93 ± 0.18	68.05 ± 0.45	0.87 ± 0.02
Longissimus dorsi: Ribeye Petite Roast or Ribeye Filet	PC	6.77[bc] ± 0.43	21.81[bc] ± 0.18	69.83[bc] ± 0.42	1.06 ± 0.04
	LC	4.57[a] ± 0.39	22.87[a] ± 0.16	71.54[a] ± 0.38	1.02 ± 0.04
	SE	3.69[a] ± 0.39	23.03[a] ± 0.16	72.47[a] ± 0.38	1.11 ± 0.04
	ALL CH	5.30[c] ± 0.28	22.51 ± 0.12	70.97[c] ± 0.28	1.04 ± 0.03
	ALL GRADES	4.66 ± 0.23	22.72 ± 0.10	71.57 ± 0.22	1.07 ± 0.02
	Heifers	5.02 ± 0.40	22.84 ± 0.17	71.10 ± 0.39	1.03 ± 0.04
	Steers	4.48 ± 0.29	22.66 ± 0.12	71.81 ± 0.29	1.09 ± 0.03
	YG 2	4.86 ± 0.34	22.62 ± 0.14	71.48 ± 0.33	1.11 ± 0.03
	YG 3	4.45 ± 0.33	22.82 ± 0.14	71.67 ± 0.32	1.03 ± 0.03

[1]Characteristics: PC = Premium Choice; LC = Low Choice; SE = Select; All Choice = PC:LC weighted 1:2; All Grades = PC:LC:SE weighted 1:2:2; YG 2 = USDA Yield Grade 2; YG 3 = USDA Yield Grade 3.

[a] Different than PC ($P \leq 0.0125$).

[b] Different than LC ($P \leq 0.0125$).

[c] Different than SE ($P \leq 0.0125$).

[d] Difference between Gender ($P \leq 0.05$).

[e] Difference between YG ($P \leq 0.05$).

Table 3.6: Weighted Mean Estimates ± Standard Error for Cooked Rib Cuts

Cut	Characteristic[1]	Fat (%)	Protein (%)	Moisture (%)	Ash (%)
Spinalis dorsi: Ribeye Cap Steak	PC	19.25[c] ± 0.98	23.55[c] ± 0.38	54.25[c] ± 0.81	0.92 ± 0.04
	LC	16.24 ± 0.87	24.58 ± 0.34	56.52 ± 0.72	0.97 ± 0.03
	SE	13.41[a] ± 0.64	25.27[a] ± 0.34	59.29[a] ± 0.72	0.92 ± 0.03
	All CH	17.25[c] ± 0.87	24.24 ± 0.34	55.77[c] ± 0.54	0.95 ± 0.02
	All Grades	15.71 ± 0.52	24.65 ± 0.20	57.17 ± 0.43	0.94 ± 0.02
	Heifers	17.04 ± 0.90	23.89[d] ± 0.35	56.47 ± 0.75	0.98 ± 0.03
	Steers	15.05 ± 0.66	25.03 ± 0.26	57.53 ± 0.55	0.92 ± 0.02
	YG 2	16.75 ± 0.76	24.17[e] ± 0.30	56.28 ± 0.63	0.97 ± 0.03
	YG 3	14.67 ± 0.74	25.13 ± 0.29	58.07 ± 0.62	0.91 ± 0.03
Longissimus dorsi: Ribeye Petite Roast	PC	10.34[c] ± 0.83	27.11 ± 0.36	61.40[c] ± 0.61	0.97 ± 0.03
	LC	7.44[c] ± 0.35	28.46 ± 0.32	63.07 ± 0.55	1.11 ± 0.05
	SE	5.68[ab] ± 0.23	28.39 ± 0.32	65.02[a] ± 0.55	1.14 ± 0.04
	All CH	8.41[c] ± 0.36	28.01 ± 0.24	62.52[c] ± 0.40	1.06 ± 0.03
	All Grades	7.32 ± 0.23	28.16 ± 0.19	63.52 ± 0.32	1.09 ± 0.03
	Heifers	7.60 ± 0.46	28.37 ± 0.33	62.96 ± 0.56	1.13 ± 0.04
	Steers	7.18 ± 0.29	28.06 ± 0.24	63.80 ± 0.41	1.08 ± 0.03
	YG 2	7.11 ± 0.36	27.99 ± 0.28	63.78 ± 0.48	1.10 ± 0.04
	YG 3	7.52 ± 0.34	28.34 ± 0.28	63.25 ± 0.46	1.08 ± 0.04
Longissimus dorsi: Ribeye Filet	PC	12.02[bc] ± 0.63	27.55[c] ± 0.33	58.38[c] ± 0.57	1.08 ± 0.05
	LC	9.40[a] ± 0.53	28.75 ± 0.30	60.42 ± 0.51	1.13 ± 0.04
	SE	7.55[a] ± 0.56	29.46[a] ± 0.30	62.26[a] ± 0.51	1.12 ± 0.04
	All CH	10.27[c] ± 0.41	28.35[c] ± 0.22	59.74[c] ± 0.38	1.11 ± 0.03
	All Grades	9.18 ± 0.33	28.79 ± 0.18	60.75 ± 0.30	1.12 ± 0.02
	Heifers	10.71[d] ± 0.58	28.62 ± 0.31	59.74[d] ± 0.53	1.14 ± 0.04
	Steers	8.42 ± 0.42	28.88 ± 0.22	61.25 ± 0.38	1.10 ± 0.03
	YG 2	9.61 ± 0.49	28.78 ± 0.26	60.36 ± 0.45	1.06 ± 0.04
	YG 3	8.76 ± 0.47	28.81 ± 0.25	61.14 ± 0.43	1.17 ± 0.04

[1]Characteristics: PC = Premium Choice; LC = Low Choice; SE = Select; All Choice = PC:LC weighted 1:2; All Grades = PC:LC:SE weighted 1:2:2; YG 2 = USDA Yield Grade 2; YG 3 = USDA Yield Grade 3

[a] Different than PC ($P \leq 0.0125$).

[b] Different than LC ($P \leq 0.0125$).

[c] Different than SE ($P \leq 0.0125$).

[d] Difference between Gender ($P \leq 0.05$).

[e] Difference between YG ($P \leq 0.05$).

Table 3.7: Weighted Mean Estimates ± Standard Error for Raw Top Loin Cuts

Cut	Characteristic[1]	Fat (%)	Protein (%)	Moisture (%)	Ash (%)
Longissimus dorsi: Top Loin Petite Roast or Top Loin Filet	PC	7.76[c] ± 0.58	21.70[bc] ± 0.25	68.64[c] ± 0.49	1.05 ± 0.05
	LC	5.86 ± 0.52	22.90[a] ± 0.22	70.31 ± 0.43	0.98 ± 0.04
	SE	4.89[a] ± 0.52	22.77[a] ± 0.22	71.82[a] ± 0.43	1.01 ± 0.04
	All CH	6.49 ± 0.38	22.50 ± 0.16	69.75[c] ± 0.32	1.00 ± 0.033
	All Grades	5.85 ± 0.31	22.61 ± 0.13	70.58 ± 0.26	1.00 ± 0.03
	Heifers	6.12 ± 0.53	22.59 ± 0.23	69.96 ± 0.45	0.98 ± 0.05
	Steers	5.72 ± 0.39	22.62 ± 0.17	70.89 ± 0.33	1.02 ± 0.03
	YG 2	5.93 ± 0.45	22.42 ± 0.19	70.68 ± 0.38	1.01 ± 0.04
	YG 3	5.77 ± 0.44	22.80 ± 0.19	70.48 ± 0.37	1.00 ± 0.04

[1]Characteristics: PC = Premium Choice; LC = Low Choice; SE = Select; All Choice = PC:LC weighted 1:2; All Grades = PC:LC:SE weighted 1:2:2; YG 2 = USDA Yield Grade 2; YG 3 = USDA Yield Grade 3.

[a] Different than PC ($P \leq 0.0125$).

[b] Different than LC ($P \leq 0.0125$).

[c] Different than SE ($P \leq 0.0125$).

[d] Difference between Gender ($P \leq 0.05$).

[e] Difference between YG ($P \leq 0.05$).

Table 3.8: Weighted Mean Estimates ± Standard Error for Cooked Top Loin Cuts

Cut	Characteristic[1]	Fat (%)	Protein (%)	Moisture (%)	Ash (%)
Longissimus Dorsi: Top Loin Filet	PC	12.60[bc] ± 0.83	26.79[b] ± 0.46	58.42[c] ± 0.80	1.17 ± 0.07
	LC	8.67[a] ± 0.74	28.93[a] ± 0.41	60.40 ± 0.71	1.19 ± 0.06
	SE	6.94[a] ± 0.74	28.54 ± 0.41	62.61[a] ± 0.71	1.14 ± 0.06
	All CH	9.98[c] ± 0.55	28.22 ± 0.30	59.74[c] ± 0.52	1.19 ± 0.04
	All Grades	8.77 ± 0.44	28.35 ± 0.24	60.89 ± 0.421	1.17 ± 0.04
	Heifers	9.09 ± 0.76	28.50 ± 0.42	60.36 ± 0.74	1.24 ± 0.06
	Steers	8.61 ± 0.56	28.27 ± 0.31	61.15 ± 0.54	1.13 ± 0.05
	YG 2	8.77 ± 0.65	28.22 ± 0.35	61.04 ± 0.62	1.18 ± 0.05
	YG 3	8.77 ± 0.63	28.47 ± 0.34	60.74 ± 0.60	1.15 ± 0.05
Longissimus Dorsi: Top Loin Petite Roast	PC	11.21[bc] ± 0.61	28.64[c] ± 0.23	58.31[c] ± 0.76	1.11 ± 0.08
	LC	8.67[a] ± 0.54	29.17 ± 0.20	60.78 ± 0.67	1.20 ± 0.07
	SE	7.12[a] ± 0.54	29.84[a] ± 0.20	61.70[a] ± 0.67	1.15 ± 0.07
	All CH	9.52[c] ± 0.40	28.99[c] ± 0.15	59.95 ± 0.50	1.17 ± 0.05
	All Grades	8.56 ± 0.32	29.33 ± 0.12	60.65 ± 0.40	1.16 ± 0.04
	Heifers	9.42 ± 0.56	29.33 ± 0.21	59.69 ± 0.70	1.13 ± 0.07
	Steers	8.13 ± 0.41	29.33 ± 0.15	61.13 ± 0.51	1.17 ± 0.05
	YG 2	8.41 ± 0.48	28.84[e] ± 0.18	61.18 ± 0.59	1.11 ± 0.06
	YG 3	8.70 ± 0.46	29.82 ± 0.17	60.13 ± 0.57	1.22 ± 0.06

[1]Characteristics: PC = Premium Choice; LC = Low Choice; SE = Select; All Choice = PC:LC weighted 1:2; All Grades = PC:LC:SE weighted 1:2:2; YG 2 = USDA Yield Grade 2; YG 3 = USDA Yield Grade 3.

[a] Different than PC ($P \leq 0.0125$).

[b] Different than LC ($P \leq 0.0125$).

[c] Different than SE ($P \leq 0.0125$).

[d] Difference between Gender ($P \leq 0.05$).

[e] Difference between YG ($P \leq 0.05$).

Table 3.9: Weighted Mean Estimates ± Standard Error Raw Sirloin Cuts

	Characteristic[1]	Fat (%)	Protein (%)	Moisture (%)	Ash (%)
Biceps Femoris: Sirloin Cap Steak	PC	6.89[bc] ± 0.32	21.06 ± 0.21	71.30[bc] ± 0.36	1.00 ± 0.07
	LC	5.28[a] ± 0.29	21.49 ± 0.18	73.11[a] ± 0.32	0.98 ± 0.06
	SE	4.71[a] ± 0.29	21.43 ± 0.18	73.55[a] ± 0.32	0.97 ± 0.06
	All CH	5.81[c] ± 0.21	21.35 ± 0.14	72.50 ± 0.24	0.99 ± 0.04
	All Grades	5.37 ± 0.17	21.38 ± 0.11	72.92 ± 0.19	0.98 ± 0.04
	Heifers	6.02[d] ± 0.30	21.39 ± 0.19	72.11[d] ± 0.33	1.05 ± 0.06
	Steers	5.05 ± 0.22	21.38 ± 0.14	73.33 ± 0.24	0.94 ± 0.05
	YG 2	5.29 ± 0.25	21.34 ± 0.16	73.17 ± 0.28	0.96 ± 0.05
	YG 3	5.46 ± 0.25	21.42 ± 0.16	72.68 ± 0.27	1.00 ± 0.05
Gluteus Medius: Sirloin Petite Roast or Sirloin Filet	PC	5.28[bc] ± 0.26	22.68 ± 0.26	71.42[bc] ± 0.21	1.06 ± 0.03
	LC	3.96[ac] ± 0.09	23.20 ± 0.23	72.69[a] ± 0.19	1.04 ± 0.03
	SE	3.35[ab] ± 0.10	23.07 ± 0.23	73.25[a] ± 0.19	1.07 ± 0.03
	All CH	4.40[c] ± 0.10	23.03 ± 0.17	72.27[c] ± 0.14	1.05 ± 0.02
	All Grades	3.98 ± 0.07	23.04 ± 0.14	72.66 ± 0.11	1.05 ± 0.02
	Heifers	4.30[d] ± 0.15	23.13 ± 0.24	72.25[d] ± 0.20	1.04 ± 0.03
	Steers	3.82 ± 0.09	23.00 ± 0.17	72.87 ± 0.14	1.06 ± 0.02
	YG 2	4.10 ± 0.11	22.92 ± 0.20	72.74 ± 0.17	1.04 ± 0.03
	YG 3	3.87 ± 0.11	23.17 ± 0.19	72.59 ± 0.16	1.07 ± 0.03

[1]Characteristics: PC = Premium Choice; LC = Low Choice; SE = Select; All Choice = PC:LC weighted 1:2; All Grades = PC:LC:SE weighted 1:2:2; YG 2 = USDA Yield Grade 2; YG 3 = USDA Yield Grade 3.

[a] Different than PC ($P \leq 0.0125$).

[b] Different than LC ($P \leq 0.0125$).

[c] Different than SE ($P \leq 0.0125$).

[d] Difference between Gender ($P \leq 0.05$).

[e] Difference between YG ($P \leq 0.05$).

Table 3.10: Weighted Mean Estimates ± Standard Error Cooked Sirloin Cuts

Cut	Characteristic[1]	Fat (%)	Protein (%)	Moisture (%)	Ash (%)
Biceps Femoris: Sirloin Cap Steak	PC	8.74[c] ± 0.52	27.17 ± 0.40	60.50[c] ± 0.77	1.07 ± 0.06
	LC	7.59 ± 0.47	28.68 ± 0.36	62.22 ± 0.68	1.16 ± 0.05
	SE	6.13[a] ± 0.47	28.38 ± 0.36	64.09[a] ± 0.68	1.21 ± 0.05
	All CH	7.97[c] ± 0.34	28.18 ± 0.26	61.65[c] ± 0.50	1.13 ± 0.04
	All Grades	7.24 ± 0.28	28.26 ± 0.21	62.62 ± 0.41	1.17 ± 0.03
	Heifers	8.12[d] ± 0.48	28.19 ± 0.37	61.36[d] ± 0.71	1.13 ± 0.05
	Steers	6.79 ± 0.35	28.29 ± 0.27	63.26 ± 0.52	1.19 ± 0.04
	YG 2	7.49 ± 0.41	28.23 ± 0.31	62.43 ± 0.60	1.14 ± 0.04
	YG 3	6.98 ± 0.40	28.28 ± 0.30	62.81 ± 0.58	1.19 ± 0.04
Gluteus Medius: Sirloin Petite Roast	PC	7.29[c] ± 0.42	28.33 ± 0.31	63.19 ± 0.55	1.02 ± 0.06
	LC	5.94 ± 0.37	29.29 ± 0.28	63.85 ± 0.49	1.15 ± 0.05
	SE	5.21[a] ± 0.37	29.37 ± 0.28	64.37 ± 0.49	1.13 ± 0.05
	All CH	6.39 ± 0.27	28.97 ± 0.21	63.63 ± 0.36	1.11 ± 0.04
	All Grades	5.92 ± 0.22	29.13 ± 0.17	63.92 ± 0.29	1.12 ± 0.03
	Heifers	5.87 ± 0.38	28.85 ± 0.29	64.31 ± 0.51	1.10 ± 0.06
	Steers	5.94 ± 0.28	29.27 ± 0.21	63.73 ± 0.37	1.13 ± 0.04
	YG 2	6.08 ± 0.32	29.13 ± 0.24	63.90 ± 0.43	1.08 ± 0.05
	YG 3	5.75 ± 0.32	29.13 ± 0.24	63.95 ± 0.42	1.15 ± 0.05
Gluteus Medius: Sirloin Filet	PC	6.48[bc] ± 0.25	29.87 ± 0.33	62.59 ± 0.40	1.09[b] ± 0.07
	LC	5.48[a] ± 0.22	30.72 ± 0.29	62.59 ± 0.35	1.43[a] ± 0.07
	SE	4.75[a] ± 0.22	30.79 ± 0.29	63.32 ± 0.35	1.30 ± 0.07
	All CH	5.82[c] ± 0.16	30.44 ± 0.22	62.59 ± 0.26	1.32 ± 0.05
	All Grades	5.39 ± 0.13	30.58 ± 0.17	62.88 ± 0.21	1.31 ± 0.04
	Heifers	5.45 ± 0.23	30.73 ± 0.30	62.81 ± 0.37	1.40 ± 0.07
	Steers	5.36 ± 0.17	30.50 ± 0.22	62.91 ± 0.27	1.27 ± 0.05
	YG 2	5.49 ± 0.19	30.62 ± 0.26	62.86 ± 0.31	1.33 ± 0.06
	YG 3	5.29 ± 0.19	30.54 ± 0.25	62.90 ± 0.30	1.30 ± 0.06

[1]Characteristics: PC = Premium Choice; LC = Low Choice; SE = Select; All Choice = PC:LC weighted 1:2; All Grades = PC:LC:SE weighted 1:2:2; YG 2 = USDA Yield Grade 2; YG 3 = USDA Yield Grade 3.

[a] Different than PC ($P \leq 0.0125$).

[b] Different than LC ($P \leq 0.0125$).

[c] Different than SE ($P \leq 0.0125$).

[d] Difference between Gender ($P \leq 0.05$).

[e] Difference between YG ($P \leq 0.05$).

Table 3.11: Differences in Cooking Method[1]

Muscle[2]	Cook Method	Protein (%)	Fat (%)	Moisture (%)	Cholesterol (mg/100 g)
Rib, LD	Grilled	28.40 ± 0.14	6.88[a] ± 0.24	61.34[a] ± 0.28	81.71[a] ± 0.77
	Roasted	27.97 ± 0.10	7.76 ± 0.19	64.06 ± 0.28	84.73 ± 0.77
Strip, LD	Grilled	29.34[a] ± 0.15	7.95 ± 0.38	60.86[a] ± 0.40	86.83[a] ± 0.68
	Roasted	28.33 ± 0.15	8.31 ± 0.38	61.70 ± 0.40	81.98 ± 0.68
GM	Grilled	30.65[a] ± 0.19	5.01 ± 0.19	63.98[a] ± 0.21	84.41 ± 0.96
	Roasted	29.36 ± 0.19	4.90 ± 0.19	62.97 ± 0.21	87.01 ± 0.96

[1]Differences are averaged over quality grade.

[2]LD = *Longissimus dorsi*; GM = *Gluteus medius*.

[a]Indicates difference between cook method within cut ($P < 0.05$).

Table 3.12: Raw Premium Choice Fatty Acid Profile[1] (g/100 g)

	Ribeye		Top Loin	Sirloin	
Fatty Acid	SD (Steak)[2]	LD (Roast/Filet)[2]	LD (Roast/Filet)[3]	BF (Steak)[4]	GM (Roast/Filet)[4]
C14:0	0.49 ± 0.01	0.27 ± 0.03	0.27 ± 0.01	0.21 ± 0.02	0.13 ± 0.02
C16:0	3.87 ± 0.14	2.12 ± 0.27	2.23 ± 0.02	1.72 ± 0.15	1.22 ± 0.08
C17:0	0.24 ± 0.002	0.13 ± 0.01	0.16 ± 0.02	0.11 ± 0.03	0.07 ± 0.02
C18:0	2.23 ± 0.15	1.09 ± 0.28	1.25 ± 0.18	0.91 ± 0.11	0.71 ± 0.07
C20:0	0.01 ± 0.003	0.06 ± 0.07	0.01 ± 0.01	. ± .	0.01 ± .
Total SFA	**6.84**	**3.68**	**3.92**	**2.95**	**2.14**
C14:1	0.08 ± 0.004	0.05 ± 0.004	0.08 ± 0.03	0.04 ± 0.01	0.05 ± 0.02
C16:1	0.41 ± 0.03	0.20 ± 0.001	0.29 ± 0.05	0.27 ± 0.01	0.18 ± 0.03
C17:1	0.11 ± 0.01	0.05 ± 0.005	0.09 ± 0.01	0.08 ± 0.02	0.05 ± 0.01
t11 C18:1	0.89 ± 0.14	0.54 ± 0.13	0.70 ± 0.15	0.40 ± 0.07	0.27 ± 0.05
c9 C18:1	4.12 ± 0.56	1.97 ± 0.14	2.93 ± 0.58	2.68 ± 0.28	1.86 ± 0.23
Total MUFA	**5.60**	**2.80**	**4.08**	**3.47**	**2.41**
c9,c12 C18:2	0.02 ± 0.002	0.04 ± 0.04	0.09 ± 0.002	0.22 ± 0.05	0.12 ± 0.04
c9,t11 C18:2	0.01 ± 0.00	0.01 ± 0.003	0.01 ± 0.005	0.02 ± 0.01	0.01 ± 0.005
t10,c12 C18:2	0.01 ± 0.00	0.01 ± 0.004	0.01 ± 0.002	. ± .	. ± .
c9,c12 C18:3	0.02 ± 0.004	0.01 ± 0.003	0.02 ± 0.01	0.01 ± 0.005	0.02 ± 0.003
C20:5	0.01 ± 0.001	0.01 ± 0.01	. ± .	. ± .	0.01 ± 0.0005
Total PUFA	**0.07**	**0.08**	**0.13**	**0.25**	**0.16**

[1]Estimates ± Standard Error; Fatty acid with . for value indicates amount not detectable.

[2]SD (Steak) = *Spinalis dorsi*: Ribeye Cap Steak; LD (Roast) = *Longissimus dorsi*: Ribeye Petite Roast; LD (Roast) = *Longissimus dorsi*: Ribeye Filet.

[3]LD (Roast) = *Longissimus dorsi*: Top Loin Petite Roast; LD (Filet) = *Longissimus dorsi*: Top Loin Filet.

[4]BF (Steak) = *Biceps femoris*: Top Sirloin Cap Steak; GM (Roast) = *Gluteus medius*: Top Sirloin Petite Roast; GM (Filet) = *Gluteus medius*: Top Sirloin Filet.

Table 3.13: Raw Premium Choice Fatty Acid Profile[1] (Weight Percent)

	Ribeye		Top Loin	Sirloin	
Fatty Acid	SD (Steak)[2]	LD (Roast/Filet)[2]	LD (Roast/Filet)[3]	BF (Steak)[4]	GM (Roast/Filet)[4]
C14:0	3.55 ± 0.18	3.71 ± 0.11	3.14 ± 0.46	2.96 ± 0.03	2.70 ± 0.08
C16:0	28.08 ± 0.79	28.94 ± 1.67	25.72 ± 2.89	24.61 ± 1.07	24.56 ± 0.87
C17:0	1.74 ± 0.13	1.82 ± 0.01	1.84 ± 0.004	1.48 ± 0.22	1.43 ± 0.21
C18:0	16.13 ± 0.04	14.88 ± 2.75	14.27 ± 0.28	12.92 ± 0.13	14.14 ± 0.13
C20:0	0.07 ± 0.03	0.83 ± 1.01	0.13 ± 0.06	. ± .	0.10 ± .
Total SFA	**49.57**	**50.19**	**45.10**	**41.97**	**42.93**
C14:1	0.61 ± 0.07	0.62 ± 0.01	0.85 ± 0.26	0.57 ± 0.07	1.07 ± 0.19
C16:1	2.95 ± 0.04	2.72 ± 0.17	3.37 ± 0.18	3.88 ± 0.33	3.61 ± 0.29
C17:1	0.78 ± 0.01	0.75 ± 0.12	1.00 ± 0.05	1.06 ± 0.15	0.99 ± 0.10
t11 C18:1	6.49 ± 1.40	7.41 ± 2.22	7.92 ± 0.74	5.70 ± 0.28	5.36 ± 0.41
c9 C18:1	29.73 ± 2.16	26.90 ± 0.11	33.42 ± 2.62	37.92 ± 0.44	37.25 ± 0.76
Total MUFA	**40.56**	**38.40**	**46.57**	**49.13**	**48.27**
c9,c12 C18:2	0.15 ± 0.01	0.58 ± 0.55	1.08 ± 0.11	3.16 ± 0.31	2.47 ± 1.01
c9,t11 C18:2	0.09 ± 0.005	0.14 ± 0.03	0.13 ± 0.04	0.23 ± 0.09	0.30 ± 0.13
t10,c12 C18:2	0.09 ± 0.002	0.11 ± 0.05	0.08 ± 0.01	. ± .	. ± .
c9,c12 C18:3	0.17 ± 0.02	0.12 ± 0.03	0.17 ± 0.07	0.14 ± 0.05	0.39 ± 0.09
C20:5	0.05 ± 0.001	0.17 ± 0.13	. ± .	. ± .	0.20 ± 0.03
Total PUFA	**0.54**	**1.12**	**1.46**	**3.53**	**3.37**

[1]Estimates ± Standard Error; Fatty acid with . for value indicates amount not detectable.

[2]SD (Steak) = *Spinalis dorsi*: Ribeye Cap Steak; LD (Roast) = *Longissimus dorsi*: Ribeye Petite Roast; LD (Roast) = *Longissimus dorsi*: I

[3]LD (Roast) = *Longissimus dors*i: Top Loin Petite Roast; LD (Filet) = *Longissimus dorsi*: Top Loin Filet.

[4]BF (Steak) = *Biceps femoris*: Top Sirloin Cap Steak; GM (Roast) = *Gluteus medius*: Top Sirloin Petite Roast; GM (Filet) = *Gluteus mediu* Top Sirloin Filet.

Table 3.14: Cooked Premium Choice Fatty Acid Profile[1] (g/100 g)

	Ribeye			Top Loin		Sirloin		
Fatty Acid	SD (Steak)[2]	LD (Roast)[2]	LD (Filet)[2]	LD (Roast)[3]	LD (Filet)[3]	BF (Steak)[4]	GM (Roast)[4]	GM (Filet)[4]
C14:0	0.60 ± 0.03	0.31 ± 0.005	0.34 ± 0.00	0.43 ± 0.01	0.42 ± 0.04	0.26 ± 0.02	0.18 ± 0.02	0.18 ± 0.01
C16:0	4.59 ± 0.36	2.47 ± 0.07	2.81 ± 0.08	3.59 ± 0.09	3.43 ± 0.16	2.19 ± 0.07	1.62 ± 0.10	1.64 ± 0.10
C17:0	0.26 ± 0.10	0.17 ± 0.001	0.20 ± 0.011	0.19 ± 0.02	0.18 ± 0.02	0.14 ± 0.03	0.10 ± 0.03	0.11 ± 0.01
C18:0	2.79 ± 0.34	1.41 ± 0.10	1.67 ± 0.144	1.87 ± 0.12	1.73 ± 0.01	1.16 ± 0.10	0.92 ± 0.09	0.93 ± 0.03
C20:0	0.16 ± 0.12	0.01 ± 0.003	0.01 ± 0.003	. ± .	. ± .	0.01 ± 0.001	0.01 ± 0.003	0.004 ± 0.00
Total SFA	**8.41**	**4.37**	**5.03**	**6.08**	**5.76**	**3.77**	**2.84**	**2.87**
C14:1	0.22 ± 0.12	0.13 ± 0.01	0.13 ± 0.020	0.07 ± 0.002	0.07 ± 0.002	0.07 ± 0.01	0.08 ± 0.005	0.11 ± 0.00
C16:1	0.73 ± 0.04	0.36 ± 0.01	0.41 ± 0.038	0.39 ± 0.004	0.39 ± 0.02	0.42 ± 0.01	0.23 ± 0.01	0.27 ± 0.03
C17:1	0.17 ± 0.03	0.10 ± 0.01	0.14 ± 0.019	0.09 ± 0.01	0.10 ± 0.002	0.11 ± 0.02	0.06 ± 0.04	0.07 ± 0.006
t11 C18:1	1.44 ± 0.06	0.72 ± 0.08	0.88 ± 0.087	0.73 ± 0.10	0.31 ± 0.43	0.49 ± 0.07	0.35 ± 0.08	0.35 ± 0.02
c9 C18:1	6.78 ± 1.14	3.38 ± 0.47	3.99 ± 0.36	3.97 ± 0.35	3.89 ± 0.43	3.53 ± 0.22	2.45 ± 0.20	2.55 ± 0.17
Total MUFA	**9.35**	**4.69**	**5.54**	**5.25**	**4.76**	**4.62**	**3.17**	**3.35**
c9,c12 C18:2	0.45 ± 0.11	0.20 ± 0.01	0.31 ± 0.03	0.11 ± 0.01	0.16 ± 0.04	0.31 ± 0.05	0.26 ± 0.04	0.27 ± 0.01
c9,t11 C18:2	0.05 ± 0.01	0.02 ± 0.002	0.04 ± 0.005	. ± .	0.01 ± .	0.04 ± 0.002	0.03 ± 0.005	0.01 ± 0.01
t10,c12 C18:2	0.02 ± 0.002	0.01 ± 0.00	0.01 ± 0.001	. ± .	. ± .	0.01 ± 0.002	0.01 ± 0.004	0.01 ± .
c9,c12 C18:3	0.05 ± 0.02	0.02 ± 0.01	0.03 ± 0.00	. ± .	. ± .	0.03 ± 0.00	0.02 ± 0.01	0.02 ± 0.001
C20:5	0.10 ± 0.12	0.01 ± 0.002	0.01 ± 0.001	. ± .	. ± .	0.02 ± 0.00	0.02 ± 0.00	0.02 ± 0.00
Total PUFA	**0.67**	**0.26**	**0.40**	**0.11**	**0.16**	**0.39**	**0.35**	**0.34**

[1]Estimates ± Standard Error; Fatty acid with . for value indicates amount not detectable.

[2]SD (Steak) = *Spinalis dorsi*: Ribeye Cap Steak; LD (Roast) = *Longissimus dorsi*: Ribeye Petite Roast; LD (Roast) = *Longissimus dorsi*: Ribeye Filet.

[3]LD (Roast) = *Longissimus dorsi*: Top Loin Petite Roast; LD (Filet) = *Longissimus dorsi*: Top Loin Filet.

[4]BF (Steak) = *Biceps femoris*: Top Sirloin Cap Steak; GM (Roast) = *Gluteus medius*: Top Sirloin Petite Roast; GM (Filet) = *Gluteus medius*: Top Sirloin Filet.

Table 3.15: Cooked Premium Choice Fatty Acid Profile[1] (Weight Percent)

	Ribeye			Top Loin		Sirloin		
Fatty Acid	SD (Steak)[2]	LD (Roast)[2]	LD (Filet)[2]	LD (Roast)[3]	LD (Filet)[3]	BF (Steak)[4]	GM (Roast)[4]	GM (Filet)[4]
C14:0	2.96 ± 0.26	3.17 ± 0.21	3.00 ± 0.19	3.58 ± 0.26	3.62 ± 0.41	2.83 ± 0.01	2.66 ± 0.02	2.65 ± 0.08
C16:0	22.50 ± 1.33	25.29 ± 0.62	24.52 ± 0.88	30.00 ± 0.66	29.77 ± 2.22	23.50 ± 0.57	23.55 ± 1.40	23.70 ± 0.44
C17:0	1.59 ± 0.32	1.77 ± 0.08	1.77 ± 0.02	1.62 ± 0.21	1.58 ± 0.20	1.48 ± 0.24	1.47 ± 0.27	1.59 ± 0.22
C18:0	13.63 ± 0.20	14.49 ± 0.31	14.54 ± 0.33	15.57 ± 0.27	14.97 ± 0.51	12.43 ± 0.34	13.39 ± 0.29	13.47 ± 0.11
C20:0	0.76 ± 0.50	0.13 ± 0.03	0.10 ± 0.02	. ± .	. ± .	0.08 ± 0.005	0.09 ± 0.04	0.06 ± 0.002
Total SFA	**41.45**	**44.85**	**43.93**	**50.77**	**49.95**	**40.32**	**41.15**	**41.46**
C14:1	1.12 ± 0.75	1.30 ± 0.13	1.12 ± 0.10	0.61 ± 0.05	0.65 ± 0.002	0.75 ± 0.11	1.15 ± 0.07	1.57 ± 0.07
C16:1	3.59 ± 0.28	3.70 ± 0.14	3.55 ± 0.10	3.24 ± 0.12	3.37 ± 0.10	4.48 ± 0.41	3.32 ± 0.56	3.84 ± 0.24
C17:1	0.83 ± 0.04	1.02 ± 0.03	1.19 ± 0.09	0.77 ± 0.15	0.86 ± 0.01	1.17 ± 0.16	0.88 ± 0.42	1.06 ± 0.13
t11 C18:1	7.12 ± 1.24	7.44 ± 1.16	7.73 ± 1.25	6.09 ± 1.08	5.86 ± 0.89	5.24 ± 0.42	5.06 ± 0.55	5.07 ± 0.56
c9 C18:1	33.04 ± 1.06	34.55 ± 3.02	34.75 ± 0.94	33.14 ± 1.37	33.67 ± 2.83	37.75 ± 0.19	35.53 ± 1.51	36.91 ± 0.87
Total MUFA	**45.70**	**48.00**	**48.35**	**43.84**	**44.41**	**49.39**	**45.94**	**48.45**
c9,c12 C18:2	2.26 ± 0.82	2.08 ± 0.19	2.67 ± 0.06	0.88 ± 0.13	1.36 ± 0.30	3.28 ± 0.35	3.83 ± 0.13	3.90 ± 0.34
c9,t11 C18:2	0.27 ± 0.01	0.24 ± 0.04	0.34 ± 0.02	. ± .	0.06 ± .	0.39 ± 0.05	0.46 ± 0.01	0.18 ± 0.16
t10,c12 C18:2	0.08 ± 0.003	0.07 ± 0.002	0.08 ± 0.01	. ± .	. ± .	0.06 ± 0.02	0.08 ± 0.05	0.09 ± .
c9,c12 C18:3	0.24 ± 0.05	0.24 ± 0.07	0.28 ± 0.02	. ± .	. ± .	0.27 ± 0.02	0.32 ± 0.12	0.35 ± 0.002
C20:5	0.46 ± 0.53	0.09 ± 0.02	0.13 ± 0.00	. ± .	. ± .	0.19 ± 0.01	0.36 ± 0.05	0.35 ± 0.02
Total PUFA	**3.31**	**2.72**	**3.49**	**0.88**	**1.41**	**4.20**	**5.06**	**4.87**

[1]Estimates ± Standard Error; Fatty acid with . for value indicates amount not detectable.

[2]SD (Steak) = *Spinalis dorsi*: Ribeye Cap Steak; LD (Roast) = *Longissimus dorsi*: Ribeye Petite Roast; LD (Roast) = *Longissimus dorsi*: Ribeye Filet.

[3]LD (Roast) = *Longissimus dorsi*: Top Loin Petite Roast; LD (Filet) = *Longissimus dorsi*: Top Loin Filet.

[4]BF (Steak) = *Biceps femoris*: Top Sirloin Cap Steak; GM (Roast) = *Gluteus medius*: Top Sirloin Petite Roast; GM (Filet) = *Gluteus medius*: Top Sirloin Filet.

Table 3.16: Raw Low Choice Fatty Acid Profile[1] (g/100 g)

	Ribeye		Top Loin	Sirloin	
Fatty Acid	SD (Steak)[2]	LD (Roast/Filet)[2]	LD (Roast/Filet)[3]	BF (Steak)[4]	GM (Roast/Filet)[4]
C14:0	0.40 ± 0.04	0.16 ± 0.001	0.18 ± 0.04	0.16 ± 0.04	0.10 ± 0.01
C16:0	3.32 ± 0.26	1.37 ± 0.001	1.56 ± 0.27	1.21 ± 0.15	0.94 ± 0.02
C17:0	0.23 ± 0.03	0.09 ± 0.004	0.11 ± 0.02	0.09 ± 0.01	0.06 ± 0.003
C18:0	1.96 ± 0.25	0.75 ± 0.05	0.81 ± 0.21	0.62 ± 0.08	0.53 ± 0.003
C20:0	0.01 ± 0.002	0.00 ± 0.00	0.01 ± 0.002	0.01 ± 0.001	. ± .
Total SFA	**5.92**	**2.38**	**2.66**	**2.09**	**1.64**
C14:1	0.08 ± 0.01	0.03 ± 0.001	0.04 ± 0.01	0.08 ± 0.02	0.02 ± 0.001
C16:1	0.35 ± 0.001	0.16 ± 0.02	0.20 ± 0.01	0.25 ± 0.04	0.12 ± 0.005
C17:1	0.11 ± 0.01	0.05 ± .	0.07 ± 0.01	0.08 ± 0.003	0.04 ± 0.003
t11 C18:1	0.74 ± 0.01	0.32 ± 0.002	0.35 ± 0.05	0.31 ± 0.07	0.24 ± 0.02
c9 C18:1	3.70 ± 0.09	1.65 ± 0.05	2.08 ± 0.21	1.89 ± 0.12	1.36 ± 0.05
Total MUFA	**4.97**	**2.22**	**2.74**	**2.60**	**1.78**
c9,c12 C18:2	0.02 ± 0.00	0.06 ± 0.007	0.09 ± 0.004	0.21 ± 0.02	0.17 ± 0.002
c9,t11 C18:2	0.01 ± 0.002	0.01 ± .	0.01 ± 0.004	0.02 ± 0.01	0.01 ± .
t10,c12 C18:2	0.01 ± 0.001	0.01 ± .	0.004 ± 0.00	0.01 ± 0.01	. ± .
c9,c12 C18:3	0.02 ± 0.00	0.01 ± 0.00	0.01 ± 0.00	0.02 ± 0.01	0.01 ± .
C20:5	0.01 ± 0.001	0.003 ± 0.002	0.003 ± .	0.01 ± 0.00	. ± .
Total PUFA	**0.07**	**0.08**	**0.11**	**0.27**	**0.19**

[1]Estimates ± Standard Error; Fatty acid with . for value indicates amount not detectable.

[2]SD (Steak) = *Spinalis dorsi*: Ribeye Cap Steak; LD (Roast) = *Longissimus dorsi*: Ribeye Petite Roast; LD (Roast) = *Longissimus dorsi*: Ribeye Filet.

[3]LD (Roast) = *Longissimus dorsi*: Top Loin Petite Roast; LD (Filet) = *Longissimus dorsi*: Top Loin Filet.

[4]BF (Steak) = *Biceps femoris*: Top Sirloin Cap Steak; GM (Roast) = *Gluteus medius*: Top Sirloin Petite Roast; GM (Filet) = *Gluteus medius*: Top Sirloin Filet.

Table 3.17: Raw Low Choice Fatty Acid Profile[1] (Weight Percent)

	Ribeye		Top Loin	Sirloin	
Fatty Acid	SD (Steak)[2]	LD (Roast/Filet)[2]	LD (Roast/Filet)[3]	BF (Steak)[4]	GM (Roast/Filet)[4]
C14:0	3.33 ± 0.16	3.22 ± 0.03	3.06 ± 0.12	3.06 ± 0.35	2.63 ± 0.26
C16:0	27.57 ± 0.51	27.04 ± 0.12	26.16 ± 0.60	22.98 ± 0.03	24.83 ± 0.35
C17:0	1.87 ± 0.13	1.86 ± 0.09	1.81 ± 0.11	1.63 ± 0.02	1.61 ± 0.10
C18:0	16.24 ± 1.07	14.83 ± 1.14	13.52 ± 1.41	11.80 ± 0.03	14.08 ± 0.04
C20:0	0.09 ± 0.01	0.10 ± 0.01	0.09 ± 0.02	0.17 ± 0.04	. ± .
Total SFA	**49.09**	**47.06**	**44.66**	**39.64**	**43.16**
C14:1	0.64 ± 0.06	0.64 ± 0.02	0.63 ± 0.02	1.42 ± 0.18	0.58 ± 0.03
C16:1	2.93 ± 0.19	3.09 ± 0.28	3.38 ± 0.42	4.70 ± 0.12	3.13 ± 0.09
C17:1	0.88 ± 0.01	1.01 ± 0.05	1.12 ± 0.08	1.46 ± 0.14	1.07 ± 0.09
t11 C18:1	6.12 ± 0.26	6.42 ± 0.02	5.93 ± 0.14	5.84 ± 0.60	6.42 ± 0.55
c9 C18:1	30.73 ± 1.13	32.58 ± 0.89	35.20 ± 1.85	35.97 ± 2.30	35.78 ± 1.74
Total MUFA	**41.30**	**43.75**	**46.27**	**49.39**	**46.98**
c9,c12 C18:2	0.15 ± 0.01	1.18 ± 0.15	1.53 ± 0.17	3.96 ± 0.13	4.60 ± 0.02
c9,t11 C18:2	0.11 ± 0.02	0.13 ± .	0.10 ± 0.05	0.39 ± 0.16	0.25 ± .
t10,c12 C18:2	0.10 ± 0.01	0.11 ± .	0.07 ± 0.003	0.20 ± 0.19	. ± .
c9,c12 C18:3	0.18 ± 0.01	0.13 ± 0.002	0.14 ± 0.03	0.30 ± 0.09	0.23 ± .
C20:5	0.06 ± 0.01	0.07 ± 0.04	0.05 ± .	0.23 ± 0.03	. ± .
Total PUFA	**0.59**	**1.62**	**1.88**	**5.07**	**5.08**

[1]Estimates ± Standard Error; Fatty acid with . for value indicates amount not detectable.

[2]SD (Steak) = *Spinalis dorsi*: Ribeye Cap Steak; LD (Roast) = *Longissimus dorsi*: Ribeye Petite Roast; LD (Roast) = *Longissimus dorsi*: Ribeye Filet.

[3]LD (Roast) = *Longissimus dorsi*: Top Loin Petite Roast; LD (Filet) = *Longissimus dorsi*: Top Loin Filet.

[4]BF (Steak) = *Biceps femoris*: Top Sirloin Cap Steak; GM (Roast) = *Gluteus medius*: Top Sirloin Petite Roast; GM (Filet) = *Gluteus medius*: Top Sirloin Filet.

Table 3.18: Cooked Low Choice Fatty Acid Profile[1] (g/100 g)

	Ribeye			Top Loin		Sirloin		
Fatty Acid	SD (Steak)[2]	LD (Roast)[2]	LD (Filet)[2]	LD (Roast)[3]	LD (Filet)[3]	BF (Steak)4	GM (Roast)[4]	GM (Filet)[4]
C14:0	0.45 ± 0.04	0.26 ± 0.02	0.27 ± 0.01	0.29 ± 0.07	0.29 ± 0.02	0.24 ± 0.02	0.15 ± 0.01	0.15 ± 0.02
C16:0	3.64 ± 0.18	2.24 ± 0.18	2.30 ± 0.10	2.56 ± 0.47	2.42 ± 0.22	1.88 ± 0.06	1.29 ± 0.07	1.26 ± 0.10
C17:0	0.27 ± 0.04	0.11 ± 0.004	0.17 ± 0.01	0.15 ± 0.04	0.12 ± 0.05	0.14 ± 0.02	0.10 ± 0.01	0.09 ± 0.005
C18:0	2.26 ± 0.21	1.20 ± 0.04	1.41 ± 0.16	1.34 ± 0.33	1.24 ± 0.21	0.97 ± 0.03	0.75 ± 0.04	0.73 ± 0.04
C20:0	0.01 ± 0.00	. ± .	0.01 ± 0.002	. ± .	. ± .	0.01 ± 0.00	0.01 ± 0.00	0.00 ± .
Total SFA	**6.63**	**3.81**	**4.15**	**4.35**	**4.07**	**3.23**	**2.29**	**2.22**
C14:1	0.20 ± 0.03	0.04 ± 0.004	0.05 ± 0.00	0.05 ± 0.01	0.05 ± 0.001	0.09 ± 0.02	0.07 ± 0.004	0.07 ± 0.03
C16:1	0.52 ± 0.01	0.24 ± 0.04	0.32 ± 0.04	0.31 ± 0.02	0.28 ± 0.001	0.31 ± 0.02	0.21 ± 0.01	0.20 ± 0.02
C17:1	0.21 ± 0.00	0.07 ± 0.01	0.11 ± 0.01	0.09 ± 0.01	0.07 ± 0.02	0.12 ± 0.004	0.07 ± 0.01	0.07 ± 0.001
t11 C18:1	1.04 ± 0.00	0.41 ± 0.06	0.67 ± 0.01	0.49 ± 0.09	0.40 ± 0.07	0.50 ± 0.02	0.35 ± 0.04	0.34 ± 0.04
c9 C18:1	5.80 ± 0.26	2.65 ± 0.28	3.48 ± 0.05	3.18 ± 0.28	2.78 ± 0.26	2.99 ± 0.23	1.99 ± 0.04	1.85 ± 0.01
Total MUFA	**7.78**	**3.41**	**4.63**	**4.11**	**3.58**	**4.00**	**2.68**	**2.53**
c9,c12 C18:2	0.30 ± 0.01	0.07 ± 0.002	0.28 ± 0.015	0.12 ± 0.02	0.11 ± 0.01	0.31 ± 0.02	0.27 ± 0.01	0.28 ± 0.02
c9,t11 C18:2	0.04 ± 0.00	. ± .	0.04 ± 0.00	. ± .	. ± .	0.03 ± 0.01	0.03 ± 0.004	0.01 ± 0.01
t10,c12 C18:2	0.01 ± 0.00	. ± .	0.01 ± 0.002	. ± .	. ± .	0.01 ± 0.002	0.003 ± 0.00	0.00 ± 0.001
c9,c12 C18:3	0.02 ± 0.02	. ± .	0.03 ± 0.005	. ± .	. ± .	0.02 ± 0.001	0.02 ± 0.00	0.02 ± 0.002
C20:5	0.01 ± 0.00	. ± .	0.02 ± 0.002	. ± .	. ± .	0.02 ± 0.00	0.02 ± 0.002	0.02 ± 0.004
Total PUFA	**0.39**	**0.07**	**0.37**	**0.12**	**0.11**	**0.39**	**0.34**	**0.33**

[1]Estimates ± Standard Error; Fatty acid with . for value indicates amount not detectable.

[2]SD (Steak) = *Spinalis dorsi*: Ribeye Cap Steak; LD (Roast) = *Longissimus dorsi*: Ribeye Petite Roast; LD (Roast) = *Longissimus dorsi*: Ribeye Filet.

[3]LD (Roast) = *Longissimus dorsi*: Top Loin Petite Roast; LD (Filet) = *Longissimus dorsi*: Top Loin Filet.

[4]BF (Steak) = *Biceps femoris*: Top Sirloin Cap Steak; GM (Roast) = *Gluteus medius*: Top Sirloin Petite Roast; GM (Filet) = *Gluteus medius*: Top Sirloin Filet.

Table 3.19: Cooked Low Choice Fatty Acid Profile[1] (Weight Percent)

	Ribeye			Top Loin		Sirloin		
Fatty Acid	SD (Steak)[2]	LD (Roast)[2]	LD (Filet)[2]	LD (Roast)[3]	LD (Filet)[3]	BF (Steak)[4]	GM (Roast)[4]	GM (Filet)[4]
C14:0	2.86 ± 0.20	3.40 ± 0.03	2.81 ± 0.02	3.24 ± 0.27	3.57 ± 0.22	3.00 ± 0.33	2.64 ± 0.10	2.68 ± 0.24
C16:0	23.34 ± 0.68	28.80 ± 1.45	23.49 ± 0.46	28.60 ± 0.76	30.01 ± 0.74	23.39 ± 0.06	23.18 ± 0.47	23.06 ± 0.66
C17:0	1.74 ± 0.21	1.64 ± 0.09	1.69 ± 0.11	1.68 ± 0.18	1.49 ± 0.44	1.70 ± 0.13	1.76 ± 0.06	1.59 ± 0.01
C18:0	14.47 ± 1.05	15.94 ± 0.79	14.36 ± 1.25	14.91 ± 1.32	15.29 ± 0.83	12.09 ± 0.04	13.44 ± 0.23	13.36 ± 0.07
C20:0	0.10 ± 0.01	· ± ·	0.09 ± 0.02	· ± ·	· ± ·	0.11 ± 0.002	0.10 ± 0.01	0.05 ± ·
Total SFA	**42.51**	**49.78**	**42.45**	**48.43**	**50.36**	**40.29**	**41.11**	**40.73**
C14:1	1.31 ± 0.18	0.72 ± 0.31	0.52 ± 0.01	0.57 ± 0.02	0.62 ± 0.08	1.08 ± 0.26	1.18 ± 0.04	1.32 ± 0.46
C16:1	3.36 ± 0.00	3.18 ± 0.29	3.26 ± 0.48	3.45 ± 0.32	3.51 ± 0.39	3.81 ± 0.09	3.71 ± 0.09	3.65 ± 0.12
C17:1	1.32 ± 0.02	0.87 ± 0.06	1.11 ± 0.08	1.01 ± 0.07	0.83 ± 0.20	1.51 ± 0.01	1.33 ± 0.24	1.26 ± 0.05
t11 C18:1	6.70 ± 0.14	5.99 ± 1.07	6.90 ± 0.29	5.43 ± 0.11	4.99 ± 0.26	6.20 ± 0.47	6.25 ± 0.46	6.15 ± 0.36
c9 C18:1	37.27 ± 2.50	34.06 ± 0.78	35.62 ± 0.38	35.75 ± 2.51	34.46 ± 0.8	37.30 ± 1.44	35.65 ± 1.89	34.02 ± 1.55
Total MUFA	**49.96**	**44.83**	**47.40**	**46.21**	**44.41**	**49.90**	**48.12**	**46.40**
c9,c12 C18:2	1.95 ± 0.11	1.30 ± 0.43	2.87 ± 0.08	1.30 ± 0.004	1.35 ± 0.04	3.94 ± 0.42	4.78 ± 0.02	5.14 ± 0.08
c9,t11 C18:2	0.25 ± 0.001	· ± ·	0.36 ± 0.01	· ± ·	· ± ·	0.33 ± 0.12	0.46 ± 0.05	0.17 ± 0.17
t10,c12 C18:2	0.06 ± 0.007	· ± ·	0.08 ± 0.02	· ± ·	· ± ·	0.07 ± 0.02	0.06 ± 0.01	0.09 ± 0.02
c9,c12 C18:3	0.14 ± 0.14	· ± ·	0.31 ± 0.04	· ± ·	· ± ·	0.28 ± 0.004	0.33 ± 0.01	0.33 ± 0.014
C20:5	0.06 ± 0.02	. ± ·	0.15 ± 0.02	· ± ·	· ± ·	0.24 ± 0.01	0.43 ± 0.06	0.40 ± 0.06
Total PUFA	**2.48**	**1.30**	**3.78**	**1.30**	**1.35**	**4.86**	**6.06**	**6.13**

[1]Estimates ± Standard Error; Fatty acid with . for value indicates amount not detectable.

[2]SD (Steak) = *Spinalis dorsi*: Ribeye Cap Steak; LD (Roast) = *Longissimus dorsi*: Ribeye Petite Roast; LD (Roast) = *Longissimus dorsi*: Ribeye Filet.

[3]LD (Roast) = *Longissimus dors*i: Top Loin Petite Roast; LD (Filet) = *Longissimus dorsi*: Top Loin Filet.

[4]BF (Steak) = *Biceps femoris*: Top Sirloin Cap Steak; GM (Roast) = *Gluteus medius*: Top Sirloin Petite Roast; GM (Filet) = *Gluteus medius*: Top Sirloin Filet.

Table 3.20: Raw Select Fatty Acid Profile[1] (g/100 g)

	Ribeye		Top Loin	Sirloin	
Fatty Acid	SD (Steak)[2]	LD (Roast/Filet)[2]	LD (Roast/Filet)[3]	BF (Steak)[4]	GM (Roast/Filet)[4]
C14:0	0.37 ± 0.04	0.14 ± 0.02	0.16 ± 0.01	0.13 ± 0.02	0.08 ± 0.01
C16:0	2.78 ± 0.30	1.09 ± 0.16	1.29 ± 0.04	1.05 ± 0.09	0.79 ± 0.11
C17:0	0.15 ± 0.01	0.06 ± 0.00	0.07 ± 0.01	0.09 ± 0.01	0.05 ± 0.01
C18:0	1.62 ± 0.05	0.61 ± 0.01	0.69 ± 0.06	0.63 ± 0.05	0.49 ± 0.07
C20:0	0.01 ± 0.003	0.01 ± 0.002	0.02 ± 0.03	0.01 ± 0.003	. ± .
Total SFA	**4.93**	**1.90**	**2.23**	**1.91**	**1.41**
C14:1	0.06 ± 0.01	0.03 ± 0.01	0.03 ± 0.004	0.07 ± 0.01	0.02 ± 0.003
C16:1	0.33 ± 0.03	0.13 ± 0.03	0.16 ± 0.02	0.21 ± 0.01	0.098 ± 0.01
C17:1	0.07 ± 0.01	0.03 ± 0.001	0.04 ± 0.001	0.07 ± 0.01	0.04 ± 0.004
t11 C18:1	0.60 ± 0.08	0.23 ± 0.03	0.25 ± 0.06	0.27 ± 0.05	0.16 ± 0.002
c9 C18:1	3.15 ± 0.12	1.28 ± 0.21	1.59 ± 0.10	1.67 ± 0.20	1.14 ± 0.12
Total MUFA	**4.21**	**1.70**	**2.07**	**2.29**	**1.45**
c9,c12 C18:2	0.01 ± 0.01	0.08 ± 0.002	0.08 ± 0.01	0.18 ± 0.01	0.14 ± 0.02
c9,t11 C18:2	0.01 ± 0.001	. ± .	. ± .	0.02 ± 0.002	. ± .
t10,c12 C18:2	0.004 ± 0.00	. ± .	. ± .	. ± .	. ± .
c9,c12 C18:3	0.01 ± 0.01	0.01 ± .	0.01 ± 0.00	0.01 ± 0.005	. ± .
C20:5	. ± .	. ± .	0.002 ± .	0.01 ± 0.004	. ± .
Total PUFA	**0.04**	**0.09**	**0.09**	**0.22**	**0.14**

[1]Estimates ± Standard Error; Fatty acid with . for value indicates amount not detectable.

[2]SD (Steak) = *Spinalis dorsi*: Ribeye Cap Steak; LD (Roast) = *Longissimus dorsi*: Ribeye Petite Roast; LD (Roast) = *Longissimus dorsi*: Ribeye Filet.

[3]LD (Roast) = *Longissimus dorsi*: Top Loin Petite Roast; LD (Filet) = *Longissimus dorsi*: Top Loin Filet.

[4]BF (Steak) = *Biceps femoris*: Top Sirloin Cap Steak; GM (Roast) = *Gluteus medius*: Top Sirloin Petite Roast; GM (Filet) = *Gluteus medius*: Top Sirloin Filet.

Table 3.21: Raw Select Fatty Acid Profile[1] (Weight Percent)

	Ribeye		Top Loin	Sirloin	
Fatty Acid	SD (Steak)[2]	LD (Roast/Filet)[2]	LD (Roast/Filet)[3]	BF (Steak)[4]	GM (Roast/Filet)[4]
C14:0	3.67 ± 0.21	3.55 ± 0.20	3.45 ± 0.11	2.76 ± 0.15	2.57 ± 0.03
C16:0	27.38 ± 1.34	27.36 ± 1.14	27.47 ± 0.39	22.35 ± 0.18	24.96 ± 0.40
C17:0	1.44 ± 0.15	1.50 ± 0.16	1.48 ± 0.19	1.82 ± 0.05	1.74 ± 0.04
C18:0	16.04 ± 0.49	15.40 ± 1.36	14.69 ± 1.51	13.34 ± 0.13	15.61 ± 0.35
C20:0	0.12 ± 0.02	0.13 ± 0.03	0.52 ± 0.61	0.18 ± 0.08	. ± .
Total SFA	**48.65**	**47.93**	**47.61**	**40.45**	**44.88**
C14:1	0.61 ± 0.03	0.67 ± 0.09	0.68 ± 0.08	1.38 ± 0.02	0.62 ± 0.02
C16:1	3.24 ± 0.06	3.35 ± 0.34	3.51 ± 0.29	4.55 ± 0.14	3.10 ± 0.08
C17:1	0.70 ± 0.12	0.80 ± 0.07	0.82 ± 0.04	1.52 ± 0.04	1.12 ± 0.01
t11 C18:1	6.00 ± 1.15	5.91 ± 1.36	5.27 ± 1.41	5.71 ± 0.50	5.07 ± 0.53
c9 C18:1	31.11 ± 0.67	32.28 ± 1.92	33.85 ± 1.62	35.40 ± 0.74	36.24 ± 0.61
Total MUFA	**41.66**	**43.01**	**44.14**	**48.55**	**46.16**
c9,c12 C18:2	0.11 ± 0.07	2.04 ± 0.16	1.68 ± 0.12	3.83 ± 0.52	4.45 ± 0.03
c9,t11 C18:2	0.07 ± 0.01	. ± .	. ± .	0.34 ± 0.02	. ± .
t10,c12 C18:2	0.04 ± 0.002	. ± .	. ± .	. ± .	. ± .
c9,c12 C18:3	0.15 ± 0.07	0.16 ± .	0.14 ± 0.01	0.30 ± 0.07	. ± .
C20:5	. ± .	. ± .	0.05 ± .	0.31 ± 0.11	. ± .
Total PUFA	**0.36**	**2.20**	**1.87**	**4.78**	**4.45**

[1]Estimates ± Standard Error; Fatty acid with . for value indicates amount not detectable.

[2]SD (Steak) = *Spinalis dorsi*: Ribeye Cap Steak; LD (Roast) = *Longissimus dorsi*: Ribeye Petite Roast; LD (Roast) = *Longissimus dorsi*: Ribeye Filet.

[3]LD (Roast) = *Longissimus dorsi*: Top Loin Petite Roast; LD (Filet) = *Longissimus dorsi*: Top Loin Filet.

[4]BF (Steak) = *Biceps femoris*: Top Sirloin Cap Steak; GM (Roast) = *Gluteus medius*: Top Sirloin Petite Roast; GM (Filet) = *Gluteus medius*: Top Sirloin Filet.

Table 3.22: Cooked Select Fatty Acid Profile[1] (g/100 g)

	Ribeye			Top Loin		Sirloin		
Fatty Acid	SD (Steak)[2]	LD (Roast)[2]	LD (Filet)[2]	LD (Roast)[3]	LD (Filet)[3]	BF (Steak)[4]	GM (Filet)[4]	GM (Filet)[4]
C14:0	0.45 ± 0.07	0.20 ± 0.004	0.24 ± 0.03	0.24 ± 0.04	0.23 ± 0.02	0.18 ± 0.01	0.10 ± 0.02	0.12 ± 0.01
C16:0	3.42 ± 0.42	1.59 ± 0.02	1.81 ± 0.21	1.91 ± 0.36	1.98 ± 0.35	1.49 ± 0.05	0.91 ± 0.26	1.02 ± 0.12
C17:0	0.23 ± 0.02	0.07 ± 0.01	0.11 ± 0.01	0.08 ± 0.00	0.11 ± 0.03	0.13 ± 0.003	0.10 ± 0.02	0.07 ± 0.01
C18:0	2.09 ± 0.09	0.86 ± 0.08	1.11 ± 0.02	0.99 ± 0.13	1.03 ± 0.14	0.89 ± 0.03	0.58 ± 0.17	0.65 ± 0.07
C20:0	0.01 ± 0.00	. ± .	0.01 ± 0.00	. ± .	. ± .	0.01 ± 0.00	0.01 ± 0.00	0.001 ± 0.002
Total SFA	**6.19**	**2.72**	**3.27**	**3.22**	**3.35**	**2.69**	**1.70**	**1.86**
C14:1	0.18 ± 0.04	0.03 ± 0.01	0.10 ± 0.02	0.04 ± 0.02	0.04 ± 0.01	0.12 ± 0.01	0.03 ± 0.02	0.05 ± 0.01
C16:1	0.56 ± 0.09	0.19 ± 0.02	0.28 ± 0.03	0.25 ± 0.05	0.24 ± 0.04	0.28 ± 0.01	0.14 ± 0.04	0.16 ± 0.02
C17:1	1.04 ± 1.38	0.04 ± 0.003	0.08 ± 0.01	0.05 ± 0.00	0.06 ± 0.02	0.10 ± 0.002	0.05 ± 0.01	0.06 ± 0.01
t11 C18:1	0.94 ± 0.02	0.26 ± 0.01	0.47 ± 0.01	0.35 ± 0.02	0.37 ± 0.08	0.38 ± 0.05	0.22 ± 0.02	0.24 ± 0.003
c9 C18:1	4.93 ± 0.72	1.87 ± 0.10	2.52 ± 0.33	2.41 ± 0.52	2.43 ± 0.54	2.42 ± 0.15	1.36 ± 0.32	1.51 ± 0.15
Total MUFA	**7.65**	**2.39**	**3.44**	**3.11**	**3.14**	**3.30**	**1.81**	**2.03**
c9,c12 C18:2	0.30 ± 0.02	0.12 ± 0.004	0.19 ± 0.03	0.16 ± 0.01	0.08 ± 0.03	0.13 ± 0.00	0.18 ± 0.05	0.22 ± 0.00
c9,t11 C18:2	0.04 ± 0.01	. ± .	0.02 ± 0.00	. ± .	. ± .	0.03 ± 0.003	0.02 ± 0.01	0.01 ± 0.01
t10,c12 C18:2	0.01 ± 0.00	. ± .	0.004 ± .	. ± .	0.04 ± .	0.01 ± 0.001	0.01 ± 0.01	. ± .
c9,c12 C18:3	0.03 ± 0.001	. ± .	0.02 ± 0.00	. ± .	. ± .	0.02 ± 0.004	0.02 ± 0.01	0.02 ± 0.001
C20:5	0.01 ± 0.00	. ± .	0.01 ± 0.00	. ± .	. ± .	0.02 ± 0.001	0.02 ± 0.01	0.02 ± 0.001
Total PUFA	**0.40**	**0.12**	**0.25**	**0.16**	**0.12**	**0.21**	**0.26**	**0.27**

[1]Estimates ± Standard ErrorFatty acid with . for value indicates amount not detectable.

[2]SD (Steak) = *Spinalis dorsi*: Ribeye Cap Steak; LD (Roast) = *Longissimus dorsi*: Ribeye Petite Roast; LD (Roast) = *Longissimus dorsi*: Ribeye Filet.

[3]LD (Roast) = *Longissimus dorsi*: Top Loin Petite Roast; LD (Filet) = *Longissimus dorsi*: Top Loin Filet.

[4]BF (Steak) = *Biceps femoris*: Top Sirloin Cap Steak; GM (Roast) = *Gluteus medius*: Top Sirloin Petite Roast; GM (Filet) = *Gluteus medius*: Top Sirloin Filet.

Table 3.23: Cooked Select Fatty Acid Profile[1] (Weight Percent)

	Ribeye			Top Loin		Sirloin		
Fatty Acid	SD (Steak)[2]	LD (Roast)[2]	LD (Filet)[2]	LD (Roast)[3]	LD (Filet)[3]	BF (Steak)[4]	GM (Roast)[4]	GM (Filet)[4]
C14:0	3.17 ± 0.23	3.68 ± 0.07	3.32 ± 0.01	3.60 ± 0.02	3.34 ± 0.34	2.65 ± 0.02	2.45 ± 0.17	2.61 ± 0.02
C16:0	24.34 ± 0.75	29.51 ± 0.30	25.02 ± 0.39	28.50 ± 0.29	28.9 ± 0.41	22.39 ± 0.62	21.55 ± 0.31	22.74 ± 0.54
C17:0	1.65 ± 0.01	1.22 ± 0.21	1.49 ± 0.08	1.26 ± 0.16	1.51 ± 0.18	1.96 ± 0.08	2.69 ± 1.38	1.66 ± 0.02
C18:0	14.92 ± 0.73	15.98 ± 1.46	15.36 ± 1.29	14.79 ± 0.68	15.1 ± 0.90	13.38 ± 0.35	13.86 ± 0.18	14.49 ± 0.29
C20:0	0.10 ± 0.01	· ± .	0.14 ± 0.04	· ± ·	· ± ·	0.09 ± 0.001	0.14 ± 0.04	0.03 ± 0.03
Total SFA	**44.17**	**50.39**	**45.33**	**48.15**	**48.85**	**40.46**	**40.70**	**41.53**
C14:1	1.25 ± 0.14	0.59 ± 0.15	1.31 ± 0.19	0.65 ± 0.14	0.52 ± 0.03	1.83 ± 0.03	0.86 ± 0.67	1.21 ± 0.05
C16:1	3.96 ± 0.24	3.49 ± 0.29	3.91 ± 0.08	3.78 ± 0.14	3.54 ± 0.03	4.15 ± 0.43	3.44 ± 0.07	3.63 ± 0.15
C17:1	0.66 ± 0.33	0.71 ± 0.05	1.04 ± 0.08	0.79 ± 0.07	0.85 ± 0.14	1.44 ± 0.05	1.22 ± 0.05	1.40 ± 0.15
t11 C18:1	6.76 ± 0.75	4.85 ± 0.23	6.50 ± 0.82	5.25 ± 0.65	5.43 ± 0.05	5.78 ± 0.42	5.36 ± 1.17	5.48 ± 0.43
c9 C18:1	35.08 ± 1.86	34.59 ± 1.87	34.75 ± 1.00	35.79 ± 1.34	35.23 ± 1.03	36.46 ± 0.09	32.65 ± 2.06	33.79 ± 0.22
Total MUFA	**47.70**	**44.24**	**47.51**	**46.26**	**45.58**	**49.68**	**43.55**	**45.51**
c9,c12 C18:2	2.18 ± 0.07	2.30 ± 0.07	2.65 ± 0.08	2.37 ± 0.28	1.14 ± 0.20	2.02 ± 0.12	4.35 ± 0.19	4.83 ± 0.43
c9,t11 C18:2	0.32 ± 0.07	· ± .	0.31 ± 0.02	· ± ·	· ± ·	0.42 ± 0.02	0.48 ± 0.02	0.28 ± 0.26
t10,c12 C18:2	0.05 ± 0.002	· ± .	0.06 ± ·	· ± ·	0.49 ± ·	0.09 ± 0.03	0.22 ± 0.17	· ± ·
c9,c12 C18:3	0.23 ± 0.03	· ± .	0.26 ± 0.01	· ± ·	· ± ·	0.33 ± 0.05	0.46 ± 0.12	0.40 ± 0.01
C20:5	0.06 ± 0.01	· ± .	0.12 ± 0.01	· ± ·	· ± ·	0.26 ± 0.02	0.55 ± 0.04	0.56 ± 0.02
Total PUFA	**2.83**	**2.30**	**3.39**	**2.37**	**1.63**	**3.11**	**6.07**	**6.06**

[1]Estimates ± Standard Error; Fatty acid with . for value indicates amount not detectable.

[2]SD (Steak) = *Spinalis dorsi*: Ribeye Cap Steak; LD (Roast) = *Longissimus dorsi*: Ribeye Petite Roast; LD (Roast) = *Longissimus dorsi*: Ribeye Filet.

[3]LD (Roast) = *Longissimus dorsi*: Top Loin Petite Roast; LD (Filet) = *Longissimus dorsi*: Top Loin Filet.

[4]BF (Steak) = *Biceps femoris*: Top Sirloin Cap Steak; GM (Roast) = *Gluteus medius*: Top Sirloin Petite Roast; GM (Filet) = *Gluteus medius*: Top Sirloin Filet.

Table 3.24: Cholesterol Data (mg/100 g) ± Standard Error

		Ribeye		Strip Loin	Sirloin	
Cooking Method[1]	Grade[2]	*Spinalis dorsi*	*Longissimus dorsi*	*Longissimus dorsi*	*Biceps femoris*	*Gluteus medius*
RAW	PC	73.75 ± 1.81	62.55[b] ± 0.92	63.70 ± 1.13	73.45 ± 1.12	76.60 ± 1.61
	LC	69.95 ± 1.81	68.95[ac] ± 0.92	68.75 ± 1.13	67.25 ± 1.12	69.55 ± 1.61
	SE	73.75 ± 1.81	63.35[b] ± 0.92	71.05 ± 1.13	67.20 ± 1.12	69.60 ± 1.61
	All CH	71.22 ± 1.35	66.82 ± 0.69	67.07 ± 0.84	69.32 ± 0.83	71.90 ± 1.20
	All Grades	72.23 ± 1.09	65.43 ± 0.55	68.66 ± 0.68	68.47 ± 0.67	70.98 ± 0.96
GRILL	PC	83.50 ± 1.81	82.35 ± 1.29	84.15 ± 1.13	87.60 ± 1.12	87.55 ± 1.61
	LC	80.65 ± 1.81	81.25 ± 1.29	87.65 ± 1.13	85.10 ± 1.12	87.35 ± 1.61
	SE	73.85 ± 1.81	81.85 ± 1.29	87.35 ± 1.13	89.25 ± 1.12	79.90 ± 1.61
	All CH	81.60 ± 1.35	81.62 ± 0.96	86.48 ± 0.84	85.93 ± 0.83	87.42 ± 1.20
	All Grades	78.50 ± 1.09	81.71 ± 0.77	86.83 ± 0.68	87.26 ± 0.67	84.41 ± 0.96
ROAST	PC		85.15 ± 1.29	83.50 ± 1.13		87.25 ± 1.61
	LC		81.15 ± 1.29	79.55 ± 1.13		89.70 ± 1.61
	SE		88.10 ± 1.29	83.65 ± 1.13		84.20 ± 1.61
	All CH		82.48 ± 0.96	80.87 ± 0.84		88.88 ± 1.20
	All Grades		84.73 ± 0.77	81.98 ± 0.68		87.01 ± 0.96
ALL COOK	PC		83.75 ± 1.11	83.83 ± 1.13		87.40 ± 1.29
	LC		81.20 ± 1.11	83.60 ± 1.13		88.53 ± 1.29
	SE		84.98 ± 1.11	85.50 ± 1.13		82.05 ± 1.29
	All CH		82.05 ± 0.83	83.68 ± 0.84		88.15 ± 0.96
	All Grades		83.22 ± 0.67	84.41 ± 0.68		85.71 ± 0.77

[1]GRILL = Steaks and Filets; ROAST = Roasts.

[2]PC = Premium Choice; LC = Low Choice; SE = Select; ALL CH = PC:LC weighted 1:2;
All grades = PC:LS:SE weighted 1:2:2.

[a] Different than PC ($P \leq 0.0125$).

[b] Different than LC ($P \leq 0.0125$).

[c] Different than SE ($P \leq 0.0125$).

Table 3.25: Vitamin B-12 (µg/100g) ± Standard Error

	Ribeye		Top Loin	Sirloin	
Grade[1], Cook Method	SD[2]	LD[2]	LD	BF[2]	GM[2]
PC, Raw	3.84 ± 0.55	2.61 ± 0.03	2.52 ± 0.18	2.72 ± 0.85	3.40 ± 0.49
LC, Raw	3.39 ± 0.55	3.40 ± 0.69	3.04 ± 0.63	2.68 ± 0.14	3.27 ± 0.49
SE, Raw	2.68 ± 0.55	2.66 ± 0.33	2.79 ± 0.12	2.61 ± 0.03	2.66 ± 0.49
ALL CH, Raw	3.54 ± 0.41	3.14 ± 0.46	2.87 ± 0.42	2.70 ± 0.30	3.32 ± 0.36
All Grades, Raw	3.19 ± 0.33	2.95 ± 0.31	2.84 ± 0.26	2.66 ± 0.18	3.05 ± 0.29
PC, Grilled	3.12 ± 0.55	4.09 ± 0.03	4.09 ± 0.18	3.57 ± 0.85	4.41 ± 0.49
LC, Grilled	2.93 ± 0.55	2.93 ± 0.69	3.47 ± 0.63	2.76 ± 0.14	4.09 ± 0.49
SE, Grilled	3.49 ± 0.55	3.49 ± 0.33	4.84 ± 0.12	2.91 ± 0.03	3.77 ± 0.49
ALL CH, Grilled	2.99 ± 0.41	3.31 ± 0.46	3.67 ± 0.42	3.03 ± 0.30	4.20 ± 0.36
All Grades, Grilled	3.19 ± 0.33	3.38 ± 0.31	4.14 ± 0.26	2.98 ± 0.18	4.03 ± 0.29
PC, Roasted		4.09 ± 0.03	4.09 ± 0.18		4.09 ± 0.49
LC, Roasted		3.77 ± 0.69	3.77 ± 0.63		3.47 ± 0.49
SE, Roasted		4.88 ± 0.33	4.88 ± 0.12		4.84 ± 0.49
ALL CH, Roasted		3.88 ± 0.46	3.88 ± 0.42		3.67 ± 0.36
All Grades, Roasted		4.28 ± 0.31	4.28 ± 0.26		4.14 ± 0.29
PC, Cooked		4.09 ± 0.02	4.09 ± 0.12		4.25 ± 0.38
LC, Cooked		3.35 ± 0.49	3.62 ± 0.45		3.78 ± 0.38
SE, Cooked		4.19 ± 0.24	4.86 ± 0.09		4.30 ± 0.38
ALL CH, Cooked		3.59 ± 0.32	3.77 ± 0.30		3.94 ± 0.29
All Grades, Cooked		3.83 ± 0.22	4.21 ± 0.18		4.08 ± 0.23

[1]PC = Premium Choice; LC = Low Choice; SE = Select; ALL CH = PC:LC weighted 1:2; All grades = PC:LS:SE weighted 1:2:2.

[2]SD=*Spinalis dorsi*; LD=*Longissimus dorsi*; BF=*Biceps femoris*; GM=*Gluteus medius.*

Table 3.26: Selenium (ppm) ± Standard Error

	Ribeye		Top Loin	Sirloin	
Grade[1], Cook Method	SD[2]	LD[2]	LD	BF[2]	GM[2]
PC, Raw	0.26 ± 0.03	0.23 ± 0.01	0.25 ± 0.03	0.25 ± 0.02	0.26 ± 0.01
LC, Raw	0.25 ± 0.03	0.25 ± 0.02	0.28 ± 0.03	0.29 ± 0.02	0.30 ± 0.01
SE, Raw	0.25 ± 0.03	0.24 ± 0.01	0.24 ± 0.03	0.29 ± 0.02	0.23 ± 0.01
ALL CH, Raw	0.25 ± 0.02	0.24 ± 0.01	0.27 ± 0.02	0.27 ± 0.02	0.28 ± 0.01
All Grades, Raw	0.25 ± 0.02	0.24 ± 0.01	0.25 ± 0.02	0.28 ± 0.01	0.26 ± 0.01
PC, Grilled	0.32 ± 0.006	0.33 ± 0.01	0.32 ± 0.01	0.34 ± 0.02	0.36 ± 0.01
LC, Grilled	0.32 ± 0.006	0.33 ± 0.02	0.35 ± 0.01	0.35 ± 0.02	0.34 ± 0.01
SE, Grilled	0.32 ± 0.006	0.36 ± 0.01	0.33 ± 0.01	0.36 ± 0.02	0.31 ± 0.01
ALL CH, Grilled	0.32 ± 0.005	0.33 ± 0.01	0.34 ± 0.01	0.35 ± 0.02	0.35 ± 0.01
All Grades, Grilled	0.32 ± 0.004	0.34 ± 0.01	0.34 ± 0.00	0.35 ± 0.01	0.33 ± 0.01
PC, Roasted		0.36 ± 0.01	0.35 ± 0.03		0.32 ± 0.01
LC, Roasted		0.32 ± 0.02	0.34 ± 0.03		0.36 ± 0.01
SE, Roasted		0.39 ± 0.01	0.34 ± 0.03		0.34 ± 0.01
ALL CH, Roasted		0.34 ± 0.01	0.35 ± 0.03		0.35 ± 0.01
All Grades, Roasted		0.36 ± 0.01	0.34 ± 0.02		0.35 ± 0.01
PC, Cooked		0.35 ± 0.01	0.34 ± 0.02		0.34 ± 0.01
LC, Cooked		0.33 ± 0.01	0.35 ± 0.02		0.35 ± 0.01
SE, Cooked		0.37 ± 0.01	0.34 ± 0.02		0.33 ± 0.01
ALL CH, Cooked		0.33 ± 0.01	0.34 ± 0.01		0.35 ± 0.01
All Grades, Cooked		0.35 ± 0.01	0.34 ± 0.01		0.34 ± 0.01

[1]PC = Premium Choice; LC = Low Choice; SE = Select; ALL CH = PC:LC weighted 1:2; All grades = PC:LS:SE weighted 1:2:2.

[2]SD=*Spinalis dorsi*; LD=*Longissimus dorsi*; BF=*Biceps femoris*; GM=*Gluteus medius.*

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APPENDIX A

"Lean" cuts of Beef (starting with leanest)

Eye Round Roast and Steak

Sirloin Tip Side Steak

Top Round Roast and Steak

Top Sirloin Steak

Brisket, Flat Half

95% Lean Ground Beef

Round Tip Roast and Steak

Round Steak

Shank Cross Cuts

Chuck Shoulder Pot Roast

Sirloin Tip Center Roast and Steak

Chuck Shoulder Steak

Bottom Round (Western Griller) Steak

Top Loin (Strip) Steak

Shoulder Petite Tender and Medallions

Flank Steak

Shoulder Center (Ranch) Steak

Tri-Tip Roast and Steak

Tenderloin Roast and Steak

T-Bone Steak

APPENDIX B

Major Cuts from Red Meat Species Requiring Mandatory Nutritional Labeling

Beef

-Beef, chuck blade roast,

-Beef, loin top loin steak,

-Beef, rib roast large end,

-Beef, round eye round steak,

-Beef, round top round steak,

-Beef, round tip roast,

-Beef, chuck arm pot roast,

-Beef, loin sirloin steak,

-Beef, round bottom round steak,

-Beef, brisket (whole, flat half, or point half),

-Beef, rib steak small end,

-Beef, loin tenderloin steak,

-Ground beef without added seasonings

-Ground beef about 17% fat

Pork

-Pork loin chop,

-Pork loin country style ribs,

-Pork loin top loin chop boneless,

-Pork loin rib chop,

-Pork spareribs,

-Pork loin tenderloin,

-Pork loin sirloin roast,

-Pork shoulder blade steak,

-Pork loin top roast boneless,

-Ground pork

Lamb

-Lamb shank

-Lamb shoulder arm chop,

-Lamb shoulder blade chop,

-Lamb rib roast

-Lamb loin chop,

-Lamb leg (whole, sirloin half, or shank half)

Veal

-Veal shoulder arm steak,

-Veal shoulder blade steak,

-Veal rib roast,

-Veal loin chop,

-Veal cutlets

APPENDIX C

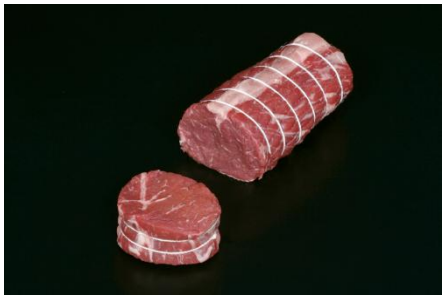
SOP: Fabrication of BAM Beef Ribeye Cuts

1. Start with a 112A Ribeye Roll.
2. Weigh and record the Ribeye Roll.
    a. The posterior end should have one muscle, the *Longissimus dorsi* (ribeye muscle).
    b. The anterior end should have up to four muscles: the *Longissimus dorsi*, *Spinals dorsi/Multifidus dorsi*, and the *complexus*.

3. Remove intercostal muscles (rib fingers), if present.
4. Remove the lip. Do not score the *Longissimus dorsi* muscle.

5. Trim external fat to 1/8 inch (note: picture not trimmed to 1/8).
6. Weigh trimmed ribeye roll.
7. Remove and separate the *Spinalis dorsi* (ribeye cap), *Multifidus dorsi*, and *complexus* muscles.
    a. Starting at the anterior end, separate the ribeye cap from the ribeye at the natural seam.
        i. Remove the *complexus* (ribeye tender) from the *Spinalis dorsi* at the natural seam.
            1. Weigh and record the *Spinalis dorsi* (cap) and *Longissimus dorsi* (ribeye).
            2. Discard *complexus*.
8. Cut *Spinalis dorsi* into 4 inch wide steaks.
        i. Label steaks.
        ii. Weigh steaks.
        iii. Vacuum package.
        iv. Store in -18°C freezer.

9. Create the blade eye and center-cut ribeye.
    a. Make a cut perpendicular to the longitudinal axis of the *Longissimus dorsi* muscle at the outermost curvature (where the small cap muscle terminates and where the eye muscle tapers).
    b. Cut 1 1/4 inch steaks from the blade eye to make boneless filets.
        i. Label boneless Ribeye Filets.
        ii. Weigh individual boneless Ribeye Filets.
        iii. Vacuum package boneless Ribeye Filets.
        iv. Store in -18°C freezer.
    c. Cut the center-cut ribeye in half (longitudinally) from anterior to posterior end, equidistance from either side of the muscle to make the Ribeye Petite Roast, boneless.
        i. Label individual boneless Ribeye Petite Roast.
        ii. Weigh individual boneless Ribeye Petite Roast
        iii. Vacuum package boneless Ribeye Petite Roast.
        iv. Store in -18°C freezer.

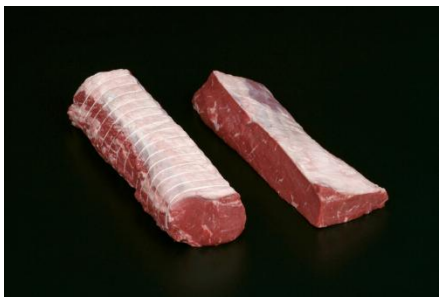


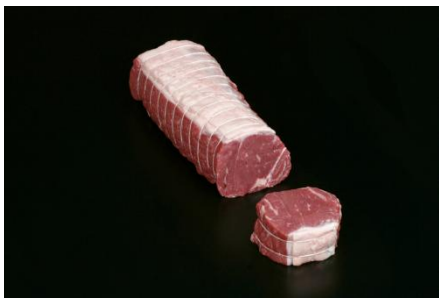
APPENDIX D

SOP : Fabrication of the Beef Loin, Strip Loin into BAM Cuts

1. Start with a 180 Beef Loin, Strip Loin, Boneless.
    a. Weigh the strip loin.
    b. The anterior end should have one muscle, the *Longissimus dorsi*, present.
    c. The posterior end should have two muscles, the *Longissimus dorsi* and the
    d. *Gluteus medius* present.
2. Remove the tail from the loin.
    a. Trim external fat thickness to .32 cmm
    b. Remove the vein roast (portion including *Gluteus medius*).
    c. Cut perpendicular to the longitudinal axis of the *Longissimus dorsi* at the origin of the *Gluteus medius*.
    d. We do not need this roast.

3. Weigh the *Longissimus dorsi* muscle (center-cut strip loin).
4. Fabricate the center-cut strip loin.
    a. Cut the center-cut striploin in half longitudinally by starting at a point equidistance from the sides on the anterior face and ending at a point equidistance from the sides on the posterior face.
    b. Weigh and record both halves.
    c. Cut one side in half equidistant from the anterior and posterior ends to generate two Top Loin Petite Roasts, boneless.
        i. Label roasts.
        ii. Weigh roasts.
        iii. Vacuum package roasts.
        iv. Store in -18°C freezer.
    d. Cut other side of center-cut strip loin into 1 ¼ inch thick boneless filets.
        i. Label filets.
        ii. Weigh individual filets
        iii. Vacuum package individual filets.
        iv. Store in -18°C freezer.



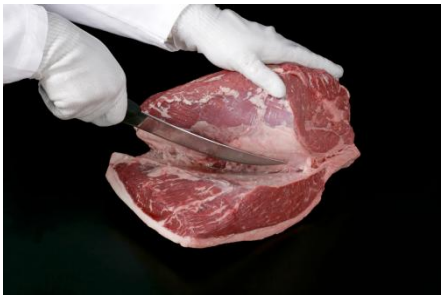


APPENDIX E

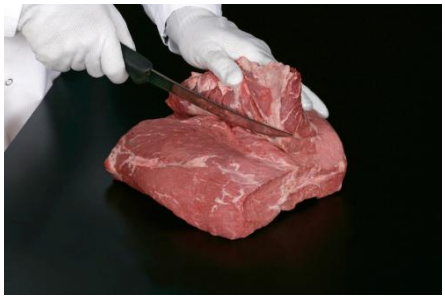
SOP: Fabrication of the Beef Loin, Top Sirloin Butt into BAM Cuts

1. Start with a 184 Beef Loin, Top Sirloin Butt.
2. Weigh and record Top Sirloin Butt.

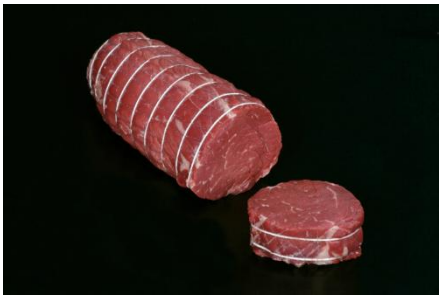
3. Trim external fat to 1/8 inch.
4. Remove the *Biceps femoris* (top sirloin cap) at the natural seam.
    a. Weigh and record the cap.
    b. Cut top sirloin cap into 1 ¼ inch steaks.
    c. Label individual steaks.
    d. Weigh and record individual steaks.
    e. Vacuum package individual steaks.
    f. Store in -18 °C freezer.



5. Remove *Gluteus accesorius* and *Gluteus profundis* ("mouse" meat) from *Gluteus medius* (center portion of the top sirloin butt).
    a. Weigh and record the center portion of the top butt.
    b. Cut center portion into thirds.

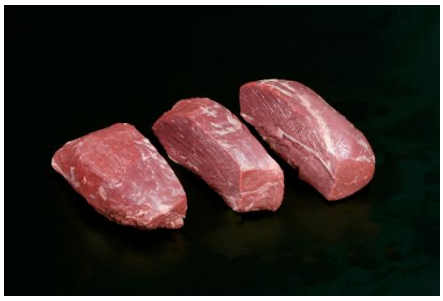


    c. Randomly select one section to cut into Top Sirloin Filets:
        i. Cut section into 1 1/4 inch steaks.
            1. Label steaks.
            2. Weigh steaks.
            3. Vacuum package steaks.
            4. Store in -18°C freezer.



ii. Leave remaining two sections for petite roasts:

1. Weigh each roast.
2. Label roasts.
3. Vacuum package individual roasts.
4. Store in -18°C freezer.



APPENDIX F

SOP: Grilling Protocol—Direct Cooking

1. Purpose: To describe the procedure for preparing and grilling BAM cuts.
2. Materials:
    a. Electric Grill: George Forman Grilling Machine. Model GRP99B. Lake Forest, IL
    b. Thermometers/thermocouples
        i. Type J or K thermocouple—calibrated prior to use
        ii. Type J or K insulated wire
            1. Same type wire must be used with corresponding thermocouple type
        iii. Infrared Thermometer—grill surface heat detection
    c. Digital Scale
        i. Calibrate daily
        ii. Record to nearest 0.1g
    d. BAM samples (Frozen, -18°C)
        i. Beef Ribeye, Cap Steak, Boneless
        ii. Beef Ribeye, Filet, Boneless
        iii. Beef Loin, Top Loin, Filet, Boneless

iv. Beef Loin, Top Sirloin, Filet, Boneles

v. Beef Loin, Top Sirloin, Cap Steak, Boneless

e. Stainless steel tongs

f. Data entry form for grilling

3. BAM Cuts preparation prior to cooking

a. Thaw frozen raw samples in original package, under refrigeration (0-4°C), for 24-48 hours; record thaw start and stop date and time.

b. Remove product from packaging and blot with a paper towel.

c. Record raw weight of each individual steak or filet to nearest 0.1 g.

d. Insert the thermocouple in the geometric center, or thickest portion of the meat.

i. Probe positioning should not affect product's contact with the cooking surface

e. Record initial internal temperature of each individual steak or filet (should not exceed 5°C for thawed product)

4. Pre-heating

a. Turn on grill according to manufacturer's instructions.

b. Preheat grill for approximately ten minutes with lid closed.

c. Record surface temperature of the grill plates using the infrared thermometer—grill surface should be approximately 195°C before cooking begins.

5. Grilling

a. Arrange cuts on grill so that they do not contact each other.

b. Record starting time (when steak or filet is put on grill).

c. Cook with grill lid closed.

d. Cook steaks and filets to an internal temperature of 70°C.

e. Remove from grill with tongs and place on wire rack at room temperature.

f. Record end grilling time.

g. Record internal peak temperature after removing from grill.

h. Record cooked weight to nearest 0.1 g at time it is removed from the grill.

6. Post-Cooking (Stand-time)

    a. Allow product to chill uncovered on wire rack under refrigeration (0-4°C) for at least 12 hours before dissection.

        i. Assure all cuts maintain proper identification.

APPENDIX G

SOP: Roasting Protocol

1. Purpose: To describe the procedure for preparing and roasting BAM cuts.
2. Materials:
    a. Calphalon Non-stick Roasting Pan with rack (anodized aluminum-16x13x4in)
    b. Thermometers/thermocouples
        i. Type J or K Thermocouple (calibrated)
        ii. Type J or K insulated wire
            1. Same type wire must be used with corresponding thermocouple type
    c. Digital Scale
        i. Calibrate daily
        ii. Record to nearest 0.1 g
    d. BAM samples (Frozen, -18°C)
        i. Beef Ribeye, Petite Roast, Boneless
        ii. Beef Loin, Top Loin, Petite Roast, Boneless
        iii. Beef Loin, Top Sirloin, Petite Roast, Boneless
        ii. Stainless steel tongs

b. Wire racks for cooling

c. Data entry form for roasting

7. BAM cuts Preparation prior to cooking

    a. Thaw frozen raw samples in original package, under refrigeration (0-4°C), for 24-48 hours; record thaw start and stop date and time

    b. Remove product from packaging and blot with a paper towel.

    c. Record raw weight of each individual roast to nearest 0.1 g.

    d. Insert the thermocouple in the geometric center, or thickest portion of the meat.

        i. Probe positioning should not affect product's contact with the cooking surface.

    e. Record initial internal temperature of each individual roast (should not exceed 5°C for thawed product).

8. Pre-heating Oven

    a. Position oven rack so that beef sample will be in center of the oven.

    b. Preheat oven ten minutes or until 160°C (325°F) is reached.

    c. Record actual oven temperature.

9. Cooking

    a. Position roast in center of the rack in the roasting pan

        i. Roasts should be fat side up on Top Loin and Ribeye Petite Roasts

    b. Position roasting pan with beef sample on oven rack in center of oven

        i. Multiple roasts may be placed in oven at the same time if the oven rack will accommodate multiple roasting pans.

c. Record starting time (when roast is placed in oven).

d. Roast to internal temperature of 60°C (140°F).

e. Remove roasting pan from oven.

    i. Record the time removed and internal product temperature when removed from oven.

    ii. Remove roast from pan and place on wire rack at room temperature.

    iii. Monitor and record peak internal temperature and time peak was reached.

    iv. Record cooked weight of roast to the nearest 0.1 g *thirty minutes after removal* from oven.

10. Post-Cooking (Stand-time)

    a. Allow product to chill uncovered on wire rack under refrigeration (0-4°C) for at least 12 hours before dissection.

        i. Assure all roasts maintain proper identification.

APPENDIX H

SOP: Homogenization Protocol

HOMOGENIZATION OF BEEF RETAIL CUT SAMPLES

NOTE: All homogenization must be done in the absence of direct light.

1. Purpose

To describe the procedure for preparing and homogenizing raw and cooked beef samples.

2. Safety

2.1 Be careful when handling the Robot-Coupe 7 blade-it is very sharp.

2.2 Cryogenic gloves, lab coat and safety goggles must be worn when handling liquid nitrogen.

3. Materials

NOTE: All utensils and equipment used in homogenization must be thoroughly cleaned and dried between each sample to assure there is no cross-contamination of materials that would affect nutrient analysis.

3.1 Robot Coupe Blixer 7 BX 6V batch processor (M1-45-3) or other approved blending/homogenizing device

3.2 Dissected and cubed beef samples to be homogenized Freezer (-80 ± 5° C ULTRA LOW TEMP)

3.3 Digital thermometer (Fisher Cat #15-078J) or equivalen

3.4 Whil-pak bag or equivalent

3.5 Gallon size freezer Ziploc bags

3.6 11-13/16” Ellipso-Spoon J spatula (Fisher Cat #14-375-57), or equivalent

3.7 Permanent, cryogenic marker (Fisher Cat #13-382-52), or equivalent

3.8 Teri Wipers (Fisher Cat #15-235-61), or equivalent

3.9 Powder-free nitrile gloves (Fisher Cat #18-999-4099), or equivalent

3.10 Ice bucket (Insulated bucket capable of withstanding liquid N), at least ~2 quarts size

3.11 One (1) medium (7-quart) stainless steel bowl

3.12 Cryogenic labels preprinted with sample numbers (Avery #5520), or equivalent

3.13 Large siliconized Rubbermaid spatula or equivalent

3.14 Analytical balance (M1-39-9 or M1-42-3, Fisher #01-913-317), or equivalent

3.15 Liquid nitrogen

3.16 Large stainless steel spoon

3.17 Safety goggles

3.18 Lab coat

3.19 Cryogenic gloves

3.20 Data sheet

3.21 Protocol

4. Procedure

4.1 Prepare for homogenization

Note: It is extremely important to protect the samples from contamination. Do not touch utensils or equipment that comes in contact with the sample. Wear clean, powder-free nitrile gloves when working with utensils, equipment and samples.

Note: All homogenization must be done in the absence of direct light to prevent nutrient loss.

4.1.1 Adhere a pre-printed label on the outside, at the bottom of all the whirl-pak bags needed. Use the specific size for the following:

4.1.1.1 Proximate – 4 oz

4.1.1.2 Total Fat – 2 oz

4.1.1.3 Back Up/Archive – 18 oz

4.1.1.4 Secondary bag – 18 oz

4.1.2 Prepare the station for homogenization. Set out labeled bags and homogenization utensils.

4.2 Homogenize the sample

Note: Wear powder-free gloves throughout the homogenization procedure.

Note: Always use the same balance throughout the entire procedure.

4.2.1 Raw Lean Samples

4.2.1.1 Remove the samples to be homogenized from the –18°C freezer. Allow the samples to thaw in the refrigerator (0°C to 4°C) for 24-48 h. When samples are thawed, the retail cut shall be dissected into separable lean, separable fat and

refuse. Once dissection is complete, proceed to the homogenization procedure.

4.2.2 Cooked Lean Samples

4.2.2.1 Remove the samples to be cooked from the –18°C freezer. Allow the samples to thaw in the refrigerator (0°C to 4°C) for 24-48 h. When samples are thawed, the retail cut shall be cooked according to study protocol. Cooked samples will be tempered for 24 h (0°C to 4°C) prior to dissection into separable lean, separable fat, and refuse. Once dissection is complete, proceed to the homogenization procedure.

4.2.3 Fat Samples

4.2.3.1 Fat samples will be homogenized by each university per subprimal and cook/raw. Dissected fat samples should be separated into two groups as follows

-external fat, raw

-external fat, cooked

Note: The total time necessary to complete steps 4.2.4 through 5.1 must not exceed two hours. If the time limit is exceeded, notify a supervisor and record the deviation on the homogenizing lab form

4.2.4 Following completion of dissection of cooked and raw samples, reserve samples in refrigeration (0°C to 4°C)

4.2.5 Prior to homogenization, place Robot Coupe 7 bowl in -80 freezer.

4.2.6 Record starting time on form.

4.2.5 Fill ice bucket with liquid nitrogen to fill line.

4.2.6 Carefully transfer sample to the ice bucket while stirring with stainless steel spoon to avoid pieces freezing to the bottom and sides of the bucket. Using the stainless steel spoon, check that all of the pieces are completely frozen. If they are not, add more liquid nitrogen in increments until the composite is completely frozen. Drain the liquid nitrogen into another bucket.

4.2.7 Transfer the frozen sample from the ice bucket into the Robot Coupe 7 bowl. (store bowl in -80 freezer until needed)

Note: Do not place more than 2500 grams of beef into the Robot Coupe 7 bowl.

4.2.8 Set the speed setting on the Robot Coupe 7 to 1500 rpm. Blend the composite for 10 seconds by turning on the power switch.

4.2.9 Turn off, then turn switch to 3500 rpm.

4.2.10 Blend the sample for 30 seconds at 3500 rpm by turning on the power switch of the Robot Coupe 7.

4.2.11 Remove the Robot Coupe 7 lid and scrape any material adhering to the lid back into the Robot Coupe 7 bowl using the large siliconized Rubbermaid 7 spatula. Scrape the residue off the spatula on the inside of the Robot Coupe 7 bowl.

4.2.12 Repeat steps 4.2.12 through 4.2.13. If the contents of the Robot Coupe 7 bowl appear to be homogeneous, proceed to step 4.2.15. Contents should be in fine powdered form free of chunks, etc. If not, repeat steps 4.2.12 through 4.2.13. If needed, store homogenized samples in -80°C freezer before aliquoting.

4.2.13 Transfer the contents of the Robot Coupe 7 bowl to a clean medium stainless steel bowl using the large stainless steel spoon. Immediately place the bowl into a bucket with liquid nitrogen.

4.2.14 Using the stainless steel spoon, stir the sample in the following manner; start at the outer edge of the bowl and work toward the center and then back out again in a smooth motion. Repeat the stirring pattern for 30 seconds.

4.3 Aliquot into sample bags for proximate analysis and for compositing.

4.3.1 Using the Ellipso-Spoon J spatula, fill a Whirl-pak bag with the required amount for sampling – Record proximate and back-up weights (tare scale for bags or weigh bags and subtract bag weight)

4.3.1.1 Proximate analysis a ***minimum of 60 grams*** for all cuts (unless noted below)

4.3.1.2 Proximate Back-up and Archive = 100 grams each

Note: 100 g of sample may not be attainable for cuts with less total product weight. For those cuts, Proximate Back-up and Archive will be aliquoted after aliquots have been made. Divide half of remaining sample into Proximate, Back-up, and Archive.

4.3.2 Make sure there is no sample residue on the opening or on the outside of the bags. Clean the bags with a Teri Wiper 7 if necessary.

4.3.3 Fold each sample bag and seal. Be sure to press out all air.

4.3.4 Place sample bag inside 18oz Whirl-pak bag, fold and seal. Store in -80°C freezer until ready for proximate analysis.

4.3.5 Aliquot 450 grams from the remainder (for each animal) into a Freezer Ziploc Bag that is properly labeled with the sample identification; remove all air and seal securely. This sample is for compositing and will be referred to as "For Composite".

Note: This is the minimum amount needed for compositing and nutritional analysis. If less than 160 g are available, contact Project Director.

4.3.5.2.1 Aliquot remaining sample accordingly

4.3.6 Record "For Composite" sample weight (tare scale for bags or weigh bags and subtract bag weight).

4.3.7 Aliquot another 450g from the remainder that is left after the sample "For Composite1". This remainder that is left should be double Ziploc bagged and stored in the -80°C freezer. This remainder, referred to as "Backup/ Archive" may be used for compositing.

Note: 450 g may not be attainable for all cuts, in this case, Backup/Archive will consist of one –half of remaining sample

(additional half used for Proximate Back-up) after all aliquots have been made.

4.3.8 Record weight of the remainder of sample- referred to as "Backup Archive" (tare scale for bags or weigh bags and subtract bag weight).

4.3.9 Record end time of homogenization of a single animal on the data sheet upon storage.

6. Storage

6.1 Make sure each bag is tightly sealed. Store the samples kept for proximates, backups, and archives in the - 80°C ± 5°C ultra-cold freezer until needed for proximate analysis. Record end time.