DIFFERENTIATION OF BEEF FLAVOR ACROSS MUSCLES AND QUALITY GRADES

A Thesis

by

CHRISLY MARY PHILIP

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

MASTER OF SCIENCE

May 2011

Major Subject: Food Science and Technology

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Approved by:

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ABSTRACT

Differentiation of Beef Flavor Across Muscles and Quality Grades.

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In an effort to increase beef demand, the beef industry has expanded beyond commodity beef merchandizing into value-added cuts. As these beef cuts are developed it is critical that the industry be able to characterize the flavor attributes of these products. A trained sensory panel is typically utilized to determine flavor characteristics of food products including beef. Prior to product evaluation, a product lexicon or dictionary of terms is developed in order to anchor and orient panelists to the various samples. Once the lexicon is developed, it can be used by a descriptive panel to evaluate samples.

Currently, the beef industry does not have a full beef flavor lexicon with defined references; therefore a comprehensive sensory lexicon for describing the aroma and flavor of beef was developed by a 6-member panel at Kansas State University with extensive experience in lexicon development and descriptive analysis. Three descriptive panels utilized the beef flavor lexicon developed in Phase I by Kansas State University to evaluate the effect of USDA Quality Grade and cut on beef flavor and to validate the beef flavor lexicon to determine if it is ready for use by scientists.

Results indicated that Choice steaks and roasts were higher in fat-like, and overall sweet flavor. Eye of round roasts were lowest in aroma and flavor attributes and bottom round roasts were highest in liver-like flavor. Flat iron steaks were highest in fat-like flavor compared to other cuts and top loin steaks tended to have the lowest intensity in flavor attributes compared to the steak cuts. The three sensory panels rated steaks and roasts similarly for aroma and flavor attributes and were generally less than 2- to 1-point different in rating intensities. The beef flavor lexicon was easily applied across the three institutions and should be ready to be used as a viable research and product development tool.

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CHAPTER I

INTRODUCTION

Flavor is a very important component of meat palatability and is defined by consumers to be of equal importance to tenderness for consumer satisfaction (Lorenzen, Miller, Taylor, Neely, Tatum, Wise, Buyck, Reagan, and Savell, 2003). In a consumer study conducted across several major cities, flavor was found to be the most important factor affecting purchasing habits when tenderness was held constant (Sitz, Calkins, Feuz, Umberger, and Eskridge, 2005). The beef industry has made great strides in improving tenderness in beef, however, less research has been focused on understanding and defining beef flafvor. Beef flavor is a complex system, made up of multiple attributes. One of the most valuable tools used to determine flavor is descriptive flavor sensory evaluation using an expert panel. Almost all major food companies use this method while developing and monitoring products. A key to the success of this scientific method is that a lexicon, or dictionary of terms, be developed. A product lexicon includes defining flavor attributes that could be found within a product class, providing a reference that can be purchased to anchor panelists on the attribute and then providing scaling examples to clarify intensity differences. This lexicon can then be used by any trained sensory panel to evaluate beef products.

This thesis follows the style of the *Journal of Food Science.*

In order to characterize the flavor components of various beef products it is critical that the beef industry develop a full beef lexicon that identifies all the flavor attributes present in beef. If we do not know what comprises "beef flavor" then we cannot develop systems for identifying beef flavor. In addition, characterization of beef flavor in major beef cuts of differing quality grades is needed as a baseline. This information will be critical to the beef industry as beef flavor and issues related to it are addressed. Currently, the beef industry does not have a full beef flavor lexicon. While some components of a beef flavor lexicon have been developed for specific flavor defects or specific processing (Johnsen and Civille, 1986; Luchsinger, Kroph, Chambers, Zepeda, Stroda, Hollingsworth, Marsden, and Kastner, 1997; Campbell, Hunt, Levis, Chambers, 2001) and provide a good base for evaluating beef flavor, a full lexicon with defined references has not been developed. Until flavor attributes can be adequately evaluated, the beef industry is at a distinct disadvantage. As new products are developed, if flavor issues arise, a standard lexicon or common language for evaluating beef flavor is needed to address those issues. In the meat industry, flavor is commonly rated by evaluating overall flavor intensity and if any off-flavors are detected, the panel will rate them in a very subjective, non-anchored way.

While some meat scientists use descriptive analysis methods, like the Spectrum™ method, others continue to use overall flavor intensity. It is imperative that beef flavor be evaluated as a multiple component system. For example, prior to the introduction of the flat iron steak, extensive flavor evaluation was not conducted and as a result the intermittent livery flavor that is found in flat iron steaks was not determined. If this flavor issue had been determined prior to its introduction, problems associated with this off- flavor could have been addressed before the initial marketing of the product. After development of a beef flavor lexicon, characterizing flavor and variation of flavor for multiple muscles across quality grades would assist the beef industry in more effective marketing and trouble shooting beef flavor issues.

In this study we are hypothesizing that beef differs in flavor across different cuts and quality grades and that a standard beef lexicon developed by Kansas State University can be similarly implemented across panels varying in experience. Our objective will be to utilize a standard beef lexicon to characterize and determine the effects of USDA quality grade, cut and sensory location on beef flavor.

CHAPTER II

LITERATURE REVIEW

Lexicons

A flavor lexicon is a set of words used to describe the flavor of a product or commodity (Drake and Civille, 2003). It provides a list of terms to describe a category of products, like commodities or finished products. The lexicon is then applied using descriptive sensory analysis techniques. There are several steps to developing a lexicon and they include: collecting a product frame of reference, generating terms, reviewing references and examples and developing a final descriptor list (Drake et al., 2003). Two key characteristics of a good flavor lexicon is that it is both discriminating and descriptive. In order to produce a good lexicon, the language should be developed from a broad representative sample set that is indicative of all the potential variability within the product (Meilgaard and Civille, 1999). After tasting the representative samples, the aromatics, tastes and feeling factors are described and make up the basis for the lexicon. Once panelists have generated the terms, the panel and panel leader will choose references to provide clarification and scaling examples for the terms. After references have been established the panel can go back to the original list of terms to establish the final lexicon. Like terms are merged or eliminated and attributes are organized in order of frequency and importance (Drake et al., 2003).

Lexicon Application

Since lexicons contain standardized definitions and references it can be used to accurately communicate among different research groups even when independent lexicons are used. Lotong et al. (2001) reported descriptive analysis results for orange juice of two independent highly trained panels that used independent lexicons and different descriptive methods. Results showed similar patterns of differentiation among samples for the two groups. Another study examined panel performance among thirteen different groups descriptively analyzing two different food categories. Both scales and descriptors were standardized among the groups prior to the study. Again, similar patterns of differentiation were observed despite minor differences in scale usage and attribute significance (Pages and Hudson, 2001). Drake et al. (2002) evaluated the performance of three descriptive panels trained at different sites and by different panel leaders. All panels were trained using the same previously developed and standardized lexicon (Drake et al., 2002). Panels were able to accurately identify attribute differences among the samples and similar patterns of differentiation were seen, though there were differences in scale usage and attribute recognition. These dissimilarities were probably a result of differences in panel leadership, panelist experience and hours of training.

Beef Lexicon

Currently, the beef industry does not have a complete aroma and flavor lexicon for beef. Beef flavor has been generally evaluated as overall flavor intensity. If off-flavors were detected, the sensory panel would rate them on a subjective, non-anchored way, producing results that could not be replicated by another panel since the flavor attributes were not defined or referenced. Though some components of a lexicon have been developed they have been used to characterize aroma and flavor of beef with certain flavor defects or beef that has undergone specific processing. Johnson and

Civille (1986) developed a standardized lexicon for warmed-over descriptors in meat. Panelists tasted beef, chicken and pork and were asked to identify off-flavors, specifically those associated with reheated meat. Panelists identified eight flavor attributes specific to beef (cooked beef – lean, cooked beef – fat, browned, serum/bloody, grainy/cowy, cardboard, oxidized/rancid/painty, and fishy) and these terms have been used as a baseline in further beef flavor research. Several studies have also examined the effect of diet regime on the flavor of meat. In a study comparing the flavor profiles of grass-finished versus grain-finished ground beef patties, panelists identified 7 distinct attributes among the product (Melton, Amiri, Davis and Backus, 1982). Miller et al. (1996) also examined flavor attributes of beef fed with different diets and identified 8 flavor descriptors (livery, soured, corn, corn/barley, barley, sour, bitter, salty); however, these terms were not scaled or referenced. Distinct flavor descriptors have also been identified in beef that has undergone different processing techniques. In one study, the flavor attributes of irradiated ground and whole muscle beef were examined. A total of 9 aroma and 13 flavor descriptors were identified and referenced (Luchsinger et al., 1997). Another study researched the effects of dry-aging on the flavor, tenderness and juiciness of beef. Dry-aged strip loins and shorts loins were evaluated and panelists determined 6 flavor attributes among the dry-aged samples (Campbell et al., 2001). The current flavor descriptors provide a good foundation for understanding the flavor of different beef products, but as more value-added cuts of beef and beef products are developed, it is important that the industry has a standardized flavor lexicon to better characterize and evaluate the flavor attributes of these beef products.

Beef Flavor

Flavor is the sensory impression that is determined by the chemical senses of taste and smell. It is a result of the combination of basic tastes (sweet, sour, salty, bitter and umami) and odors derived from a variety of compounds present in the food substance (Brewer, 2006). Taste perception is a result of water-soluble compounds binding to the taste buds, which stimulate a response that is then perceived by the brain. Similarly, odor is perceived when volatile compounds bind to receptors in the olfactory blub and stimulate a response (Brewer, 2006).

The aromas and flavors specifically associated with beef are developed during heating. Raw meat has little aroma and its flavor can be mainly described as bloody, however, it is composed of compounds that upon heating produces the aromas and flavors we commonly identify in meat (Crocker, 1945). Meat is composed of water, proteins, lipids, carbohydrates, minerals and vitamins. Proteins, lipids and carbohydrates play a primary role in flavor development because they are composed of various compounds that develop into flavor precursors when heated (Spainer and Miller, 1993; Mottram, 1998). Each of these main components contributes to the overall identity of beef flavor. Amino acids that make up the proteins in meat play an important role in the perception of basic tastes, for instance, the coupling of amino acids with organic acids give rise to the sour flavor present in meat and carbohydrates such as sugars generate the sweet flavors in meat (MacLeod, 1994). Lipids are a particularly important source of flavor constituents and are present in meat as subcutaneous (external), intermuscular (seam) and intramuscular (marbling) fat. They work to impart flavor both directly (unmodified) and indirectly (reaction products). These lipids are composed of fatty acids that may be saturated, unsaturated, or methyl-branched. Lipids are a storehouse for aromatic compounds that are released when cooking; chemical changes occur in fatty acids during heating that produce flavor compounds. When unsaturated fatty acids are heated, oxidation is induced resulting in the formation of intermediate hydroperoxides that decompose via free radical mechanisms to produce aldehydes, ketones, lactones, and unsaturated alcohols (Brewer, 2006). These compounds have relatively low detection thresholds and distinct flavor and odor characteristics. Aldehydes have meaty, tallowy odors (Rowe, 2002) and certain lactones have sweet, dairy or waxy notes.

The “meaty flavor” characteristic of most red meats is associated with the lean portion of the meat. Studies have identified more than 60 compounds that contribute to the “meaty” aromatics (Shahidi, 1998). A majority of these compounds are sulfur or carbonyl-containing compounds (Hogan, 2002). The species-specific flavor is most associated with the lipid portion of meat because more than 650 fat volatiles are released in beef when heated (Shahidi, 1994; MacLeod, 1994). Motram (1998) reported that the addition of 10% fat from either beef or pork into ground lean enabled panelists to distinguish between species.

Intrinsic Factors Effecting Beef Flavor

Breed

Studies have shown that breed can have an effect on the flavor of meat; the flavors of both water-soluble compounds and lipid compounds differ among beef from different cattle (Sato, Nakamura, Numata, Kuwahara, Homma, Sato, and Fujimaki, 1995; and Insausti, Beriain, Gorraiz, and Purroy, 2002). In a study comparing the flavor differences among Friesian and Pirenaica cattle, a descriptive sensory panel described the beef from the Friesian cattle as having a stronger fatty flavor and aftertaste than the Pirenaica cattle (Gorraiz, Beriain, Chasco, and Insausti, 2002). These differences in flavor were attributed to the different volatile compound profiles among the breeds due to their different lipid compositions; the meat from Pirenaica cattle have more unsaturated intramuscular fat than the meat from Friesian cattle (Alzueta, 2000).

In another study, flavor differences were found in hamburgers made from lean and fat derived from Wagyu versus hamburgers made from fat from dairy cattle. Wagyu hamburgers were perceived to have better sensory quality than the hamburgers made with fat from dairy cattle. The Wagyu hamburgers had higher concentrations of volatile acids, ketones, and lactones whereas samples made with fat from dairy cattle had high concentrations of aldehydes and ketones (Sato et al., 1995). The differences in the chemical makeup of these two breeds caused the perceived flavor differences. However, scientific evidence suggested that non-genetic effects (external factors) have a greater influence on beef flavor than genetic effects (Gregory, Cundiff, Dikeman, and Koohmaraie, 1994). The breed-flavor differences that have been documented tend to be somewhat correlated with breed differences in marbling (Gregory et al., 1994). Therefore, selection of cattle for increased marbling or IMF would result in improvements of beef flavor (Tatum, 2008).

Gender

Gender, like breed, affects the volatile compound profiles among cattle. The flavor between bulls and heifers were compared in a study and results indicated that bull meat had a stronger liver-like odor and flavor, and bloody flavor while heifer meat had a stronger characteristic "beefy" flavor (Gorraiz et. al, 2002). These differences may be related to the production of sex hormones and their influence on lipid compositions, which would create different profiles of volatile compounds (Sink, 1979). In the study, researchers observed higher triglyceride and lower phospholipid percentages in heifer intramuscular fat than in the fat of bulls; this difference is believed to be the cause of the observed flavor differences. In general, testosterone increases muscle growth and decreases lipid deposition causing meat-like flavors to increase and fat flavors to decrease (Miller, 2001). In addition, intact males are more likely to have higher myoglobin content than their female counterparts. Higher levels of myoglobin in bull meat have been associated with higher intensities of metallic, liver, serumy/bloody, and bitter attributes (Miller, 2001).

Animal Age

Several studies have shown that as carcass maturity increases, palatability traits generally decrease (Miller, 2001; Boleman, Miller, Buyck, Cross, and Savell, 1996; Miller, Tatum, Cross, Bowling, and Clayton, 1983; Berry, Smith, and Carpenter, 1974).

In a study conducted by Smith, Savell, Cross and Carpenter (1983) a negatively correlated relationship was found between carcass maturity and flavor desirability; as carcass maturity increased, flavor desirability decreased. In a study comparing the palatability traits of beef produced from bulls and steers, hedonic flavor scores significantly decreased when the age of the bulls and steers were increased by 100 days (Reagan, Carpenter, Smith and King, 1971). Supplemental feeding of older animals has been used as an attempt to improve the palatability of the meat. For instance, in one study, mature cows were fed a high-energy diet for more than 28 days, causing significant changes in flavor intensity and the overall flavor profile. Flavor intensity was greater and off-flavors were less noticeable in the meat from the animals fed the supplemental diet (Boleman, Miller, Buyck, Cross and Savell, 1983).

External Factors Effecting Beef Flavor

Diet

Flavor differences caused by diet have been primarily compared between grain-fed and pasture-fed animals. High-energy diets as compared to low-energy forage and grass diets produce a more acceptable and intense flavor in red meats (Melton, 1990). In general, as the energy content of the finishing diet fed to cattle is increased, there is an improvement in carcass quality grade and tenderness (Larick, Hedrick, Bailey, Williams, Hancock, Garner, Morrow, 1987). Consumer sensory studies conducted in the United States indicate that the general public prefers the flavor of grain-fed beef over the flavor of beef from cattle fed low-energy forage and grass diets (Sitz, Calkins, Feuz, Umberger and Eskridge, 2005; Jeremiah, Beauchemin, Jones, Gibson, and Rode, 1998).

Numerous studies have been conducted comparing the flavor of corn-fed and grass-fed beef; the results of these studies indicate that there is a difference in flavor among pasture and grain-fed animals, specifically the presence of “off-flavors” in the meat of grass-fed animals. The less desirable flavor of grass-fed beef has been attributed to its sour, fishy and grassy characteristics (Brown, Melton, Riemann, Backus, 1979; and Berry, Maga, Calkins, Wells, Carpenter, Cross, 1980). Flavor differences among grass-fed and grain-fed cattle are not only due to differences in fatness, but flavor is also influenced by the deposition of compounds (from feed source) into the fat component of the animal system (Melton et al., 1982). A study comparing the effects of forage vs. grain feeding on fatty acid composition and beef flavor concluded that the main cause of the differences in flavor was due to the different fatty acid concentrations among the cattle (Mandell, Buchanan-Smith and Campbell, 1998). Grain-fed cattle have a higher concentration of oleic and linoleic acid, whereas grass-fed cattle have high concentrations of alpha-linolenic and other n-3 polyunsaturated fatty acids (Vasta and Priolo, 2006; Enser, Hallett, Hewitt, Fursey, Wood, and Harrington, 1998). High levels of linolenic acid impart flavors characterized as “grassy” and “fishy” (Wood, Richardson, Nute, Fisher, Campo, Kasapidou, Sheard, and Enser, 2003). Numerous volatiles derived from these fatty acids have been identified and contribute to the unique profiles of grain-fed and grass-fed beef (Elmore, Warren, Mottram, Scollan, Enser, Richardson and Wood, 2004; Brewer, 2006; Calkins and Hodgen, 2007). The compounds that are deposited into the lipid portion of the animal impart flavors that can be detected during tasting.

Meat Aging

Meat aging also influences flavor and it is widely accepted that meat flavor improves with age up to a certain limit, after which it begins to degrade and turn rancid (Touraille and Girarad, 1985). Studies have shown that aging up to 14 days increases fatty flavor and positive flavor notes such as “beefy” and “brothy”, however, beyond 14 days of age, negative flavors, such as “painty”, “cardboard”, “bitter”, and “sour” also increased (Gorraiz et al., 2002). Proteolytic and lipolytic enzymes during meat aging cause alteration of different compounds like peptides, free amino acids, and fatty acids that result in these flavor changes. Aging also increases carbonyl amounts derived from lipid oxidation, some of which contributes to the increase of off-flavors. Aging for more than 21 days has been shown to decrease flavor identity and aging for 35 days has caused increases in metallic flavor (Yancey, Dikeman, Hachmeister, Chambers and Milliken, 2005). Enhancement has shown to reduce the time of aging required to increase tenderness and juiciness, while decreasing the development of metallic flavors (Wicklund, McKeith, and Brewer, 2003).

The environment under which beef is aged also affects the ultimate flavor of the meat. Beef aged in high oxygen environments tend to develop burnt or toasted off flavors (Rowe, 2002). Studies have also shown that dry-aging beef (meat is left in cooler with controlled humidty) had increased beef flavor as compared to beef products aged in vacuum or carbon dioxide packaging (Campbell et al., 2001; Sitz, Calkins, Feuz, Umberger, and Eskridge, 2006; and Jeremiah and Gibson, 2003). Fourteen and twentyone day dry-aged steaks had higher beef flavor intensities, dry-aged flavor, and brown roasted aromas compared to 14 and 21-day wet-aged steaks (Campbell et al., 2001). Off flavors tend to develop more in meat that has been dry-aged because of its contact with air (oxygen).

Cooking

Of these external factors, cooking probably has the most significant affect on the flavor of beef. The volatile compounds produced during cooking create the aroma attributes that contribute to the characteristic flavors of meat. During cooking several reactions occur including myoglobin degradation and Maillard reactions. Heat causes the myoglobin in meat to degrade, which ultimately results in changes in the flavor profile from serumy/blood to cooked beefy/brothy. Flavor is also developed via the browning (Maillard) reaction. During the Maillard reaction amnio compounds condense with a carbonyl group of a reducing sugar to produce glycoslamine. Glycosylamine is rearranged and dehydrated to form fufural, furanone derivatives, hydroxyketones, and dicarbonyl compounds (Hogden, 2006). The sulfur containing amino acids can produce hydrogen sulfide and ammonia, which are some of the most pungent compounds generating during cooking (Mottram, 1998). These compounds can then continue to react with amine and other amino acids to produce more flavor-contributing compounds (Mottram, 1998; Guth and Grosh, 1993; and MacLeod and Ames, 1986). The temperature to which beef is cooked can also have a significant effect on the flavor profile of the meat. In a study where beef roasts were cooked to four different internal temperatures, results indicated that at higher degrees of doneness, intensities of attributes such as cooked beef/brothy, cowy/grainy, and cardboard increased. At lower degrees of doneness serumy/bloody, painty, and soured aromatics intensities were higher (Belk, Miller, Evans, Liu, and Acuff, 1993).

Affect of Quality Grade on Beef Flavor

Quality grades are determined by evaluating a composite of several factors that affect the palatability of meat (tenderness, juiciness and flavor). The two main factors used to determine quality grade are degree of marbling and degree of maturity. Marbling refers to the amount and distribution of intramuscular fat within the ribeye; beef cuts with high levels of marbling are expected to be more tender, juicy and flavorful than cuts with lower levels of marbling (Tatum, 2007). Carcasses are also evaluated for maturity, which refers to the age of the animal. There are five maturity groupings. Classification of maturity grouping is determined by evaluating the size, shape and ossification of the bones and cartilages in the carcass and by evaluating the color and texture of the ribeye muscle (Tatum, 2007). After determination of these factors, carcasses are designated into one of the eight USDA quality grades; the eight quality grades for beef are: Prime, Choice, Select, Standard, Commercial, Utility, Cutter and Canner.

In general, beef classified as Prime, Choice or Select are more flavorful and are preferred by consumers over beef in the other grades. Several studies have been conducted in order to understand the palatability differences among beef products of different quality grades. In one study, loin and round steaks from each quality grade were evaluated for overall palatability. Trained descriptive panelists evaluated flavor, juiciness and tenderness and Warner-Bratzler shear force measurements were obtained from each steak (Smith, Savell, Cross, Carpenter, Murphey, Davis, Abraham, Parrish, and Berry, 1987). Results of the study indicated that Prime steaks were more palatable than the steaks of lower USDA Quality Grades. The flavor of steaks in the Prime, Choice and Select categories were rated significantly higher than the steaks from the other USDA Quality Grades (Smith et al.,1987). Similarly, in a study comparing strip steaks from US Choice grade carcasses to those graded US Select, the Choice steaks had higher flavor intensity ratings than the Select steaks (Miller, Kerth, Wise, Lansdell, Stowell, and Ramsey, 1997). USDA Quality Grade and marination effects on consumer evaluation of top round steaks were studied in an in-home beef study. Results of this study showed that steaks from Top Choice carcasses received significantly higher ratings for overall like, tenderness, juiciness, and flavor like than steaks from High Select carcasses (Behrends, Goodson, Koohmaraie, Shackelford, Wheeler, Morgan, Reagan, Gwartney, Wise and Savell, 2005). However, other studies have not shown significant differences in flavor among Choice and Select samples. In a study conducted to determine the sensory, chemical and cooking characteristics of retail cuts differing in intramuscular and external fat, results indicated no significant differences in flavor intensity for select and choice top loin steaks, top sirloin steaks, eye of round steaks, eye of round roasts, and rib roasts (Luchak, Miller, Belk, Hale, Michaelsen, Johnson, West, Leak, Cross and Savell, 1998).

Marbling, which is a key determinant of quality grade has a large impact on beef flavor. Increased marbling increases the amount of fat available for formation of flavor compounds. The minimum level of intramuscular fat for consumer acceptance and preference is approximately 3%, however, as the percentage of intramuscular fat increases beyond 7.3%, perception of flavor and acceptability is negatively effected (Miller, 2001).

Affect of Cut on Beef Flavor

In the market there are over 50 retail beef cuts created from the eight primal cuts of the animal. Palatability differences among cuts have been studied and attributed to differences in background connective tissue (Harris, Miller, Savell, Cross and Ringer, 1992), sarcomere length (Herring, Cassens, and Briskey, 1968), and the amount of chemical fat in the lean (Jones, Savell and Cross, 1992). These cuts not only differ in tenderness and juiciness, but in flavor as well.

Studies have identified distinct flavor characteristics in several of these cuts. The *Psoas major* (tenderloin) and *Teres major* (chuck shoulder) muscles have more intense beefy flavor than the *Rectus femoris* (round); however, the round was noted as having less off-flavors than the tenderloin and chuck steaks (Yancey et al., 2005; Stetzer, Tucker, McKeith, Brewer, 2007). Results from this study also characterized the *Vastus lateralis* (round) and *Vastus medialis* (round) as having higher liver flavor than the *Longissimus dorsi* (loin) and *Complexus* (chuck) (Stetzer et al., 2007). Conflicting results from another study characterize the *Longissimus dorsi* as being most intense in beef flavor and the *Psoas major* as the least intense (Rhee, Wheeler, Shackleford, and Koohmarie, 2004). In a study analyzing off flavors among muscles in the beef chuck and round, the *Infraspinatus* had the lowest off-flavor intensity with panelists detecting the lowest amounts of sour, metallic and oxidized flavors. The *Vastus lateralis* had the most intense off-flavor and was the highest in sour, charred and oxidized flavors (Meisinger, James and Calkins, 2006). These flavor variations may be explained by the differences in fiber type among these muscles. In general, muscles that had a high amount of oxidative muscle fibers had higher pH values. Research has shown that muscles with a high pH have more intense sour, bitter and rancid flavors (Wulf, Emnett, Leheska, and Moeller, 2002; Yancey, 2002). The flavor differences between muscles can be mainly attributed to the inherent compositional differences among those cuts. In another study the effects of cooking rate, fat trim, aging, endpoint temperature and oven type on the palatability of several beef foodservice roasts were investigated. Results indicated that the peeled knuckle roast had the lowest flavor intensity compared to other roasts and that the peeled tenderloin had the highest flavor intensity among the other roasts (Belk, Luchak and Miller, 1993).

CHAPTER III

MATERIALS AND METHODS

Lexicon Validation and Characterization of Cuts

Three institutions (Texas A&M University, USDA, Roman L. Hruska Meat Animal Research Center in Clay Center, and University of Arkansas) were provided the beef lexicon and asked to train using the lexicon (Appendix A). This is the Beef Lexicon developed by Kansas State University. The institutions selected had functioning expert or trained flavor descriptive attribute panels. All non-perishable references and a training guideline were provided to each institution. The lexicon training guideline (Appendix B) included a schedule for attribute introduction and suggested list of beef samples for evaluation to help anchor and achieve panelist proficiency for rating that attribute. The beef samples were provided to each institution and preparation instructions for those samples were also provided as listed in the training guideline. After training was complete, each panel evaluated several extra beef samples as part of a calibration study to determine panel proficiency. Based on the calibration results, panels determined which attributes required retraining, if any.

For validation of the lexicon, beef samples from USDA Select and USDA Choice carcasses and from eight cuts (top loin steaks, flat iron steaks, bottom round roasts, inside round roasts, eye of round roasts, top sirloin steaks, knuckle roasts and tenderloin steaks) were supplied to each institution (n=6 per institution of each cut within Quality Grade). Six of each whole beef muscle cut was collected from the Cargill Meat Solutions processing plant in Plainview, Texas and were then fabricated and packaged at the

Rosenthal Meat Science and Technology Center at Texas A&M University. Top loins, flat irons, top sirloins and tenderloins were cut into one inch steaks and then vacuum packaged individually in Cryovac B160 beef bags (Cryovac Sealed Air, INC, Duncan, NC, OTR). Bottom rounds, inside rounds, eye of rounds and knuckles were cut into four inch roasts and then vacuum packaged in Cryovac B160 beef bags (Cryovac Sealed Air, INC, Duncan, NC, OTR). Samples were then aged for fourteen days in a $0^{o}C$ cooler. The aged samples were then flash frozen at $-40^{o}C$ to stop the effects of aging and to minimize the effect of freezing on meat quality. By flash freezing the product at very low temperatures meat quality will not be noticeably affected. Freezing causes the formation of ice crystals in the meat, however, very cold, rapid freezing will cause the formation of very small ice crystals; the smaller the ice crystals the less effect it will have on meat quality (Rahelic and Puac, 1985; Dransfield, 1994). After flash freezing, samples were kept frozen in $-10^{o}C$ freezer until sensory evaluation.

Thawing, cooking and preparation instructions per cut type and randomization of serving day and order were also supplied. Steaks were thawed for twenty-four hours at $0^{o}C$ the day before evaluation, whereas roasts were thawed for forty-eight hours at $0^{o}C$ two days before evaluation. Roasts were cooked in a standard gas oven at $325^{o}F$ until an internal temperature of $70^{o}C$ or $65^{o}C$ was reached. Steaks were cooked on an electric clam-shell (George Foreman Precision Grill-Model GRP99; George Foreman/Applica Consumer Products Inc., Miramar, FL) set at $375^{o}F$ and grilled until established internal temperatures were reached. Internal temperatures of both roasts and steaks were monitored by copper-constantan and iron-constantan thermocouples (Omega

Engineering, Stanford, CT) inserted into the geometric center of each steak and roast. Temperatures were displayed using an Omega HH501BT Type T thermometer. Panels from Location 1 and Location 2 cooked all samples to an internal temperature of 70^{o}C and temperature was monitored using a copper-constantan thermocouple. Location 3 cooked all samples to an internal temperature of 65^{o}C and temperature was monitored using an iron-constantan thermocouple. After samples were cooked to the appropriate internal temperatures, they were prepared for serving to the panelists. Fat and ends from both steaks and roasts were removed before cutting into 1.27 cm cubes for serving; roasts were first cut into 2.54 cm steaks and then cut into 1.27cm cubes. Samples were served in warm 190mL clear glass custard cups (Anchor Hocking-DC-032410; Anchor Hocking Company, Lancaster, OH) covered with a warm watch glass (Pyrex-Brand 9985, Corning Inc., Corning, NY) to retain heat.

Each panelist received three 1.27cm cubes of each sample to be evaluated. Prior to the start of each evaluation day, panelists received one orientation or “warm up” sample that was evaluated, discussed orally and consensus reached for all flavor attributes present. Warm up samples were selected at random from any extra steaks or roasts. After evaluation of the orientation sample, panelists were served the first sample of the session and asked to individually rate the sample. Double distilled water, unsalted saltine crackers and ricotta cheese were available for cleansing the palette between samples.

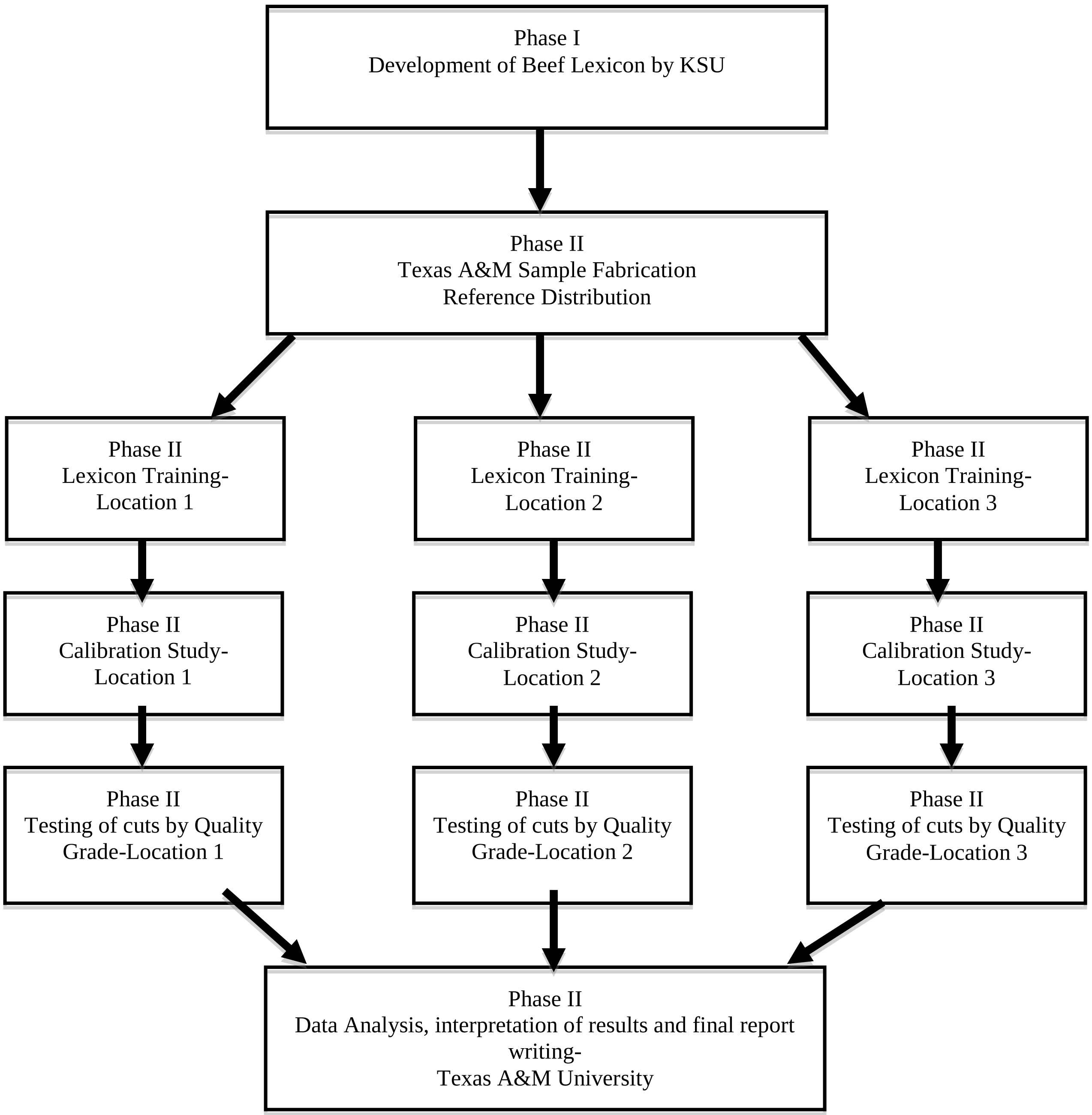


Figure 1. Flow chart of phases of the project

During evaluation, panelists were seated in individual breadbox style booths separated from the preparation area and samples were evaluated under red-light. In order to prevent taste fatigue, each evaluation day was divided into two sessions, with a fifteen-minute break between sessions and samples were served three minutes apart. Panels from both Texas A&M and University of Arkansas evaluated a total twelve samples per day (six samples per session), however the panel from Clay Center evaluated a total of eight samples per day (four samples per session). A total of ninety-six samples were evaluated over a course of a month, with each panel evaluating samples no more than four times a week. A flow chart was made to show the phases of the project and division of tasks among the different institutions (Figure 1).

Statistical Analyses

Data were analyzed using the Proc GLM procedure of SAS (SAS Institute, Cary, NC) with an α of $P<0.05$. The data were averaged across panelists within a sample and institution. An experimental unit was defined as the average evaluation of panelists within an institution for a roast or steak. The first model included random effects of date within a sensory location, order, and session. The main effects of Quality Grade (Choice, Select), cut (bottom round roast, eye of round roast, inside round, roast, knuckle roast, flat iron steak, top sirloin steak, top loin steak and tenderloin steak), location (University of Arkansas, Roman L. Hruska U.S. Meat Animal Research Center in Clay Center, and Texas A&M University were identified numerically so that specific panels could not be identified) and their two and three way interaction were included in the initial model. If interactions were not significant ($p > 0.05$), they were removed from the model and a final model was analyzed and least squares means was calculated. If main effects or interactions were significant ($p < 0.05$), differences in least squares means were separated using the pdiff function of SAS.

To understand location effects, a second model was conducted where an experimental unit was defined as an evaluation of a sample by each panelist. Data were analyzed as previously defined except the effect of panelist and panelist by location, cut and quality grade were included in the model. This analysis was conducted to understand panelists variation within a location. A third analysis was conducted using the same experimental units as the first model. In the third model location was included as a covariate. This analysis was conducted to remove location effects and to understand the effect of quality grade, cut and quality grade by cut interaction. The effect of sensory day, order and session were included as random effects. A fourth analysis was conducted using Unscrambler, CV10, CAMO, INC, Woodbridge, N.J. Multivariate analysis was performed on the data to produce principle component plots that were used to examine patterns and associations among samples and locations.

CHAPTER IV

RESULTS AND DISCUSSION

Effect of Location on Beef Aroma and Flavor Attributes and Efficacy of Beef Lexicon

In order to understand the effect of location on aroma and flavor attributes, the variables of location or sensory panel and their interactions were included as main effects in the statistical model. Three sensory panels participated in this study. Panel one has extensive experience with the Spectrum method and have been trained with multiple lexicons to evaluate a wide variety of food and consumer products. Panel two has extensive experience in evaluating the texture and juiciness of meat using 8-point scales as defined by AMSA (1995). Panel three also has extensive experience using the Spectrum method and with evaluating a variety of products, however, a majority of their expertise is in evaluating the aroma, flavor and texture of beef and pork products. These three panels were used in this study to determine the effect of cut and quality grade on beef aroma and flavor and to determine the lexicon's ease of use, and it's application in order to determine if similar results could be obtained across panels.

Effect of Location on Beef Aroma

Panel location affected all aroma attributes except barnyard, floral, smokey-wood, dairy, sour milk/sour dairy, refrigerator and soapy aromas (Tables 1a, 1b, 1c).

Significant differences were not found among these attributes due to the low levels of intensity. Among the attributes that were significant ($p<0.05$), location 1 and 3 rated beefy, green-hay-like, sour, rancid, heated oil, chemical, leather, medicinal, and cooked milk aromas similarly. Location 1 and 2 rated metallic, sweet, green and spoiled aromas similarly and location 2 and 3 rated liver-like, musty, smoky-charcoal and warmed over aromas similarly. The remaining aroma attributes: brown-roasted, bloody/serumy, fat-like, and animal hair were rated significantly ($p<0.05$) different at each location. Location 1 and 3 rated attributes more similarly than location 2, this is probably due to the fact that panels 1 and 3 have more experience using the spectrum method and more experience evaluating flavor. Overall, location 1 tended to rate aroma intensity higher than locations 2 and 3. Location 1 rated the attributes brown-roasted, bloody/serumy, fat-like, liver-like, musty/earthy/humus, and smoky-charcoal aroma significantly higher than locations 2 and 3 (Tables 1a, 1b, 1c).

Table 1. Least squares means for beef aroma attributes[g] segmented by location.

(a)

Effect	Beefy	Brown/ Roasted	Bloody/ Serumy	Fat-like	Metallic	Liver-like	Green-hay-like	Sweet	Sour	Animal Hair	Barnyard	Burnt	Rancid
Location	0.0001[f]	0.0001[f]	0.0001[f]	0.0001[f]	0.0001[f]	0.0001[f]	0.0001[f]	0.0001[f]	0.0001[f]	0.0001[f]	0.45[f]	0.0001	0.0001[f]
1	3.9[b]	2.5[c]	1.6[c]	1.0[c]	0.4[a]	1.4[b]	0.1[a]	0.2[a]	0.4[b]	0.2[b]	1.1	0.1[a]	0.2[a]
2	2.5[a]	0.8[a]	1.0[b]	0.7[b]	0.5[a]	0.0[a]	0.6[b]	0.3[a]	1.4[a]	0.3[c]	0.6	0.1[a]	0.5[b]
3	3.8[b]	1.2[b]	0.3[a]	0.1[a]	0.1[b]	0.0[a]	0.0[a]	0.5[b]	0.5[b]	0.0[a]	0.0	0.1[a]	0.1[a]
RMSE[e]	0.44	0.40	0.35	0.28	0.19	0.26	0.19	0.19	0.26	0.16	0.30	0.30	0.20

[abc]Least squares mean values within a column and effect followed by the same letter are not significantly different ($P > 0.05$)
[e] Root Mean Square Error
[f] P-value from analysis of variance tables.
[g] Aroma measured where 0 = none and 15 = extremely intense.

Table 1. Continued

(b)

Effect	Heated oil	Chemical	Leather	Green	Musty-Earthy/Humus	Floral	Petrolium-Medicinal	Smokey like	Charcoal
Location	0.0001[c]	0.0001 [e]	0.0001 [e]	0.0001 [e]	0.0001 [e]	0.37 [e]	0.0009 [e]	0.03 [e]	0.0001 [e]
1	0.0[b]	0.0[a]	0.0[a]	0.0[b]	0.4[b]	0.1	0.0[a]	0.0[b]	0.2[b]
2	0.1[a]	0.1[b]	0.1[b]	0.0[b]	0.1[a]	0.0	0.1[b]	0.0[a]	0.0[a]
3	0.0[b]	0.0[a]	0.0[a]	0.0[a]	0.1[a]	0.0	0.0 [a]	0.0[a]	0.0[a]
RMSE[d]	0.07	0.10	0.07	0.07	0.18	0.10	0.07	0.06	0.08

[abc]Least squares mean values within a column and effect followed by the same letter are not significantly different (P > 0.05).

[e] Root Mean Square Error

[f] P-value from analysis of variance tables.

[g] Aroma measured where 0 = none and 15 = extremely intense.

Table 1. Continued

(c)

Effect	Smokey Wood	Spoiled-Putrid	Dairy	Buttery	Cooked Milk	Sour Milk/ Sour Dairy	Refrigerator	Soapy	Warmed Over	Caramel
Location	0.43[e]	0.0001[e]	0.17[e]	0.0001[e]	0.008[e]	0.67[e]	0.09[e]	0.10[e]	0.0001[e]	0.004 [e]
1	0.0	0.1[b]	0.0	0.1[ab]	0.0[a]	0.1	0.1	0.0	0.1[b]	0.0[ab]
2	0.0	0.0[b]	0.0	0.0[a]	0.1[b]	0.1	0.1	0.0	0.0[a]	0.0[a]
3	0.0	0.0[a]	0.0	0.1[b]	0.0[a]	0.1	0.1	0.0	0.0[a]	0.0[b]
RMSE[d]	0.06	0.14	0.08	0.11	0.08	0.15	0.09	0.05	0.10	0.01

[abc]Least squares mean values within a column and effect followed by the same letter are not significantly different (P > 0.05).

[e] Root Mean Square Error

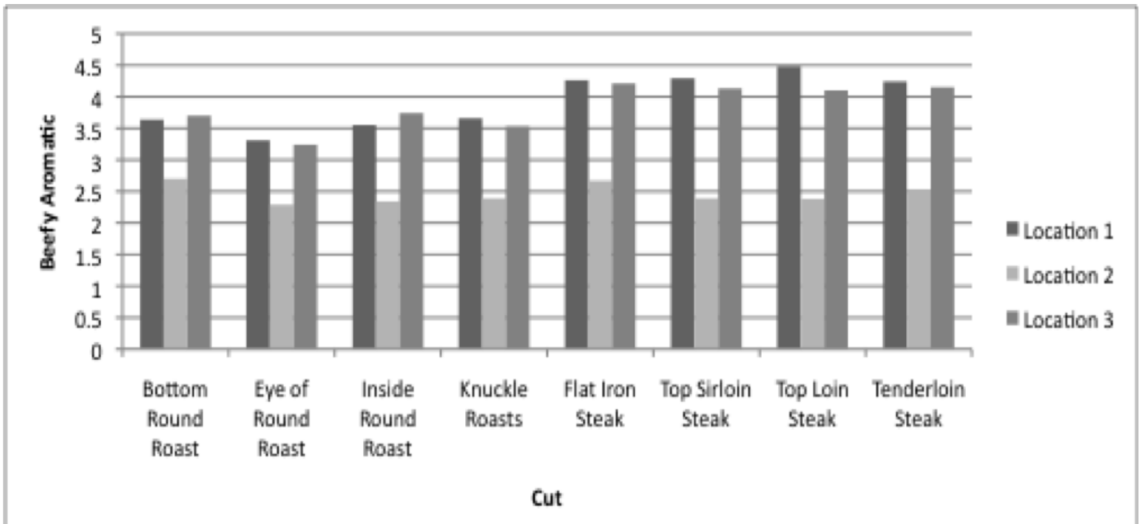
[f] P-value from analysis of variance tables.

[g] Aroma measured where 0 = none and 15 = extremely intense.

Cut by Location Interactions for Beef Aroma

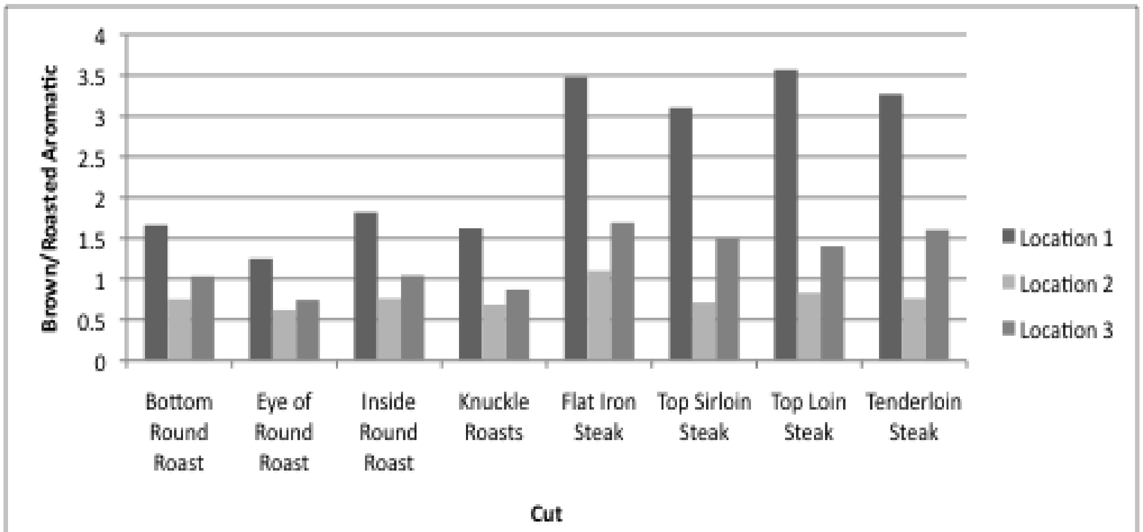
There were several significant cut by location interactions, which indicates that panels evaluated attributes differently among the different cuts. Significant cut by location interactions for aroma include: beef, brown/roasted, fat-like, liver-like, green-hay-like, sweet, animal hair, barnyard, rancid, chemical, leather, musty/earthy/humus, smoky-charcoal, smoky-wood, putrid, warm-over, burnt, refrigerator, and caramel aroma. However, only beef, brown/roasted, fat-like, liver-like and barnyard aroma attributes were above detectable levels (>0.5) and only these will be represented by graphs. For beef aroma, locations 1 and 3 rated the attribute similarly among all the cuts, however, location 2 rated beef aroma 1 to 2 points lower for all the cuts (Figure 2). Locations 1 and 3 rated the steak cuts higher for beef aroma than the roasts, whereas location 2 rated beef aroma similarly among all the cuts.

The interaction graph for brown/roasted aroma (Figure 3) shows that location 1 detected brown/roasted aroma intensity significantly ($p<0.05$) higher among all the cuts than locations 2 and 3. In general, location 1 rated aroma at least 0.5 to 2 points higher than location 2 and 3 (Figure 3). Though ratings did differ among panels, the general characterizations of the cuts among the locations were the same. For example, all panels rated the roasts lower in brown/roasted aroma than the steaks. In addition, flat iron steaks were rated the highest for brown/roasted aroma and eye of round roasts were rated the lowest for the attribute at each location.



	Bottom	Eye	Inside	Knuckle	Flat Iron	Top Sirloin	Top Loin	Tenderloin
Location 1	3.64[a]	3.31[a]	3.55[a]	3.66[a]	4.26[a]	4.29[a]	4.48[a]	4.24[a]
Location 2	2.7[b]	2.29[b]	2.34[b]	2.39[b]	2.67[b]	2.39[b]	2.38[b]	2.51[b]
Location 3	3.7[a]	3.24[a]	3.74[a]	3.53[a]	4.21[a]	4.13[a]	4.1[a]	4.15[a]

Figure 2. Least squares means for cut by location interaction for beefy aroma.
[abc]Least squares mean values across cuts and locations followed by the same letter are not significantly different ($P > 0.05$).

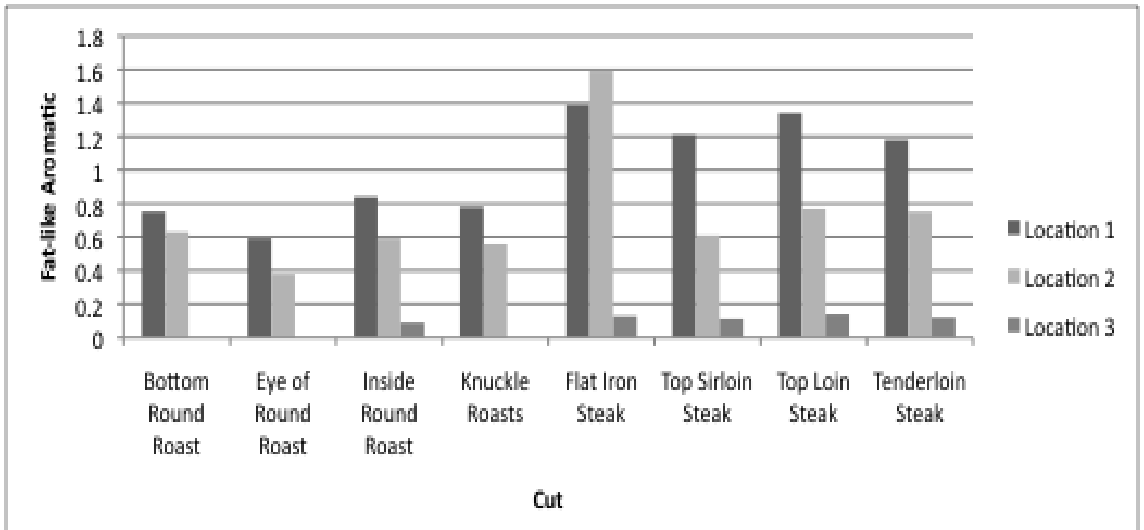


	Bottom	Eye	Inside	Knuckle	Flat Iron	Top Sirloin	Top Loin	Tenderloin
Location 1	1.66[a]	1.25[a]	1.82[a]	1.62[a]	3.48[a]	3.1[a]	3.57[a]	3.27[a]
Location 2	0.75[b]	0.62[b]	0.76[b]	0.68[b]	1.1[b]	0.71[b]	0.83[b]	0.76[b]
Location 3	1.03[c]	0.74[c]	1.04[c]	0.87[b]	1.69[c]	1.5[c]	1.4[c]	1.6[c]

Figure 3. Least squares means for cut by location interaction for brown/roasted aroma. [abc]Least squares mean values across cuts and locations followed by the same letter are not significantly different ($P > 0.05$).

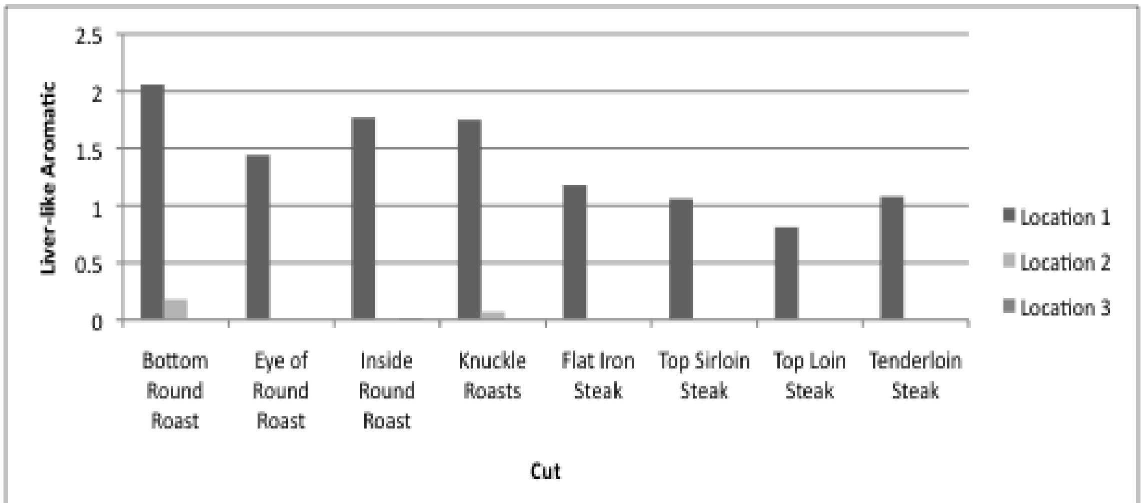
Location 3 detected very little fat-like aroma in the cuts as compared to locations 1 and 2 (Figure 4). Though panelists at location 3 perceived little to no fat-like aroma in the cuts, differentiation was seen between the roasts and the steaks. Panelists at location 3 detected slightly more fat-like aroma in the steak cuts as opposed to the roast cuts; panels at location 1 and 2 also detected more fat-like aroma in the steaks. Flat iron and top loin steaks were perceived by all panels to have the highest fat-like aroma and eye of round roasts were perceived to have the lowest. Location 1 and 2 rated the attribute similarly, especially among the roast cuts.

Panelists at location 1 rated liver-like aroma 1 to 2 points higher than the panelists at locations 2 and 3. Locations 2 and 3 did not detect or detected very low liver-like aroma among all of the cuts (Figure 5). Rating differences among panels may be attributed to differences in experience and training. For instance, prior to this study panelists at location 1 had not specifically rated liver-like aroma and flavor but rather would rate the attribute “organ-like”, which contained the liver-like component. Since panelists at location 1 were not used to rating liver-like aroma and flavor as an independent attribute, ratings probably were representative of overall organ aroma rather than specific liver aroma. Therefore, if discrimination between these attributes did not occur intensities would be higher than expected.



	Bottom	Eye	Inside	Knuckle	Flat Iron	Top Sirloin	Top Loin	Tenderloin
Location 1	0.75[a]	0.60[a]	0.84[a]	0.78[a]	1.39[a]	1.21[a]	1.34[a]	1.18[a]
Location 2	0.63[a]	0.38[a]	0.59[a]	0.56[a]	1.59[b]	0.61[b]	0.77[b]	0.75[b]
Location 3	0[b]	0[b]	0.09[b]	0[b]	0.13[c]	0.11[c]	0.14[c]	0.12[c]

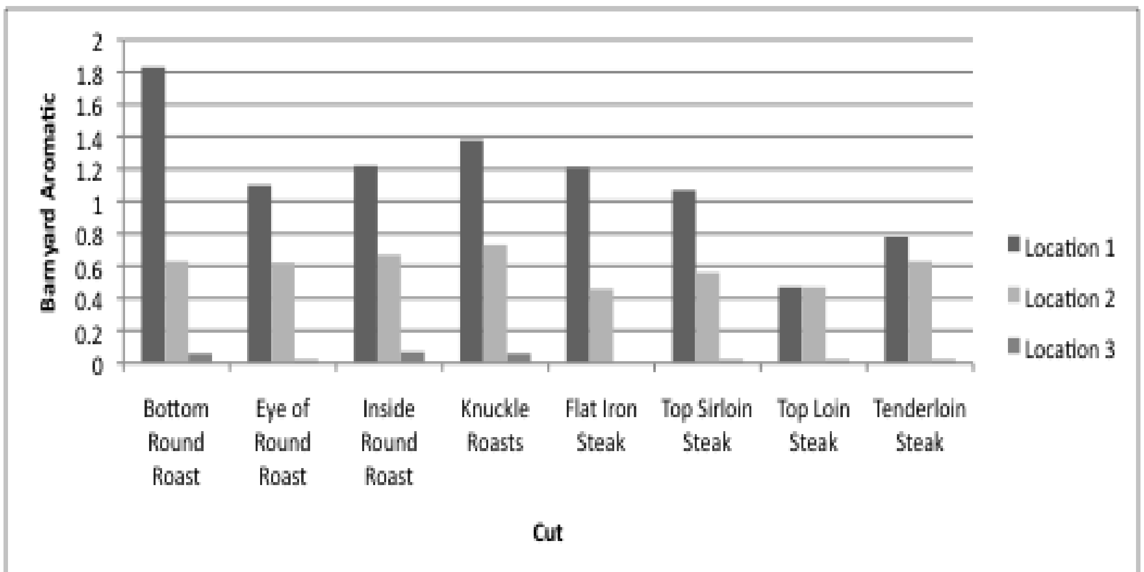
Figure 4. Least squares means for cut by location interaction for fat-like aroma.
[abc]Least squares mean values across cuts and locations followed by the same letter are not significantly different (P > 0.05).



	Bottom	Eye	Inside	Knuckle	Flat Iron	Top Sirloin	Top Loin	Tenderloin
Location 1	2.06[a]	1.44[a]	1.77[a]	1.75[a]	1.18[a]	1.06[a]	0.81[a]	1.08[a]
Location 2	0.18[b]	0[b]	0[b]	0.07[b]	0[b]	0[b]	0[b]	0[b]
Location 3	0[c]	0[b]	0.01[b]	0[b]	0[b]	0[b]	0[b]	0[b]

Figure 5. Least squares means for cut by location interaction for liver-like aroma.
[abc]Least squares mean values across cuts and locations followed by the same letter are not significantly different (P > 0.05).

Location 3 detected very little to no barnyard aroma as compared to locations 1 and 2 (Figure 6). Panelists at location 1 generally rated the attribute 0.5 points higher than location 2 for all the cuts. Despite the intensity differences among locations 1 and 2, both panels characterized the cuts similarly: roasts were perceived to have higher barnyard aroma than the steaks. Bottom round roasts and knuckle roasts were among the highest for barnyard aroma and top loin steaks were rated the lowest for the attribute.



	Bottom	Eye	Inside	Knuckle	Flat Iron	Top Sirloin	Top Loin	Tenderloin
Location 1	1.83[a]	1.1[a]	1.22[a]	1.38[a]	1.21[a]	1.07[a]	0.47[a]	0.78[a]
Location 2	0.63[b]	0.62[b]	0.67[b]	0.73[b]	0.46[b]	0.56[b]	0.47[a]	0.63[a]
Location 3	0.06[c]	0.02[c]	0.07[c]	0.06[c]	0[c]	0.02[c]	0.02[b]	0.02[b]

Figure 6. Least squares means for cut by location interaction for barnyard aroma.
[abc]Least squares mean values across cuts and locations followed by the same letter are not significantly different ($P > 0.05$).

Effect of Location on Beef Flavor

Panel location had an effect on all flavor attributes except for dairy flavor (Tables 2a and 2b). Of the significant flavor attributes, several of the attributes were rated below detection levels at each location including: heated oil, chemical, asparagus, buttery, cooked-milk, refrigerator, warmed-over and musty flavor. Among the significant attributes ($p<0.05$), location 1 and 3 rated beefy, overall sweet, bitter, rancid, heated oil, cooked milk, and sour milk/sour dairy flavor similarly. Location 1 and 2 rated fat-like, asparagus, buttery, astringent and musty flavor similarly and location 2 and 3 rated warmed-over flavor similarly. The remaining flavor attributes: brown/roasted, bloody/serumy, metallic, liver-like, green/hay-like, umami, sweet, sour, salty, and chemical were rated as significantly different ($p<0.05$) at each location. Location 1 and 3 rated flavor attributes more similarly than location 2. Locations 1 and 3 had more experience evaluating aroma and flavor and more experience using the Spectrum method. Location 1 tended to rate the flavor attributes higher than location 2 and 3. Brown/roasted, bloody/serumy, metallic, liver-like, umami, sweet, and salty flavor were rated the highest at location 1 (Tables 2a and 2b). Location 2 rated several attributes significantly lower ($p<0.05$) than locations 1 and 3, including: beefy, brown/roasted, metallic, umami, overall sweet and salty. Location 3 tended to rate attributes at intermediate intensities compared to locations 1 and 2 (Tables 2a and 2b).

Table 2. Least squares means for beef flavor attributes[g] segmented by location

(a)

Effect	Beefy	Brown/ Roasted	Bloody/ Serumy	Fat-like	Metallic	Liver-like	Green-hay-like	Umami	Overall Sweet	Sweet	Sour	Salty	Bitter	
Location	0.0001[f]	0.0001[f]	0.0001[f]	0.0001[f]	0.0001[f]	0.0001[f]		0.0001[f]	0.0001[f]	0.0001[f]	0.0001[f]	0.0001[f]	0.0001[f]	0.0001[f]
1	4.5[b]	2.1[c]	2.8[c]	1.4[b]	1.9[c]	1.8[c]	0.1[b]	2.6[c]	0.7[b]	0.6[c]	2.3[b]	2.0[c]	1.0[a]	
2	3.2[a]	0.9[a]	1.6[b]	1.5[b]	1.0[a]	0.5[b]	0.6[c]	0.3[a]	0.1[a]	0.4[b]	2.5[c]	0.3[a]	1.5[b]	
3	4.4[b]	1.2[b]	1.2[a]	0.6[a]	1.3[b]	0.0[a]	0.1[a]	0.8[b]	0.6[b]	0.0[a]	1.2[a]	0.7[b]	1.2[a]	
RMSE[i]	0.45	0.35	0.39	0.50	0.29	0.38	0.21	0.25	0.15	0.20	0.38	0.17	0.32	

[abc]Least squares mean values within a column and effect followed by the same letter are not significantly different ($P > 0.05$).

[e] Root Mean Square Error

[f] P-value from analysis of variance tables.

[g] Aroma measured where 0 = none and 15 = extremely intense.

Table 2. Continued

(b)

Effect	Rancid	Heated oil	Chemical	Asparagus	Dairy	Buttery	Cooked Milk	Sour Milk/ Sour Dairy	Refri- gerator	Warmed Over	Astringent	Musty
Location	0.0001[f]	0.0001[f]	0.0001[f]	0.02[f]	0.66[f]	0.0001[f]	0.002[f]	0.0001	0.21	0.0005[f]	0.0001[f]	0.0001[f]
1	0.2[a]	0.0[a]	0.0[a]	0.0[b]	0.1	0.1[a]	0.0[a]	0.1[a]	0.2	0.3[b]	0.0[a]	0.0[a]
2	0.6[b]	0.1[b]	0.2[c]	0.0[b]	0.0	0.1[a]	0.1[b]	0.5[b]	0.1	0.1[a]	0.0[a]	0.0[a]
3	0.1[a]	0.1[a]	0.1[b]	0.0[a]	0.0	0.2[b]	0.0[a]	0.3[a]	0.1	0.1[a]	0.1[b]	0.1[b]
RMSE[e]	0.30	0.14	0.11	0.06	0.07	0.12	0.09	0.21	0.13	0.17	0.07	0.06

[abc]Least squares mean values within a column and effect followed by the same letter are not significantly different (P > 0.05)

[e] Root Mean Square Error

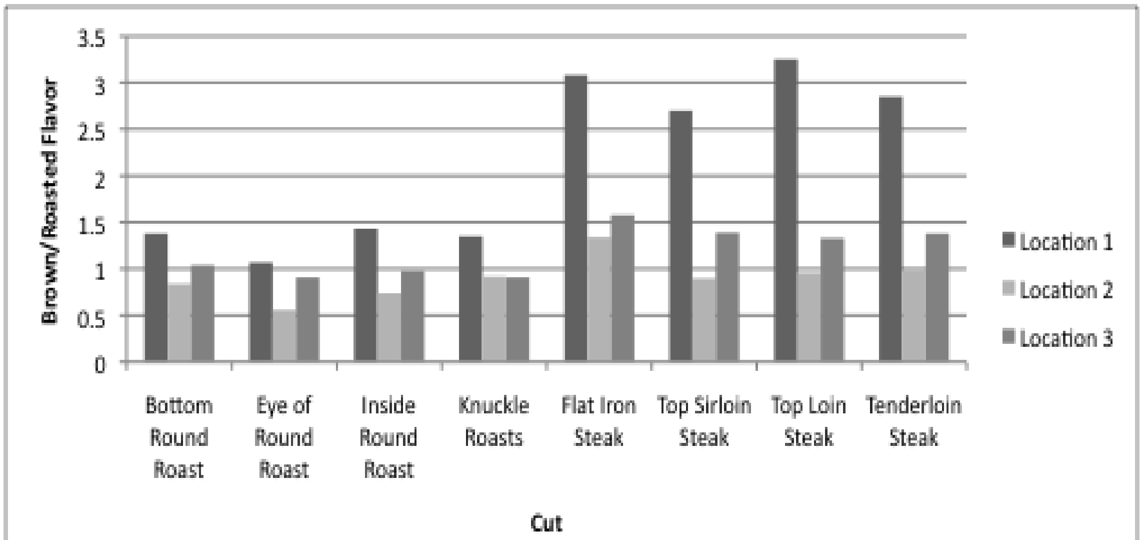
[f] P-value from analysis of variance tables.

[g] Aroma measured where 0 = none and 15 = extremely intense.

Cut by Location Interactions for Beef Flavor

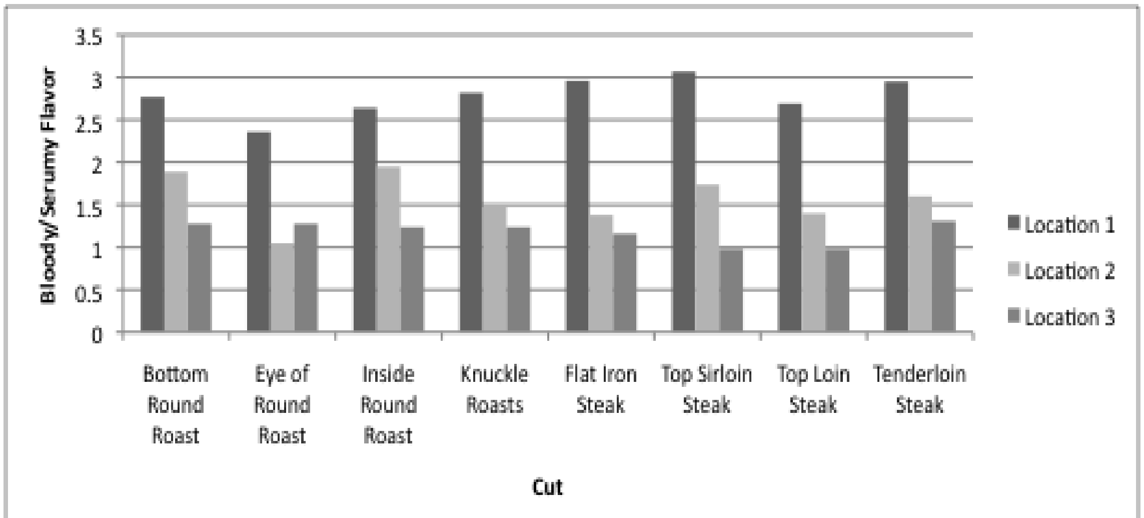
There were several significant cut by location interactions ($p<0.05$) for beef flavor indicating that panels perceived intensities differently among cuts for certain attributes. Significant ($p<0.05$) cut by location interactions for flavor include: brown/roasted, bloody/serumy, fat-like, liver-like, umami, overall sweet, sour, salty, bitter, chemical rancid, dairy, sour milk/sour dairy, refrigerator, and warmed-over flavor. However, only brown/roasted, bloody/serumy, fat-like, sour, bitter and liver-like were above detectable levels (>0.5) and only these interactions will be represented. For brown/roasted flavor, location 1 rated the attribute higher in all the cuts compared to locations 2 and 3. Panelists at location 2 rated brown/roasted flavor lowest in all the cuts compared to other locations and location 3 intensities were intermediate compared to location 1 and 2 (Figure 7). Despite differences among the locations general conclusions were the same, for instance, each panel perceived the roast cuts to have lower brown/roasted flavor as compared to the steak cuts.

Location 3 again perceived bloody/serumy flavor lower in all the cuts compared to the other locations. Location 3 did not detect as much bloody/serumy flavor in the cuts as locations 1 and 2 (Figure 8). Differences in panels were between 1 to 2 points, but again similar trends were found among the panels. All three locations rated the eye of round low in bloody/serumy flavor as compared to the other cuts and the tenderloin steak was rated as having relatively high bloody/serumy flavor compared to the other cuts.



	Bottom	Eye	Inside	Knuckle	Flat Iron	Top Sirloin	Top Loin	Tenderloin
Location 1	1.38[a]	1.07[a]	1.43[a]	1.35[a]	3.08[a]	2.7[a]	3.25[a]	2.85[a]
Location 2	0.84[b]	0.56[b]	0.74[b]	0.92[b]	1.34[b]	0.9[b]	0.96[b]	0.99[b]
Location 3	1.04[ab]	0.91[a]	0.98[b]	0.91[b]	1.58[b]	1.39[c]	1.33[c]	1.38[c]

Figure 7. Least squares means for cut by location interaction for brown/roasted flavor. [abc]Least squares mean values across cuts and locations followed by the same letter are not significantly different (P > 0.05).

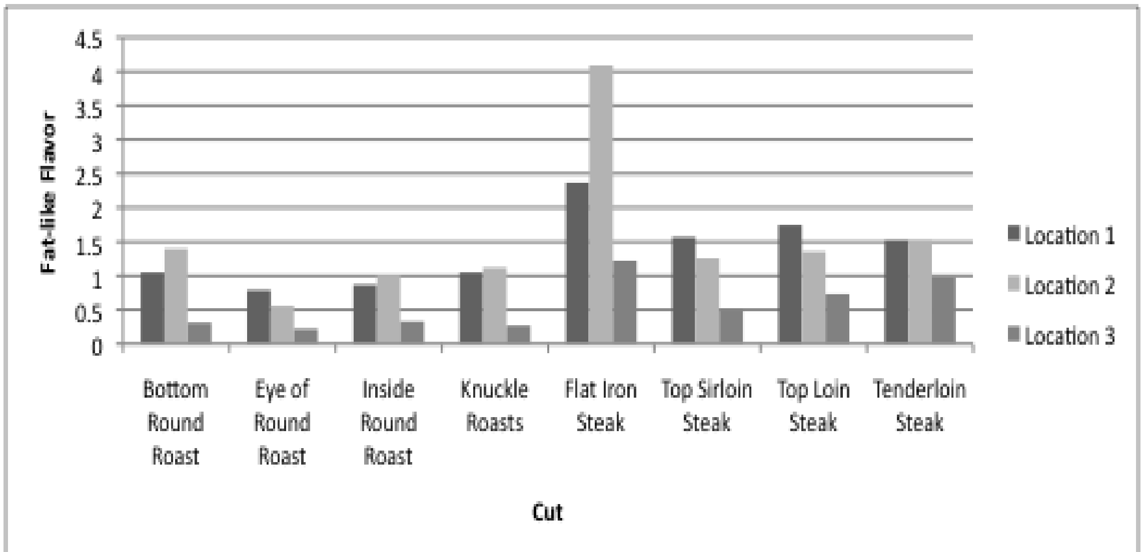


	Bottom	Eye	Inside	Knuckle	Flat Iron	Top Sirloin	Top Loin	Tenderloin
Location 1	2.77[a]	2.36[a]	2.64[a]	2.82[a]	2.96[a]	3.07[a]	2.69[a]	2.95[a]
Location 2	1.89[b]	1.05[b]	1.95[b]	1.49[b]	1.38[b]	1.74[b]	1.4[b]	1.6[b]
Location 3	1.28[b]	1.28[b]	1.24[c]	1.24[b]	1.16[b]	0.98[c]	0.98[c]	1.31[b]

Figure 8. Least squares means for cut by location interaction for bloody/serumy flavor. [abc]Least squares mean values across cuts and locations followed by the same letter are not significantly different (P > 0.05).

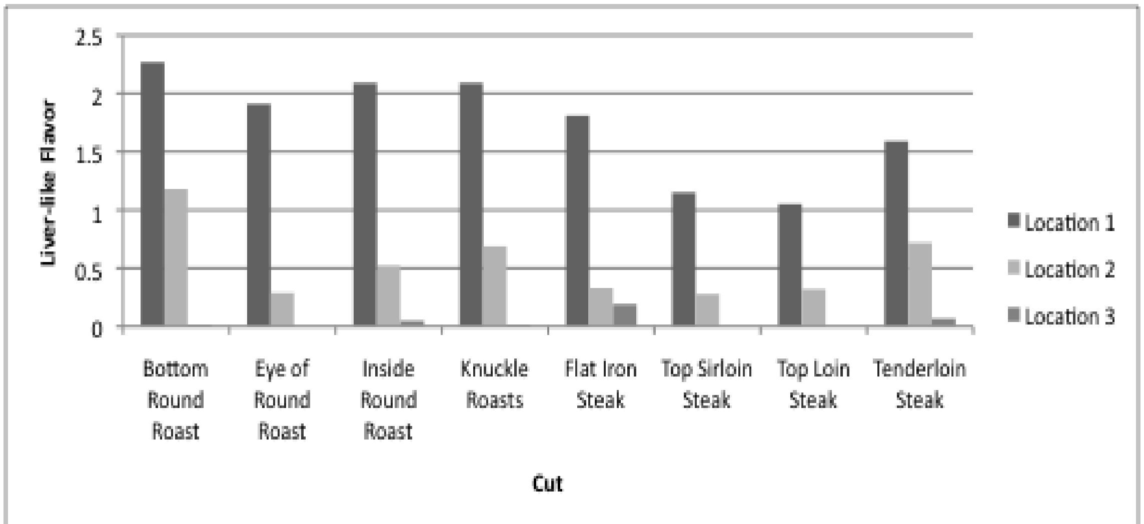
Locations 1 and 2 rated fat-like flavor similarly for all the cuts except in the flat iron steak, where location 2 rated fat-like intensity 2 to 3 points higher than both locations 1 and 3. Location 3 rated fat-like flavor the lowest in all the cuts as compared to the other locations. Though there were some rating differences, characterizations of the cuts by the panels were similar. Panels perceived the roast cuts as less intense in fat-like flavor than the steak cuts (Figure 9).

The interaction graph for liver-like flavor shows that panelists at location 1 rated cuts 1-to-2 points higher for liver-like flavor and panels at locations 2 and 3 rated most cuts very low for liver-like flavor (Figure 10). Panelists at location 3 did not find detectable levels of liver-like flavor in any of the cuts and location 2 found detectable levels of liver-like flavor in the bottom round, inside round, knuckle and tenderloin cuts. Both location 1 and 2 rated the bottom round roast to be most intense in liver-like flavor and the top sirloin and top loin steaks to be the least intense.



	Bottom	Eye	Inside	Knuckle	Flat Iron	Top Sirloin	Top Loin	Tenderloin
Location 1	1.05[a]	0.79[a]	0.87[a]	1.05[a]	2.37[a]	1.57[a]	1.75[a]	1.52[a]
Location 2	1.4[a]	0.56[ab]	1.01[a]	1.12[a]	4.09[b]	1.26[a]	1.36[a]	1.52[a]
Location 3	0.31[b]	0.22[b]	0.33[b]	0.27[b]	1.22[c]	0.51[b]	0.73[b]	0.98[b]

Figure 9. Least square means for cut by location interaction for fat-like flavor.
[abc]Least squares mean values across cuts and locations followed by the same letter are not significantly different (P > 0.05).



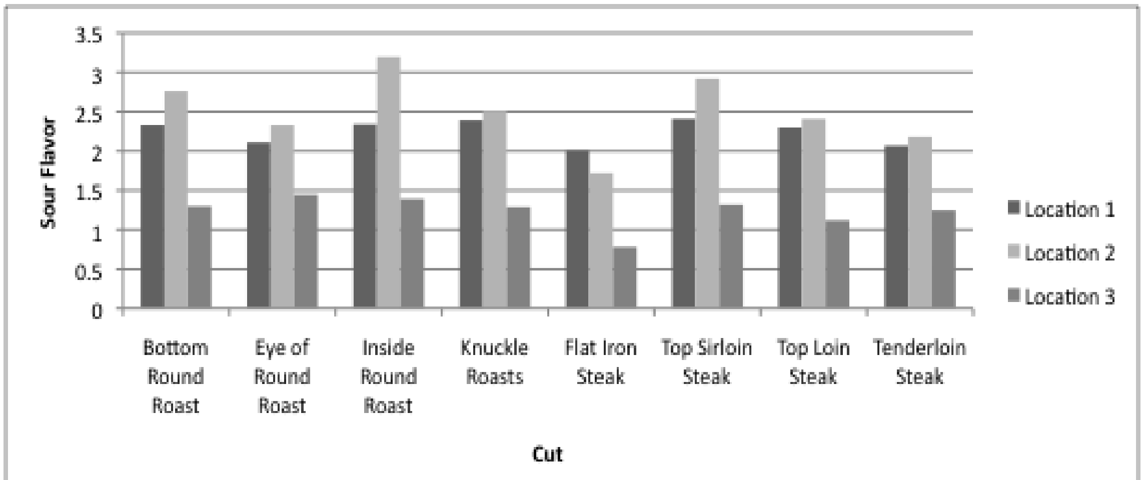
	Bottom	Eye	Inside	Knuckle	Flat Iron	Top Sirloin	Top Loin	Tenderloin
Location 1	2.27[a]	1.91[a]	2.09[a]	2.09[a]	1.81[a]	1.15[a]	1.05[a]	1.59[a]
Location 2	1.18[b]	0.29[b]	0.52[b]	0.69[b]	0.33[b]	0.28[b]	0.32[b]	0.72[b]
Location 3	0.01[c]	0[b]	0.05[c]	0.01[c]	0.19[b]	0[b]	0[c]	0.07[c]

Figure 10. Least square means for cut by location interaction for liver-like flavor.
[abc]Least squares mean values across cuts and locations followed by the same letter are not significantly different ($P > 0.05$).

For sour flavor, location 1 and 2 rated the attribute similarly, and location 3 perceived sour flavor at least 1 point lower than locations 1 and 2 among all the cuts. (Figure 11). All panels rated the sour flavor intensity in the flat iron steak lower than all other cuts. Generally, all panels perceived more sour flavor in the roasts cuts than in the steaks.

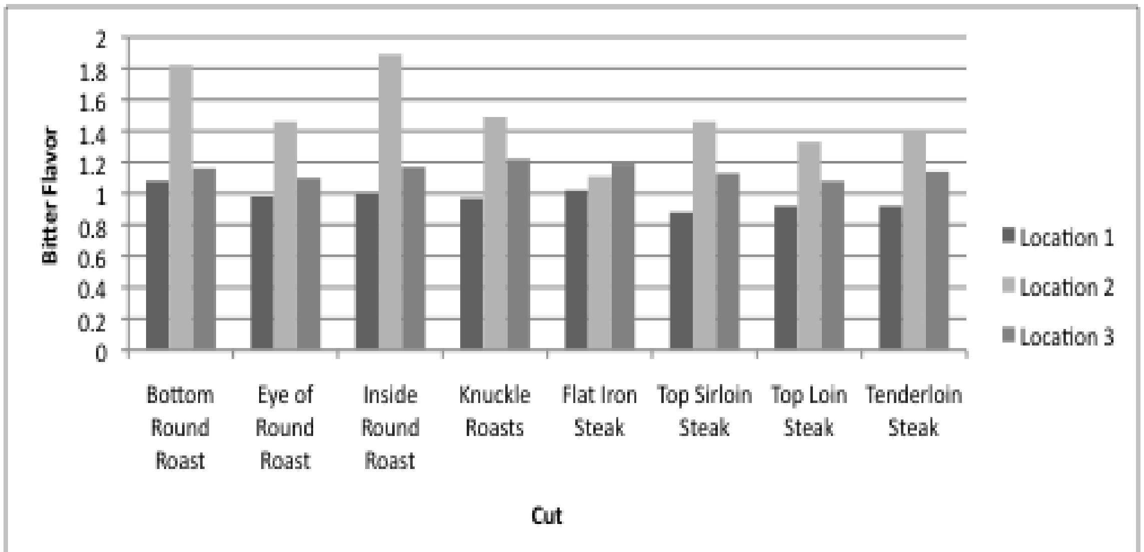
Location 2 rated bitter flavor significantly ($p<0.05$) higher than panelists in locations 1 and 3 for all the cuts (Figure 12). Locations 1 and 3 rated the attribute somewhat similarly across the cuts; location 3 rated bitter flavor slightly higher than location 1. The bottom round roast was characterized by location 1 and 2 as having the most intense bitter flavor compared to the other cuts. In general, the roast cuts were characterized as more intense in bitter flavor than the steak cuts.

Overall, significant rating differences were found for aroma and flavor attributes across the three panels. Despite significant location effects, application of the beef lexicon was successfully implemented by all three locations. In addition, similar patterns of differentiation among samples were observed and panels were able to accurately communicate attribute differences among the beef samples.



	Bottom	Eye	Inside	Knuckle	Flat Iron	Top Sirloin	Top Loin	Tenderloin
Location 1	2.33[a]	2.11[a]	2.34[a]	2.39[a]	2.01[a]	2.41[a]	2.3[a]	2.07[a]
Location 2	2.76[b]	2.33[a]	3.2[b]	2.51[a]	1.72[a]	2.92[b]	2.41[a]	2.18[a]
Location 3	1.3[c]	1.45[b]	1.39[c]	1.29[b]	0.78[b]	1.32[c]	1.12[b]	1.25[b]

Figure 11. Least square means for cut by location interaction for sour flavor.
[abc]Least squares mean values across cuts and locations followed by the same letter are not significantly different (P > 0.05).



	Bottom	Eye	Inside	Knuckle	Flat Iron	Top Sirloin	Top Loin	Tenderloin
Location 1	1.08[a]	0.98[a]	1[a]	0.97[a]	1.02	0.88[a]	0.92[a]	0.92[a]
Location 2	1.82[b]	1.46[b]	1.89[b]	1.49[b]	1.11	1.46[b]	1.33[b]	1.4[b]
Location 3	1.16[a]	1.1[a]	1.17[a]	1.22[a]	1.19	1.13[a]	1.08[ab]	1.14[ab]

Figure 12. Least square means for cut by location interaction for bitter flavor.
[abc]Least squares mean values across cuts and locations followed by the same letter are not significantly different (P > 0.05).

Panelist Effects

Data was analyzed to determine the effect of panelist variation within a location. Results indicated that there were significant panelist to panelist differences at each location. Locations 1 and 2 seemed to have the most panelist variation among the attributes. Though differences were seen in location 3, ratings were more consistent among panelists as compared to locations 1 and 2. When rating differences were found at location 3, they were no greater than one point between panelists. However, rating differences between panelists at location 1 and 2 were up to two points.

Initially, as an effort to decrease panelist variation prior to the study, panels were required to conduct a calibration study after lexicon training was complete. Panelists at each location evaluated extra samples and rated each attribute from the beef lexicon. Results were then analyzed and panel leaders were asked to determine which attributes had the most variation among panelist ratings and which panelists had consistently different ratings compared to other panelists. Based on the results panel leaders could then determine which attributes and panelists required more training. The additional training should have helped remove some panelist variation, but as mentioned in the previous paragraph significant panelist rating differences were still seen at each location. This indicates that even more re-training was required overall to achieve more consistent results among panelists.

Cook Yield

Cook yield by cut ($p<0.0001$, Table 3a) and location ($p<0.0001$, Table 3a) were significant, however cook yield by quality grade was not significant ($p=0.55$, Table 3a). Cook yields for cut generally ranged from 75% to 87%, with the eye of round roast having the lowest least square means and the top loin steak having the highest least squares means (Table 3a). Cook yield was highest for location 3 and lowest for location 2; all three locations were significantly ($p<0.05$) different (Table 3a). Cook yield differences among quality grade were not significant ($p<0.05$); both Choice and Select samples had yields around 79%. Steak cuts had overall higher cook yield percentages (80% to 87%) than the roast cuts (75% to 79%). Steak cuts were grilled on George Foreman grills at a high temperature (375^{o}F), whereas the roasts were roasted in the oven at a lower temperature (325^{o}F). Due to the higher and faster heat transfer of grilling as compared to roasting, the steak cuts reached the assigned final internal temperature (70^{o}C) more rapidly than the roasts. Several studies have shown increased cook loss (decreased cook yield) with increased cooking time (Hamm, 1986). Differences in cook yield between locations can be attributed to the different final internal temperatures the samples were cooked to at each location. Locations 1 and 2 monitored temperature using a copper-constant thermocouple and cooked samples to an internal temperature of 70^{o}C, however location 3 unintentionally monitored internal temperature using an iron-constant thermocouple and samples were only cooked to an internal temperature of 65^{o}C, even though the Omega HH501BT Type T thermometer indicated that sample was at 70^{o}C. Iron-constant thermocouples require Type J thermometers for accurate temperature readings. Drip loss occurs when water and volatilized fats are released from meat during the cooking process. With a continued increase in leakage, cook yield decreases. As internal temperature rises, more protein penetration occurs and internal water floods the surface of the meat where evaporation and drip occur (Godsalve, Davis, Gordon, & Davis, 1977). Differences in final internal temperatures, human error and improper thermocouple placement are all factors that influence cook yield. While cook yield effects were reported for location 3, location effects on beef lexicon attributes were not appreciably impacted by the cooking differences, as location 3 was not consistently different in sensory ratings within an attribute than locations 1 and 2.

Table 3. Least squares means for cook yield percentage (%) segmented by quality, cut and location.

Effect	Cook yield
Quality Grade	*0.55*[f]
Choice	79.85
Select	79.50
Cut	*0.0001*[f]
Bottom round roast	76.77[ab]
Eye of round roast	75.82[a]
Inside round roast	78.86[bc]
Knuckle roast	75.89[a]
Flat iron steak	80.92[cd]
Top sirloin steak	81.80[d]
Top loin steak	86.55[e]
Tenderloin steak	80.76[cd]
Location	*0.0001*[f]
1	79.24[b]
2	74.78[a]
3	84.99[c]
RMSE[e]	4.67

[abcd] Least squares mean values within a column and effect followed by the same letter are not significantly different (P > 0.05).

[e] Root Mean Square Error

[f] P-value from analysis of variance tables.

Effect of Cut and Quality Grade on Beef Aroma and Flavor Attributes

In order to obtain an accurate characterization of beef aroma and flavor among samples of different cuts and quality grades, the effect of location was eliminated as a main effect from the statistical model and was included as a covariate. By removing location, the influence of panel training, cooking, and other factors associated with location were eliminated. This analysis was used to understand the effect of quality grade, cut and quality grade by cut interactions.

Aroma

Beef samples had low, but detectable levels of beefy and brown/roasted aroma, barely detectable levels of bloody/serumy, fat-like, liver-like, sour, and barnyard aroma, and non-detectable levels of all other attributes (Tables 4a, 4b, 4c). Attributes with low, but detectable levels were identified as having intensities of 1.5 to 4.0, barely detectable levels included intensities in the range of 0.5-1.5 and non-detectable attributes had intensities of less than 0.5. Choice and Select samples had low, but detectable levels of beefy and brown/roasted aroma, barely detectable levels of bloody/serumy, fat-like, liver-like, sour, and barnyard aroma, and non-detectable levels of all other attributes (Tables 4a, 4b, 4c). Additionally, least squares means were not reported in tabular form for apricot, green, asparagus, cumin, beet and chocolate/cocoa aroma attributes because panelists did not detect levels across the three laboratories. A majority of the aroma attributes that had detectable and barely detectable levels were classified as major notes and one attribute (barnyard aroma) was designated as a minor/other note (Appendix A-lexicon). Attributes that were present in most samples were classified as 'major

Table 4. Least squares means for beef aroma attributes[g] segmented by quality grade and cut.

(a)

Effect	Beefy	Brown/ Roasted	Bloody/ Serumy	Fat-like	Metallic	Liver-like	Green-hay-like	Sweet	Sour	Animal Hair	Barnyard	Burnt	Rancid
Quality Grade	*0.81*[f]	*0.99*[f]	*0.14*[f]	*0.36*[f]	*0.82*[f]	*0.92*[f]	*0.92*[f]	*0.81*[f]	*0.53*[f]	*0.95*[f]	0.22[f]	0.92[f]	0.45[f]
Choice	3.0	1.5	1.4	0.9	0.5	0.8	0.3	0.2	1.0	0.3	1.0	0.0	0.3
Select	3.0	1.5	1.5	0.9	0.5	0.8	0.3	0.2	1.0	0.3	1.0	0.0	0.4
Cut	*0.0001*[f]	*0.0001*[f]	*0.0016*[f]	*0.0001*[f]	*0.0399*[f]	*0.0002*[f]	*0.0254*[f]	*0.77*[f]	*0.0246*[f]	*0.2092*[f]	*0.0055*[f]	*0.0001*[f]	*0.013*[f]
Bottom round roast	3.0[bd]	1.1[a]	1.6[a]	0.8[abc]	0.5[bc]	1.0[ad]	0.3[ab]	0.2	1.0[ab]	0.3	1.3[b]	0.0[b]	0.3[be]
Eye of round roast	2.6[a]	0.9[a]	1.4[a]	0.6[b]	0.5[abc]	0.8[cde]	0.4[ab]	0.2	0.9[bc]	0.3	1.1[bc]	0.0[b]	0.2[a]
Inside round roast	2.9[d]	1.1[a]	1.6[a]	0.8[abc]	0.5[bc]	0.9[acde]	0.4[ac]	0.2	1.1[a]	0.4	1.1[bc]	0.0[b]	0.4[bc]
Knuckle roast	2.8[ad]	1.0[a]	1.6[a]	0.7[abc]	0.6[c]	0.9[ade]	0.5[a]	0.2	1.1[a]	0.3	1.2[b]	0.0[b]	0.4[bd]
Flat iron steak	3.3[c]	2.1[b]	1.4[a]	1.3[e]	0.4[ab]	0.7[bcde]	0.3[b]	0.2	0.9[bc]	0.3	1.0[abcd]	0.1[a]	0.4[b]
Top sirloin steak	3.2[bc]	1.8[b]	1.4[a]	1.0[cd]	0.5[abc]	0.7[bce]	0.3[ab]	0.3	1.0[abc]	0.3	1.0[ac]	0.1[a]	0.3[acde]
Top loin steak	3.2[bc]	1.8[b]	1.1[b]	1.0[d]	0.4[a]	0.5[b]	0.3[bc]	0.3	0.8[c]	0.2	0.8[ad]	0.0[b]	0.3[ab]
Tenderloin steak	3.2[bc]	1.9[b]	1.4[a]	1.0[d]	0.5[abc]	0.8[ce]	0.3[bc]	0.3	1.0[abc]	0.2	1.0[ac]	0.1[a]	0.4[be]
RMSE[e]	0.55	0.59	0.53	0.49	0.27	0.43	0.24	0.23	0.33	0.20	0.46	0.13	0.25

[abcde]Least squares mean values within a column and effect followed by the same letter are not significantly different (P > 0.05).
[e] Root Mean Square Error
[f] P-value from analysis of variance tables.
[g] Aroma measured where 0 = none and 15 = extremely intense

Table 4. Continued

(b)

Effect	Heated oil	Chemical	Leather	Green	Musty-Earthy/Humus	Floral	Medicinal	Petroleum-like	Smokey Charcoal
<u>*Quality Grade*</u>	*0.83*[e]	*0.22*[e]	*0.39*[e]	*0.19*[e]	*0.17*[e]	*0.69*[e]	*0.34*[e]	*0.47*[e]	*0.67*[e]
Choice	0.0	0.1	0.0	0.0	0.2	0.0	0.0	0.0	0.1
Select	0.0	0.1	0.1	0.0	0.2	0.1	0.0	0.0	0.1
<u>*Cut*</u>	*0.036*[e]	*0.44*[e]	*0.03*[e]	*0.79*[e]	*0.47*[e]	*0.39*[e]	*0.38*[e]	*0.36*[e]	*0.0021*[e]
Bottom round roast	0.0[bc]	0.1	0.0[ac]	0.0	0.2	0.0	0.0	0.0	0.0[ab]
Eye of round roast	0.0[c]	0.1	0.0[ac]	0.1	0.2	0.0	0.0	0.0	0.0[ac]
Inside round roast	0.2[bc]	0.1	0.0[ac]	0.0	0.2	0.1	0.0	0.0	0.0[a]
Knuckle roast	0.2[bc]	0.1	0.1[ab]	0.4	0.2	0.0	0.0	0.0	0.0[ae]
Flat iron steak	0.1[a]	0.1	0.1[b]	0.0	0.2	0.1	0.0	0.0	0.1[bd]
Top sirloin steak	0.1[ab]	0.1	0.1[abc]	0.0	0.2	0.0	0.0	0.0	0.1[bcde]
Top loin steak	0.1[abc]	0.1	0.0[c]	0.1	0.1	0.1	0.1	0.0	0.1[d]
Tenderloin steak	0.0[abc]	0.1	0.0[ac]	0.0	0.2	0.0	0.0	0.0	0.1[d]
RMSE[d]	0.07	0.11	0.08	0.08	0.22	0.10	0.08	0.06	0.10

[abcde]Least squares mean values within a column and effect followed by the same letter are not significantly different (P > 0.05).
[d] Root Mean Square Error
[e] P-value from analysis of variance tables.
[g] Aroma measured where 0 = none and 15 = extremely intense

Table 4. Continued

(c)

Effect	Smokey Wood	Spoiled-Putrid	Dairy	Buttery	Cooked Milk	Sour Milk/ Sour Dairy	Refrigerator	Soapy	Warmed Over	Caramel
<u>*Quality Grade*</u>	*0.65*[e]	*0.37*[e]	*0.07*[e]	*0.14*[e]	*0.25*[e]	*0.07*[e]	*0.98*[e]	*0.16*[e]	*0.36*[e]	*0.10*[e]
Choice	0.0	0.1	0.0	0.1	0.0	0.2	0.1	0.0	0.1	0.0
Select	0.0	0.1	0.0	0.1	0.0	0.1	0.1	0.0	0.1	0.0[b]
<u>*Cut*</u>	*0.08*[e]	*0.25*[e]	*0.28*[e]	*0.48*[e]	*0.41*[e]	*0.56*[e]	*0.02*[e]	*0.52*[e]	*0.0043*[e]	*0.18*[e]
Bottom round roast	0.0	0.1	0.1	0.1	0.1	0.2	0.1[ab]	0.0	0.2[b]	0.0
Eye of round roast	0.0	0.1	0.0	0.0	0.1	0.1	0.1[ab]	0.0	0.2[bc]	0.0
Inside round roast	0.0	0.2	0.0	0.0	0.0	0.2	0.1[b]	0.0	0.1[bde]	0.0
Knuckle roast	0.0	0.1	0.1	0.1	0.0	0.1	0.1[a]	0.0	0.1[bdf]	0.0
Flat iron steak	0.0	0.2	0.1	0.1	0.0	0.1	0.1[a]	0.0	0.1[ad]	0.0
Top sirloin steak	0.0	0.1	0.1	0.1	0.0	0.1	0.1[a]	0.0	0.1[a]	0.0
Top loin steak	0.0	0.1	0.1	0.1	0.0	0.1	0.1[a]	0.0	0.1[acef]	0.0
Tenderloin steak	0.0	0.1	0.1	0.1	0.0	0.1	0.1[b]	0.0	0.1[bc]	0.0
RMSE[d]	0.06	0.16	0.08	0.12	0.10	0.18	0.10	0.05	0.12	0.02

[abcdef]Least squares mean values within a column and effect followed by the same letter are not significantly different (P > 0.05).

[d] Root Mean Square Error

[e] P-value from analysis of variance tables.

[g] Aroma measured where 0 = none and 15 = extremely intense

attributes' and those that were only present in certain samples were classified as 'other notes.' Overall, the aroma attributes were rated lower in intensity than flavor. Aroma intensities were on average 0.5 to 1 point less intense than their flavor counterparts.

Flavor

Among flavor, beef samples had low, but detectable levels of beefy, brown/roasted, bloody/serumy and sour flavor, barely detectable levels of fat-like, metallic, liver-like, umami, sour, salty, and bitter flavor, and very low to non-detectable levels of all other flavor attributes (Tables 5a and 5b). Choice and Select samples had low, but detectable levels of beefy, brown/roasted, bloody/serumy, and sour flavor, barely detectable levels of fat-like, metallic, liver-like, umami, salty and bitter flavor, and very low to non-detectable levels of all other flavor attributes (Tables 5a and 5b). Least square means were not reported for cumin, floral, beet, chocolate/cocoa and petroleum-like flavor attributes because panelists did not detect any levels for these attributes across the three laboratories. In addition, it should be noted that the three trained sensory panelists in this study were trained using companion samples, consistent training methods and each panel was validated prior to initiation of the testing portion. As defined in this study, trained panelists can detect 1-point differences consistently after proper training. Based on this level of sensitivity and the use of 5 or more panelists, least squares mean differences less than 0.5 are usually not different, repeatable or defined as important by sensory professionals.

Table 5. Least squares means for beef flavor attributes[i] segmented by quality grade and cut.

(a)

Effect	Beefy	Brown/ Roasted	Bloody/ Serumy	Fat-like	Metallic	Liver-like	Green-hay-like	Umami	Overall Sweet	Sweet	Sour	Salty	Bitter
<u>*Quality Grade*</u>	*0.94*[a]	*0.32*[h]	*0.65*[h]	*0.039*[h]	*0.73*[h]	*0.07*[h]	*0.95*[h]	*0.79*[h]	*0.01*[h]	*0.73*[h]	*0.89*[h]	*0.76*[h]	*0.19*[h]
Choice	3.6	1.5	2.4	1.7[b]	1.5	1.3	0.4	1.5	0.3[b]	0.5	2.5	1.2	1.2
Select	3.6	1.4	2.3	1.5[a]	1.5	1.2	0.4	1.5	0.3[a]	0.5	2.5	1.2	1.2
<u>*Cut*</u>	*0.0001*[h]	*0.0001*[h]	*0.013*[h]	*0.0001*[h]	*0.0001*[h]	*0.0001*[h]	*0.17*[h]	*0.0001*[h]	*0.0001*[h]	*0.1443*[h]	*0.0001*[h]	*0.0044*[h]	*0.03*[h]
Bottom round roast	3.4[a]	1.1[a]	2.4[acd]	1.3[ae]	1.6[acd]	1.6[b]	0.4	1.4[d]	0.2[ab]	0.5	2.7[bc]	1.1[ab]	1.4[a]
Eye of round roast	3.1[b]	1.0[a]	2.1[bd]	1.0[de]	1.5[dfg]	1.2[ad]	0.5	1.2[df]	0.2[a]	0.4	2.6[bc]	1.1[a]	1.2[ab]
Inside round roast	3.4[a]	1.0[a]	2.5[c]	1.1[de]	1.7[ce]	1.3[ae]	0.5	1.3[de]	0.2[ab]	0.4	2.8[b]	1.1[ac]	1.4
Knuckle roast	3.4[a]	1.1[a]	2.4[acd]	1.3[ad]	1.5[adg]	1.3[a]	0.5	1.4[cd]	0.2[ab]	0.5	2.6[bc]	1.3[b]	1.2[acd]
Flat iron steak	4.0[c]	2.0[b]	2.3[abcd]	3.0[b]	1.2[b]	1.3[be]	0.4	1.7[ae]	0.4[d]	0.5	2.0[a]	1.1[adc]	1.1[bc]
Top sirloin steak	3.8[c]	1.7[c]	2.3[abcd]	1.5[ca]	1.6[acdf]	1.0[cde]	0.5	1.6[bc]	0.3[bc]	0.6	2.8[bc]	1.2[bc]	1.1[b]
Top loin steak	3.9[c]	1.8[bc]	2.2[bd]	1.7[c]	1.4[bg]	0.9[c]	0.4	1.6[abc]	0.4[d]	0.5	2.5[c]	1.2[bd]	1.1[b]
Tenderloin steak	4.0[c]	1.8[bc]	2.5[ac]	1.7[c]	1.5[adg]	1.4[ab]	0.4	1.8[ab]	0.3[cd]	0.5	2.5[c]	1.2[bd]	1.2[bd]
RMSE[i]	0.53	0.52	0.57	0.70	0.32	0.62	0.27	0.40	0.19	0.30	0.60	0.24	0.36

[abcdef]Least squares mean values within a column and effect followed by the same letter are not significantly different (P > 0.05).

[g] Root Mean Square Error

[h] P-value from analysis of variance tables.

[i] Flavor measured where 0 = none and 15 = extremely intense.

Table 5. Continued

(b)

Effect	Rancid	Heated oil	Chemical	Asparagus	Dairy	Buttery	Cooked Milk	Sour Milk Sour Dairy	Refri-gerator	Warmed Over	Astringent	Musty
Quality Grade	*0.59*[f]	*0.79*[f]	*0.06*[f]	*0.17*[f]	*0.10*[f]	*0.79*[f]	*0.90*[f]	*0.37*[f]	*0.90*[f]	*0.50*[f]	*0.41*[f]	*0.24*[f]
Choice	0.5	0.1	0.1	0.0	0.1	0.1	0.0	0.3	0.1	0.2	0.0	0.0
Select	0.5	0.1	0.1	0.0	0.1	0.1	0.0	0.3	0.1	0.2	0.0	0.0
Cut	*0.0001*[f]	*0.0002*[f]	*0.41*[f]	*0.43*[f]	*0.57*[f]	*0.0001*[f]	*0.11*[f]	*0.009*[f]	*0.0021*[f]	*0.0033*[f]	*0.40*[f]	*0.82*[f]
Bottom round roast	0.5[a]	0.1[a]	0.1	0.0	0.0	0.1[ac]	0.1	0.3[ab]	0.1[ac]	0.3[ac]	0.0	0.0
Eye of round roast	0.4[a]	0.1[a]	0.1	0.0	0.1	0.0[a]	0.1	0.3[ab]	0.2[ab]	0.3[a]	0.0	0.0
Inside round roast	0.5[a]	0.1[a]	0.2	0.0	0.1	0.1[ac]	0.0	0.4[a]	0.2[b]	0.3[ade]	0.0	0.0
Knuckle roast	0.5[a]	0.1[a]	0.1	0.0	0.1	0.0[ac]	0.0	0.4[ad]	0.2[ad]	0.2[bce]	0.0	0.0
Flat iron steak	0.8[b]	0.2[b]	0.1	0.0	0.1	0.2[b]	0.1	0.2[bc]	0.1[ac]	0.2[bcd]	0.0	0.0
Top sirloin steak	0.4[a]	0.1[a]	0.1	0.0	0.1	0.1[cd]	0.0	0.4[ac]	0.1[cd]	0.2[be]	0.0	0.0
Top loin steak	0.4[a]	0.1[a]	0.1	0.0	0.1	0.1[bd]	0.0	0.2[b]	0.1[ad]	0.2[b]	0.0	0.0
Tenderloin steak	0.4[a]	0.1[a]	0.1	0.0	0.1	0.1[ac]	0.0	0.3[abd]	0.1[cd]	0.2[bc]	0.0	0.0
RMSE[e]	0.34	0.14	0.12	0.06	0.07	0.13	0.10	0.24	0.13	0.20	0.08	0.06

[abcde]Least squares mean values within a column and effect followed by the same letter are not significantly different (P > 0.05).

[e] Root Mean Square Error

[f] P-value from analysis of variance tables.

[g] Flavor measured where 0 = none and 15 = extremely intense.

Quality Grade

Within quality grade, Choice and Select beef samples did not significantly differ ($p>0.05$) in beef aromatic attributes (Tables 4a, 4b, 4c). Since aroma is detected at lower levels than flavor attributes, it is not surprising that aroma attributes did not differ across Quality grade. Choice and Select samples did differ in some flavor attributes: fat-like flavor ($p=0.039$) and overall sweet flavor ($p=0.01$). Choice steaks and roasts were higher in fat-like and overall sweet flavor than Select steaks and roasts (Tables 4 and 5). Since Choice beef has inherently more marbling or intramuscular fat than Select beef, the higher fat-like and overall sweet flavor would be expected in the Choice samples. Several studies comparing the aroma and flavor attributes of beef of different quality grade did not show many significant differences among aroma and flavor attributes (Luchak et al., 1998). There was a significant cut by Quality grade interaction ($p=0.0276$) for refrigerator aroma, but as the intensity level is below detectable levels, the interaction will not be represented. Significant cut by Quality grade interactions were not found for the remaining aroma or flavor attributes, indicating that cuts within Quality grade were rated similarly for those attributes.

Beef Cut

Eight cuts, four roasts and four steaks were evaluated for beef aroma and flavor. The beef cuts significantly ($p<0.05$) differed in most aroma and flavor attributes except for sweet, animal hair, chemical, green, musty-earthy/humus, floral, medicinal, petroleum-like, spoiled-putrid, dairy, buttery, cooked milk, sour dairy/sour milk, soapy and caramel aromas and green/hay-like, sweet, chemical, asparagus, dairy, cooked milk, astringent and musty flavors (Tables 4a, 4b, 4c, 5a, 5b). Most of the non-significant attributes were classified as ‘other notes’; therefore, they would not be expected to be present in most samples or would be present at very low levels. Additional tables for significant ($p<0.05$) and detectable (intensities greater than 0.5) aroma and flavor attributes were reported (Tables 6a and 7a).

Roasts (bottom round, eye of round, inside round and knuckle round) were rated similarly for a majority of the aroma and flavor attributes excluding: beefy and sour aroma and beefy, bloody, fat-like, metallic, liver-like and salty flavor. Eye of round roasts were lowest in intensity compared to both roasts and steaks for several attributes including: beefy, brown/roasted, and fat-like aroma and beefy, bloody/serumy, fat-like, and umami flavor (Table 6a, 7a). In general, eye of round roasts are considered to be slightly lower in overall aroma and flavor and less beefy than other roasts from the round (Morgan, Savell, Hale, Miller, Griffin, Cross and Shackelford, 1991; Coleman, Rhee, and Cross, 1998). Bottom round roasts had the highest liver-like aroma and flavor which is probably due to the high heme content of the muscle in combination with low fat-like flavor that may have contributed to the heightened detection of liver-like aroma and flavor (Meisinger et. al, 2006). Total heme content is the amount of both hemoglobin and myoglobin (Wadhwani, 2008). Both hemoglobin and myoglobin contain iron and when heated the heme begins to degrade which causes an increase in free ionic iron (Wadhwani, 2008). Studies by Im and others (2004) and Lugay and Beale (1978) show that free ionic iron greatly accelerates lipid oxidation and liver off-flavor development.

Bottom round, inside round and knuckle roasts were intermediate in intensity for characteristic “beefy” aroma and flavor as compared to the eye of round roast and the steak cuts. Compared to the steak cuts, all the roasts were rated lower for aroma and flavor attributes that could be classified as “characteristic” or “positive”, but higher in attributes that are commonly classified as off-aromas and flavors. Roasts were rated lower than the steaks for beefy, brown/roasted, fat-like and umami aroma and flavor, but higher in bloody, metallic, liver-like, sour, barnyard and bitter aroma and flavor (Table 6a and 7a). Cooking method and inherent differences in the cuts likely explain the aroma intensity differences between the roast and steak cuts. Cooking method and degree of doneness can impact beefy, brown/roasted, umami and bloody aroma and flavor attributes. The steak cuts have more intense beefy and brown/roasted aroma and umami flavor than the roasts because they were grilled rather than roasted. Since grilling involves the use of high, direct heat, the Maillard reaction is initiated which causes chemical reactions between amino acids and reducing sugars. The Maillard reaction reacts more readily at high temperatures (Brewer, 2006) and grilling uses higher

Table 6. Least squares means for significant, detectable[g] beef aroma attributes[i] segmented by cut.

Effect	Beefy	Brown/ Roasted	Bloody/ Serumy	Fat-like	Metallic	Liver-like	Sour	Barnyard
<u>*Cut*</u>	*0.0001*[f]	*0.0001*[f]	*0.0016*[f]	*0.0001*[f]	*0.0399*[f]	*0.0002*[f]	*0.0246*[f]	*0.0055*[f]
Bottom round roast	3.0[bd]	1.1[a]	1.6[a]	0.8[abc]	0.5[bc]	1.0[ad]	1.0[ab]	1.3[b]
Eye of round roast	2.6[a]	0.9[a]	1.4[a]	0.6[b]	0.5[abc]	0.8[cde]	0.9[bc]	1.1[bc]
Inside round roast	2.9[d]	1.1[a]	1.6[a]	0.8[abc]	0.5[bc]	0.9[acde]	1.1[a]	1.1[bc]
Knuckle roast	2.8[ad]	1.0[a]	1.6[a]	0.7[abc]	0.6[c]	0.9[ade]	1.1[a]	1.2[b]
Flat iron steak	3.3[c]	2.1[b]	1.4[a]	1.3[e]	0.4[ab]	0.7[bcde]	0.9[bc]	1.0[abcd]
Top sirloin steak	3.2[bc]	1.8[b]	1.4[a]	1.0[cd]	0.5[abc]	0.7[bce]	1.0[abc]	1.0[ac]
Top loin steak	3.2[bc]	1.8[b]	1.1[b]	1.0[d]	0.4[a]	0.5[b]	0.8[c]	0.8[ad]
Tenderloin steak	3.2[bc]	1.9[b]	1.4[a]	1.0[d]	0.5[abc]	0.8[ce]	1.0[abc]	1.0[ac]
RMSE[e]	0.55	0.59	0.53	0.49	0.27	0.43	0.33	0.46

[abcde]Least squares mean values within a column and effect followed by the same letter are not significantly different ($P > 0.05$).
[e] Root Mean Square Error
[f] P-value from analysis of variance tables
[g] Intensities greater than 0.5
[i]Flavor measured where 0 = none and 15 = extremely intense.

Table 7. Least squares means for significant, detectable[j] beef flavor attributes[i] segmented by cut.

Effect	Beefy	Brown/ Roasted	Bloody/ Serumy	Fat-like	Metallic	Liver-like	Umami	Sour	Salty	Bitter
<u>*Cut*</u>	*0.0001*[h]	*0.0001*[h]	*0.013*[h]	*0.0001*[h]	*0.0001*[h]	*0.0001*[h]	*0.0001*[h]	*0.0001*[h]	*0.0044*[h]	*0.03*[h]
Bottom round roast	3.4[a]	1.1[a]	2.4[acd]	1.3[ae]	1.6[acd]	1.6[b]	1.4[d]	2.7[bc]	1.1[ab]	1.4[a]
Eye of round roast	3.1[b]	1.0[a]	2.1[bd]	1.0[de]	1.5[dfg]	1.2[ad]	1.2[df]	2.6[bc]	1.1[a]	1.2[ab]
Inside round roast	3.4[a]	1.0[a]	2.5[c]	1.1[de]	1.7[ce]	1.3[ae]	1.3[de]	2.8[b]	1.1[ac]	1.4[a]
Knuckle roast	3.4[a]	1.1[a]	2.4[acd]	1.3[ad]	1.5[adg]	1.3[a]	1.4[cd]	2.6[bc]	1.3[b]	1.2[acd]
Flat iron steak	4.0[c]	2.0[b]	2.3[abcd]	3.0[b]	1.2[b]	1.3[be]	1.7[ae]	2.0[a]	1.1[adc]	1.1[bc]
Top sirloin steak	3.8[c]	1.7[c]	2.3[abcd]	1.5[ca]	1.6[acdf]	1.0[cde]	1.6[bc]	2.8[bc]	1.2[bc]	1.1[b]
Top loin steak	3.9[c]	1.8[bc]	2.2[bd]	1.7[c]	1.4[bg]	0.9[c]	1.6[abc]	2.5[c]	1.2[bd]	1.1[b]
Tenderloin steak	4.0[c]	1.8[bc]	2.5[ac]	1.7[c]	1.5[adg]	1.4[ab]	1.8[ab]	2.5[c]	1.2[bd]	1.2[bd]
RMSE[g]	0.53	0.52	0.57	0.70	0.32	0.62	0.40	0.60	0.24	0.36

[abcdefg]Least squares mean values within a column and effect followed by the same letter are not significantly different (P > 0.05)
[g] Root Mean Square Error
[h] P-value from analysis of variance tables.
[i]Flavor measured where 0 = none and 15 = extremely intense.
[j] Intensities greater than 0.5

temperatures than oven roasting. This reaction induces aroma and flavor changes in the product that can be characterized as caramelized or brown/roasted. Umami is the taste described as savory, brothy or beefy and is produced by compounds like glutamic acid, glutamates and nucleotides, which are all naturally present in beef (Brewer, 2006). Since beefy aroma and flavor are so closely related to umami flavor, steak cuts that were perceived to be more intense in beef aroma and flavor were also rated higher for umami flavor.

Degree of doneness was closely controlled using thermocouples inserted in the geometric center of each roast and cut so differences in bloody/serumy aroma and flavor attributes are probably due to inherent differences in cuts. Roast cuts, except for the eye of round roast were perceived to have slightly more intense bloody/serumy aroma than the steaks (Table 6a and 7a). The roasts from the round tend to have higher heme content than the steak cuts (Patten, Hodgen, Stelzleni, Calkins, Johnson and Gwartney, 2008). Myglobin and hemoglobin have several distinct aroma and flavor characteristics, one of them being bloody/serumy flavor. In addition, the roasts did not have high intensities of the other aroma attributes that would mask the bloody/serumy aroma as they did in the steak cuts. Top loin steaks, like the eye of round roasts, were perceived as having low bloody aroma and flavor as compared to the other steak and roast cuts (Table 6a and 7a). Top loin steaks had significantly ($p<0.05$) lower bloody/serumy aroma than all the other cuts and lower bloody/serumy flavor than inside round roasts and tenderloin steaks. As top loin steaks are lower in myoglobin content than many of these cuts, these results are not surprising (McKenna, Mies, Baird, Pfeiffer, Ellebracht, and Savell, 2005).

The roast cuts also had lower fat-like aroma compared to the steak cuts. As the roasts are from the round cut of the animal, they are lower in chemical lipid than the steaks cuts. Terrell, Suess and Bray (1969) quantified the lipid composition of six bovine muscles and found significantly less chemical lipid in several of the round muscles (eye of round and inside round) as compared to some of the steak cuts (top loin and tenderloin). The results indicate that the chemical lipid differences were detectable by trained sensory panelists and contribute to the aroma and flavor differences in beef cuts.

Flat iron steaks were rated significantly higher than all other cuts for both fat-like aroma and flavor. In addition, flat iron and tenderloin steaks were rated higher for liver-like aroma and flavor than both top loin and top sirloin steaks. Flat irons were also perceived as having the lowest sour flavor among all the cuts (Table 7a). In a study conducted to determine flavor relationships among muscles from the beef chuck and round, the *infraspinatus* (Flat Iron) was tested by a descriptive sensory panel and was characterized as having higher fatty flavor and lower sour flavor than the other muscles tested in the study (Meisinger et. al, 2006). The results of that study are similar to our results. Flat iron steaks are a value-added cut developed from the chuck and have been added to menus as a steak comparable to top sirloin and top loin steaks. There have been some complaints that flat iron steaks will intermittently have a high level of livery and metallic flavors. Livery flavor is derived from the myoglobin content and oxidation of lipids. The higher fat and liver flavors in the flat iron steak are indicative that flavor issues may arise. Also, flat iron steaks were lowest in sour flavor. The combination of slight differences in flavor attributes most likely slightly differentiates the flat iron steak from top loin and top sirloin steaks.

Principle Component Analysis

Pricinple Component Analysis (PCA) was performed on select samples and locations in order to study patterns, if any, among the samples. Figure 13 is a PCA plot of sample scores as distributed by location. PC1 explained 60% and PC2 explained 23% of the total varation in the data set. There appeared to be three major clusters of samples; the clusters seem to be grouped by location, with cluster 1 comprised of samples evaluated at Location 1 (designated by square markers), cluster 2 comprised of samples evaluated at Location 2 (designated by triangle markers) and cluster 3 comprised of samples evaluated at Location 3 (designated by circle markers).

As indicated by the graph, there is clear separation of the scores by location. Panelsits at each location rated the samples differently. In cluster 1, there are two sub-groups with the steaks in one group and the roasts in another. Among the other clusters, the distinction between steaks and roasts were not as signifcant as in cluster 1. This indicated that panelists at location 1 (cluster 1) were able to better differentiate between the different types of cuts. Despite the rating differences among the locations, the overall characterizations of the cuts among the panels were the same.

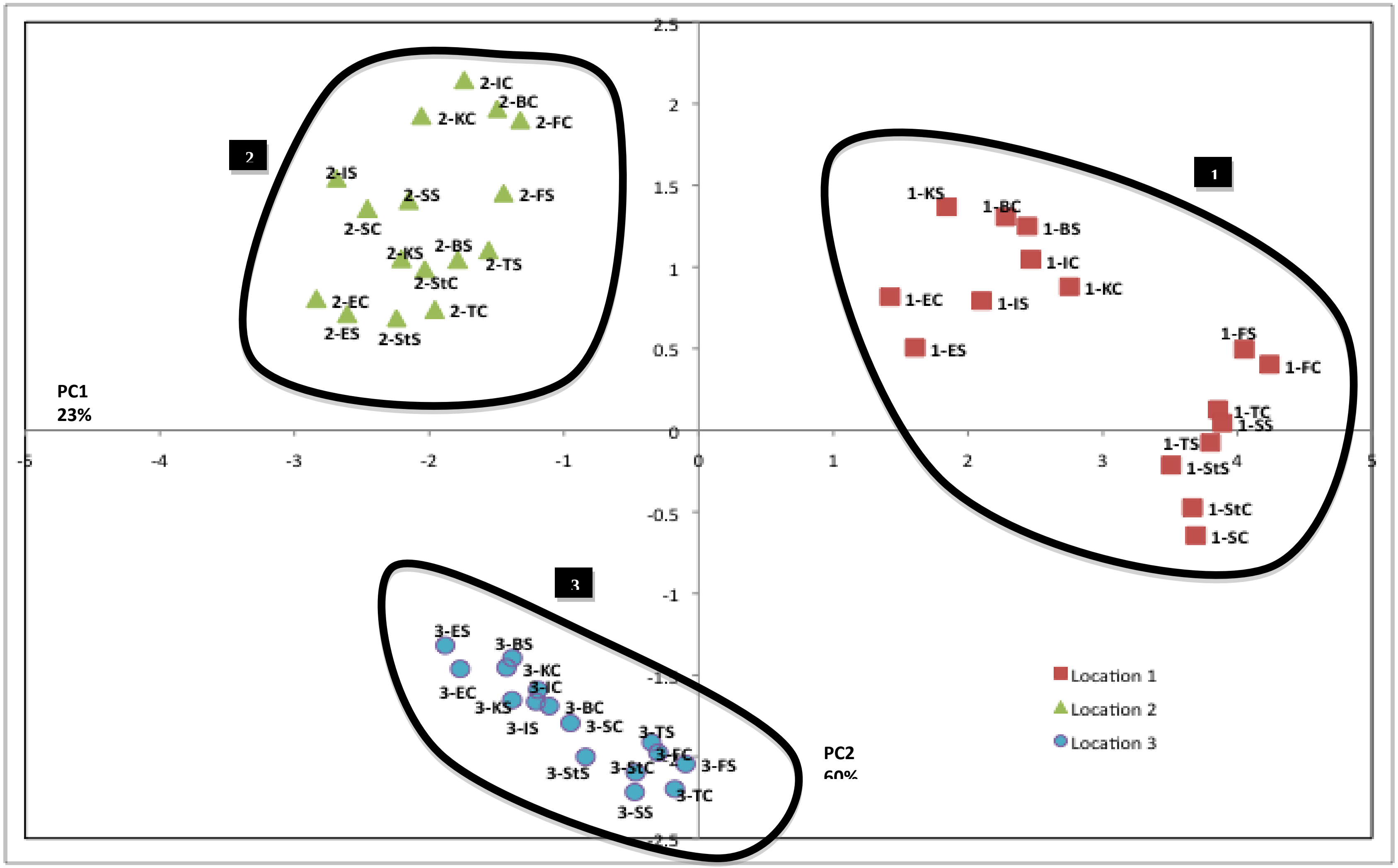


Figure 13. Principal component analysis plot of cuts specified by location, cut and Quality Grade. Location is designated by either a "1", "2" or "3". Cut is designated by the letters after the hyphen, so that I=inside round roast; B=bottom round roast; E=eye of round roast; K=knuckle roast; F=flat iron steak; T= tenderloin steak; St=strip/top loin steaks and S=top sirloin steaks. Quality grade follows the cut abbreviation and is designated as C=Choice and S=Select.

Figures 14, 15 and 16 are bi-plots of sample scores with detectable (intensities greater than 0.5) aroma and flavor attributes. Figure 14 shows the distribution of samples scores from location 1 in relation to certain aroma and flavor attributes. PC1 explained 80% and PC2 explained 8% of the total variation. There appeared to be three major clusters among the samples. Cluster 1 consisted of roast samples and was primiarly described to have “liver-like”, “barnyard”, “bloody”, “bitter”, “musty” and “sour” characteristics. Cluster 2 was composed of all the steak cuts except Choice and Select flat iron steaks. These samples were characterized by “browned” and “beefy” attributes. Cluster 3 consisted of both Choice and Select flat iron steaks and was in closer proximity to “fatty” and “browned” attributes. In general panelists at location 1 evaluated the roast cuts as having more “off” or “negative” attributes as compared to the steak cuts. Steak cuts were more associated with “characteristic” or “postive” notes.

Figure 15 is a bi-plot that examines the differences among samples at location 2 . PC1 explained 59% and PC2 explained 18% of the total variation. The analysis divided the samples into four clusters. Cluster 1 consisted of both Choice bottom and inside round roast samples. These samples were characterized by “bloody”, “liver”, and “sour” notes. Cluster 2 was composed of both roast and steak cuts and the samples were mainly characterized by their “bitter”, “sour”, “metallic”, “sweet” and “umami” aromas and flavors. Cluster 3 consisted of several roast and steak samples that was characterized by their “grassy” flavor. Cluster 4 included Choice and Select flat iron steaks and can be mainly characterized by their high “fatty” flavor. Overall, panelists at location 2 percieved the flavor of roast and steaks somewhat differently, with the most

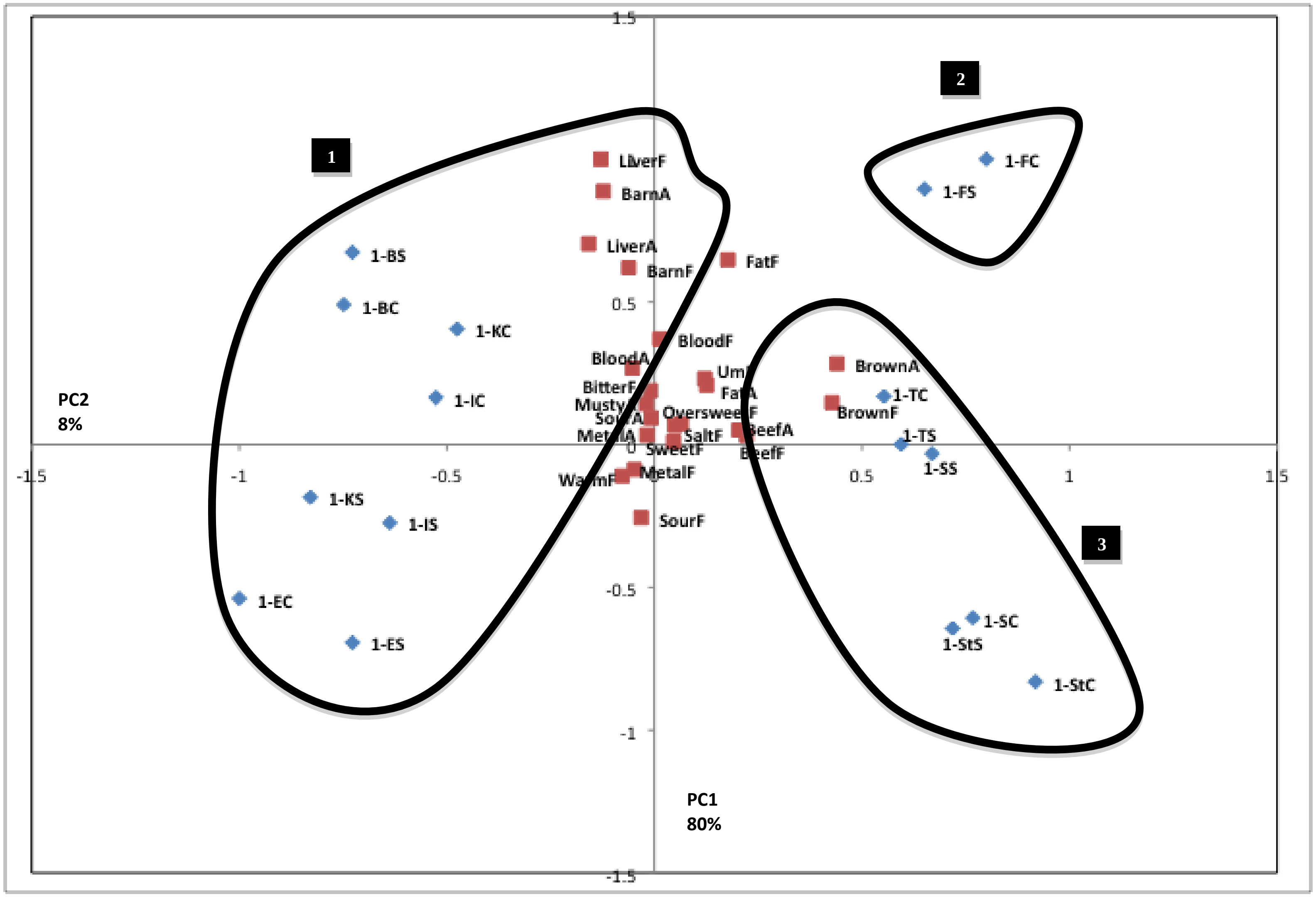


Figure 14. Bi-plot of cuts specified by location 1, cut and Quality Grade with detectable (>0.5) aroma and flavor attributes. Location is designated by a “1”. Cut is designated by the letters after the hyphen, so that I=inside round roast; B=bottom round roast; E=eye of round roast; K=knuckle roast; F=flat iron steak; T= tenderloin steak; St=strip/top loin steaks and S=top sirloin steaks. Quality grade follows the cut abbreviation and is designated as C=Choice and S=Select.

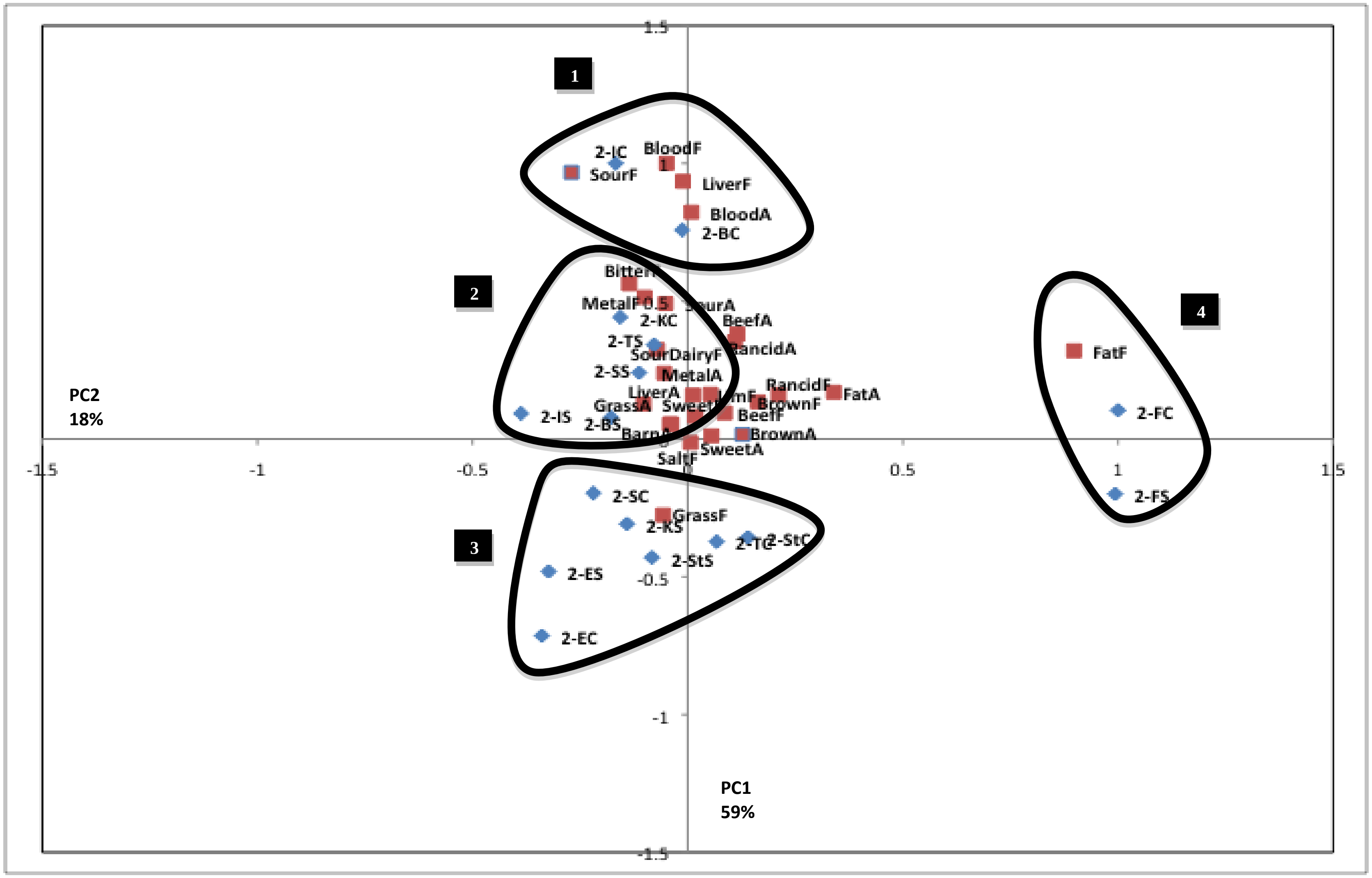


Figure 15. Bi-plot of cuts specified by location 2, cut and Quality Grade with detectable (>0.5) aroma and flavor attributes. Location is designated by a “2”. Cut is designated by the letters after the hyphen, so that I=inside round roast; B=bottom round roast; E=eye of round roast; K=knuckle roast; F=flat iron steak; T= tenderloin steak; St=strip/top loin steaks and S=top sirloin steaks. Quality grade follows the cut abbreviation and is designated as C=Choice and S=Select.

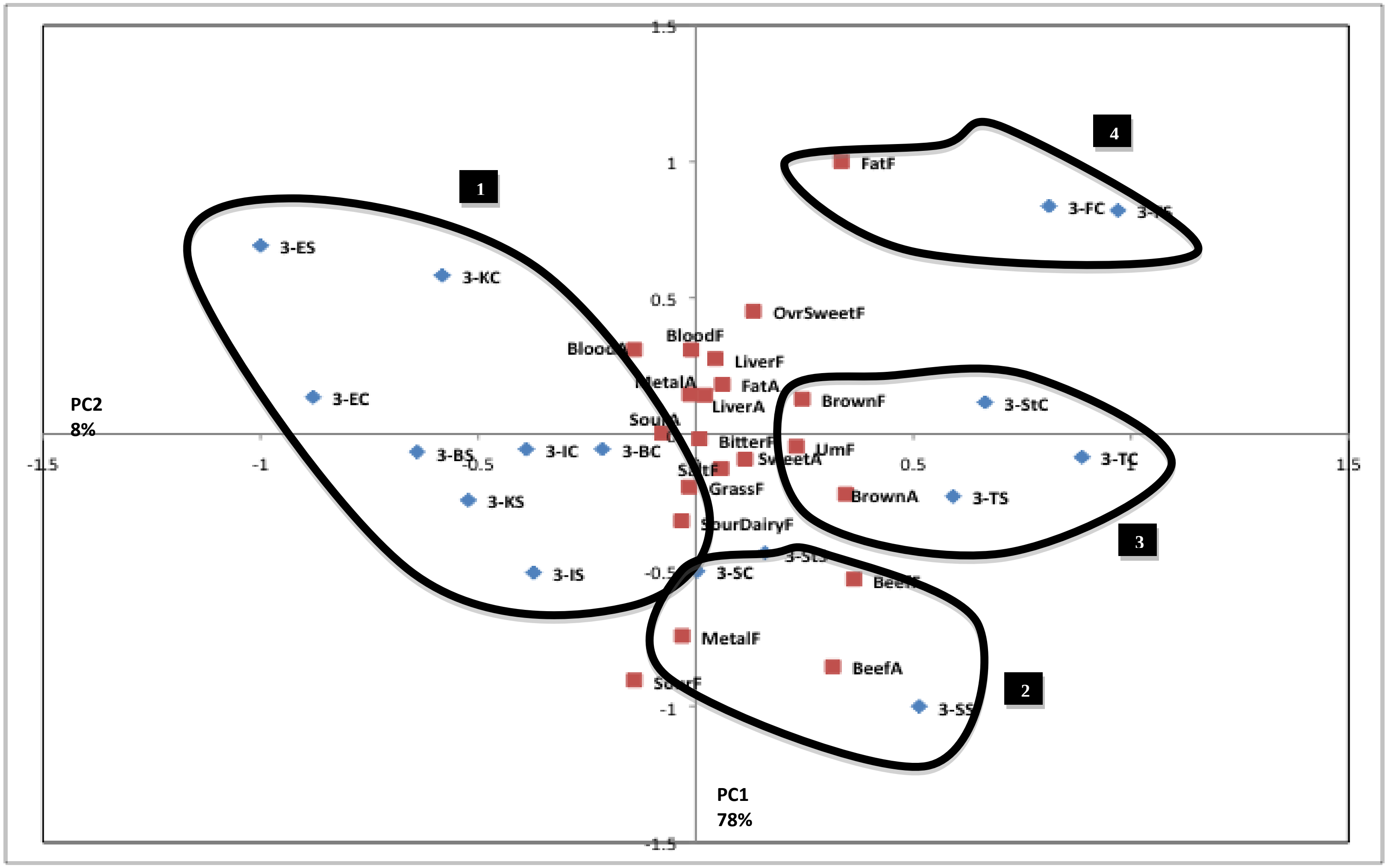


Figure 16. Bi-plot of cuts specified by location 3, cut and Quality Grade with detectable (>0.5) aroma and flavor attributes. Location is designated by a “3”. Cut is designated by the letters after the hyphen, so that I=inside round roast; B=bottom round roast; E=eye of round roast; K=knuckle roast; F=flat iron steak; T= tenderloin steak; St=strip/top loin steaks and S=top sirloin steaks. Quality grade follows the cut abbreviation and is designated as C=Choice and S=Select.

differentiation among the flat iron steaks. However, the separation among samples was not as defined as location 1. Figure 16 represents the distribution of sample scores from location 3 in realation to detectable aroma and flavor characteristics. PC1 explained 78% and PC2 explained 8% of the total varation. These samples can be separated into 4 major clusters. Cluster 1 consisted of roast samples and is characterized by “bloody”, “bitter”, “metallic”, “grassy” and “liver-like” notes. Select strip and top sirloin steaks were grouped into cluster 2 and had higher “sour”, “metallic” and “beefy” flavors. Cluster 3 included Choice strip and tenderloin steaks, which were high in “browned” flavor, “browned” aroma and “umami” flavor. Cluster 4 was composed of Choice and Select flat iron steaks and was characterized by their “fat-like” flavor. Bi-plots of locations 1, 2 and 3 (Figures 14, 15 and 16) did show some similar patterns of differentiation. In general, roast cuts were evaluated by each location as having higher “off” or “negative” notes and steaks were rated to have higher “characteristic” or “positive” notes.

Figure 17 examined the distribution of samples designated by cut and quality grade and their relationships among each other without the effect of location. PC1 explained 70% and PC2 explained 14% of the total variation in the data set. There appears to be three major clusters of beef samples. Cluster 1 was composed of the roast cuts, cluster 2 consisted of all the steak cuts, except for the flat iron steaks and cluster 3 was composed of the flat iron steaks.

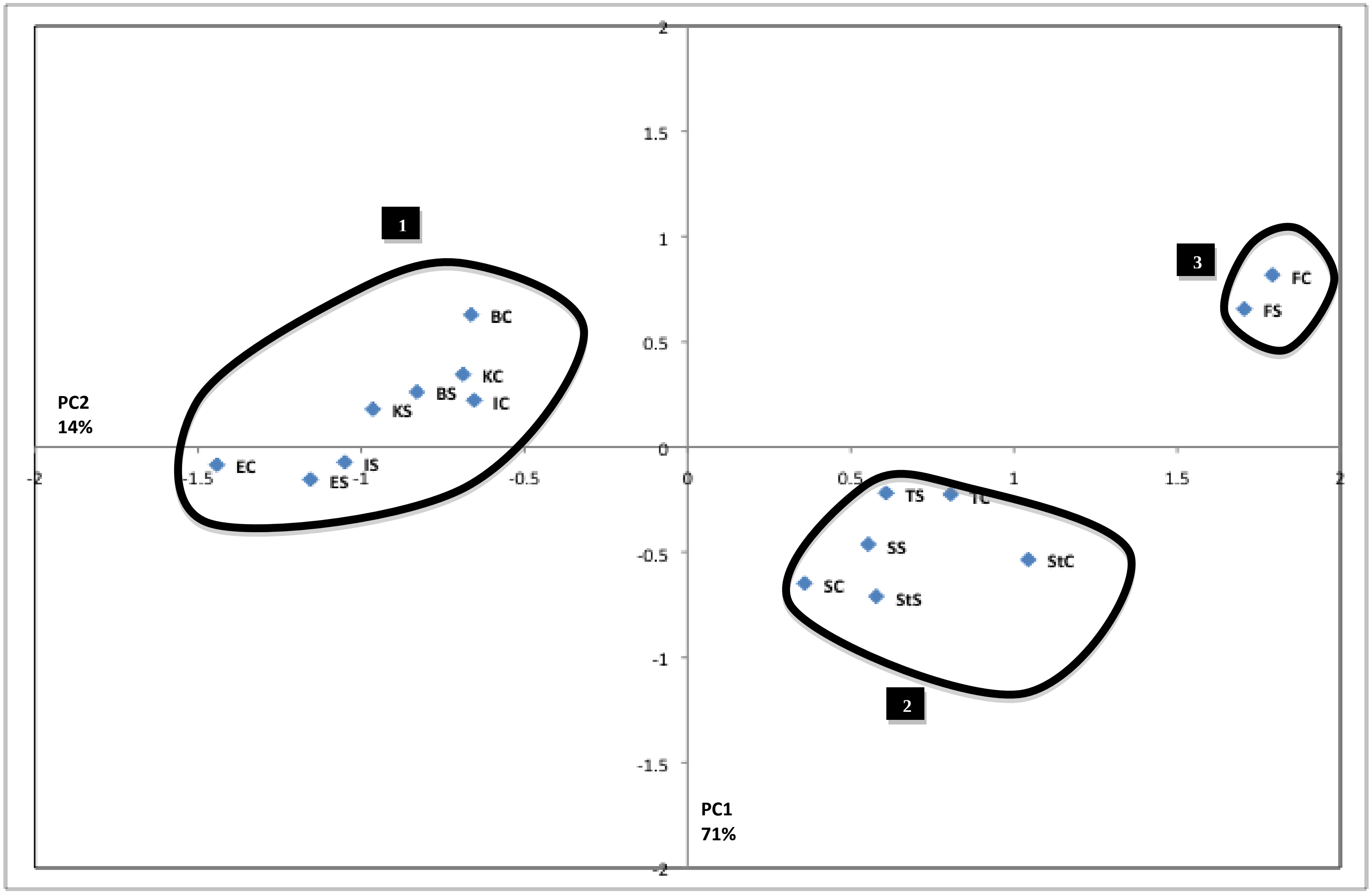


Figure 17. Principle component analysis plot of cuts specified by cut and Quality Grade without the effect of location. Cut is designated by letters, so that I=inside round roast; B=bottom round roast; E=eye of round roast; K=knuckle roast; F=flat iron steak; T= tenderloin steak; St=strip/top loin steaks and S=top sirloin steaks. Quality grade follows the cut abbreviation and is designated as C=Choice and S=Select.

Cooking method and cut were factors that could potentially distinguish each of the groups. The formation of the groups and their separation was expected since roasts were rated similarly and steaks were also rated similarly. Among the steaks, the flat irons were not grouped with the other steaks. Flat irons were rated differently from the other steak cuts for several attributes.

Figure 18 is a bi-plot; it is the distribution of samples as seen in Figure 17 with added detectable attributes (intensities greater than 0.5). Cluster 1 was composed of the roast cuts and was in closer proximity to attributes that could be defined as “off” or “negative”. The cuts can be characterized by “liver”, “bloody/serumy”, “sour”, “metallic”, and “barnyard” aroma and flavor attributes. Cluster 2 included all the steak cuts except the flat iron. These cuts were characterized by attributes such as “beefy”, “brown/roasted”, and “umami.” Cluster 3 consisted of the flat iron steaks (Choice and Select) and can be mainly characterized by their fat flavor. As reported in previous studies, cooking method seemed to be the primary factor in determining the flavor profile of beef. Bhumiratana et al (2010) found that countertop electric charbroiling and electric grilling consistently brought out desirable aroma and flavor attributes as compared to the other cooking methods used in the study. Our results were consistent with Bhumiratana et al (2010) and the steaks cuts, which were cooked on electric grills, were characterized mainly by desirable traits as opposed to the roast cuts, which were cooked in the oven.

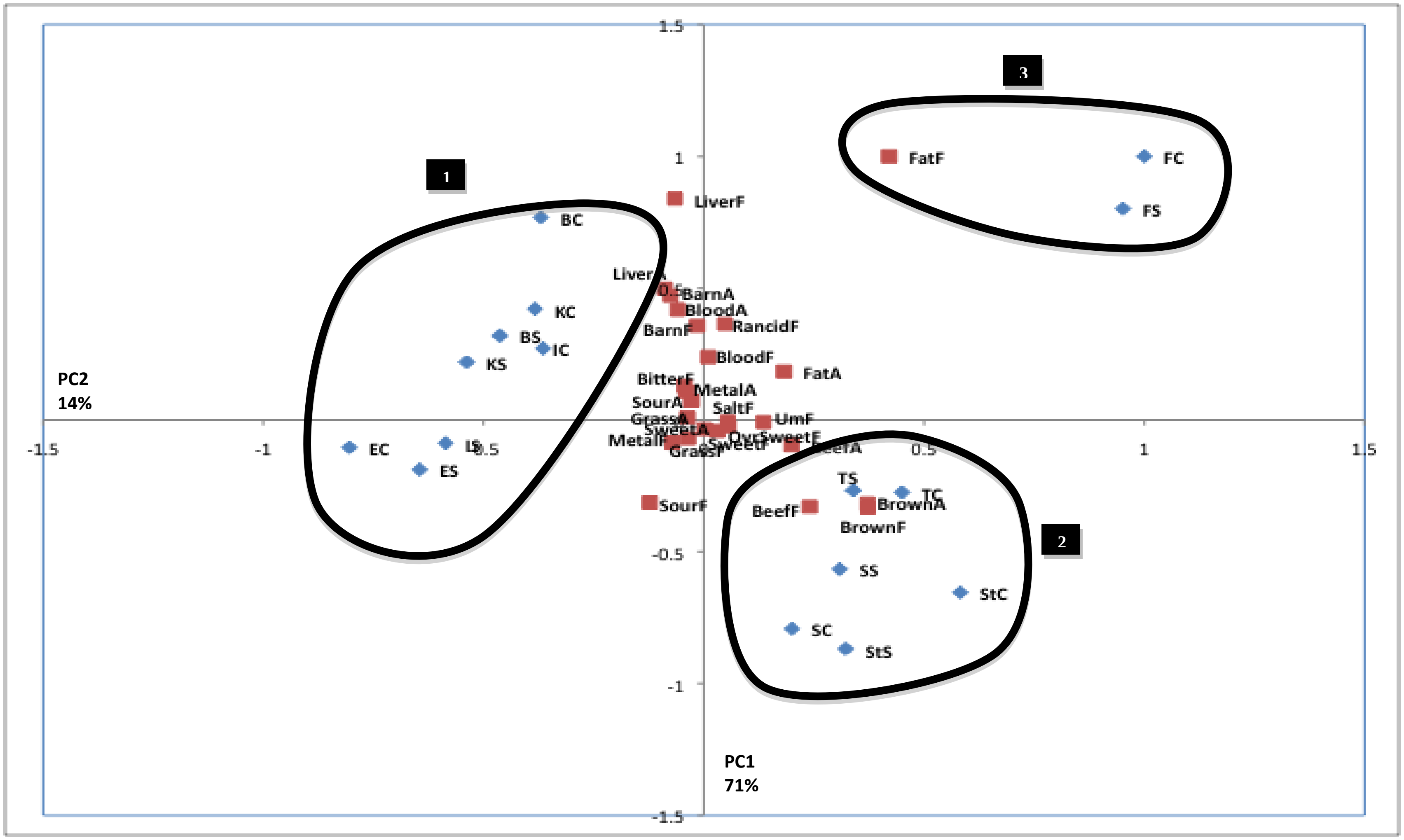


Figure 18. Bi-plot of cuts specified by cut and Quality Grade with detectable (>0.5) aroma and flavor attributes. Cut is designated by letters, so that I=inside round roast; B=bottom round roast; E=eye of round roast; K=knuckle roast; F=flat iron steak; T= tenderloin steak; St=strip/top loin steaks and S=top sirloin steaks. Quality grade follows the cut abbreviation and is designated as C=Choice and S=Select.

CHAPTER V

CONCLUSIONS

Data from this study indicated that panelists at each location effectively utilized the beef lexicon to characterize major beef cuts differing in Quality grade. Though differences were found for aroma and flavor attributes across the three panels, application of the beef lexicon was successfully implemented by all three locations. When location rating dissimilarities were found, differences in levels were no greater than two points on the scale and for most attributes, differences were one point or less. These differences in scale usage and attribute recognition among the panels can be credited to differences in panel leadership and hours of panelist training. As recommended by several studies, (Martin, Molimard, Spinnler and Schlich, 2000 and Drake et al., 2002) the most effective ways to rectify these differences are to lengthen panel training time, increase panel to panel communication and to promote strong panel leader interaction. However, despite the differences in panel ratings similar patterns of differentiation among samples were observed and panels were able to accurately communicate attribute differences among the beef samples.

Overall, cuts differed in aroma and flavor with the greatest differences between steaks and roasts. Within steak cuts, top loin steaks tended to be the lowest in aroma and flavor attributes and when different, top sirloin and tenderloin steaks tended to have slightly higher aroma and flavor attributes than top loin steaks. Flat iron steaks were high in fat-like and liver-like flavor attributes and would be defined as slightly different in flavor than the other three steaks. Roasts were slightly lower in beef and brown/roasted aroma and flavor than steaks. Many of the aroma and flavor differences between the steak and roast cuts can be attributed to the different cooking methods used.

Based on these results it can be concluded that the beef lexicon can be easily applied by panels and can effectively identify and rate intensity differences in beef aroma and flavor attributes. The beef lexicon can serve as viable research and product developmental tool and should be published in combination with the suggested training exercises for use by meat scientists across the world.

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APPENDIX A

LEXICON

MAJOR AROMA / FLAVOR NOTES

Beef flavor ID	Definition	Amount of beef flavor identity in the sample.	
	Aroma	Reference	Beef Brisket = 4.0 (Tasted) Swanson's Beef Broth = 5.0 (Tasted) 80% Lean Ground Chuck = 7.0 (Tasted)
		Preparation	Heat broth up to 165 ^{o}F (74 ^{o}C). Serve ½ oz in a 1 oz cup. Cook lean ground chuck on a pan to 160 ^{o}F (71 ^{o}C). Serve 1.5 oz in 3.25 oz cups, covered. Cut brisket into 1 inch thick steaks. Grill on High until internal temperature reach 160 F. Discard edges and cut into ½″ cubes. Serve 3 cubes in 3.25 oz cups.
	Flavor	Reference	Beef Brisket = 4.0 (Tasted) Swanson's Beef Broth = 5.0 (Tasted) 80% Lean Ground Chuck = 7.0 (Tasted)
		Preparation	Heat broth up to 165 ^{o}F (74 ^{o}C). Serve ½ oz in a 1 oz cup. Cook lean ground chuck on a pan to 160 ^{o}F (71 ^{o}C). Serve 1.5 oz in 3.25 oz cups, covered. Cut brisket into 1 inch thick steaks. Grill on High until internal temperature reach 160 F. Discard edges and cut into ½″ cubes. Serve 3 cubes in 3.25 oz cups.

Brown/Roasted	Definition	A round, full aromatic generally associated with beef suet that has been broiled.	
	Aroma	Reference	Beef Suet (broiled) = 8.5 (Tasted)
		Preparation	Pan-fry beef suet until brown. Cut suet into ½ inch pieces. Serve 2 pieces in 1 oz cups.
	Flavor	Reference	80% Lean Ground Chuck = 10.0 (Tasted)
		Preparation	Cook lean ground chuck on a pan to160 ^{o}F (71^{o} C). Serve 1.5 oz in 3.25 oz cups, covered.

Bloody/Serumy	Definition	An aromatic associated with blood on cooked meat products. Closely related to metallic aromatic.	
	Aroma	Reference	Select Strip Steak = 5.5 (Tasted) Beef Brisket = 6.0 (Tasted)
		Preparation	Grill Strip Steak on “High” until internal temperature reach 140^{o}F (60 ^{o}C). Serve 3 cubes in a 3.25 oz cups. Cut brisket into 1 inch thick steaks. Grill on High until internal temperature reach 160 ^{o}F (71 ^{o}C). Discard edges and cut into ½″ cubes. Serve 3 cubes in a 3.25 oz cups.
	Flavor	Reference	Select Strip Steak = 5.5 (Tasted) Beef Brisket = 6.0 (Tasted)
		Preparation	Grill Strip Steak on “High” until internal temperature reach 140^{o}F (60 ^{o}C). Serve 3 cubes in a 3.25 oz cups. Cut brisket into 1 inch thick steaks. Grill on High until internal temperature reach 160 ^{o}F (71 ^{o}C). Discard edges and cut into ½″ cubes. Serve 3 cubes in a 3.25 oz cups.

Fat-like	Definition	Aromatics associated with cooked animal fat.	
	Aroma	Reference	Beef suet (broiled) = 12.0 (Tasted)
		Preparation	Pan-fry beef suet until brown. Cut suet piece into 1/2 inch thick fat. Serve 2 pieces in 1 oz cups.
	Flavor	Reference	Hillshire Farms lit’l Beef Smokies = 7.0 (Tasted) Beef suet (broiled) = 12.0 (Tasted)
		Preparation	Microwave for 2 ½ min on high 1 package of smokies with ¼ cup of water in covered dish.. Serve 1 warm smoky in 3.25 oz cups. Pan-fry beef suet until brown. Cut suet into ½ inch pieces. Serve 2 pieces in 1 oz cups.

Metallic	Definition	The impression of slightly oxidized metal, such as iron, copper, and silver spoons.	
	Aroma	Reference	0.10% Potassium Chloride Solution = 1.5 (Tasted) Select Strip Steak = 4.0 (Tasted) Dole Canned Pineapple Juice = 6.0 (Tasted)
		Preparation	100 mg of potassium chloride in 1 L of deionized water. Serve in 1 oz cups. Grill Strip Steak on "High" until internal temperature reach 140°F (60 °C). Serve 3 cubes in 3.25 oz cups. The can of Dole Canned Pineapple Juice will be provided to the panelists. Panelists pour approximately ⅔ oz in 1 oz cups at the moment of testing.
	Flavor	Reference	0.10% Potassium Chloride Solution = 1.5 (Tasted) Select Strip Steak = 4.0 (Tasted) Dole Canned Pineapple Juice = 6.0 (Tasted)
		Preparation	100 mg of potassium chloride in 1 L of deionized water. Serve in 1 oz cups. Grill Strip Steak on "High" until internal temperature reach 140°F (60 °C). Serve 3 cubes in a 3.25 oz cups. The can of Dole Canned Pineapple Juice will be provided to the panelists. Panelists pour approximately ⅔ oz in 1 oz cups at the moment of testing.

Liver-like	Definition	Aromatics associated with cooked organ meat/liver.	
	Aroma	Reference	Beef Liver (broiled) = 7.5 (Tasted)
		Preparation	Pan-fry liver and cut into 2.54 cm (1- inch) square. Cut liver into 1/2 inch pieces thick liver. Serve 2 pieces in 1 oz cups.
	Flavor	Reference	Brauschweiger liver sausage = 10 (Tasted and swallowed)
		Preparation	1 teaspoon of Brauschweiger liver sausage in 3.25 ounce cups.

Green – haylike	Definition	Brown/green dusty aromatics associated with dry grasses, hay, dry parsley and tea leaves.	
	Aroma	Reference	Dry parsley in medium snifter = 5.0 (Smelled)
		Preparation	1 teaspoon of dry parsley in medium snifter. Cover.
	Flavor	Reference	Dry parsley in 1 oz cups = 6.0 (Tasted)
		Preparation	¼ teaspoon of dry parsley in 1 oz cups.

Umami	Definition	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 (Tasted)
		Preparation	350 mg of Accent Flavor Enhancer in 1 L of deionized water. Serve in 1 oz cups.

Overall Sweet	Definition	The combination of sweet taste and sweet aromatics.	
	Flavor	Reference	Post Shredded Wheat Spoon Size = 1.5 (Tasted) Hillshire Farms Lit'l Beef Smokies = 3.0 (Tasted)
		Preparation	Fill up 3.25 ounce cups with Shredded Wheat, covered. Microwave for 2 ½ min on high 1 package of smokies with ¼ cup of water in covered dish. Serve 1 warm smoky in 3.25 oz cups.

Sweet	Definition	Aromatics associated with the impression of sweet or the fundamental taste factor associated with a sucrose solution.	
	Aroma	Reference	SAFC Ethyl Maltol 99 % = 4.5 (Smelled)
		Preparation	Put 1 g of SAFC Ethyl Maltol 99 % in a medium snifter, covered.
	Flavor	Reference	2.0% Sucrose Solution = 2.0 (Tasted)
		Preparation	20 g of sucrose in 1 L of deionized water. Serve in 1 oz cups.

Sour Aromatics	Definition	Aromatics associated with sour substances.	
	Aroma	Reference	Dillon's buttermilk (covered) = 5.0 (Smelled)
		Preparation	Serve ½ oz buttermilk in 1 oz cups.

Sour	Definition	The fundamental taste factor associated with a citric acid solution.	
	Flavor	Reference	0.015% Citric Acid Solution = 1.5 (Tasted) 0.050% Citric Acid Solution = 3.5 (Tasted)
		Preparation	150 mg of citric acid in 1 L of deionized water. Serve in 1 oz cups. 500 mg of citric acid in 1 L of deionized water. Serve in 1 oz cups.

Salty	Definition	A fundamental taste factor of which sodium chloride is typical.	
	Flavor	Reference	0.15% NaCl Solution = 1.5 0.25% NaCl Solution = 3.5
		Preparation	1.5 g of NaCl in 1 L of deionized water. Serve in 1 oz cups. 2.5 g of NaCl in 1 L of deionized water. Serve in 1 oz cups.

Bitter	Definition	The fundamental taste factor associated with a caffeine solution.	
	Flavor	Reference	0.01% Caffeine Solution = 2.0 0.02% Caffeine Solution = 3.5
		Preparation	100 mg of Caffeine in 1 L of deionized water. Serve in 1 oz cups. 200 mg of Caffeine in 1 L of deionized water. Serve in 1 oz cups.

OTHER NOTES:

<table>
<tr><td rowspan="3">Animal hair</td><td>Definition</td><td colspan="2">The aromatic perceived when raw wool is saturated with water.</td></tr>
<tr><td rowspan="2">Aroma</td><td>Reference</td><td>Caproic acid (Hexanoic acid) = 12.0 (Smelled)</td></tr>
<tr><td>Preparation</td><td>Put one drop of caproic acid on cotton ball in a medium snifter, cover.</td></tr>
</table>

<table>
<tr><td rowspan="5">Barnyard</td><td>Definition</td><td colspan="2">Combination of pungent, slightly sour, hay-like aromatics associated with farm animals and the inside of a horn.</td></tr>
<tr><td rowspan="2">Aroma</td><td>Reference</td><td>White pepper in water = 4.5
Tinture of civet = 6.0</td></tr>
<tr><td>Preparation</td><td>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. Served in 3.25 oz cups covered.
Civet-Full strength: 3 drops on a cotton ball in a medium snifter, cover.</td></tr>
<tr><td rowspan="2">Flavor</td><td>Reference</td><td>White pepper in water = 4.0</td></tr>
<tr><td>Preparation</td><td>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. Served in 3.25 oz cups.</td></tr>
</table>

<table>
<tr><td rowspan="5">Burnt</td><td>Definition</td><td colspan="2">The sharp/acrid flavor note associate with over roasted beef muscle, something over baked or excessively browned in oil.</td></tr>
<tr><td rowspan="2">Aroma</td><td>Reference</td><td>Alf's Red Wheat Puffs (2 pieces) = 5.0 (Tasted)</td></tr>
<tr><td>Preparation</td><td>Fill up 1 oz cups with Red Wheat Puffs. The panelist will put two pieces in their mouths per tasting.</td></tr>
<tr><td rowspan="2">Flavor</td><td>Reference</td><td>Alf's Red Wheat Puffs (2 pieces) = 5.0 (Tasted)</td></tr>
<tr><td>Preparation</td><td>Fill up 1 oz cups with Red Wheat Puffs. Panelists put two pieces in their mouths per tasting.</td></tr>
</table>

Rancid	Definition	An aromatic commonly associated with oxidized fat and oils. These aromatics may include cardboard, painty, varnish, and fishy.	
	Aroma	Reference	Wesson Vegetable Oil (3 min) = 7.0 (Tasted) Wesson Vegetable Oil (5 min) = 9.0 (Tasted)
		Preparation	Microwave ½ cup oil on high power for 3 or 5 minutes. Let cool and pour approximately ⅓ oz into 1 oz cups.
	Flavor	Reference	Wesson Vegetable Oil (3 min) = 7.0 (Tasted) Wesson Vegetable Oil (5 min) = 9.0 (Tasted)
		Preparation	Microwave ½ cup oil on high power for 3 or 5 minutes. Let cool and pour approximately ⅓ oz into 1 oz cups.

Heated oil	Definition	The aromatics associated with oil heated to a high temperature.	
	Aroma	Reference	Lays potato chips = 4.0 (Smelled) Wesson vegetable oil = 7.0 (Tasted)
		Preparation	Place 4 whole potato chips in a large snifter, covered. Microwave ½ cup oil on high power for 3 minutes. Let cool and pour approximately ⅓ oz into 1 oz cups.
	Flavor	Reference	Wesson vegetable oil = 7.0 (Tasted)
		Preparation	Microwave ½ cup oil on high power for 3 minutes. Let cool and pour approximately ⅓ oz into 1 oz cups.

Chemical	Definition	Aromatic associated with garden hose, hot Teflon pan, plastic packaging and petroleum based products such as charcoal liter fluid.	
	Aroma	Reference	Zip-Loc in a medium snifter = 13.0 (Smelled)
		Preparation	Put 1 sandwich Zip-Loc bag in a medium snifter, covered.
	Flavor	Reference	Clorox® in water = 6.5 (Tasted)
		Preparation	1 drop of Clorox in 200 mL of deionized water. Serve approximately 1/3 oz in 1 oz cup.

Leather (old)	Definition	Musty, old leather (like old book bindings).	
	Aroma	Reference	2,3,4-Trimethoxybenzaldehyde (neat) = 3.0 (Smelled)
		Preparation	One drop on a cotton ball in a medium snifter, covered.

Apricot		Fruity aromatics that can be described as specifically apricot.	
	Flavor	Reference	Sun sweet dried apricot = 7.5 (Tasted)
		Preparation	Serve 1 dried apricot in 1 oz cup.

Green	Definition	Sharp slightly pungent aromatics associated with green/plant/vegetable matter such as parsley, spinach, pea pod, fresh cut grass, etc.	
	Aroma	Reference	Hexanal in propylene glycol (5000 ppm) = 6.5 (Smelled)
		Preparation	50 ml of Hexanal diluted to 10 mL with propylene glycol in a volumetric flask. Dip an Orlandi Perfumer Strip #27995 2.2cm into the prepared solution (second marking line) and place dipped strip (marking line up) in a glass test tube with screw cap.
	Flavor	Reference	Fresh parsley water = 9.0 (Tasted)
		Preparation	25 g of fresh parsley, rinse, chop, and add 300 ml of water. Let sit for 15 min. Filter and serve ½ oz of the liquid part in 1 oz cups.

Asparagus	Definition	The slightly brown, slightly earthy green aromatics associated with cooked green asparagus.	
	Aroma	Reference	Asparagus water = 7.5 (Smelled)
		Preparation	Weigh 40 g of fresh asparagus, wash, dice, add 300 ml water, cover, microwave for 3 min on high. Serve ½ oz of the supernatant in 1 oz cups.
	Flavor	Reference	Asparagus water = 6.5 (Tasted)
		Preparation	Weigh 40 g of fresh asparagus, wash, dice, add 300 ml of water, cover, microwave during 3 minutes on high. Serve ½ oz of the liquid part in 1 oz cups.

Musty-Earthy/Humus	Definition	Musty, sweet, decaying vegetation.	
	Aroma	Reference	1000 ppm of 2,6-Dimethylcyclohexanol (in propylene glycol) = 9.0 (Smelled)
		Preparation	10 ml of 2,6-Dimethylcyclohexanol diluted to 10 mL with propylene glycol in a volumetric flask. One drop of the solution on a cotton ball in a medium snifter, covered.

<table>
<tr><td rowspan="5">Cumin</td><td>Definition</td><td colspan="2">The aromatics commonly associated with cumin and characterized as dry, pungent, woody and slightly floral.</td></tr>
<tr><td rowspan="2">Aroma</td><td>Reference</td><td>McCormick or Shilling Ground Cumin = 10.0 (Smelled)</td></tr>
<tr><td>Preparation</td><td>¼ teaspoon cumin in a medium snifter, covered.</td></tr>
<tr><td rowspan="2">Flavor</td><td>Reference</td><td><u>McCormick or Shilling Ground Cumin = 7.0 (Tasted)</u></td></tr>
<tr><td>Preparation</td><td>Place ¼ teaspoon cumin in 1 oz cup. Panelists take one pinch into their mouth.</td></tr>
</table>

<table>
<tr><td rowspan="5">Floral</td><td>Definition</td><td colspan="2">Sweet light, slightly perfume impression associated with flowers.</td></tr>
<tr><td rowspan="2">Aroma</td><td>Reference</td><td>Welch’s White grape juice = 5.0 (Tasted)

Geraniol = 7.5 (Smelled)</td></tr>
<tr><td>Preparation</td><td>Dilute Welch’s White grape juice with water of a 1:1 ratio. Serve approximately ½ oz in 1 oz cups.
Put 2 drops of geraniol on a cotton ball, serve in a large snifter, covered.</td></tr>
<tr><td rowspan="2">Flavor</td><td>Reference</td><td><u>Welch’s White grape juice = 5.0 (Tasted)</u></td></tr>
<tr><td>Preparation</td><td>Dilute Welch’s White grape juice with water of a 1:1 ratio. Serve approximately ½ oz in 1 oz cups.</td></tr>
</table>

<table>
<tr><td rowspan="5">Beet</td><td>Definition</td><td colspan="2">A dark damp-musty-earthy note associated with canned red beets.</td></tr>
<tr><td rowspan="2">Aroma</td><td>Reference</td><td>Food club sliced beets = 6.0 (Tasted)</td></tr>
<tr><td>Preparation</td><td>1 part juice to 2 parts water served ½ oz in 1 oz cups.</td></tr>
<tr><td rowspan="2">Flavor</td><td>Reference</td><td><u>Food club sliced beets = 4.0 (Tasted)</u></td></tr>
<tr><td>Preparation</td><td>1 part juice to 2 parts water served ½ oz in 1 oz cups.</td></tr>
</table>

Chocolate/Cocoa	Definition	Aromatics associated with cocoa beans and powdered cocoa and chocolate bars. Brown, sweet, dusty, often bitter aromatics.	
	Aroma	Reference	Hershey chocolate kiss = 7.5 (Tasted)
		Preparation	Put one Hershey chocolate kiss (wrapped) in 1 oz cups.
	Flavor	Reference	Hersey cocoa powder in water = 3.0 (Tasted) Hersey chocolate kiss = 8.5 (Tasted)
		Preparation	½ tea spoon cocoa powder in ½ cup of water. Serve ½ oz in 1 oz cups. Put one Hershey chocolate kiss (wrapped) in 1 oz cups.

Medicinal	Definition	A clean sterile aromatic characteristic of antiseptic like products such as Band-Aids, alcohol and iodine.	
	Aroma	Reference	Band-Aid = 6.0 (Smelled)
		Preparation	Place 1 Band-Aid in a medium snifter, covered.

Petroleum-like	Definition	A specific chemical aromatic associated with crude oil and it's refined products that have heavy oil characteristics.	
	Aroma	Reference	Vaseline petroleum jelly = 3.0 (Smelled)
		Preparation	1/2 teaspoon of Vaseline in 1 oz cups.

Smoky charcoal	Definition	An aromatic associated with meat juices and fat dripping on hot coats which can be acrid, sour, burned, etc.	
	Aroma	Reference	Wright's Natural Hickory seasoning in water = 9.0 (Smelled)
		Preparation	Put ¼ tsp seasoning in 100 ml water in a large snifter, covered.

Smoky wood	Definition	Dry, dusty aromatic reminiscent of burning wood.	
	Aroma	Reference	Wright's Natural Hickory seasoning in water = 7.5 (Smelled)
		Preparation	Put ¼ tsp seasoning in 100 ml water in a large snifter, covered.

Spoiled-putrid	Definition	The presence of inappropriate aromatics and flavors that is commonly associated with the products. It is a foul taste and or smell that indicates the product is starting to decay and putrefy.	
	Aroma	Reference	Dimethyl disulfide (10000 ppm) = 12.0
		Preparation	100 ml of dimethyl disulfide diluted to 10 mL with propylene glycol in a volumetric flask. Dip an Orlandi Perfumer Strip #27995 2.2cm into the prepared solution (second marking line) and place dipped strip (marking line up) in a Fisherbrand Disposable Borosilicate Glass Tubes with Threaded End (15x150mm), cap.

Dairy	Definition	Aromatics associated with products made from cow's milk, containing butter fat such as cream, milk, sour cream or butter milk.	
	Aroma	Reference	Dillon's 2 % milk = 8.0 (Tasted)
		Preparation	¾ oz of milk in 1 oz cups.
	Flavor	Reference	Dillon's 2 % milk = 8.0 (Tasted)
		Preparation	¾ oz of milk in 1 oz cups.

Buttery	Definition	Sweet, dairy-like aromatic associated with natural butter.	
	Aroma	Reference	Land O'Lakes Unsalted Butter = 7.0 (Tasted)
		Preparation	½ tablespoon of butter in 1 oz cups.
	Flavor	Reference	Land O'Lakes Unsalted Butter = 7.0 (Tasted)
		Preparation	½ tablespoon of butter in 1 oz cups.

Cooked milk	Definition	The combination of sweet, brown flavor notes, and aromatics associated with heated milk.	
	Aroma	Reference	Dillon's whole milk = 4.5 (Tasted) Mini Babybel Original Swiss Cheese Regular = 2.5 (Tasted)
		Preparation	1 cup whole milk microwaved on high for 2 min. Serve ½ oz milk in 1 oz cups. Serve one Mini Babybel Cheese Regular (remove the plastic wrapping) in 3.25 oz cups.
	Flavor	Reference	Dillon's whole milk = 4.5 Mini Babybel Original Swiss Cheese Regular = 2.5
		Preparation	1 cup whole milk microwaved on high for 2 min. Serve ½ oz milk in 1 oz cups. Serve one Mini Babybel Cheese Regular (remove the plastic wrapping) in 3.25 oz cups.

Sour milk/Sour dairy	Definition	Sour, fermented aromatics associated with dairy products such as buttermilk and sour cream.	
	Aroma	Reference	Laughing Cow Light Swiss Cheese = 3.0 (Smelled) Dillon's Buttermilk = 4.0 (Smelled)
		Preparation	Serve one Laughing Cow Light Swiss Cheese (remove the aluminum wrap) in 3.25 oz cups. Serve ½ oz buttermilk in 1 oz cups.
	Flavor	Reference	Laughing Cow Light Swiss Cheese = 7.0 (Tasted) Dillon's Buttermilk = 9.0 (Tasted)
		Preparation	Serve one Laughing Cow Light Swiss Cheese (remove the aluminum wrap) in 3.25 oz cups. Serve ½ oz buttermilk in 1 oz cups.

Refrigerator stale	Definition	Aromatics associated with products left in refrigerator for an extended period of time and absorbing a combination of odors (lack of freshness/flat).	
	Aroma	Reference	Ground beef = 5.5 (Smelled)
		Preparation	Cook approximately ½ pound ground beef in a skillet over medium-high temperature until internal temperature of 165 ^{o}F is reached. Drain grease and left cool. Store overnight in a covered glass container. Serve at room temperature in 3.25 oz cups.
	Flavor	Reference	Ground beef = 4.5 (Tasted)
		Preparation	Cook approximately ½ pound ground beef in a skillet over medium-high temperature until internal temperature of 165 ^{o}F is reached. Drain grease and left cool. Store overnight in a covered glass container. Serve at room temperature in 3.25 oz cups.

Soapy	Definition	An aromatic commonly found in unscented hand soap.	
	Aroma	Reference	Ivory Bar Soap = 6.5 (Smelled)
		Preparation	Place 0.5 g bar soap in 100 ml of room temperature water. Serve in large snifter, covered.

Warmed over	Definition	Perception of a product that has been previously cooked and reheated.	
	Aroma	Reference	Reheated ground beef = 6.0 (Tasted)
		Preparation	Cook approximately ½ pound ground beef in a skillet over medium-high temperature until internal temperature of 165 ^{o}F is reached. Drain grease and left cool. Store overnight in a covered glass container. The next morning re-heat cooked ground beef in a 400 ^{o}F oven in an 8×8″ glass baking dish until internal temperature of 165 ^{o}F is reached (approximately 7 min). Serve 1.5 oz in 3.25 oz cups.
	Flavor	Reference	Reheated ground beef = 6.0 (Tasted)
		Preparation	Cook approximately ½ pound ground beef in a skillet over medium-high temperature until internal temperature of 165 ^{o}F is reached. Drain grease and left cool. Store overnight in a covered glass container. The next morning re-heat cooked ground beef in a 400 ^{o}F oven in an 8×8″ glass baking dish until internal temperature of 165 ^{o}F is reached (approximately 7 min). Serve 1.5 oz in 3.25 oz cups.

APPENDIX B

TRAINING GUIDELINE

Suggested lexicon training exercises provided for use in training using the Beef Lexicon prior to completing the evaluation of steaks and roasts in Phase II.

Day 1

-Introduce Lexicon and Project Objectives

- Objectives:
    - To determine the efficacy of the Beef flavor Lexicon
    - To characterize the flavor of 8 different muscle cuts across two different grades. (Choice and Select)

-Present Universal Scale for flavor intensity

- 2.0-Soda flavor in Saltine Crackers
- 5.0-Apple flavor in Motts Apple Sauce
- 7.0-Orange flavor in Minute Maid Orange Juice
- 10.0-Grape flavor in Welch's Grape Juice
- 12.0-Cinnamon flavor in Big Red Chewing Gum

-Introduce Basic Tastes-recognize intensity levels across attributes

- Salt
- Sweet
- Bitter
- Sour

-Taste non-meat items for flavor intensity and basic tastes

- Lay's Classic Potato Chips
    - Rate potato flavor using universal scale
    - Salt-12.0
    - Sweet-4.5
    - Sour-1.5
    - Bitter-2.0
- Minute Maid Orange Juice-Frozen Concentrate Reconstituted
    - Rate Orange flavor using universal scale
    - Sweet-8.0
    - Sour-3.5
    - Bitter-1.5
- Haagen-Dazs Vanilla Ice Cream
    - Rate vanilla flavor using universal scale
    - Sweet-12.0
    - Salt-2.0
    - Sour-2.0
    - Bitter-1.0

Day 2

-Review universal scale and basic tastes

-Train on Attribute 1-Beef Flavor and Aroma ID

- Provide references for both Aroma and Flavor

-Sample evaluation for Beef flavor/Aroma ID and Basic tastes

- Panelists will evaluate individually and then come to consensus
- High Beef Flavor/Aroma ID-Prime Strip Steak cooked on grill to 70C
- Low Beef Flavor/Aroma ID-Standard Strip Steak Cooked on grill to 70C

Day 3

-Review Beef flavor/Aroma ID and have references available
-Present universal scale and basic tastes and have panelists anchor on their own with the references
-Warm-Up sample-Choice Strip Steak cooked to 70C

- Evaluate Beef flavor/aroma ID and basic tastes
    - Panelists will come to consensus

-Train on Brown/Roasted Flavor and Aroma

- Present references

-Sample evaluation (Brown roasted flavor/aroma, Beef flavor/aroma and basic tastes)

- Choice Strip steak cooked to 135F (57C)-low brown roasted flavors
- Choice Strip steak cooked to higher than 175(79.4C)-high brown roasted
- Choice Strip steak cooked to 70C-unknown level; panelists will determine

Day 4

-Evaluate panel progress-if Day 3 went well move on to Bloody/Serumy and Metallic if not retrain until panelist are proficient in scaling Beef flavor, Basic tastes and Brown/Roasted flavor.
-Bloody/Serumy Flavor and Aroma

- Present references

-Metallic flavor and aroma

- Present references

-Sample evaluation (Bloody/Serumy, Metallic, Brown roasted, Beef ID, Basic tastes)

- Select Tenderloin steak grilled to 65C-high bloody/serum, metallic notes
- Select Top Sirloin steak grilled to 70C-unknown, panelists determine levels

Day 5

-Review attributes; provide references if needed
-Fat-like Flavor/Aroma

- Provide references

-Liver-like Flavor/Aroma

- Provide references

-Sample evaluation (Fat-like, Liver-like, Bloody/Serumy, Metallic, Brown roasted, Beef ID, Basic tastes)

- Prime Strip Steak broiled till 70C-should have strong fat-like flavor and low liver

- Cow Strip Steak broiled to 135F (57C)-strong liver notes

Day 6

-Review attributes; provide references if needed
-Green-haylike Flavor/Aroma

- Present references

-Umami

- Present references

-Sample evaluation (Green-haylike, Umami, Fat-like, Liver-like, Bloody/Serumy, Brown roasted, Beef ID, Basic tastes)

- Grass fed steak broiled to 135 (57C)-green and umami notes

Day 7

-Review attributes; provide references if needed
-Overall Sweet flavor

- Present references

-Sweet Aroma

- Present aroma reference

-Sour Aroma

- Present aroma reference

-Sample evaluation (Overall Sweet, Sweet Aroma, Sour Aroma, Green-haylike, Umami, Fat-like, Liver-like, Bloody/Serumy, Brown roasted, Beef ID, Basic tastes)

- Choice Strip grilled to 70C

Day 8

-Calibration Day

- Panelists will individually evaluate 3 muscles for the MAJOR NOTES
    - Warmup-Select strip steak grilled to 70C
        - Panelists will come to consensus
    - Sample 1-Extra Knuckle Roast-No consensus, individual evaluation
    - Sample 2-Extra Top Sirloin Steak-No consensus, individual evaluation
    - Sample 3-Extra Eye of Round Roast-No consensus, individual evaluation
- Determine panel proficiency on MAJOR NOTES

Day 9

-Overview MAJOR NOTES and provide references if necessary
-Train on OTHER NOTES

- Animal Hair Aroma
    - Present References
- Barnyard Aroma and Flavor
    - Present references

-Sample evaluation (MAJOR NOTES, Animal Hair Aroma and Barnyard)

- Bull Tenderloin broiled to 165F (~74C)-Animal Hair Aroma and Barnyard flavor

-Practice (ALL ATRIBUTES LEARNED TO THIS POINT)

- Select Strip Steak (Grilled to 70C)
- Choice Knuckle Roast (Roasted to 70C)

Day 10

-Review attributes; provide references if needed
-Burnt Aroma/Flavor

- Present References

-Rancid Aroma/Flavor

- Present References

-Sample evaluation (ALL ATRIBUTES LEARNED, Burnt and Rancid)

- Standard Strip grilled to greater than 175F (~79.4C) or until visibly burnt
- Low Choice Strip stewed to 155F (~68C)

-Practice (ALL ATRIBUTES LEARNED TO THIS POINT)

- Select Inside Round Roast (70C)
- Choice Flat Iron Steak (70C)

Day 11

-Review attributes; provide references if needed
-Heated oil Aroma/Flavor

- Present References

-Chemical Aroma/Flavor

- Present References

-Sample evaluation (ALL ATRIBUTES LEARNED, Heated oil and Chemical)

- Top Choice Top Butt broiled to 155F (~68C)-Chemical aromas and flavors

\- Practice (ALL ATRIBUTES LEARNED TO THIS POINT)

- Choice Eye of Round Roast (70C)
- Choice Tenderloin (70C)

Day 12

-Review attributes; provide references if needed
-Leather (old) Aroma

- Present references

-Apricot Flavor

- Present references

-Sample evaluation (ALL ATRIBUTES LEARNED, Leather aroma and Apricot)

- Cow Top Round stewed to 165F (~74C)-Leather aromas

\- Practice (ALL ATRIBUTES LEARNED TO THIS POINT)

- Select Tenderloin (70C)
- Choice Bottom Round Roast (70C)

Day 13

- Review attributes; provide references if needed
-Green Aroma/Flavor
    - Present references
-Asparagus
    - Present references
-Sample evaluation (ALL ATRIBUTES LEARNED, Green and Asparagus)
    - Cow strip broiled to 135F (~57C)-Green flavors
    - Cow strip stewed to 145F (~63C)
- Practice (ALL ATRIBUTES LEARNED TO THIS POINT)
    - Select Knuckle Roast (70C)
    - Select Flat Iron Steak (70C)

Day 14
- Review attributes; provide references if needed
-Musty-Earthy/Humus Aroma
    - Present references
-Cumin Aroma and Flavor
    - Present references
-Sample evaluation (ALL ATRIBUTES LEARNED, Musty and Cumin)
    - Cow tenderloin roasted to 145F (~63C)
    - Select strip steak with cumin (1/2 tsp) rubbed all over and grilled to 70C
- Practice (ALL ATRIBUTES LEARNED TO THIS POINT)
    - Choice Inside Round Roast (70C)
    - Select Top Sirloin (70C)

Day 15
- Review attributes; provide references if needed
-Floral Aroma/Flavor
    - Present references
-Beet Aroma/Flavor
    - Present references
-Sample evaluation (ALL ATRIBUTES LEARNED, Floral and Beet)
    - Cow tenderloin stewed to 175F (~79.4C)-Beet flavors
- Practice (ALL ATRIBUTES LEARNED TO THIS POINT)
    - Select Bottom Round Roast (70C)
    - Choice Strip Steak (70C)

Day 16
- Review attributes; provide references if needed
-Chocolate/Cocoa Aroma/Flavor
    - Present references
-Medicinal Aroma
-Petroleum-like Aroma

-Sample Evaluation (ALL ATRIBUTES LEARNED, Chocolate, medicinal, petroleum)

- Bull tenderloin grilled to 145F (~63C)-Chocolate aroma

- Practice (ALL ATRIBUTES LEARNED TO THIS POINT)

- Choice Top Sirloin Steak (70C)
- Select Eye of Round Roast (70C)

Day 17

- Review attributes; provide references if needed

-Smoky Charcoal Aroma

-Smoky Wood Aroma

-Spoiled-putrid Aroma

-Sample Evaluation (ALL ATRIBUTES LEARNED, Smoky Charcoal, Smoky Wood, Spoiled-putrid)

- Smell spoiled standard tenderloin grilled to 155F (~68C) for spoiled-putrid aroma
- Prime strip steak Food service gas grilled to 155F(~68C)-Smoky Charcoal aroma

- Practice (ALL ATRIBUTES LEARNED TO THIS POINT)

- Select Strip (70C)
- Choice Strip (70C)

Day 18

- Review attributes; provide references if needed

-Dairy Aroma/Flavor

-Buttery Aroma/Flavor

-Sample Evaluation (ALL ATRIBUTES LEARNED, Dairy, Buttery)

- Top Choice Top Butt roasted to 145F(~63C)-Dairy Aroma
- Bull tenderloin grilled to 145F(~63C)-Buttery flavor

- Practice (ALL ATRIBUTES LEARNED TO THIS POINT)

- Select Eye of Round Roast (70C)
- Choice Eye of Round Roast (70C)

Day 19

- Review attributes; provide references if needed

-Cooked milk Aroma/Flavor

-Sour milk/sour dairy Aroma/Flavor

-Sample Evaluation (ALL ATRIBUTES LEARNED, Cooked milk, Sour dairy)

- Milk-fed veal strip steak-cooked milk

- Practice (ALL ATRIBUTES LEARNED TO THIS POINT)

- Select Top Sirloin Steak (70C)
- Choice Top Sirloin Steak (70C)

Day 20

- Review attributes; provide references if needed

-Refrigerator Stale Aroma/Flavor

-Soapy Aroma
-Warmed Over Aroma/Flavor
-Sample Evaluation (ALL ATRIBUTES LEARNED, Refrigerator Stale, Soapy, Warmed Over)

- Cow Strip broiled to 135F(~57C)-Refrigerator Stale notes and Warmed over flavor
- Select tenderloin broiled to 175F(~78C)-warmed over aroma and flavor

- Practice (ALL ATRIBUTES LEARNED TO THIS POINT)

- Choice Flat Iron Steak (70C)
- Select Flat Iron Steak (70C)

CALIBRATION

Day 21 (Evaluate ALL ATRIBUTES)

- Warm-Up: Choice Strip Steak
- Sample 1: Select Eye of Round Roast
- Sample 2: Choice Top Sirloin Steak
- Sample 3: Choice Knuckle Roast
- Sample 4: Select Flat Iron

Day 22 (Evaluate ALL ATRIBUTES)

- Warm-up: Choice Eye of Round Roast
- Sample 1: Select Inside Round Roast
- Sample 2: Choice Bottom Round Roast
- Sample 3: Choice Flat Iron
- Sample 4: Select Tenderloin

******Training schedule is adjustable and may be changed to optimize panel performance.

VITA

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