IMPACT OF SEASONINGS ON SENSORY ATTRIBUTES OF BEEF ACROSS THREE CUTS OF STEAK AND TWO USDA GRADES

by

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Abstract

Three cuts of steak (strip, chuck-eye and top blade) of two United States Department of Agriculture grades (choice and select) underwent seasoning and tenderization treatments to study whether flavor and texture quality could be enhanced within cut and grade of steak. Treatments included: 1) seasoning alone, 2) a combination of seasoning + bromelain (enzymatic tenderizer), or 3) control (no seasoning and/or bromelain). The seasoning included: kosher salt, black pepper, onion powder, garlic powder, cumin, and ground oregano. All of the steaks were cooked to an internal temperature of 71° C (medium doneness). Six trained descriptive panelists evaluated the samples. The results of this study indicate that it may be possible to improve eating quality of choice and select chuck-eye and choice top blade to be more similar to strip steaks of the same USDA grade. Both treatments increased flavor and texture attributes in these samples that have been shown to have an impact on liking scores. Choice chuck-eye samples had decreased bloody/serumy and metallic scores and increased umami and initial flavor impact with both treatments. Both treatments increased brown/roasted flavor in select chuck-eyes. Tenderness, fat-like and umami were increased with the seasoning + bromelain treatment in select chuck-eyes. Choice top blade steaks with seasoning alone had increased umami flavor. Both treatments impacted attributes (fat-like, umami and sour) of the select strip steak that differed from choice strip steaks. The next step to this research is to investigate whether consumer liking scores are consistent with conclusions made from descriptive analysis results. Overall, these treatments could be a valuable tool for beef retailers.

Table of Contents

List of Figures

List of Tables

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Chapter 1 - Literature Review

Today's consumers are very price conscious, and grocery prices are on the rise. Beef is more expensive per kilogram than chicken or pork (National Cattlemen's Beef Association 2010). However, consumers may be more willing to pay a higher price for beef if they see it as a good value (Shackelford and others 2001). The quality of beef is typically determined by evaluation of three factors: texture, flavor and juiciness. Consumers want tender and juicy beef, and they are willing to purchase beef if these traits are available for an economical price. If consumers knew they could get flavor similar to a choice cut of beef by simply seasoning a select cut they would be more likely to increase their purchases of select cuts of beef.

Literature suggests that little sensory analysis work has been conducted on cooked and seasoned beef with a focus on how seasonings affect the flavor of the sample. The general lexicon for beef developed by Adhikari and others (2010) was based on intact muscle samples that were unseasoned. However, most consumers do not consume unseasoned beef in their homes or in restaurants. A recent study by Vázquez-Araújo and others (submitted) found that seasonings do alter the base flavor notes of the sample, but the change is dependent mainly on the cooking method.

USDA Quality Grade

United States Department of Agriculture (USDA) quality grading system may play an important role in the consumer's decision making process when purchasing meats, and it is vital to the beef producer as higher quality grade carcasses produce more profit. The intent of grading beef is to separate a large variety of carcasses into groups that are more uniform in eating quality and composition. Quality grade is determined by carcass indicators of physiological maturity and marbling and the specifications for each grade can be seen in table 1.1. A visual representation of these specifications can be seen in figure 1.1.

Table 1.1 USDA Beef Grading Criteria*

USDA Quality Grade	Degree of Marbling	Maturity**
Prime	Slightly Abundant	A to B
Choice	Moderate to Small	A to B
Select	Slight	A
Standard	Practically Devoid	A to B
Commercial	Slightly Abundant to Small	C to E
Utility	Moderate to Practically Devoid	B to E
Cutter	Slight to Practically Devoid	C to E

*Assumes that firmness of lean is comparably developed with the degree of marbling and that the carcass is not a "dark cutter"
**Maturity increases from A to E
USDA (1997)

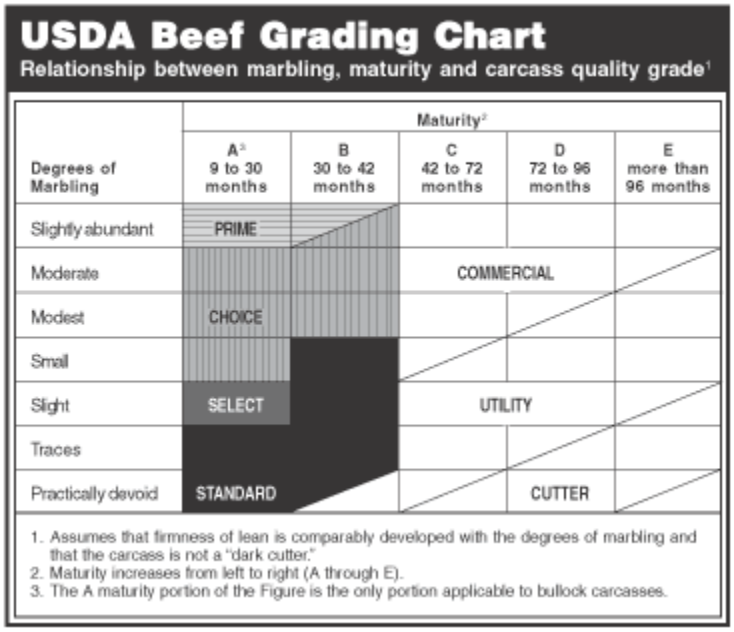

Figure 1.1 USDA Beef Grading Chart

(North Dakota State University 2003)

The age of an animal at the time of slaughter has a direct impact on the tenderness of the meat produced from the carcass (Tatum 2007). As the age of cattle increases, the tenderness of the meat decreases. Because of this effect on tenderness an evaluation of carcass maturity is part of the USDA quality grade process. USDA has designated five groups of maturity lettered A

through E. The approximate age represented by each group is as follows: A, 9 to 30 months; B, 30 to 42 months; C, 42 to 72 months; D, 72 to 96 months; and E, older than 96 months. An employee of the USDA determines carcass age by visual inspection where maturity is assessed through the size, shape and ossification of bones and cartilage, and the color and texture of the ribeye muscle.

The primary determinant of USDA quality grade is marbling, or the amount and distribution of intramuscular fat, within the ribeye. Marbling is evaluated visually at the twelfth rib cross-section using color photographic standards to determine marbling degree (Tatum 2007). Some researchers believe that this may not be a good indicator due to systematic and random variation within a carcass (Hildrum and others 2009). Gilpin and others (1965) found that marbling differed between adjacent steaks, thus a marbling score of the whole muscle did not necessarily apply to individual steaks. High levels of marbling are thought to indicate that cuts are more tender, juicy and flavorful than cuts with lesser amounts of marbling. Percentages of fat in highly marbled steaks are higher than those in low marbled steaks (Gilpin and others 1965). Most consumers are likely to accept beef that has a quality grade of USDA Select or higher (Tatum, 2007).

Impact of USDA Quality Grade on Liking

Several studies have investigated the impact of quality grade on liking and palatability traits with varying results. McBee and Wiles (1967) concluded that USDA prime cuts were most desirable and that standard was least desirable. However, McBee and Wiles also found high variability within USDA quality grades. Lorenzen and others *(*1999) found that among top choice, low choice, high select and low select, consumers had the highest preference for top choice and the lowest preference for low select. However, a similar study by Goodson and others (2002) found that USDA quality grade had a cut specific effect on consumer evaluations. Consumers in this study reported liking top choice for top round steaks, either choice or select for top sirloin steaks and did not have a preference for grade in clod steaks. The *National Beef Tenderness Survey of 1998* (Brooks and others 2000) aimed to evaluate the tenderness of retail and foodservice beef cuts from different USDA quality grades and cuts. Among consumers steaks that were graded USDA prime had the highest overall liking scores. However, steaks of other quality grades did not differ in their liking scores. For the retail cuts of top sirloin, clod

steak and top round ratings did not change with quality grade for any of the sensory attributes rated in the study.

Neely and others (1998) found a cut by grade interaction in in-home use tests with consumers in Chicago, Philadelphia, Houston and San Francisco. The effects of grade on overall liking scores were greatest among top loin steaks. Top choice top loin steaks were rated higher in overall liking than low choice, top select and low select samples. However, this trend was not seen in other cuts sampled in this study, therefore indicating that USDA quality grade may not work as well on muscles other than *longissimus* (Neely and others 1998).

Longissimus thoracis steaks were used in a study to determine the impact of USDA quality grade on palatability of steaks cooked well done (Wheeler and others 1999). Top choice and low select steaks aged for 3 or 14 days were analyzed by Warner-Bratzler shear force (WBSF). Steaks with a WBSF rating of less than 5.0 kg were considered to be tender. All samples were taken from steaks which met this criterion. A trained descriptive panel found that top choice had higher beef flavor and juiciness than the low select samples. In steaks aged for 3 days top choice scored higher tenderness ratings than did low select. After aging for 14 days samples from both grades were similar in tenderness ratings.

Factors Affecting Beef Palatability

In general there are three main factors that drive beef liking and palatability: tenderness, juiciness and flavor. There is some controversy over the order of importance of these palatability attributes in determining consumer liking and acceptability. Huffman and others (1996) reported that when asked, 51% of consumers considered tenderness to be the attribute they desired most in a steak, followed by flavor (39%) and juiciness (10%). Other studies have shown that flavor liking and tenderness may be equally important (Miller and others 1995; Goodson and others 2002; Lorenzen and others 2005; Rodas-González and others 2009).

Data collected from consumers sampling loin steaks both in-home and at a white table cloth restaurant showed variation in influence over overall palatability scores. In homes flavor alone accounted for the most variation in overall palatability. However, when consumers sampled steaks at the white table cloth restaurant, tenderness explained the most variation in overall palatability. Also, a large portion of variation was left unaccounted for which could indicate that dining environment plays a role in palatability scoring (Huffman and others 1996).

Enhancing Palatability

There are multiple factors that may influence tenderness, juiciness and flavor, including carcass maturity, production methods, storage length, cut, cooking methods, end-point temperatures and many more. These factors have been the focus of many studies aiming to optimize palatability attributes through various methods.

To investigate the cooking method and degree of doneness that would produce the most desirable characteristics from chuck steaks, Adhikari and others (2004) used both select and low choice steaks. A trained sensory panel did not find significant differences in toughness between cooking methods and end-point temperatures. It was determined that grilling chuck muscles to a medium rare doneness produced higher ratings for juiciness and roasted flavor indicating grilling would be the most ideal preparation method for chuck steaks.

Marinades and Injections

Calcium chloride injection into beef samples prior to retail sale and cooking has been shown to increase tenderness (Miller and others 1995). Many consumers prefer the calcium chloride injected steaks when compared to an untreated control sample. Miller and others (1995) found that these injections improve tenderness, juiciness and flavor desirability without adding any off-flavors.

It has been hypothesized that age of the animal at time of slaughter, degree of marbling, cut of steak, degree of doneness and calcium chloride injections could all have effects on the palatability of beef steaks (Wulf and others 1996). One study found that the cut of beef had the greatest effect on sensory panel tenderness ratings. Juiciness was most influenced by degree of doneness. Calcium chloride injections resulted in an improvement of all sensory attributes and reduced toughening during cooking.

Injecting beef samples with a combination of water, salt and sodium tripolyphosphate improved WBSF values in some beef samples (Molina and others 2005). Samples marinated in the same solution had improved juiciness scores, but some off-flavors did develop. Overall, the enhancements improved palatability in selected muscles but results were inconsistent.

Aging

Campbell and others (2001) investigated the effects of vacuum storage length on palatability traits before and after dry aging. The results showed that aging samples in vacuum

packaging for 7 or 14 days had no effects on flavor parameters, juiciness or tenderness. Dry aging time prior to vacuum packaging was found to have significant effects on all attributes apart from astringent taste. Tenderness was lowest for control samples (which were vacuum aged for 14 days). Dry aging for 7 or 14 days increased tenderness. The control samples and those dry aged for 7 days prior to vacuum packaging had the lowest ratings for juiciness; samples aged for 21 days had the highest juiciness ratings. Samples stored in vacuum packages after dry aging saw their flavor peak at 9 days post dry aging, and flavors began to decrease at day 16 of vacuum storage. Tenderness was shown to improve during post aging storage, but juiciness was not affected. The study concludes that beef producers can dry age beef that has been previously vacuum packaged without sacrificing any flavor or tenderness.

Inconsistency in Palatability

Inconsistency in palatability attributes has been an issue for the beef industry for some time (Jeremiah and others 2003). A Canadian study looked at beef muscles that were roasted in an oven. Cooked muscles were evaluated by a descriptive panel for palatability attributes. The flat iron was among the top rated samples for initial tenderness and had one of the most intense beef flavor ratings. Strip loin samples were found to have the most bland beef flavor. This study used the descriptive panel data to infer conclusions about consumer acceptability and found that the flat iron was among the muscles rated above the mean score for overall palatability (Jeremiah and others 2003).

Muscle Profiling

Several published studies have focused on muscle profiling to characterize different cuts of beef using sensory, chemical and physical analysis methods (Jones and others 2003; Hildrum and others 2009). Muscle profiling of Norwegian Red Bulls found highly significant differences in all sensory tenderness attributes between different muscle types. Average scores for chuck muscles (including *longissimus*) were higher than for round muscles. *M. infraspinatus* ranked the highest in tenderness and among the top in juiciness. *M. longissimus* fell in the intermediate group for both attributes. As indicated previously, ranking for tenderness is not necessarily valid because variation is seen within a given muscle. The *M. infraspinatus* was found to have the highest ratings for all attributes, and it is possible that these desirable characteristics have led to the cut's increased popularity in the U.S. (Hildrum and others 2009).

Tenderness & Juiciness

Tenderness is the state of being easily comminuted or masticated (Ramsbottom and Strandine 1948). Among the most important palatability traits that affect consumer preference in beef is tenderness (Miller and others 1995). Studies have indicated that consumers are willing to pay more for beef that is guaranteed to be tender (Shackelford and others 2001; Boleman and others 1997). Much research has been done in the area of factors affecting tenderness. Although tenderness has been shown to vary within and among the muscles of the beef carcass, more than other attributes (Ramsbottom and Strandine 1948), muscles that are used more often have higher proportions of connective tissue resulting in less tender meat. Muscle fiber characteristics also play an important role in determining tenderness. Tenderness is dependent upon the diameter of muscle fiber, area of the primary bundles and area of the secondary bundles. The smaller each of these is the more tender the muscle will be (Brady 1937). Cooking time has been shown to have a detrimental effect on tenderness in most cases (Ramsbottom and others 1945).

Calkins and Sullivan (2007) compiled data from many published works on tenderness. They described three commonly used categorizations of factors that influence meat tenderness as: the actomyosin effect, background effect and bulk density/lubrication effect. In the actomyosin effect actin and myosin combine in sarcomeres of the muscle fibers during rigor mortis contraction to form actomyosin. Short sarcomeres are less tender, and length is affected by muscle position during rigor mortis. Some muscles are more stretched than others resulting in different sarcomere lengths. Temperature also influences sarcomere length with colder temperatures encouraging shorter sarcomeres. Sarcomeres also influence tenderness by the ease with which they are fragmented during cooking. The fragility of sarcomeres is affected by storage length and temperature and with increases in either the result will be higher tenderness. The term “background effect” relates to the connective tissue present in the muscle. Muscles that experience more use have higher proportions of connective tissue present. Connective tissue retains its strength throughout aging in cool temperatures. Connective tissue can be softened in slow cooking conditions; however, connective tissue in the muscles of older animals is less soluble when heated. The bulk density/lubrication effect is caused by intramuscular fat which may dilute the protein in a bite size piece. This fat might lower the density within the sample, thereby increasing tenderness. Another aspect of this effect is that fat contained between cells

could thin connective tissue and provide lubrication between muscle fibers increasing tenderness perception. Fat may also help to protect against overcooking.

Many studies have attempted to rank muscles by tenderness but the majority have differing results. Calkins and Sullivan (2007) compiled data from many published works and found correlation coefficients to form a tenderness ranking system. The *infraspinatus* (muscle of the top blade steak) was classified among the most tender. *Longissimus lumborum* (source of the strip steak) and *Complexus* (location of the chuck-eye steak) were classified as intermediate. The study found clear differences between WBSF and sensory tenderness ratings. The correlation was evaluated and found to be -0.85 for mean tenderness to shear force ratings. Overall, comparing the results of different studies on tenderness is difficult due to the lack of precise description of the exact location in the carcass from which samples were taken.

It is a common belief that a higher quality grade indicates a more tender portion of meat. However, Morgan and others (1991) found that quality grade did not explain variation in sensory panel tenderness ratings. This may lead to the conclusion that the beef industry needs to find a way to control the variation in tenderness of beef produced for consumers.

Consumers' Evaluations and Perceptions of Tenderness

A consumer survey conducted by Shackelford and others (2001) investigated the value of "Tender Select" steaks to US consumers. Consumers (n = 1,036) were presented with a concept introducing them to Tender Select. The concept explained that Tender Select steaks would be guaranteed to be tender and lean. Eighty-nine percent of respondents indicated they "would definitely buy" or "would probably buy" guaranteed tender select steaks. Nearly half of the respondents said they would be willing to pay $0.50 more per pound for meat that is guaranteed tender.

Consumers are able to differentiate tenderness levels, and they are willing to pay a premium for meat that is guaranteed to be tender (Boleman and others 1997). When consumers were given steak samples with varying WBSF values they were most satisfied with samples having low WBSF values and least satisfied with samples having the highest WBSF values. Samples with lowest WBSF values were also rated as being juicier and had more desirable flavor scores. When presented the opportunity to purchase the steaks they had sampled nearly 95% of consumers chose to purchase those steaks with the lowest WBSF values despite the premium price for those steaks.

Tenderness perception among consumers may vary according to geographical location. Neely and others (1998) found a significant interaction between grade and city in an in-home use test. Consumers in Chicago and Philadelphia found top choice samples to be more tender than low choice, top select and low select samples. Consumers in Houston and San Francisco were unable to perceive differences in tenderness among the grades. This is thought to be because retail beef in Chicago and Philadelphia is commonly USDA choice, whereas, in Houston and San Francisco beef is more likely to be USDA select.

Correlating Mechanical and Sensory Tenderness

Perhaps the most common mechanical measure of tenderness is Warner-Bratzler shear force. WBSF can be performed using a Warner-Bratzler shear machine or another automated texture analysis machine fitted with a WBSF blade (see figure 1.2). A round core 1.27 cm in diameter is removed from the meat sample and by cutting parallel to the muscle fibers. This core is then placed directly under the "V" of the WBSF blade so that the blade will cut through the sample perpendicular to the muscle fiber orientation (Wheeler and others 2009). Figure 1.3 shows how the test is performed. The WBSF value is a measure of the force required to cut through (or "shear") a sample. Tender steaks require less force to cut through than tough steaks. Steak samples with a WBSF value of 11 lbs or less (Goodson and others 2002) or 5.0 kg or less (Wheeler and others 1999) are considered to be tender.

Figure 1.2Warner-Bratzler shear force blade

(Wheeler and others 2009)

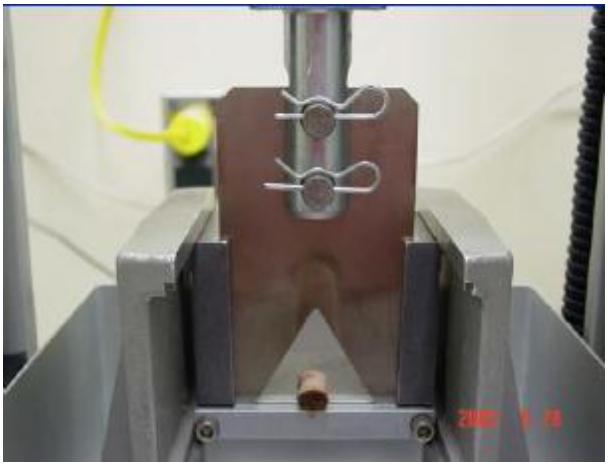

Figure 1.3 Warner-Bratzler shear force for texture analysis

(Wheeler and others 2009)

Some research has aimed to develop a correlation between sensory tenderness and mechanical tenderness ratings. In a study using Venezuelan beef, trained panelists evaluated

ribeye steaks from different breeds, sexes and ages to obtain a tenderness threshold. Beef production in Venezuela relies mainly on grass-fed, intact males and is marketed 2 to 6 days post-mortem (US beef is sometimes marketed as late as 15 days post mortem). Sensory tenderness ratings were compared to WBSF ratings to find a tenderness threshold of 37.98 N. Steaks rated slightly tender corresponded to a value of 37.98 N. Steaks with shear force values less than 37.98 N were rated as "tender" (Rodas-González and others 2009). There are several differing tenderness thresholds reported in other studies, and this variation could be due to a number of attributes including: beef production method, cooking method (if any), precise location of samples within a muscle and numerous other factors. From a consumer standpoint this study found that when all samples are equally tender, consumers turn to flavor as the main influence over satisfaction. Flavor liking was the most correlated to overall liking in this study but other studies disagree (Lorenzen and others 2005; Rodas-González and others 2009; Bruce and others 2005; Goodson and others 2002).

Enzymatic Tenderization Methods

Papain, bromelain, ficin, *Aspergillus oryzae* protease and *Bacillus subtilis* protease enzymes, commonly used for meat tenderization, have earned Generally Recognized as Safe (GRAS) status in the US. Steaks treated with these enzymes through needle injection have shown improvements in both WBSF values and sensory tenderness ratings. Papain often proves to be the most effective in improving tenderness but can negatively affect juiciness and other textural qualities. Bromelain has been shown to be active at 0° C, although this activity is low and does increase dramatically in the range of 50- 70° C (Sullivan and Calkins 2010).

Huerta-Montauti and others (2008) used enzymatic and mechanical tenderization techniques to improve tenderness of beef fajita meat. The treatment groups were: control, papain, blade tenderizer, and papain plus blade tenderizer. Papain (0.033%) was used in a brine mixture that was added to beef samples prior to vacuum packaging. For the mechanical tenderization samples passed through a blade tenderizer twice. Results from trained descriptive panel data showed that papain treatments (including the papain plus blade tenderizer treatment) improved the muscle fiber tenderness of several muscles, including: *M. transversus abdominus, M. obliquus abdominus internus*, *M. rhomboideus, M. latissimus*, and *M. trapezius.* The *M. serratus ventralis* and *M. diaphragma pars costalis* were least improved after a papain treatment. However, these two muscles were more tender than all other treated samples.

Effect of End-Point Temperature on Tenderness

End-point temperature may impact the tenderness of beef steaks. Gilpin and others (1965) observed that steaks broiled to internal temperatures of 140° F, 160°F and 180°F did not differ in instrumental shear force ratings. However, a trained sensory panel did score rib steaks lower in tenderness as end-point temperature increased. This could be explained by the thinking that panel ratings of tenderness are concerned with rating overall tenderness, whereas, shear force is only a measure of one tenderness component. Also, the range of sensory scores for tenderness was quite narrow and shear force values had a wide range of scores.

One study cooked steaks from *M. longissimus thoracis et lumborum* to six different end-point temperatures. Results of consumer testing indicated samples that were cooked very rare were highest in tenderness, and tenderness decreased as cooking temperature increased. This result was supported by WBSF values for the samples. However, consumer scores were not different for overall liking and flavor liking among steaks cooked to different temperatures. This may indicate that consumers can detect differences in tenderness and juiciness, but that flavor is playing an equal role in consumer liking (Lorenzen and others 2005).

Beef Flavor

Tenderness has been thought to be the most important palatability attribute in beef when it comes to consumer acceptance and liking. However, several published studies have now pointed to beef flavor as the most important, or an equally important, factor (Lorenzen and others 2005; Rodas-González and others 2009; Bruce and others 2005; Goodson and others 2002).

End-point temperature has been shown to have an effect on beef flavor levels. Gilpin and others (1965) found that rib steaks and eye of round steaks broiled to 140° F had higher flavor ratings than those broiled to 160° or 180° F.

Injection-enhancement of strip loin steaks can increase some beef flavor characteristics while limiting undesirable flavors. Steaks injected with potassium lactate have been shown to have increased beef and brown-roasted flavors and limited rancid notes (Knock and others 2006). Injecting beef samples with sodium acetate worked to decrease shear force, however this change was not reflected in sensory panel data. Steaks injected with salt had an increase in salt taste and in rancid flavor development.

With terms like “grass fed” and “grain fed” becoming mainstream in the beef retail world it is important to consider whether production method (including variations in raising the cattle, i.e., diet and environment) has an impact on beef palatability. Beef raised from the same farm has less flavor variation than beef found in general retail cases (Bruce and others 2005). This finding suggests that the development of “beef brands” that offer a particular set of flavor characteristics is a plausible future direction for the beef industry. This may prove to be particularly important as methods for controlling and guaranteeing beef tenderness are improved, thus bringing beef flavor to the forefront.

Beef Flavor Lexicon Development

A general lexicon for sensory evaluation of beef has been developed (Adhikari and others 2011). Panelists tasted samples of unseasoned beef (a variety of cuts, diets, storage methods and doneness) to create a list of descriptors to describe the flavor of beef. Six highly trained panelists identified and referenced 36 aroma attributes, 30 flavor attributes and five fundamental tastes. The most common attributes were: beef identity, brown/roasted, bloody/serumy, fat-like, metallic, liver-like, green (hay-like), overall sweet and all five fundamental tastes (sweet, sour, salty, bitter and astringent); these were collectively called the “major attributes”. The other attributes identified occurred only in some samples, so these were called “other notes”.

Prior to work by Adhikari and others (2011), there was no reference for beef flavor attributes that was standardized and universally usable. Studies often evaluate only one general flavor attribute, commonly called “beef flavor.” However, because beef flavor is composed of multiple attributes (general flavors, aromatics, basic tastes, feeling factors and after tastes) it was necessary to develop a lexicon encompassing all common beef flavor attributes. Adhikari and others (2004) worked to determine cooking techniques and temperatures required to optimize the flavor of beef chuck. The panelists generated descriptors through consensus and created definitions and references. However, these references were not anchored or standardized, therefore they could not be used in the same manner by another panel. In a different study (Lorenzen and others 2005) a similar method was used to generate descriptors aimed to evaluate the effect of end-point temperatures on the flavor profile of beef steak. Again, the references used in this study were not standardized to be used by a different panel.

Effect of Herbs and Spices on Beef Flavor Attributes

Prior to the study by Vázquez-Araújo and others (submitted), there had been little insight into how added seasonings affect beef flavor characteristics. Some research had been done concerning herbs that might work as antioxidants or otherwise enhance shelf life or the nutritive value of beef products. However, these studies did not focus on the changing of flavor within the beef other than to detect the presence of off-flavors. Vázquez-Araújo and others (submitted) found that the addition of herbs and spices did alter some main beef flavor attributes, but the change was dependent on cooking method. Attributes most affected were beef identity, brown/roasted and bloody/serumy. Salt and pepper were found to have a significant effect when using an outdoor grill, thus increasing the brown/roasted, fat like, sourness, saltiness, bitterness and initial flavor impact of the samples. Other seasonings were found only to slightly increase these same attributes over the control samples. The use of olive oil and salt on samples cooked on an indoor electric grill was found to increase bloody/serumy and salt flavors. Seasonings used in this study were determined through consumer surveys in Spain, the US, and Argentina. Salt, black pepper, fresh parsley, cayenne pepper, oregano, rosemary, chili powder, fresh garlic, garlic powder, onion flakes, beef bouillon, powdered steak seasoning and mixed seasoning rub were the herbs and spices chosen by at least 30% of US survey respondents.

Objective

There has been little insight into how added seasonings affect beef flavor characteristics. However, most consumers do not consume unseasoned beef in their homes or at restaurants. It is possible that the addition of seasonings could enhance consumers' perception of quality in beef steaks. This could benefit consumers by allowing them to purchase more economical cuts and grades of beef steaks and adding some seasoning to enhance the eating quality. Beef producers could also benefit from increased sales if seasonings are able to improve flavor and texture of some beef steaks. There were 2 major objectives in this study. The first was to investigate whether adding seasonings to chuck-eye and top blade steaks would impact flavor attributes and increase flavor quality. The second major objective was to determine if USDA select steaks could be enhanced with the addition of seasonings. A secondary objective in this study was to evaluate the impact of enzymatic tenderization on the quality of these cuts and grade of steak.

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Chapter 2 - Detailed Methods & Materials

Panel

Six highly-trained panelists from the Sensory Analysis Center at Kansas State University (Manhattan, KS) evaluated the samples for this project. The panel room had controlled temperature, lighting, and humidity. Panelists had each completed a general training course in descriptive sensory testing (120-h) and had about 2,000 h of testing experience with a variety of products. Panelists also had experience testing beef and using the beef lexicon developed by Adhikari and others (2011). Approval from Kansas State University's Institutional Review Board Committee for Research on Human Subjects (IRB) was obtained prior to testing.

Samples

Steak samples were strip (*Longissimus dorsi*), chuck-eye (*Complexus*) and top blade (*Infrraspinatus*). These cuts were selected to represent a range of quality (strip = high quality, top blade = mid-range and chuck = low). For each steak there were two USDA grades (choice and select). Choice was selected for this study because it is the grade that is typically available for retail sale. Select is one grade below choice and it was chosen to determine if the treatments could eleveate sensory attributes of select steaks to be comparable to choice steaks. Strip and chuck-eye steaks were purchased from Riley County Meat Locker (Riley, KS) and top blade steaks were purhcased from Ray's Apple Market (Manhattan, KS).

Strip and chuck-eye samples had a similar weight, approximately 340 g. Top blade steaks were smaller and were grouped together in twos or threes to achieve a weight of approximately 340 g per sample. All samples were individually vacuum sealed and frozen (Jamison Built Doors, Hagerstown, Md., U.S.A.) at -23° C prior to testing. According to a randomized test design (see Appendix A) samples were removed from frozen storage 24 h prior to cooking and allowed to thaw in a refrigerator (True Manufacturing Co., St Louis, Mo., U.S.A.) at 3.5 °C.

Sample Preparation

Samples were assigned to control (no seasoning), seasoning or seasoning + bromelain (S+B) treatment groups for seasoning. Many of the seasonings were chosen based on what is

commonly used by consumers in the U.S. as reported by Vázquez-Araújo and others (submitted). The seasoning contained: 13.5 g kosher salt, 4.6 g ground black pepper, 4.8 g onion powder, 6.2 g garlic powder, 3.6 g ground oregano, and 1.8 g ground cumin. One teaspoon of the seasoning was evenly distributed over the sample.

For the S+B treatment, steaks were submerged into a bromelain solution (20 mg/L) (Enzeco Bromelain 240 provided by Enzyme Development Corporation). Samples were submerged for 10 s, drained and refrigerated for 10 min. Samples were then seasoned according to the method described previously.

The cooking procedure was similar to that reported by Adhikari and others (2011) for grilling. Immediately after seasoning (for non-control samples) samples were cooked on an electric grill (George Foreman model GPR 100, Miramar, FL). The grill was pre-heated on "high" for 10 min. The samples were placed in the center of the grill, the top of the grill was closed and samples were cooked until they reached an internal temperature of 71 °C (medium doneness). Internal temperatures (read from the approximate geometric center) of all samples were monitored during cooking using a probe thermometer (Mainstays ™ Black Acu-Rite meat thermometer with probe, Model 00993STW1, Lake Geneva, WI). After samples reached 71 °C they were removed from the grill and cut into approximately 1.25 cm cubes. Any excess fat or cartilage on the edge of the steak was removed prior to cubing.

Glass jelly jars (Ball Corporation, Daleville, IN) of approximately 120 mL labeled with a random three digit code were placed on a warming tray (The Maxim Co. model WT48, Newark, NJ) for at least one h prior to being used for serving the sample. The jars were covered with screw top lids (Ball Corporation, Daleville, IN) and each jar was placed into a tin tray on a heated clay brick to keep the sample warm (bricks had been heated for at least 2 h in an oven at 127°C). Three cubes of each sample were placed into the warmed glass jelly jars. Samples were then served to the panel. Samples were monadic sequentially, about 15 min apart.

Sample Evaluation

During two 1.5 h orientation sessions the panel checked the seasoning amount to determine if it was appropriate. Panelists were asked to taste the seasoned samples to determine if any of the spices were overwhelming (masking the natural flavor of the sample, or standing out among the rest of the seasoning ingredients). A range of samples was served during

orientation to allow the panel to ensure all of the appropriate attributes were included on the testing ballot. Panelists reviewed the references and added several more to the definition sheet (see Appendix A) as necessary. Panelists used the beef flavor lexicon developed by Adhikari and others (2011), selecting only attributes which applied to this sample set and adding in attributes representative of flavors perceived due to the seasoning. Also, two texture attributes (overall tenderness and juiciness) were added by investigators as texture has been shown to be important in beef quality perception.

The panel evaluated four to six samples per day in 90 minute sessions. A total of 72 samples (3 cuts × 2 grades × 3 treatments × 4 replications) were evaluated over 16 d. Strip and chuck-eye samples were served according to a randomized complete block design with samples being randomized within each replication. One set of the samples received was the incorrect cut therefore top blade steak samples were repurchased and all top blade steak samples were tested last. Top blade steak samples were also randomized within each replication; the test design can be seen in Appendix B.

Panelists evaluated each sample for 30 flavor and texture attributes (see table 2.1 for terms and definitions). The panel rated the intensity of each attribute on a 0 to 15-point scale with 0.5 point increments (with 0 representing "none" and 15 representing "high"). Evaluation took place under red lighting to minimize visual differences between samples and prevent bias. Panelists were provided with reverse osmosis, de-ionized, carbon filtered water and unsalted-top saltine crackers for palate cleansing and to reduce any build-up of flavors that could occur from one sample to the next.

Table 2.1 Terms, definitions, and references used in evaluating seasoned beef samples for flavor and texture.

Attribute	Definition	References
Texture		
Juiciness	The amount of liquid expressed from the sample during the first 6 chews.	Hormel Cure 81 Extra Lean Boneless Ham (skin removed, 0.5 inch cubes) = 6.5
Overall Tenderness	Ease with which a sample can be cut through with molars.	Hormel Cure 81 Extra Lean Boneless Ham (skin removed, 0.5 inch cubes) = 9.0
General Aroma/Flavor		
Initial Flavor Impact	The immediate reaction to the dominant flavor notes and their intensities. Rated during the first 2-3 chews of the sample.	N/A
Beef Identity	Amount of beef flavor identity in the sample.	Swanson's Beef Broth = 5.0 (aroma and flavor) 80% Lean Ground Chuck = 7.0 (aroma and flavor) Beef Brisket = 11.0 (aroma and flavor)
Brown/Roasted	A round, full aromatic generally associated with beef suet that has been broiled.	Beef Suet (broiled) = 8.5 (aroma and flavor) 80% Lean Ground Chuck = 10.0 (aroma and flavor)
Bloody/Serumy	The aromatics associated with blood on cooked meat products. Closely related to metallic aromatic.	USDA choice strip steak = 5.5 (aroma and flavor) Beef Brisket = 6.0 (aroma and flavor)
Liver-like	Aromatics associated with cooked organ meat/liver.	Beef Liver (broiled) = 7.5 (aroma and flavor) Brauschweiger liver sausage = 10 (aroma and flavor- must taste and swallow)
Metallic	The impression of slightly oxidized metal, such as iron, copper, and silver spoons.	0.10% Potassium Chloride Solution = 1.5 (flavor) USDA choice Strip Steak = 4.0 (aroma and flavor) Dole Canned Pineapple Juice = 6.0 (aroma and flavor)
Fat-like	Aromatics associated with cooked animal fat.	Beef suet = 12.0 (aroma and flavor) Hill Shine Farms Lit'l Beef Smokies = 7.0 (aroma and flavor)

Attribute	Definition	References
Rancid	An aromatic commonly associated with oxidized fat and oils. These aromatics may include cardboard, paint, varnish, and fishy.	Wesson Vegetable Oil (3 min) = 7.0 (flavor) Wesson Vegetable Oil (5 min) = 9.0 (flavor)
Green- hay like	Brown/green dusty aromatics associated with dry grasses, hay, dry parsley and tea leaves.	Dry parsley in medium snifter = 5.0 (aroma)
Umami	Flat, salty, somewhat brothy. The taste of glutamate, salts of amino acids and other molecules called nucleotides.	0.035% Accent Flavor Enhancer Solution = 7.5 (flavor) Swanson's Beef Broth = 8.0 (flavor)
Overall Sweet	A combination of sweet taste and sweet aromatics. The aromatics associated with the impression of sweet.	Post Shredded Wheat Spoon Size = 1.5 (flavor) Hillshire Farms Lit'l Beef Smokies = 3.0 (flavor) SAFC Ethyl Maltol 99% = 4.5 (aroma)
Sweet	The fundamental taste factor associated with sucrose.	2.0% Sucrose Solution = 2.0 (flavor)
Sour Aromatics	Aromatics associated with sour substances.	Dillon's buttermilk (covered) = 5.0 (flavor)
Sour	The fundamental taste factor associated with citric acid.	0.015% Citric Acid Solution = 1.5 (flavor) 0.050% Citric Acid Solution = 3.5 (flavor)
Salty	The fundamental taste factor of which sodium chloride is typical.	0.15% NaCl Solution = 1.5 (flavor) 0.25% NaCl Solution = 3.5 (flavor) 0.35% NaCl Solution = 5.0 (flavor)
Bitter	The fundamental taste factor associated with a caffeine solution.	0.01% Caffeine Solution = 2.0 (flavor) 0.02% Caffeine Solution = 3.5 (flavor)
Barnyard	Combination of pungent, slightly sour, hay-like aromatics associated with farm animals and the inside of a barn.	White pepper in water = 4.5 (aroma), 4.0 (flavor) Tincture of civet = 6.0 (aroma)
Burnt	The sharp/acrid flavor note associate with over roasted beef muscle, something over baked or excessively browned in oil.	Alf's Red Wheat Puffs (aroma and flavor) = 5.0

Attribute	Definition	References
Green	Sharp slightly pungent aromatics associated with green/plant/vegetable matter such as parsley, spinach, pea pod, fresh cut grass, etc.	Hexanal in propylene glycol (5000 ppm) = 6.5 (aroma) Fresh parsley water = 9.0 (flavor)
Musty-earthy	Musty, sweet, decaying vegetation.	2,6-Dimethylcyclohexanol (1000 ppm in propylene glycol) = 9.0 (aroma)
Refrigerator Stale	Aromatics associated with products left in refrigerator for an extended period of time and absorbing a combination of odors (lack of freshness, flat).	80 % Lean Ground Beef (1-day old) = 5.5 (aroma), 4.5 (flavor)
Warmed Over	Perception of a product that has been previously cooked and reheated.	80 % Lean Ground Beef (reheated) = 6.0
Black Pepper	The aromatics associated with ground black pepper that are spicy, pungent, musty and woody.	McCormick or Shilling Ground Black Pepper = 13.0 (a) McCormick or Shilling Ground Black Pepper in Swanson Fat Free Beef Broth = 9.0 (flavor)
Onion	The aromatics commonly associated with dehydrated onion and characterized as sweet, slightly brown, and slightly pungent.	McCormick Onion Powder in Swanson Fat Free Beef Broth= 7.5 (flavor) McCormick Onion Powder = 9.5 (aroma)
Garlic	The musty, slightly brown, sweet, pungent aromatics associated with garlic.	McCormick Garlic Powder = 9.5 (aroma) McCormick Garlic Powder in Swanson Fat Free Beef Broth = 7.5 (flavor)
Oregano	A sharp, pungent, woody, green aromatic that is somewhat musty and petroleum/rubber-tire like.	McCormick Ground Oregano = 12.5 (a) McCormick Ground Oregano in Swanson Fat Free Beef Broth = 8.5 (flavor)
Cumin	The aromatics commonly associated with cumin and characterized as dry, pungent, woody and slightly floral.	McCormick or Shilling Ground Cumin = 10.0 (aroma), 7.0 (flavor)
White Pepper	Spicy, pungent, musty, woody, slightly soured hay-like barnyard aromatics.	White pepper in Swanson Fat Free Beef Broth = 8.0 (flavor)

Data Collection and Statistical Analysis

Data collection was done through paper ballots (see Appendix A). Data was analyzed using PROC GLIMMIX in SAS ® version 9.1 (SAS Institute Inc., Cary, NC) to obtain analysis of variance (see Appendix for SAS code). Post-hoc means separation was done using Fisher's Least Significant Difference (LSD) at 5% level of significance. Principal components analysis (PCA) was conducted (The Unscrambler X ®, 2011, version 10.1; Camo A/S. Oslo, Norway) to show relationships between the sample treatments and the sensory attributes.

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Chapter 3 - Impact of Seasoning on Sensory Attributes of Beef Across Three Cuts of Steak and Two USDA Grades

Abstract

Three cuts of steak (strip, chuck-eye and top blade) of two United States Department of Agriculture grades (choice and select) underwent seasoning and tenderization treatments to study whether flavor and texture quality could be enhanced within cut and grade of steak. Treatments included: 1) seasoning alone, 2) a combination of seasoning + bromelain (enzymatic tenderizer), or 3) control (no seasoning and/or bromelain). The seasoning included: kosher salt, black pepper, onion powder, garlic powder, cumin, and ground oregano. All of the steaks were cooked to an internal temperature of 71° C (medium doneness). Six trained descriptive panelists evaluated the samples. The results of this study indicate that it may be possible to improve eating quality of choice and select chuck-eye and choice top blade to be more similar to strip steaks of the same USDA grade. Both treatments increased flavor and texture attributes in these samples that have been shown to have an impact on liking scores. Choice chuck-eye samples had decreased bloody/serumy and metallic scores and increased umami and initial flavor impact with both treatments. Both treatments increased brown/roasted flavor in select chuck-eyes. Tenderness, fat-like and umami were increased with the seasoning + bromelain treatment in select chuck-eyes. Choice top blade steaks with seasoning alone had increased umami flavor. Both treatments impacted attributes (fat-like, umami and sour) of the select strip steak that differed from choice strip steaks. The next step to this research is to investigate whether consumer liking scores are consistent with conclusions made from descriptive analysis results. Overall, these treatments could be a valuable tool for beef retailers.

Introduction

United States Department of Agriculture (USDA) quality grade may play an important role in the consumer's decision when purchasing meats, and it is also vital to the beef producer because higher quality grade carcasses lead to more profits. The intent of grading beef is to separate a large variety of carcasses into groups that are somewhat uniform in eating quality and composition. Quality grade is determined by a USDA employee who bases the grade on carcass indicators of physiological maturity and marbling.

Several studies have investigated the impact of quality grade on liking and palatability traits with varying results. McBee and Wiles (1967) concluded that USDA prime cuts were most desirable and that standard was least desirable. However, McBee and Wiles also found high variability within USDA quality grades. Lorenzen and others *(*1999) found that among top choice, low choice, high select and low select, consumers had the highest preference for top choice and the lowest preference for low select. However, a similar study by Goodson and others (2002) found that USDA quality grade had a cut specific effect on consumer evaluations. Consumers in this study reported liking top choice for top round steaks, either choice or select for top sirloin steaks and did not have a preference for grade in clod steaks. The *National Beef Tenderness Survey of 1998* (Brooks and others 2000) aimed to evaluate the tenderness of retail and foodservice beef cuts from different USDA quality grades and cuts. Consumers gave steaks that were graded USDA prime the highest overall liking scores. However, steaks of other quality grades did not differ in their liking scores. For the retail cuts of top sirloin, clod steak and top round ratings did not change with quality grade for any of the sensory attributes rated in the study.

In general there are three main factors that drive beef liking and palatability: tenderness, juiciness and flavor. There is some controversy over the order of importance of these palatability attributes in determining consumer liking and acceptability. Huffman and others (1996) reported that when asked, 51% of consumers considered tenderness to be the attribute they desired most in a steak, followed by flavor (39%) and juiciness (10%). Other studies have shown that flavor liking may be equally or even more important (Miller and others 1995; Goodson and others 2002; Lorenzen and others 2005; Rodas-González and others 2009).

There are multiple factors that may influence tenderness, juiciness and flavor, including carcass maturity, production methods, storage length, cut, cooking methods, end-point

temperatures and many more. These factors have been the focus of numerous studies aiming to optimize palatability attributes through various methods. Tenderness is the state of being easily comminuted or masticated (Ramsbottom and Strandine 1948). Among the most important palatability traits that affect consumer preference in beef is tenderness (Miller and others 1995). Studies have indicated that consumers are willing to pay more for beef that is guaranteed to be tender (Shackelford and others 2001; Boleman and others 1997). Much research has been done in the area of factors affecting tenderness. Although tenderness has been shown to vary within and among the muscles of the beef carcass, more than other attributes (Ramsbottom and Strandine 1948), muscles that are used more often have higher proportions of connective tissue resulting in less tender meat. Muscle fiber characteristics also play an important role in determining tenderness. Tenderness is dependent upon the diameter of muscle fiber, area of the primary bundles and area of the secondary bundles. The smaller each of these is the more tender the muscle will be (Brady 1937). Cooking time has been shown to have a detrimental effect on tenderness in most cases (Ramsbottom and others 1945).

Papain, bromelain, ficin, *Aspergillus oryzae* protease and *Bacillus subtilis* protease enzymes, commonly used for meat tenderization, have earned Generally Recognized as Safe (GRAS) status in the US. Steaks treated with these enzymes through needle injection have shown improvements in both WBSF and sensory tenderness ratings. Papain often proves to be the most effective in improving tenderness but can negatively affect juiciness and other textural qualities. Bromelain has been shown to be active at 0° C, although this activity is low and does increase dramatically in the range of 50- 70° C. (Sullivan and Calkins 2010).

A general lexicon for sensory evaluation of beef has been developed (Adhikari and others 2011). Panelists tasted samples of unseasoned beef (a variety of cuts, diets, storage methods and doneness) to create a list of descriptors to describe the flavor of beef. Six highly trained panelists identified and referenced 36 aroma attributes, 31 flavor attributes and five fundamental tastes. The most common attributes were: beef identity, brown/roasted, bloody/serumy, fat-like, metallic, liver-like, green (hay-like), overall sweet and all five fundamental tastes (sweet, sour, salty, bitter and astringent); these were collectively called the “major attributes”. The other attributes identified occurred only in some samples, so these were called “other notes”.

Prior to work by Adhikari and others (2011), there was no reference for beef flavor attributes that was standardized and universally usable. Studies often evaluate only one general

flavor attribute, commonly called "beef flavor." However, because beef flavor is composed of multiple attributes (general flavors, aromatics, basic tastes, feeling factors and after tastes) it was necessary to develop a lexicon encompassing all common beef flavor attributes.

Until recently there had been little insight into how added seasonings affect beef flavor characteristics. Some research had been done concerning herbs that might work as antioxidants, enhance shelf life or the nutritive value of beef products. However, these studies did not focus on the changing of flavor within the beef other than to detect the presence of off-flavors. In a recent study on descriptive analysis of seasoned beef samples, Vázquez-Araújo and others (submitted) found that the addition of herbs and spices did alter some main beef flavor attributes, but the change was dependent on cooking method. Attributes most affected were beef identity, brown/roasted and bloody/serumy. Salt and pepper were found to have a significant effect when using an outdoor grill, thus increasing the brown/roasted, fat like, sourness, saltiness, bitterness and initial flavor impact of the samples. Other seasonings were found only to slightly increase these same attributes over the control samples. The use of olive oil and salt on samples cooked on an indoor electric grill was found to increase bloody/serumy and salt flavors. Seasonings used in this study were determined through consumer surveys in Spain, the US, and Argentina. Salt, black pepper, fresh parsley, cayenne pepper, oregano, rosemary, chili powder, fresh garlic, garlic powder, onion flakes, beef bouillon, powdered steak seasoning and mixed seasoning rub were the herbs and spices chosen by at least 30% of US survey respondents.

Choice and select steaks are widely available for retail sale and choice steaks are more expensive than select steaks. Choice steaks have a higher degree of marbling which is thought to result in more flavorful, juicy and tender meat (Tatum 2007). Select steaks are priced lower and have a lower degree of marbling. Strip steaks are considered to be a high quality steak and top blade and chuck-eye steaks are viewed as lower quality cuts. Today's consumers are very price conscious, and grocery prices are on the rise. Beef is more expensive per kilogram than chicken or pork (National Cattlemen's Beef Association 2010). However, consumers may be more willing to pay a higher price for beef if they see it as a good value (Shackelford and others 2001). If consumers knew they could get flavor similar to a choice cut of beef by simply seasoning a select cut they would be more likely to increase their purchases of select cuts of beef. This same principal could apply to top blade and chuck-eye steaks.

There has been little insight into how added seasonings affect beef flavor characteristics. However, most consumers do not consume unseasoned beef in their homes or at restaurants. Consumers may increase their purchases of these economical cuts if the quality could be enhanced by addition of seasoning. There were 2 major objectives in this study. The first was to investigate whether adding seasonings to chuck-eye and top blade steaks would impact flavor attributes and increase flavor quality. The second major objective was to determine if USDA select steaks could be enhanced with the addition of seasonings. A secondary objective in this study was to evaluate the impact of enzymatic tenderization on the quality of these cuts and grade of steak.

Methods and Materials

Samples

Steak samples were strip (*Longissimus dorsi*), chuck-eye (*Complexus*) and top blade (*Infraspinatus*). These cuts were selected to represent a range of quality (strip = high quality, top blade = mid-range and chuck = low). For each steak there were two USDA grades (choice and select). Strip and chuck-eye samples had a similar weight, approximately 340 g. Top blade steaks were smaller and were grouped together in twos or threes to achieve a weight of approximately 340 g per sample. All samples were individually vacuum sealed and frozen at -23° C prior to testing. According to a randomized test design samples were removed from frozen storage 24 h prior to cooking and allowed to thaw in a refrigerator at 3.5 °C.

Sample Preparation

Samples were assigned to control (no seasoning or seasoning+bromelain), seasoning or seasoning + bromelain (S+B) treatment groups for seasoning. Many of the seasonings were chosen based on what is commonly used by consumers in the U.S. as reported by Vázquez-Araújo and others (submitted). The seasoning contained: 13.5 g kosher salt, 4.6 g ground black pepper, 4.8 g onion powder, 6.2 g garlic powder, 3.6 g ground oregano, and 1.8 g ground cumin. One teaspoon of the seasoning was evenly distributed over the sample.

For the S+B treatment, steaks were submerged into a solution (20 mg/L) of bromlain (Enzeco Bromelain 240 provided by Enzyme Development Corporation). Samples were

submerged for 10 s, drained and refrigerated for 10 min. Samples were then seasoned according to the method described previously.

Immediately after seasoning (except for the control samples) samples were cooked on an electric grill (George Foreman model GPR 100, Miramar, FL). The grill was pre-heated on "high" for 10 min. The samples were placed in the center of the grill, the top of the grill was closed and samples were cooked until they reached an internal temperature of 71 °C corresponding to a medium doneness. Internal temperatures (read from the approximate geometric center) of all samples were monitored during cooking using a probe thermometer (Mainstays ™ Black Acu-Rite meat thermometer with probe, Model 00993STW1, Lake Geneva, WI). After samples reached 71 °C they were removed from the grill and cut into approximately 1.25 cm cubes. Any excess fat or cartilage on the edge of the steak was removed prior to cubing.

Glass jelly jars (Ball Corporation, Daleville, IN) of approximately 120 mL labeled with a random three digit code were placed on a warming tray (The Maxim Co. model WT48, Newark, NJ) for at least 1 h prior to being used for serving the sample. The jars were covered with screw top lids (Ball Corporation, Daleville, IN) and each jar was placed into a tin tray on a heated clay brick to keep the sample warm (bricks had been heated for at least 2 h in an oven at 127°C). Three cubes of each sample were placed into the warmed glass jelly jars. Samples were then served to the panel. Samples were served monadic sequentially, about 15 min apart.

Descriptive Analysis

Six highly-trained panelists from the Sensory Analysis Center at Kansas State University (Manhattan, KS) evaluated the samples for this project. The panel room had controlled temperature, lighting, and humidity. Panelists had each completed a general training course in descriptive sensory testing (120-h) and had about 2,000 h of testing experience with a variety of products. Panelists also had experience testing beef and using the beef lexicon developed by Adhikari and others (2011).

During two 1.5 h orientation sessions the panel checked the seasoning amount to determine if it was appropriate. Panelists were asked to taste the seasoned samples to determine if any of the spices were overwhelming (masking the natural flavor of the sample, or standing out among the rest of the seasoning ingredients). A range of samples was served during orientation to allow the panel to ensure all of the appropriate attributes were included on the

testing ballot. Panelists used the beef flavor lexicon developed by Adhikari and others (2011), selecting only attributes which applied to this sample set and adding in attributes representative of flavors perceived due to the seasoning. Also, two texture attributes (overall tenderness and juiciness) were added by investigators as texture has been shown to be important in beef quality perception.

The panel evaluated four to six samples per day in 90 min sessions. A total of 72 samples (3 cuts × 2 grades × 3 treatments ×4 replications) were evaluated over 16 days. Strip and chuck-eye samples were served according to a randomized complete block design with samples being randomized within each replication. One set of the samples received was the incorrect cut therefore top blade steak samples were repurchased and all top blade steak samples were tested last. Top blade steak samples were also randomized within each replication. All samples were served monadic sequentially.

Panelists evaluated each sample for 30 flavor and texture attributes (see table 2.1 for terms and definitions). The panel rated the intensity of each attribute on a 0-15-point scale with 0.5 point increments (with 0 representing "none" and 15 representing "high"). Evaluation took place under red lighting to minimize visual differences between samples and prevent bias. Panelists were provided with reverse osmosis, de-ionized, carbon filtered water and unsalted-top saltine crackers for palate cleansing and to reduce any build-up of flavors that could occur from one sample to the next. Compusense® (Version 5.2.19; 2010, Compusense Inc., Guelph, Ontario, Canada) is used by the panelists to collect the data.

Table 3.1 Terms, definitions, and references used in evaluating seasoned beef samples for flavor and texture.

Attribute	Definition
Texture	
Juiciness	The amount of liquid expressed from the sample during the first 6 chews.
Overall Tenderness	Ease with which a sample can be cut through with molars.
General Aroma/Flavor	
Initial Flavor Impact	The immediate reaction to the dominant flavor notes and their intensities. Rated during the first 2-3 chews of the sample.
Beef Identity	Amount of beef flavor identity in the sample.
Brown/Roasted	A round, full aromatic generally associated with beef suet that has been broiled.
Bloody/Serumy	The aromatics associated with blood on cooked meat products. Closely related to metallic aromatic.
Liver-like	Aromatics associated with cooked organ meat/liver.
Metallic	The impression of slightly oxidized metal, such as iron, copper, and silver spoons.
Fat-like	Aromatics associated with cooked animal fat.
Rancid	An aromatic commonly associated with oxidized fat and oils. These aromatics may include cardboard, paint, varnish, and fishy.
Green- hay like	Brown/green dusty aromatics associated with dry grasses, hay, dry parsley and tea leaves.
Umami	Flat, salty, somewhat brothy. The taste of glutamate, salts of amino acids and other molecules called nucleotides.
Overall Sweet	A combination of sweet taste and sweet aromatics. The aromatics associated with the impression of sweet.
Sweet	The fundamental taste factor associated with sucrose.
Sour Aromatics	Aromatics associated with sour substances.

Attribute	Definition
Sour	The fundamental taste factor associated with citric acid.
Salty	The fundamental taste factor of which sodium chloride is typical.
Bitter	The fundamental taste factor associated with a caffeine solution.
Barnyard	Combination of pungent, slightly sour, hay-like aromatics associated with farm animals and the inside of a barn.
Burnt	The sharp/acrid flavor note associate with over roasted beef muscle, something over baked or excessively browned in oil.
Green	Sharp slightly pungent aromatics associated with green/plant/vegetable matter such as parsley, spinach, pea pod, fresh cut grass, etc.
Musty-earthy	Musty, sweet, decaying vegetation.
Refrigerator Stale	Aromatics associated with products left in refrigerator for an extended period of time and absorbing a combination of odors (lack of freshness, flat).
Warmed Over	Perception of a product that has been previously cooked and reheated.
Black Pepper	The aromatics associated with ground black pepper that are spicy, pungent, musty and woody.
Onion	The aromatics commonly associated with dehydrated onion and characterized as sweet, slightly brown, and slightly pungent.
Garlic	The musty, slightly brown, sweet, pungent aromatics associated with garlic.
Oregano	A sharp, pungent, woody, green aromatic that is somewhat musty and petroleum/rubber-tire like.
Cumin	The aromatics commonly associated with cumin and characterized as dry, pungent, woody and slightly floral.
White Pepper	Spicy, pungent, musty, woody, slightly soured hay-like barnyard aromatics.

Data Collection and Statistical Analysis

Data was analyzed using PROC GLIMMIX in SAS ® version 9.1 (SAS Institute Inc., Cary, NC) to obtain analysis of variance (ANOVA). The panelists were treated as a random effect. Post-hoc means separation was done using Fisher's Least Significant Difference (LSD) at 5% level of significance. Principal components analysis (PCA) in the covariance matrix was conducted (The Unscrambler X ®, 2011, version 10.1; Camo A/S. Oslo, Norway) to show relationships between the sample treatments and the sensory attributes.

Results and Discussion

There were 30 attributes included on the initial ballot for descriptive testing. Nine flavor attributes were detected at very low intensities in some of the samples, and hence were eliminated before data analysis. These included: burnt, barnyard, liver-like, refrigerator stale, warmed over, rancid, green hay-like, green, and musty/earthy. The mean scores of the remaining 21 attributes for all samples can be seen in table 3.2.

Table 3.2 Mean scores of selected texture and flavor attributes for seasoned beef steak samples.

Attribute	C-E B	C-E C	C-E S	TB B	TB C	TB S	Str B	Str C	Str S
Initial Flavor Impact									
Choice	10.4^{abc}	8.9^{cd}	^{x}10.6^{ab}	9.1^{bcd}	7.9^{d}	9.8^{abc}	10.8^{ab}	10.1^{abc}	11.3^{a}
Select	9.4^{b}	8.3^{bc}	^{y}9.0^{b}	9.1^{b}	7.5^{c}	9.2^{b}	11.3^{a}	9.5^{b}	11.4^{a}
Beef Flavor Identity									
Choice	7.7^{a}	7.5^{ab}	6.3^{ab}	6.0^{b}	6.4^{ab}	6.8^{ab}	7.4^{ab}	7.4^{ab}	7.2^{ab}
Select	7.0^{ab}	6.5^{ab}	6.3^{ab}	5.5^{b}	5.5^{b}	5.5^{b}	7.9^{a}	6.0^{ab}	7.3^{ab}
Brown/ Roasted									
Choice	9.4^{abc}	6.9^{d}	8.0^{bcd}	8.4^{abcd}	7.6^{cd}	9.2^{abc}	9.8^{ab}	10.4^{a}	10.2^{a}
Select	8.6^{abc}	6.9^{c}	8.5^{abc}	8.4^{abc}	7.3^{bc}	8.1^{bc}	10.4^{a}	9.0^{ab}	10.3^{a}
Bloody/Serumy									
Choice	3.4^{b}	^{x}5.4^{a}	3.0^{b}	3.5^{b}	3.7^{b}	3.6^{b}	3.1^{b}	3.8^{b}	2.7^{b}
Select	3.4^{ab}	^{y}4.1^{a}	3.3^{ab}	2.9^{b}	3.9^{ab}	3.6^{ab}	3.2^{ab}	3.9^{ab}	3.0^{ab}
Metallic									
Choice	2.5^{cd}	3.6^{a}	2.1^{d}	3.2^{abc}	3.3^{ab}	2.8^{bcd}	2.6^{bcd}	2.6^{bcd}	2.3^{d}
Select	2.6^{ab}	3.3^{a}	2.4^{b}	2.9^{ab}	3.3^{a}	3.4^{a}	2.4^{b}	3.3^{a}	2.4^{b}
Fat-like									
Choice	4.0^{a}	3.2^{ab}	3.6^{ab}	^{x}3.0^{ab}	2.5^{b}	2.9^{ab}	3.8^{ab}	^{x}3.5^{ab}	3.1^{ab}
Select	3.6^{a}	2.8^{ab}	2.6^{abc}	^{y}1.5^{c}	2.4^{bc}	2.6^{abc}	3.2^{ab}	^{y}2.2^{bc}	3.0^{ab}
Umami									
Choice	6.4^{ab}	5.5^{bcd}	5.9^{abc}	4.6^{d}	5.0^{cd}	^{x}5.9^{abcd}	6.6^{ab}	^{x}6.9^{a}	6.3^{ab}
Select	6.7^{a}	4.6^{bc}	5.8^{ab}	4.9^{bc}	4.5^{c}	^{y}4.5^{c}	6.7^{a}	^{y}4.9^{bc}	6.7^{a}
Overall Sweet									
Choice	1.8^{abcd}	1.7^{abcd}	1.5^{bcd}	1.4^{d}	1.4^{cd}	1.5^{abcd}	1.8^{abc}	^{x}1.8^{ab}	1.9^{a}
Select	1.9^{a}	1.4^{cd}	1.6^{abc}	1.5^{bcd}	1.2^{d}	1.4^{cd}	1.8^{ab}	^{y}1.2^{d}	1.8^{ab}
Sweet									
Choice	1.0^{ab}	1.1^{ab}	1.0^{ab}	0.9^{b}	1.0^{ab}	1.0^{ab}	1.1^{ab}	1.1^{ab}	1.2^{a}
Select	1.1^{a}	0.8^{c}	1.1^{ab}	1.0^{abc}	0.8^{c}	0.9^{abc}	1.1^{ab}	0.8^{bc}	1.1^{ab}
Sour Aromatics									
Choice	2.8^{b}	2.6^{bc}	2.7^{bc}	3.5^{a}	3.6^{a}	3.4^{a}	2.5^{bc}	^{y}2.1^{bc}	2.1^{c}
Select	2.5^{b}	3.0^{ab}	3.2^{ab}	3.5^{a}	3.5^{a}	3.5^{a}	2.5^{b}	^{x}3.2^{ab}	2.5^{b}
Sour									
Choice	2.3^{b}	2.3^{bc}	^{y}2.2^{bc}	3.1^{a}	3.1^{a}	3.0^{a}	2.1^{bc}	^{y}1.7^{c}	1.9^{bc}
Select	2.1^{c}	2.7^{abc}	^{x}2.9^{ab}	3.1^{a}	3.1^{a}	3.1^{a}	2.1^{c}	^{x}2.8^{abc}	2.3^{bc}

Attribute		C-E B	C-E C	C-E S	TB B	TB C	TB S	Str B	Str C	Str S
Salty										
	Choice	4.1^{b}	2.5^{c}	4.2^{b}	^{x}4.1^{b}	2.7^{c}	4.1^{b}	4.6^{ab}	^{x}3.1^{c}	^{x}5.1^{a}
	Select	3.7^{c}	2.9^{cd}	3.9^{bc}	^{y}3.3^{cd}	2.3^{e}	3.8^{c}	4.6^{a}	^{y}2.1^{e}	^{y}4.5^{ab}
Bitter										
	Choice	3.7	3.2	3.7	3.6	3.4	3.6	3.6	3.4	3.6
	Select	3.4^{ab}	3.4^{ab}	3.8^{a}	3.7^{a}	3.1^{b}	3.7^{a}	3.8^{a}	3.4^{ab}	3.7^{a}
Black Pepper										
	Choice	2.3^{ab}	0.0^{c}	2.5^{a}	1.7^{b}	0.0^{c}	2.4^{a}	2.4^{a}	0.0^{c}	^{x}2.8^{a}
	Select	1.8^{bc}	0.0^{d}	2.3^{ab}	1.7^{c}	0.0^{d}	2.1^{abc}	2.4^{a}	0.0^{d}	^{y}2.0^{abc}
Onion										
	Choice	1.9^{ab}	0.0^{c}	2.0^{ab}	1.7^{b}	0.0^{c}	1.7^{b}	2.1^{ab}	0.0^{c}	2.5^{a}
	Select	2.1^{ab}	0.0^{c}	1.5^{b}	1.5^{c}	0.0^{c}	1.6^{ab}	1.9^{ab}	0.0^{c}	2.4^{a}
Garlic										
	Choice	1.6^{bc}	0.0^{d}	1.7^{abc}	1.5^{c}	0.0^{d}	1.6^{bc}	2.4^{ab}	0.0^{d}	2.5^{a}
	Select	1.9^{ab}	0.0^{c}	1.4^{b}	1.4^{b}	0.0^{c}	1.6^{b}	1.7^{ab}	0.0^{c}	2.4^{a}
Oregano										
	Choice	0.7^{ab}	0.0^{b}	0.0^{b}	0.6^{ab}	0.0^{b}	^{y}0.5^{b}	^{x}1.3^{a}	0.0^{b}	0.6^{ab}
	Select	0.1^{c}	0.0^{c}	0.5^{ab}	1.0^{ab}	0.0^{c}	^{x}1.6^{a}	^{y}0.3^{c}	0.0^{c}	0.2^{c}
Cumin										
	Choice	0.6	0.0	0.8	0.4	0.0	1.2	0.0	0.0	0.8
	Select	0.4^{ab}	0.0^{b}	1.1^{a}	0.8^{ab}	0.0^{b}	1.1^{a}	0.0^{b}	0.0^{b}	0.4^{ab}
White Pepper										
	Choice	0.0	0.0	0.6	0.7	0.4	0.9	0.9	0.0	0.5
	Select	0.5^{abcd}	0.0^{d}	1.0^{abc}	1.1^{a}	0.2^{bcd}	1.1^{ab}	0.1^{cd}	0.0^{d}	1.0^{abcd}
Juiciness										
	Choice	7.4^{ab}	^{x}7.8^{a}	7.3^{abc}	6.9^{bcd}	6.6^{cd}	7.0^{bcd}	7.5^{ab}	6.5^{d}	7.5^{ab}
	Select	7.5^{a}	^{y}5.7^{b}	6.8^{ab}	6.4^{ab}	6.4^{ab}	6.5^{ab}	7.1^{a}	6.2^{ab}	7.3^{a}
Overall Tenderness										
	Choice	6.2^{cd}	5.9^{cd}	5.5^{d}	7.7^{abcd}	7.4^{bcd}	8.1^{abc}	10.0^{a}	9.0^{ab}	9.4^{ab}
	Select	7.9^{a}	4.6^{b}	3.7^{b}	8.3^{a}	7.4^{a}	7.9^{a}	9.0^{a}	8.4^{a}	9.1^{a}

^{a,b,c,d,e} Row means with no common superscripts differ ($P \leq 0.05$).

^{x,y} Column means within an attribute with no common superscripts differ ($P \leq 0.05$).

C-E B= Chuck-eye seasoning + bromelain, C-E C= Chuck-eye control, C-E S= Chuck-eye seasoning,

TB B= Top blade seasoning + bromelain, TB C= Top blade control, TB S= Top blade seasoning,

Str B= Strip seasoning + bromelain, Str C= Strip control, Str S= Strip seasoning

Impact of Treatments on Samples by Cut

Mean attribute scores of treated chuck-eye and top blade steaks were compared to scores from strip steaks (control) to determine if flavor or texture quality was enhanced. Control chuck-eye steaks differed from control strip steaks in that chuck-eyes were lower in brown/roasted and overall tenderness. These differences were seen in both grades. In USDA choice samples only chuck-eyes were higher in bloody/serumy, metallic and juiciness and lower in umami than choice strip samples.

Among choice steaks treatments had the greatest effect on chuck-eye steaks. Both treatments lowered scores for bloody/serumy and metallic flavors in choice chuck-eye steaks. Umami flavor and initial flavor impact were increased by both treatments. Treatment with seasoning + bromelain (S+B) also increased the brown/roasted flavor of the sample. Juiciness was not impacted by either treatment, and all choice chuck-eye scores for juiciness were significantly higher than juiciness scores for strip steak (control). However, treatments did not increase overall tenderness scores for choice chuck-eye steaks, and these scores were significantly lower than overall tenderness scores for choice strip steaks. A principal components analysis (PCA) performed on choice samples is shown in figure 3.1. The PCA shows that control choice chuck-eye samples were more correlated with metallic and bloody/serumy flavors than were choice chuck-eye samples with either treatment. Although the chuck-eye samples all had high ratings for juiciness, the chuck-eyes with seasoning and S+B are much closer to juiciness on the PCA than is the control chuck-eye sample. This is likely because the metallic and bloody/serumy attributes are more related to the control sample and are pulling the control sample away from the other attributes. Chuck-eye samples with either treatment are positioned near many of the attributes in the seasoning and initial flavor impact which is consistent with ANOVA results.

Figure 3.1 Sensory map of the first two principal components for flavor and texture attributes of USDA choice steaks

USDA grade is denoted with Ch for choice and Sl for selectC-E B= Chuck-eye seasoning + bromelain, C-E C= Chuck-eye control, C-E S= Chuck-eye seasoning, TB B= Top blade seasoning + bromelain, TB C= Top blade control, TB S= Top blade seasoning, Str B= Strip seasoning + bromelain, Str C= Strip control, Str S= Strip seasoning

Control top blade steaks differed from control strip steaks because they had less initial flavor impact. This difference was seen in top blade steaks of both choice and select. Choice top blade steaks had lower brown/roasted, umami, overall sweet and higher sour and sour aromatics ratings than did control choice strip steaks. Initial flavor impact was increased with both treatments, as was the brown/roasted flavor. The treatment with seasoning alone increased umami flavor for choice top blade steaks. Treatment with S+B did not increase the tenderness and juiciness scores for choice top blade steaks, however these scores were not significantly different than those scores for strip steak (control). Choice top blade steaks had significantly higher scores for sourness and sour aromatics than all other samples and this was not impacted by either treatment. The PCA for choice samples (figure 3.1) shows that top blade steaks with either treatment were more related with brown/roasted flavor and initial flavor impact than were control choice top blade steaks. It does not show that choice top blade samples were not different in tenderness and juiciness than strip samples. This may be because top blade samples had high ratings for sour and sour aromatics and this relationship could be preventing the top blade sample from being positioned too far from these attributes.

There are not many published studies focused on descriptive analysis between different cuts and grades of steak. Those studies that are published are mostly consumer studies. Those that are descriptive analysis do not use a lexicon to describe beef flavors (many simply use beef flavor intensity or a similar term). The flavor changes identified in the present study may result in an increase in consumer flavor liking over the control chuck-eye and top blade samples. Maughan and others (2012) showed that umami, brown and roasted flavors (among others) are positively correlated with liking and may drive consumer acceptance.

Among select steaks chuck-eye steaks were most improved by treatment with S+B. Both treatments significantly increased brown/roasted flavor in select chuck-eye steaks. ANOVA results show that both treatments increased overall sweet flavor, but this difference does not have much impact on the samples because the absolute values of the overall sweet scores between treatments are very similar. Select chuck-eye steaks treated with S+B had an increase in overall tenderness, fat-like and umami. The mean overall tenderness scores for select chuck-eye steaks treated with S+B was not significantly different than overall tenderness score for control select strip steaks. The mean juiciness score for these all select chuck-eye steaks (control and both treatments) was greater than the mean juiciness score for control select strip steaks. PCA for

select samples (figure 3.2) show that chuck-eye steaks treated with S+B were more correlated with fat-like and umami than were control select chuck-eye steaks. The PCA also shows that select chuck-eye steaks treated with S+B were more related with overall tenderness than were chuck-eye steaks without bromelain. Increased juiciness, tenderness, brown/roasted, fat-like, umami may result in increased consumer acceptance as similar attributes have been reported to be positively correlated with liking (Maughan and others 2012).

Select top blade steaks were generally unchanged by either treatment. Both treatments increased initial flavor impact. The mean score for initial flavor impact in select top blade steaks with either treatment applied was not significantly different than that score for control select strip steaks. It is important to note that no flavor or texture attribute scores in select top blade steaks were significantly different than scores for select strip steaks (control). The PCA for select samples (see figure 3.2) supports these results, showing that top blade steaks with either treatment are more correlated with initial flavor impact than control top blade samples.

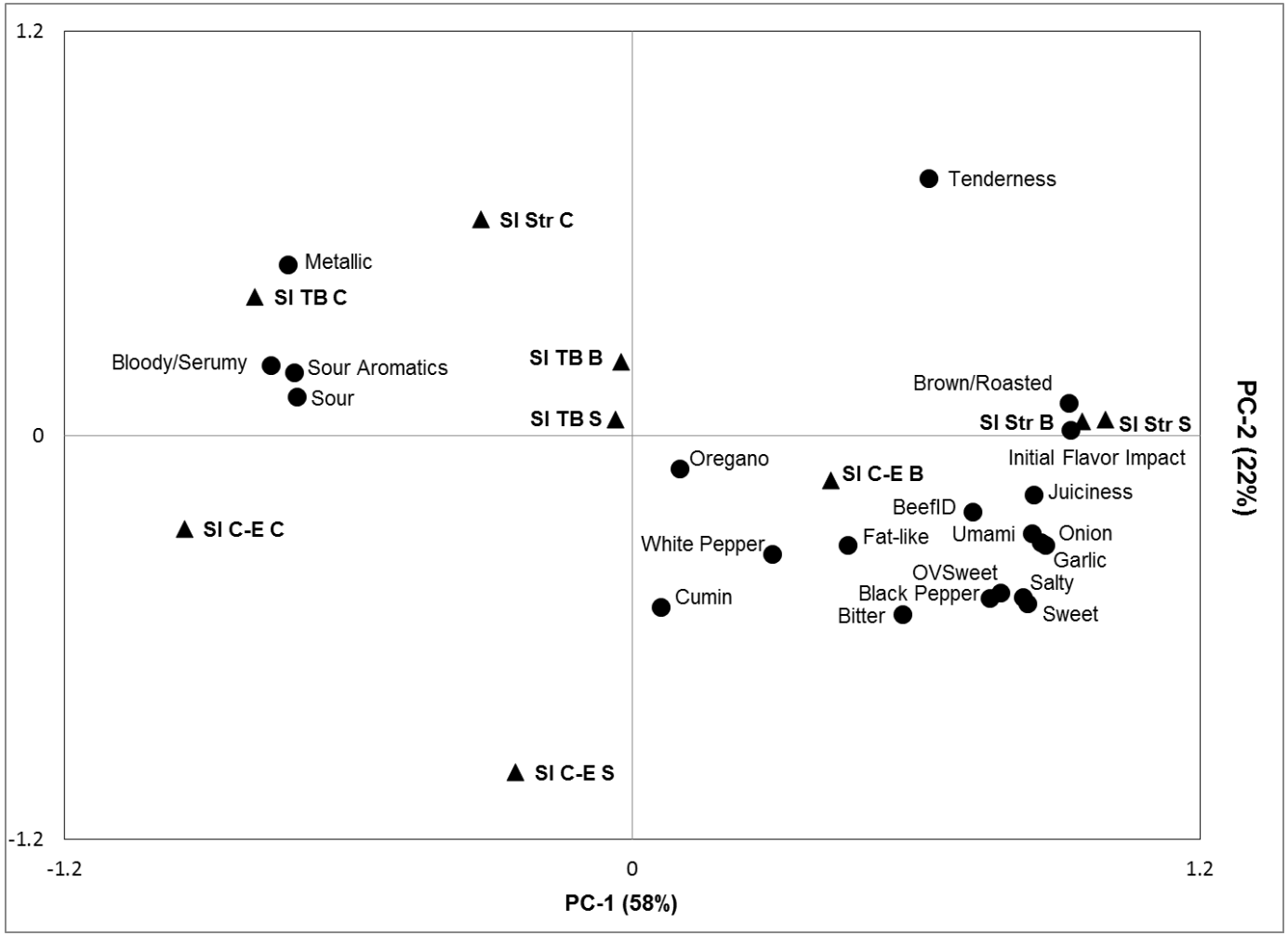

Figure 3.2 Sensory map of the first two principal components for flavor and texture attributes for USDA select steaks

USDA grade is denoted with Ch for choice C-E B= Chuck-eye seasoning + bromelain, C-E C= Chuck-eye control, C-E S= Chuck-eye seasoning, TB B= Top blade seasoning + bromelain, TB C= Top blade control, TB S= Top blade seasoning, Str B= Strip seasoning + bromelain, Str C= Strip control, Str S= Strip seasoning

Impact of Treatments on USDA Select Steaks

Strip Steaks

The mean intensity rating for fat-like was lower in the select strip control samples than in the choice strip control samples. The application of either treatment increased the mean fat-like score to be comparable to the fat-like score for any of the choice strip samples. This same trend was seen with the mean umami rating (either treatment increased of the intensity of umami in the select chuck-eye samples to be comparable to the scores for the choice samples). Again, ANOVA results show significant differences in overall sweet score between choice and select strips but this difference has little impact on the samples because the absolute value of the ratings is very similar. Select strip control samples were more sour than the choice strip control samples. Both treatments lowered sourness in the select strip samples to a level comparable to the choice samples. This same trend was seen for the intensity rating for sour aromatics. This decrease in sour and sour aromatics would likely be an improvement to the steak because sour has been shown to be negatively correlated to liking (Maughan and others 2012). The results of the PCA for all samples (shown in figure 3.3) show that select strip samples with either treatment applied were more correlated with fat-like, umami and overall sweet flavors than were control select strip samples. Select and choice strip samples with either treatment are positioned near one another on the PCA indicating that these samples are correlated with the same attributes.

These results differ from a study on *Longissimus dorsi* (source of the strip steak) of Hanwoo cattle from Korea where investigators found no significant flavor differences between samples of different quality grades (Kim and Lee 2003). This could be because samples in the study were graded according to the Korean grading system and not the USDA grading system. Adhikari and others (2004) found that grilled *longissimus dorsi* (source of the strip steak) had brown/roasted flavor and high juiciness. The strip samples in the present study had high ratings for brown/roasted flavor and these ratings were among the highest for all samples tested in the study. The juiciness was not as high for the strip samples in this study, but this difference could be due to a difference in degree of doneness.

A similar study (Vázquez-Araújo and others submitted) found that the addition of herbs and spices altered some main beef flavor attributes, but the change was dependent on cooking method. Attributes most affected were beef identity, brown/roasted and bloody/serumy. This

finding is consistent with the results of the current study, as many samples had changes in these same attributes with seasoning or S+B. Vázquez-Araújo and others found that samples cooked on an outdoor grill with salt and pepper had increased brown/roasted, fat like, sourness, saltiness, bitterness and initial flavor impact of the samples. Although samples were cooked in the present study on an electric grill, many of the attributes affected by treatment remained the same.

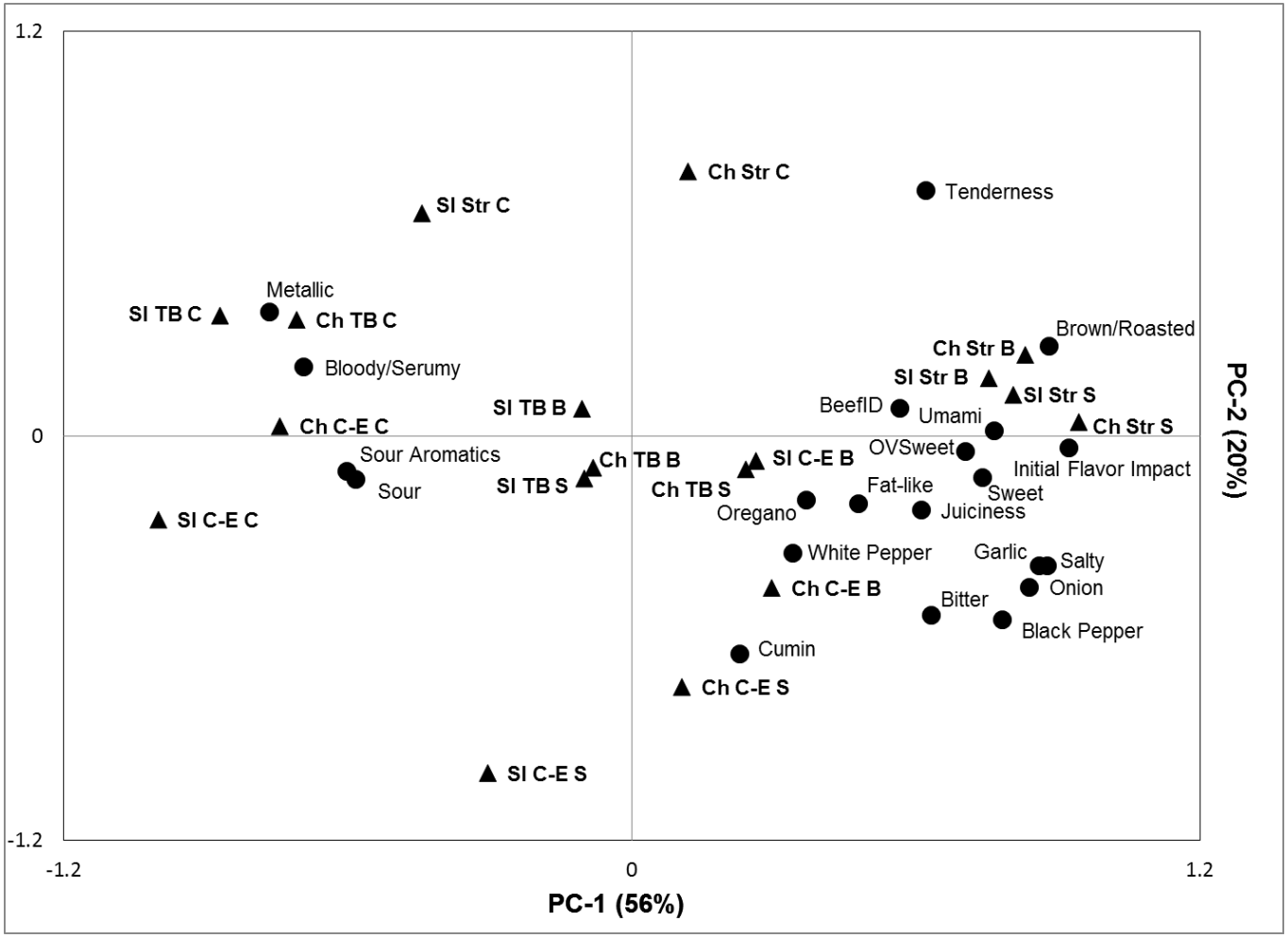

Figure 3.3 Sensory map of the first two principal components for flavor and texture attributes for seasoned beef steak samples

USDA grade is denoted with Sl for select

C-E B= Chuck-eye seasoning + bromelain, C-E C= Chuck-eye control, C-E S= Chuck-eye seasoning, TB B= Top blade seasoning + bromelain, TB C= Top blade control, TB S= Top blade seasoning, Str B= Strip seasoning + bromelain, Str C= Strip control, Str S= Strip seasoning

Chuck-eye Steaks

The treatments applied in this study impacted several important flavor and texture attributes in the chuck-eye steaks. Treatment caused some attributes in the select chuck-eye samples to become more similar to attributes of the choice chuck-eye samples. Results of the ANOVA show that there were two significant differences between choice chuck-eye control steaks and select chuck-eye control steaks. Choice chuck-eye steaks had higher intensities of juiciness and bloody/serumy. Overall tenderness ratings were not shown to be significantly different between grades for chuck-eye samples. Juiciness was significantly increased in select chuck-eye samples when treated with seasonings and was increased a greater amount when treated with S+B. Mean juiciness intensity for treated (either with seasoning alone, or S+B) select chuck-eye steaks was not different from mean juiciness intensity for any of the choice chuck-eye samples. Control samples of select chuck-eye steaks had a lower mean intensity rating for bloody/serumy than control samples of choice chuck-eye. However, both treatments lowered the mean bloody/serumy score for choice chuck-eyes to a level comparable with select chuck-eyes. Between choice chuck-eye treated samples and select chuck-eye treated samples, there was no significant difference in mean bloody/serumy intensity. Seasoned select chuck-eye samples were more sour than the seasoned choice chuck-eyes. Treatment with S+B lowered sourness in the select chuck-eye samples to a level comparable to the choice samples. The PCA for all samples (figure 3.3) shows that control chuck-eye steaks were related to the bloody/serumy attribute. It also shows that chuck-eye samples treated with S+B are more correlated with juiciness than were control select chuck-eye samples. These results support the findings of the ANOVA.

Adhikari and others (2004) recommended that grilling USDA select and low choice *complexus* (source of the chuck-eye steak) to a medium-rare doneness. They found that this cooking method and temperature produced high juiciness and roasted flavor. Roasted flavor of the control chuck-eye samples in the current study was low, but was increased with either treatment. Juiciness was found to be lower in select chuck-eye but again was improved by either treatment. One reason for the variation in these attributes between studies could be the difference in degree of doneness.

Top Blade Steaks

Overall there were no significant differences between choice top blade control samples and select top blade control samples. Select top blade samples had the lowest ratings for beef flavor identity of any of the samples tested, and this was not improved by the treatments. Top blade samples had the highest ratings for sour and sour aromatics with the mean intensity scores for these attributes being significantly higher than for most other samples tested. Treatment did not affect mean ratings for these attributes. Results of the PCA (figure 3.3) support ANOVA findings for top blade steaks. Control choice and select top blade steaks are positioned near one another indicating that they are correlated with the same attributes (metallic, sour and sour aromatics).

Yancey and others (2005) studied the effect of pH, maturity and marbling on flavors in top-blade, top-sirloin and tenderloin steaks. Steaks in the study were from A or B-maturity carcasses with slight or small amounts of marbling. These characteristics are consistent with the USDA grades of choice and select. The study found that top blade steaks had higher bloody/serumy flavor than the top-sirloin and tenderloin steaks. Steaks from B-maturity carcasses or with high pH had more intense bloody/serumy ratings. In the present study control choice chuck-eye steaks were found to have the highest rating for bloody/serumy and top blade steaks ratings for bloody/serumy were consistent with those of strip steaks. Yancey and others (2005) reported that the effect of marbling on brown/roasted flavor ratings in top blade, top sirloin and tenderloin steaks was inconsistent. The present study did not find any significant differences in brown/roasted flavor ratings between grades for the cuts in this study. Top blade steaks had less intense beef flavor than the other cuts in the study by Yancey and others (2005). The study also concluded that top-sirloin steaks are expected to have more sour flavor than top blade or tenderloin steaks. Top blade steaks in the current study were found to have significantly higher ratings for sour and sour aromatics than chuck-eye or strip steaks. Ratings for beef flavor identity for top blade samples were slightly lower than those for chuck-eye or strip steaks, but ANOVA results did not show this difference to be significant.

Effects of Bromelain Treatment

Treatment with S+B increased overall tenderness and juiciness in select chuck-eye steaks. Other samples' tenderness ratings were slightly but not significantly improved with the S+B

treatment. However within each cut there were no significant differences found in overall tenderness ratings between choice and select steaks. This may indicate that higher USDA grade does not necessarily mean increased tenderness in beef steaks. Voges and others (2007) and Brooks and others (2000) report a similar finding, with no significant differences found in tenderness among steaks of top choice, low choice and select.

One reason that bromelain did not significantly impact the tenderness of most of the samples in this study may be because of the application method. McKeith and others (1994) showed that dipping or tumbling a sample in brine was less effective than injecting the enzyme solution into the sample.

Conclusions

The results of this study indicate that it may be possible to improve eating quality of choice chuck-eye, choice top blade and select chuck-eye steaks to be more similar to strip steaks of the same USDA grade. The next step to this research is to conduct consumer evaluations of the samples thought to be improved by the treatments in this study. This could be done by comparing liking scores for each of these samples to liking scores for strip steak of the same grade. Select strip and chuck-eye steaks may be enhanced by these treatments enough that they could be similar in liking to choice strip and chuck-eye steaks. This finding should also be examined in consumer testing by comparing liking scores between the USDA choice and select samples with treatments applied to the select samples.

The treatments employed in this investigation could be applied to other low quality cuts to determine if flavor and texture attributes could be improved. Also, applying enzymatic tenderization through injection may produce an increased tenderness in samples. It is possible that samples in this study would have higher tenderness ratings using this method. Overall, these treatments could be a valuable tool for consumers who would be able to purchase a better steak at a lower price, and beef retailers who would be able to sell more select beef.

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Chapter 4 - Summary & Future Directions

The results of this study indicate that it may be possible to improve eating quality of choice chuck-eye, choice top blade and select chuck-eye steaks to be more similar to strip steaks of the same USDA grade. The next step to this research is to conduct consumer evaluations of the samples thought to be improved by the treatments in this study. This could be done by comparing liking scores for each of these samples to liking scores for strip steak of the same grade. Select strip and chuck-eye steaks may be enhanced by these treatments enough that they could be similar in liking to choice strip and chuck-eye steaks. This finding should also be examined in consumer testing by comparing liking scores between the USDA choice and select samples with treatments applied to the select samples. Comparing choice and select chuck-eye control is important to determine if the consumers' liking score differs between the two. Several studies have been conducted to determine whether consumer liking is impacted by USDA quality grade (McBee and Wiles 1967; Neely and others 1998; Lorenzen and others 1999; Brooks and others 2000; Goodson and others 2002), but results have been inconsistent. Some studies suggest that liking differences between grades may be dependent on the cut of the steak (Neely and others 1998; Goodson and others 2002).

The treatments employed in this investigation could be applied to other low quality cuts to determine if flavor and texture attributes could be improved. Also, applying enzymatic tenderization through injection may produce an increased tenderness in samples. It is possible that samples in this study would have higher tenderness ratings using this method. Overall, these treatments could be a valuable tool for consumers who would be able to purchase a better steak at a lower price, and beef retailers who would be able to sell more select beef.

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Appendix A - Descriptive Testing Ballot

Beef (S)

Sept 2011

Panelist _____ Sample _____ Date _____

Flavor																															
Initial Fl. Impact	**0**	**0.5**	**1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**4**	**4.5**	**5**	**5.5**	**6**	**6.5**	**7**	**7.5**	**8**	**8.5**	**9**	**9.5**	**10**	**10.5**	**11**	**11.5**	**12**	**12.5**	**13**	**13.5**	**14**	**14.5**	**15**
Juiciness	**0**	**0.5**	**1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**4**	**4.5**	**5**	**5.5**	**6**	**6.5**	**7**	**7.5**	**8**	**8.5**	**9**	**9.5**	**10**	**10.5**	**11**	**11.5**	**12**	**12.5**	**13**	**13.5**	**14**	**14.5**	**15**
OV Tenderness	**0**	**0.5**	**1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**4**	**4.5**	**5**	**5.5**	**6**	**6.5**	**7**	**7.5**	**8**	**8.5**	**9**	**9.5**	**10**	**10.5**	**11**	**11.5**	**12**	**12.5**	**13**	**13.5**	**14**	**14.5**	**15**
Beef Flavor ID	**0**	**0.5**	**1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**4**	**4.5**	**5**	**5.5**	**6**	**6.5**	**7**	**7.5**	**8**	**8.5**	**9**	**9.5**	**10**	**10.5**	**11**	**11.5**	**12**	**12.5**	**13**	**13.5**	**14**	**14.5**	**15**
Brown/Roasted	**0**	**0.5**	**1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**4**	**4.5**	**5**	**5.5**	**6**	**6.5**	**7**	**7.5**	**8**	**8.5**	**9**	**9.5**	**10**	**10.5**	**11**	**11.5**	**12**	**12.5**	**13**	**13.5**	**14**	**14.5**	**15**
Bloody/Serumy	**0**	**0.5**	**1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**4**	**4.5**	**5**	**5.5**	**6**	**6.5**	**7**	**7.5**	**8**	**8.5**	**9**	**9.5**	**10**	**10.5**	**11**	**11.5**	**12**	**12.5**	**13**	**13.5**	**14**	**14.5**	**15**
Liver-like	**0**	**0.5**	**1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**4**	**4.5**	**5**	**5.5**	**6**	**6.5**	**7**	**7.5**	**8**	**8.5**	**9**	**9.5**	**10**	**10.5**	**11**	**11.5**	**12**	**12.5**	**13**	**13.5**	**14**	**14.5**	**15**
Metallic	**0**	**0.5**	**1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**4**	**4.5**	**5**	**5.5**	**6**	**6.5**	**7**	**7.5**	**8**	**8.5**	**9**	**9.5**	**10**	**10.5**	**11**	**11.5**	**12**	**12.5**	**13**	**13.5**	**14**	**14.5**	**15**
Fat-like	**0**	**0.5**	**1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**4**	**4.5**	**5**	**5.5**	**6**	**6.5**	**7**	**7.5**	**8**	**8.5**	**9**	**9.5**	**10**	**10.5**	**11**	**11.5**	**12**	**12.5**	**13**	**13.5**	**14**	**14.5**	**15**
Rancid	**0**	**0.5**	**1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**4**	**4.5**	**5**	**5.5**	**6**	**6.5**	**7**	**7.5**	**8**	**8.5**	**9**	**9.5**	**10**	**10.5**	**11**	**11.5**	**12**	**12.5**	**13**	**13.5**	**14**	**14.5**	**15**
Green-hay like	**0**	**0.5**	**1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**4**	**4.5**	**5**	**5.5**	**6**	**6.5**	**7**	**7.5**	**8**	**8.5**	**9**	**9.5**	**10**	**10.5**	**11**	**11.5**	**12**	**12.5**	**13**	**13.5**	**14**	**14.5**	**15**
Umami	**0**	**0.5**	**1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**4**	**4.5**	**5**	**5.5**	**6**	**6.5**	**7**	**7.5**	**8**	**8.5**	**9**	**9.5**	**10**	**10.5**	**11**	**11.5**	**12**	**12.5**	**13**	**13.5**	**14**	**14.5**	**15**
OV Sweet	**0**	**0.5**	**1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**4**	**4.5**	**5**	**5.5**	**6**	**6.5**	**7**	**7.5**	**8**	**8.5**	**9**	**9.5**	**10**	**10.5**	**11**	**11.5**	**12**	**12.5**	**13**	**13.5**	**14**	**14.5**	**15**
Sweet	**0**	**0.5**	**1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**4**	**4.5**	**5**	**5.5**	**6**	**6.5**	**7**	**7.5**	**8**	**8.5**	**9**	**9.5**	**10**	**10.5**	**11**	**11.5**	**12**	**12.5**	**13**	**13.5**	**14**	**14.5**	**15**
Sour Aromatics	**0**	**0.5**	**1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**4**	**4.5**	**5**	**5.5**	**6**	**6.5**	**7**	**7.5**	**8**	**8.5**	**9**	**9.5**	**10**	**10.5**	**11**	**11.5**	**12**	**12.5**	**13**	**13.5**	**14**	**14.5**	**15**
Sour	**0**	**0.5**	**1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**4**	**4.5**	**5**	**5.5**	**6**	**6.5**	**7**	**7.5**	**8**	**8.5**	**9**	**9.5**	**10**	**10.5**	**11**	**11.5**	**12**	**12.5**	**13**	**13.5**	**14**	**14.5**	**15**
Salty	**0**	**0.5**	**1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**4**	**4.5**	**5**	**5.5**	**6**	**6.5**	**7**	**7.5**	**8**	**8.5**	**9**	**9.5**	**10**	**10.5**	**11**	**11.5**	**12**	**12.5**	**13**	**13.5**	**14**	**14.5**	**15**
Bitter	**0**	**0.5**	**1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**4**	**4.5**	**5**	**5.5**	**6**	**6.5**	**7**	**7.5**	**8**	**8.5**	**9**	**9.5**	**10**	**10.5**	**11**	**11.5**	**12**	**12.5**	**13**	**13.5**	**14**	**14.5**	**15**
Barnyard	**0**	**0.5**	**1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**4**	**4.5**	**5**	**5.5**	**6**	**6.5**	**7**	**7.5**	**8**	**8.5**	**9**	**9.5**	**10**	**10.5**	**11**	**11.5**	**12**	**12.5**	**13**	**13.5**	**14**	**14.5**	**15**
Burnt	**0**	**0.5**	**1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**4**	**4.5**	**5**	**5.5**	**6**	**6.5**	**7**	**7.5**	**8**	**8.5**	**9**	**9.5**	**10**	**10.5**	**11**	**11.5**	**12**	**12.5**	**13**	**13.5**	**14**	**14.5**	**15**
Green	**0**	**0.5**	**1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**4**	**4.5**	**5**	**5.5**	**6**	**6.5**	**7**	**7.5**	**8**	**8.5**	**9**	**9.5**	**10**	**10.5**	**11**	**11.5**	**12**	**12.5**	**13**	**13.5**	**14**	**14.5**	**15**
Musty- earthy	**0**	**0.5**	**1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**4**	**4.5**	**5**	**5.5**	**6**	**6.5**	**7**	**7.5**	**8**	**8.5**	**9**	**9.5**	**10**	**10.5**	**11**	**11.5**	**12**	**12.5**	**13**	**13.5**	**14**	**14.5**	**15**

Beef (S)

Sept 2011

Refrigerator stale	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Warmed over	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Black pepper	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Onion	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Garlic	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Oregano	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Cumin	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
White pepper	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
_______________	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
_______________	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
_______________	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
______________	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
_______________	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
_______________	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15

COMMENTS:

Appendix B - Experimental Test Design

Table B.1 Experimental design for evaluating seasoned beef steak samples

Replication	Code	Grade	Cut	Seasoning
1	816	Choice	Chuck-eye	control
1	798	Select	KC-Strip	control
1	783	Select	KC-Strip	seasoning&bromelain
1	53	Choice	KC-Strip	seasoning&bromelain
1	900	Choice	KC-Strip	seasoning
1	208	Select	Chuck-eye	seasoning
1	751	Select	Flat Iron/Top blade	seasoning
1	351	Choice	Flat Iron/Top blade	seasoning
1	119	Select	Chuck-eye	seasoning&bromelain
1	490	Select	Flat Iron/Top blade	seasoning&bromelain
1	310	Choice	Flat Iron/Top blade	seasoning&bromelain
1	542	Select	KC-Strip	seasoning
1	109	Select	Chuck-eye	control
1	737	Choice	Chuck-eye	seasoning&bromelain
1	759	Choice	Chuck-eye	seasoning
1	460	Choice	KC-Strip	control
1	580	Select	Flat Iron/Top blade	control
1	649	Choice	Flat Iron/Top blade	control
2	556	Choice	KC-Strip	control
2	988	Choice	Flat Iron/Top blade	seasoning&bromelain
2	101	Select	Flat Iron/Top blade	seasoning
2	139	Select	KC-Strip	seasoning
2	381	Select	Chuck-eye	seasoning
2	327	Choice	Chuck-eye	seasoning&bromelain
2	187	Select	Flat Iron/Top blade	control
2	126	Choice	KC-Strip	seasoning
2	625	Choice	Flat Iron/Top blade	control
2	62	Choice	Chuck-eye	control
2	956	Choice	KC-Strip	seasoning&bromelain
2	452	Select	KC-Strip	control
2	994	Select	Flat Iron/Top blade	seasoning&bromelain

2	97	Choice	Chuck-eye	seasoning
2	41	Choice	Flat Iron/Top blade	seasoning
2	421	Select	KC-Strip	seasoning&bromelain
2	620	Select	Chuck-eye	control
2	372	Select	Chuck-eye	seasoning&bromelain
3	886	Choice	Flat Iron/Top blade	seasoning
3	285	Choice	Chuck-eye	seasoning&bromelain
3	104	Select	Chuck-eye	seasoning
3	399	Select	Flat Iron/Top blade	control
3	180	Choice	Chuck-eye	seasoning
3	212	Select	Flat Iron/Top blade	seasoning&bromelain
3	723	Select	Flat Iron/Top blade	seasoning
3	496	Choice	KC-Strip	control
3	796	Select	Chuck-eye	seasoning&bromelain
3	65	Select	Chuck-eye	control
3	667	Choice	Flat Iron/Top blade	seasoning&bromelain
3	820	Select	KC-Strip	seasoning
3	790	Choice	Flat Iron/Top blade	control
3	871	Select	KC-Strip	control
3	4	Select	KC-Strip	seasoning&bromelain
3	343	Choice	KC-Strip	seasoning
3	822	Choice	Chuck-eye	control
3	926	Choice	KC-Strip	seasoning&bromelain
4	811	Choice	Chuck-eye	seasoning&bromelain
4	765	Select	Flat Iron/Top blade	seasoning
4	232	Select	Flat Iron/Top blade	seasoning&bromelain
4	198	Choice	KC-Strip	control
4	627	Select	KC-Strip	seasoning
4	792	Select	Chuck-eye	seasoning&bromelain
4	103	Select	KC-Strip	seasoning&bromelain
4	756	Select	Chuck-eye	seasoning
4	743	Select	Chuck-eye	control
4	193	Choice	KC-Strip	seasoning
4	640	Choice	Chuck-eye	seasoning

4	424	Select	KC-Strip	control
4	413	Choice	Chuck-eye	control
4	606	Choice	KC-Strip	seasoning&bromelain
1	396	Select	Top blade	seasoning&bromelain
1	898	choice	Top blade	seasoning
1	981	choice	Top blade	seasoning&bromelain
1	644	Choice	Top blade	control
1	38	Select	Top blade	seasoning
1	186	Select	Top blade	control
2	271	Select	Top blade	control
2	277	Choice	Top blade	control
2	808	choice	Top blade	seasoning
2	118	choice	Top blade	seasoning&bromelain
2	481	Select	Top blade	seasoning
2	028	Select	Top blade	seasoning&bromelain
3	600	Select	Top blade	seasoning&bromelain
3	760	choice	Top blade	seasoning&bromelain
3	904	Choice	Top blade	control
3	519	Select	Top blade	seasoning
3	859	choice	Top blade	seasoning
3	664	Select	Top blade	control
4	77	choice	Top blade	seasoning
4	385	Select	Top blade	seasoning&bromelain
4	510	Select	Top blade	seasoning
4	72	choice	Top blade	seasoning&bromelain
4	757	Select	Top blade	control
4	290	Choice	Top blade	control

Appendix C - Attributes, Definitions, and References Used in Descriptive Analysis

GENERAL AROMA / FLAVOR

Initial Flavor Impact: The immediate reaction to the dominant flavor notes and their intensities. Rated during the first 2-3 chews of the sample.

Juiciness: **The amount of liquid expressed from the sample during first 6 chews.**

FLAVOR:
Reference: Hormel Cure 81 Extra Lean Boneless Ham = 6.5
Preparation: Cut edges off of ham and discard. Cut remaining ham into ½ inch cubes.

Beef flavor ID: **Amount of beef flavor identity in the sample.**

AROMA and FLAVOR:
Reference: Swanson's Beef Broth = 5.0
80% Lean Ground Chuck = 7.0
Beef Brisket = 11.0
Preparation: Heat broth up to 165 ^{o}F (74 ^{o}C). Serve warm into 1 oz cups.
Cook lean ground chuck on a pan to 160 ^{o}F (71 ^{o}C). Serve warm into 3.25 oz cups.
Cut brisket into 1 inch thick steaks. Grill on High until internal temperature reach 160 F. Discard edges and cut into ½'' cubes. Place three cubes into 3.25 oz cups. Serve warm.

Brown/Roasted **A round, full aromatic generally associated with beef suet that has been broiled.**

AROMA and FLAVOR:
Reference: Beef Suet (broiled) = 8.5
80% Lean Ground Chuck = 10.0
Preparation: Pan-fry beef suet in a skillet on high until brown. Cut suet into ½'' pieces. Place 2 pieces in 1 oz cup. Serve warm.
Cook lean ground chuck on a pan to 160 ^{o}F (71 ^{o}C). Serve warm into 3.25 oz cups.

Bloody/Serumy: **An aromatic associated with blood on cooked meat products. Closely related to metallic aromatic.**

AROMA and FLAVOR:

Reference: USDA choice Strip Steak = 5.5
Beef Brisket = 6.0

Preparation: Grill Strip Steak on "High" until internal temperature reach 140°F (60 °C). Discard edges and cut into ½ inch cubes. Place three cubes into 3.25 oz cups. Serve warm.
Cut brisket into 1 inch thick steaks. Grill on High until internal temperature reach 160 F. Discard edges and cut into ½'' cubes. Place three cubes into 3.25 oz cups. Serve warm.

Liver-like: **Aromatics associated with cooked organ meat/liver.**

AROMA and FLAVOR:

Reference: Beef Liver (broiled) = 7.5
Brauschweiger liver sausage = 10 (must taste and swallow)

Preparation: Pan-fry liver on a skillet on medium high until internal temperature reaches 160 °F (71 °C) or liver is brown throughout. Cut into 1"square. Place two pieces into 1 oz cups. Serve warm.
Place one tsp of liver sausage in 3.25 oz cup.

Metallic: **The impression of slightly oxidized metal, such as iron, copper, and silver spoons.**

AROMA and FLAVOR:

Reference: 0.10% Potassium Chloride Solution = 1.5 (flavor)
USDA choice Strip Steak = 4.0 (aroma and flavor)
Dole Canned Pineapple Juice = 6.0 (aroma and flavor)

Preparation: Grill Strip Steak on "High" until internal temperature reach 140°F (60 °C). Discard edges and cut into ½'' cubes. Place three cubes into 3.25 oz cups. Serve warm.
Provide unopened canned pineapple juice to panel. Juice is poured into 1 oz cup during evaluation.

Fat-like: **Aromatics associated with cooked animal fat.**

AROMA and FLAVOR:

Reference: Beef suet = 12.0
Hill Shine Farms lit'l Beef Smokies = 7.0

Preparation: Pan-fry beef suet in a skillet on high until brown. Cut suet into ½'' pieces. Place 2 pieces in 1 oz cup. Serve warm.
Heat 1 package of smokies (400 g) with ¼ cup of water in covered Corelle bowl. Microwave for 2 ½ min. Place one smokie in 3.25 oz cup. Serve warm.

Green haylike: **Brown/green dusty aromatics associated with dry grasses, hay, dry parsley and tea leaves.**

AROMA:
Reference: Dry parsley in medium snifter = 5.0
Preparation: Place 1 tsp of dry parsley in medium snifter. Cover.
FLAVOR:
Reference: Dry parsley in 1 oz cup = 6.0
Preparation: 1 tsp of dry parsley in 1 oz cup.

Overall Sweet: **A combination of sweet taste and sweet aromatics. The aromatics associated with the impression of sweet.**

FLAVOR:
Reference: Post Shredded Wheat Spoon Size = 1.5
Hillshire Farms Lit'l Beef Smokies = 3.0
Preparation: Heat 1 package of smokies (400 g) with ¼ cup of water in covered Corelle bowl. Microwave for 2 ½ min. Place one smokie in 3.25 oz cup. Serve warm.
AROMA**:**
Reference: SAFC Ethyl Maltol 99 % = 4.5
Preparation: Place 1 g Ethyl Maltol 99 % in a medium snifter. Cover.

Umami: **Flat, salty, somewhat brothy. The taste of glutamate, salts of amino acids and other molecules called nucleotides.**

FLAVOR:
Reference: 0.035% Accent Flavor Enhancer Solution = 7.5
Swanson's Beef Broth = 8.0
Preparation: Heat broth up to 165 ^{o}F (74 ^{o}C). Serve warm into 1 oz cups.

Sweet: **The fundamental taste factor associated with a sucrose solution.**

Reference: 2.0% Sucrose Solution = 2.0

Sour Aromatics: **Aromatics associated with sour substances.**

FLAVOR:
Reference: Dillon's buttermilk (covered) = 5.0

Sour: **The fundamental taste factor associated with a citric acid solution.**

Reference: 0.015% Citric Acid Solution = 1.5
0.050% Citric Acid Solution = 3.5

Salty: **A fundamental taste factor of which sodium chloride is typical.**

Reference: 0.15% NaCl Solution = 1.5
0.25% NaCl Solution = 3.5
0.35% NaCl Solution = 5.0

Bitter: **The fundamental taste factor associated with a caffeine solution.**

FLAVOR:
Reference: 0.01% Caffeine Solution = 2.0
0.02% Caffeine Solution = 3.5

OTHER NOTES:

Barnyard: **Combination of pungent, slightly sour, hay-like aromatics associated with farm animals and the inside of a barn.**

AROMA and FLAVOR:
Reference: White pepper in water = 4.5 (aroma), 4.0 (flavor)
Tinture of civit = 6.0 (aroma)
Preparation: Steep 0.45 g of ground white pepper in 300 ml of water at 180 F for 30 min. Filter the solution and let cool for 10 min. Serve ¼ cup in a medium snifter.
Place 3 drops of Civet (full strength) on a cotton ball in a medium snifter. Cover.

Burnt: **The sharp/acrid flavor note associate with over roasted beef muscle, something over baked or excessively browned in oil.**

AROMA and FLAVOR:
Reference: Alf's Red Wheat Puffs (2 pieces in the mouth) = 5.0
Preparation: Serve in 1 ounce cups.

Rancid: **An aromatic commonly associated with oxidized fat and oils. These aromatics may include cardboard, paint, varnish, and fishy.**

FLAVOR:
Reference: Wesson Vegetable Oil (interval heating) = 2.5
Wesson Vegetable Oil (3 min) = 7.0
Wesson Vegetable Oil (5 min) = 9.0
Preparation: Add 300 ml of oil from a newly purchased and opened bottle of Wesson Vegetable Oil to a 1000 ml glass beaker. Heat in the microwave oven on high power for 3 m. Remove from microwave and let sit at room temperature to cool for approximately 25 m. Then heat another 3 mintues, let cool another 25 m, and heat for one additional 3 minute interval. Let beaker sit on counter uncovered overnight. Serve the cooled oil in 1 oz cups.
Microwave ½ cup oil on high power for 3 or 5 m. Let cool and pour into 1 ounce cups. Serve covered.

Green: **Sharp slightly pungent aromatics associated with green/plant/vegetable matter such as parsley, spinach, pea pod, fresh cut grass, etc.**

AROMA and FLAVOR:
Reference: Hexanal in propylene glycol (5000 ppm) = 6.5 (aroma)
Fresh parsley water = 9.0 (flavor)
Preparation: Dip a Orlandi Perfumer Strip #27995 (2.2 cm) in the hexanal solution to the second marking line and place dipper strip (marking line up) in a glass test tube with screw cab.
Rinse and chop 25 g of fresh parsley. Add 300 ml of water. Let sit for 15 min. Filter and serve the liquid part in 1 oz cup.

Musty-Earthy/Humus: Musty, sweet, decaying vegetation.

AROMA:
Reference: 2,6-Dimethylcyclohexanol (1000 ppm in propylene glycol) = 9.0
Preparation: One drop on a cotton ball in a covered medium snifter.

Cumin: **The aromatics commonly associated with cumin and characterized as dry, pungent, woody and slightly floral.**

AROMA:
Reference: McCormick or Shilling Ground Cumin = 10.0 (aroma), 7.0 (flavor)
Preparation: Serve ¼ tea spoon cumin in a medium covered snifter.
For flavor: serve cumin into 1 oz cups. Panelists take one pinch of cumin into their mouths.

Refrigerator stale: **Aromatics associated with products left in refrigerator for an extended period of time and absorbing a combination of odors (lack of freshness, flat).**

AROMA and FLAVOR:
Reference: 80 % Lean Ground Beef (1-day old) = 5.5 (aroma), 4.5 (flavor)
Preparation: Cook ground beef in a skillet, on medium-high temperature, to 165 ^{o}F (71 ^{o}C). Drain grease. Refrigerate overnight in a covered glass container. Fill 3.25 cup half full with the refrigerated ground beef. Serve at room temperature.

Warmed over: **Perception of a product that has been previously cooked and reheated.**

AROMA and FLAVOR:
Reference: 80 % Lean Ground Beef (reheated) = 6.0
Preparation: Cook ground beef in a skillet, on medium-high temperature, to 165 ^{o}F (71 ^{o}C). Drain grease. Refrigerate overnight in a covered glass container. The next day, place cooked ground beef in a in an 8x8'' glass baking dish. Pre-heat oven on bake at 400 ^{o}F (204 ^{o}C). Heat ground beef until internal temperature reaches 165 ^{o}F (71 ^{o}C) (approximately 7 min). Fill 3.25 cup half full with the reheated ground beef. Serve warm.

Black pepper: **The aromatics associated with ground black pepper that are spicy, pungent, musty and woody.**

AROMA and FLAVOR:

Reference: McCormick or Shilling Ground Black Pepper = 13.0 (a)
McCormick or Shilling Ground Black Pepper in Swanson Fat Free Beef Broth = 9.0 (flavor)

Preparation: Place ½ tsp black pepper in a medium snifter. Cover.
Add ½ tsp black pepper to 14.5 oz beef broth in a saucepan and bring to a boil. Remove from heat and let cool. Serve in individual 1 oz cups.

Onion: **The aromatics commonly associated with dehydrated onion and characterized as sweet, slightly brown, and slightly pungent.**

FLAVOR:

Reference: McCormick Onion Powder in Swanson Fat Free Beef Broth= 7.5 (flavor)
McCormick Onion Powder = 9.5 (a)

Preparation: Add ½ tsp onion powder to 7.25 oz beef broth in a saucepan and bring to a boil. Remove from heat and let cool. Serve in individual 1 oz cups.
Place ½ tsp onion powder in a covered medium snifter, cover.

Garlic: **The musty, slightly brown, sweet, pungent aromatics associated with garlic.**

AROMA:

Reference: McCormick Garlic Powder = 9.5 (a)
McCormick Garlic Powder in Swanson Fat Free Beef Broth = 7.5 (flavor)

Preparation: Place ½ tsp garlic powder in a medium snifter. Cover.
Add ½ tsp garlic powder to 7.25 oz beef broth in a saucepan and bring to a boil. Remove from heat and let cool. Serve in individual 1 oz cups.

Oregano: **A sharp, pungent, woody, green aromatic that is somewhat musty and petroleum/rubber-tire like.**

AROMA:

Reference: McCormick Ground Oregano = 12.5 (a)
McCormick Ground Oregano in Swanson Fat Free Beef Broth = 8.5 (flavor)

Preparation: Place 1/4 tsp ground oregano in a medium snifter. Cover.
Add 1/4 tsp ground oregano to 7.25 oz beef broth in a saucepan and bring to a boil. Remove from heat and let cool. Serve in individual 1 oz cups.

White pepper: **Spicy, pungent, musty, woody, slightly soured hay-like barnyard aromatics.**

FLAVOR:
Reference: White pepper in broth = 8.0
Preparation: Steep 0.23 g of ground white pepper in 300 mL of Swanson beef broth at 180 F for 30 m. Filter the solution and let cool for 10 min. Serve in 3.25 oz cups, covered.

Overall Tenderness: **Ease with which a sample can be cut through with molars**

TEXTURE:
Reference: Hormel Cure 81 Extra Lean Boneless Ham = 9.0
Preparation: Cut ham into ½ inch cubes.

Appendix D - SAS code for data analysis

To calculate analysis of variance for each flavor and texture attribute across cut within each grade:

```
proc glimmix;
class Panelist  Sample     Rep;
model ATR1 = sample/ddfm=sat;
random rep(sample) panelist sample*panelist;
lsmeans sample/pdiff lines;
run;
```

To calculate analysis of variance for each flavor and texture attribute across grade:

```
proc glimmix;
class Panelist  grade Sample     Rep;
model ATR1 = grade*sample/ddfm=sat;
random rep(grade*sample) panelist grade*sample*panelist;
lsmeans grade*sample/pdiff lines;
run;
```

Appendix E - Institutional Review Board (IRB) Approval

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TO: Koushik Adhikari
Human Nutrition
143E Justin

Proposal Number: 5808

FROM: Rick Scheidt, Chair
Committee on Research Involving Human Subjects

DATE: March 23, 2011

RE: Proposal Entitled, "Impact of seasonings on sensory attributes of beef across two USDA grades and three cuts of steak"

The Committee on Research Involving Human Subjects / Institutional Review Board (IRB) for Kansas State University has reviewed the proposal identified above and has determined that it is EXEMPT from further IRB review. This exemption applies only to the proposal - as written – and currently on file with the IRB. Any change potentially affecting human subjects must be approved by the IRB prior to implementation and may disqualify the proposal from exemption.

Based upon information provided to the IRB, this activity is exempt under the criteria set forth in the Federal Policy for the Protection of Human Subjects, **45 CFR §46.101, paragraph b, category: 6, subsection: ii.**

Certain research is exempt from the requirements of HHS/OHRP regulations. A determination that research is exempt does not imply that investigators have no ethical responsibilities to subjects in such research; it means only that the regulatory requirements related to IRB review, informed consent, and assurance of compliance do not apply to the research.

Any unanticipated problems involving risk to subjects or to others must be reported immediately to the Chair of the Committee on Research Involving Human Subjects, the University Research Compliance Office, and if the subjects are KSU students, to the Director of the Student Health Center.