DETERMINING THE EFFECT OF PORKLOIN INTRAMUSCULAR FAT CONTENT ON CONSUMER ATTITUDES

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ABSTRACT

The current study evaluated consumer sensory perception, acceptance and preference of porkloin from varied intramuscular fat (IMF) categories in five states. Porkloins (NAMP #413; n =180) were selected according to National Pork Producers Council (NPPC) IMF standards (n= 60/category) of high (NPPC 10), medium (NPPC 5) and low (NPPC 1). Samples from each category were evaluated for flavor, juiciness, tenderness and overall acceptability. Consumers ranked samples from most to least liked. As IMF increased, consumer's found samples more flavorful ($P < 0.001$), juicy ($P < 0.001$), tender ($P < 0.001$) and rated them higher in overall acceptability ($P < 0.001$). Trained panelists found as IMF increased, improvements were made in tenderness ($P = 0.01$), sustained tenderness ($P = 0.01$) overall acceptability ($P = 0.05$) and flavor intensity tended to be higher ($P = 0.08$). Intramuscular fat appears to play a role in consumer acceptance of porkloins, suggesting a need for further inquiry.

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INTRODUCTION

Pork quality has been the topic of research for the past 3 decades and the debate continues as to the role intramuscular fat plays in palatability or consumer acceptance. Previous investigations have reported intramuscular fat (IMF) has a positive influence on the sensory qualities of pork meat (Brewer et al., 2001, DeVol et al., 1988, Ellis et al., 1996, Fernandez et al., 1999). Some studies conclude there is no significant correlation between IMF and palatability factors (Purchas et al., 1990, Lentsch et al., 1991 and Tornberg et al., 1993). While still others found IMF to have had a negative effect on palatability (Cameron et al., 1990 and Lan et al., 1993). As consumers seek a healthier product, the selection of pork products with a high IMF percentage has decreased (Brewer et al., 2001) resulting in decreasing consumer acceptance. It seems plausible that a blind evaluation based on taste would yield contrasting results. While it is possible that the effects of IMF on pork quality have been studied on a multi-state level, there is limited research with a large sample group. Therefore, the objective of this study was to characterize the influence IMF has on pork eating quality across a more comprehensive sample size.

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LITERATURE REVIEW

Pork Quality

Fresh meat quality encompasses several factors including wholesomeness, healthfulness, visual properties and palatability (Moeller et al., 2010). These traits can be affected by a number of production and slaughter factors (Rosenvold and Anderson, 2003). These factors affect both consumer acceptance and physical attributes of meat, including color, water-holding capacity (WHC) and texture (Ryu et al., 2008).

Color

All light rays contain color; however, the visible range (400-700 nanometer long waves) can be perceived by the human eye. The longest wavelength the human eye can perceive is red, and the shortest is violet. Light that is absorbed by an object is not visible; however, the light that is reflected produces the color that is seen. Pigments are molecules which absorb some of the wavelengths from the light that illuminates an object (Brewer and Hunt, 2001). Color is important not only in the pork industry, but the entire food industry. Fresh pork meat color is a cue for the consumers' intention to purchase (Brewer et al., 2001). Consumers most commonly look for a reddish-pink lean color, as compared to a pale lean color. Lean color is affected by a number of factors including pH, myoglobin content and temperature.

A major factor influencing color in fresh and processed pork is the pH of the product. During the conversion of muscle to meat, a normal pH will decline from 7.0 to 5.6. However, pH can be affected by anti-mortem factors. Short term stress prior to slaughter can cause a buildup of lactic acid in the muscle which causes the pH to drop dramatically. Upon the loss of 50% of blood, the animal's oxygen supply is quickly depleted. The depletion of oxygen supply forces aerobic respiration to be superseded by the process of anaerobic glycolysis. Anaerobic glycolysis is the conversion of glucose to pyruvate under conditions where oxygen stores are limited. Limited amounts of oxygen remains bound to myoglobin and stays in the muscle. This limited oxygen allows glycolysis to continue until such time it is depleted and the metabolism type is altered. In anaerobic glycolysis, the pyruvate generated by glycolysis is broken down via fermentation. This fermentation yields ATP, carbon dioxide and lactic acid (Kerth, 2013). In a live animal, the circulatory system removes waste such as lactic acid. Lactic acid is carried to the liver where it is resynthesized into glucose and glycogen. Post-mortem, lactic acid builds up in the muscle until all of the glycogen stores have been depleted. The conversion of glycogen to lactic acid results in the pH to steadily decline from the homeostatic pH level of (7.0-7.4) to 5.6 for meat presenting optimal qualities. The depletion of ATP causes muscle movement to cease. The depletion of ATP is brought on by the depletion of glycogen as glycogen stores are converted to lactic acid. The amount of glycogen present in the muscle at the time of slaughter is directly proportional to the amount of lactic acid found in fresh meat (Lonergan, 2008). The higher amount of glycogen present in the muscle, the greater chance for the pH to be lower. When pH declines rapidly before the muscle has been significantly chilled, a partial denaturation of sarcoplasmic protein (water soluble protein in muscle and meat) occurs (Lonergan, 2008). More importantly is the denaturation of myoglobin. Myoglobin is the red, water soluble protein found in muscle which is responsible for the pink/red color observed in fresh and processed meat products. The pigment protein, myoglobin, stores oxygen in cells and is responsible for the red color in meat. Under extreme conditions, denaturation of the myofibrillar proteins alters the color by allowing those structures to reflect more light (Lonergan, 2008). This causes fresh meat to be a more pale color. Muscle pH and quality are factors that have a large effect on cooked meat color. Pale, soft and exudative (PSE) meat is a quality defect resulting from a rapid decline in pH. This makes myoglobin more heat-labile, leading to premature browning in cooked meat products. Conversely, dark, firm and dry (DFD) meat possesses a higher pH. This higher pH protects myoglobin and keeps meat pink.

The chemical reaction of oxymyoglobin and oxygenation reduction produce 3 forms of myoglobin which lead to the changes in color as meat is exposed to heat (Hunt and Zegner, 1998). Different forms of myoglobin produce different colors according to Hunt and Zenger (1998). Deoxymyoglobin results in a purple color, oxymyoglobin (red) and metmyoglobin (brown).

Post-mortem temperature also affects lean color. After an animal has been slaughtered, a cascade of changes begins to take place. Upon exsanguination, the circulatory system can no longer transport nutrients and oxygen or remove waste and heat from the muscle. Thus, as a result of exsanguination, the tissue loses its ability to regulate temperature. At this point, the inability of the circulatory system to remove heat from the deeper muscles of the carcass can cause a short increase in temperature. This is especially true in animals that are stressed prior to slaughter or are genetically predisposed to producing PSE meat (Huff-Lonergan, 2001). This increases the rate of pH decline within the meat. As the temperature increases, the rate of metabolism increases, thus causing pH to decline at an accelerated rate. This combination of temperature and pH can affect meat quality by denaturing myoglobin and creating a PSE product.

According to Huff-Lonergan (2001), shortening the period of time between exsanguination and chilling is one way to effectively alter the rate of temperature and pH decline. To minimize the risk of a high temperature carcass with a low pH, rapid chilling can be implemented (Huff-Lonergan, 2001).

Water-Holding Capacity

Fresh meat's ability to retain water is termed water-holding capacity (WHC). This is an important property of fresh meat and affects multiple characteristics including yield and quality. Yield is the percentage of closely trimmed retail cuts in regard to the carcass weight. An increased WHC will result in a heavier carcass and increase red meat yield. The meat's ability to retain water during cooking plays a key role in sensory attributes such as juiciness. According to Kapper et al. (2004), WHC can be characterized several ways, however in fresh, minimally processed meat products it is described as drip loss or purge. The rate by which drip or purge is lost from meat is influenced by both the pH of the tissue and by the amount of space in the muscle cell, more specifically the space in the myofibril that exists in which water resides (Huff-Lonergan, 2005). There are multiple factors affecting both the rate and amount of moisture lost through purge or drip. These factors can consist of how the product was handled or processed such as how the product was cut, size of pieces and orientation of the cut with respect to the axis of the muscle cell as well as the rate of temperature decline after harvest and temperature during storage. According to Huff-Lonergan (2005) an extreme importance is placed on the metabolic state of the live animal at the time of harvest. Additionally, this can be influenced by the genetic makeup of the animal and how it was handled. Characteristics of the muscle in the live animal including stress, genetics, pre slaughter handling and chilling have a strong influence on the amount of moisture which is lost from the resulting meat products (Kapper et al., 2004).

Water holding capacity is closely tied to pH. Accelerated pH decline and low ultimate pH are related to the development of low WHC and high purge loss. A rapid decline in pH to ultimate or near ultimate pH while the carcass is still warm results in the loss of functionality of many proteins (Huff-Lonergan, 2005). The most recognized and extreme purge or drip loss is found in PSE products from hogs that have a mutation in the ryanodine receptor/calcium release channel in the sarcoplasmic reticulum. This is known as the halothane gene. This mutation results in the impairment of the ability for the channel to control calcium release into the sarcoplasm of the muscle cell, particularly in periods of physical stress (Huff-Lonergan, 2005).

There are additional physical and biochemical factors in muscle that affect WHC. Once the pH has reached the isoelectric point (pI) of the major proteins such as myosin (pI=5.4), the net charge of the protein is zero, meaning the numbers of positive and negative charges on the proteins are essentially equal (Huff-Lonergan, 2005). The aforementioned positive and negative groups within the protein are attracted to each other and can result in a reduction in the amount of water that can be attracted and held by that protein (Huff-Lonergan, 2005). Since like charges repel, as the net charge of the proteins making up the myofibril approaches zero, the repulsion of structures in the myofibril is reduced. This allows for those structures to pack more closely, thus resulting in less space within the myofibril. Therefore, the tightly packed myofibril leaves no room for water to be bound.

Protein denaturation is not due to pH alone. The primary reason rapid pH decline has such a detrimental effect on muscle proteins is due to the fact that acidic pH values are attained while the muscle is still warm (Kerth, 2013). The combination of a low pH and a relatively unchanging carcass temperature denature protein and impair its functionality. Lowering the carcass temperature quickly can resolve some of these problems. Thus, chilling the carcass slows the metabolic process and denaturation of proteins.

Marbling

The degree of marbling is important for estimating the eating quality of pork loins. According to an article by Cannata et al. (2010), it is generally accepted that an increase in the intramuscular fat (IMF) increases palatability in pork among consumers. Marbling is influenced by a number of factors including nutrition, genetics and age.

Nutrition plays a key role in the animal's lean: fat ratio, which is important in both the overall carcass and within the muscle as marbling. According to Pettigrew and Esnaola (2001) carcass fatness and marbling are not perfectly correlated, but in general, nutritional changes that alter one (fatness or marbling) can cause the other to move in the same direction.

Leanness is simply the relative amounts of protein/lean and fat in the animal's body. In general, lean can be increased by increasing the amount of protein accreted (deposited), by reducing the amount of fat accreted, or both (Pettigrew and Esnaola, 2001). Nuria et al. (2014) suggests the same feeding strategy as outlined in Pettigrew and Esnaola (2001) for increasing IMF by reducing the supply of protein. If the flow of nutrients is redirected from fat deposition to protein deposition, an increase in leanness will occur. Conversely, increasing marbling can be caused by providing a protein-deficient feed. Pettigrew and Esnaola (2001) reviewed a total of 18 comparisons of protein-adequate and protein-deficient diets in pigs. In each comparison a protein-deficient diet yielded a carcass with more marbling. On average, the deficient treatments increased marbling score by approximately 0.4 (on a 5-point scale) and percentage fat by approximately 1.4. It should be noted that these protein-deficient dietary treatments also impaired growth performance and increases fatness of the carcass. Unless a specific market is created, it is unlikely that the industry would adopt this method to increase marbling due to potential inefficiencies.

The amount of protein a pig can accrete daily is limited by either nutritional factors or non-nutritional factors. According to Pettigrew and Esnaola (2001), non-nutritional factors put a limit on the amount of protein the pig is capable of accreting. The most important of these factors is genetic, but sex, health and various environmental factors also appear to have significant effects (Pettigrew and Esnaola, 2001). In a study conducted by Stoller et al., (2003), it was reported that loins from Berkshire and Duroc pigs had a greater ($P < 0.05$) marbling score. These results supported findings of NPPC (1995), in which Duroc and Berkshire genetic lines displayed greater loin marbling scores.

Sex certainly plays a role in the growth and development of an animal. Differences in hormone production between gilts, barrows and boars affect their growth and development. In hogs, an intact boar will be leaner and have a greater feed efficiency than that of a castrate or gilt (Dunshea et al., 1993 and Latorre et al., 2003). Quality may also be affected by sex. There is no difference in pH among gilts and barrows (Latorre et al., 2003, Latorre et al., 2004 and Lampe et al., 2006). Additionally there is no difference in drip loss (Suzuki et al., 2005). Moreover, barrows have a higher amount of IMF (Furman, 2007, Latorre et al., 2003 and Lampe et al., 2006). Quality is affected by many environmental and genetic factors. Specifically, nutrition plays a key role in IMF production through elements available to the animal to produce IMF.

Pork Palatability

Typically, palatability is evaluated by a meat product's juiciness, tenderness and flavor. Aroma, color and texture also contribute to palatability; however, they are evaluated in palatability research to a lesser extent. It is important to realize that consumers place different importance on juiciness, tenderness and flavor.

Tenderness

Tenderness, instrumentally measured, is referred to as shear force and is defined as the pounds of force needed to shear 2.54 cm cores of cooked meat samples. No palatability factor has received more research study than tenderness (Aberle et al., pg. 260). The perception of meat tenderness has been divided into certain conditions within meat during mastication. These include softness to tongue and cheek, resistance to tooth pressure, ease of fragmentation, mealiness, adhesion and residue after chewing. According to van Laack et al. (2001), connective tissue, IMF and myofibrillar structure are determinants of meat tenderness.

Connective tissue plays a major role in meat tenderness. Many of the meat tenderness differences associated with animal, age, muscle location and sex result from differences in connective tissue. The size of individual muscle bundles as well as the amount of connective tissue in muscle affects the texture and tenderness of meat. Large bundles of muscle fibers and large amounts of perimysial connective tissue surrounding primary and secondary bundles are associated with coarse textured meat (Aberle et al., pg. 140). Connective tissue is found throughout muscle, both surrounding individual muscle fibers and muscle bundles. In tough muscles fibers, there is an abundance of collagen surrounding fibers. The perimysium surrounding primary and secondary muscle bundles is composed primarily of collagen (Warriss, 2010). Additionally, collagen is present in epimysium surrounding whole muscles as well as endomysium surrounding the individual muscle fibers. Different muscles in the animal have specific purposes and functions. Muscles used for locomotion have relatively high amounts of connective tissue and are less tender when compared to muscles which are used less.

It was generally accepted that an increased level of IMF had a positive influence on the sensory qualities of fresh pork meat. However, the topic has been studied intensively in the past 3 decades, yielding conflicting results. Fernandez et al. (1999) found that the observed trends towards an effect of IMF level on flavor and toughness were of low magnitude. In a study conducted by van Laack et al. (2001), researchers found a small but significant positive correlation between IMF and Warner Bratzler Shear Force, which indicates an IMF increase results in higher tenderness level. Research conducted by Cannata et al. (2010), grouped loins on visual marbling in to 3 categories. Cannata et al. (2010) reported no significant difference for tenderness in marbling groups medium and high; however, the medium and high groups significantly scored higher for tenderness than the low marbling group. In a study designed by Moeller et al. (2010), loins were divided into 6 IMF percentages, ranging from 1 to 6. The Moeller et al. (2010) study reported that increasing loin IMF by 1% improved sensory tenderness level ratings by only 0.23 on a scale of 1-10. A study conducted by Brewer et al. (2001), reveled a 1 unit improvement in tenderness on a scale from 1 to 5 when comparing IMF levels of $<1\%$ with IMF of $\geq 3.5\%$. In a similar study conducted by Fortin et al. (2005), 5 IMF groups were clustered, ranging from 1 to 2.99% IMF. Fortin et al. (2005) reported only attributes describing tenderness, average shear force, softness, initial tenderness and chewiness were significantly correlated with IMF. It can be concluded that there is conflicting literature as to the effect IMF has on tenderness.

Another factor influencing tenderness is rigor state and the structural integrity of the myofibrils. During rigor mortis, cross bridges are formed between actin and myosin. This causes a marked increase in muscle toughness. This loss of tenderness in the first few hours postmortem is termed rigor toughening. The shortening of muscle fibers can be regulated by temperature or electrical stimulation. The combination of cross-bridge formation and shortening causes muscle fibers to toughen. Water holding capacity and tenderness are reduced after muscle undergoes rigor associated changes. Many contractile proteins interact and form stable structures, thus muscle fibers become firm and inextensible. As a result of protein to protein interactions, there are fewer available sites for water to bind. Thus, the densely protein packed muscle becomes partially dehydrated.

Juiciness

Meat juices play an important role in palatability. They contain many important flavors profiles and aid in fragmentation and softening of meat during mastication. According to Aberle et al. (pg. 263), the absence of juiciness severely limits fresh meats acceptability and destroys its unique palatability characteristics. Juiciness facilitates chewing and brings the flavor component in contact with the taste buds. The juiciness of meat depends on the raw quality of the meat, as well as the cooking procedure implemented. Eikelenboom and Hoving-Bolink (1994), reported that juiciness is slightly correlated to IMF (R^2=0.33) but even more correlated to pH (R^2 = 0.68).

The primary sources of juiciness, detected by consumers, are intramuscular lipids and water. These lipids, when melted and water constitute a broth which is retained in meat and released during mastication. The lubrication effect of marbling relies on higher fat levels in marbled meat — simulating salivation and giving the perception of increased juiciness of meat while chewing (Juarez et al., 2001).

Marbling indirectly enhances juiciness. According to Aberle et al. (pg. 263) during cooking, melted fat becomes translocated along bands of perimysial connective tissue. The uniform distribution of lipid throughout the muscle may act as a moisture barrier during cooking to minimize moisture loss (Aberle et al., pg. 263). Therefore, meat with some marbling shrinks less during cooking than meat devoid of fat and thus remains juicier. Moreover, during dry heat roasting, subcutaneous marbling reduces drying and moisture loss.

Water holding capacity is a major determinant of juiciness. Meat contains 3 types of water, free, bound and immobilized. Free water is held by capillary forces and is the easiest form of water to be lost from meat. Immobilized water is held in meat by strong chemical bonds and is difficult to remove from meat. Bound water is water that exists in the vicinity of non-aqueous constituents (like proteins) and has reduced mobility (Extension, 2010). Large amounts of unbound, or less tightly associated water, are often related with reduced WHC (Kapper, 2004).

It is still unclear how IMF, pH, WHC and temperature affect juiciness. In beef, juiciness and cooking loss are negatively correlated (Toscas et al., 1999). This implies that a high cooking loss results in a low juiciness score. In pork, however, the correlation is not easily understood.

Factors impacting juiciness and cooking loss are not restricted to environmental impacts. Genetics can have an effect on the WHC and cooking loss in fresh pork meat. In a study conducted by Fjelkner-Modig, (1986), meat with the same water content from purebred Hampshire, Landrace and Yorkshire breeds were measured for cooking loss. The study showed purebred Hampshire had the highest cooking loss; however the meat did not have the lowest juiciness scores (Fjelkner-Modig, 1986).

MATERIALS AND METHODS

Loin Procurement

Porkloins (NAMP# 413; n=300), from a commercial abattoir were visually selected according to National Pork Producers Council (NPPC) intramuscular fat (IMF) standards by trained personnel to acquire loins (n=100/category) of high (NPPC 10), medium (NPPC 5) and low (NPPC 1) IMF content. Visual IMF was confirmed utilizing an Association of Analytical Communities (AOAC) approved laboratory method. Additionally all loins possessed a pH between 5.3-5.7 and were obtained from a commercial genetic line raised under similar conditions and harvested on the same day to minimize extraneous variation. All identified loins were vacuum packaged and boxed. Selected loins were then transported under refrigeration (4°C) to the Angelo State University Food Safety and Product Development Laboratory, within 72 hours PM.

Fabrication and Initial Evaluation

Loins were removed from packaging at 10 days PM and fabricated for proximate analysis. Loins were sliced in the geometric center to expose the loineye. Samples for proximate analysis were taken from the most anterior, middle and most posterior as seen in Figure 1. Loins and samples were vacuum packaged and stored at 4°C until further fabrication and analysis.

Proximate Analysis

Samples for proximate analysis were transported to Texas Tech University Animal and Food Science Laboratory. Samples were stored at refrigeration prior to analysis.

Samples were then denuded and individually ground through a ¼ inch plate using a domestic electric meat grinder. Samples were then analyzed according to procedures outlined by Luque et al. (2011) as an average of duplicate measurements, using a Foss® FoodScan™. Averages for fat, moisture and protein are in Table 1.

Upon completion of proximate analysis, samples were ordered from lowest to highest IMF percentage. The lowest 60 loins were designated as low IMF; the following 35 loins were deemed a buffer and were not included in the study. The preceding 60 loins were designated as medium. The next 35 loins were deemed a buffer. The highest 60 loins were designated at high IMF. Selected loins were removed from packaging on day 20 PM for further fabrication and analysis. Instrumental color was measured using a HunterLab MiniScan MS, portable spectrometer with illuminant A for CIE L*,a* and b* values at a standard observation angle of 10° and a 2.54 cm aperture. Previously, chops 1, 7 and 16 had been assigned for proximate analysis as seen in Figure 1. The remaining 2 pieces of the loin were sliced so that at least 16 chops were derived from each loin. Chops 2-6 were assigned for IMF consumer analysis. The remaining portions of the loins were vacuumed packaged for trained sensory panels. Chops were then serially assigned to analysis type, vacuumed packaged and frozen at -20°C for storage until consumer analysis. Thus, per retail market, a total of 6 loins from each IMF category were surveyed.

Retail Outlet/State Selection

Attention was paid to population distribution, impact of retail market and proximity to state institutional contacts from the University of Arkansas and Louisiana State University. Five cities within 5 states were selected, Houston, Texas; Denver, Colorado;

Fayetteville, Arkansas, Baton Rouge, Louisiana and Albuquerque, New Mexico. Two retail outlets in each city were selected to obtain a diverse group of consumers in terms of demographics and socioeconomic level.

Consumer Analysis Sample Preparation

Designated frozen samples for consumer analysis were thawed at refrigeration temperatures (4°C) 24 hr prior to service to consumer panel. Samples were prepared according to procedures as outlined by Kerth et al. (2003) utilizing clam-shell style grills (George Foreman, model GRP 99, Westmont, NJ), cooked to an internal temperature of 62°C. Cooked samples were cut into cubes (2 cm^2), placed in warming pans (45°C) for a maximum of 15 minutes while available for service to individual consumers.

Consumer Analysis

A minimum of 120 consumers/retail market completed the survey for a total of 1,200 (120 surveys/retail market × 10 retail markets) in-store surveys. Within each store 90 designated chops from a total of 6 loins/IMF Category/ (6 loins x 5 chops/loin × 3 IMF categories) were evaluated. A total of 30 individual panels (4 consumers/panel ×30 panels = 120 consumers) in which each consumer evaluated all 3 IMF categories was conducted. Each consumer completed demographic data including gender, ethnicity, age, household income and the number of times they have consumed pork within the last week and month. Consumers then evaluated samples from each of the specified IMF categories (High = NPPC 10, Medium = NPPC 5 and Low = NPPC 1). Consumers evaluated the samples based on flavor, juiciness, tenderness and overall acceptance utilizing a modified hedonic scale ballot as shown in Figure 2. The ballot consisted of a continuous 160 mm line anchored with extreme like and dislike characteristics. For the respective attribute, 0 represented extreme dislike, 80 represented a neutral opinion and 160 represented extreme like. Data was interpreted as distance in mm from the left (extreme dislike) anchor point. Consumers were instructed to make a vertical line on each of inquiry scales, indicating their opinion of each of the samples.

Trained Sensory Panels

Loins were sliced 2.54 cm thick and held at refrigerated temperature until analysis. Samples were prepared according to procedures as outlined by Kerth et al. (2003) utilizing clam-shell style grills (George Foreman, model GRP 99, Westmont, NJ) to an internal temperature of 62°C. Cooked samples were cut into cubes (2 cm^2), placed in a warming cabinet (45°C). Samples were served according to procedures outlined by (AMSA 1995 and Cross et al., 1979) under red incandescent lighting in attempt to minimize sample variation due to color. Panelists cleansed their palettes before the first sample and in between samples with unsalted, saltine crackers and filtered water. All samples were served and analyzed by a trained sensory panel. The trained sensory ballot, as seen in Figure 3, consisted of initial juiciness, sustained juiciness, initial tenderness, sustained tenderness, amount of connective tissue, off flavor, flavor intensity and overall acceptability. All questions were evaluated on an 8 point categorical intensity scale, except for off flavor, which was measure on a 4 point scale.

Statistical Analysis

Color attributes (L*,a*,b*) consumer attributes (juiciness, tenderness, flavor and overall acceptability), and trained sensory attributes (Initial juiciness, sustained juiciness, initial tenderness, sustained tenderness, amount of connective tissue, flavor intensity, off flavor and overall acceptability) dependent variables were included in the model and were analyzed as a completely randomized design using mixed model (PROC MIXED) procedures of SAS (SAS Inst. Inc., Cary, NC). With intramuscular fat (IMF) content, state, retail store and all 2-way interactions as fixed effects.

Consumer ranking data for surveys were analyzed for frequency distribution (PROC FREQ) and Chi Square analysis. All demographic data was summarized utilizing the (PROC FREQ) frequency distribution procedures. Individual loin served as experimental unit and significant ($P \leq 0.05$) treatment means were separated using Fisher's protected least significant difference.

RESULTS AND DISCUSSION

Loin Quality

Loins were selected from a commercial genetic line. Diet, management practices, slaughter and slaughter date were reported to be in line with current commercial standards by a plant official. Table 1 displays a summary of IMF minimum, maximum and average percentages for the 180 loins over the low, medium and high IMF treatment categories. Table 1 indicates a range of extractable lipid from 1.70 to 8.41% in the *longissimus.* Loins were assigned to a treatment of either High, Medium or Low based on IMF content (1.70-2.94, 3.62-4.23 and 4.90-8.41 respectively). Previously, Fortin et al. (2005) evaluated 5 IMF categories with averages of 0.81%, 1.23%, 1.74%, 2.21% and 2.83%. Additionally, Moeller et al. (2010) created 6 distinct IMF categories ranging from 1% to 6% IMF. A study by Rinker et al. (2008) identified an IMF range of 0.76 to 8.09% with 5 distinct IMF categories averaging 1.58%, 2.54%, 3.56%, 4.53% and 5.73%.

When evaluating loins for Hunter Color analysis it was found that loin color was affected by treatment ($P < 0.001$). Loin color was evaluated using CIE L*, a*, b* values which can be seen in Table 2. Loins from the low marbling category were lighter when compared to the medium category, but similar to the high marbling category. Loins from the low marbling category were redder (8.89±0.17) as compared to medium (8.32±0.18) and high (8.19±0.16). Additionally, loins from the low category were more yellow (16.93±0.14) as compared to medium (16.68±0.15) and high (16.44±0.14). In a study conducted by Moeller et al., (2010), loins were evaluated by consumers and trained panelists. Loins containing a relatively large amount of IMF (6%) or from dark loins

(Minolta L* 46.9 units) scored more favorably for juiciness, tenderness, chewiness and flavor attributes. Spencer et al. (2005) studied the effects modified diets had on lean color in fresh pork and reported no effects of crude protein level or fat addition in hogs diets on 24 hour a* or 24 hour b* values in the ham or *longissimus dorsi*. The study did report that higher fat addition provided darker cut ham and *longissimus dorsi* lean surfaces as shown by lower 24 hour L* values (P = 0.02) (Spencer et al., 2005). If a higher fat addition caused a higher IMF content in the lean, then the results reported by Spencer et al. (2005) would be in line with the current work. However subsequent studies have revealed conflicting results. In a study conducted by Brewer at al. (2001), 3 IMF categories were evaluated (high, medium and low) with average IMF percentages of 1.05, 2.33 and 3.46%. When evaluated by consumers on a scale from 1 (not pink) to 5 (very pink), high marbled chops were lighter pink (2.42) than those with a low (3.73) or medium (3.38). Additionally, Fernandez et al. (1999) reported no difference in visual color intensity of pork in various IMF categories. The current study instrumentally evaluated color, whereas the aforementioned studies used subjective methods to evaluate pinkness in fresh pork meat. In the current study, however, chops from the low marbling category were both lighter and more red than the medium and high category which could be perceived as pink.

Consumer Panels

The population representing the consumer panel is displayed in Table 3. Of those surveyed, the majority of consumers (36.6%) consumed pork more than 4 times in the past month, 19.6% 3 times, 21.9% 2 times, 12.9% 1 time and 9.1% had not consumed pork in the past month. All were more than 18 years of age. The largest age group was 46-55

(21.8%) years old, followed by 56-65 (18.0%), 26-35 (16.9%), 36-45 (16.2%), 18-25 (13.7%) and 13.4% percent of consumers were 66 years of age or older. Additionally, 52.8% of participants were female and 47.2% were male. The largest ethnic group was white (non-Hispanic) (50.9%) followed by Hispanic or Latino (31.2%), Black or African American (13.6), Native American or Alaskan Native (2.2%) and Asian (1.1%). Consumers reported varying household income levels. The largest income group was >$99,999 (15.7%) and the smallest income group was $10,000-14,999 (7.5%).

Upon completion of demographic data, consumers where asked to evaluate 3 samples on flavor, juiciness, tenderness and overall acceptability utilizing the survey tool illustrated in Figure 2. The scale for consumer opinion of these attributes was measured from 0 to 160 mm, 0 representing extreme dislike, a value of 80 represented moderate opinion and 160 representing extreme like. The level of IMF in the loin had an effect on flavor ($P < 0.001$), juiciness ($P < 0.001$), tenderness ($P < 0.001$) and overall acceptability ($P < 0.001$). Table 4 exhibits the least square means for the consumer analysis for each marbling category.

Consumer analysis revealed flavor increased as IMF content increased ($P < 0.001$). The low marbling category had the lowest value for flavor (75.19±1.13) which is below the mid-point of the scale, while the high marbling category had the highest value for flavor (92.16±1.13) which is above the midpoint of the scale. The medium marbling treatment had the second highest score for flavor (85.83±1.13). This is in agreement with previous works from Fortin et al. (2005), who looked at IMF levels from 0.81% to 2.95% in a commercial line and reported a low, but positive relationship between IMF levels and flavor as well as Brewer et al. (2001) who reported that chops containing 3.46% IMF were more flavorful than chops containing 1.05%. However, a study conducted by Rinker et al. (2008) concluded that IMF did not affect consumer perception of pork flavor intensity which is contrary to results from the current study. Differences in results may be due to the population used in the consumer studies. Rinker et al. (2008) utilized 148 consumers in a single geographical location. The current study's population of 1,200 consumers in 5 different states. Additionally, Fernandez et al. (1999) found that an increase in IMF resulted in an increase in the triglyceride content in the muscle which has a low content of poly-unsaturated fatty acids (PUFA). Previous investigations show that fatty acid composition of the *longissimus dorsi* muscle is related to pork eating quality, with saturated and monounsaturated fatty acids being positively correlated with pork flavor and PUFA being negatively correlated (Cameron and Enser, 1991). The quality of the IMF may play a role in consumer acceptability as developed thoroughly in other species (beef). Cameron et al. (2000) found a negative correlation between flavor attributes and neutral lipids and fatty acids (Linoleic acid, α linoleic acid, omega 3 and 6 fatty acids, eicosapentaenoic acid and compound methyl docosahexaenoate) but a positive correlation with palmitoleic acid and oleic acid. Table 5 displays consumer analysis results by state. Flavor was affected by state ($P < 0.001$) as Texas scored flavor the lowest (75.89±1.43) among states and New Mexico scored flavor the highest (93.16±1.45). Additionally there was no difference between Louisiana and Colorado ($P = 0.40$) or Colorado and Arkansas ($P = 0.19$). Flavor was not dependent on store ($P = 0.07$) or treatment by state ($P = 0.79$) or treatment by store ($P = 0.54$). When evaluating flavor, Texas consumers behaved differently, when comparing IMF levels, than consumers in other states included in the current study. Similarly, Neely et al. (1998) found that consumers from Houston scored flavor differently among other cities. Neely et al. (1998) conducted a study among 4 cities comparing 4 cuts of beef across 4 USDA quality grades. Neely et al. (1998) reported 2 significant main effect interactions for flavor desirability which were quality grade × city (P = 0.05) as well as cut × city (P <0.001). Additionally, flavor intensity was analyzed. There were 2 significant main effect interactions for flavor intensity, which were quality grade × city (P = 0.02) and cut × city (P < 0.001). Within the USDA quality grades, participants from Houston rated steaks higher for flavor desirability and intensity of flavor (P < 0.05) than the other 3 cities (Philadelphia, PA, San Francisco, CA and Chicago, IL).

Consumers were instructed to evaluate juiciness of the 3 IMF treatments and as IMF content increased, consumers found chops to be juicier (P < 0.001). The low marbling category had the lowest value for juiciness (84.55±1.26), while the high marbling category had the highest value for juiciness (102.36±1.26) which is a difference of 17.81 on a scale from 0 to 160. The medium marbling treatment had the second highest score for juiciness (95.82±1.13) which is well above the mid-point of the scale. A study conducted by Brewer et al. (2001) used 3 IMF categories of low, medium and high with average IMF of 1.05%, 2.33% and 3.46% respectively. Brewer et al. (2001) reported that the chops in the high IMF category were more juicy than chops from the low IMF category (2.53±1.14 vs. 3.69±1.24 on a scale 1 = not at all to 5 = very much). These results are supported by Fernandez et al. (1999) who reported that juiciness levels increased as IMF content increased from <1.5% to >3.5%. Conversely, Rinker et al. (2008) reported that juiciness levels slightly increased as chops approached an IMF content of 3.5% to 4.5% and unexplainably declined in juiciness levels for chops with the highest IMF content.

Additionally, Rinker et al. (2008) consisted of geographically limited sample size of 148 consumers. In the current work, juiciness levels increased by the largest margin when moving from the low marbling category to the high marbling category. Table 5 displays consumer analysis results by state. Additionally, juiciness was affected by state ($P < 0.001$) as Texas scored juiciness lowest (89.95±1.60) among states and Louisiana scored juiciness the highest (100.01±1.61). Regardless of state, juiciness scores showed a positive correlation with IMF content. There was no difference in juiciness scores between Arkansas and Colorado ($P = 0.87$), Arkansas and Texas ($P = 0.20$), Colorado and Texas ($P = 0.26$), New Mexico and Arkansas ($P = 0.87$), New Mexico and Colorado ($P = 0.15$) and New Mexico and Louisiana ($P = 0.07$). Juiciness was not dependent on store ($P = 0.17$) or treatment by state ($P = 0.39$) or treatment by store ($P = 0.72$). In reference to juiciness, Houston consumers behaved differently to IMF levels than consumers in other states included in the current study. Similarly, Neely et al. (1998) conducted a study among 4 cities comparing 4 cuts of beef across 4 USDA quality grades. Neely et al. (2008) reported 2 significant main effect interactions for juiciness which were quality grade × city ($P = 0.02$) and cut × city ($P < 0.001$). In a similar manner, Houston consumers gave the highest juiciness ratings for steaks from each of the 4 cuts which were higher than the other 3 cities (Philadelphia, PA, San Francisco, CA and Chicago, IL).

Consumers were instructed to evaluate tenderness of the 3 IMF treatments. As IMF content increased consumer scored chops more tender ($P < 0.001$) and tenderness was dependent on state ($P = 0.003$) as well as store ($P < 0.002$). Consumers reported the low IMF category to be the toughest (92.83±1.21); conversely, they found the highest IMF category to be the most tender (104.15±1.21). The medium marbling treatment had the second highest score for tenderness (97.75±1.21). The relationship between IMF and pork tenderness is controversial (van Laack et al., 2001). Researchers have published mixed results with some reporting a positive relationship (DeVol et al., 1988, Eikelenboom and Hoving-Bolink, 1994, Goodwin and Burroughs, 1995), and others finding no correlation (Goransson et al., 1992). Rinker et al. (2008) found a small difference in tenderness among consumers in a study with similar parameters as the current study and suggested a threshold level of IMF. Fernandez et al. (1999) reported a low correlation between sensory tenderness and IMF content. However, he concluded that the correlation may be factual; it is nevertheless not systematic. Recent results from van Laack have reported results similar to Fernandez et al. (1999) finding a small, but significant ($P = 0.05$) correlation between IMF and Warner Bratzler Shear Force. The results from the current study does suggest as IMF content increase consumers find chops to be more tender and does not suggest a threshold level. Table 5 displays consumer analysis results by state. Additionally, tenderness was affected by state (P = 0.003) as Texas scored tenderness lowest (94.81±1.53) among states and Louisiana scored tenderness the highest (102.89±1.54). Additionally, tenderness was affected by store ($P = 0.002$). Values between store 1 and store 2 were different in Baton Rouge, Denver and Houston with consumers from store 2 scoring chops higher for tenderness. Regardless of state, tenderness scores showed a positive correlation with IMF content. There was no difference between tenderness scores between New Mexico and Louisiana ($P = 0.09$), New Mexico and Colorado ($P = 0.63$), New Mexico and Arkansas ($P = 0.18$), Colorado and Texas ($P = 0.13$) and Arkansas and Texas ($P = 0.54$).

Consumer analysis of overall acceptability was affected by treatment (*P* < 0.001). As IMF content increased, consumers found chops to be overall more acceptable. The low marbling category had the highest value for overall acceptability (90.17±1.39), while the high marbling category had the highest values for overall acceptability (105.51±1.40). The medium marbling category ranked second for overall acceptability (99.11±1.40). Table 5 displays consumer analysis results by state. Additionally, overall acceptability was dependent on state (*P* < 0.001). Overall acceptability was not dependent on store (*P* = 0.09), additionally there was no treatment by state (*P* = 0.54) or treatment by store (*P* = 0.50) interaction. Texas scored overall acceptability lowest (88.28±1.77) among state and New Mexico scored overall acceptability the highest (102.67±1.80). Regardless of state, overall acceptability scores showed a positive correlation with IMF content. There was no difference between overall acceptability scores between New Mexico and Louisiana (*P* = 0.33), New Mexico and Colorado (*P* = 0.42), New Mexico and Arkansas (*P* = 0.24), Louisiana and Colorado (*P* = 0.87), Louisiana and Arkansas (*P* = 0.82) and Colorado and Arkansas (*P* = 0.70). Current fresh pork meat studies have not included overall acceptability in consumer analysis. Previous studies in beef comparing USDA quality grades commonly use overall acceptability in consumer analysis. In multiple studies USDA Prime or USDA Choice carcasses have produced steaks that were more palatable resulting in scores higher for tenderness, juiciness and overall acceptability than USDA quality grades of USDA Select through USDA Canner (Tedford et al., 2014). Direct correlations cannot be made between beef and pork, however studies indicate a strong correlation in consumer panels between IMF and consumer acceptability.

Consumer rankings of the 3 marbling categories are shown in Table 6. When ranking the 3 marbling categories, the majority of consumers ranked the high marbling category first (49.50%). The medium marbling category was ranked second (29.92%), followed by the low marbling category (20.59%). Previous studies have not included a ranking of pork chops among consumers. However this data reinforces the preferences of the consumers for a high marbled pork product. Consumers, when presented with a situation in which they are forced to reveal their preference choose the high IMF pork chop over the medium and low marbled pork chop. More research should be done to determine purchase intent of various IMF content to determine if the consumer's palette and visual cues in pork dictate purchase intent.

Trained Sensory Panels

Results from the trained sensory analysis are displayed in Table 7. Initial and sustained juiciness (IJ,SJ) were not affected by treatment (P = 0.35 and P = 0.23 respectively). As IMF content increased, panelists did not find that initial or sustained juiciness levels increased. Trained sensory panels in a study conducted by Moeller et al. (2010) reported a predicted mean response for juiciness of ~ 0.11 unit increase for each 1% increase in IMF on a ten-point scale. Additionally, Rinker et al. (2008) reported a weak relationship between IMF content and sensory properties among trained panelists. The Rinker et al. (2008) study utilized 6 trained panelists evaluating 5 discrete marbling categories across 3 degrees of doneness. This could account for the differences in results.

Initial tenderness (IT) was affected by treatment (P = 0.008) as chops from the high IMF treatment were initially scored more tender (6.28±0.08) when compared to the medium (6.22±0.08) marbling category. There was a difference between the high marbling category (6.28±0.08) and the low marbling category (5.95±0.08). Additionally a difference between low (5.95 ±0.08) and medium (6.22±0.08) was observed. These results support findings by van Laack et al., (2001) who found a small, but significant ($P < 0.05$) correlation between IMF and WBS across 3 aging treatments of 2d, 7d and 14d.

Sustained tenderness (ST) was affected by treatment ($P = 0.005$) as chops from the high IMF category were scored higher for sustained tenderness (6.39±0.08) when compared to low (6.04±0.08) as well as between medium (6.32±0.08) and low (6.04±0.08). This suggests a threshold of 3 to 3.5% for tenderness. This is supported by Moeller et al. (2010), who reported increasing IMF by 1% improved sensory tenderness levels by 0.23 on a 10 point scale. In Moeller et al. (2010) study, loins from 3 plants were utilized and were used in trained panels at Texas A&M University and at Iowa State University. The current study implemented a larger geographical area. These results align with research in which tenderness was instrumentally measured. Ramsey et al. (1990) reported marbling was negatively related to shear force values (r^2=0.35), meaning that as IMF increased shear force values indicated a more tender product. Moreover, when describing the effects IMF had on eating quality, Fortin et al. (2005) reported only attributes describing tenderness (average shear force, softness, initial tenderness and chewiness) were significantly correlated to IMF. In the Fortin et al. (2005) work, IMF was determined using petroleum ether extraction. Additionally, the work differed in the cooking method utilized; wherein the current study utilized a shell type clam grill, the Fortin et al. (2005) study used a convection oven to cook samples. Cooking method can greatly affect sensory attributes. IMF has been shown to influence tenderness; however its role has not been conclusively determined (van Laack et al., 2001). Consumer perception of texture and taste in pork as well as juiciness is enhanced with increased IMF levels (Fernandez, 1999); however, the exact relationship between tenderness and IMF is not clear. Tenderness and IMF are both heritable traits in swine (Gjerlaug-Enger et al., 2010). A study conducted by Suzuki et al. (2005) reported that IMF is affected by the pig's environment. An explanation for environmental effects on IMF content and tenderness may be that the nutritional diet needed to obtain a high IMF content is low in protein (Pettigrew and Esnaola, 2001). A lower protein diet results in less protein accretion in the body, resulting in reduced growth.

Additionally, a trend was reported in panelist's response to flavor intensity (FI) which was observed at $P = 0.09$. Moeller et al. (2010) observed a small, but significant association between IMF and flavor. A similar relationship between IMF and flavor was observed by Fernandez et al. (1999), reporting a trend of a positive influence IMF had on flavor ($P = 0.09$) in his first experiment and significant improvements in flavor scores with an increase in IMF during the second experiment. Moreover, a statistical significance was reported in a study conducted by Fortin et al. (2005), in which IMF was significantly correlated to flavor. Previous investigations reiterate the results of the current study with small but significant correlations or similar trends.

Connective tissue (CT) levels were not affected by treatment ($P = 0.45$). As IMF content increased there was no difference in connective tissue detected by the panelists. Moeller et al. (2010) reported chewiness levels (CL) were only slightly reduced as IMF content increased; moreover, increasing IMF from 1% to 6% improved CL by 0.19 units on a ten point scale. In a study conducted by Fortin et al. (2005), CL were correlated with

IMF (*P* < 0.001). Additionally, off flavor (OF) levels were not affected by treatment (*P* = 0.34). As IMF content increased, there was no difference in detected off flavors by the panelists. This is supported by Fortin et al. (2005), which found OF scores were very low and not influenced by IMF levels. The absence of off-flavors is critical for the acceptance of pork by the consumer (Risvik, 1994 and Bryhni et al., 2003)

Overall acceptability was affected by treatment (*P* = 0.05), as chops from the high marbling category were scored higher (6.19±0.09) when compared to low (5.90 ±0.09), as well as between medium (6.14±0.09) and low (5.90±0.09). Overall acceptability scores are not widely reported in fresh pork meat evaluation. However, in beef research it is more common. Neely et al. (1998) evaluated 3 cuts across 4 USDA quality grades. Trained panelists evaluated Top Choice, Low Choice, High Select and Low Select USDA quality grades. Neely et al. (1998) reported Top Choice steaks rated higher for overall likeability (*P* < 0.05) than the reminder of the grades. Direct links to beef and pork cannot be substantiated; however, previous investigations have indicated a strong correlation exists between marbling grades in beef, including overall acceptability levels among trained sensory panelists.

CONCLUSION

Results from this study indicate that marbling does influence eating quality within a commercial genetic line from hogs harvested from a single abattoir on the same day when surveying consumers from Texas, New Mexico, Louisiana, Colorado and Arkansas. As IMF content increased, consumers found chops to be more flavorful, juicy and tender as well as scored higher for overall acceptability. The sensory panel revealed supporting results for tenderness and overall acceptability. In beef it is accepted that IMF is correlated to palatability. Additionally, marketing, genetics and nutrition is well developed in beef to produce animals with high IMF. In conclusion, research suggests marbling does play a role in determining palatability. These results suggest consumers prefer higher IMF products when evaluating cooked pork chops among the 5 cities included in the study. The marketing of higher marbled fresh pork meat should be researched to determine the economic value of high marbled pork meat as well as purchasing cues that affect the consumers' decision making.

Table 1. Intramuscular fat content, moisture and protein summary data for porkloins within high, medium and low categories[1]

	Marbling Category		
Item	Low	Medium	High
Minimum % lipid	1.70	3.62	4.90
Maximum % lipid	2.94	4.23	8.41
Average % lipid	2.43	3.91	5.67
Average % Moisture	72.82	72.32	70.54
Average % Protein	23.03	22.40	22.07

[1]A total of 180 loins (n=60 per marbling category)

Table 2. LS means ± SE of L*, a* and b* values of loins from IMF categories (*n* =180).

Treatment	L*	a*	b*	P>F
Low	53.80±0.37^{y}	8.89±0.17	16.93±0.14	<0.001
Medium	50.88±0.40	8.32±0.18^{z}	16.68±0.15^{zy}	<0.001
High	53.33±0.37^{y}	8.19±0.16^{z}	16.44±0.14	<0.001

^{yz} Values within an column (attribute) lacking common superscripts differ (P < 0.05)
[1]Light vs. Dark. A low (0-50) indicates dark and a higher number (51-100) indicates light.
[2]Red vs. Green. A positive number indicates a red and a negative number indicates green.
[3]Yellow vs. Blue. A positive number indicates yellow and a negative number indicates blue.

Table 3. Consumer Demographic Data (*n* =1190).

Gender	%	Ethnicity	%	Age[a]	%	Income	%	Consumption[b]	%
Male	47.2	White (Non-Hispanic)	50.9	18-25	13.7	<$10k	15.4	0	9.1
Female	52.8	Black or African American	13.6	26-35	16.9	$10k-14,999	7.5	1	12.9
		Hispanic or Latino	31.2	36-45	16.2	$15k-24,999	11.7	2	21.9
		Asian	1.1	46-55	21.8	$25k-34,999	12.1	3	19.6
		Pacific Islander	0	56-65	18.0	$35k-49,999	13.2	≥4	36.6
		Native American or Alaska Native	2.2	66+	13.4	$50k-74,999	14.1		
		Other	1.9			$75k-99,999	10.3		
						>$99,999	15.7		

[a]Age in years
[b]Frequency of pork consumption in the last month

Table 4. LS means ± SE of sensory attributes by marbling category as rated by consumers (*n* =180)

Attribute[1]	Marbling Category			P>F				
	Low	Medium	High	Treatment	State	Store	Treatment × State	Treatment × Store
Flavor	75.19±1.13	85.83±1.13	92.16±1.13	<0.001	<0.001	0.07	0.78	0.54
Juiciness	84.55±1.26	95.82±1.26	102.36±1.26	<0.001	<0.001	0.17	0.39	0.73
Tenderness	92.83±1.21	97.75±1.21	104.15±1.21	<0.001	0.003	0.002	0.64	0.79
Overall Acceptability	90.17±1.39	99.11±1.40	105.51±1.40	<0.001	<0.001	0.09	0.54	0.50

[1] Attributes for each sample were rated on a paper ballot with 160-mm continuous line scale, 0 representing extreme dislike, 80 representing the mid-point and 160 being extreme like.

Table 5. LS means ± SE of sensory attributes by marbling category as rated by consumers per state (n =180).

	State					
Attribute[1]	Texas	Arkansas	Colorado	New Mexico	Louisiana	P>F
Flavor	75.89 ± 1.43^{z}	86.71 ± 1.50^{x}	84.00 ± 1.46^{yx}	93.16 ± 1.45^{w}	82.24 ± 1.44^{y}	<0.001
Juiciness	89.95 ± 1.60^{z}	92.90 ± 1.67^{zy}	92.52 ± 1.63^{zy}	95.85 ± 1.62^{yx}	100.01 ± 1.06^{x}	<0.001
Tenderness	94.81 ± 1.53^{z}	96.19 ± 1.61^{zy}	98.13 ± 1.57^{zy}	99.20 ± 1.56^{yx}	102.90 ± 1.54^{x}	<0.001
Overall Acceptability	88.28 ± 1.77^{z}	99.60 ± 1.86^{yx}	100.60 ± 1.81^{yx}	102.67 ± 1.80^{yx}	100.19 ± 1.78^{x}	<0.001

^{wxyz} Values within a row (attribute) lacking common superscripts differ ($P < 0.05$)

[1]Attributes for each sample were rated on a paper ballot with 160-mm continuous line scale, 0 representing extreme dislike, 80 representing the mid-point and 160 being extreme like.

Table 6. Frequency of consumer treatment ranking (*n* =1190).

State	Rank 1 Low (%)	Rank 1 Medium (%)	Rank 1 High (%)	Rank 2 Low (%)	Rank 2 Medium (%)	Rank 2 High (%)	Rank 3 Low (%)	Rank 3 Medium (%)	Rank 3 High (%)
New Mexico	21.94	23.63	54.43	27.00	52.32	20.68	51.05	24.05	24.89
Louisiana	20.65	28.34	51.01	21.46	54.66	23.89	57.89	17.00	25.10
Colorado	25.42	31.25	43.33	28.75	45.42	25.83	45.83	23.33	30.83
Arkansas	16.37	28.76	54.87	29.65	49.56	20.80	53.98	21.68	24.34
Texas	18.33	37.50	44.17	26.25	41.25	32.50	55.42	21.25	23.33
P > F									
State		0.01			0.02			0.23	
Gender		0.90			0.47			0.90	
Ethnicity		0.67			0.34			0.09	
Age		0.12			0.58			0.17	
Income		0.29			0.79			0.74	
Pork Consumption		0.03			0.59			0.37	

Table 7. LS means ± SE of trained sensory panels by Intramuscular Fat (IMF) category.

	Attribute							
Treatment[9]	IJ[1]	SJ[2]	IT[3]	ST[4]	CT[5]	OF[6]	FI[7]	OA[8]
Low	5.89±0.09	5.93±0.09	5.95±0.08^{y}	6.04±0.08^{y}	7.72±0.03	3.99±0.00	5.80±0.06^{z}	5.90±0.09^{y}
Medium	6.00±0.09	6.11±0.09	6.22±0.08^{z}	6.32±0.08^{z}	7.74±0.03	3.98±0.00	5.91±0.06^{yz}	6.14±0.09^{z}
High	6.07±0.09	6.13±0.09	6.28±0.08^{z}	6.39±0.08^{z}	7.72±0.03	3.97±0.00	6.00±0.06^{z}	6.19±0.09^{z}
P>F								
Treatment	0.35	0.23	<0.001	<0.001	0.45	0.34	0.09	0.05

^{yz} Values within an column (attribute) lacking common superscripts differ ($P < 0.05$)
[1]Initial Juiciness: 1=Extremely Dry, 8=Extremely Juicy
[2]Sustained Juiciness: 1=Extremely Dry, 8=Extremely Juicy
[3]Initial Tenderness: 1=Extremely Tough, 9=Extremely Tender
[4]Sustained Tenderness: 1=Extremely Tough, 9=Extremely Tender
[5]Connetive Tissue: 1=None, 8=Abundant
[6]Off Flavor: 1=Extreme Off Flavor, 4=None
[7]Flavor Intensity: 1=Extremely Bland, 8=Extremely Intense
[8]Overall Acceptability: 1=Dislike Extremely, 8=Like Extremely
[9]Intramuscular fat levels of low, medium and high.

Figure 1. Pork *Longissimus* chop allotment to various analyses.

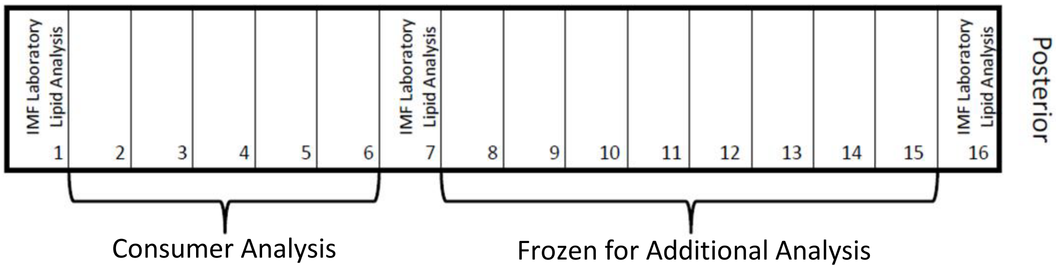

Figure 2. Consumer sensory survey.

Please circle the appropriate response **Survey Code:**

Gender:	Male	Female	**Ethnicity**:	White (Not Hispanic)	Black or African American	Hispanic or Latino	Asian	Pacific Islander	Native American or Alaska Native	Other
Age:	18-25	26-35	36-45	46-55	56-65	66+				
Household Income	<10,000	10,000-14,999	15,000-24,999	25,000-34,999	35,000-49,999	50,000-74,999	75,000-99,999	>99,999		
How many times in the last month have you consumed pork?	0	1	2	3	>4					

Please mark a vertical line on the scale based on your opinion of the samples respective to flavor and overall acceptance.

Sample A

Extreme Dislike — **Extreme Like**

Flavor

Juiciness

Tenderness

Overall Acceptability

Sample B

Extreme Dislike — **Extreme Like**

Flavor

Juiciness

Tenderness

Overall Acceptability

Sample C

Extreme Dislike — **Extreme Like**

Flavor

Juiciness

Tenderness

Overall Acceptability

Please rank the samples from most liked to least liked. ____ ____ ____

Figure 3. Trained sensory evaluation survey.

Angelo State University
Food Safety and Product Development Laboratory

Pork Sensory Data Sheet

Panelist: ______________________ Project ________________ Date: ________

Time: ______________________ Panel# ______________________________

Sample No.	Juiciness		Tenderness		Amount of Connective Tissue	Flavor Intensity	Off Flavor	Overall Acceptability
	Initial	Sustained	Initial	Sustained				

Initial Juiciness
8 Extremely juicy
7 Very juicy
6 Moderately juicy
5 Slightly juicy
4 Slightly dry
3 Moderately dry
2 Very dry
1 Extremely Dry

Sustained Juiciness
8 Extremely juicy
7 Very juicy
6 Moderately juicy
5 Slightly juicy
4 Slightly dry
3 Moderately dry
2 Very dry
1 Extremely Dry

Tenderness
(First Impression)
8 Extremely tender
7 Very tender
6 Moderately tender
5 Slightly tender
4 Slightly tough
3 Moderately tough
2 Very tough
1 Extremely tough

Tenderness
(Overall Impression)
8 Extremely tender
7 Very tender
6 Moderately tender
5 Slightly tender
4 Slightly tough
3 Moderately tough
2 Very tough
1 Extremely tough

Amount of Connective Tissue
8 None
7 Practically None
6 Traces
5 Slight
4 Moderate
3 Slightly abundant
2 Moderately abundant
1 Abundant

Flavor Intensity
8 Extremely intense
7 Very intense
6 Moderately intense r
5 Slightly intense
4 Slightly bland
3 Moderately bland
2 Very bland
1 Extremely bland

Off Flavor
4 None
3 Slight off flavor
2 Moderate off flavor
1 Extreme off flavor

Overall Acceptability
8 Like extremely
7 Like very much
6 Like moderately
5 Like slightly
4 Dislike slightly
3 Dislike moderately
2 Dislike very much
1 Dislike extremely

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VITA

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