

PERCEPTIONS OF MODERN MEAT-ANIMAL PRODUCTION FROM CONSUMERS TWO  
TO THREE GENERATIONS REMOVED FROM THE FARM

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**Title**

Perceptions of modern meat-animal production from consumers two to  
three generations removed from the farm.

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## **ABSTRACT**

Consumer is defined as a person who purchases goods and services for personal use or a person or thing that eats or uses something (Merriam-Webster, 2019). Consumers either want or need to eat meat, whether it is for self-gratification or nutritive purposes. The modern consumer definition of “meat” has changed from the original hunter stalking prey to now contemporary livestock production practices that confine and feed sophisticated diets in an effort to achieve outstanding muscle-food quality. Those who produce and supply consumers with food and fiber must achieve a higher level of education in keeping with technological advances. Further, there is a change in the demographics of modern farmers/ranchers, with more women entering the field (Lucier, 2019). Younger generations are technologically savvy and seek “finger-tip” evaluation access of the meat they are considering for a purchase. These consumers demand instant access to industry trends in order to keep current with the next meat branding idea (ex. Guaranteed Tender and Flavorful Beef). Consumers are no longer waiting for the producer and product to come to them, they are seeking out local and reliable agricultural products suppliers in their hometown. This “buy local” idea is pushing a food trend in restaurants and food service to provide menu options consisting of locally grown and prepared items (Mealey, 2019). Innovative development of technology that provides instant access to information regarding the places that offer these food products as well as information regarding the product quality is giving consumers purchasing power. The following research will examine the aspects of consumer perception of meat production relative to modern consumers that are two to three generations removed from the farm.

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Philippians 4:13 & Matthew 6:33

## **DEDICATION**

To my Father, DeMetris Reed, Sr.

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## CHAPTER 1. INTRODUCTION AND LITERATURE REVIEW

### Introduction to Meat Palatability

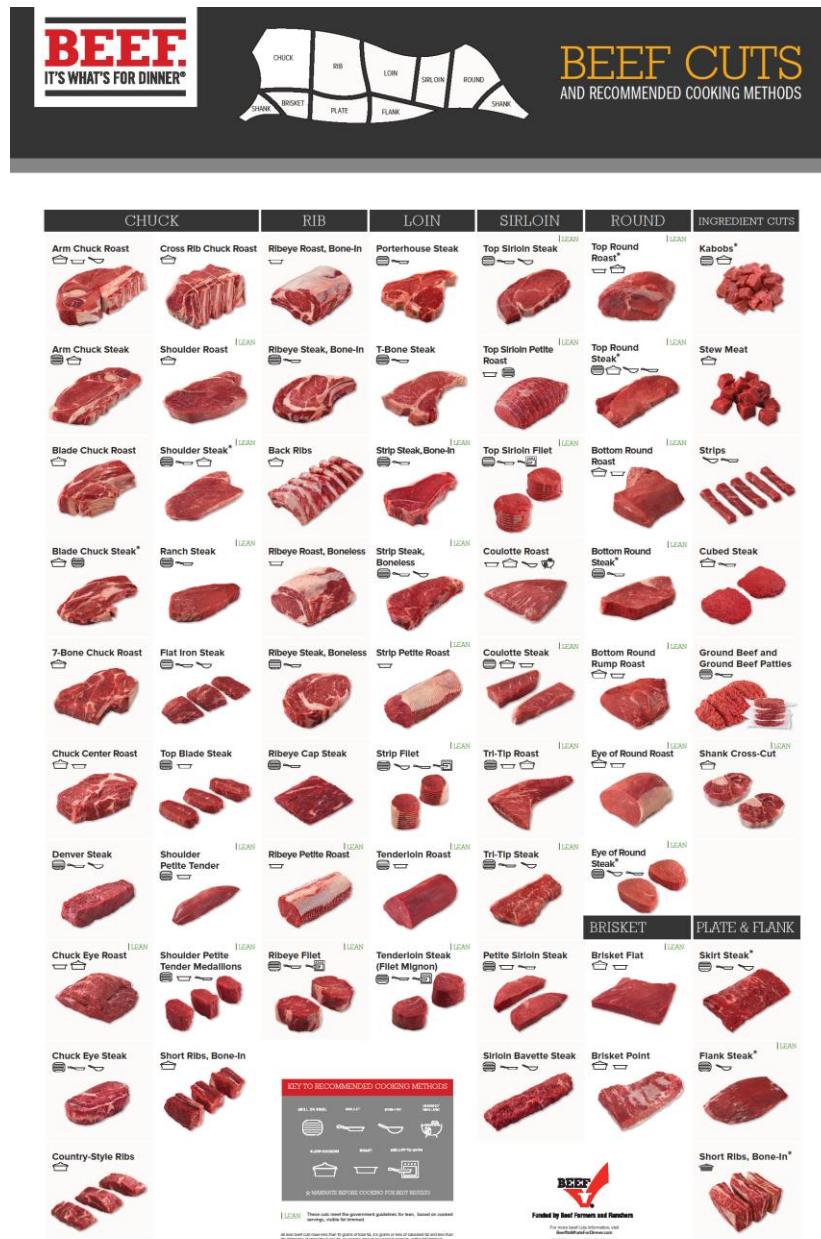
The flavor of meat ranks as the third most important trait that consumer's desire in a meat product (followed by tenderness and juiciness) according to consumer sensory analysis (Reed et al., 2016). Calkins and Hodgen (2007) stated that "*flavor*" is composed of a complex of interactions that may be perceived differently by different individuals and in different situations which, therefore, can influence the perception of meat and impact the perceived sensory characteristics of meat. Beef has been known to have a certain flavor distinctive from other meats (such as pork or lamb) which makes it more palatable and increases the euphoria that is associated with consuming beef. The main precursors to meat flavor have been researched and identified. Ba et al. (2013) found that the fats in meat are the most important when it comes to cooked meat flavor and sensory characteristics. Therefore, any research conducted with the attempt to improve the palatability (tenderness and juiciness) of meat must also evaluate the flavor profile of the product.

Beef is the name of fresh meat of the bovine species. The largest consumers of beef annually in the world include Argentina (41.2 kg), Brazil (26.5 kg), United States (25.8 kg), Paraguay (25.5 kg), and Australia (20.9 kg) (Agriculture Output OECD, 2017). Beef is the highest consumed source of meat in many countries. People eat meat due to its nutritive value, availability, tradition, and religious beliefs. According to the U.S. Meat Export Federation, the United States exported 1.26 million metric tons of beef in 2017 for a net value of \$7.27 billion. The marketing of cattle in the United States is based on the *ante-mortem* production of the beef primarily from cattle <30 months age, well-fed steers or heifers that weigh from 408 to 544 kg. Beef carcasses marketed after evaluation under the United States Department of Agriculture

(USDA) Food Safety and Inspection Service will, on average, possess the following characteristics. The fat should be firm and from 6.35 to 12.7 mm thick over the center of the back. The round should be full, plump and well-muscled with the sides straight and smooth. Popular retail cuts include tri-tip, often called the California brisket, is marketed as steaks or whole roast, ribeye (loin or steak) processed into roasts and (or) sliced for steaks, and the round which can be kept in large roast size.

The beef eating experience is only as good as the cook preparing the beef. For example, the bottom round steak is a popular cut obtained from the hind quarter (round). It can be marinated and grilled or broiled till tender to cut against the grain. An ethnic cut would be the outside round; commonly known as the heel. Because it is a muscle that was associated with locomotion, it is very lean but less tender. The heel can be slow braised until tender. The difference in cooking methods such as grill, broil, braise/pot roast, skillet, and stir-fry are used to obtain the greatest eating experience for each cut. Each cooking technique requires attention to time, temperature, and humidity to provide the most conducive cooking environment and allow for the most enjoyable eating experiences. Muscle meats obtained from locomotion areas (shank, brisket, chuck, plate and round) are leaner and less tender due to a greater concentration of connective tissue. Cuts from muscles of locomotion must therefore be cooked for longer periods of time at a lower temperature (between 76°C and 82°C) to allow the collagen associated with the connective tissue to gelatinize and denature or marinades can also be used to improve tenderness. Those muscle meats that served to provide support to posture (rib, loin, sirloin, and flank) are more tender, contain more fat externally, and more marbling (intramuscular fat) where they can be cooked at higher temps for shorter time and maintain a high palatability. Lean and fat

trimmings are used for sausage and shortribs are kept whole to be sold fresh, smoked, or barbequed (Figure 1.1.).



**Figure 1.1.** National Beef Check-Off: Beef retail cuts and recommended cooking methods poster.

Today’s consumers prefer to purchase beef (or other meats) that have satisfactory palatability. Consumers are willing to pay for expensive cuts of meat that they consider to be tender, juicy, and (or) more flavorful. Consumers are provided information on all cuts and how

they can be prepared by visiting <https://www.beefitswhatsfordinner.com/cuts/cut-charts>. Beef graded as USDA Prime possesses the highest amount of marbling (intramuscular fat) and is rather expensive to purchase depending on the cuts of meat obtained from different areas of the carcass. For example, the tenderloin and ribeye beef cuts are priced higher than sirloin steak in the retail case because they are superior in these palatability characteristics. That said, the tenderloin contains much less intramuscular fat than the Prime ribeye. Overall steak palatability quantified in sensory panel rating scores are strongly correlated to flavor provided by fat compared to the components of tenderness and juiciness (Huffman et al., 1996).

### **Components of Meat Palatability**

Meat palatability is impacted by ante- and post-mortem factors that affect the underlying chemical and physical components of meat (Miller, 2001). The palatability attributes of meat which consumers continually seek consist of three essential tasting qualities; tenderness, juiciness, and flavor. Let us examine these three aspects of palatability individually. Tenderness is the perceived amount of pressure needed to chew and cut through a piece of meat (Rhodes and Nute, 1980). Meat juiciness is the perceived quantity of juices experienced during the act of mastication (chewing). Consumers can distinguish if meat is dry or juicy and they typically associate dry with toughness and juicy with tenderness (Rhodes and Nute, 1980). Flavor which is taste, mouthfeel, aroma, and past experiences (or memory) associated with that food item. The sensor cells which respond to taste are located in our mouth and are present over the tongue in clusters commonly referred to as taste buds (Crosby, 2012). The five tastes identified and associated with detection by the taste buds are 1) sweet, 2) sour, 3) salty, 4) bitter, and 5) umami. The taste and flavor of beef can be impacted by numerous factors under the control of those



raising the livestock and processing the food item; including animal genetics, production environment, transportation stress, ante-mortem practices, processing, and cookery.

## **Genetics**

Genetics associated with palatability can be impacted by environment. Genetics are defined as the study of heredity and the characteristics inherited with their variations (Merriam-Webster, 2019). The ten most popular cattle breeds in the United States include Black Angus, Charolais, Hereford, Simmental, Red Angus, Texas Longhorn, Gelbvieh, and Holstein (AgDaily, 2018). Research has shown that certain breeds are genetically more palatable once they are processed for meat production (Rodrigues et al., 2017). Rodrigues et al. (2017) stated *Bos indicus* beef (i.e. Brahman cattle) are generally leaner and tougher than *Bos taurus* such as Angus and other continental breeds. When studying *Bos indicus* and *Bos taurus* cattle genetics, temperament of the cattle has been identified as a genetic component that could impact ultimate meat quality. Magolski et al. (2013) suggested evaluation and quantification of market cattle temperament at production could be used as a way to differentiate post-mortem beef palatability. Temperament is an inherited trait. It is good herd management to select cows with a desirable temperament to pass on to future progeny. Hall et al. (2011) concluded that excitable temperament can cause a negative response on growth, carcass quality, reproduction management, and overall herd health. As stated previously, *Bos indicus* have a history of increased or excitable temperament that is inherently passed on to progeny. This has become such a concern for the American Brahman Breeders Association (ABBA) that they have commissioned research to study temperament of registered sires and dams to provide information identifying registered docile genetics. Brahman have also exhibited higher calpastatin activity that would positively correlate to increased toughness in meat (Rodrigues et al., 2017).

Calpastatin is the metabolic inhibitor of a group of proteolytic hormones known as calpains. The calpains have been identified as a primary contributor to postmortem protein degradation and development of tenderness (Carlin et al, 2013). In the living animal, calpains are responsible for protein turnover and therefore animals possessing higher concentration of calpastatins are generally more muscular. Therefore, there is a genetic component to calpastatin, muscular phenotype, and meat toughness.

Producers have incorporated genetic research to improve meat palatable traits. For example, one of the most extreme genetic examples for marbling deposition would be associated with the Wagyu breed of beef. Wagyu type breeds have been researched to study their marbling deposition and effect on tenderness, juiciness, and flavor (Mears et al., 2001). Wagyu genetics for marbling have been used to improve crossbreeding programs whereby Wagyu sires are bred to dams of continental breeds (Angus and Hereford) (May et al., 1993). In Japan, researchers found the key to the succulent flavor of kuroge-wagyu beef was highly correlated with the percentage of the monounsaturated fatty acid; oleic acid (Kyo Torigoe, 2009). Genetics can effect palatability on the basic level previous to initial production practices and must be given attention as the basis of herd management.

According to the USDA Agriculture Marketing Service (Certified Beef Programs, 2018), there are 93 branded beef programs that market their beef as “guaranteed tender.” Many of these programs focus on genetics. Certified Angus Beef (CAB) has a three point process to verify their tender beef: 1) cattle have a minimum of 50% Angus genetics, 2) must be source verified, and 3) must be age verified to qualify for the CAB program. Sales of CAB began in 1978. The sales effort focused on the introduction of a high quality branded product to the meat retail industry. Certified Angus Beef was the leader for establishing the foundation for USDA-certified branding

programs. The USDA certification designation provides legitimacy to branded programs under their purview by ensuring that the terms and conditions necessary to obtain the “brand” are quantifiable and managed appropriately. Branded programs, like CAB that place a large emphasis on a guaranteed tender product, pay a premium to producers who deliver cattle that qualify for the branding designation. The success of the program has grown over the years because of the participants desire to receive a premium for their cattle.

### **Production Practices**

Cattle are not indigenous to the United States. Many modern U.S. breeds are descendants of cattle that arrived on our shores with the Spaniards and later Europeans. For much of the 19th and early 20th Century, cattle meat was supplied by the Spanish influenced Longhorn breed. “*The meat is fine-grained and close or similar to venison, it is apt (has a tendency) to be a little tough*” reported the New York Tribune in 1854. Historically, meat from these “tougher” breeds was cooked in a manner to compensate for the lack of tenderness. Moisture was added during the cooking process to facilitate the breakdown of connective tissue.

Hereford cattle in Kentucky were becoming an important breed in the mid-1800s as the population spread westward. Brahman cattle were being bred in Louisiana circa 1854 from cattle brought from India while 1200 head of Scotland Angus cattle that had been imported to the Midwest in 1873 saw an explosive growth in breed registries from 1878 to 1883 (The First Angus in America, 2019). Ranchers recognized that the moderate framed Angus and Hereford were able to reach a desirable market weight in a shorter period of time compared to the Spanish Longhorn. Furthermore, management of the more docile Angus and Herford breeds had advantages for both human and animal safety compared with the more volatile temperament of the long horned cattle.

The introduction of feedlot cattle management operations in Oklahoma and the Texas Panhandle moved cattle from the open range grass finishing to confinement pens where cattle were finished on grain. The diets (nutrients) consumed by beef, pork, lamb and poultry can alter the flavor of the subsequent meat product either positively or negatively. For example, diets commonly fed to feedlot beef consist of corn, silage, and distiller's grains. The composition of this diet results in beef fat that is a desirable white color and produces a fatty acid profile primarily composed of oleic acid (originated in the corn oil). Grass-finished cattle will have a higher deposition of carotenoids deposited into the fat which provides an off-flavor classified as "grassy" (Daley et al., 2010). Cattle finish much faster on grain than they do on grass and possess a greater proportion of body fat. The availability of corn in proximity to the feedlots provide a feed ration that would improve carcass quality with the most important factor of carcass quality being intramuscular fat (marbling). A well-marbled steak would be perceived by consumers as the juiciness component and is the primary determinant of the USDA quality grading designations for Prime, Choice, and Select. Once again it is important to emphasize the role that the production environment plays on ultimate meat quality. Chronic stress experienced at the production site(s) can impact meat tenderness and the ability of beef to deposit marbling. As previously noted, many branded programs will pay a monetary premium for the meat attributes of tenderness and marbling.

### **Transport and Stress**

Stress is described by Hans Selye as a non-specific physiological response to a demand placed on an individual. Sheridan et al. (1991) defined stress as any external or internal challenge that disrupts the internal environment. Grandin (1997) emphasized two categories of stress involved in livestock production; psychological and physical. The psychological stress is

attributed to perceived danger as a result commingling with unfamiliar animals, loud handling, or fear of a novel environment. The psychological stress can also be associated and enhanced in the presence of physical stress caused by hunger, disease or injury. Livestock subjected to acute stress (short in duration) may not necessarily impact the animal in a negative manner, but rather could serve to “prime” the immune system to combat a future physical stress. However, chronic stress experienced for an extended period of time could lead to overwhelming the immune system, decreased quality of life, and detrimental consequences for carcass quality (Grandin, 1997).

Transport can impact meat animals and their carcass palatability. Grandin (2016) stated that transportation was an unfamiliar and a life threatening event for domestic animals which involves handling animals from pasture or pen and movement from a large (familiar) area into a (unfamiliar) confinement space. Transport can lead to stress, sickness, injury and death which can result in financial losses associated with bruising and monetary discounting of bruised carcasses paid at slaughter. Bruising, if not caught at the processing plant, could reach the consumer and result in a negative purchasing experience (Grandin, 2016) and could propose a perception of inhumane handling of the animal and negative outlook on producers. Effort must be made to reduce transport stress in order to deliver a marketable animal for exceptional meat consumption.

### **Lairage and Ante/post-mortem Practices at the Packing Plant**

Short term stress associated with loading, trucking, and in lairage can negatively impact carcass quality and negate the low stress efforts imposed at the production site. Lairage is defined as a place where sheep or cattle may be rested after transit to market or abattoir (Merriam-Webster, 2019). As described previously, transportation is an unfamiliar and stressful

situation to animals being handled and then placed into a novel confinement facility at the packing plant with strange animals, strange sights and sounds. Reducing animal stress in lairage can improve tenderness and post-mortem processing. Every production factor that impacts an animals ability to be alive, survive, and thrive will have either a negative or a positive impact on the quantity and (or) quality of the subsequent meat product produced. Production environment and practices that impose stress will result in animals unable to achieve their optimal genetic potential. Increased stress in the production and ante-mortem environment can cause the meat to become tough. Producers who take steps to improve handling facilities, train stockpersons in low stress handling of cattle, keep animals fed, dry and healthy not only impact the welfare of the livestock in their care, but also positively impact the valuation of the meat products produced.

Once an animal is stunned at the abattoir their muscles begin to accumulate lactic acid and the pH lowers. The process of rigor mortis takes place within the animal converting muscle into meat. Rigor mortis is an essential component of the conversion of muscle to meat. The onset and resolution of rigor mortis partially determines the tenderness of meat. However, in chronic stressed cattle ante-mortem conditions can lead to post-mortem meat quality defects. Cattle that experience chronic stress experienced in handling, transport, commingling in the pens, and (or) heat exhaustion can cause the animal to deplete intramuscular glycogen stores which results in a higher postmortem muscle (meat) pH (Miller, 2007). A high postmortem beef pH that occurs prior to rigor will result in a dark, firm, and dry (DFD) meat. This meat quality is a negative quality characteristic that will result in a discount of the carcass, not due to its inability to be eaten, but is perceived in a negative manner by consumers. Reducing stress during the ante-mortem period will increase profit because of improved consumer acceptance of wholesome beef cuts.

## **Processing and Cookery**

To truly taste, we must rely on all five senses: sight, touch, taste, smell, and sound. We eat with our senses. Take the time to close your eyes and think of a favorite dish; the way it looked, the touch of it with your hand or utensil, the smell of its distinct aroma, maybe even the sound of a crunch that only this specific dish can make. All of these experiences are a large intangible that impacts our perception of what is perceived as “flavor.” The chemical nature of taste has to do with the receptors present on taste buds for the five tastes; sweet, salty, sour, bitter, and umami. Flavor is the distinct combination of art (gastronomy; eating experience) and science (chemical receptors of the five tastes). Crosby (2012) reported from research conducted at The University of Florida Center for Taste and Smell that a single individual could possess up to 10 times more taste buds as another. This degree of human to human variation in taste sensation can result in serious implications to businesses who rely on providing food products that appeal to the taste and flavor preferences of the consuming public (Crosby, 2012). The distinct and identifiable flavor of muscle foods is dependent upon factors such as the animal’s species, age, breed, sex, type of diet consumed, post-mortem processing, and ultimately the method of cooking (Spanier, et al., 1996).

Flavor is a sensory trait that influences consumer acceptance of food. Meat flavor, which develops when heat is applied, depends on the amount and proportion of different compounds present within that species of meat. Meat is composed of water, proteins, lipids, carbohydrates, minerals and vitamins. The compounds of proteins, lipids and carbohydrates are critical in obtaining flavor development because they include several compounds capable of developing into important flavor precursors when heated. Flavor is essentially the mixture of the proteins and lipids to obtain a euphoric feeling when eating cooked beef. Flavor can also be enhanced by

incorporating liquid mixtures with additives such as salt, water, or sugar into or on the meat. Calkins and Hodgen (2007) referenced that hundreds of compounds interact to influence the perception of the flavor and aroma of meat. Torigoe (2009) found that beef marbling that containing a higher percentage of oleic acid scored much higher for taste satisfaction among consumers. In contrast, meat from cattle finished on grass possess an excess amount of stored  $\beta$ -carotene within their fat which generates a yellow color that is undesirable to many consumers. Their fat is yellow due to their diet of grass/forages; a major source of the natural  $\beta$ -carotene pigment. Grass-fed cattle are lower in total fat compared to grain-fed, yet no consistent differences are observed for saturated fatty acid content (Daley et al. 2010). Daley (2010) also reported that the differences associated with the fatty acid content of grass-fed beef possess a distinct grass flavor detected by taste panelists.

Dry aging is the process used to produce a unique flavor of beef. It has a distinct beefy, brown roasted, nutty flavor (Dashdorj et al., 2016). The dry-aging process changes beef by two means: 1) moisture is evaporated from the muscle, creating a greater concentration of beef flavor and taste and 2) natural enzymes present in postmortem beef break down the connective tissue in the muscle which leads to more tender beef. Dry aging takes place over a 28-35 day period with beef maintained at a humidity level of 80-85 % with continuous air flow at a temperature of -0.5-1 °C. At this point, meat can reach a potential balance between tenderness, taste, and juiciness (Campbell et al., 2001).

Wet aging is the process used by 95 % of American beef processors whereby beef is typically aged in a vacuum-sealed bag to retain its moisture. The process provides for less moisture loss resulting in less product weight loss compared to dry aging (DeGreer et al., 2009). Wet-aging is popular because it takes less time: typically only a few days. “It is mistaken that



using packaging you are aging beef. Sealing beef is actually not aging it but preserving it, and it doesn't improve taste but may improve only tenderness" (DeGreer et al., 2009). Beef that has not been aged has a weak, bland odor, while aged beef has a strong, savory, roasted odor. Aging can increase fatty flavor and positive flavor notes such as beefy, brothy, sweet and browned caramel. That said, aging can also increase some negative flavor attributes such as painty, cardboard, bitter and sour. Wet-aged beef can accumulate a mild sour and strong bloody/serummy flavor. Spanier et al. (1996) evaluated the effects of post-mortem aging on meat flavor quality noting that such desirable flavors as beefy, brothy, browned-caramel and sweet declined as aging progressed, while off-flavors of bitter and sour increased.

Degree of doneness and marbling content are factors that impact the consumer's ability to perceive juiciness. Angus genetics, feedlot diets formulated to increase marbling, and meat thermometers provide a great head start for cooks attempting to provide a satisfying meat eating experience. Whole muscle cuts such as steak can be cooked to a lower final temperature (52 °C to 66 °C). Ground meat products such as hamburgers must be cooked to a higher temperature (71 °C or higher) because if bacterial contamination was present on trimmings, the potentially pathogenic organisms would be ground into the final food product. Obviously this does not occur with intact, whole muscle steaks, so the high heat exposed to the exterior of the steak will almost instantly kill any potentially harmful organisms.

Changes in the connective tissue and myofibrillar proteins result from the change in meat tenderness as a result of cooking. It is well known and reported that connective tissues (collagen) will contract under high heat and increase toughness of the final meat product; however, lower cooking temperatures (76 to 82 ° C) applied in a more humid environment (such as crock pot or bar-b-que) result in collagen denaturation that will enhance overall tenderness. Research has

focused on the effects of low-temperature and extended cooking times to improve tenderness and decrease cooking loss (Bramblett et al., 1964). Bramblett et al. (1964) reported that maintaining meat at an internal temperature of 57 to 60 ° C significantly improved tenderness. Cooking can improve tenderness and other palatability attributes of beef as cooking denatures collagen crosslinking.

### **Palatability Combinations**

We have evaluated the aspects of palatability individually, but the consumption of meat is a holistic experience and the aspects of palatability combine to provide what is ultimately perceived as desirable by the individual. For example, correlations between juiciness and flavor are the most desired attributes of consumer preference. The lack of one of the three aspects of palatability may be forgiven, but to have an undesired experience for two attributes will result in a negative perception made by the consumer. This is why consumers look for more than one attribute when reaching a quality eating experience. Killinger (2004) reported 51 % of surveyed consumers attributed eating satisfaction with tenderness, however the in-home survey that they completed for beef cooked at home suggested that ‘flavor’ affected the overall perception of palatability.

O’Quinn (2015) reported a decrease in consumer acceptability for each palatability trait as fat level decreased ( $P < 0.05$ ). Beef fat (tallow) impacts all three aspects associated with palatability and provides consumers a euphoric experience during sensory evaluations of fattier beef. Kerry (2002) suggested four theories regarding how beef lipids provide an influence on beef palatability. The first is the bulk density theory. The density theory suggests that fat is not as dense as heat-denatured meat proteins, therefore meat with higher fat content is perceived as more tender. The second theory is the lubricant effect. The lubricant theory indicates that lipids

act as a mechanical “*give way*” to provide less resistance during chewing of meat. The third is the insurance theory. The insurance theory is that lipids protect against heat-induced toughening of muscle fibers during cooking serving as a buffer to the insult of heat. The final is the strain theory of fat in meat cuts. Imbedding of marbling between the muscle fibers and muscle bundles impacts tenderness because as marbling increases, connective tissue is weakened by the strain induced on the epi- and perimysium connective tissue resulting in more tender meat. These theories do not work independently of each other. All are essential to the consumer eating experience and subsequent repeat purchase.

### **Industrial Quantification of Beef Palatability**

#### **Subjective Measurement**

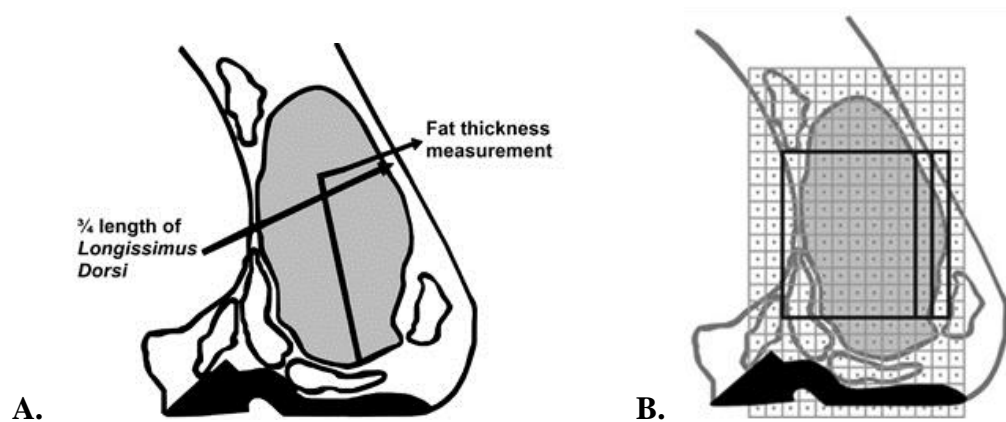
We have established that consumers purchase beef based on palatability attributes that they have found through experience or marketing to provide a pleasurable eating experience. The valuation of beef carcasses is based on quantity of beef to be sold and quality of beef sought by the consumer. The Agriculture Marketing Service of the USDA provides two distinct and separate services relative to evaluation of muscle-foods in America. Those entities are divided into the Inspection and Grading Services. The USDA Food Safety and Inspection Service (FSIS) is responsible for inspecting the humane treatment of animals entering the slaughter process as well as ensuring safe processing of meat producing animals to provide a safe and wholesome meat product for consumers. Food safety inspection provided by the FSIS is a service provided to the food industry by the federal government and is paid for by American tax dollars. The USDA Grading Service, on the other hand, is a voluntary program paid for by the meat packing industry. This service determines beef carcass grades for quality and yield grade (USDA FSIS, 2016).

Yield grade (YG) is numeric index from 1 to 5 used to predict carcasses that produce the best cutability (Meat Buyers Guide, 2014) or more accurately described as the yield of boneless, closely trimmed retail cuts (BCTRC) from the round, loin, rib, and chuck. A YG 1 carcass will yield an average superior to 52.3 % BCTRC, YG 2 = 52.3 – 50 %, YG 3 = 50 – 47.7 %, YG 4 = 47.7 – 45.5 %, and a YG 5 will yield less than 45.4 % BCTRC. In simple terms, an YG 1 beef carcass would possess the most muscle and least fat and YG 5 would have the least muscle mass in relation to the greatest amount of trimmable fat. Yield grade is more objective than quality grading and is calculated from a mathematical equation.

$$\text{Yield Grade} = 2.50 + (2.5 \times \text{adjusted fat thickness in inches}) + (0.2 \times \text{percent kidney, pelvic, and heart fat}) + (0.0038 \times \text{hot carcass weight}) - (0.32 \times \text{ribeye area in square inches})$$

Yield grades are determined by four quantitative variables: 1) external fat measured on the cut lean surface of the interface between the 12<sup>th</sup> and 13<sup>th</sup> thoracic ribs, 2) kidney, pelvic, and heart fat (KPH) expressed as a percentage of hot (pre-rigor) carcass weight, 3) ribeye area also measured at the cut lean surface of the interface between the 12<sup>th</sup> and 13<sup>th</sup> thoracic ribs (Figure 2), and 4) hot carcass weight (Figure 2-A). The measure of external fat (Figure 2-B) is referred to as the preliminary yield grade (PYG) and has the biggest impact on carcass valuation because most consumers do not consume external fat and it ends up as plate waste (discarded). As PYG increases, final YG will increase because the higher the yield grade, the greater the amount of trimmable fat. The ribeye area (REA) is measured to provide an indication of muscle yield. The larger the REA, the lower the final YG because a lower YG is indicative of more edible lean and less fat. While on the surface it may seem that “*bigger is better*” because consumers may desire a larger loin or rib steak, however, there are negative associations with a large ribeye similar to the

heavy carcasses. Heavier carcasses are discounted (lower valuation) to compensate for the ability of the processor to handle the large heavy muscled animal on the processing rail. Larger carcasses decrease the workers ability to fabricate cuts in a timely manner. The kidney, pelvic, and heart fat (KPH) are evaluated subjectively by the grader and expressed as a percentage of the total hot carcass weight. The average beef carcass will possess between 2 to 4 percent KPH. On average, KPH higher than 3.5 % will result in an increase in PYG and final YG, while below 3.5 % will decrease final YG (USDA AMS, 2019).



**Figure 1.2.** Anatomical locations for determination of (A) external fat depth (preliminary yield grade; PYG) and (B) ribeye area at the cut lean surface of the interface between the 12<sup>th</sup> and 13<sup>th</sup> thoracic ribs. Source: Tatum, D. 1997. Beef facts: meat science beef grading. National Cattlemen’s Beef Association. pp. 1-4.

Quality grade provides a designation standard that is used to classify beef on basis of palatability and cooking traits (Maddock, 2018) with the higher quality grade designation resulting in higher carcass valuation. Three factors are evaluated when the USDA Grader determines a quality grade 1) carcass maturity, 2) lean color, and 3) marbling. Bone ossification of the cartilage located on the dorsal process of the 9 to 12<sup>th</sup> thoracic vertebrae and ribeye lean color are the two means for determining carcass maturity. Age of the carcass is an estimate of the chronological age of the animal before slaughter that is determined by means of evaluating the progression of cartilage to bone ossification. The cartilage on the outer tip of the dorsal process

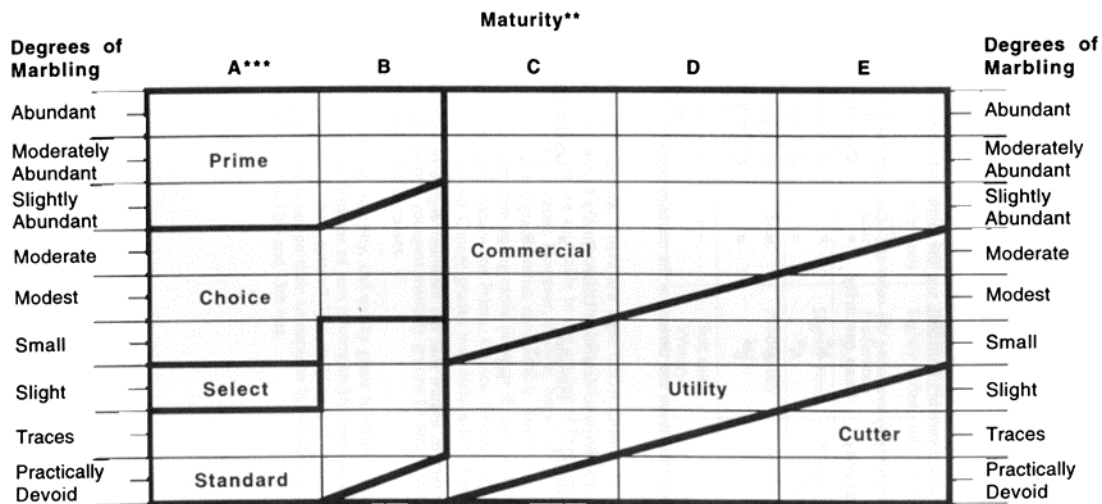
of the 9 to 12<sup>th</sup> thoracic vertebrae is commonly referred to as the “cartilage buttons” in the industry. These buttons are most prominent, softest and least ossified in younger carcasses. Maturity classification starts as an “A” designation that is indicative of cattle that were 9-30 mo of age. Maturity classification continues as the cartilage buttons show more evidence of bone ossification with B at 30-42 mo., C at 42-72 mo., D at 72-96 mo., and the oldest, E greater than 96 mo. of age (often referred to as “hard bone”). Chronological age is the most important factor impacting meat tenderness. Younger cattle provide more tender cuts of meat because the older, more mature cattle will have had more time for connective tissue to toughen through formation of collagen cross-linkages. Furthermore, over time, the ratio between muscle protein and connective tissue declines. Both conditions combine to present a tougher cut of meat.

Lean color is also subjectively evaluated by graders as an indicator of age. The most desirable color for beef lean is a bright cherry-red color. Graders evaluate lean color on the cut lean surface of the ribeye at the 12/13<sup>th</sup> rib interface. Lean color is designated by the same A to E maturity categories as bone ossification with A indicative of light cherry red, B slightly dark red, C slightly darker red, D moderately dark red, and E a dark brick red designated as a “dark cutter.” The color of lean can result in dropping the carcass quality grade a full category (i.e. from choice to select). Dark lean receives a discount on quality grade because consumers avoid dark beef in the retail case and they prefer the cherry red color that designates an A color score.

Marbling is the most important factor for determination of USDA quality grade. As discussed above, intramuscular fat plays an important role in the perception of all aspects of palatability; tenderness juiciness, and flavor. The quality grade is based on 1) degrees of marbling (Figure 3, vertical axis) and 2) maturity (age) (Figure 3, horizontal axis). The beef quality grades are (from most palatable quality to least) Prime, Choice, Select, Standard,

Commercial, Utility, Cutter, and Canner (National Cattlemen’s Association; Beef Facts, 2019). An example of subjective analysis a carcass can be A maturity and marbling score of moderate and be classified as Choice<sup>+</sup> yet a B maturity carcass with slightly abundant marbling score can be considered Prime<sup>-</sup> or Choice<sup>+</sup> dependent on the grader.

**Relationship Between Marbling, Maturity, and Carcass Quality Grade\***



\* Assumes that firmness of lean is comparably developed with the degree of marbling and that the carcass is not a "dark cutter."

\*\* Maturity increases from left to right (A through E).

**Figure 1.3.** USDA quality grade grid for determining palatability grade from the subjective analysis of marbling and maturity.

### Objective Measurement of Beef Quality

In the 80 year history of beef quality assessment to evaluate attributes such as carcass yield and quality grade, subjective human judgement has been used as the primary tool to determine carcass value. After 28 years of research and construction of video image analysis (VIA) for yield assessment the USDA-AMS adopted the standards of the VIA prediction of marbling score (Woerner et al., 2009). The approval of this technology to predict beef quality opened the door for other red meat species to utilize the technology (pork and lamb). Camera and computer vision systems have been used to analyze color, protein degradation, marbling, fatty acid content and palatability. Color can be evaluated on three attributes: hue, chroma, and value

(Judge, 1989). Objective computer vision systems (CVS) remove the subjectivity associated with the human grader and possess a greater outcome for predicting consistent, desirable beef quality analysis (Sun et al., 2011). Human visual assessment cannot identify physio-chemical factors (such as protein degradation) that impact meat tenderness or fatty acid profile that may impact beef flavor (Sun et al., 2011). Sun et al. (2014) reported that support vector model (SVM) technology was a more accurate predictor for the classification of protein degradation (improved tenderness) in comparison to a stepwise regression model. It was concluded that in order to develop accurate models, larger training and testing sets are required. Sun et al. (2016) investigated the analytical potential of CVS processing and texture analysis to quantify fatty acids associated with soft pork. The image texture features were utilized in linear and stepwise regression models to predict percentages of total fat for oleic, linoleic, and linolenic fatty acids and iodine values (Sun et al., 2016). The study reported that the linear regression model produced effective values compared to the non-linear regression which required a larger population of pork samples. Computer vision systems hold great potential as a means to objectively assess meat quality compared to traditional subjective analysis used for carcass valuation.

## **Consumer Education**

### **Public Influencers of Consumer Perceptions of Red Meat**

Generations Y (millennials), X, and boomers enjoy cooking; they enjoy good food and good food combinations. According to a recent Harris Poll (Marketing Charts, 2010), nearly half of Americans watch cooking shows either occasionally (34 %) or often (15 %) yet the key influencers of red meat cookery in the U.S. today are barbecue purists, instagrammers, traditional cooks, television competitors, restaurateurs, and those peer enthusiasts who champion the



satisfying eating experience attributed to traditional red meat flavor, tenderness, and juiciness. Scripps Networks Interactive, is the umbrella company for a new video network called Genius Kitchen. Launched in 2017, Genius Kitchen describes itself as “edible entertainment”. In an interview with online magazine OZY - Fresh Stories and Bold Ideas (2018), Vikki Neil (Senior Vice President of Scripps Networks Interactive) described how Scripps (which is the parent company of the Food Network) is reaching multiple generations’ interest in food and cooking:

‘The thinking is they [younger people] want [recipes] that aren’t fussy — not as technical’ she says. Popular shows on the [Genius Kitchen] network include *Carnivorous*, where comedian Courtney Rada experiments with all forms of protein — Neil says the real-person approach resonates with viewers. Plus, her team is quick to jump on any social food trends [that] ‘You wouldn’t find on the Food Network,’ that’s relevant because Scripps owns the Food Network, and Genius Kitchen can be considered its sassy teenage offshoot. As it’s available on web, mobile, app and Apple TV, Neil says GK is platform agnostic — with more than 500,000 recipes in its library.

Marketing agencies may point to social media and popular television shows as points of education with regard to food selection and preparation; however, a survey by the International Food Information Council (IFIC) revealed consumers place the most trust in government agencies for information on food. In 2018, 38 % of consumers turned to government agencies for information about food, which was an increase from 25 % seen in 2017. In 2018, 19 % of consumers often obtained information from their local extension offices and USDA pamphlets which was almost double of that seen in 2017 at 11 % (IFIC Survey, 2018). Agricultural organizations or clubs recognized on the national level are another means to provide muscle food information to young/future consumers. When it comes to consumer education, the platform of 4-H and FFA are combating the negative perception of red meat. Members involved in these organizations may learn meat science in the high school classroom or as a proficiency project. These young members are knowledgeable of the basics of meat science associated with carcass evaluation, wholesale and retail cut fabrication, the importance of marbling, tenderness, and

cooking methods (National 4-H Meat Judging Resources AMSA, 2018). In fact, Swan and De Lay (2014) noted that freshmen entering college who were members of an agriculture organization in secondary school or younger had an advanced knowledge of subject topics in agriculture compared those who were not members.

### **Land- Grant Institutions**

The educational impact of such national organizations as 4-H and FFA regarding the agricultural knowledge of young people has been essential to the agriculture education sector. Adult 4-H volunteers (leaders) and Agricultural Education teachers (FFA), of primary agriculture education had to receive their training and knowledge from someplace therefore Land Grant Universities (LGU; the “State” universities) were created and founded on the principles of agricultural education.

The historic purpose of the LGU was to provide an opportunity for secondary education to the common citizen and the development and expansion of the LGU was an important aspect of rebuilding the nation after the Civil War. The succession of South Carolina preceded the confederates attack and the overtaking of Union-controlled Fort Sumter off the coast of South Carolina on April 12, 1861. The country was divided by White House Administration (President Abraham Lincoln), Political Parties (Northern & Southern Democratic Party) both of which split their votes and lost the election of 1860, and Slavery (Library of Congress, American Battlefield Trust; 2018). During this political upheaval, Senator Justin S. Morrill of Vermont was petitioning his fellow colleagues to pass legislation to create educational institutions across the country that would teach agriculture, mechanics, home economics and other practical trades of the time. Michigan had already passed a bill that established the Agriculture College of the State of Michigan (now Michigan State University; Constitution of Michigan, 1850). Illinois Senator

Lyman Trumbull thought it best to introduce the land-grant bill using an eastern representative, Justin Morrill. Previously in 1859, President James Buchanan had vetoed the bill. President Buchanan had vetoed the bill in support of the southern delegates who believed that education was a state issue, not a federal issue. The political timing of the proposed bill was considered excellent by Senator Trumbull given the newly elected President (Abraham Lincoln) hailed from his home state of Illinois and, like him, represented the Republican Party. The revised 1861 bill included teaching military strategy with the inclusion of agriculture and engineering (U.S. Congressional Documents, 1774-1875). On June 10, 1862, the U.S. Senate passed the Morrill Act and seven days afterward, with the succession of southern delegates who had a negative outlook of President Lincoln and his administrative goals, it passed the House of Representatives. President Lincoln signed the bill in 1862. The Pacific Railroad Act, Homestead Act, and the Morrill Act would be essential and pivotal to the westward expansion of the country after the Civil War had ended. The Morrill Act provided 30,000 acres to each eligible state; federal land to be sold to raise funds to create, build, and finance these institutions of higher learning. The intention for this system of education was to provide an outlet for all who chose to receive an education to remove the social limitations that previously provided education only to the elites. Post-Civil War America saw the victorious Union accept the terms of the Confederate surrender at the Appomattox Courthouse. The agreement of the surrender ensured that the Morrill Act of 1862 benefits were afforded to the former Confederate States as well. A second Morrill Act in 1890 was created to require the former Confederate States to either allow persons of color (former slaves) to be admitted to the current institutions or provide separate land-grant institutions thus creating the Negro Normal Schools, now known as Historically Black Colleges and Universities (HBCU).

In 1890, North Dakota state legislation (Laws of 1<sup>st</sup> Legislative Assembly ND, 1890) introduced a bill to create a research land-grant institution. On January 3, 1892, 123 students enrolled in the newly founded North Dakota Agricultural College (NDAC) in Fargo, ND. As recorded by the NDAC, Flora Elliot was the first female student in agriculture in 1934. Elliot was active on the first livestock judging team 42 years after the first students attended NDAC. The education of animal science was driven by the new found need to improve techniques of animal production.

The three aspects of the LGU are: teaching, research, and extension. “Teaching” provides the ideas or principles taught by an authority (Merriam-Webster, 2018). Of course teaching begins at home with parents, grandparents, neighbors, community members, etc. and all of these associations will impact the teach-ability of young people entering LGUs. Teaching is an everyday learning activity, but besides dissemination of an educationally specific message, higher education has the potential to increase and improve human capital (Knight and Yorke, 2003) and to focus on improving the skills that are deficient in previous graduates. Robinson and Garton (2008) suggested that faculty incorporate problem-solving and decision-making skills into current curriculum. They state further that students who leave university with these skills are highly desired by employers.

Research is the systematic investigation into, and study of, materials and sources in order to establish facts and reach new conclusions (Merriam-Webster, 2018). Land Grant Universities strive to investigate issues that are important to the industry who will hire their graduates (ex. biology, engineering, animal health, etc.). It is also important for the research conducted at the LGU to benefit communities within the state where the university is located. Research founded in food and agriculture science is in the interest of the nation as well. United States consumers

desire more wholesome, abundant, reasonably priced food that possesses a higher nutritive value, is environmentally conscious, and provides opportunities for small-scale farmers (Reichelderfer, 1991).

President Woodrow Wilson signed into law the 1914 Smith-Lever Act, which provided the third function of the LGU. The branch referred to as "extension" was created to disseminate information from the agricultural college campus classrooms and research to the people of the state. The information was literally "extended" from campus classrooms and labs to the common person. Extension/Outreach, managed by the State Agriculture Extension Services (SAESs) is the link to people and consumer/community education. A secondary platform of the SAES is to increase interest in the university among the youth that interact with the extension workers. The interaction between youth and LGU Extension educators has been facilitated in part through the national 4-H organization.

### **Diversity at Land Grant Universities**

Gavazzi (2019) wrote the *Land-Grant Universities for the Future: Higher Education for the Public Good* and examined the viewpoint of diversity at LGUs. Christopher Gonzalez noted in a 2019 interview that:

Alienating either rural dwellers or urbanites, moreover, imperils the mission of the university. If one constituency feels excluded, its levels of support for universities will decrease, and so will the willingness of its residents to fund colleges with their tax dollars.

- Christopher A. Gonzalez, Heterodox Academy, 2019

The Land Grant Institutions were created to educate the *industrial classes* or the "working class" of the nation seeking the possibility to achieve the American Dream through higher education. Such institutions as Cornell, Michigan State, Texas A&M, University of California, University of Illinois, Iowa State, and numerous others have grown to become the largest public institutions of

higher education in the United States. They promote themselves as described in the land-grant mandate set in 1860 however their selective admissions requirements exclude those who would need their assistance and education the most, including more rural and urban citizens. Those unable to obtain admission to these large LGUs have found admission to other land-grant universities such as the HBCU and tribal colleges. For example, Cheyney University of Pennsylvania has been serving the minority population (Black, Hispanic, Native American, Asian, and Women) since 1837 (HBCU Historical Facts, 2018). Wood (2018) suggested that LGU institutions are indeed remaining true to their mission for increasing diversity in the student enrollment; however, retention of minorities is 12 % lower than that of Caucasian students who represent a retention rate of 73 %. Furthermore, minority students have seen a decrease enrollment of 7 % and increase of 2 yr. added to the length of time necessary to complete graduation for black students. Felder (2010) studied the influence of faculty mentorship and success of African-American doctoral students enrolled at the university. The study reported, faculty diversity is an important socialization factor to the African-American doctoral students, yet faculty support is welcomed and appreciated regardless of race. When evaluating females in academia Chandler (1996) stated:

There is evidence women who pursue careers in traditionally male-dominated fields, such as STEM focused, plan to interrupt or reduce their labor-force participation to accommodate their expected child rearing. Men generally don't incorporate family plans into their careers.

This thinking has stifled the enrollment of women into the academic fields of Science, Technology, Engineering, and Mathematics (STEM) for decades. Whitaker and Montgomery (2014) reported underrepresentation of women and minorities at institutions is not just the matter of increasing entry into the pipeline associated to obtaining a degree. Institutional reform must also seek to support the underrepresented from student-level through entry into programs and on

to progression into the faculty and leadership ranks (Sethna, 2011). Access shouldn't be the only improvement of LGUs, but success and improvements in diversity of students entering the academic leadership pipe-line reform will transform the universities and live up to the mission statement of the Morrill Act of 1860.

### **Youth Organizations Affiliated with Agriculture**

When entering most rural towns in America we see welcome signs created by the local 4-H club or the high school FFA (former Future Farmers of America). In 1906, the three leaf clover was the emblem to represent "head, heart, and hand." In 1911, health was added as a fourth "H" added to the now four leaf clover and, in 1913, the insignia 4-H was approved. This paved the way to develop a creed and pledge and eventually a National 4-H Club Camp in Washington D.C.

As part of the North Dakota Land Grant Extension mission, efforts to help farmers and rural youth were included in the venture of education (Bale, 1989). Early attempts to energize interest in agricultural/vocational education around 1905 included what a few records referred to as the Industrial Contest for boys and girls that targeted young people from farms. The contest included corn quality and production and expanded to include pigs, chickens, canning, and sewing. These efforts led to the annual State Youth Achievement Institute held in Fargo.

The creation of the Boy's and Girl's Club of North Dakota interacted with a few aspects of agriculture; mainly corn and hog production. By 1913, the Boy's and Girl's Club had adopted the motto, colors and emblem of 4-H. At that time, there were 300 participants in the pork production contest and 553 boys age 10-18 in the corn contest. After the end of World War I, the Director, Mr. Randlett, felt that the clubs needed more direct supervision than in previous years and so the clubs fell under the advisement of public school officials (with superintendent

permission). In 1922, the responsibility of the 4-H Clubs became the charge of either the county extension agents or the assistant county agents. Leadership was locally assigned to volunteer adults and led to increased projects and program training meetings. In 1973, 4-H expanded to include urban 4-H programs in six counties of North Dakota. Urban 4-H projects included classroom demonstrations conducted on a “learn by doing” basis with two or three workshops performed yearly. Programs included jelly and jam workshops, gardening, small engines, gun safety, industry tours, leathercraft, community beautification and a host of other workshops/clinics (Bale, 1989).

### **Learning**

We buy food (meat/beef) repeatedly because we like its palatability. More education on palatability improves our ability to cook and makes the meat taste better. The increased opportunity to learn how to cook meat properly is available again as it was in high school home economics class. The difference is we don't have to neglect palatability for the sake of safety (over cooking) because of lack of information regarding cooking red meat. Identification of technology that objectively classifies highly palatable meat makes this process even easier. Food apps using IOS and Android systems provide new educational avenues to give power of purchasing back to the consumer. Meat comes from animals, so indirectly we learn about animals and their products from programs like 4-H and FFA. The incorporation of urban chapters and rural education of agriculture will transform the outlook of agriculture education and production. The changing possibilities for young agriculturalist, new agriculture technology, and consumer education of agriculture products will be the next educational expansion in the U.S. and those who are recognized as specialists must be ready to answer the questions that will be asked of our industry.



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## CHAPTER 2. PRODUCT YIELD, NUTRIENT AND FATTY ACID CONTENT OF NORTH DAKOTAN MULE DEER, ELK, AND MOOSE<sup>1</sup>

### Abstract

The objective of this study was to compare loin muscle fatty acid profile (stearic and oleic acid) and edible meat yield from three different species of cervids. Twenty-nine mule deer (*Odocoileus hemionus*; MUL), 22 moose (*Alces alces*), and 21 elk (*Cervus canadensis*) were harvested from the field and processed at the North Dakota State University Meat Science Laboratory. Fatty acid analysis was conducted for stearic and oleic acid for each species according to AOAC and AOCS methods. Yield data were collected and compared across species to include shot loss and edible lean availability. Larger species had heavier whole body (WB), field dressed (FD), carcass (CARC), and lean (LN) yield, while the smaller species (MUL) had the highest FD expressed as a percentage of WB (77.19%). Shot loss significantly impacted the percentage of lean lost from Elk (16.59%,  $P = 0.02$ ), MUL (13.24%), and Moose (12.32%). The most edible lean (332.53 kg) was obtained from Moose while MUL tended to yield more lean as a percentage of WB (42.07%,  $P = 0.06$ ). Moose had the least crude fat on a DM basis, the least total kcals/100g of loin sample, and least total cholesterol (mg/100g of loin sample). Mule deer and elk exhibited a higher percentages of intramuscular oleic acid (24.1% and 29.7%,

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<sup>1</sup> The material in this chapter was co-authored by D. D. Reed, Jr., P. T. Berg, M. Marchello, J. M. Young, K. Maddock-Carlin, and E. P. Berg. D. D. Reed, Jr. was responsible for data collection and writing of this chapter. P. T. Berg designed the study, assisted with animal sample collection, carcass evaluation, and assisted in writing of this chapter. M. Marchello designed the study and assisted with data collection. J. M. Young was responsible for statistical analyses and assisted in writing of this chapter. K. Maddock-Carlin assisted in writing of this chapter. E. P. Berg was responsible for formatting the data collection and writing of this chapter.

respectively expressed as a percentage of crude fat content) than moose (14.5%,  $P < 0.01$ ). Mule deer had the highest stearic acid content (24.7 %) compared to elk (12.83%) and moose (21.62%). This research found that Elk and MUL have more desirable MUFA and SFA of total fat content than Moose which possess the highest lean yield percentage.

### **Introduction**

Hunting provides opportunities for procurement of a variety of muscle foods. Each species provides the hunter with a different pursuit challenge that culminates with the harvest of game meat which provides an alternative source of protein that possesses a unique flavor profile. While the average and range of live weights are readily available for many species of wild game, there are few documented sources reporting the edible, whole-muscle yield of many species harvested by hunters. Further, information on the extent of shot loss, bullet damage, and ante-mortem stress in wild game is limited. Hoffman and Wiklund (2006) indicated that wild harvested, free range game are being imported into Europe and the United States from South Africa, suggesting that wild game possesses positive nutrient attributes that are available to fill the desire for consumers seeking low impact production-sourced, high quality protein foods. Furthermore, the harvest of game animals is an important tool in conservation and serves as a means for promoting animal biodiversity.

Hoffman and Wiklund (2006) suggested that consumers perceive lean tissue produced by free roaming animals as nutritionally superior to meat from animals raised under intensive management conditions. However, there are limited data available to consumers that would allow for side-by-side comparisons of wild vs. domesticated meat species. Previous research (Marchello et al. 1985) on the cutability and nutrient content of whitetail deer is available, yet data from other large game species were not included. Furthermore, information on the extent of

shot loss, bullet damage, and ante-mortem stress in wild game is limited. The objective of this study was to determine and document proportion of edible lean from harvested big game species (mule deer, elk, and moose), analyze nutritive value, and discuss the implications of shot range on loss of edible lean.

## **Materials and Methods**

### **Harvesting Process**

Hunters, in collaboration with wildlife clubs and the North Dakota Game and Fish Department, were recruited to deliver their field harvested game animals to the North Dakota State University (NDSU, Fargo, ND) meat laboratory for processing. Twenty-nine mule deer (MUL), 32 moose, and 21 elk were received for analysis. The animals were harvested using bow, rifle, or muzzleloader as regulated by the ND Game and Fish licensing laws. Hunters were provided with a contractor grade, heavy duty plastic bag to retain the entrails to accompany the field dressed carcass to the NDSU meat lab.

### **Lean Processing**

All carcasses were field dressed (viscera and blood removed) by the licensed hunter. Field dressed (FD) carcasses and the entrails were weighed and recorded at the NDSU meat laboratory. The summation of FD and entrails served as whole body weight (WB) and was used in place of live weight due to the inability of methods to account for blood loss in the field. Carcasses were skinned (CARC) and weighed, then lean tissue (LN) was separated and weighed. The progression of cutout weights obtained were WB, FD, CARC, LN and shot loss (SHOT; weight of tissue discarded due to bullet damage or other causes which rendered the lean inedible). Differences in post-harvest carcass dehydration (shrink) were considered random.

The carcasses were kept in a 3°C cooler (1 to 3 days) until processing. The boneless lean was denuded of visible fat and processed into portions according to the hunter's specification. One *longissimus* muscle sample (approximately 454 grams) was taken adjacent the 12<sup>th</sup> and 13<sup>th</sup> thoracic vertebra from each carcass for proximate analysis. Each individual muscle sample was frozen, lyophilized, and stored at -18 °C.

### **Proximate Analysis**

Longissimus samples were trimmed of excess fat thoroughly homogenized and pulverized in a food processor (Cuisinart, East Windsor, NJ) and stored at -20 °C. Dry matter was determined by oven drying at 105 °C, protein was determined by the macro-Kjeldahl method (Kjeldahl, 1883) and the total fat content by the Foss-Let procedure (AOAC, 1980) whereby total lipids were extracted gravimetrically with chloroform-methanol mixture (2:1) as described by Folch et al. (1957). Gross energy was determined by bomb calorimetry as described in the Parr 1241 Oxygen Bomb Calorimeter Manual. Cholesterol from lipid extracts was analyzed by an acetic anhydride-sulfuric acid colorimetric method (Stadtman, 1957). A portion of each lyophilized longissimus sample was sent to the USDA Grand Forks Human Nutrition Research Center for fatty acid analysis based on AOAC # 996.06.

### **Consumer Survey**

A survey (Appendix A) was administered to consumers at the NDSU BBQ Bootcamp (n = 5,863) with participants who had an interest in outdoor cookery. Three questions were designed to provide insight into factors that influence food purchase decisions.

### **Processor survey**

A questionnaire (Appendix B) was mailed to 20 wild game processors in the state of North Dakota. The survey consisted of 6 questions in an effort to obtain demographic

information and services provided by the processors. The demographic information included reference to the processors location and how the lean meat was used during further processing.

### **Statistical Analysis**

Data were analyzed using the mixed procedure in SAS (v. 9.2, SAS Institute, Cary, NC). The fixed effects included MUL, Moose, and Elk with harvest data (WB, FD, CARC, LN, and SHOT) as dependent variables, and nutrient composition (dry matter, protein, fat, ash, energy, cholesterol, and fatty acid) as random variables. The least squared means (LSMEAN) were calculated using the LSMEANS statement and differences were defined at  $P < 0.05$ .

## **Results**

### **Hunter Harvest and Yield Data**

Carcass yield and percentages are presented in Table 2.1. The three species evaluated in the present study significantly differed ( $P < 0.001$ ) from each another in WB, FD, hide weight, LN, and SHOT in the order of moose, elk, and MUL (heaviest to lightest, kg). Moose produced the greatest proportion of lean tissue lost as shot loss (SHOT/LN), followed by MUL, and elk with the least. The lightweight MUL yielded a higher percentage of CARC/WB than moose (elk did not differ from MUL or moose;  $P = 0.04$ ) and higher percentage of CARC/FD than both elk and moose ( $P < 0.001$ ). Edible lean yield expressed as a percentage of WB or CARC did not differ across species. Mule deer and elk had a higher percentage of LN/FD than moose.

**Table 2.1.** Least square means ( $\pm$  standard error) and P-value for processing yield of mule deer, elk, and moose harvested in North Dakota.

	Mule Deer ( <i>Odocoileus hemionus</i> )	Elk ( <i>Cervus canadensis</i> )	Moose ( <i>Alces alces</i> )	P-value
Number harvested	29	21	22	
Whole Body (WB), kg	63.35 ( $\pm$ 9.37) <sup>a</sup>	238.92 ( $\pm$ 13.24) <sup>b</sup>	410.95 ( $\pm$ 9.61) <sup>c</sup>	<0.001
Field Dressed (FD), kg	48.51 ( $\pm$ 6.94) <sup>a</sup>	176.52 ( $\pm$ 9.82) <sup>b</sup>	302.22 ( $\pm$ 6.94) <sup>c</sup>	<0.001
FD/WB, %	77.19 ( $\pm$ 2.03)	73.76 ( $\pm$ 2.88)	74.79 ( $\pm$ 2.08)	0.41
Skinned carcass (CARC), kg	40.53 ( $\pm$ 5.12) <sup>a</sup>	141.94 ( $\pm$ 7.24) <sup>b</sup>	226.06 ( $\pm$ 5.12) <sup>c</sup>	<0.001
CARC/WB, %	64.44 ( $\pm$ 1.68) <sup>b</sup>	59.35 ( $\pm$ 2.38) <sup>ab</sup>	56.05 ( $\pm$ 1.72) <sup>a</sup>	0.04
CARC/FD, %	83.39 ( $\pm$ 0.51) <sup>c</sup>	80.48 ( $\pm$ 0.72) <sup>b</sup>	75.07 ( $\pm$ 0.51) <sup>a</sup>	<0.001
Hide, kg.	11.22 ( $\pm$ 4.21) <sup>b</sup>	28.57 ( $\pm$ 13.34) <sup>a</sup>	39.42 ( $\pm$ 24.09) <sup>c</sup>	<0.001
Lean Yield (LN), kg	26.44 ( $\pm$ 8.03) <sup>a</sup>	95.24 ( $\pm$ 11.35) <sup>b</sup>	150.83 ( $\pm$ 8.03) <sup>c</sup>	<0.001
LN/WB, %	42.07 ( $\pm$ 1.64)	39.99 ( $\pm$ 2.32)	37.65 ( $\pm$ 1.68)	0.06
LN/FD, %	54.21 ( $\pm$ 1.89) <sup>b</sup>	54.19 ( $\pm$ 1.89) <sup>b</sup>	50.32 ( $\pm$ 1.33) <sup>a</sup>	0.04
LN/CARC, %	64.98 ( $\pm$ 1.68)	67.37 ( $\pm$ 2.37)	67.01 ( $\pm$ 1.68)	0.41
Shot Loss, (SHOT) kg	3.27 ( $\pm$ 1.44) <sup>a</sup>	14.69 ( $\pm$ 2.04) <sup>b</sup>	18.57 ( $\pm$ 1.44) <sup>c</sup>	0.02
SHOT/LN, %	13.24 ( $\pm$ 1.71) <sup>b</sup>	16.59 ( $\pm$ 2.42) <sup>c</sup>	12.32 ( $\pm$ 1.71) <sup>a</sup>	0.02

<sup>a b c</sup> Means within a row with different superscripts differ by  $P < 0.05$ .

### Wild Game Nutrient Analysis and Composition

The LSMEANS for nutrient content ( $\pm$  standard error) of the trimmed *longissimus dorsi* are presented in Table 2.2. Mule deer had a higher percentage protein than moose and elk ( $P < 0.001$ ). The three species differed from each other in content of crude fat and total cholesterol (mg/100g) with MUL possessing the highest percentage of fat and cholesterol, followed by elk, then moose. Mule deer possessed the most kcals per 100 grams of meat sample ( $P < 0.001$ ), while elk and moose did not differ. With regard to saturated fatty acids, elk had the highest percentage of myristic (14:0; followed by MUL then moose) and palmitic acid (16:0; followed by moose and MUL which did not differ), yet the lowest content of stearic acid (18:0) followed by moose, then MUL. With regard to mono-unsaturated fats, elk possessed a higher content of myristoleic (14:1) and palmitoleic acid (16:1) than MUL or moose which did not differ. That said, elk had the lowest concentration of oleic acid (18:1) per 100 grams of muscle which

**Table 2.2.** Least square means ( $\pm$  standard error) for nutrient analysis and fatty acid composition of trimmed LD of mule deer, elk, and moose harvested in North Dakota.

	<b>Mule Deer</b> ( <i>Odocoileus hemionus</i> )	<b>Elk</b> ( <i>Cervus canadensis</i> )	<b>Moose</b> ( <i>Alces alces</i> )	<b>P-value</b>
Number harvested	29	21	22	
<b>Proximate analysis</b>				
Dry matter, %	97.46 (0.15) <sup>a</sup>	97.71 (0.18) <sup>ab</sup>	97.88 (0.14) <sup>b</sup>	0.04
Crude protein, %	23.22 (0.23) <sup>a</sup>	22.99 (0.27) <sup>a</sup>	22.11 (0.21) <sup>a</sup>	0.10
Crude fat (CF), %	1.60 (0.11) <sup>c</sup>	1.03 (0.13) <sup>b</sup>	0.60 (0.10) <sup>a</sup>	<0.001
Ash, %	4.03 (0.12) <sup>a</sup>	4.73 (0.15) <sup>c</sup>	4.58 (0.12) <sup>b</sup>	0.002
Energy, (kcal/100g)	87.13 (4.64) <sup>c</sup>	60.27 (5.46) <sup>a</sup>	61.71 (4.42) <sup>b</sup>	0.0002
Cholesterol, (mg/100g)	150.78 (1.86) <sup>a</sup>	143.10 (2.19) <sup>b</sup>	132.81 (1.77) <sup>c</sup>	<0.001
<b>Fatty acid, % of CF</b>				
Myristic acid (14:0)	1.56 (0.16) <sup>b</sup>	4.95 (0.20) <sup>b</sup>	0.48 (0.15) <sup>a</sup>	<0.001
Myristoleic acid (14:1)	0.15 (0.06) <sup>a</sup>	1.72 (0.08) <sup>b</sup>	0.19 (0.06) <sup>a</sup>	<0.001
Palmitic acid (16:0)	21.28 (1.07) <sup>c</sup>	26.68 (1.35) <sup>c</sup>	14.79 (1.01) <sup>a</sup>	<0.001
Palmitoleic acid (16:1)	1.77 (0.35) <sup>b</sup>	10.21 (0.45) <sup>c</sup>	1.11 (0.34) <sup>a</sup>	<0.001
Stearic acid (18:0)	24.76 (0.50) <sup>c</sup>	12.83 (0.64) <sup>a</sup>	21.62 (0.48) <sup>b</sup>	<0.001
Oleic acid (18:1)	29.79 (1.17) <sup>c</sup>	14.52 (1.49) <sup>a</sup>	24.18 (1.11) <sup>b</sup>	<0.001
Linoleic acid (18:2)	11.64 (1.61) <sup>a</sup>	18.99 (2.05) <sup>b</sup>	23.34 (1.53) <sup>c</sup>	<0.001
Alpha-Linoleic (18:3)	4.40 (0.27) <sup>c</sup>	3.15 (0.34) <sup>a</sup>	3.72 (0.25) <sup>b</sup>	0.005
Arachidonic acid (20:4)	4.15 (0.64) <sup>a</sup>	6.72 (0.81) <sup>b</sup>	10.61 (0.61) <sup>c</sup>	0.01
Total saturated fatty acids	47.6 (0.09) <sup>c</sup>	44.46 (0.30) <sup>b</sup>	36.89 (0.73) <sup>a</sup>	<0.001
Total unsaturated fatty acids	51.8 (1.05) <sup>a</sup>	55.31(0.59) <sup>b</sup>	63.15(1.23) <sup>c</sup>	0.042

<sup>a b c</sup> Means within a row with different superscripts differ by  $P < 0.05$ .

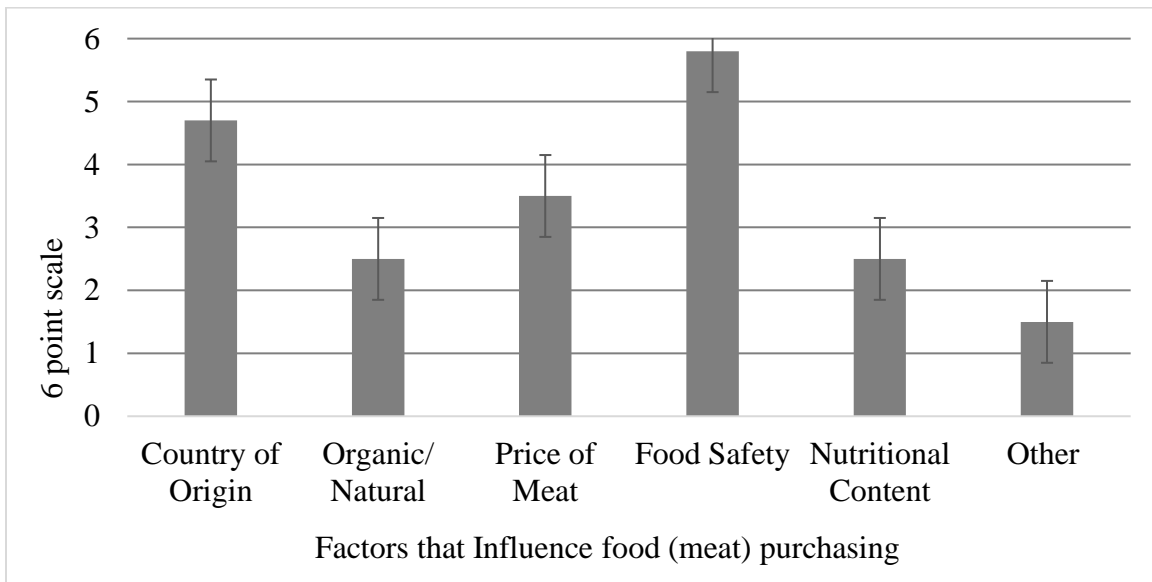
differed from MUL (highest 18:1 concentration) and moose. The three species differed from each other for poly-unsaturated fatty acids with moose possessing the highest percentage of linolenic (18:2) and arachidonic acid (20:4), followed by elk, then MUL. Mule deer had a higher content of  $\alpha$ -linoleic acid (18:3) than elk and moose which did not differ.

### Consumer Survey

Demographics of respondents are presented in Table 2.3. The most reported factor that influenced food purchasing decisions for consumers was food safety at 5.8 points on a 6 point scale (Figure 2.1). The “other” category received the fewest comments and of those comments climate change and political influence were the most common. As female and male consumers aged, their concern for where (Figure 2.2) and how (Figure 2.3) food was produced became more of a concern.

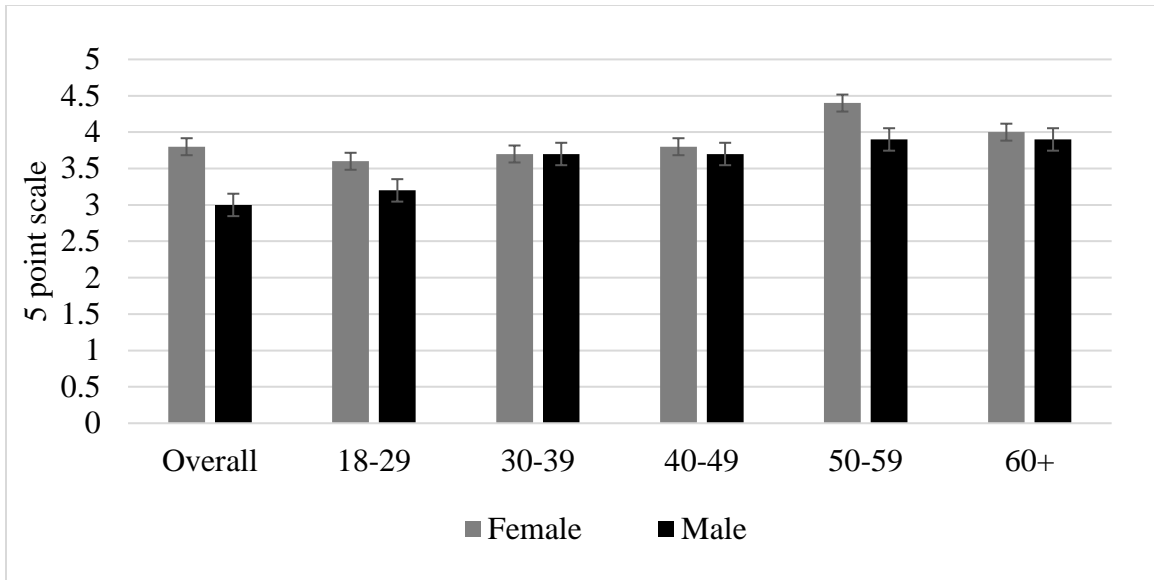
**Table 2.3.** Demographics of consumers with a common interest in outdoor cooking who completed a survey examining their food purchasing decisions.

Age, yr.	Gender		Total
	Male	Female	
18-29	407	285	692
30-39	607	371	978
40-49	803	671	1474
50-59	566	518	1084
60+	1030	605	1635

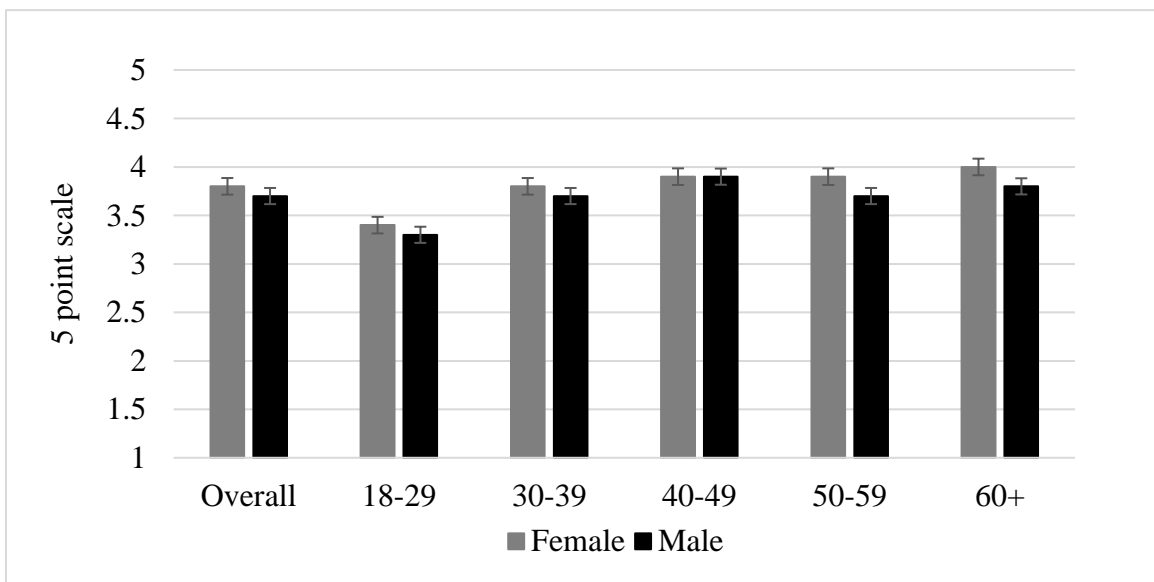


**Figure 2.1.** Consumers’ response to the question: “Please rank by importance how the following factors influence the purchasing decisions for the food (meat) you buy.” (where 1 = not important and 6 = extremely important).





**Figure 2.2.** Consumers’ age x gender interaction response to the question: “Please rank by importance where your food was produced.” (where 1 = not important and 5 = very important).



**Figure 2.3.** Consumers’ age x gender interaction response to the question: “Please rank by importance of how your food was produced.” (where 1 = not important and 5 = very important).

**Table 2.4.** Processor questionnaire responses for wild game processing facilities in North Dakota

Variables	Frequency
<b>Question and Reponses</b>	
Are you a wild game meat processor?	
Yes	100%
No	0%
Where is your operation/facility located in North Dakota? (Bismarck is center location)	
North	14%
South	43%
East	14%
West	29%
Are you an official state processing, state slaughter establishment or custom exempt for red meat and wild game?	
Yes	85%
No	15%
Species of processed game at your Facility (percent of time)	
Bighorn Sheep	7%
Elk	29%
Mule Deer	43%
Moose	14%
Pronghorn Deer	7%
Whitetail Deer	100%
Is the predominate amount of your wild game processed into sausage, adding other ingredients to enhance taste?	
Yes	80%
No	20%
Do you, in your professional opinion, think wild game meat is under-estimated in its importance as a meat protein source?	
Yes	21%
No	79%

## **Processor Survey**

Of the 20 surveys mailed to North Dakota wild game processors, 14 were completed and returned (Table 2.4). The majority of responding establishments identified as custom exempt (57 %) and 27 % were state inspected slaughter/processing establishments. All of the respondent's processed wild game each hunting season. Sixty-four percent of the processors reported that 80 % of the carcass was converted to sausage (or otherwise further processed via the adding of ingredients such as pork and seasoning). In the professional opinion of the wild game processors, 79 % believe that game meat is perceived as an important protein source (Table 2.4).

## **Discussion**

Processors of wild game recognize that game meat is an important source of animal protein. Consumers like to know where their food comes from and are most concerned about food safety. Social food movements and concern for sustainability in agriculture have piqued the concerns of consumers and spurred food retailers to seek avenues for the creation of locally grown niche markets (Lafave, 2013). Improving the availability of locally obtained meat products is becoming increasingly important to the current generation of consumers that appear to be more interested in the story behind the food than they are the cost of the food (Low et al., 2015). Local processors appeal to the local clientele because they are more likely to form a personal relationship with that local processor.

Game meat is an optional source of animal protein. All three species evaluated had over 22 grams protein per 100 grams of lean tissue. In 2017, ND hunters harvested a total of 2,101 MUL, 221 moose, and 211 elk. Calculating the average weight of bulls and cows and adding the percent of edible lean, North Dakota averaged 28,682 kg for MUL, 23,571 kg moose, 13,648 kg elk. The Dietary Reference Intake (Institute of Medicine of the National Academies of Science)

suggests males 19 to 70 years of age should consume 56 g of protein per day and females ages 14 to 70 years consume 46 grams/day (or 0.8 grams of protein per kilogram of body weight; US Department of Health and Human Services, 2018). Based on these numbers, the amount of edible product generated from the harvest of MUL in ND could provide the average recommended daily allowance of high quality protein to 1,000 mature American women for 623 days and 1,000 American men for 512 days. Likewise, the ND elk and moose harvest could feed 1,000 American men for 665 days.

All three species are a very lean source of protein that possess less than 2 grams of fat per 100 grams lean sample. Total cholesterol appeared to parallel the total crude fat content present in loin tissue. Moose had the least proportion of saturated fat and most unsaturated. In recent studies by Texas A&M University, Dr. Stephen Smith (2016) reported ground beef possessing a higher fat content was linked to increased high-density lipoprotein (HDL; the so-called “good” cholesterol) in men and women (Smith, 2016).

Mule deer had the highest concentration of oleic acid; elk the lowest. A project conducted by Japanese restaurants evaluating wagyu beef consumers noticed that an increase in marbling did not generate a greasy mouth feel, but rather was described as “*melt in the mouth beef*” that possessed a pleasant taste (Torigoe, 2009). Torigoe (2009) concluded that the key to succulent palatability was associated with the high percentage of oleic acid present in the intramuscular fat. Further, the “*melt in the mouth*” palatability trait increased as the content of oleic acid increased in the beef. Mule deer habitat is often in closer proximity to land used for crop production. Therefore, the increased content of oleic acid seen in the MUL population of this study could have been consuming more corn. Corn and other conventionally farmed grains contain a higher proportion of oleic acid than grasses and forages traditionally consumed by game species who

live in the upper Great Plains. The habitat for moose and elk is traditionally more remote and further removed from land used for crop production. Increased sightings of moose and elk in areas of greater crop production could result in a change in the meat palatability characteristics of these species of game. As human farming moves closer to elk and moose grazing areas, it is likely that the oleic acid content will increase in the edible lean. Future research should be performed on the sensory characteristics of wild game meat compared to farm-raised game that are fed in a manner similar to other domesticated meat-animal species.

Moose were highest in linolenic acid which could be due to the increased consumption of grass. The main fatty acid produced as a result of a grass diet is linolenic acid and it can give an off-flavor to meat and has been seen to cause beef to taste fishy (Prieto, 2017). Grass fed ruminants generate higher levels of linolenic acid. Only when concentrations of  $\alpha$ -linolenic acid (18:3) approach 3 % of neutral lipids or phospholipids are there any adverse effects on meat quality, defined in terms of shelf life (lipid and myoglobin oxidation) and flavor (Wood et al., 2004).

North Dakota wild game processors reported that the majority of the game carcasses (80%) was further processed and converted to sausage. The adding of ingredients such as pork and seasoning will change the nutritional content of the original whole muscle cuts through the action of grinding and adding other ingredients. The addition of pork meat and seasonings will change the amount or condition of the fatty acid profile of the new product. Consumers may view this as either a positive or negative change.

We can conclude from these findings that game meat is an excellent source of high quality, low fat dietary protein that meets consumer demand for locally obtained foods.

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### CHAPTER 3. POST-MORTEM BEEF FLAVOR PREDICTION OF AKAUSHI, PRIME, AND CHOICE BEEF STEAKS USING IMAGE PROCESSING TECHNOLOGIES<sup>1</sup>

#### Abstract

Ninety boneless beef *longissimus dorsi* (IMPS, 112A) muscles were purchased from a local membership warehouse grocer or commercial beef packing plant. The loins included USDA graded classes of extremely high prime (n = 30; Akaushi-HeartBrand Beef, Flatonia, TX 78941), prime (n = 30; Certified Angus Beef- Costco), and choice (n = 30; upper 2/3 Certified Angus Beef, Costco). The rib rolls were randomly assigned to one of four evaluations including imaging technology, tenderness evaluation, consumer sensory, or proximate analysis. All rib rolls were wet-aged for 14 d after delivery to the NDSU meat lab (Fargo, ND), then processed for computer vision imaging systems analysis to predict wavelength of intramuscular fat (IMF-marbling) and visible flavor components of palatability. Correlation of computer vision to sensory evaluation and fatty acid analysis was conducted to support technology improvement as an objective evaluation of IMF. Proximate fat analysis revealed Akaushi (AK) treatment had average fat (40.6 %) and protein (59.36%) based on a dry matter basis and with more ( $P < 0.001$ ) fat (respectively, +11.41, 24.29%) than Prime (29.23%) and Choice (16.23%) loin samples. Warner-Bratzler shear force data demonstrated higher ( $P < 0.001$ ) values for choice loin steaks

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<sup>1</sup> The material in this chapter was co-authored by D. D. Reed, Jr., J. B. Frandrup, J.-H. Liu, J. M. Young, G. Stokka, X. Sun, E. P. Berg. D. D. Reed, Jr. was responsible for data collection and writing of this chapter. J.B. Frandrup assisted with sample collection and spectral analysis. J.-H. Liu assisted in data collection and spectral analysis. J. M. Young was responsible for statistical analyses and assisted in writing of this chapter. G. Stokka, assisted in writing of this chapter. X. Sun designed the study, assisted with data collection and the writing of this chapter. E. P. Berg was responsible for research formatting and writing of this chapter.

(3.4 kg.) as compared to the prime and Akaushi steaks (2.5 vs. 2.6 kg, respectively).

Hyperspectral imaging system showed differential pixel factors (pF) for each grade/loin class, the factor values ranged as follows; Akaushi (pF = 0.66), prime (pF = 0.51), and choice steaks (pF = 0.33). Further investigation on appropriate wavelength and pixel factors of marbling features from hyperspectral image processing methods are necessary to detect specific quantification of fat chemical content.

### **Introduction**

With increased public expectations for food products of high quality and safety, accurate, fast, and objective quality techniques must be developed to achieve this goal (Sun, 2004).

Computer vision system technology utilizes nondestructive image processing techniques to extract image features for objective analysis and quantification of quality parameters (Wu and Sun, 2013) of meat and fish, cheese, grain, and other food products (Arngren et al. 2011; Cheng and Sun, 2015; ElMasry et al., 2013; Gowen et al., 2009; Okamoto and Lee, 2009). Traditional visual quality inspection has been performed by human inspectors which could be replaced by the computer vision technology (Sun, 2004).

Xiong et al. (2014) reviewed the merits of hyperspectral imaging systems (HIS) to accurately detect important quality attributes of pork, beef, and lamb. Xiong et al. (2014) found HIS to be a powerful technique for predicting the essential red meat quality attributes of muscle pH, color, tenderness, WHC, and marbling. Li et al. (2011a) reported that HIS was able to accurately predict ( $R^2 = 0.92$ ) beef marbling within the spectral range of 400-1100 nm. Online industrial tests are necessary to determine validity and the cost effective applications of image systems, and real-time industrial studies are necessary to support the systems use. The objective

of this research project was to test the effectiveness of hyperspectral image processing analysis of heavily marbled beef steaks to quantify fatty acids associated favorable beef flavor.

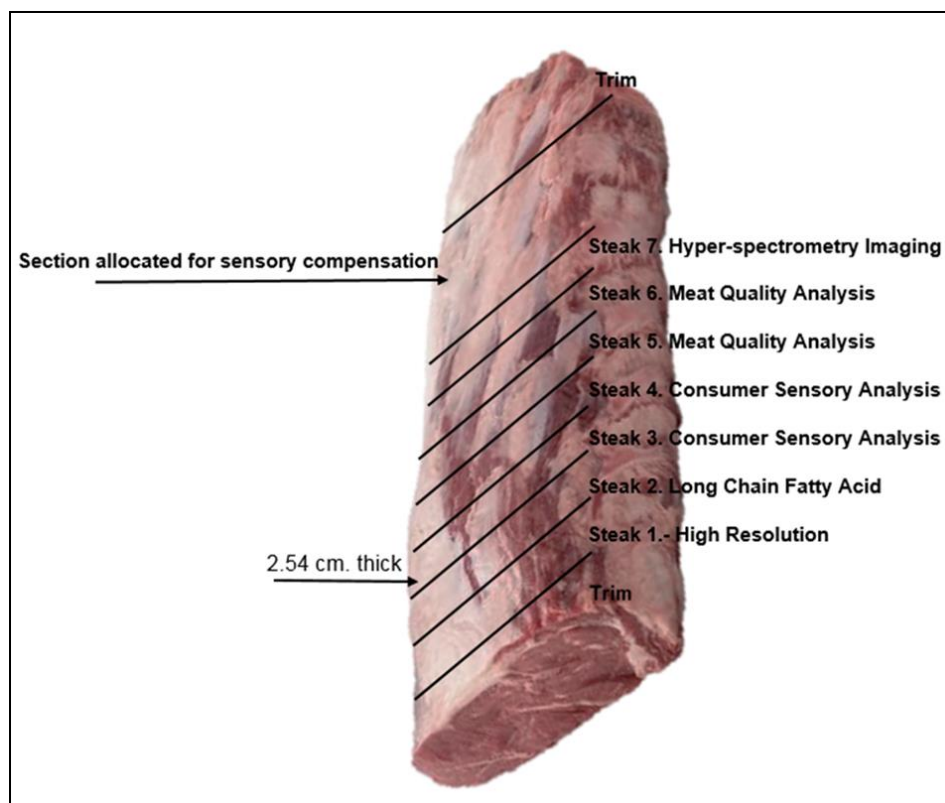
## **Materials and Methods**

### **Muscles**

Boneless beef ribeye roll, lip-on subprimals (IMPS 112A) were utilized for analysis. USDA Prime (n = 30) and Choice (n = 30) quality grade ribeye rolls were purchased from the local (Fargo, ND) Costco Warehouse Meat Department. An additional 30 ribeye rolls were obtained from USDA graded HeartBrand (Flatonia, Texas) Akaushi steers (avg. 35% Prime, 88% Choice). The rolls arrived at the NDSU Meat Science Laboratory (Fargo, ND) each individually vacuumed packaged where they were stored at 2° C for 14 d post purchase.

### **Steak Allocation**

After 14 d post-purchase aging, the ribeye rolls were fabricated into 2.45 cm thick steaks beginning at the anterior end (Figure 3.1.) The steaks were assigned for analysis as follows: steak 1 – high resolution imaging, steak 2 – fatty acid analysis, steaks 3 and 4 – untrained panel sensory analysis, steaks 5 and 6 – Warner Bratzler shear force analysis, and steak 7 – Hyperspectral Imaging Systems analysis.

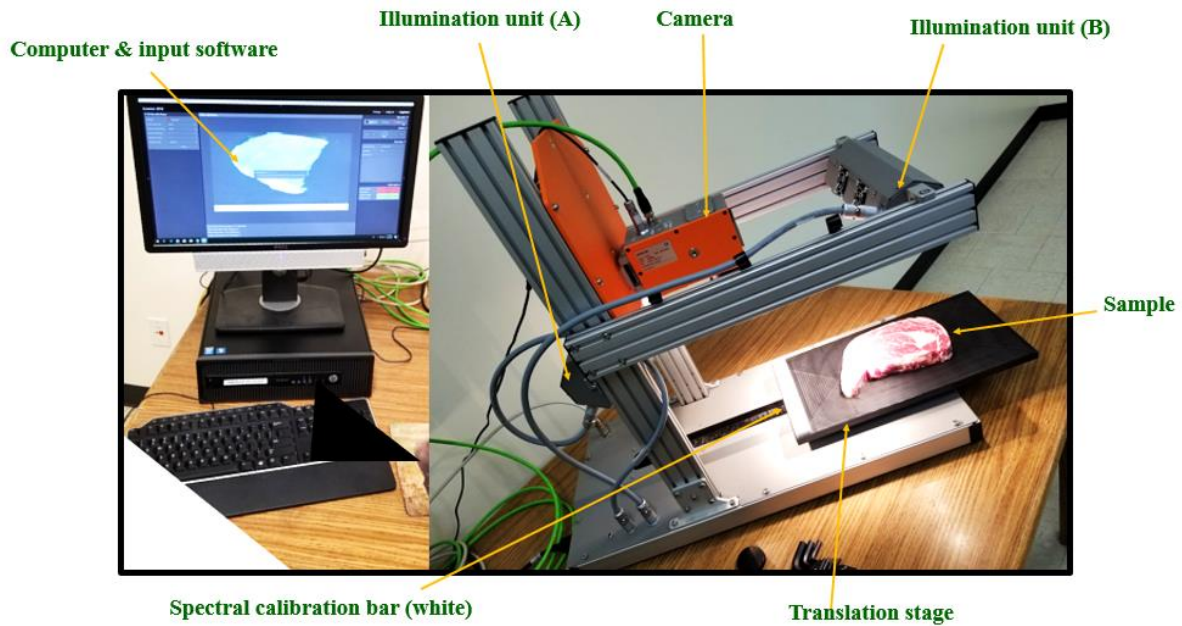


**Figure 3.1.** Allocation of steak analysis.

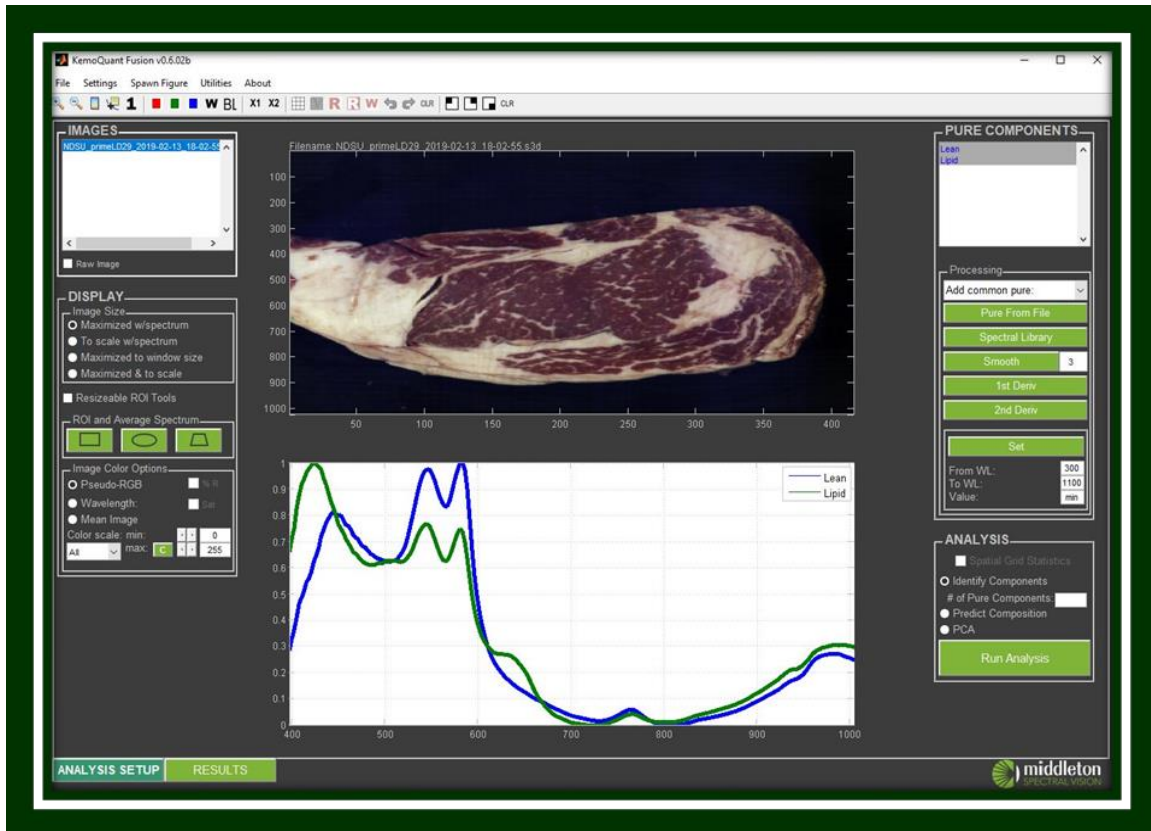
### **Image Acquisition and Hyperspectral Imaging Systems**

Each rib roll (location, steak 7) was captured by an image acquisition system (hyperspectral imaging system) after an industry standard 20 minute bloom time. The hyperspectral imaging system contains four parts (Figure3.2): 1) a hyperspectral image sensor (wavelength from 400nm to 1000nm); 2) illumination system (Via-Spec™ II Halogen Reflectance Illumination-MRC-920-045) 3) sample conveying acquisition system (Lab Scanner Setup 40 x 20-MRC-313-004-05); 4) software package for image analysis (MATLAB V9.5, MathWorks, Natick, MA, USA). The hyperspectral imaging samples were thawed for 12 hours prior to being processed. The Lumo Scanner application for Specim’s hyperspectral scanner systems was used to capture the raw image data (Specim’s Model: FX 10e, Middleton Spectral Vision; Middleton, WI). The software allows the user to setup, adjust and acquire data for the supported Specim spectral camera and is designed to work with data sets covering multiple wavelength regions. Once all ninety samples had been

analyzed using the HIS, the raw data were saved to the collection software. The collection software (KemoQuant™ Analysis Software, Version 2013, Middleton Spectral Vision; Middleton, WI) provided a complete set of image interrogation and analysis tools to aid in the imaging process.



**Figure 3.2.** Lumo Scanner and Specim's Camera™, Model FX 10e setup for taking images.



**Figure 3.3.** KemoQuant™ analysis software.

### Image Processing

Image analysis was conducted separately using image analyzing software (KemoQuant™). Processing algorithms and analyses were developed to separate the fat (marbling) area of interest from the background area. Briefly, color images were segmented into the background (dark) and meat sample (light) areas. After digital removal of the background, the color threshold value criterion will separate the fat from the lean area to allow detailed image feature extractions (Figure 3.3).

### Warner-Bratzler Shear Force Determination

Steaks were transported from the meat lab at 2 °C then cooked on a George Foreman grill (George Grill, GRP99Silver, 23645 Mercantile Rd., Suite B, Beachwood, OH 44122,) set at 177°C. Internal temperature of each steak was monitored using copper-constantan thermocouples

(Omega Engineering, Stamford, VT) positioned in the geometric center of each steak and connected to a temperature monitoring device (Omega Engineering Stamford, VT); steaks were removed from the oven at 70.1° C in order to reach an endpoint temperature of 71° C. Steaks were cooled on a rack for approximately 60 minutes, and chilled for 60 minutes. After chilling, six cores (1.27 cm diameter) were removed from each steak parallel to the muscle fiber orientation using a mechanical coring device. Cores were immediately sheared once through the center using a V-shaped blade on a Warner-Bratzler shear force machine (G-R Manufacturing, Manhattan, KS). Peak shear force was displayed on a Mecmesin BGN-500 Shear Force Gauge (Newton House, United Kingdom) and recorded. A total of ten cores per sample (5 from each matching pair) were removed from center of the steak.

### **Consumer Sensory Evaluation**

One hundred and eighty pairs of sample steaks (30 CH/ 30 PR/ 30 AK) were evaluated at North Dakota State University by untrained consumers (n = 120) for sensory attributes using a 1 to 9 hedonic scale (1-dislike extremely, 9-like extremely). Panelists scored samples for tenderness, flavor, juiciness, and texture. Investigators prepared and served 60 steaks per-day at a temperature of 71° C. Steaks were defrosted at 2° C for 24 h then cooked on a George Foreman grill (George Grill, GRP99Silver, 23645 Mercantile Rd., Suite B, Beachwood, OH 44122,) set at 177°C. Internal temperature of each steak was monitored using copper-constantan thermocouples (Omega Engineering, Stamford, VT) positioned in the geometric center of each steak and connected to a temperature monitoring device (Omega Engineering Stamford, VT); steaks were removed from the grill at 65.5° C to target an endpoint temperature of 71° C. Each steak was labeled to their respective loin and wrapped in foil to be transported to a warming oven. Samples were kept at temperature (71° C) until a consumer was ready to consume the samples. Samples

were then cut into 1.27 x 1.27 cm cubes. Each participant completed a consent form, demographics information, and palatability attributes survey (Appendix C.) and was informed that upon completion of the survey they would receive a package of two steaks. Each consumer received one USDA choice, one USDA prime, and one Akaushi brand steak sample set and asked to provide their visual preference and overall preference.

### **Proximate Analysis**

Beef ribeye steak samples were trimmed of any excess fat, cut into 2.54 cm cubes, frozen in freezer cabinet, and pulverized in a food processor (Cuisinart, East Windsor, NJ). Upon removal from the processor 13g ± 5g samples from each steak (uncooked samples) were placed in a labeled sample bag, frozen, and taken to NDSU Nutrition laboratories to proceed with the analyses of the samples. Quantification of moisture, fat, and protein were performed in duplicate per procedures reported by NDSU nutrition laboratories in Fargo, North Dakota (Moisture, AOAC 934.01; Crude protein, AOAC 990.03; Crude fat, AOAC 2003.06). At NDSU Nutrition laboratories the samples were re-thawed and weighed to obtain a wet weight and placed in an oven to dry for 3 h at 130°C. After removal from the oven, samples were placed into a desiccator to allow samples to cool without producing moisture. Upon removal from the desiccator, samples were weighed again to obtain a dry weight. Moisture concentration (percent) was calculated using the following formula  $100 * [\text{sample weight} - (\text{last Re-weigh} - \text{Tare weight})] / \text{sample weight}$ . Crude protein was calculated using the formula, Crude protein, % (w/w) = % N \* 6.25. A plug of defatted cotton was placed on top of the sample to keep it in the thimble during extraction; 70–90 mL of solvent was used. The sample was raised and suspended over the boiling solvent. During rinsing, residual traces of the extractable material were flushed out of the sample and retained in the extraction cup. The beef ribeye samples lipid concentration were



weighed into the extraction thimbles and calculated: % Fat =  $(W2 - W1)/W3 * 100$ , where W1 = weight of the extraction cup; W2 = weight of the extraction cup + extract; W3 = weight of the sample.

### **Statistical Analysis**

Statistical analysis was conducted using a MIXED model Fixed effect of treatment and random effects of class and ribeye identification (Akaushi, prime, choice, and ID: 1-30) using SAS software platform (SAS 9.4 SAS Institute Inc. 100 SAS Campus Drive; Cary, NC). Sensory overall preference data were analyzed using a Chi-square test. Proc CORR was used for the pixel/fatty acid analysis comparison as a random effect and the fixed effects was loin and class.

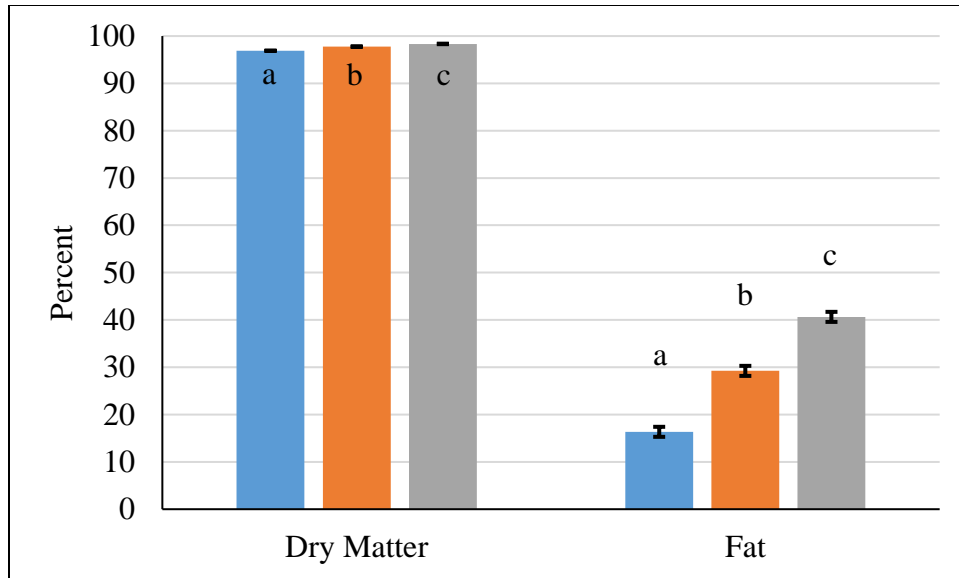
## **Results and Discussion**

### **Proximate Analysis**

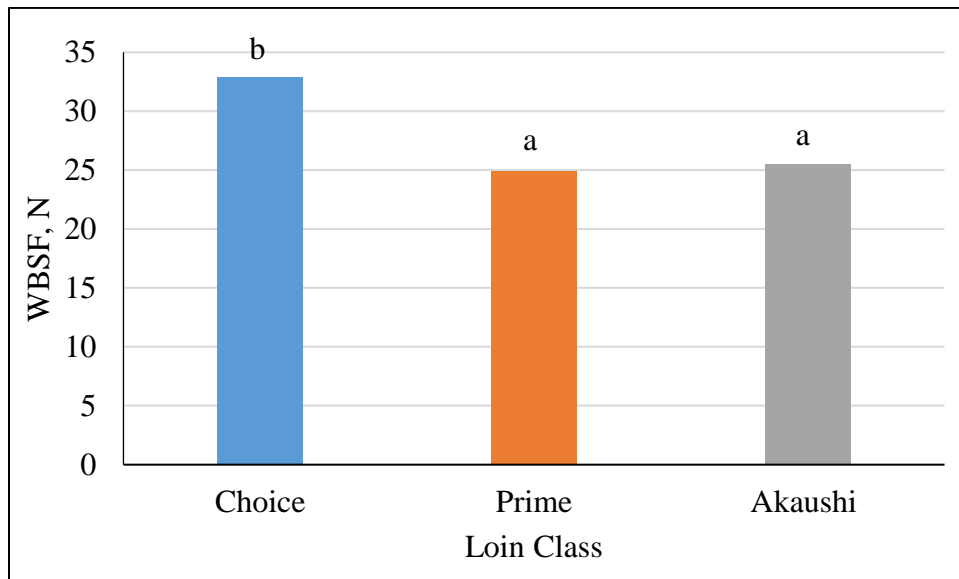
Proximate analyses were performed at the NDSU Nutrition Lab (1300 Albrecht Blvd., Fargo, ND 58102). Fat content increased as grade quality increased ( $P < 0.001$ ). Akaushi had the greater ( $P < 0.001$ ) fat content (40.64%, DM basis) than prime and choice loins (Figure 3.4).

### **Warner-Bratzler Shear Force**

Warner-Bratzler shear force data (Figure 3.5) demonstrated greater ( $P < 0.001$ ) peak force values for choice steaks as compared to the prime and Akaushi steak samples (32.91 vs. 24.94 and 25.54 N, respectively).



**Figure 3.4.** Mean dry matter (%) and mean fat content (%) for Choice (blue bars), Prime (orange bars), and Akaushi (gray bars). Means within a variable with different superscripts differ by  $P < 0.05$ .



**Figure 3.5.** Warner-Bratzler shear force values for Choice, Prime, and Akaushi. Means with different superscripts differ by  $P < 0.05$ .

**Table 3.1.** Demographics of consumer sensory survey participants.

<b>Variables</b>	<b>Frequency</b>
<b>Gender</b>	
Male	51%
Female	49%
<b>Age</b>	
< 21	33%
22-29	35%
30-39	14%
40-49	9%
50-59	2%
> 59	7%
<b>Education</b>	
Less than High School	0%
High School	32%
Trade School	1%
Associates Degree	14%
Bachelor's Degree	18%
Master's Degree	18%
Professionals Degree	17%
Other	0%
<b>Ethnicity</b>	
African-American/Black	5%
Asian Pacific/Islander	7%
Hispanic/Latino	10%
Interracial	6%
Native American/American Indian	0%
Caucasian/ White	68%
Other	0%
<b>Income, \$</b>	
less than 10,000	20%
10,001-30,000	31%
30,001-50,000	12%
50,001-70,000	11%
70,001-90,000	10%
90,001-100,000	6%
100,001 or more	10%

### **Consumer Sensory Evaluation**

Demographic data indicated that the participants were 51 % male and 49 % female consumers (Table 3.1). Of the one-hundred and twenty consumers, they ranged in ages from 18

years to 68 years old, with a median age of 29. Highest levels of education completed were reported as: High School- 32%; Trade School-0%; Associates Degree -15%; Bachelor's Degree - 18%; Master's Degree- 18%; Professionals Degree (Ph.D., Ed.D., M.D., J.D., or D.V.M.) -17%. Consumers were represented by 5% African-American/Black, 7% Asian Pacific/Islander, 10% Hispanic/Latino, 6% Interracial, 0% Native American/American Indian, 68% Caucasian/ White.

Consumers scored on the hedonic scale, a random visual appraisal to their preference of the three classes of steaks. The average scores were: choice- 5.62, prime- 5.39, and Akaushi- 5.29 for the randomized steak visuals (Figure 3.6.). The visual appraisal of the research steaks indicated the preference as: 37 (31%) visually preferred prime steak, 29 (24%) visually preferred the Akaushi steak, 54 (45%) visually preferred the choice steak.



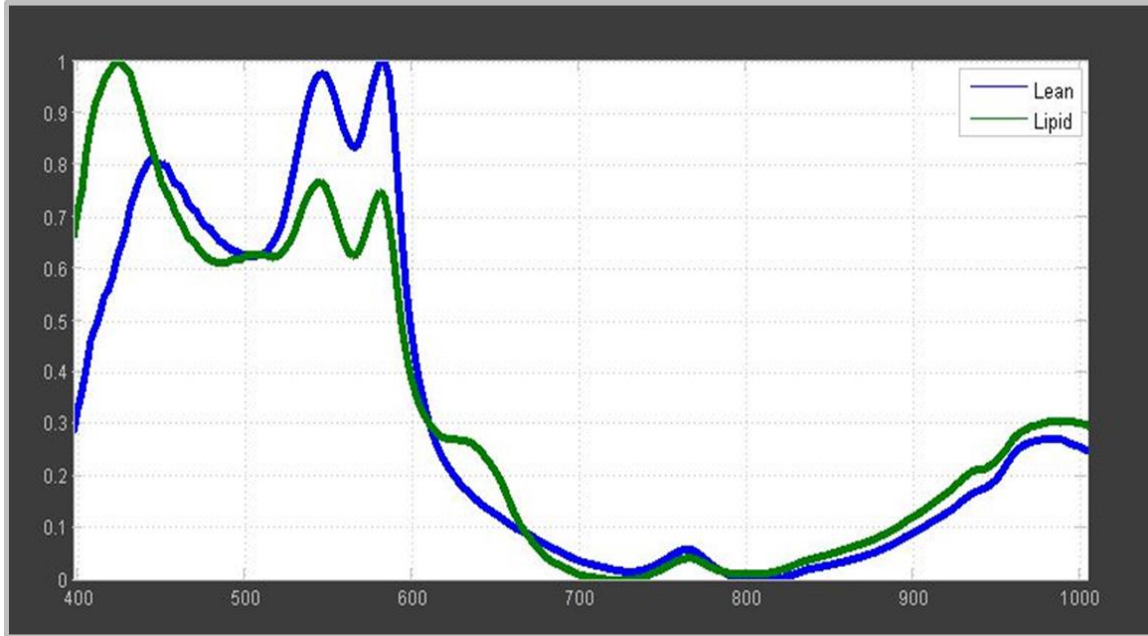
**Figure 3.6.** Visual appraisal presentation slide used during the consumer sensory and palatability evaluation.

The objective of the consumer palatability analysis was to evaluate each steak and rank tenderness, juiciness, flavor, and texture using a 9-point hedonic scale: 9= extremely like, 8= like very much, 7= like moderately, 6= like slightly, 5= Neutral, 4= dislike slightly, 3= dislike moderately, 2= dislike very much, 1= dislike extremely) and to specify overall preference

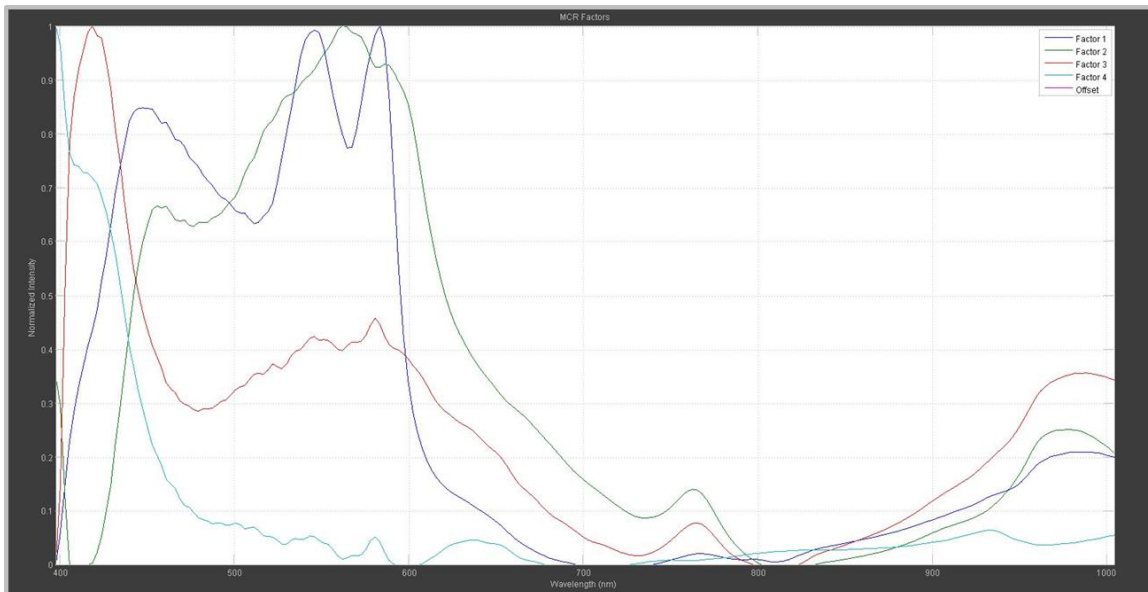
between the choice steak, prime steak, and Akaushi steak. Consumers ( $P = 0.04$ ) rated the prime steaks ( $3.78 \pm 0.24$ ) more tender than choice and more tender to Akaushi steaks ( $4.30 \pm 0.7$ ). For juiciness, consumers rated the choice and Akaushi steaks ( $5.35 \pm 0.75$ ) as juicier ( $P = 0.05$ ) than the prime steaks ( $4.87 \pm 0.60$ ). However, scores for flavor were higher in Akaushi (6.42 vs. 4.85, and 5.23), and showed a difference at  $P < 0.001$ . No difference was seen in consumer rating of texture of the three classes of steaks. Consumers were asked to choose which sample they preferred based on tenderness, juiciness, flavor, and texture ratings using the 9-point hedonic scale. Of the 120 consumers, 43 (36%) of consumers preferred the Choice steaks ( $P = 0.10$ ) whereas 41 (34%) of the consumers preferred the Akaushi steaks and 36 (30%) preferred Prime steaks. Consumers were asked, “When their income increases, does their quality of meat purchases also increase?” We recorded 36 (30%) maybe, 2 (2%) undecided, 6 (5%) no, and 76 (63%) yes. Consumers were also asked, “if selection of meat purchased for gatherings (parties, grilling, BBQ) reflects their social-economic status with their guest?” We recorded 34 (28%) maybe, 3 (3%) undecided, 29 (24%) no, and 54 (45%) yes.

### **Hyperspectral Analysis and Correlation**

Wavelength is defined as the distance between successive crests of a wave (Merriam-Webster, 2019). During analysis of the sample steaks we observed wavelength values for lean and lipid of the steaks. The Lumo analysis quantified that lean values could be observed at



**Figure 3.7.** Initial wavelength parameters for calculating lean and lipid algorithm factors.

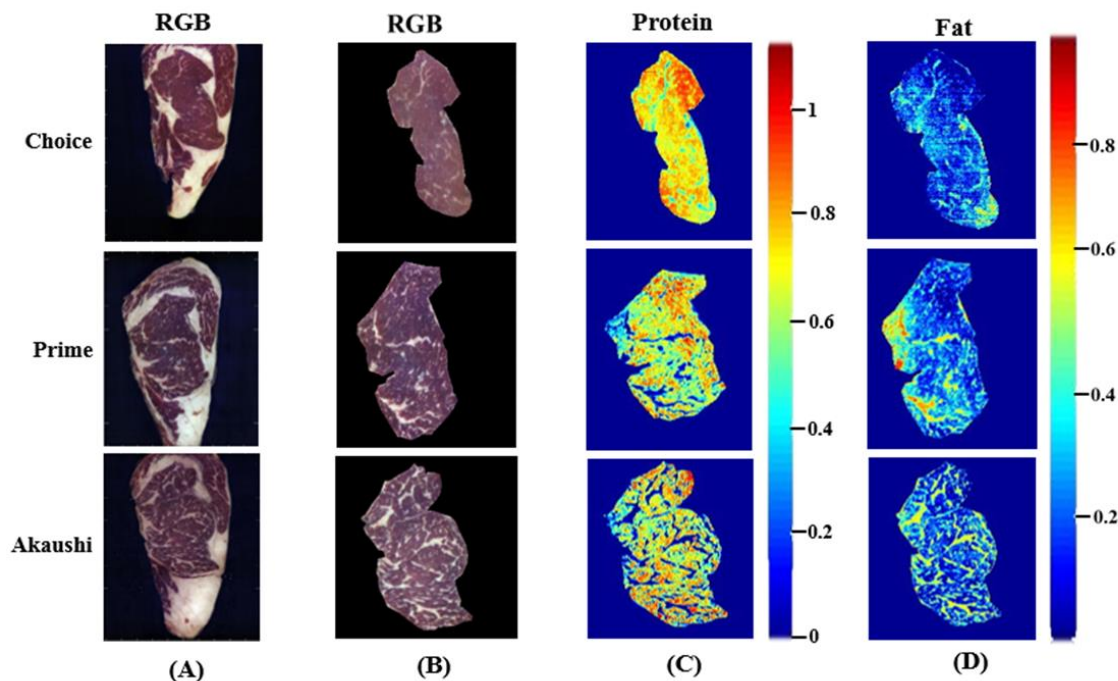


**Figure 3.8.** Protein and IMF wavelength output for quantification factors of lean and lipid content of steak samples.

wavelengths 400-440 nm, 460-520 nm, 540-570 nm, and 600 nm. The Lumo analysis quantified lipid (IMF) values could be observed at wavelengths 400-430 nm, 440-530 nm, 540-570 nm, and 590-600nm. Those wavelengths were used in the analysis to identify pure components and the factors to quantify lean and intramuscular fat. The output provided four factors. The first two

were of lean and lipid and the last two were values (Figure 3.7) for the prediction values provided in the excel sheets (Figure 3.8).

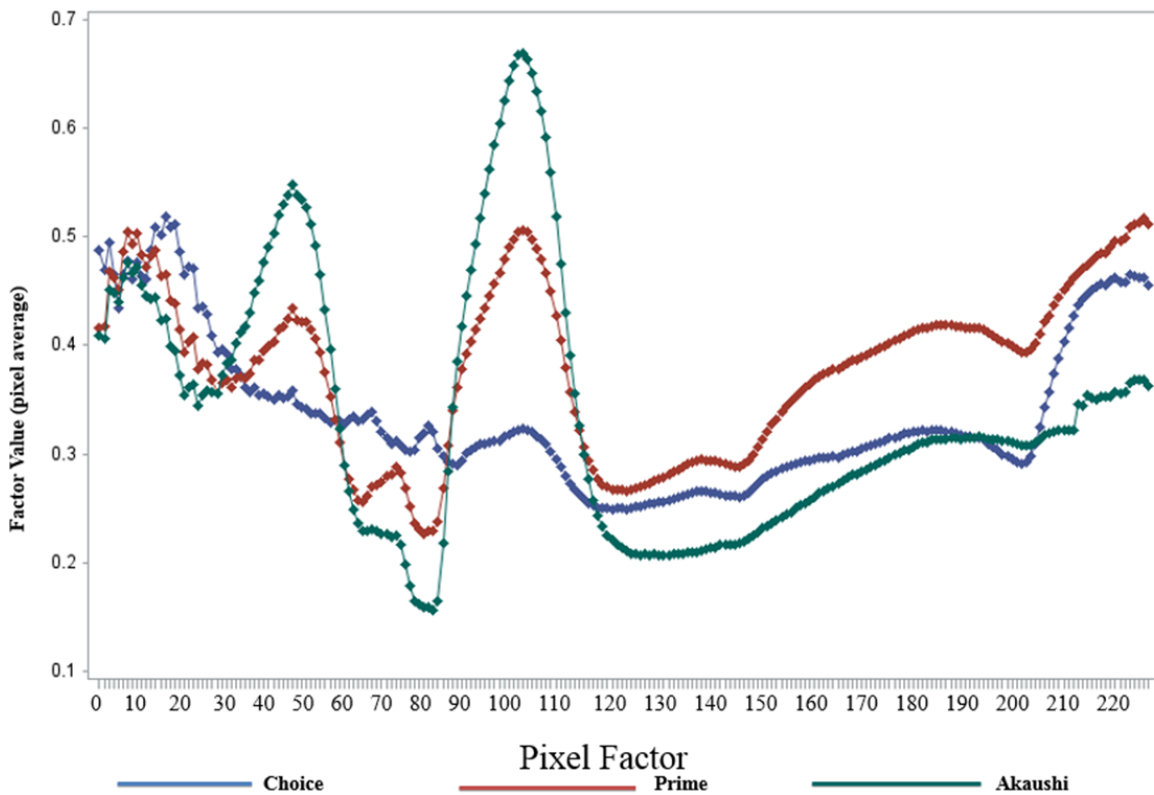
Figure 3.9 exhibits an example of the chemical images produced for RGB, lean, and fat from three different class samples converted to intact forms. The contrast in the chemical images was based on the chemical differences between the various components of the beef samples. The power of these chemical images resides in the quick access to the spatial distribution of chemical compositions and their relative concentrations indicated in the color bar beside each image. The color bar was extended from a low content (in blue) to a high content (in red).



**Figure 3.9.** Concentration maps for fresh beef meat samples: (A) pseudo-color image composed by concentrating three wavelengths (420, 500, and 640 nm), (B) pseudo-color image of longissimus area of interest, (C) concentration map of protein, and (D) fat.

The resulting false color mapping with intensity scaling was then used to display compositional contrast between pixels in the image. Although it was not difficult to recognize the difference in concentration of the two major constituents (lean and fat) from the color image shown, the difference in concentration from sample to sample and within the same sample was

very appealing and easy to be distinguished from the resulting chemical images. The data collected was able to correlate imaging values to detect specific IMF values. These hyperspectral image spectral feature values 0.33 (choice), 0.51 (prime), and 0.66 (Akaushi) in association to fatty acid IMF quantification and consumer sensory preference resulting in the detection of the flavor intensity of beef using camera vision systems (Figure 3.10). Further investigation regarding appropriate wavelength of marbling features from hyperspectral image processing methods is necessary.



**Figure 3.10.** Hyperspectral imaging system pixel factors by loin class and in correlation to intramuscular fat content.

### Conclusion

The hyperspectral imaging computer vision system provides simultaneous data retrieval of information from both spectral and spatial data, allowing for the analysis of chemical profiles and concentration gradients of the major crude protein and intramuscular fat components in beef



ribeye samples. The similarity in shear value and no statistical difference between prime and Akaushi could be attributed to the Akaushi genetic line at HeartBrand crossbred to English breeds. The accurate estimation of protein and IMF concentrations could be visualized in a pixel-factorial manner showing the distribution and amount of the crude constituents within and between samples of different or similar grade classes (ElMasry et al. 2013). The advantages of predicting lean and marbling meat quality attributes using this method facilitates the mapping of intramuscular fat deposition. The data collected was able to detect specific IMF values. These hyperspectral image spectral features can be identified through the machine vision and used to sort marbling quality seen through the hyperspectral image spectral feature values of 0.33 for USDA choice, 0.51 for USDA prime, 0.66 for Akaushi branded beef in association to marbling content.

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## CHAPTER 4. THE IMPACT OF STUDENT AGRICULTURAL BACKGROUND ON SUCCESS IN AN *INTRODUCTION TO ANIMAL SCIENCES* CLASS<sup>1</sup>

### Abstract

Students enrolled in ANSC 114 *Introduction to Animal Sciences* (fall and spring semester, 2013 to 2018) were surveyed to collect student academic history regarding past agriculture experience relevant to rural vs urban living and activities or organizations they participated in prior to attending university. Once collected, the data was correlated to academic success based on overall final grade average (numeric points achieved vs numeric points available, %). The geographic demographics were as follows; 25% from cities with a population greater than 10,000 (urban), 18% from small towns with a population less than 10,000, and 13% from a rural setting where the main household income did not stem directly from agriculture and 44% from the farm. There were more females majoring in the Animal Sciences; 37% (n = 438) male and 63% (n = 738) female. Female students enrolled in ANSC 114 had a greater overall final grade average than their male counterparts (91.6% vs. 89.0%;  $P = 0.004$ ). Geographic upbringing had no significant impact on student academic success ( $P > 0.05$ ), yet students who were 4-H members/participants achieved a higher final grade percentage than other agricultural background experiences ( $P = 0.01$ ). Despite differences across gender and agriculture background, no differences were seen for the interaction of gender  $\times$  agriculture experience;

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<sup>1</sup> The material in this chapter was co-authored by D. D. Reed, Jr., L. Baranko, J. B. Frandrup, J. M. Young, A. Marx, and E. P. Berg. D. D. Reed, Jr. was responsible for data collection, data entry, and the writing of this chapter. J. B. Frandrup assisted with data collection and spectral analysis. L. Baranko assisted with data collection and data entry for analysis. J. M. Young was responsible for statistical analyses and assisted in writing of this chapter. A. Marx assisted in writing of this chapter. E. P. Berg responsible for design of research writing of this chapter.

however, females who entered university with livestock showmanship experience obtaining the highest final grade average ( $95.0 \pm 1.09$ ;  $P < 0.001$ ) compared to other demographics. It can be concluded that participation in organized agricultural clubs and pre-college agricultural experience has a positive impact on academic scores in an introductory animal science course.

### **Introduction**

The demographic population of student enrolled in animal science courses at Land-Grant institutions has changed in the last 25 years. Female and urban students are filling the classroom chairs formerly occupied by male “farm kids.” The need for diversity within the agriculture industry was heard and women are obtaining degrees in the agricultural sciences. Proportionally there is an increase in women compared to men enrolled in agricultural sciences. Gender and ethnic differences influence potential students’ perceptions of agricultural education opportunities available at Land-Grant institutions. Caucasian and Black women have been subjected to stereotypes that steer them away from math, science, and engineering (Maple, 1991; Beasley and Fischer, 2012). In comparison, ethnic groups identified as Black and Hispanic are less likely to venture into agricultural career paths due to historically negative presumptions associated with agriculture (Frick et al., 1995). Law and Pepple (1990) said,

*“Men and women of all ages and ethnic groups have a vested interest in agriculture. Many factors influence academic success or failure of university students.”* (as cited by Hoover, 2017).

Jean-Philippe et al. (2017) stated that a number of studies have noted that a lack of requisite education in agriculture among minorities may be the reason that a positive attitude toward agriculture as a career field has not developed in minority students. University agricultural science professionals must consider the following questions: 1) how effective is our instruction and 2) are we providing student-perceived value, interest, and enjoyment in the classroom

experience? Today's Generation Z (those born 1995-2010) students require that the instructor capture and hold the interest of the students. Both instruction factors must be present for success in agriculture classes (Hoover, 2017). Furthermore, Ball and Garton (2001) suggested that students who entered college with FFA and 4-H program experience maintained a higher retention rate and better academic performance. Prior to entering post-secondary education, these individuals interacted as young agriculturalists by becoming members of organizations such as 4-H and FFA to practice and perfect an understanding and appreciation for agriculture. Participation in these organizations opened doors to success and prepared students for challenges ahead in college courses. Agriculturally focused activities and clubs emphasize techniques and leadership opportunities that prepare a student for the independence of university studies.

The objective of this study was to determine the impact of an agricultural background and geographic location on student success in an introductory animal sciences course. With that, the research hypothesis was that students possessing a rural or farm/ranch background entered university with the impression that they possessed greater knowledge of the animal science curriculum compared to urban students within the same program. In the following report we will demonstrate the positive effect agriculture experience has on classroom success. This research will provide university instructors a better understanding of student background, which will allow them to adjust teaching and learning strategies accordingly.

### **Materials and Methods**

Students enrolled in *Introduction to Animal Sciences* (ANSC 114; n= 1,176) at North Dakota State University (spring and fall semesters of 2013, 2014, 2015, 2016, 2017, and 2018) were asked to complete a questionnaire (Appendix D) pertaining to their background and demographics.

## **NDSU ANSC 114 Course Background**

The *Introduction to Animal Sciences* course at NDSU presents general principles of the animal industry and relationships to humankind. It consists of 2 lecture periods per week and 1 two-hour laboratory split into three or four sections depending on the number of students enrolled. Lecture topics include issues in animal agriculture, growth and development, animal behavior, nutrition physiology, reproductive physiology, foods of animal origin, and fiber products generated from animal agriculture (i.e. wool/ mohair). The lecture pairs with lab visits to the NDSU production units (beef, lamb, dairy, swine, and equine) where students are allowed hands-on application of the topics covered in lecture.

### **Student Questionnaire**

A survey research method using a questionnaire was approved by the NDSU Institutional Review Board (Protocol #AG16027) was presented to all students enrolled in ANSC 114 (*Introduction to Animal Sciences*). All students were read the informed consent and given the option to participate or not. Students who did not wish to participate turned in blank surveys. A unique identifier was used to keep participants' identity confidential for summative survey results. Final course scores (number of points achieved vs number of points available) were matched with the corresponding unique identifier by the course instructor. The data were then provided to the statistical technician to evaluate and distinguish patterns between questionnaire data points and academic performance.

### **Statistical Analysis**

Data were analyzed using the mixed procedure of SAS (v. 9.2, SAS Institute, Cary, NC). The fixed effects included semester, gender, classification (i.e. freshman, sophomore, etc), major, geographical demographic and agriculture background (high school Ag, FFA, 4-H,

livestock judge, livestock showman, and (or) family farm business). Interactions were analyzed for gender  $\times$  agriculture background. The least squared means (LSMEAN) were calculated using the LSMEANS statement and differences were defined at  $P < 0.05$ .

## Results

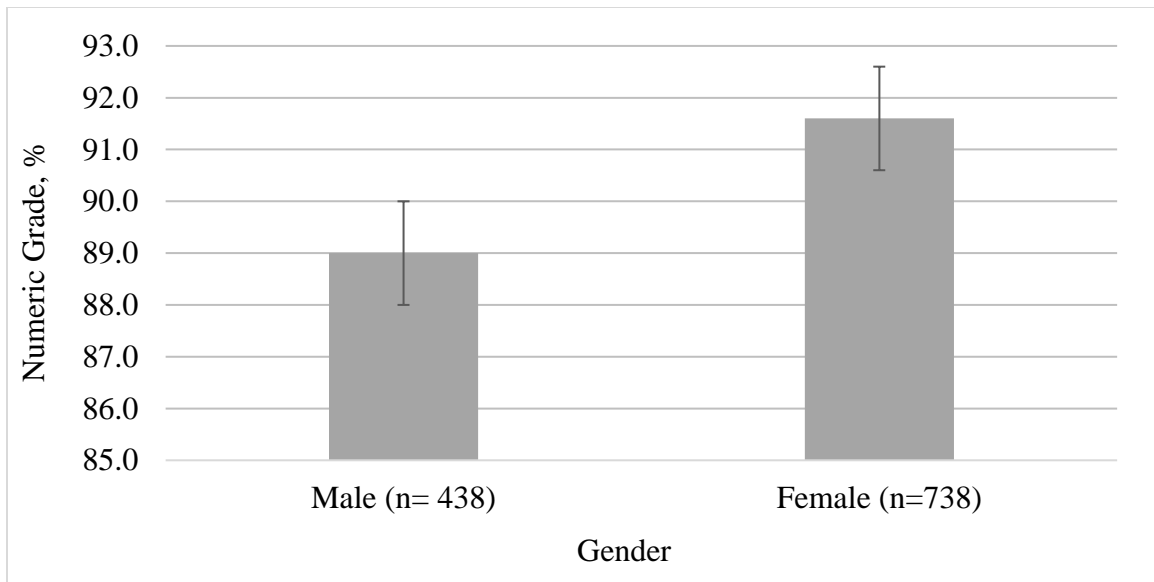
Student demographics are reported in Table 4.1. Of the 1,176 students who completed the questionnaire, 37 % ( $n = 438$ ) were male and 63 % ( $n = 738$ ) were female. Female students out-scored their male counterparts (Figure 16.) by a margin of 1.6 % (91.6 % vs. 89.0 %;  $P = 0.004$ ). The vast majority of student participants (97.2 %) were self-identified as Caucasian ( $n = 1,148$ ). The remaining ethnic demographics were African-American ( $n = 5$ ), Asian ( $n = 7$ ), Hispanic/Latino ( $n = 6$ ), Interracial ( $n = 5$ ), Native American ( $n = 2$ ), and other ( $n = 3$ ). These non-Caucasian ethnic groups comprised 2.8% of the sample size.

The survey participant breakdown according to geographic location included 295 (25 %) students from cities with a population greater than 10,000 (urban), 210 (18 %) from small towns with a population less than 10,000, and 157 (13 %) came from a rural setting where the main household income did not stem directly from agriculture. The largest geographic demographic population (44 %) grew up on a “farm” that was actively involved in production agriculture ( $n = 514$ ). Only 14 % of the survey participants reported having no agricultural background while 49 % had completed agricultural coursework or programs prior to attending university. Other organized agriculture programmatic experiences reported by the students included FFA organization (39 %) and (or) FFA livestock judging team (27 %) and 4-H club member (34 %) and (or) 4-H livestock judging team member (30 %). Finally, 27 % of those surveyed reported experience fitting and showing livestock for competition.

**Table 4.1.** Demographics of ANSC 114 introduction to animal science survey participants

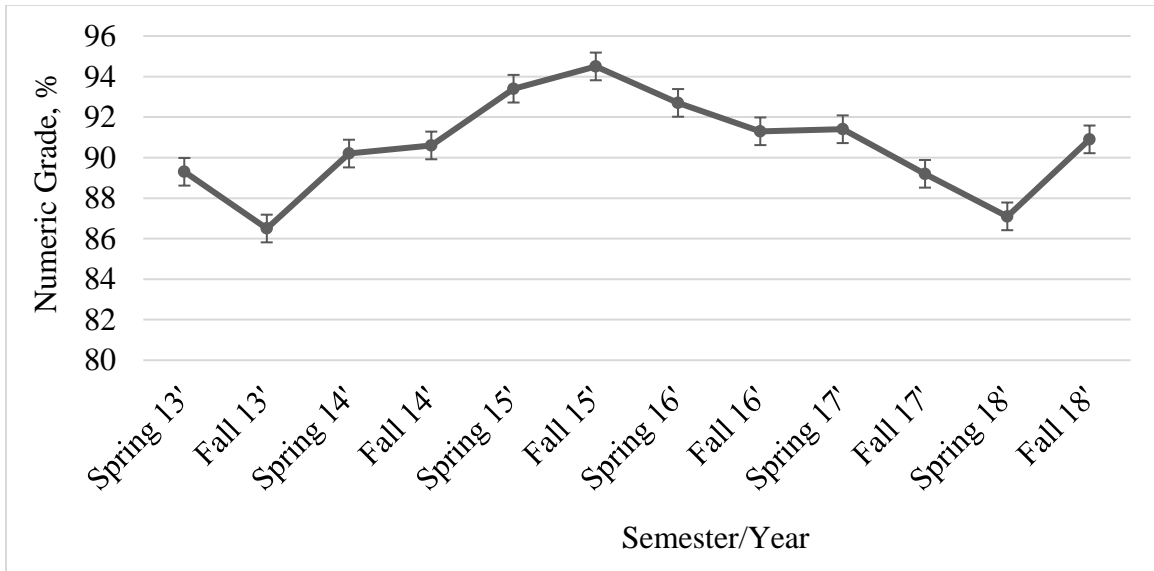
<b>Variables</b>	<b>N</b>	<b>Frequency</b>
<b>Gender</b>		
Male	438	37%
Female	738	63%
<b>Ethnicity</b>		
African-American/Black	5	0.5%
Asian Pacific/Islander	7	0.7%
Hispanic/Latino	6	0.6%
Interracial	5	0.5%
Native American/American Indian	2	0.2%
Caucasian/ White	1,148	97.2%
Other	3	0.3%
<b>Geography (hometown)</b>		
Urban (over 10,000 people)	294	25%
Small Towns (<10,000 people)	212	18%
Rural Area	153	13%
Grew up on a farm	517	44%
<b>Agriculture Background</b>		
FFA (No Involvement)	720	61%
FFA (Active Participant)	456	39%
No High School related Ag Course	595	51%
High School related Ag Course	581	49%
4-H (No Involvement)	771	66%
4-H (Active Participant)	405	34%
FFA Judge Team	316	27%
No Involvement FFA Judge Team	860	73%
4-H Judge Team	357	30%
No involvement 4-H Judge	819	70%
Livestock Showman	331	14%
No Involvement in Livestock Show	845	86%





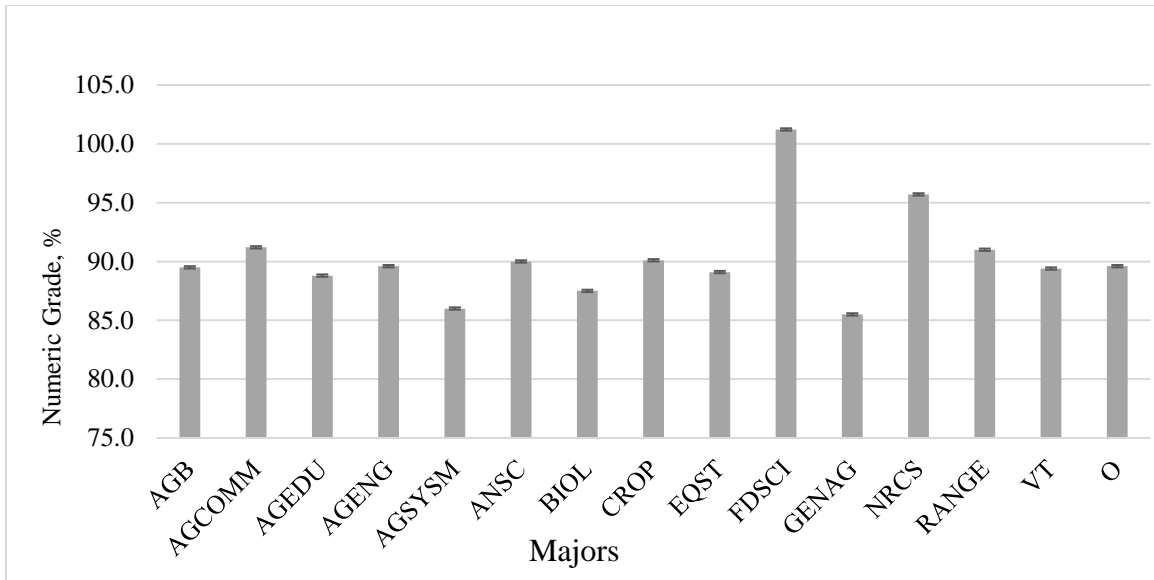
**Figure 4.1.** LSMeans and standard errors comparing overall final grade percentages for gender of students enrolled in an Introduction to Animal Science course. ( $P = 0.004$ )

Figure 4.2 displays the variation in the final scores from 2013 to 2018. Throughout the six years of survey data collection, there were semesters where the course was taught by different instructors. While the lecture portion of the class was taught by two faculty, laboratory instruction often fell as the responsibility of graduate student teaching assistants. These teaching assistants assisted with laboratory instruction, and were under the constant supervision of the faculty member responsible for the course. The course was supervised by a substitute faculty instructor the Spring/Fall semesters of (2018) with the remaining semesters under the supervision of the main faculty instructor.

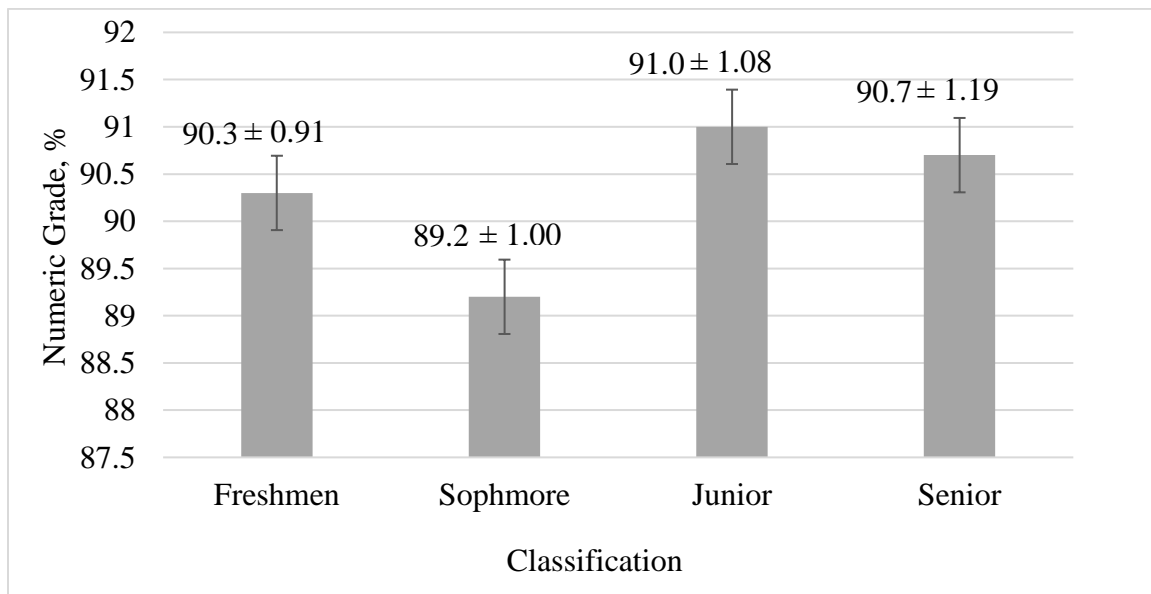


**Figure 4.2.** LSMeans and standard errors comparing overall final grade percentages distributed across semester and year in an Introduction to Animal Science course from 2013-2018.  $P < 0.001$

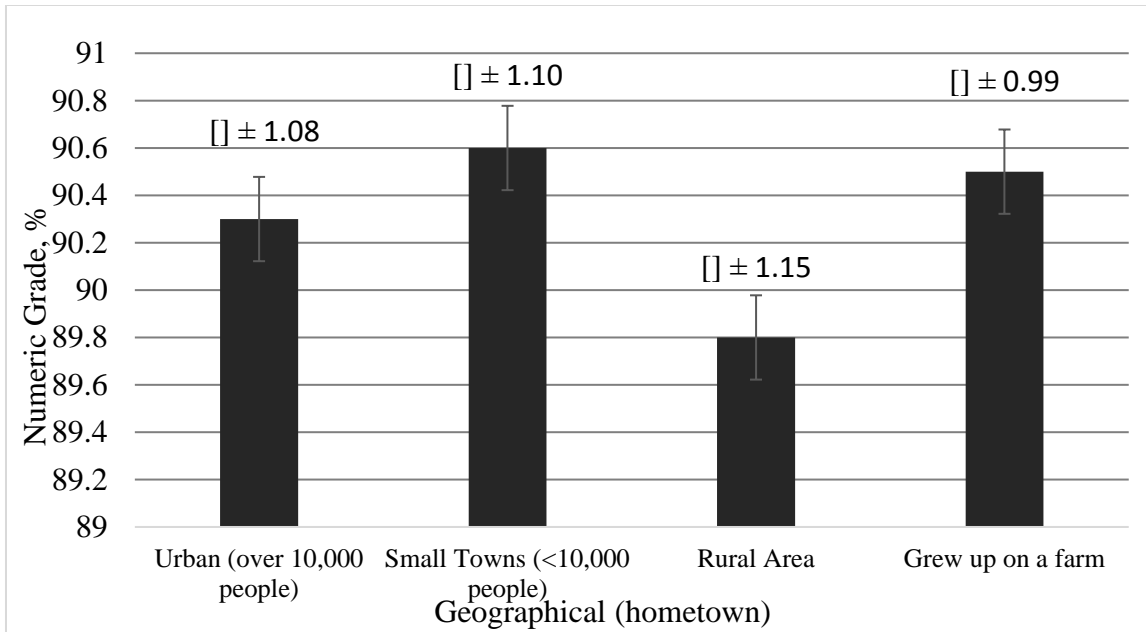
Figure 4.3 presents the final average percentage score for academic performance in ANSC 114 across the academic majors. No significant differences were observed across classification ( $P = 0.30$ ) however, students who took the course as sophomores possessed the lowest final percentage (89.2 %). According to the final grading scheme, this would equate to a final grade of B while freshmen, juniors, and seniors who took the class finished with low A grades (Figure 4.4). Differences were observed for academic major ( $P < 0.0001$ ). The top three majors were Food Science (101.2 %  $\pm$  6.59), Natural Resource and Conservation Science (95.7 %  $\pm$  5.37), and Agriculture Communications (91.2 %  $\pm$  2.84); Animal Science majors ranked fifth numerically (90.0 %  $\pm$  0.76).



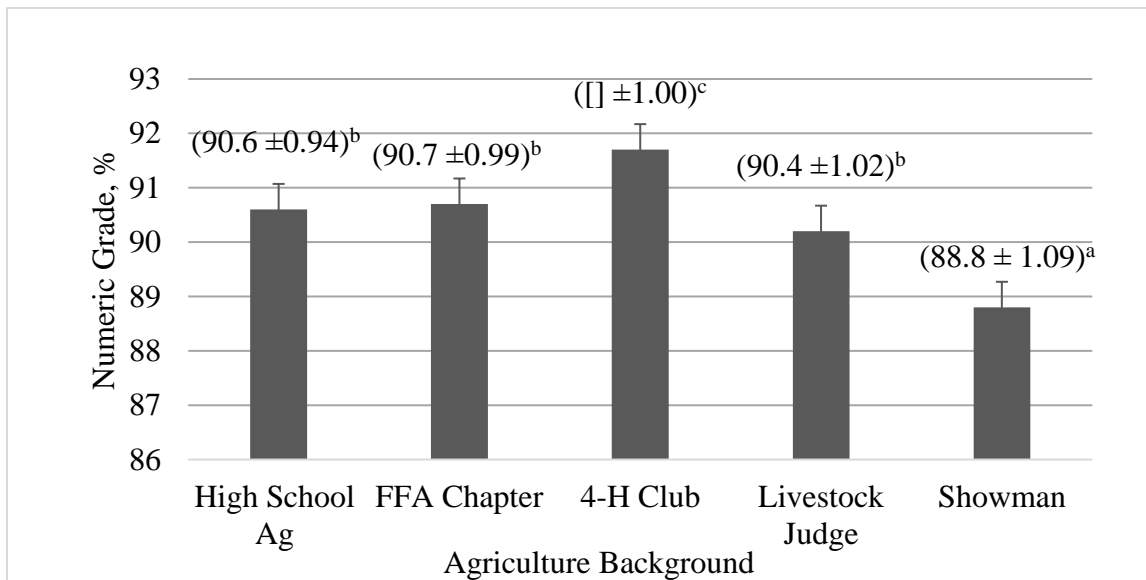
**Figure 4.3.** LSMeans and standard errors comparing overall final grade percentages distributed across academic major for students enrolled in an Introduction to Animal Science course from 2013-2018. ( $P=0.30$ ) Abbreviations for majors: AGB- Agriculture business, AGCOMM- Agriculture communications, AGEDU- Agriculture education, AGENG- Agriculture engineering, AGSYSM- Agriculture systems management, ANSC- Animal science, BIOL- Biology, CROP- Crop science, EQST- Equine science, FDSCI- Food science, GENAG- General Agriculture, NRCS- Natural Resource and Conservation science, RANGE- Range management science, VT- Veterinary Technology, O- Other



**Figure 4.4.** LSMeans and standard errors comparing overall final grade percentages of each academic year classification of students enrolled in an Introduction to Animal Science course.  $P = 0.24$



**Figure 4.5.** LSMeans and standard errors comparing overall final grade percentages for geographical upbringing of students enrolled in an Introduction to Animal Science course. ( $P=0.89$ )

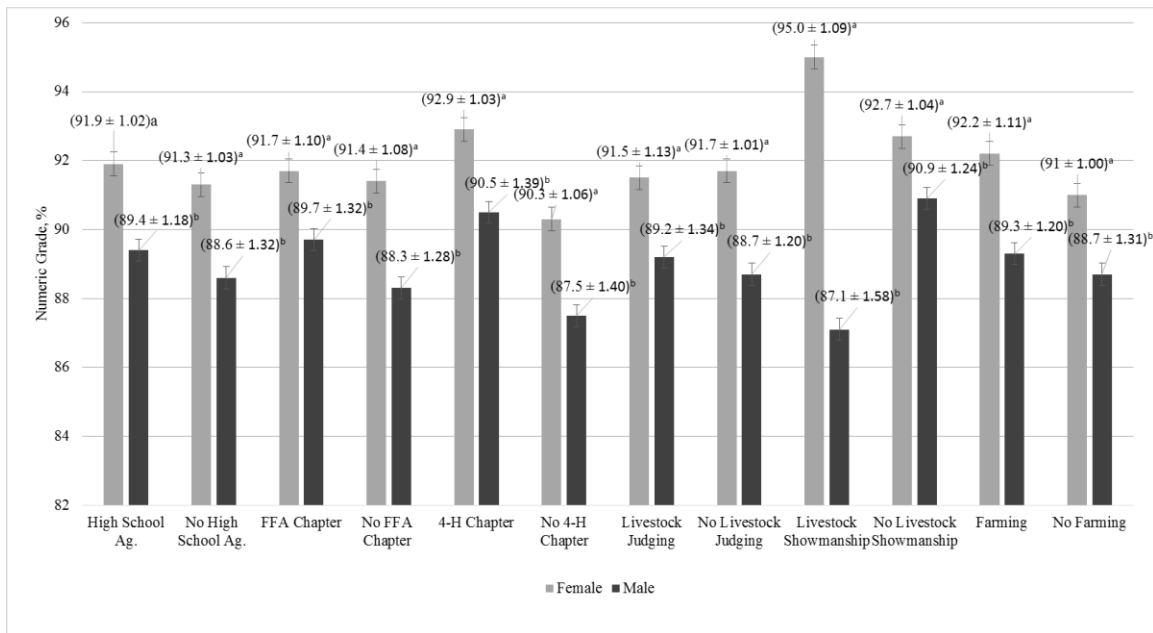


**Figure 4.6.** LSMeans and standard errors comparing agriculture experience interaction for students enrolled in an Introduction to Animal Science course.

Geographic upbringing had no significant impact on student academic success (Figure 4.5). Those students who were 4-H member/participants achieved a higher final grade percentage (91.7 %,  $P = 0.01$ ) than other agricultural background experiences. Reported High School

agriculture courses ( $P = 0.43$ ), FFA membership ( $P = 0.41$ ), and judging experience ( $P = 0.87$ ) impact on numerical final grade percentage (Figure 4.6).

Despite differences across agriculture background, no differences were seen for the interaction of gender  $\times$  agriculture experience when comparing those who participated and those who didn't have previous agriculture background (Figure 4.7). Evidently in livestock showmen, female students obtained the highest final grade average ( $95.0 \pm 1.09$  vs.  $87.1 \pm 1.58$ ;  $P < 0.001$ ). Overall, participation in organized agricultural clubs and pre-college courses impacted academic scores in ANSC 114 in a positive manner.



**Figure 4.7.** LSMeans and standard errors comparing overall final grade percentages for the gender  $\times$  agriculture experience interaction for students enrolled in an Introduction to Animal Science course. ( $P < 0.0001$ ) Means with different superscripts a, b, c showed significant difference.

## Discussion

Agriculture, technology, and diversity grants are more accessible for younger individuals who possess a knowledge and interest in modern agriculture technology (Jones et al., 2007).

Young individuals who capitalize on these opportunities have more opportunity to remain or

return to rural America as young agriculturists. Further, traditional Land Grant Universities have been the academic home for not only agriculture science, but also STEM (science, technology, engineering, and math) fields since their development in the late 1800s. Emphasis on agricultural STEM has shown a greater appeal to a generation that has grown up utilizing technology. A field of study that was once dominated by Caucasian males has seen increased opportunities for women and non-Caucasian agriculturists. Millennial, and Generation Z women and men who possess a desire for a rural (lifestyle) combined with a career interest in technology are enhancing the diversity of rural America as traditional stereotypes begin to breakdown (Abouseleiman, 2019).

Women have represented 80% of the animal science student population at NDSU (n = 589) since 2013 (NDSU Enrollment Data, 2018). Nationally, students majoring in agriculture/natural resources received degrees from four year-institutions represent 2% of the total students who received degrees from 2013-2017 (National Library of Education, 2017). Compared to the national trend, women represent 1% of all registered majors (National Library of Education, 2017). In the present study, women outperformed men in ANSC 114 by 1.6 percentage points on their final grade. In this case, male NDSU students averaged a B, while their female counterparts obtained an A grade (based on cumulative test scores and assignments). Bettinger and Long (2005) performed a large-scale, longitudinal study of university data that was available in the mid 1990's. They acknowledge that women have matched or surpassed men when it comes to gaining entry into college or equality of scholastic achievement, but remain less likely to pursue science-related fields of study.

Neumark and Gardecki (1998) reported that female doctoral students who have a female mentor were more likely to succeed. Wang and Degol (2017) stated:

Although the gender gap in math course-taking and performance has narrowed in recent decades, females continue to be underrepresented in math-intensive Science, Technology, Engineering and Mathematics (STEM).

The Department of Animal Sciences at North Dakota State University is consistent with this national trend where 54 % of the departmental professors/lecturers and 75 % of the research specialist/technicians are female. The opportunity for female mentorship and positive influence is present at NDSU and may be reflected on the female student success observed in ANSC 114.

In the present study, we found that college students who possessed past experiences and involvement in local 4-H programs performed significantly better in an *Introduction to Animal Sciences* course (Table 4.6). The impact of 4-H involvement has yet to be fully studied. Fox et al. (2003) reported how involvement in 4-H club activities impacted various life skills. The top three life skills enhanced by former 4-H involvement were 1) sense of responsibility (58.8%), 2) product production skills (54.2%), and 3) ability to handle competition (53.8%). Fox and co-workers (2003) also stated that the relationship between Land Grant university extension programs and 4-H is very important when considering the development of young people “*to become capable, competent adults.*” Park and Dyer (2005) studied students who held positions of leadership in the College of Agriculture and Life Sciences (CALs) at the University of Florida. A common theme was seen whereby former 4-H and FFA members held more positions of leadership in university and participated as members of various on- and off-campus organizations more than those students who had never participated in 4-H or FFA at a younger age. Park and Dyer (2005) reported females dominated the positions of leadership (72.2% female vs. 27.2% male). They also found that of the 167 positional leaders surveyed in the University of Florida CALs, 72.2% were former 4-H members compared to 62.2% who were involved in FFA. Rusk et al. (2003) studied the impact of 4-H livestock projects on the development of life and

project skills on Indianan 4-H livestock members. He reported that former 4-H members used the responsibility skills they developed from raising animal projects to complete homework assignments, be punctual at work, and care for their siblings. Rusk et al. (2003) stated that this was to their benefit in school assignments, home, and jobs to be dependable, confident, and qualified individuals. Skurupey (2017, December 6, Personal Interview) stated that 4-H projects, training, and competitions held across the state [of North Dakota] prepare students for success at the college level and especially benefit those university students who enter fields where the hands-on experience obtained through 4-H can be applied to their field of study. University students who may have been more involved in FFA activities may not have the same hands-on agricultural experience. Involvement in local FFA chapters may be more of a leadership oriented experience. In the present study, 4-H and livestock showmanship experience (a hands-on animal agriculture activity) were the two agriculture background events that had a positive impact on academic success in ANSC 114. Further research is necessary to determine if this impact could extend to other courses in university or overall academic success.

### **Conclusion**

Through 4-H projects, assignments, and leadership training, students develop an overall greater sense of responsibility, which leads to success in the classroom, not only in understanding of theory, but also in performing practical work. The foundation for success in college agriculture courses could be the interaction and participation in organizations for youth that affiliate themselves with the industry. Further research is needed to investigate the effect of agriculture background to other coursework classes in the STEM related fields. We can conclude that students who participate in 4-H and Showmanship will obtain higher grades than other pre-



college entities. The proximity of the NDSU student demographics to agriculture production could account for the insignificant value of geographic background on the overall average.

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## **CHAPTER 5. SUMMARY**

### **Overview of Consumer Meat Perceptions Two to Three Generation Removed From the Farm**

Consumers purchase food (meat/beef) repeatedly because they like its palatability. Baby boomer, Generation Y (millennial), Generation Z (1995-2010) all enjoy cooking and experimenting with food combinations. Millennials have occupied the largest consumer demographic in the last 10 years and are credited with establishing the basis for food trends and marketing concepts from grocery stores to restaurants (Rosenbloom, 2018). Based on recent polls by Quartz.com (2017), millennials are on track to consume as much meat as their Baby Boomer predecessors. However, millennials remain concerned with living a healthy lifestyle and when they choose to not consume meat, they turn to other meat sources that they may perceive to be less impacted by modern production technology; such as wild game. Severson (2019) reported that after years of hunter decline, interest in hunting is on the rise. Those engaging in renewing the tradition of hunting are seeking a direct connection to what they eat and this growing group of hunting enthusiasts has been comprised of millennials and Generation Z demographics. Environmentally driven millennials know that hunting and eating wild-game is important for population control but also appreciate the fact that it is considered a locally sourced food that provides a high quality, essential protein source.

Consumers who purchase and eat meat are aware that it comes from animals, so indirectly they learn about animals and their products because of their growing interest in origins of food (the story behind their food). At a younger age, many future consumers learn about animal agriculture through programs like 4-H and FFA. Consumers live in the age of information so meat and (or) cooking education materials are now available on podcast, YouTube, Instagram,

and social media. Much of the information available to the public has been provided by the meat industry itself (Cooper, 2015) and may be considered marketing as much as it is considered education.

The growing interest in meat, cooking, and food has gained momentum from Gen X, Millennial, and Gen Y dependence on technology. Identification of technology that objectively classifies highly palatable meat makes the process of accessing meat education materials easier. Food apps using IOS and Android systems provide new educational avenues to give power of purchasing back to the consumer (Jansen, 2018). The computers that are literally within our grasp are changing the way we purchase meat based on consumer demand for meat that is tender, juicy, and flavorful (Sun, 2018).

Lastly, the demographic that once dominated the agriculture production industry is changing. As stated by Lucier (2019), “*Men are leaving animal agriculture, and more ranches being led by women,*” Further stating that the female gender is reclaiming the American west and they are using innovative techniques and technology while maintaining a conscience of the land and ecology (Lucier, 2019). The previous research support these ideals and progressive practices that span from consumption of wild game meats, use of computer vision systems to accurately identify and market high quality meat products, and in strong support of a growing demographic within the animal industry.

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## APPENDIX B. WILD-GAME PROCESSORS SURVEY

The Department of Animal Science; Meat Science, NDSU is interested in hearing from wild game meat processors who are processing, and/or providing a service to hunters to process their game. The evaluation is anonymous and will be used in a discussion section of a journal article on nutrition value and harvest of wild game in North Dakota. Please complete the survey below by July 30th, 2017.

1. Are you a wild game meat processor?

- Yes
- No

2. If yes, where is your operation located in North Dakota?

- Eastern
- Southern
- Northern
- West
- 

3. Are you an official state processing, state slaughter establishment or custom exempt for Beef, Pork, or Lamb species as well as wild game?

- Yes
- No

4. Check the species or animals which you process?



- Mule deer
- Elk
- Moose
- Pronghorn
- Bighorn sheep
- Whitetail deer

6. Is the predominate amounts of your processed wild game processed into sausage, adding other ingredients to enhance taste?

- Yes
- No

7. Do you in your professional opinion think wild game meat is under-estimated in its importance as a protein source?

- Yes
- No

**APPENDIX C. EVALUATION OF IMAGING PROCESSING TECHNOLOGY TO PREDICT OUTSTANDING BEEF FLAVOR: CONSUMER SENSORY SURVEY**

**Ballot Instructions and Demographic Information**

Please complete the demographic information below. After you have received your cooked steak sample we ask that you consume it as you would normally do and not share your thoughts with those around you, as you fill out this ballot. Please, remember to insert your Participant ID number in the appropriate blank. ATT: YOU MUST BE 18 YEARS OF AGE TO COMPLETE THIS SURVEY. Thank you again for participating in this consumer survey. REMINDER: ALL SURVEYS WILL REMAIN CONFIDENTIAL. Once you have completed the survey please place in the basket provided. This survey should only take 10-15 minutes of your time.

1. **YOUR PARTICIPANT NUMBER** \_\_\_\_\_

2. **GENDER**

MALE

FEMALE

3. **AGE**

\_\_\_\_\_

4. **HIGHEST LEVEL OF EDUCATION COMPLETED.**

Less than High School

High School

Trade School

Associates Degree

Bachelor's Degree

Master's Degree

PhD, EdD, MD, JD, DVM, or other professional degree

Other (Please Specify) \_\_\_\_\_

5. **ETHNICITY**

AFRICAN-AMERICAN  ASIAN PACIFIC/ISLANDER  HISPANIC/ LATINO

INTERRACIAL  NATIVE AMERICAN/ AMERICAN INDIAN  WHITE/ CAUCASION

OTHER (PLEASE SPECIFY) \_\_\_\_\_

**6. ANNUAL HOUSEHOLD INCOME. PLEASE ONLY CHOOSE ONE.**

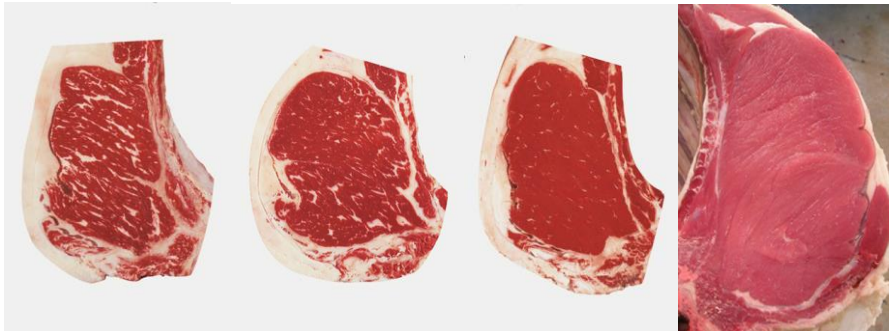
- LESS THAN \$10,000
- \$10,001-\$30,000
- \$30,001-\$50,000
- \$50,001-\$70,000
- \$70,001-\$90,000
- \$90,001-\$100,000
- \$100,001 OR MORE

**7. HOW OFTEN DO YOU CONSUME BEEF?**

CONSUMPTION OF BEEF  DAILY  WEEKLY  MONTHLY  YEARLY  NEVER

**8. WHICH GRADE OF BEEF DO YOU PREFER?**

- PRIME  CHOICE  SELECT  STANDARD  NO PREFERENCE



**PRIME      CHOICE      SELECT      STANDARD**

**SAMPLES AND RATINGS**

On this section of the ballot enter the three digit code for each of your steak samples in the boxes as the code is displayed on the label. Next, rate each sample based on tenderness, juiciness and flavor. After you have rated each sample please enter the code of the sample you prefer overall.

**9. REVIEW THE VISUAL APPRAISAL OF THE UN-COOKED STEAKS & PLEASE RATE EACH SAMPLE**

Like extremely, like very much, like slightly, like, Neutral, Dislike, dislike slightly, dislike very much, dislike extremely

STEAK A

STEAK B

STEAK C



**A.**



**B.**



**C.**

10. PLEASE ENTER THE CODE FOR STEAK #1 HERE. \_\_\_\_\_

11. RATE THE FIRST STEAK BASED UPON TENDERNESS, JUICINESS, TEXTURE, AND FLAVOR.

Like extremely, like very much, like slightly, like, Neutral, dislike, dislike slightly, dislike very much, dislike extremely

Tenderness

Juiciness

Flavor

Texture

12. PLEASE ENTER THE CODE FOR STEAK #2 HERE. \_\_\_\_\_

13. RATE THE SECOND SAMPLE BASED UPON TENDERNESS, JUICINESS, TEXTURE AND FLAVOR.

Like extremely like very much, like slightly, like, Neutral, dislike, dislike slightly, dislike very much, dislike extremely

Tenderness

Juiciness

Flavor

Texture

14. PLEASE ENTER THE CODE FOR STEAK #3 HERE. \_\_\_\_\_

15. RATE THE SECOND SAMPLE BASED UPON TENDERNESS, JUICINESS, TEXTURE AND FLAVOR.

Like extremely like very much, like slightly, like, Neutral, dislike, dislike slightly, dislike very much, dislike extremely

Tenderness

Juiciness

Flavor

Texture

16. PLEASE ENTER THE CODE FOR THE STEAK YOU PREFER OVERALL BASED ON YOUR RATINGS ABOVE. \_\_\_\_\_

17. COMMENTS:

Flavor-

Tenderness-

Juiciness-

Texture-

18. In your opinion does quality of meat purchased increases as income increases (ex. ground beef to whole muscle cuts, steaks)?

Yes  No  Maybe  Undecided

19. In your opinion do your meat selection/purchase for gatherings (picnic, grilling, parties, etc.) reflect your social-economic standing as a host?

Yes  No  Maybe  Undecided

IRB: #AG18155

## APPENDIX D. ANSC 114 FINAL TEACHING ASSESSMENT QUESTIONNAIRE

Unique Identifier: \_\_\_\_\_ (FIRST three letters of your last name followed by the LAST three digits of your student ID number. i.e. Sally Smith SID 765321 would have a unique identifier or SMI321)

Please circle the appropriate answer(s) and if you circle other, please add a description in the blank.

1. Gender:            Male                      Female
2. Year in School:            Freshmen                      Sophomore                      Junior                      Senior
3. Major: Animal Sciences    Ag Business/ Ag Econ    Ag Education    Ag Systems Management  
Biological Sciences    Crop and Weed    Equine Studies    General Ag    Vet Tech  
  
Other: \_\_\_\_\_
4. Ethnicity: Caucasian    Asian    African-American                      Hispanic    Other: \_\_\_\_\_
5. Geography of your hometown: Urban (over 10,000 people)    Small Towns (<10,000 people)  
Rural Area    Grew up on a farm
6. How many students were in your graduating class? \_\_\_\_\_
7. Cumulative GPA in High School based on a 4.0 Scale: 4.00 – 3.50    3.49 – 3.00    2.99 – 2.50  
2.49 – 2.00    1.99 – 1.50    Below 1.49
8. Did you take an agricultural related course in High School?            Yes                      No
9. In High School, were you involved in FFA?            Yes            No
10. In High School, were you involved in 4-H?            Yes            No
11. If Yes, in either questions 9 or 10, please state how many years you were involved in each organization. FFA \_\_\_\_\_ years    4-H \_\_\_\_\_ years
12. In High School, did you participate on a Judging Team?    Yes    No

13. If Yes, to question 12, what team did you participate on (circle all that apply):

Livestock Dairy Meats Crops Soils Land Other: \_\_\_\_\_

14. If Yes, to question 12, did you participate as a FFA or 4-H member? FFA 4-H

15. Did you grow up on a farm? Yes No

16. If Yes to question 15, which livestock specie(s) did your raise?

Beef Dairy Sheep Swine Goats Other: \_\_\_\_\_

No livestock, just crops

17. Did you show livestock growing up? Yes No

18. If Yes, to the previous question (17) please list which species and division were shown (ex.

Beef – Market Steers, Sheep – Breeding Ewes, Swine – Market Hogs etc.)

\_\_\_\_\_

19. How many hours per week did you work with your FFA/4H livestock project? \_\_\_\_\_

20. Was all or a portion of your immediate family's income derived from raising livestock?

Yes No

21. Have you taken Introduction to Animal Science 114? Yes No

22. Have you taken Livestock Production 220? Yes No

\*All responses are strictly confidential and will only be shared in the aggregate or anonymously.

**IRB: #AG16027**