

RETAIL BEEF TENDERNESS SURVEILLANCE: ASSESSMENT OF WARNER-
BRATZLER SHEAR, SLICE SHEAR AND SENSORY PANEL RATINGS FOR BEEF
FROM US RETAIL ESTABLISHMENTS

A Thesis

by

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ABSTRACT

The purpose of this study was to obtain beef top loin steaks ($n=1,613$) from retail stores in four cities across the United States for WBS, SSF and consumer sensory determinations. The study was conducted over a 12-month period by four universities (California Polytechnic State University, Colorado State University, University of Missouri and Texas A&M University). The 12-month period was separated into four quarters with each collaborating university responsible for the collection of 100 steaks from their assigned metropolitan area per quarter. Measurements for SSF were obtained from the lateral portion of steaks ($n=751$). WBS measurements were obtained from the lateral, middle, and medial portion of steaks ($n=749$). Subjective measurements were obtained on steaks ($n=112$) from consumer laboratory panels. Enhanced/blade tenderized top loin steaks had the lowest ($P < 0.05$) WBS and SSF values, whereas non-enhanced top loin, bone-in had the highest ($P < 0.05$) WBS and SSF values. Enhanced/blade tenderized top loin steaks received the highest ($P < 0.05$) ratings by consumers for palatability scores whereas non-enhanced top loin, bone-in steaks had the lowest ($P < 0.05$) consumer panelist ratings. USDA quality grade did have an effect ($P < 0.05$) on the tenderness of the non-enhanced steaks. The WBS values and consumer sensory values for top loin steaks were comparable to the 2010 National Beef Tenderness Survey, signifying that no drastic changes in tenderness have occurred due to changes in antemortem or postmortem conditions.

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1. INTRODUCTION AND LITERATURE REVIEW

1.1. Introduction

Consumer satisfaction is a very important factor influencing the amount of beef that is purchased by households in the United States (Reicks et al., 2011). Therefore, consumer satisfaction and consistency of the product are highly important to maintain in an ever-changing beef market. Live management and post-harvest practices can ultimately affect the palatability of meat products. Factors that are attributed to determine beef palatability are tenderness, juiciness and flavor.

The Beef Consumer Satisfaction Study showed that tenderness is a highly influential attribute that affects a consumers' eating experience (Lorenzen et al., 1999; Neely et al., 1999, 1998; Savell et al., 1999). In addition, other research revealed that consumers are willing to pay a premium for guaranteed tender beef products (Boleman et al., 1997; Miller et al., 2001; Savell and Shackelford, 1992). Belew et al. (2003) acknowledged that the four general characteristics that had the greatest effect on meat tenderness, which are postmortem proteolysis, intramuscular fat, connective tissue, and the contractile state of a muscle. This finding helps explain some of the variation among muscles and cuts throughout a carcass.

In 1990, Texas A&M University conducted the first National Beef Tenderness Survey (Morgan et al., 1991). The purpose of this study was to determine the tenderness of beef in retail meat cases across the U.S. based on Warner-Bratzler shear (WBS) force values and trained sensory panels. Morgan et al. (1991) solely focused on the retail sector and showed tenderness concerns for the round and chuck subprimals. This study

also served as a benchmark for tenderness at the retail level. The increased growth of the food service industry in the 1990s made it important to also evaluate the tenderness of steaks from that segment of the industry and to create a baseline for tenderness. Thus, in the successive surveys of 1998, 2005, and 2010, food service cuts were added to the study, and consumer sensory panels were substituted for trained sensory panels. In the 2010 National Beef Tenderness Survey, the collection period was adjusted to a 12-month time frame to account for possible seasonality changes of product in retail and food service markets. Wholesale clubs also were added to the sampling population to account for the expanding segment. As the cattle industry constantly changes, there is a continuous need for monitoring tenderness of beef products, and these surveys have allowed the beef industry to make comparisons and improve beef tenderness.

The Retail Beef Tenderness Surveillance was conducted much in the same manner as the National Beef Tenderness Survey 2010. Unlike previous studies, steaks were purchased without obtaining any additional information about source or post-fabrication age of subprimals. After the steaks were collected in the respective cities, steaks were processed the same day of purchase at the collaborating university and frozen immediately for at least 48 hours before shipping to Texas A&M University. Furthermore, Slice shear force (SSF) determinations were included in this study for an additional objective measurement for tenderness analysis. The objective was to evaluate top loin steaks from four U.S. cities for WBS, SSF, and sensory evaluations, and to make comparisons to the findings of the previous National Beef Tenderness Survey 2010.

1.2. Literature Review

Meat tenderness is a highly influential trait for consumers when evaluating overall palatability (Lorenzen et al., 1999; Neely et al., 1999, 1998; Savell et al., 1999). Additionally, research has implied that 10 to 25% of beef products found at the retail level are considered tough (Morgan et al., 1991; Savell et al., 1991; Voges et al., 2007). Tenderness is influenced by many factors that are important to understand in their entirety to better serve beef customers. Variability among steak locations and muscle groups creates a challenge when determining the tenderness threshold for beef. By better understanding the mechanisms that affect beef tenderness, scientists can better comprehend how tenderness can affect consumer satisfaction.

1.2.1. Tenderness Analysis

Substantial research has been conducted to evaluate different methods to objectively and subjectively measure beef tenderness. The two methods to objectively measure beef tenderness that are most commonly used in the meat industry are Warner-Bratzler shear force (WBS) analysis and Slice shear force (SSF) analysis. Additionally, trained sensory panels and consumer sensory panels are two of the most common methods for subjectively evaluating palatability attributes for beef.

Of the two objective methods for tenderness determinations, WBS is the most commonly practiced analysis method. Warner-Bratzler shear force is the measurement of force required to shear across whole muscle fibers. Using the WBS method, steaks are cooked to 70°C and cooled to an internal temperature of 4°C. In order to perform WBS, steaks must be allowed to equilibrate to room or refrigerated temperature for

approximately 2- to 24-hours (Crouse and Koohmaraie, 1990; Wheeler et al., 1994). Six 1.3-cm cores then are removed from the medial, middle and lateral portions of the steak with careful attention to the direction of the muscle fiber to ensure the cores were removed parallel to the muscle fiber direction. Research has shown that a tenderness gradient exists among steaks and across muscles, therefore it is important to remove these cores from various locations from across a sample (Kerth et al., 2002). Every core is cross sectioned using a WBS analyzer and is measured in kilograms. A single value is produced per core which is then averaged to produce a single value for the tenderness of each steak. By averaging the six samples, some of the variation that exists among a single steak is taken into account. Furthermore, the WBS method of analysis produces tenderness values that correlate well to consumer tenderness ratings (Miller et al., 2001).

The National Beef Tenderness Survey has been conducted for four iterations and has solely used WBS as the objective tenderness measurement. Morgan et al. (1991) showed that shear force values indicate that a high percentage of retail cuts from the chuck and round would receive an overall tenderness rating scores less than “slightly tender.” The National Beef Tenderness Survey 1998 showed an improvement in tenderness ratings thought to be attributed to the reduction of cuts that were not sufficiently aged before consumption (Brooks et al., 2000). Voges et al. (2007) showed a majority of steaks were considered tender; however, round retail cuts still require more attention postmortem to ensure acceptable tenderness. When compared to past surveys, all WBS values improved. In Guelker et al. (2013) most steaks were considered tender,

but when compared with the most recent survey in 2006 not all WBS values decreased, or improved in tenderness.

Another common objective tenderness measurement technique was developed as a rapid method for in-line sorting of carcasses for tenderness based marketing programs, called Slice shear force (SSF). Slice shear force (SSF) was developed by Shackelford et al. (1999) as a simplified technique that could easily be implemented into in-line testing and that would be more repeatable due to a more standardized protocol. The SSF protocol was originally developed to measure the tenderness of the *M. longissimus lumborum* muscle and has since been adapted to quantify and classify multiple muscles using this rapid technique. In the SSF method, samples are cooked to 70°C and then removed from the grill surface. A cut is made across the width of the *M. longissimus lumborum* at a point about 1- to 2-cm from the lateral end of the muscle. Using the sample sizing box, a second cut was made across the width of the *M. longissimus lumborum* parallel to and at a distance of 5-cm from the first cut. A 1-cm × 5-cm slice was removed from the lateral end of the steak at a 45° angle parallel to the muscle fibers. Engineering difficulties associated with rapid, accurate removal of six cores from a hot steak led to the realization that it would be easier to obtain a rectangular slice from a steak rather than round cores (Shackelford and Wheeler, 2009). Although both SSF and WBS are very similar in that they both measure the amount of force to shear across whole muscle fibers, SSF can be determined in minutes versus hours for the WBS method. With a tenderness gradient being present within a steak, the SSF method does not account for the inherent variation. However, Kerth et al. (2002) showed that

toughest portion of the tenderness gradient within a single steak is the lateral end, which also is the end the SSF measurement is conducted on to be the most conservative in tenderness estimation. The SSF method has been proven as a highly repeatable method to assess *M. longissimus lumborum* tenderness and more repeatable (0.91 versus 0.85) than WBS measurements conducted by the same scientists (Shackelford et al., 1999).

Another method developed to analyze beef tenderness in a production setting is near-infrared reflectance (NIR) spectroscopy. Over ten years ago at a technology and tenderness meeting, it was determined that “technology to classify carcasses based on tenderness must be accurate, fast, durable, reasonably priced, and have the ability to reflect tenderness of the various cuts after advanced aging” (NCBA, 2002). Near-infrared reflectance is one of the technology outcomes of that meeting. Near-infrared reflectance is a non-invasive, rapid method that utilizes light to analyze lean properties of beef muscle to predict beef tenderness (Rust et al., 2008). The NIR system also was developed for in-line application as opposed to a laboratory setting. Work on the NIR technology continues as there has yet to be an accurate predictor of beef tenderness that also is a non-invasive prediction system. Most recently, De Marchi (2013) found that there are still limits of the NIR technique to predict WBS, but this technology has the promising ability to predict color, cooking loss, and pH of *M. longissimus lumborum*.

To track progress of the beef industry, many researchers employ sensory evaluations on their beef products to determine consumer acceptability of a certain product. Sensory evaluations are conducted on products to gain consumer insight on preference and acceptability for new products or changes/alterations in the formulation

of an existing product line. The primary function of sensory testing is to obtain valid, reliable data on which decisions can be made (Meilgaard et al., 1999). Sensory testing involves the five senses: sight, smell, taste, feel, and hearing; however, food product sensory testing focuses on odor, aroma, fragrance, consistency and flavor of the product (Meilgaard et al., 1999). There are two types of subjective tenderness measurements frequently used in meat science research and keeping the objective of the project in mind can help a researcher determine which measurement to use.

Trained sensory evaluation uses panelists who undergo extensive training to heighten their sensitivity to a specific set of traits. These panelists are calibrated amongst each other and because of their extensive training on certain traits a researcher can collect more consistent results about a product because even the slightest differences can be detected. Traits commonly evaluated by trained sensory panelists include myofibrillar tenderness, connective tissue tenderness, juiciness sustained juiciness, and flavor. While trained sensory panelists are a good measure to use when trying to detect minute differences, trained panels are not a good predictor of consumer preference.

Consumer panels are good predictors of how the general public will perceive or accept a product. Because consumer demand is the driver of any industry, fulfilling the demands and needs of consumers to keep beef as a center of the plate item is of utmost importance. Consumer sensory evaluations are a preferred method to accomplish the task of gaining insight of consumer preference or opinion based on characteristics such as overall liking or overall acceptability. A large population of consumer panelists is needed to provide sound results because of the added variation obtained by consumer

panelists (Meilgaard et al., 1999). Measurements commonly associated with consumer panels are tenderness, juiciness, flavor, overall like and overall acceptability of beef products. While instrumental, objective measures of tenderness can be conducted on beef products, consumer panelists give an insight to consumer thresholds of tenderness and help researchers determine the consumer acceptable/unacceptable tenderness line.

1.2.2. Factors Influencing Beef Tenderness

Tenderness is influenced by many factors that are important to understand in their entirety to better serve beef customers. The tenderization process is very complex and encompasses many different possibilities that may affect the tenderness of meat, but many factors are still unknown and currently being researched.

Postmortem proteolysis is one of the most common methods employed that allows for the naturally occurring enzymes to create physiological changes within a muscle over time. Multiple changes occur within a muscle as the duration of postmortem proteolysis lengthens to a given point in time when a plateau is reached and the tenderness of beef then experiences little change from that point forward in the aging process. Postmortem proteolysis promotes tenderness through increased palatability (Bidner et al., 1985; Oreskovich et al., 1988; Smith et al., 1978). Calpain and calpastatin activity were the first components found to be associated with the degradation and disappearance of z-disks during postmortem proteolysis. The two different forms of calpains are μ -calpains and m-calpains. Koohmaraie (1992) indicated that pH and temperature, two key changes that occur in muscle during rigor development, have a dramatic effect on the inactivation of μ -calpain. Dransfield et al. (1992) demonstrated

that 68% of the variation in toughness was accounted for by variation in μ -calpain activity. Calpastatin was another protein that was originally associated with the tenderness gradient; however, it works as an inhibitor of calpain. Thus, beef with increased calpastatin activity has been found tougher than beef with normal calpastatin levels because of the increased inhibitory effect on calpain.

Another reason postmortem proteolysis is important is because of the effect that the interaction actin and myosin have on the overall tenderness of meat. It has previously been thought that the bond between actin and myosin did not degrade postmortem, but research has found that it does weaken. The bond that the two contractile proteins have displays the greatest strength in the early stages of rigor. With time, the strength of the actin/myosin bond decreases. As the actin/myosin interaction weakens between 24 and 72-h postmortem, the effects of desmin, nebulin, titin, and vinculin degradation become evident (Taylor et al., 1995).

Factors such as ionic strength and collagen solubility are probably involved in the process, but they cannot explain the differences observed in tenderness of meat obtained from animals of similar age; rather, these factors set the so-called 'background toughness' (Marsh, 1977).

Intramuscular fat has been credited by meat industry personnel with making meat more tender (Aberle et al., 2001). Studies conducted over the past several decades to quantify marbling's contribution to differences in eating quality of beef generally have established low to moderate, positive relationships between marbling and cooked beef tenderness, juiciness, and flavor (Emerson et al., 2013; Smith et al., 2008). Additionally,

(Smith et al., 1985) reported strong, positive relationships between marbling and beef palatability characteristics among *M. longissimus lumborum* steaks from A-maturity carcasses, differences in marbling (ranging from PD to MA) explained 24, 27, 30, and 34% of the variation in sensory panel ratings for juiciness, tenderness, flavor, and overall palatability, respectively. Marbling functions as lubrication, eases chewing and swallowing, and improves the perception of beef tenderness. Savell and Cross (1988) found that the “window of acceptability” ranges from the lower end of USDA Select through USDA Choice, thus it is necessary for marbling to be present to ensure the palatability of beef is acceptable.

Connective tissue content differs from muscle to muscle and results in differences of beef tenderness amongst muscles. Meat products generally are comprised of approximately 1 – 4% connective tissue, which is primarily made up of the protein collagen. As an animal ages, connective tissue content increases. Aberle et al. (2001) described the estimates of amount and nature of collagen in meat cuts generally indicates that high amounts of collagen and chemically mature collagen are associated with toughness. Connective tissue is found throughout the carcass in various layers of muscle, starting at the muscle fiber level with endomysium that surrounds the muscle fibers, then perimysium surrounding the muscle bundles, and the outermost layer of connective tissue is epimysium that surrounds the entire muscles. Research has shown that the greatest contributor to beef tenderness is the perimysial connective tissue (Bailey, 1985). More recent research found that perimysial connective tissue varies the most between muscles (Purslow, 2005), which could lend itself to be a factor in

tenderness estimates. However, Lepetit (2007) states that no one individual characteristic of intramuscular connective tissue may be critically linked to beef tenderness.

Mechanical tenderization is an additional factor that influences beef tenderness. Blade tenderization occurs after a carcass has been fabricated and whole primal cuts or steaks are punctured with needles and also may be injected with a solution. Mechanical tenderization occurs by breaking through muscle fibers and connective tissue which aids in beef tenderness. Blade tenderization decreased shear values by 15-20% for roasts tumbled for 0 or 2 hours compared to roasts that were not tenderized (Pietrasik and Shand, 2004). Although blade tenderization and injecting products with a solution have favorable results for meat tenderness, some concerns with food safety have developed. Food Safety and Inspection Service (FSIS) created a Proposed Rule requiring steaks that are raw or partially cooked products and have been mechanically tenderized, must be labeled “mechanically tenderized.” FSIS implied that this allows consumers to be aware of the product they are purchasing is non-intact meat. They also recommended cooking guidelines be stated on the label since product that has been mechanically tenderized may pose a high risk of pathogenic bacteria if not cooked to higher internal temperatures.

1.2.3. Cattle Management Practices

Cattle feeding systems in the U.S. predominately feed grain-finished beef diets to meet the needs of domestic and export markets. Grain feeding is typically associated with brighter-colored, finer-textured lean, whiter fat, and more marbling (Harrison et al.,

1978; Schaake et al., 1993; Schroeder et al., 1980). These traits have been found to be highly influential in finished beef product at the retail level. They influence consumer appeal, tenderness, juiciness and flavor, with consumer appeal being the most important at the retail level.

An alternative method to feeding grain-finished diets are forage finished diets. Melton (1983) found that feeding forage-finished diets altered the flavor profile of the product. Her research found that at similar levels of fatness, meat from pasture-finished cattle was less desirable than meat from grain-finished cattle. She stated that it could be influenced by the deposition of these compounds in the fat of an animal. A strategy that can be used to reduce the alteration in the flavor profile is to supplement the diet with a grain source while on pasture.

The use of growth promoting technology has increased drastically in the beef industry over the last 30 years. Phenelthanolamines is the class of compounds that causes a reduction in the production of fat in meat animals, an increased lean growth rate, improved dressing percentages and improved feed efficiency (Anderson et al., 1991). The more common name for phenethanolamines is β -agonists. Successful implementation of β -agonists are dependent upon the duration, age, weight and genetic propensity an animal has for these compounds (Anderson et al., 2005). Some examples of β -agonists include Cimaterol, Ractopamine, Clenbuterol, and Zilpaterol.

β -agonists work by altering some of the metabolic signals within fat and muscle cells by signaling for an increase in lean growth. This naturally occurs in young animals as their plane of nutrition requires them to constantly be growing lean tissue, but as an

animal ages they begin to deposit fat which is when β -agonists would be used to modify the signal to direct nutrients to continue growth of lean tissue as opposed to fat (Anderson et al., 2005). These signals bind to specific receptors which allow for signals to be transported to the muscle. Cattle have a greater affinity for β_2 receptors while swine have a greater affinity for β_1 receptors. Currently about 70% of the market utilizes β -agonists which can be used across species, but most commonly utilized in beef and pork. Delmore et al. (2010) studied the use of zilpaterol hydrochloride, commonly known as Zilmax, as a β -agonist fed to finishing calves and was tested against a control. In Kellermeier et al. (2009), they found an increase in the hot carcass weight by 15 kg and loin eye muscle area by 14% and a decrease in yield grade, marbling score, and USDA quality grade. In regards to palatability, it has been shown that palatability attributes for the steaks that were fed zilpaterol hydrochloride had increased WBS values, yet consumers were not able to detect differences among juiciness, flavor, overall quality, tenderness acceptability or overall acceptability. Scramlin et al. (2010) found a much greater variation among WBS values, but with ractopamine hydrochloride, another β -agonist, there were lower WBS values across all days of evaluation. Both compounds can be used to create an addition of lean muscle growth; however, cattlemen have the freedom to choose between a more aggressive β -agonist in zilpaterol hydrochloride or a weaker β -agonist in ractopamine hydrochloride, as it binds to a different beta receptor.

The U.S. cattle supply has a broad range of genetics and breed types that are chosen for milk production, quality, growth, and maturity. While this genetic diversity

offers benefits to the individual producer, it is also one of the greatest sources of variation within the industry.

Researchers found a variation in marbling score, and percent USDA Choice existed with *Bos indicus* cattle having lower values in addition to *Bos indicus* cattle having higher shear force values (Johnson et al., 1990; Wheeler et al., 2001, 2005). Also, the researchers found that the Brahman breed had the greatest amount of USDA Standard cattle. A continuation of this study with other breeds allowed researchers to look at some of the American-cross breeds to have a better understanding of the role that Brahman genetics play in regards to marbling and tenderness. Wheeler et al. (2010) analyzed the Beefmaster and Brangus breeds. Beefmaster cattle are approximately $\frac{1}{2}$ Brahman, $\frac{1}{4}$ Shorthorn and $\frac{1}{4}$ Hereford and Brangus are $\frac{5}{8}$ Angus, $\frac{3}{8}$ Brahman. In this study, the Brangus breed was within a standard deviation of the population mean for marbling similar to the percent USDA Choice, while the Beefmaster breed was much lower. Johnson et al. (1990) found that tenderness tends to decrease (i.e., shear force increases) almost linearly as percentage of *Bos indicus* breeding increases. By making effective cross breeding decisions, the beef industry can attempt to minimize the discounts from the packers, while still gaining some of the benefits that the *Bos indicus* breeds have to offer. Sherbeck et al. (1996) looked at two groups of cattle, one that was $\frac{1}{2}$ Hereford x $\frac{1}{2}$ Brahman and another that was $\frac{3}{4}$ Hereford x $\frac{1}{4}$ Brahman, to determine the effect of phenotype on marbling and tenderness characteristics. The researchers found that as the phenotypic expression of Brahman characteristics increase, such as hump height, the less tender steaks that are likely.

In addition to making wise cross breeding selections, variations within a breed can also be very significant. Tenderness is considered to be a highly heritable trait among *Bos taurus* cattle, but lowly heritable among pure strains of Brahman cattle. Expected Progeny Differences (EPD) and gene markers are a way that cattlemen can improve tenderness among a herd by selecting sires that offer benefits for tenderness and other quality traits. Gene markers that prove effective for identifying genetic differences in tenderness among breeding cattle offer tremendous potential for augmenting traditional methods of selection for improved beef tenderness (Van Ednennaam, 2005).

The beef cattle inventory is said to be at less than 30 million—the lowest number since the early 1960s. Drought has impacted a majority of the cattle producing states in the U.S. which has reduced the cattle supply over the past few years. Cargill recently announced the closure of one their largest beef packing plants in the high plains of Texas to account for the decreased fed-cattle inventory available for slaughter. Due to the economic function of supply and demand, as the cattle inventory decreases and prices of beef increase, continuing to improve beef demand is an industry-wide challenge.

2. MATERIALS AND METHODS

2.1. Product Selection

Steaks were selected ($n = 1,613$) by four universities: California Polytechnic State University, Colorado State University, University of Missouri, and Texas A&M University. These collaborators sampled four metropolitan areas chosen to represent a broad geographical range and to maintain some historical linkage with cities that have been used in the National Beef Tenderness Survey. Metropolitan areas included Los Angeles, CA; Denver, CO; Kansas City, MO; and Houston, TX. Over a 12-month time period, each city was sampled four times from July 2012 to May 2013, to account for potential seasonal variation.

In each metropolitan area, a minimum of five store chains were selected to represent the socioeconomic variation among chains within a given city, and product from approximately four to five stores per chain were sampled. Approximately 20 supermarket stores or wholesale club stores per metropolitan area were sampled. Each metropolitan area was separated into geographical quadrants with equivalent proportions of stores among quadrants. Within each store, a maximum of five steaks were obtained. Top loin steaks, similar to a (NAMP 1180; North American Meat Processors Association, 2010) were obtained in all metropolitan areas. Steaks from anterior portions of beef strip loins were purchased in an effort to eliminate vein steaks from the study. Steak packages were selected from various locations within each retail case and represented the various programs and brands offered by the retailer.

Each collection team assigned a random 4-digit number to each steak and collected information for each of the individual packages. Information gathered upon collection were store name and store number, location (city), grade, enhanced/non-enhanced, brand name, package weight, price per lb, steaks per package, package date, sell by date, and packaging material. After information was collected, a digital image was captured of each package where the steak, store label, the 4-digit identification code, and original packaging material could be clearly seen. Steak packages were then placed in Ziploc® bags and placed in insulated coolers with cooling material to ensure product remained under refrigerated temperatures until further processing of steaks was performed. Internal steak temperatures were monitored during collection to ensure refrigerated product temperatures were maintained.

Steaks were transported to the respective universities, were removed from the original package, and steak thickness (cm), average fat thickness (cm), and steak weight (g) were measured and recorded (Figure 1). Four-digit identification labels on steak packages were matched with the same four-digit identification numbers on tearless paper. Steaks were vacuum packaged individually. Steaks were placed in the freezer in a single layer for a minimum of 48 hours on flat trays prior to shipment to Texas A&M University.

Frozen steaks were shipped overnight in insulated containers with sufficient refrigerant to ensure that products were shipped and received frozen. When dry ice was used as the refrigerant, a barrier of newspaper was placed between the dry ice and the steaks. Upon arrival at Texas A&M University, steaks were processed under

refrigerated conditions (2 to 4°C). Information regarding level of freeze and package integrity was recorded during processing at Texas A&M University. Steaks were placed in a blast freezer in a single layer for a minimum of 48 hours on flat trays. Steaks were assigned randomly to be used for WBS, SSF, and consumer sensory panels.

2.2. Warner-Bratzler shear force

Steaks were thawed in a 4°C cooler for 48 hours prior to cooking. Steaks were cooked on a grated, non-stick electric grill (Hamilton Beach™ Indoor/Outdoor Grill, Southern Pines, NC). The grills were pre-heated for 15-minutes to an approximate temperature of 177°C. Before cooking, steaks were weighed for a raw weight, and initial internal temperatures were recorded. All steaks were turned upon reaching 35°C, and removed from the grill upon reaching an internal temperature of 70°C. Internal temperature was monitored with a thermocouple (Omega™ HH501BT, Stamford, CT) using a 0.02 cm diameter, copper constantan Type-T thermocouple wire. After steaks were removed from the grill, the thermocouple was removed from the steak and the steak was weighed for final steak weight. Steaks were then cooled for approximately 16 hours at 2 to 4°C.

After cooling, steaks were trimmed of visible fat and heavy connective tissue to expose muscle fiber orientation. At least six 1.3 cm cores were removed from each steak at locations from the medial, middle and lateral portions (Figure 2). Cores were removed parallel to the muscle fibers and sheared once, perpendicular to the muscle fibers, on a United Testing machine (United SSTM-500, Huntington Beach, CA) at a cross-head speed of 500 mm/min using an 226.8 kg load cell, and a 1.02 cm thick V-

shape blade with a 60° angle and a half-round peak. The peak force (N) needed to shear each core was recorded, and the mean peak shear force of the cores was used for statistical analysis.

2.3. Slice shear force

Steaks were thawed in a 4°C cooler for 48 hours before cooking. Steaks were cooked on a grated, non-stick electric grill (Hamilton Beach™ Indoor/Outdoor Grill, Southern Pines, NC). The grills were pre-heated for 15-minutes to an approximate temperature of 177°C. All steaks were turned upon reaching 35°C, and removed from the grill upon reaching an internal temperature of 70°C. Internal temperature was monitored with a thermocouple (Omega™ HH501BT, Stamford, CT) using a 0.02 cm diameter, copper constantan Type-T thermocouple wire. After cooking, the steak cook yield data were collected, the steak was trimmed of all visible fat and connective tissue. A cut was made across the width of the *M. longissimus lumborum* at a point about 1 to 2 cm from the lateral end of the muscle. Using the sample sizing box (Figure 3), a second cut was made across the width of the *M. longissimus lumborum* parallel to and at a distance of 5 cm from the first cut. A 1 cm × 5 cm slice was removed from the lateral end of the steak at a 45° angle parallel to the muscle fibers (Figure 4). The slice shear force was performed on the United Testing machine at a cross-head speed of 500 mm/min using an 226.8 kg load cell, and a 1.02 cm thick flat blade with a half-round peak. The peak force (N) needed to shear each slice was recorded, and used for statistical analysis.

2.4. Consumer panel

Consumer sensory panels and shear force determinations were conducted concurrently with sample collection when product from an entire quarter was received. Panelists were recruited from surrounding communities by randomly calling possible participants, and through email listserves. A consent form and demographic questionnaire was signed by each participant. Steaks were randomly assigned to panelists for evaluation. Each panelist received two 1.27 cm cubes of each sample and evaluated four random samples during the session. Samples were characterized using 10-point hedonic scales for overall like (10 = like extremely; 1 = dislike extremely), overall like of tenderness (10 = like extremely; 1 = dislike extremely), intensity of the tenderness (10 = extremely tender; 1 = extremely tough), overall like of flavor (10 = like extremely; 1 = dislike extremely), level of beef flavor (10 = extremely intense; 1 = extremely bland/no flavor), overall like of juiciness (10 = like extremely; 1 = dislike extremely), and level of juiciness (10 = extremely juicy; 1 = extremely dry).

2.5. Statistical analysis

Data were analyzed as analysis of variance using PROC GLM of SAS (SAS Institute, Inc., Cary, NC). Least squares means were generated for main effects and separated using PDIFF option when appropriate with an alpha-level ($P < 0.05$). The percentages of steaks stratified into tenderness classes (Belew et al., 2003; Shackelford et al., 1991; Voges et al., 2007) were analyzed using PROC FREQ of SAS.

For Warner-Bratzler shear force, slice shear force, and consumer sensory analysis data, final internal temperature was used as a covariate in the model. Steak

thickness, steak weight, steak fat thickness, steak type (top loin, boneless, top loin, bone in and enhanced/blade tenderized top loin, boneless), city, quarter, and city by quarter were included in the model. Steak type effects were reported. For Warner-Bratzler shear force, slice shear force, and consumer sensory analysis data, steak type, city, quarter, city by quarter and steak by quarter were defined as main effects. Steak effects were reported.

3. RESULTS AND DISCUSSION

3.1. Product selection

Approximately 61% of retail cuts were branded with a packer program or labeled with a store brand (data not reported in tabular form). The percentage of retail steaks from branded programs was consistent with Guelker et al. (2013) who reported that 64% of steaks in their survey were from a branded program. This was a substantial increase from the 43% reported by Voges et al. (2007). Clearly, branded beef is a major factor in today's retail marketplace.

Steak thickness, external fat thickness, and steak weight are reported in Table 1. Top loin steaks were cut the thickest ($P < 0.05$) at 2.90 cm, whereas top loin bone-in steaks were the thinnest at 2.48 cm. Mean values for thickness of top loin steaks were higher numerically than the two prior surveys. Top loin bone-in steak thickness was also lower numerically than thicknesses reported by Guelker et al. (2013). Top loin steaks, and top loin bone-in steaks had similar external fat at 0.53 cm, which is higher numerically than the external fat thickness means found in other studies (Guelker et al., 2013; Voges et al., 2007). Mean steak weight was 0.36 kg (data not reported in the tabular form). Enhanced/blade tenderized, top loin steaks weighed the most ($P < 0.05$) at 0.37 kg, whereas non-enhanced, top loin bone-in steaks weighed the least ($P < 0.05$) at 0.35 kg. Enhancement/blade tenderization then was used to stratify these data, which are shown in Table 2. Enhanced/blade tenderized top loin steaks were cut the thickest ($P < 0.05$) at 3.18 cm, whereas non-enhanced, top loin bone-in steaks were cut the thinnest

($P < 0.05$) at 2.50 cm. Enhanced/blade tenderized, top loin steaks measured a means of 0.63 cm for external fat thickness.

3.2. Warner-Bratzler shear force

WBS values are reported in Table 3. Top loin steaks had lower WBS values compared to top loin bone-in steaks. Voges et al. (2007) reported top loin, and top loin bone-in steaks were among the steaks to have the lowest WBS values. In comparison to previous National Beef Tenderness Surveys, Guelker et al. (2013) found similar least squares means values for top loin steaks in comparison to the current study at 24.5 N. Compared to Brooks et al. (2000) and Morgan et al. (1991), the WBS values have decreased numerically, and compared to Voges et al. (2007) WBS values have increased numerically. As branded programs and store brands have increased volume since the 2006 survey, a plateau in beef tenderness may have occurred. However, when stratified by enhancement/blade tenderization, WBS values were lower ($P < 0.05$) for enhanced, top loin steaks compared to either of the non-enhanced steak groups (Table 4). Additionally, seasonality and location also were analyzed in this study unlike the previous National Beef Tenderness Surveys. For WBS values, there were no ($P < 0.05$) city effects (Table 5), but there were seasonal (or quarter, if that is how you want to report this info) effects ($P < 0.05$; Table 6). Quarter 2 (October-December) had the toughest steaks at ($P < 0.05$) and Quarter 4 (April and May) had the most tender ($P < 0.05$) steaks. Over the past several decades, studies have tried to determine the relationship marbling plays in palatability traits of tenderness, juiciness and flavor. Emerson et al. (2013) and Smith et al. (1985) found strong correlations between USDA

grade and the sensory characteristics of tenderness, juiciness, and flavor. Both studies looked at steaks (ranging from USDA Standard to USDA Prime) and suggested that the marbling accounted for more than 20% of the variation in sensory panel ratings, which is much higher compared to other studies. In Table 7, the least squares means for Warner-Bratzler shear force stratified by USDA quality grade shows that as quality grade decreased, the WBS force value increased numerically. This suggests that marbling and the quality grade does play a role in beef tenderness.

Additionally, steaks were separated into the tenderness categories, developed by Belew et al. (2003) and Shackelford et al. (1991) to stratify retail steaks into the tenderness classes (Table 8). Percentage of top loin steaks across tenderness categories was similar to data reported in Emerson et al. (2013) and Guelker et al. (2013). Also, a higher percentage of more tender top loin bone-in steaks was also reported than by Guelker et al. (2013). Although an increase in the “intermediate” and “tough” categories can be seen in top loin steaks when compared to Voges et al. (2007), grade information for the steaks show that the USDA quality grade may have played an important role in WBS values. From the packages that had a USDA quality grades listed, 96% of USDA Prime, 86% of USDA Choice, and 60% of USDA Select were suitable for the “very tender,” $WBS < 31.4$ N, category (data not reported in tabular form). According to the proposed standard for WBS specifications for tenderness marketing claims developed by the ASTM International Committee F10.60 on Livestock, Meat and Poultry Marketing Claims, approximately 95% of the steaks evaluated with the WBS objective tenderness measurement met the criteria, $WBS \leq 4.4$ kg or 43.1 N, to be considered *Certified*

Tender. When compared to Guelker et al. (2013), 98% of the retail top loin bone-in and boneless steaks considered to meet the standards for ASTM *Certified Tender* claims.

Although enhanced and/or blade tenderized steaks are not eligible for tenderness claims, all of the enhanced/blade tenderized top loin steaks would have had shear values needed to be eligible for the “very tender” class.

3.3. *Slice shear force*

The values for the least means squares for SSF are reported in Table 3. In the current study, SSF values for top loin steaks were similar to top loin bone-in steaks. When stratified by enhancement, enhanced/blade tenderized top loin steaks had lower ($P < 0.05$) SSF values (Table 4). There were no ($P < 0.05$) city or seasonal effects for SSF values. Slice shear force values from steaks stratified by USDA quality grade are reported in Table 9. According to the proposed standard for SSF specifications for tenderness marketing claims developed by the ASTM International Committee F10.60 on Livestock, Meat and Poultry Marketing Claims, approximately 85% of the steaks evaluated with the SSF objective tenderness measurement met the criteria, $SSF \leq 20$ kg or 196.1 N, to be considered *Certified Tender*, which is similar to the number of steaks that qualified for the same program found in Emerson et al. (2013). Kerth et al. (2002) showed that the toughest portion of the tenderness gradient within a single steak is the lateral end, which also is the end used for the SSF measurement was conducted on to be the most conservative in tenderness estimation. Because steaks were only measured on the lateral portion of the *M. longissimus lumborum*, that may cause the number of steaks suitable for a *Certified Tender* program to be less than those suitable based on WBS

measurements as measurements were taken from all sections and then were averaged. The SSF method has been proven to be highly repeatable method used to assess *M. longissimus lumborum* tenderness and is more repeatable (0.91 versus 0.85) than WBS measurements conducted by the same scientists (Shackelford et al., 1999).

3.4. Consumer sensory evaluations

Consumer demographic information is presented in Table 10. Least squares means for sensory panel ratings are presented in Table 11. The top loin received the highest ($P < 0.05$) ratings by consumers across all categories, whereas top loin, bone-in steaks received the lowest ($P < 0.05$) ratings by all consumers. When stratified by enhancement, enhanced/blade tenderized top loin steaks received the highest ($P < 0.05$) ratings in tenderness level and flavor like/dislike categories compared to their non-enhanced counterparts which can be found in Table 12. The top loin cut was similar in ranking to Voges et al. (2007) whereas the top loin bone-in data reported in Guelker et al. (2013).

4. CONCLUSION

The majority of the steaks evaluated in this study were considered tender. When compared to the previous National Beef Tenderness Surveys, the WBS values were numerically similar to those found in the 2010 survey. This may be due to a possible plateau in beef tenderness as 61% of packages at the retail level are marked with either packer programs or store brands offering tenderness claims, which is similar to the findings of Guelker et al. (2013). These packer programs and store brands that focus on tenderness claims will continue to play a role in maximizing beef tenderness and overall consumer satisfaction.

In general, tenderness values for the current study appear to be similar in WBS values to those found in Guelker et al. (2013). When compared to previous National Beef Tenderness surveys, top loin WBS values have increased from the 2006 survey, but decreased since the 1991 and 2000 surveys. Although WBS values have increased since the work done by Voges et al. (2007), consumer panelist data for top loin steaks were similar across all categories, which may indicate that consumers have had a shift in their perception of the palatability traits. Information from our study can serve as a benchmark for the tenderness of beef available at the retail and food service levels and can be used to support further research to improve the tenderness of beef steaks in the U.S.

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APPENDIX A



Figure 1. Measuring steak parameters upon arrival to the respective laboratories.



Figure 2. Core removal for Warner-Bratzler shear force analysis.

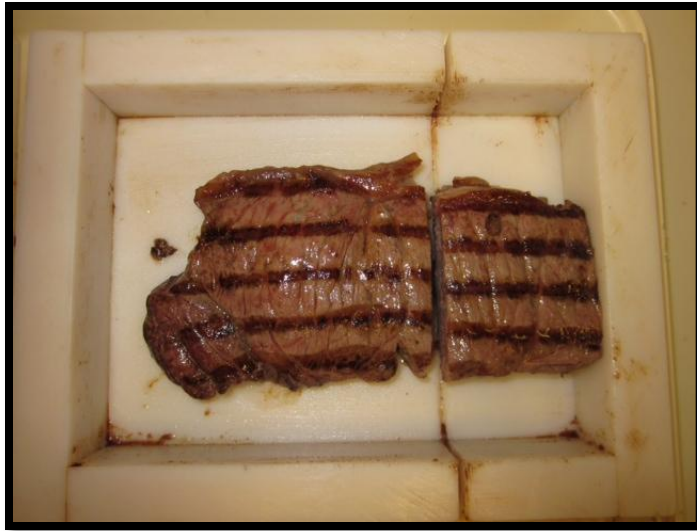


Figure 3. Steak in the slice shear force sample sizing box.

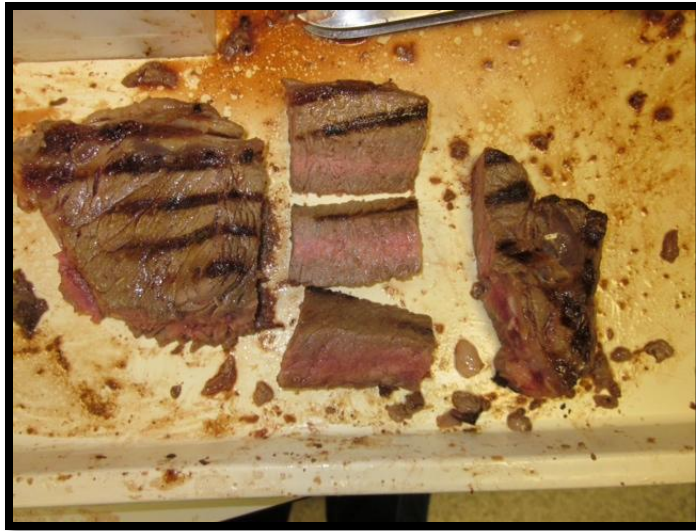


Figure 4. Slice cuts for slice shear force analysis.

APPENDIX B

Table 1. Least squares means \pm standard errors for steak thickness, external fat thickness, and steak weight of retail cuts

Steak	<i>n</i>	Steak thickness, cm	External fat thickness, cm	Steak weight, kg
Top loin	1347	2.90 ^a (± 0.02)	0.53 (± 0.01)	0.36 (± 0.00)
Top loin, bone-in	266	2.48 ^b (± 0.04)	0.53 (± 0.03)	0.35 (± 0.01)

^{a,b} Least squares means within the same column lacking a common letter differ ($P < 0.05$).

Table 2. Least squares means \pm standard errors for steak thickness, external fat thickness, and steak weight of retail cuts stratified by enhancement

		Steak thickness, cm	External fat thickness, cm	Steak weight, kg
Steak	<i>n</i>			
Non-enhanced				
Top loin	1257	2.88 ^b (± 0.02)	0.52 ^b (± 0.01)	0.36 (± 0.00)
Top loin, bone-in	266	2.50 ^c (± 0.04)	0.54 ^{ab} (± 0.03)	0.35 (± 0.01)
Enhanced/Blade Tenderized				
Top loin	90	3.18 ^a (± 0.06)	0.63 ^a (± 0.05)	0.37 (± 0.01)

^{a-c} Least squares means within the same column lacking a common letter differ ($P < 0.05$).

Table 3. Least squares means and standard errors (SE) for Warner-Bratzler shear values (N) and Slice shear values (N) of retail steaks

Steak	Warner-Bratzler shear values			Slice shear values		
	<i>n</i>	Mean, N	SE	<i>n</i>	Mean, N	SE
Top loin	631	24.50	0.36	622	152.02	2.00
Top loin, bone-in	118	27.22	0.89	129	160.14	4.75
<i>P</i> -value		<0.0001			0.0091	

Table 4. Least squares means and standard errors (SE) for Warner-Bratzler shear values (N) and Slice shear values (N) of retail steaks stratified by enhancement

	Warner-Bratzler shear values			Slice shear values		
Steak	<i>n</i>	Mean, N	SE	<i>n</i>	Mean, N	SE
Non-enhanced						
Top loin	589	25.1 ^a	0.37	576	155.09 ^a	2.11
Top loin, bone-in	118	26.8 ^a	0.90	129	157.60 ^a	4.76
<i>P</i> -value		<0.0001			<0.0001	
Enhanced/ Blade Tenderized						
Top loin	42	17.0 ^b	1.64	32	117.04 ^b	9.51
<i>P</i> -value		<0.0001			<0.0001	

^{a,b} Least squares means within the same column lacking a common letter differ ($P < 0.05$).

Table 5. Least squares means and standard errors (SE) by City for Warner-Bratzler shear values (N) and Slice shear values (N) of retail steaks

City	Warner-Bratzler shear values			Slice shear values		
	<i>n</i>	Mean, N	SE	<i>n</i>	Mean, N	SE
Denver	191	22.0	0.95	180	143.7	5.27
Houston	195	23.6	0.89	190	137.8	5.00
Kansas City	180	23.6	0.87	191	147.5	4.93
Los Angeles	183	22.6	0.77	190	144.0	4.33
<i>P</i> -value		<0.0001			<0.0001	

Table 6. Least squares means and standard errors (SE) by Quarter for Warner-Bratzler shear values (N) and Slice shear values (N) of retail steaks

Quarter	Warner-Bratzler shear values			Slice shear values		
	<i>n</i>	Mean, N	SE	<i>n</i>	Mean, N	SE
Quarter 1 (July-September)	186	23.4 ^{ab}	1.62	186	143.6	9.94
Quarter 2 (October- December)	186	24.9 ^b	1.12	188	144.0	5.84
Quarter 3 (January- March)	186	22.4 ^{ab}	0.96	186	145.7	5.60
Quarter 4 (April-May)	191	21.2 ^a	1.34	191	139.6	6.78
<i>P</i> -value		<0.0001			<0.0001	

^{a,b} Least squares means within the same column lacking a common letter differ ($P < 0.05$).

Table 7. Least squares means \pm standard errors for Warner-Bratzler values (N) of retail steaks stratified by USDA grade

Steak	USDA grade group												<i>P</i> -value
	Prime			Choice			Select			No Grade Listed			
	<i>n</i>	Mean, N	SE	<i>n</i>	Mean, N	SE	<i>n</i>	Mean, N	SE	<i>n</i>	Mean, N	SE	
Top loin	17	18.83 ^a	2.2	282	23.82 ^b	0.5	38	30.20 ^d	1.5	279	25.67 ^c	0.5	<0.0001
Top loin, bone-in				22	25.14 ^{bc}	1.9				96	26.73 ^c	0.9	<0.0001

^{a-d} Least squares means within the same column lacking a common letter differ ($P < 0.05$).

Data for USDA Prime and Select top loin, bone-in steaks were not available at retail stores to be included in sampling

Table 8. Percentage distribution of retail steaks stratified into tenderness categories

Steak	“Very Tender” WBS ¹ < 31.4 N	“Tender” 31.4 N < WBS ¹ < 38.3 N	“Intermediate” 38.3 N < WBS ¹ < 45.1 N	“Tough” WBS ¹ > 45.1 N
Top loin	80.98	10.78	5.07	3.2
Top loin, bone-in	76.27	12.71	6.78	4.24

WBS¹ = Warner-Bratzler shear values

Table 9. Least squares means \pm standard errors for Slice shear force values (N) of retail steaks stratified by USDA grade

Steak	USDA grade group								<i>P</i> -value
	Prime		Choice		Select		No Grade Listed		
	<i>n</i>		<i>n</i>		<i>n</i>		<i>n</i>		
Top loin	9	124.0±11.2	314	149.6±2.8	29	144.7±9.1	256	159.1±3.1	0.0003
Top loin, bone-in			16	170.6±12.2			113	155.6±4.6	0.0003

Data for USDA Prime and Select top loin, bone-in steaks were not available at retail stores to be included in sampling

Table 10. Demographic attributes of consumers ($n = 133$ panelists) that participated in the consumer sensory panels

Item	Retail	
	n	%
	133	
Age, yr		
<20	20	15.04
20-29	62	46.62
30-39	7	5.26
40-49	12	9.02
50-59	14	10.53
≥ 60	18	13.53
Income, US\$		
<20,000	49	36.84
20,000-29,000	15	11.28
30,000-39,000	12	9.02
40,000-49,000	12	9.02
50,000-59,000	16	12.03
$\geq 60,000$	29	21.80
Gender		
Male	60	50.00
Female	60	50.00
Working status		
Not employed	8	6.02
Full-time	29	21.80
Part-time	67	50.38
Student	29	21.80
Ethnicity		
Caucasian	123	93.18
Black	4	3.03
Hispanic	2	1.52
American Indian	0	0.00
Asian or Pacific Islander	3	2.27
Household		
1	46	34.59
2	56	42.11
3	15	11.28
4	13	9.77
5	2	1.50
≥ 6	1	0.75

Table 11. Least squares means \pm standard errors for sensory panel ratings for retail steaks¹

Steak	<i>n</i> ²	Overall like/ dislike	Tenderness like/dislike	Tenderness level	Flavor like/ dislike	Flavor level	Juiciness like/ dislike	Juiciness level
Top loin	93	6.92 \pm 0.10 ^a	6.90 \pm 0.11 ^a	6.89 \pm 0.11 ^a	6.80 \pm 0.10 ^a	6.51 \pm 0.10 ^a	6.84 \pm 0.10 ^a	6.70 \pm 0.10 ^a
Top loin, bone-in	18	6.17 \pm 0.22 ^b	6.03 \pm 0.25 ^b	5.84 \pm 0.25 ^b	6.14 \pm 0.22 ^b	5.75 \pm 0.23 ^b	5.87 \pm 0.23 ^b	5.79 \pm 0.23 ^b

^{a-c} Least squares means within the same column lacking a common letter differ ($P < 0.05$).

¹Sensory panel ratings for like/dislike: 10= like extremely, 1= dislike extremely; tenderness: 10= very tender, 1= not at all tender; flavor: 10= extreme amount, 1= none at all; juiciness: 10= very juicy, 1= not at all juicy.

²No. of steaks evaluated.

Table 12. Least squares means \pm standard errors for sensory panel ratings for retail steaks¹

Steak	<i>n</i> ²	Overall like/ dislike	Tenderness like/dislike	Tenderness level	Flavor like/ dislike	Flavor level	Juiciness like/ dislike	Juiciness level
Non-enhanced								
Top loin	87	6.90 \pm 0.11 ^a	6.88 \pm 0.12 ^a	6.86 \pm 0.12 ^b	6.74 \pm 0.11 ^b	6.46 \pm 0.11 ^b	6.82 \pm 0.11 ^a	6.67 \pm 0.11 ^a
Top loin, bone-in	18	6.03 \pm 0.29 ^b	5.89 \pm 0.33 ^b	5.62 \pm 0.32 ^c	5.92 \pm 0.29 ^c	5.69 \pm 0.31 ^c	5.71 \pm 0.31 ^b	5.67 \pm 0.30 ^b
Enhanced/blade tenderized								
Top loin	6	7.66 \pm 0.44 ^a	7.78 \pm 0.49 ^a	7.93 \pm 0.48 ^a	8.02 \pm 0.44 ^a	7.49 \pm 0.46 ^a	7.58 \pm 0.45 ^a	7.45 \pm 0.45 ^a

^{a-c} Least squares means within the same column lacking a common letter differ ($P < 0.05$).¹Sensory panel ratings for like/dislike: 10= like extremely, 1= dislike extremely; tenderness: 10= very tender, 1= not at all tender; flavor: 10= extreme amount, 1= none at all; juiciness: 10= very juicy, 1= not at all juicy.²No. of steaks evaluated.

APPENDIX C

Detail Beef Tenderness Surveillance-2012 RETAIL-TAMU Cut Information

Date _____ Evaluation Team _____ Recorded by _____

City:		Store Chain:		Store Number:	
RETAIL CUT:		Top Loin Steak BNLS		Top Loin Steak Bone-In	
SERVICE TYPE:		Full Service		Self Service	
GRADE:		Prime Top Choice Choice		Select No Grade Listed	
ENHANCED:		Yes No			
BRAND NAME:					
Wgt Wgt (lb):		Price/lb:	* Qty Qty :	Exp Date:	Sell by Date:
TAMU ID #	Steak Thickness (in)	Avg. Fat Thick (in)	Steak Weight (g)	Packaging Material	Miscellaneous

Header

City:		Store Chain:		Store Number:	
RETAIL CUT:		Top Loin Steak BNLS		Top Loin Steak Bone-In	
SERVICE TYPE:		Full Service		Self Service	
GRADE:		Prime Top Choice Choice		Select No Grade Listed	
ENHANCED:		Yes No			
BRAND NAME:					
Wgt Wgt (lb):		Price/lb:	* Qty Qty :	Exp Date:	Sell by Date:
TAMU ID #	Steak Thickness (in)	Avg. Fat Thick (in)	Steak Weight (g)	Packaging Material	Miscellaneous

City:		Store Chain:		Store Number:	
RETAIL CUT:		Top Loin Steak BNLS		Top Loin Steak Bone-In	
SERVICE TYPE:		Full Service		Self Service	
GRADE:		Prime Top Choice Choice		Select No Grade Listed	
ENHANCED:		Yes No			
BRAND NAME:					
Wgt Wgt (lb):		Price/lb:	* Qty Qty :	Exp Date:	Sell by Date:
TAMU ID #	Steak Thickness (in)	Avg. Fat Thick (in)	Steak Weight (g)	Packaging Material	Miscellaneous

City:		Store Chain:		Store Number:	
RETAIL CUT:		Top Loin Steak BNLS		Top Loin Steak Bone-In	
SERVICE TYPE:		Full Service		Self Service	
GRADE:		Prime Top Choice Choice		Select No Grade Listed	
ENHANCED:		Yes No			
BRAND NAME:					
Wgt Wgt (lb):		Price/lb:	* Qty Qty :	Exp Date:	Sell by Date:
TAMU ID #	Steak Thickness (in)	Avg. Fat Thick (in)	Steak Weight (g)	Packaging Material	Miscellaneous

Footer

Revised 7/10/12

Entered by _____ Date _____ Checked by _____ Date _____

Date _____ Evaluation Team _____ Recorded by _____

[illegible]

Entered by _____ Date _____ Checked by _____ Date _____

Texas A&M University
Retail Beef Tenderness Surveillance

Pg 1 of 3

Receiving Steaks

[illegible]

Recorded By:
Date Recorded:

Entered By:
Date Entered:

Checked By:
Date Checked:

[illegible]Page of

Entered by _____ Date _____
Checked by _____ Date _____

Revised 12/03/2012

Page ____ of ____

Entered by ____ Date ____

Checked by ____ Date ____

Recorded by _____ Date _____

1

[illegible]

Page ____ of ____

Entered by _____ Date _____ Checked by _____ Date _____

Panelist Demographic Information

Fill out the following information by placing an X in the correct box.

1. Please indicate your age by marking the appropriate blank:

<input type="checkbox"/> Under 21 years	<input type="checkbox"/> 40-49 years
<input type="checkbox"/> 22-29 years	<input type="checkbox"/> 50-59 years
<input type="checkbox"/> 30-39 years	<input type="checkbox"/> 60 years or older

2. Please indicate your income (combined income if both you and your spouse are employed) by marking the appropriate blank:

<input type="checkbox"/> Under \$20,000	<input type="checkbox"/> \$40,000-49,000
<input type="checkbox"/> \$20,000-29,000	<input type="checkbox"/> \$50,000-59,000
<input type="checkbox"/> \$30,000-39,000	<input type="checkbox"/> \$60,000 or more

3. Please indicate your household size, including yourself:

<input type="checkbox"/> 1	<input type="checkbox"/> 4
<input type="checkbox"/> 2	<input type="checkbox"/> 5
<input type="checkbox"/> 3	<input type="checkbox"/> 6 or more

4. Please indicate your current working status:

<input type="checkbox"/> Not employed	<input type="checkbox"/> Full-time
<input type="checkbox"/> Part-time	<input type="checkbox"/> Student

5. Please indicate your sex:

<input type="checkbox"/> Male	<input type="checkbox"/> Female
-------------------------------	---------------------------------

6. Please indicate your ethnic background:

<input type="checkbox"/> White	<input type="checkbox"/> American Indian
<input type="checkbox"/> Black	<input type="checkbox"/> Asian or Pacific Islander
<input type="checkbox"/> Hispanic	

Participant Number _____

Sample Number _____

Group Time _____

Date _____

1. Indicate by placing a mark in the box your **OVERALL LIKE/DISLIKE** of the meat sample.

--	--	--	--	--	--	--	--	--	--

Dislike
Extremely

No
Preference

Like
Extremely

2. Indicate by placing a mark in the box your **LIKE/DISLIKE** for the **FLAVOR** of the meat sample.

--	--	--	--	--	--	--	--	--	--

Dislike
Extremely

No
Preference

Like
Extremely

3. Indicate by placing a mark in the box how you feel about the **LEVEL** of **FLAVOR**.

--	--	--	--	--	--	--	--	--	--

Extremely
Blend or No Flavor

Extremely
Flavorful

4. Indicate by placing a mark in the box your **LIKE/DISLIKE** for the **BEEFY FLAVOR** of the meat sample.

--	--	--	--	--	--	--	--	--	--

Dislike
Extremely

Like
Extremely

5. Indicate by placing a mark in the box how you feel about the **LEVEL** of **BEEFY FLAVOR** for the meat product.

--	--	--	--	--	--	--	--	--	--

Extremely
Blend or No Flavor

Extremely
Flavorful

6. Indicate by placing a mark in the box your **LIKE/DISLIKE** for the **TENDERNESS** of the meat product.

--	--	--	--	--	--	--	--	--	--

Dislike
Extremely

Like
Extremely

Participant Number _____
Sample Number _____

Group Time _____
Date _____

7. Indicate by placing a mark in the box your **LEVEL of TENDERNESS** of the meat product.

--	--	--	--	--	--	--	--	--	--

Extremely
Tough

Extremely
Tender

8. Indicate by placing a mark in the box your **LIKE/DISLIKE** for the **JUICINESS** of the meat product.

--	--	--	--	--	--	--	--	--	--

Dislike
Extremely

Like
Extremely

9. Indicate by placing a mark in the box how you feel about the **LEVEL of JUICINESS** of the meat product.

--	--	--	--	--	--	--	--	--	--

Extremely
Dry

Extremely
Juicy