Carcass and Growth Characteristics and Consumer Acceptance of Grain vs. Forage Finishing of Standard and Miniature Cattle of the Same Age

by

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Abstract

Crossbred standard cattle (STD, n=7) and crossbred miniature cattle (MINI, n=7) were raised on grain and forage finishing systems to determine the differences in growth performance, carcass characteristics, and retail yield performance. While on feed, cattle weights were collected approximately every 28 days. Once an average back fat of 0.76 cm was reached, as determined by real time ultrasound, cattle were humanely harvested. After chilling for 24 hours, carcass characteristics were evaluated. Consumers (n=196) from the southeastern United States were surveyed at an annual event, the Ag Roundup, at Auburn University, AL for preferences in beef. Consumers were presented with 7 packages of T-bone steaks (1 steak per package) that had information cards displaying five different attributes (portion size, grain- or grass-fed, price, traceability, and region of origin). They were asked to complete a written survey. Results indicate standard cattle finished on grain or forage diets had greater growth performance, carcass characteristics, and retail yield performance when compared to miniature cattle raised under the same conditions. Similarly, cattle finished on grain diets had greater growth performance and carcass characteristics than those finished on forage diets. The results of the consumer portion demonstrate that the majority of consumers do not prefer to purchase beef steaks from miniature cattle versus standard cattle of the same age finished on both grain and forage resources. However, most

participants believe it is important to limit the size of steak they eat, and were not opposed to consuming small sized beef steaks from miniature cattle.

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List of Abbreviations

STD	Standard cattle
MINI	Miniature cattle
FOR	Forage-fed cattle
GRAIN	Grain-fed cattle
USDA	United States Department of Agriculture
FSIS	Food Safety Inspection Service
FDA	Food and Drug Administration
COOL	Country of origin labeling
LMA	Longissimus muscle area
YG	Yield grade
QG	Quality grade
HCW	Hot carcass weight
KPH	Kidney pelvic and heart fat
WBS	Warner-Bratzler shear force

Chapter 1
Introduction

In order to accommodate the changing U.S. food market, today's beef industry has begun investigating alternative methods of beef production to meet consumer demands for greater variety in product offerings. As consumers are exposed to beef products with a greater variety of features or attributes they prefer, they will be willing to pay more for those characteristics (Mennecke et al., 2007). The challenge is creating niche, or specialty products, that meet consumer preferences for various product attributes without decreasing growth performance or carcass characteristics.

Previous research has investigated the effect of frame size, as well as finishing systems on growth performance of cattle (Klosterman and Parker, 1976; Maino et al., 1981; Bidner et al., 1981; Roberts et al., 2009). However, no ideal combination of size and diet has been determined for beef cattle performance. Size and diet of beef cattle can not only affect growth performance, but also influence differences in carcass characteristics (Baggett IV et al., 2004; Maino et al., 1981; Kerth et al., 2007; Garmyn et al., 2010). However, there is a market requirement for beef from many types of cattle. Therefore, it may be necessary to develop several types, each adapted to certain economic or biological situations (Kidwell and McCormick, 1956).

Past studies have demonstrated that there is an opportunity for alternative beef production systems, and by marketing the resulting products, it may be possible to

capture the share of consumers that indicate a preference for certain attributes (Goss et al., 2002; Cox et al., 2006; Umberger et al., 2009).

The purpose of this study was to investigate growth performance and carcass characteristics of miniature and standard cattle of the same age, when finished on both forage and grain resources, along with determining if there is potential consumer desirability for beef from miniature cattle.

Chapter 2
Review of Literature

Niche Market Beef Products

The U.S. food market is transforming from a mass market to many niche, or specialty markets, placing new production and marketing demands on farmers and food companies (Barkema et al., 1991). Niche markets are defined as markets that provide unique commodities to a smaller sector of the general market (Fox et al., 2008). Consumer demand for niche, or specialty, products has created development of beef products, such as grass-fed, organic, natural, and local beef as alternatives to conventional beef.

Conventional Beef

Conventional beef, also commonly referred to as grain-fed, can be defined as beef from cattle raised in pastures for the majority of their lives, approximately 12-18 months, and then fed a grain-based diet for 120 to 200 days prior to harvest (Acevedo et al., 2006). According to the USDA, feedstuffs that are acceptable to be included in a diet as grain includes barley, canola, corn, flaxseed, mixed grain, oats, rye, sorghum, soybeans, sunflower seed, triticale, and wheat. Other feedstuffs that are acceptable are rice, millet, amaranth, buckwheat, and distiller's grain (with or without solubles) (USDA-AMS, 2008). In conventionally raised cattle, hormones and antibiotics may be used to increase live animal performance. The usage of hormones and antibiotics is regulated by the USDA. Growth implants can improve rate of gain by 15 to 20% and feed efficiency by 8

to 20% (Melroe & Loe, 2007). Antibiotics are used in conventional beef production for prevention of illness and therapy, as well as growth promotion due to depressed performance and feed intake of sick animals (Melroe & Loe, 2007). Conventional cattle producers also use technologies such as commercial fertilizers and man-made herbicides and parasite control (Acevedo et al., 2006). Overall, a conventional grain-based finishing diet is utilized to increase the marbling, tenderness and consistency of the final beef product (Acevedo et al., 2006), and is proven safe for human consumption (Melroe & Loe, 2007).

Forage-fed Beef

Forage-fed beef is derived from cattle that consume grass and forage for the lifetime of the animal, with the exception of milk consumed prior to weaning (USDA-AMS, 2008). Cattle produced in forage-finishing systems may also be referred to as grass-finished, grass-fed, or forage-fed. Forage-fed cattle are not fed grain or any grain or animal by-products (Pirog, 2004). Cattle must have continuous access to pasture during the growing season, and may be supplemented with hay, haylage, baleage, silage, crop residue without grain, or other roughage sources. Vitamin and mineral supplementation may also be included in the feeding program (USDA-AMS, 2008). If cattle are unintentionally exposed to non-forage feedstuffs, the producer must fully document the amount, frequency, and what supplements were provided (USDA-AMS, 2008). Hormone and antibiotic administration is allowed for forage-fed cattle, however forage-fed beef can also be classified as natural or organic, depending on the production practices utilized (McCluskey et al., 2005), and additional labeling claims can be made, such as free-range, no antibiotics or hormones, etc. (United States Standards for

Livestock and Meat Marketing Claims, 2007). A disadvantage of forage-fed beef production is that animals raised entirely on grass mature more slowly, have a longer production time, and a lower carcass weight at slaughter (Acevedo et al., 2006). However, increased interest in forage-fed beef could provide an additional market for beef producers to meet the demands of changing consumer preferences.

Natural Beef

Many consumers are looking for products that are produced "naturally" (Fox et al., 2008) due to concern about potential antibiotic residues or hormones in their foods (Sofos, 2008). According to the USDA, all products that are "naturally raised" must meet the following conditions: 1) no growth promotants were administered to the animals; 2) no antibiotics (other than ionophores used to prevent parasitism) were administered to the animal; and 3) no animal by-products were fed to the animals (USDA-AMS, 2009). In order for a product to be labeled natural, it must contain no artificial ingredients or added colors and is only minimally processed. Also, the label must include a statement explaining the meaning of the term natural (such as "no artificial ingredients; minimally processed") (USDA-FSIS, 2011). Therefore, all meat that does not have an ingredient label is assumed to be natural (Acevedo et al., 2006), which is not the same as making the statement "naturally raised". Scientists at the World Health Organization and FDA have concluded that residues from hormones, when properly administered in both dose and method, pose no threat to human health (Kenney & Fallert, 1989). Altering U.S. beef production to yield hormone-free beef would increase costs for producers (Lusk & Fox, 2000). However, "certified natural" cattle

have received premiums depending on the location, quality, and quantity, which can offset the losses in productivity associated with natural beef production (Troxel, 2005).

Organic Beef

Organic food differs from conventionally produced food in the way that it is grown, handled, and processed (Troxel, 2005). The USDA, however, makes no claims that organically produced food is safer or more nutritious than conventionally produced food (Troxel, 2005). The USDA organic seal verifies that producers met animal health and welfare standards, did not use growth hormones or antibiotics, used 100% organic feed, and provided animals with access to the outdoors (USDA-AMS, 2011). The National Organic Program regulates all organic products certified to the USDA organic standards through organic certification agencies that inspect and verify that organic producers, distributors, processors, and traders are complying with regulations (USDA-AMS, 2011). Retail sales of natural and organic meats and poultry are the fastest growing segment of the $10.4 billion organic food industry, with 77.8% growth between 2002 and 2003 (Organic Trade Association, 2004). However, organic beef costs 39% more to produce compared to conventional cattle due to reduced animal performance and increased cost of organic feedstuffs (Fernández & Woodward, 1999).

Local Beef

The concept of local food describes local food systems or short food supply chains, in which food is produced near the consumer (Roininen et al., 2006). Locally grown food is gaining popularity, along with a dramatic increase of farmers markets in the United States (Darby et al., 2008). Leading natural foods retailers such as Whole Foods and Wild Oats also market locally grown products to consumers (Darby et al.,

2008). Marketing products directly in local markets provides an opportunity for farmers to capture a great share of consumers' food budgets and better stimulate local economies (Darby et al., 2008). State-funded programs aimed at promoting agricultural products within the state are also gaining attention because they protect local producers from interstate competition by capitalizing on consumers' loyalty to their state of residence (Jekanowski et al., 2000). The niche market of locally grown meat products may encompass 15-20% of consumers, which could be served through development of verification systems (Maynard et al., 2003). Country of origin labeling (COOL) is an example of a verification system that provides consumers with information of where their products are produced. The COOL law requires retailers to notify their customers of the country of origin for all commodities covered under this law (USDA-FSIS, 2010). Research has shown that consumers may be willing to pay a premium for additional information on food labels, such as COOL (Umberger et al., 2003; Loureiro & Umberger, 2007).

Overall, niche market beef products are a way producers can meet consumer demands for specialized products. Though each type of niche beef product differs in its definition and standards, consumers may be willing to pay a premium for specific products based on the attributes they prefer.

Growth Performance

There has been a continuous search for the ideal beef animal. Research has focused on a variety of size of cattle from large frame to smaller frame, early maturing cattle that would finish at young ages on high roughage diets (Klosterman, 1972; Block et

al, 2001; Arango and Vleck, 2002). A high percentage of slaughter cattle are finished on high concentrate diets in feedlots, with an increasing cattle size (Klosterman, 1972). Today, packers discount carcasses that exceed hot carcass weights of 454 kg, in result from the trend of larger cattle and the reluctance for industry to accept them (Garcia et al., 2008). Forage-fed animals have been shown to have lower average daily gain and require more days on feed than grain-fed animals. However, there is a possible advantage of smaller framed cattle on grazing systems (Maino et al., 1981), suggesting that a combination of frame size and diet could create a market for alternative beef production systems.

Frame Size

Body size variability within breeds of cattle suggests there are no definite differences in efficiency related to size, that there is a biological or economic niche for each size, and that size preferences are in continuous disequilibrium due to cyclic production conditions (Cartwright, 1979). Optimal size of cattle depends on the production system. Selection has emphasized growth, favoring leaner and faster growing cattle that may not necessarily be valuable (Arango and Vleck, 2002). Numerous reports have shown a high correlation between rate of gain and efficiency of gain. Rate of gain is also positively related to mature size, increasing cattle size when selecting for rate of gain (Klosterman, 1972).

Most of the research on frame size is from the mid 1900's. According to Klosterman and Parker (1976), early maturing small frame cattle fed low energy diets outperform large frame cattle because small cattle consume more feed per unit of body weight. In 1981, Maino et al. conducted a study to evaluate the postweaning growth

characteristics of various frame size steers on forage systems. They found little advantage in average daily gain for larger cattle over smaller cattle. These results suggested the absence of a gain advantage for the larger framed cattle, along with their higher initial weight, would indicate a lower feed efficiency. This, along with a greater initial cost, suggested an advantage for smaller-framed cattle on grazing systems when gain potential is restrictive (Maino et al., 1981). Woodward et al. (1942) compared large frame and small frame Hereford steers and found that large frame steers gained faster and used less feed per pound of gain. Washburn et al. (1948) found conventional type Shorthorn steers gained faster than compact type Shorthorns, but required more time to reach an equivalent finish. Similarly, Thonney et al. (1981) found at the same weight, Holstein cattle grew faster than and more efficiently than small framed Angus cattle. In 1985, McCarthy et al. found that feed efficiency was not different between frame sizes, but small frame cattle had higher energetic efficiency due to difference in composition of gain and body composition between small and large frame cattle. Small cattle deposit proportionally more fat than protein when compared with large cattle (Garrett, 1980).

A very high proportion of the total feed going into the beef enterprise is required for maintenance, and the larger an animal becomes, the greater the maintenance needs of that animal (Klosterman, 1972). Also, as cattle approach mature weight, energy required per unit of gain increases, therefore the energy cost of muscle gain is less than the energy cost of fat gain (Thonney et al., 1981). There is a market requirement for beef from many types of cattle, therefore it may be necessary to develop several types, each adapted to certain economic or biological situation (Kidwell and McCormick, 1956).

Grain-fed versus Forage-fed

Consumer interest in forage-finished beef has created demand for further development of forage-based production systems. However, past research has found problems associated with the use of forage compared to the use of concentrates as a primary feed source for cattle (Roberts et al., 2009). Decreased average daily gain and longer finishing periods to reach a target end point have been reported for forage-finished cattle (Bidner et al., 1981, 1986). Due to the high costs of production and the increased demand for cereals for human consumption, the future availability of feed grains for cattle production is uncertain. However, beef cattle are excellent converters of forages to high quality meat, creating an opportunity to use feedstuffs not suitable for production in monogastric animals (Bidner et al., 1981).

In 1981, Bidner et al. piloted a study to compare animal performance of steers finished to similar live weights on forage or high energy diets. The study used Angus and Hereford-Angus steers (n=56) that were split into four treatments: Forage-only (A), forage-plus-grain (B), forage-plus-grain-feedlot 70 days (C), and forage-feedlot 74 days (D). They were fed until reaching an average weight of 476 kg. They found grain-fed steers gained faster over the total treatment period than steers finished on only pasture. Forage-fed steers were 160 days older at slaughter than grain-fed groups (Bidner et al., 1981). According to Martin and Rogers (2004), concentrate-fed animals grow at a faster rate because of higher energy intake, therefore forage-fed cattle take longer to finish and are usually older at harvest. Roberts et al. (2009) conducted a study to determine the effect of adding different amounts of grain to pasture diets on animal performance of finishing steers. Crossbred steers (n=72) were randomly assigned to one of six finishing

diets consisting of ryegrass pasture plus corn supplemented at either 0%, 0.5%, 1.0%, 1.5%, 2.0% of body weight on an as-fed basis, or drylot ad libitum concentrate diet. Results of the experiment indicated increasing the amount of grain in the diet decreased the number of days on feed, and increased average daily gain (Roberts et al., 2009). Similar results have been reported by Thonney et al. (1981), Tatum et al. (1988), and Berthiaume et al. (2006).

These studies show that there is no ideal size and diet for beef cattle performance. Tatum et al. (1988) determined diet and frame size can interact to affect growth rate of cattle. The authors reported differences in daily gain among large, medium, and small steers were most noticeable among cattle finished on the grain diet, but became smaller in magnitude as energy density of the diet decreased. Small steers required shorter feeding periods than large framed steers, despite their disadvantage in growth rate (Tatum et al., 1988). Further research is needed to determine the potential of combining different production systems with different cattle breeds/sizes that can create the opportunity for producers to develop profitable alternative products.

Carcass Characteristics

Beef carcass characteristics can be affected by differences in frame size and diet of cattle. Cattle frame size has been shown to have an effect on hot carcass weight, ribeye area, and kidney pelvic heart fat percentage. Diet type has a significant effect on carcass characteristics, such as hot carcass weight, ribeye area, backfat thickness, kidney pelvic heart fat percentage, muscle pH and color.

Frame Size

Frame size is a cattle characteristic related to mature size, with the implication that large-framed cattle will reach a specified level of fatness at heavier weights than small framed cattle (Block et al., 2001). An emphasis on leanness has led to increased use of large-framed cattle producing larger carcasses with less fat (Bertrand, 1980). Maino et al. (1981) found that larger frame cattle tend to have heavier carcass weights, larger ribeye area, less fat thickness, and less kidney pelvic heart fat percentage, along with lower yield and quality grades than smaller frame cattle. An absence of gain advantage for large frame cattle, along with higher initial weight and possibly greater purchase price, suggests an advantage for smaller framed cattle on grazing systems when gain potential is restricted (Maino et al., 1981). The 2005 National Beef Quality Audit concluded as hot carcass weight increased, numerical yield grade, adjusted fat thickness, marbling score, quality grade, and ribeye area increased (Garcia et al., 2008). However, Camfield et al. (1997) found large-framed, slow maturing steers had lower quality grades and marbling scores and heavier hot carcass weights than intermediate-frame slow-maturing steers. And, May et al. (1992) found when comparing carcasses of differing frame sizes, the most notable difference was the slight increase in percentage of fat trim occfuring as frame size decreased.

In 2004, Baggett IV et al. conducted a study to assess performance and net return differences of feeder cattle through the stocker, feeding, and combined stocker-feeding stages for different frame sizes and muscling scores of feeder cattle. They found large frame cattle had higher hot carcass weights, and small frame cattle had lower carcass weights compared to medium frame cattle. Small frame cattle also had a smaller ribeye

area than medium frame cattle, but there was no difference between medium and large frame cattle. There was no difference in fat thickness between small and medium frame cattle, but medium frame cattle had a greater fat thickness than large frame cattle. They found no effect of frame size of kidney pelvic heart fat percentage. When combined, frame size did not significantly affect USDA yield grade, but it did have an effect on three of the four components that make up the composite yield grade. When adding economics to the physiological differences in cattle, net returns may not be higher for large frame cattle compared with small and medium frame cattle (Baggett IV et al., 2004).

Grain-fed versus Forage-fed

Many geographical regions of the U.S. are capable of producing forage for grazing cattle exclusively and create the opportunity for profitable beef production. However, packers have discriminated against cattle that were primarily finished on forage (Martin and Rogers, 2004). Finishing diet type has an effect on carcass characteristics (Garmyn et al., 2010). Forage diets have been shown to affect carcass characteristics, such as hot carcass weight, ribeye area, backfat thickness, kidney pelvic heart fat percentage, muscle pH and color. Previous research shows hot carcass weight, backfat thickness, and kidney pelvic heart fat percentage is greater for cattle that are fed grain-based diets over cattle fed forage-based diets (Bowling et al., 1977; Mandell et al., 1998; Berthiaume et al., 2006; Moloney et al., 2008; Garmyn et al., 2010).

In 2007, Kerth et al. evaluated carcass, sensory, and consumer characteristics of Angus-cross steers finished on ryegrass alone, on grain for the last 94 days after grazing ryegrass, or on grain alone. They reported hot carcass weight of cattle finished on a

ryegrass/grain diet was higher than either ryegrass or grain finished cattle. Hot carcass weights of ryegrass finished cattle were the lowest. Steers finished on grain or ryegrass/grain diets had higher actual fat thickness, adjusted fat thickness, longissimus muscle area, kidney pelvic heart fat percentage, and USDA yield grade compared to steers finished on ryegrass. Yellowness (b*) values of subcutaneous fat were lowest in cuts taken from steers finished on grain compared to cuts from ryegrass/grain or ryegrass fed steers. Overall, they concluded cattle finished on ryegrass produced smaller carcasses with less fat and fat that was more yellow in color (Kerth et al., 2007).

Traditionally, meat with yellow fat and dark lean has been considered a lesser quality product at the retail level (Bowling et al., 1977) because consumers are accustomed to bright, cherry red lean and whiter fat associate with grain-fed beef (Martin and Rogers, 2004). Meat color is affected by muscle pH (Hoffman, 1988). Muscle pH affects muscle color by altering hue (red, yellow, green, blue, or an intermediate). Lower muscle pH is associated with beef that is redder and more yellow, whereas higher muscle pH is associated with beef that is greener and more blue (Page et al., 2001). Muir et al. (1988) and Nuernberg et al. (2002) found that forage-fed cattle had greater ultimate pH values than grain-fed cattle. At a higher muscle pH, water is bound tightly with proteins, resulting in less free water to reflect light. Therefore, muscle from forage-fed cattle will appear darker than that of grain-fed cattle (Ledward et al., 1992). Fat color is largely dependent on carotenoid content, which is derived from plants. Green, fresh pastures usually contain high quantities of carotenoids, whereas most grains contain lesser concentrations of carotenoids (Tume and Yang, 1996). In 2004, Realini et al. compared carcass characteristics of cattle finished on a forage- or concentrate- based diet and found

the longissimus muscle of animals finished on pasture had lower L* values (lightness), indicating a darker colored lean than animals on a concentrate diet. Cattle finished on pasture also had greater subcutaneous fat b* values (yellowness), indicating a more yellow fat than that of concentrate-finished cattle (Realini et al., 2004). Cattle fed concentrate diets produce greater a* (redness) values cattle fed forage diets (Warren et al., 2008).

Previous research has shown cattle frame size and diet affect beef carcass characteristics, but little research has shown the interactions and comparison of these two factors. Therefore, further research is needed to determine the effects of frame size and diet on beef carcass characteristics.

Consumer Preference in Beef

Every year, approximately 67 pounds of beef is consumed per person in the United States (Davis and Lin, 2005). Even though beef is a highly consumed meat, consumer preferences have been changing throughout the past 25 years. These changes have played a major role in decreasing beef demand. In order to increase beef consumption, industry has looked to product differentiation in quality, consistency, and convenience to attract consumers. This has created a need for alternative production systems and marketing methods within the beef industry (Goss et al., 2002). Consumer beef purchasing decisions are driven by tenderness, juiciness, flavor, and price-point (Martin and Rogers, 2004). However, today's consumers are becoming more concerned with the environment, food safety, and health and nutrition.

Portion Size

Since the 1970s, portion sizes have been increasing in the United States (Ello-Martin et al., 2005). According to USDA's My Plate, daily recommendations for the proteins food group, which includes meat, poultry, seafood, beans and peas, eggs, processed soy products, nuts, and seeds, for males and females between the ages of 9 and >51 is approximately 5 to 6.5 ounces. In 2002, Young and Nestle found, except for sliced white bread, all commonly available food portions measured in their study exceeded USDA standard portions, with steaks exceeding food portion size by 224%. The larger portion size trend has occurred along with increases in dietary intake of energy and the prevalence of overweight and obesity (Young and Nestle, 2002). People who are overweight and obese are at higher risk of developing diabetes, heart disease, stroke, and cancer (Thorpe et al., 2004). By offering a wider range of portion sizes or promoting sensible portion sizes, food providers could improve the effect of portion size on food intake (Ello-Martin et al., 2005).

The 2005 National Beef Quality Audit reported a broad range of 45 to 158 cm^2 for longissimus muscle area (LMA) in over 9000 beef carcasses across the United States (Garcia et al., 2008). This wide variation could be attributed to differences in carcass weight, sex class, breed, genetic differences within breed, implant protocol, and feeding and management strategies (Sweeter et al., 2005). The range in LMA could be utilized to promote reasonable portion sizes for consumers. Garcia et al. (2008) found as USDA yield grade (YG) increased, marbling, quality grade (QG), adjusted fat thickness, hot carcass weight (HCW), and kidney pelvic and heart fat (KPH) percentage also increased, whereas LMA decreased. McKenna et al. (2002) reported USDA yield and quality

grades were higher for smaller LMA. These studies indicate that producing animals with smaller LMA will not necessarily decrease meat quality, but may increase cutability and marbling scores. Both 2000 and 2005 National Beef Quality Audits indicated as HCW increased, LMA increased (McKenna et al., 2002; Garcia et al., 2008). However, it is common for beef packers to discount carcasses if they exceed 454 kg HCW (Garcia et al., 2008). Therefore, by producing animals with smaller LMA, carcass weights could be more acceptable to industry, resulting in application of fewer discounts.

In 2000, Dunn et al. determined carcasses with LMA between 77 to 97 cm^2 yield foodservice-portioned steaks with optimal tenderness and cooking times. However, according to Davis and Lin (2005), almost 65% of beef was purchased at retail stores for home use. In 2005, Sweeter et al. conducted a two phase study to determine the optimum beef LMA for retail consumers in Brookings, South Dakota. In Phase I of the study, they utilized ribeye steaks from five LM categories ranging from 61 to 119 cm^2 for a retail case study at a grocery store. The steaks were monitored to determine the time each steak remained in the retail case. They found time in the case and the percentage of steaks pulled did not differ among the five LMA categories. Male consumers tended to purchase steaks with a larger LMA than female consumers, but the difference was not significant, and consumers in the age category of 30 to 45 also purchased steaks with a larger LMA than all other age groups. There was no difference of steak LMA size purchased between consumers of other age groups, indicating a possible consumer for every LMA category (Sweeter et al., 2005). In Phase II of the 2005 Sweeter et al. study, three categories of ribeye steaks were used in a consumer auction: Average (80 to 90 cm^2), Large (105 to 119 cm^2), and Half (Large category steaks that were cut in half). Of

the auction participants, 58% were female. All income and age categories were represented, with the most common household size being two people. They found consumers were willing to pay $1.50/kg more for steaks from the large category over steaks from the average category, and consumers discounted ribeyes from the half category by $1.01/kg compared to steaks from the average category. Overall, no optimum LMA was determined for beef retail consumers, though there was a trend toward preference for larger LMA over smaller LMA. Age, gender, income, and household size had no effect on the premium paid for steaks with larger LMA or the discount paid for steaks that were cut in half (Sweeter et al., 2005). The trend for larger LMA relates to the increase in food portion sizes throughout the U.S. However, no optimum LMA has been determined, suggesting a possible market exists for production of animals with smaller LMA, which could promote reasonable portion sizes.

In 2011, Leick et al. conducted a study to determine consumer acceptance of ribeye, top loin and top sirloin steaks from varying hot carcass weights when cut to a constant steak weight, and to determine carcass selection criteria based on LMA and HCW to achieve optimum consumer acceptance of ribeye, top loin, and top sirloin steaks. Steaks represented five weight/loin muscle area groups: group 1, 226 to 271 kg/70.9-78.1 cm^2; group 2, 272 to 316 kg/78.7-85.8 cm^2; group 3, 317 to 361 kg/86.5-93.5 cm^2; group 4, 362 to 407 kg/94.2-101.3 cm^2; group 5, 408 to452/101.9-109.3 cm^2. Consumers were randomly selected on two different days prior to college football games in the Starkville, Mississippi area. Over two-thirds of the participants were male, and the greatest percentage of consumers represented the <$20,000 and $60,000+ income categories. Consumers were asked to rank “marbling”, “color”, “thickness”, “texture”,

and other in order of importance to the selection of that steak. The greatest percentage of consumers selected ribeye steaks from group 5 that were 408-453 kg and 102-109 cm^2 and the least from group 1 that were 227-272 kg and 71-79 cm^2. The <$20,000 income category most frequently chose steaks from group 4 and group 5, and consumers from the $30,000-$39,000 income group most frequently chose steaks from group 5. Male and female consumers chose steaks from group 4 and group five most often, though results were not different for females. Across all age groups, consumers chose ribeye steaks from group 5 most often. Overall, consumers tended to choose the thinnest ribeye steaks in group 5 that appeared to have greater surface area over thicker ribeye steaks in group 1 even though they were told the steaks weighed the same. There were no differences in hot carcass weight/loin muscle area groups for percentage of sirloin and top loin steaks chosen by consumers (Leick et al., 2011). Thickness was found to be an important factor in consumer selection of sirloin, top loin, and ribeye steaks. However, not all consumers' thickness preferences are the same. Therefore, the study suggests that there is a potential market for all sizes and types of ribeye, sirloin, and top loin steaks (Leick et al., 2011).

Previous research has shown there has been an increase in portion sizes in food, along with a potential preference for larger sizes of beef steaks. However, the findings from these studies are not representative of a larger population with diverse demographics. This creates a need for promotion of smaller, sensible portion sizes of beef that may not be highly represented in the beef industry. Further research is necessary to conclude if there is a potential market for smaller beef cuts to generate more reasonable beef portion sizes for consumers.

Grain-fed versus forage-fed

Cattle are typically raised on a grass or grass/legume pasture during the first few months of their lives. Once cattle reach a certain weight, they are transported to feedlots where they consume a high energy, grain-based diet to achieve market weight (Pirog, 2004). Cattle finished in this type of production system are referred to as grain-fed or grain-finished. Some consumers, however, believe that there could be benefits associated with forage-finished beef, regarding health, environment, and animal welfare (McCluskey et al., 2005).

In 2006, Cox et al. conducted a study to determine consumer acceptance of forage-finished and grain-finished beef in the southeastern United States and to determine the value consumers associate with forage-finished beef. They collected steaks from cattle (n =26) finished on either a grain or forage diet. The steaks were then used in a retail consumer survey in which participants from nine supermarket locations tasted cooked samples and evaluated them for flavor, overall palatability, and price they would be willing to pay per pound. Steaks were also used in a take-home survey, in which participants from the nine locations were allowed to take home uncooked samples and prepare them according to their preference. Participants from the take home survey evaluated the steaks for flavor, overall palatability, and price they would be willing to pay per pound. Take-home participants were also asked the method of preparation, the degree of doneness, and the most important factor in the eating experience in beef. Consumers from the retail study rated grain-fed beef higher for flavor, overall palatability, and price compared to forage-fed beef, while consumers in the take-home study had no difference in ratings. Approximately 34% of consumers from the retail

study preferred forage-fed beef to grain-fed beef and were willing to pay $2.38/kg more for forage-fed beef. Consumers from the take-home survey had no preference for forage-fed or grain-fed beef; however the consumers that preferred forage-fed beef were willing to pay $5.61/kg more for forage-fed beef than grain-fed beef. From this survey, the researchers concluded one-third of the consumers preferred the taste of forage-finished beef and were willing to pay a premium (Cox et al., 2006).

From 1982 to 1998, beef demand declined as a result of health information linking cholesterol and heart disease to red meat consumption (Goss et al., 2002). Specialty products such as grass-fed beef may appeal to consumers due perceived health benefits associated with those products (McCluskey et al., 2005). In 2009, Umberger et al. examined product attributes and consumer characteristics that may be predictors of consumer preferences and willingness to pay premiums for grass-finished versus grain-finished beef. They recruited consumers (n = 225) to participate in a six round experimental auction, in which the consumers bid for one grass-finished steak and one grain finished steak after evaluating and receiving different information about the steaks. In the first two rounds, participants tasted the steaks before bidding on the product. In round three, participants visually evaluated the steaks, but did not taste them or receive any information about the steaks. In round four, participants were given information about the different production methods for each steak, and in round five, they were given information about the steaks. Finally, in round six, participants were presented with production and health information, and were allowed to taste the steaks before bidding. The results of the study determined information related to the production processes increased the likelihood that consumers would be willing to pay premiums for grass-fed

beef, but that health information is an even more important factor in consumers' inclination to pay premiums for grass-fed beef.

McCluskey et al. (2005) found similar results in a study that evaluated marketing health benefits of U.S. grass-fed beef. They found participants in the study tended to prefer U.S. grass-fed beef and were willing to pay a premium. Natural beef is a niche market beef product that can be related to studies involving grass-fed beef, in which consumers are given a choice between a niche market beef product and a conventional beef product. Goss et al. (2002) conducted a survey concerning factors that influence consumer decisions related to natural beef in the southern plains. The study suggested the likelihood of consumers purchasing a specialty beef product could increase when provided with more product information. They concluded beef consumers can be categorized into three groups: those who will always choose natural beef over conventional beef even with a high price differential, those who would buy natural beef but will buy conventional beef if prices are too high, and those who will purchase conventional beef over natural beef if any price difference exists.

These studies demonstrate that there is an opportunity for alternative beef production systems. It may be possible to market alternative beef products to capture the share of consumers indicating a preference in those products and convince other consumers that do not (Goss et al., 2002). Further research regarding consumer preferences in beef is needed to effectively market forage-fed beef and provide alternative production methods to beef cattle producers.

The objectives of this study were to compare growth performance characteristics and efficiency of miniature cattle with standard cattle of the same sex on both forage and

grain resources, compare carcass characteristics of miniature cattle, including quality, yield grade, and tenderness, as well as retail cut-out values, with standard cattle, and determine consumer desirability for beef from miniature cattle.

Chapter 3

Carcass and Growth Characteristics of Grain vs. Forage Finishing of Standard and Miniature Cattle of the Same Age

Abstract

Crossbred standard cattle (STD, n=7) and crossbred miniature cattle (MINI, n=7) were raised on two different finishing systems to determine the differences in growth performance, carcass characteristics, and retail yield performance. Cattle were allotted to a ryegrass forage (FOR, n=8) diet or a diet consisting of 77% grain, 23% sorghum sudan (GRAIN, n=6) until an average back fat of approximately 0.76 cm was reached. While on feed, cattle weights were collected approximately every 28 days. In this study STD consumed a greater amount of dry matter than MINI from November 22, 2010 to January 25, 2011, however STD GRAIN, MINI GRAIN, and MINI FOR had similar gain to feed ratios during that time period (0.14 ± 0.01, 0.12 ± 0.06, 0.15 ± 0.08, respectively). STD FOR had the lowest gain to feed ratio of all treatments (0.07 ± 0.02).The final weight, total gain, and total average daily gain was greater for STD compared to MINI ($P < 0.0001$). GRAIN had a higher final weight, total gain, and total average daily gain than FOR ($P=0.0341$, $P=0.0053$, and $P=0.0053$, respectively). Once an average back fat of 0.76 cm was reached, as determined by real time ultrasound, cattle were humanely harvested. After chilling for 24 hours, carcass characteristics were evaluated. As expected, hot carcass weight ($P<0.0001$), adjusted back fat ($P=0.0705$) and ribeye area ($P<0.0001$) were greater for STD than MINI. In addition, dressing percentage, L*, and

b* were greater for STD than MINI (P=0.0301, P=0.0375, and P=0.0019, respectively). Adjusted back fat, kidney pelvic heart fat, yield grade, quality grade, and marbling values were higher for GRAIN than that of FOR (P=0.0036, P=0.0007, P=0.0006, P=0.0135, and P=0.0030, respectively). For Warner Bratzler shear force values, MINI was greater than STD (4.45 and 3.22, respectively). As expected, retail yield values were affected by size. STD yielded a greater number of each cut and a greater weight of each cut than MINI. No differences were found for number of cuts (P>0.1066) weights of cuts (P>0.2534) between GRAIN and FOR. These results indicate standard cattle finished on grain or forage diets had greater growth performance, carcass characteristics, and retail yield performance when compared to miniature cattle raised under the same conditions. Similarly, cattle finished on grain diets had greater growth performance and carcass characteristics than those finished on forage diets.

Introduction

Today's food market in the United States is transforming from conventionally produced products to include many niche, or specialty markets. Consumer demand for specialty products has led to development of alternative food products, such as grass-fed, organic, natural, and local beef. Though each type of niche beef product differs in its definition and standards, these products are a way producers can meet consumer demand. Also, consumers may be willing to pay a premium for specific products based on the attributes they prefer (Sweeter et al., 2005; Cox et al., 2006).

Miniature cattle production is a specialized niche market that is gaining popularity in the United States; however, there is no current scientific literature on growth or carcass performance of miniature cattle. Previous research has found no ideal combination of size and diet for beef cattle performance (Klosterman and Parker, 1976; Tatum et al., 1988).

Body size variability within breeds of cattle suggests there are no definite differences in efficiency based on size, and that there is a biological or economic niche for each size of beef cattle (Cartwright, 1979). Therefore, optimal size of cattle depends on production system. Beef cattle are able to convert forages to high quality meat, creating an opportunity to use feedstuffs not suitable for production in monogastric animals (Bidner et al., 1981). Consumer demand has also led to further development of forage-based beef production systems, however past research has found problems related to forage being utilized as a primary feed source for cattle in comparison to concentrates (Roberts et al., 2009). Beef carcass characteristics can be affected by differences in frame size and diet of cattle (Maino et al., 1981; Berthiaume et al., 2006), but little research has shown the interactions and comparison of these two factors. However, previous research has alluded to a possible advantage for smaller framed cattle on grazing systems (Maino et al., 1981; Baggett IV et al., 2004). This suggests that a combination of size and diet could create marketable alternative beef production systems, such as miniature cattle production.

The objectives of this study were to compare growth performance characteristics and efficiency of miniature cattle with standard cattle of the same sex on both forage and

grain resources, and to compare carcass characteristics of miniature cattle, including quality, yield grade, and tenderness, as well as retail cut-out values, with standard cattle.

Materials and Methods

Animals

Crossbred standard cattle (n=7; 3 steers, 4 heifers) with initial weights of approximately 222 kg to 267 kg born January through February 2010 with 18.75% Brahman influence were acquired from Salacoa Valley Farms in Fairmount, GA, and crossbred miniature cattle (n=7; 3 steers 4 heifers) with initial weights of approximately 59 kg to 121 kg born March through May 2010 with 12.5% Brahman influence were acquired from the Auburn University College of Veterinary Medicine foundation herd. Cattle were housed at the Auburn University Beef Cattle Evaluation Center (PRN:2010-1802). Animals were placed on test November 22, 2010. Standard cattle (n=4; 2 steers, 2 heifers) and miniature cattle (n=4; 2 steers, 2 heifers) were allotted to a diet consisting of 77% sorghum sudan, 23% alfalfa powder (FOR, n=8) until ryegrass (*Lolium multiflorum*) forage was available at E.V. Smith Research Center Beef Unit in Shorter, AL on January 25, 2011. Standard cattle (n=4; 2 steers, 2 heifers) were then placed in a 2.02 hectare ryegrass paddock and miniature cattle (n=4; 2 steers, 2 heifers) were placed in a 1.01 hectare ryegrass paddock.

Standard Cattle (n=3; 1 steer, 2 heifers) and miniature cattle (n=3; 1 steer, 2 heifers) were allotted to a diet consisting of 25% grain (cracked corn, wheat midds, soy hulls, dry distillers' grain, soybean meal, molasses, fat, vitamin premix, and limestone), 75% sorghum sudan (GRAIN, n=6) for the first three weeks of the experiment. Over a

two week period, the GRAIN diet was adjusted to 30% grain, 40% grain, and then 50% grain for a formulation of 2.9 MCAL/kg ME to produce an average daily gain (ADG) of 1.47 to 1.59 kg per day. During the last 4 weeks on test, the GRAIN diet was increased to 77% grain, 23% sorghum sudan over a 2 week period, as a finishing diet.

Cattle were fed until an average back fat of approximately 0.76 cm, as determined by real time ultrasound (Aloka SSD-500V with 17.3 cm transducer, Hitachi Aloka Medical, Ltd., Wallingford, CT) was reached. While on feed, cattle weights and hip heights were collected every 28 days. Real time ultrasound measurements were also taken at the 28 day weigh periods to estimate average back fat thickness and ribeye area. The same UGC certified ultrasound technician was used each time to collect ultrasound carcass measurements. Once average back fat of 0.76 cm was reached, cattle were transported to Auburn University Lambert Powell Meats Laboratory where they were humanely harvested under USDA-FSIS inspection on April 26, 2011.

Carcass and Fabrication

Carcass pH was recorded in the left side round of each carcass at 0 min, 30 min, 60 min, 120 min, 4 h, 6 h, 8h, and 24 h using a pH Spear probe (Oakton Instruments, Vernon Hills, IL). Hot carcass weight (HCW) was recorded after slaughter, and carcasses were chilled at 2 ± 1°C for 24 h. At 24 h postmortem, the left side of each carcass was ribbed between the 12^{th} and 13^{th} ribs, and evaluated for back fat; adjusted back fat; ribeye area (REA); percentage kidney, pelvic, and heart fat (KPH); skeletal maturity; lean maturity; average maturity; and marbling. Longissimus muscles were evaluated for objective color measurements using a Hunter Miniscan XE Plus (Hunter

Lab, Reston, Virginia) for Hunter L*, a*, and b* values. The Miniscan was calibrated according to manufacturer's recommendations, and utilized a D65 light source, a 10° viewing angle, and a 35mm viewing area. After aging for 7 days at 2 ± 1°C, carcasses were fabricated into wholesale cuts (chuck, rib, shortloin, sirloin, and round), and weights were collected for each cut. Wholesale cuts were further fabricated into bone-in subprimals and retail cuts (chuck roast, shoulder roast, rib steak, t-bone steak, sirloin tip roast, sirloin steak, round steak, rump roast, and barbecue ribs), and weights were collected for each cut. All cuts were then packaged in wax coated freezer paper, boxed, and stored at -26 °C until further analyses.

Shear Evaluation

Warner-Bratzler shear force (WBS) evaluation was performed on the longissimus muscle from T-bone steaks. Randomly selected frozen T-bone steaks were removed from the freezer and allowed to thaw for 24 h at 4°C. Steaks were removed from the freezer paper and cooked on a clam-shell-style grill (Calphalon Removable Plate Grill, Caphalon, Perrysburg, OH), preheated to ~177°C. Steaks were cooked for 7 min, resulting in an internal temperature of 71°C. Temperature was monitored with copper constantan thermocouple wire inserted into the geometric center of the steak and attached to a hand-held Omega data logger HH309A temperature recorder (Omega, Stamford, CT). Cooked steaks were then covered in aluminum foil, labeled, and chilled at 4°C for 24 h. Six cores (1.27 cm in diameter) were removed from each steak with a brass cork borer (Model 1601A Series Brass Cork Borer, Boekel Scientific, Feasterville, PA), parallel to the muscle fiber orientation. Each core was sheared once at its center,

perpendicular to the muscle fiber orientation, using a TA-XT2i Texture Analyzer shear machine (Texture Technologies Corp., Scarsdale, NY). The peak force measurements were then averaged from the 6 cores from each steak to be used for statistical analysis. The probe was programmed to be lowered 30 mm after detection of resistance. The penetration speed was 3.3 mm/s with a post-test speed of 10 mm/s and a pre-test speed of 2.0 mm/s.

Sensory Evaluation

Randomly selected frozen T-bone steaks were thawed at 4°C for 24 h and cooked as described for WBS. The longissimus muscle was removed from the steaks and trimmed of external fat and connective tissue. The samples were then cut into 1.27 cm × 1.27 cm × steak thickness portions using a plastic grid, placed in sample cups and labeled. Sample cups were then placed in pans and kept in a warming oven until served to a trained sensory panel, consisting of 8 members. Each panelist was given a sample cup containing 2 samples from each steak for evaluation of initial and sustained juiciness, initial and sustained tenderness, beef flavor intensity, and off flavor intensity on a scale of 1 to 8, where 1 = extremely dry, tough, bland, and uncharacteristic of beef, and 8 = extremely juicy, tender, intense, and characteristic of beef. Panelists evaluated samples in secluded partitioned booths with red incandescent light. Panelists were also instructed to cleanse their palate with a salt-free saltine cracker and a sip of apple juice before each evaluating each sample. Two sessions (October 11, 2011 and October 12, 2011) were utilized to complete sensory evaluation of 14 total samples, 7 samples per session.

Statistical Analysis

Data was analyzed as a completely randomized design using both the GLM and Mixed procedures of SAS (SAS Institute, Inc., Cary, NC). Main effects were cattle size and diet. Independent variables of interest were live animal performance, carcass performance and retail yield values. Significant ($P \leq 0.05$) main and interaction effect means were separated with Fisher's protected LSD using the PDIFF option of LSMEANS in SAS.

Results and Discussion

Animal Performance

Composition and nutrition analysis of diets and nutritional analysis and yield of ryegrass pastures are presented in Table 3-1 and Table 3-2, respectively. Means for growth performance characteristics are displayed in Table 3-3. In this study STD consumed a greater amount of dry matter than MINI from November 22, 2010 to January 25, 2011, however STD GRAIN, MINI GRAIN, and MINI FOR had similar gain to feed ratios during that time period (0.14 ± 0.01, 0.12 ± 0.06, 0.15 ± 0.08, respectively; Table 3-3). STD FOR had the lowest gain to feed ratio of all treatments (0.07 ± 0.02; Table 3-3). These results are similar to Klosterman and Parker (1976), who suggested early maturing small frame cattle fed low energy diets outperform large frame cattle because small cattle consume more feed per unit of body weight. Final weight, total gain, and total average daily gain were greater for STD compared to MINI ($P < 0.0001$; Table 3-4). These results agree with similar studies from McCarthy et al., 1985, Thonney et al., 1981, and Washburn et al., 1948. While the current study utilized miniature cattle and comparative literature discusses small frame cattle, it was hypothesized that miniature

and small frame cattle would behave similarly. In this study the average hip height and age of MINI translates into an average frame score of '000' (American Hereford association, 2012). The average frame score of STD is 5.5 (Beef Improvement Federation Guidelines, 2010). Variability in body size within breeds of cattle suggests that there are no definite differences in efficiency related to size, and there is a biological or economic niche for each size (Cartwright, 1979). Therefore, optimal size of cattle may depend on the production system.

In this study, GRAIN had a higher final weight, total gain, and total average daily gain than FOR (P=0.0341, P=0.0053, and P=0.0053, respectively; Table 3-4). Roberts, et al. (2009) reported increasing the amount of grain in the diet decreased the number of days on feed, and increased average daily gain. Similar results were reported by Thonney et al. (1981), Tatum et al. (1988), and Berthiaume et al. (2006). However, beef cattle are excellent converters of forages to high quality meat (Bidner et al., 1981), therefore further development of forage-based production systems could be utilized as an alternative to meet consumer demand for forage-finished beef.

Carcass Traits and Retail Yield Performance

As expected, hot carcass weight (P<0.0001) and ribeye area (P<0.0001) were greater for STD than MINI (Table 3-5). Adjusted back fat was numerically greater for STD than MINI, however the lack of difference (P=0.0705; Table 3-5) is attributed to the calculated finish endpoint based on average back fat (0.76 cm). These results compare to those found by Maino et al. (1981) and Baggett IV et al. (2004), who reported higher hot carcass weights and larger ribeye area for large frame cattle compared to smaller frame

cattle. Dressing percentage was higher (P=0.0301) for STD than MINI (Table 3-5). These results could be related to small ruminants typically having a lower dressing percentage than standard cattle. In addition, dressing percentage, L*, and b* were greater for STD than MINI (P=0.0301, P=0.0375, and P=0.0019, respectively; Table 3-8). Lower dressing percentage for MINI could be related to small ruminants having a lower dressing percentage in comparison to cattle due to smaller body size. Lower L* and b* values for MINI represent a darker and bluer lean in comparison to STD.

Adjusted back fat, kidney pelvic heart fat, yield grade, quality grade, and marbling values were higher for GRAIN than that of FOR (P=0.0036, P=0.0007, P=0.0006, P=0.0135, and P=0.0030, respectively; Table 3-5). These results agree with previous research showing backfat thickness and kidney pelvic heart fat percentage is greater for cattle fed grain-based diets over cattle fed forage-based diets (Bowling et al., 1977; Mandell et al., 1998; Berthiaume et al., 2006; Moloney et al., 2008; Garmyn et al., 2010). Kerth et al. (2007) also found that steers finished on grain or ryegrass/grain diets had higher adjusted fat thickness, kidney pelvic heart fat percentage, and USDA yield grade compared to steers finished on ryegrass.

The number of chuck roasts, shoulder roasts, rib steaks, T-bone steaks, sirloin steaks, and round steaks were greater for STD than MINI (P<0.0001, P=0.0206, P=0.0002, P=0.0005, P=0.0002, P<0.0001, respectively; Table 3-9). As expected, chuck roast, shoulder roast, rib, rib steak, shortloin, t-bone, sirloin, sirloin tip, sirloin steak, round, round steak, rump roast, bbq ribs, trim and inedible weights were greater for STD than MINI (P<0.01). No differences were found for number of cuts (P>0.1066) weights of cuts (P>0.2534) between GRAIN and FOR.

Shear Evaluation

For Warner Bratzler shear force values, MINI was greater than STD (4.45 kg and 3.22 kg, respectively; Table 3-6). These results could be attributed to possible differences in size and type of the muscle fibers between MINI and STD. Previous research suggests there is a relationship between muscle fiber type or size and shear force values and tenderness in beef (Calkins et al., 1981; Crouse et al., 1991; Klont et al., 1998). Therefore, further research is needed to determine differences in muscle fibers between MINI and STD. No difference was found for WBS values (P=0.0983; Table 3-6) between GRAIN and FOR, which agrees with results found by Roberts et al., 2009 and Cox et al., 2006. However, other studies have shown shear force values to increase with forage feeding compared to grain feeding (Bowling et al., 1977; Schroeder et al., 1980).

Sensory Evaluation

Initial juiciness and sustained juiciness values were greater for STD than for MINI (P=0.0255 and P=0.0963, respectively; Table 3-7). Initial tenderness and sustained tenderness values were greater for STD than for MINI (P=0.0156 and P=0.0152, respectively; Table 3-7). No differences were found for beef flavor or off flavor between STD and MINI (P=0.6484 and P=0.6328, respectively; Table 3-7). Initial juiciness and sustained juiciness values were greater for GRAIN than FOR (P=0.0138 and P=0.0120, respectively; Table 3-7). Differences in juiciness may have resulted from marbling, as reported by Breidenstein et al. (1968) and Gilpin et al. (1965), who found steaks from carcasses with higher marbling scores to have higher juiciness ratings for sensory

evaluation. In this study, GRAIN steaks were found to have an initial juiciness rating of 5.76, a sustained juiciness rating of 5.52, and a marbling score of 388.00, while FOR steaks had 4.91 for initial juiciness rating, 4.68 for sustained juiciness rating, and 292.50 for marbling score. Initial tenderness and sustained tenderness values were greater for GRAIN than FOR (P=0.0081 and P=0.0104, respectively; Table 3-7). These results agree with Schroeder et al. (1980), who found that steaks from forage-finished steers had lower sensory ratings for tenderness than those from grain-finished steers. The tenderness scores are relative to WBS values found during shear evaluation; GRAIN requiring 3.53 kg of force and FOR requiring 4.14 kg of force. Beef from forage-finished cattle has been found to have lower flavor scores and greater scores for off flavor than beef from grain-finished cattle (Mandell et al., 1998; Garmyn et al., 2010). No difference was found for beef flavor between GRAIN and FOR (P=0.1690; Table 3-7), however a greater off flavor value was found for FOR than GRAIN (P=0.0001; Table 3-7). Off flavors found for FOR beef include grassy, salty, warmed-over-flavor, bloody, rancid, bitter, livery, and metallic.

Implications

The results of this study indicate that miniature cattle do not have greater growth performance characteristics, carcass characteristics, and retail cut-out values than standard cattle of the same sex on both forage and grain resources. Similarly, cattle finished on grain-based diets had greater growth performance and carcass characteristics than cattle finished on forage-based diets. Therefore, there is no direct advantage for growth or carcass characteristics for miniature cattle over standard cattle finished on

grain or forage resources. However, miniature cattle can be finished on smaller acreage than standard cattle, so for a farmer wanting to finish cattle on smaller land mass, miniature cattle may have a place in a niche market.

Table 3-1. Composition and Nutritional Analysis of Diets[1]

Ingredient	Percentage	DM	CP	NDF[2]	ADF[2]
Grain Portion of Diet		89.0	13.2	9.50	6.76
Soybean Meal, 49%	4.0				
Corn grain	60.4				
Wheat Middlings	8.1				
Soybean Hulls	8.1				
Dried Distillers Grain	8.1				
Molasses	4.0				
Fat	4.0				
Vitamin ADE	0.121				
Limestone	1.2				
Microminerals	0.121				
Salt	0.806				
Rumensin	0.018				
Sodium bicarbonate	1.0				
Sorghum-Sudan Silage		33.0	7.3	57.53	35.74
Alfalfa Meal used in forage diet		92.0	17.3	41.0	32.0

[1]Cattle on grain diets were fed 50% sorghum-sudan silage and 50% grain; Cattle on forage finishing prior to ryegrass pastures were fed 50% sorghum-sudan silage and 40% alfalfa meal.

[2]Expressed as a percentage of dry matter

Table 3-2. Nutritional Analysis of Ryegrass (*Lolium multiflorum*) Pastures[2] over time.

Date	NDF[1]	ADF[1]
Standard Cattle Pasture (2.02 ha)		
January 2011	36.10	19.51
February 2011	30.71	13.96
March 2011	38.33	22.06
April 2011	49.06	26.59
Miniature cattle Pasture (1.01 ha)		
January 2011	34.72	14.51
February 2011	28.47	13.62
March 2011	39.27	22.26
April 2011	50.67	27.48

[1] Expressed as a percentage of dry matter
[2] Forage finished cattle placed on ryegrass (*Lolium multiflorum*) pastures on January 25, 2011

Table 3-3. Means ± standard deviation for growth performance characteristics of miniature versus standard cattle finished on grain and forage.

	Treatment			
	STD		MINI	
Variable	GRAIN	FOR	GRAIN	FOR
Initial weight, kg	253.41 ± 15.43	253.33 ± 20.94	80.74 ± 14.26	78.36 ± 28.73
Final weight, kg	456.61 ± 27.71	415.26 ± 34.48	153.01 ± 16.71	143.79 ± 46.45
Average daily gain, kg/d	1.37 ± 0.08	1.14 ± 0.21	0.46 ± 0.03	0.40 ± 0.12
Gain to feed, kg/kg[a]	0.14 ± 0.01	0.07 ± 0.02	0.12 ± 0.06	0.15 ± 0.08
Total dry matter consumed, kg[a]	458.09 ± 26.02	459.35 ± 95.38	250.45 ± 140.33	221.05 ± 116.10
Final hip height, cm	128.69 ± 3.88	127.64 ± 1.37	88.9 ± 5.64	90.65 ± 8.85
Final ultrasound backfat, cm	1.24 ± 0.22	0.64 ± 0.16	0.65 ± 0.05	0.58 ± 0.35
Final ultrasound ribeye area, cm^2	69.25 ± 8.17	65.65 ± 7.90	34.19 ± 4.52	36.77 ± 5.70

[a]From November 22, 2010 to January 25, 2011

Table 3-4. LSMEANS ± SEM for growth performance characteristics of miniature versus standard cattle finished on grain and forage.

	Treatment			Treatment		
Variable	MINI	STD	P>|t|	GRAIN	FOR	P>|t|
Final Weight, kg	153.51 ± 9.39	439.01 ± 9.39	<0.0001	312.74 ± 10.26	279.78 ± 8.68	0.0341
Total Gain, kg	72.15 ± 5.53	183.50 ± 5.53	<0.0001	141.87 ± 6.04	113.79 ± 5.11	0.0053
Total Average Daily Gain, kg/d	0.47 ± 0.04	1.19 ± 0.04	<0.0001	0.92 ± 0.04	0.74 ± 0.03	0.0053

Table 3-5. LSMEANS ± SEM for carcass characteristics of miniature versus standard cattle finished on grain and forage.

	Treatment			Treatment		
Variable	MINI	STD	P>|t|	GRAIN	FOR	P>|t|
Hot carcass weight, kg	78.94 ± 8.39	241.34 ± 8.39	<0.0001	169.72 ± 9.17	150.56 ± 7.75	0.1416
Dressing percentage	52.15 ± 0.88	55.24 ± 0.88	0.0301	54.01 ± 0.96	53.37 ± 0.81	0.6262
Adjusted backfat, cm	0.68 ± 0.10	0.96 ± 0.10	0.0705	1.09 ± 0.11	0.55 ± 0.09	0.0036
Ribeye area, cm^2	38.22 ± 1.71	66.33 ± 1.71	<0.0001	51.56 ± 1.87	52.98 ± 1.58	0.5755
KPH, %	2.00 ± 0.12	1.93 ± 0.12	0.6709	2.36 ± 0.13	1.56 ± 0.11	0.0007
Skeletal maturity[a]	135.07 ± 7.35	137.93 ± 7.35	0.7865	138.00 ± 8.04	135.00 ± 6.80	0.7814
Lean maturity[a]	140.32 ± 4.84	133.18 ± 4.84	0.3158	139.75 ± 5.29	133.75 ± 4.47	0.407
Average maturity[a]	137.70 ± 4.11	135.55 ± 4.11	0.7168	138.88 ± 4.49	134.37 ± 3.80	0.462
Marbling[b]	318.82 ± 17.13	361.68 ± 17.13	0.1036	388.00 ± 18.73	292.50 ± 15.83	0.003
Yield Grade[c]	2.33 ± 0.13	2.56 ± 0.13	0.2406	2.91 ± 0.14	1.98 ± 0.12	0.0006
Quality Grade[d]	293.21 ± 21.01	321.79 ± 21.01	0.3532	352.50 ± 22.97	262.50 ± 19.41	0.0135

[a]Maturity score (100 = A^{00}, 200 = B^{00}).
[b]Marbling score (200 = $traces^{00}$, 300 = $slight^{00}$, 400 = $small^{00}$).
[c]Yield Grade (1 = 52.4 or greater percent closely trimmed boneless retail cuts(% CTBRC), 2 = 50.1 to 52.3% CTBRC, 3 = 47.8 to 50% CTBRC).
[d]Quality Grade (200 = standard +, 300 = select).

Table 3-6. LSMEANS ± SEM for Warner-Bratzler Shear Force for miniature versus standard cattle and grain-finished versus forage-finished cattle

	Treatment			Treatment		
Variable	MINI	STD	P>|t|	GRAIN	FOR	P>|t|
WBS, kg	4.45 ± 0.23	3.22 ± 0.23	0.0037	3.53 ± 0.26	4.14 ± 0.22	0.0983

Table 3-7. LSMEANS ± SEM for sensory evaluation of miniature versus standard cattle and grain-finished versus forage-finished cattle.

	Treatment			Treatment		
Variable	GRAIN	FOR	P>|t|	MINI	STD	P>|t|
Initial Juiciness[a]	5.76 ± 0.22	4.91 ± 0.20	0.0138	4.97 ± 0.20	5.70 ± 0.20	0.0255
Sustained Juiciness[a]	5.52 ± 0.21	4.68 ± 0.18	0.012	4.85 ± 0.19	5.35 ± 0.19	0.0963
Initial Tenderness[b]	5.88 ± 0.31	4.55 ± 0.26	0.0081	4.64 ± 0.28	5.78 ± 0.28	0.0156
Sustained Tenderness[b]	5.72 ± 0.33	4.36 ± 0.28	0.0104	4.43 ± 0.30	5.66 ± 0.30	0.0152
Beef Flavor[c]	5.20 ± 0.15	4.91 ± 0.13	0.169	5.10 ± 0.14	5.01 ± 0.14	0.6484
Off Flavor[d]	1.36 ± 0.26	3.43 ± 0.22	0.0001	2.47 ± 0.23	2.31 ± 0.23	0.6328

[a]Scored on an 8-point scale (1 = extremely dry, 8 = extremely juicy).
[b]Scored on an 8-point scale (1 = extremely tough, 8 = extremely tender).
[c]Scored on an 8-point scale (1 = extremely bland, 8 = extremely intense beef).
[d]Scored on an 8-point scale (1 = no off flavor, 8 = extreme off flavor).

Table 3-8. LSMEANS ± SEM for Hunter L* a* and b* values and pH values for miniature versus standard cattle and grain-finished versus forage-finished cattle.

	Treatment			Treatment		
Variable	MINI	STD	P>|t|	GRAIN	FOR	P>|t|
L*[a]	31.92 ± 1.81	37.99 ± 1.81	0.0375	34.18 ± 1.98	35.73 ± 1.68	0.5625
a*[b]	20.91 ± 0.92	22.37 ± 0.92	0.2820	22.90 ± 1.00	20.38 ± 0.85	0.0849
b*[c]	15.02 ± 0.63	18.69 ± 0.63	0.0019	17.12 ± 0.69	16.58 ± 0.58	0.5591
Final pH	5.72 ± 0.05	5.78 ± 0.05	0.3689	5.76 ± 0.05	5.73 ± 0.04	0.6245

[a] L* = 0 (black) to 100 (white)
[b] a* = -a (green) to +a (red)
[c] b* = -b (blue) to +b (yellow)

Figure 3-1. pH values over time for miniature versus standard cattle and grain-finished versus forage-finished cattle.

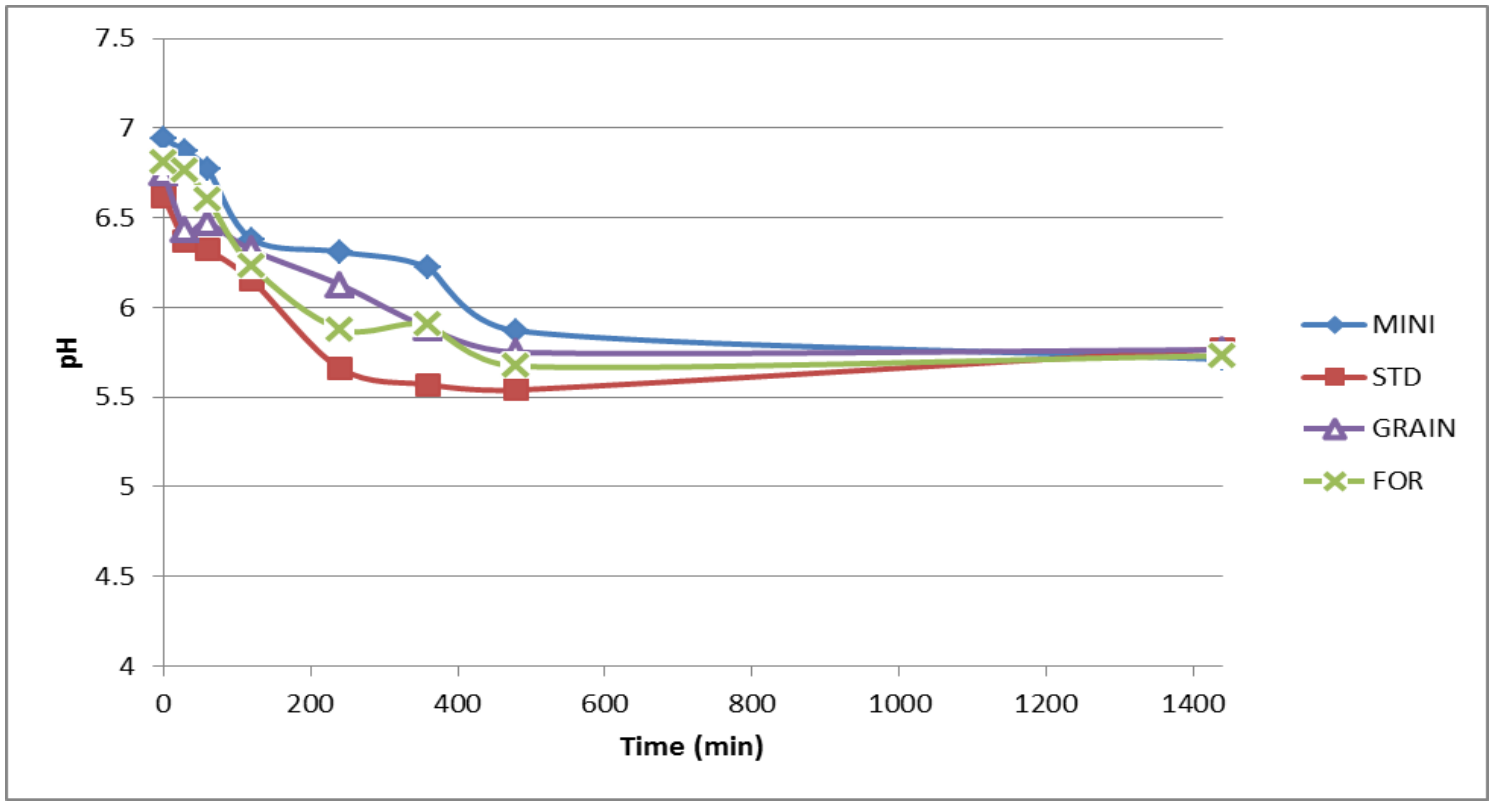

Table 3-9. LSMEANS ± SEM for retail yield performance for miniature versus standard cattle.

Variable	Treatment		P>|t|
	MINI	STD	
Cold Carcass Weight, kg	76.05 ± 7.99	226.32 ± 7.99	<0.0001
Number of Chuck Roasts	5.87 ± 0.11	12.00 ± 0.11	<0.0001
Chuck Roast Weight, kg	1.12 ± 0.10	1.92 ± 0.10	0.001
Number of Shoulder Roasts	5.13 ± 0.26	4.00 ± 0.26	0.0206
Shoulder Roast Weight, kg	0.89 ± 0.05	1.54 ± 0.05	<0.0001
Rib Weight, kg	2.63 ± 0.37	7.08 ± 0.37	0.0002
Number of Rib Steaks	18.50 ± 0.65	26.00 ± 0.65	0.0002
Rib Steak Weight, kg	0.25 ± 0.01	0.46 ± 0.01	<0.0001
Shortloin Weight, kg	3.14 ± 0.36	8.03 ± 0.36	<0.0001
Number of T-Bones	21.25 ± 0.93	30.25 ± 0.93	0.0005
T-bone Weight, kg	0.26 ± 0.01	0.49 ± 0.01	<0.0001
Sirloin Weight, kg	3.14 ± 0.36	8.03 ± 0.36	0.0004
Number of Sirloin Tips	2.51 ± 0.15	3.00 ± 0.15	0.0662
Sirloin Tip Weight, kg	2.70 ± 0.55	8.13 ± 0.55	0.0002
Number of Sirloin Steaks	11.25 ± 0.32	14.63 ± 0.32	0.0002
Sirloin Steak Weight, kg	0.40 ± 0.02	0.76 ± 0.02	<0.0001
Round Weight, kg	6.45 ± 0.67	20.50 ± 0.67	<0.0001
Number of Round Steaks	13.63 ± 0.28	21.38 ± 0.28	<0.0001
Round Steak Weight, kg	0.43 ± 0.04	0.93 ± 0.04	<0.0001
Rump Roast Weight,kg	1.17 ± 0.14	2.91 ± 0.14	0.0001
BBQ Ribs Weight, kg	0.38 ± 0.05	1.15 ± 0.05	<0.0001
Trim Weight, kg	14.96 ± 1.61	32.10 ± 1.61	0.0003
Inedible Weight, kg	17.04 ± 1.16	31.62 ± 1.16	0.0001

Chapter 4

Consumer Preference for Beef from Standard or Miniature Cattle Finished on both Grain and Forage Resources

Abstract

To assess preferences, consumers (n=196) from the southeastern United States were surveyed at an annual event, the Ag Roundup, at Auburn University, AL on November 19, 2011 for preferences in beef. Consumers were presented with 7 packages of T-bone steaks (1 steak per package) that had information cards displaying five different attributes (portion size, grain- or grass-fed, price, traceability, and region of origin). They were asked to complete a written survey. The highest percentage of participants (20.94%) were from the 36 to 45 and 46 to 55 year age groups. More females participated in the survey than males (58.76% and 41.24%, respectively). Most participants identified themselves as white, and did not consider themselves Spanish, Hispanic, or Latino. Most participants were married (66.32%) with two adults in the household (65.07%), and did not have any children in their household. Approximately 68 percent of survey participants had a four-year or graduate/professional degree. The majority of participants were employed full-time (62.18%), and 75.27 percent had a household income of $50,000 or greater. A greater percentage of respondents ranked 18oz steaks as their first choice in comparison to 9oz steaks (76.43%). Over half of the participants responded that they are responsible for 76 to 100% of food shopping for their household. Approximately 31.44% of participants responded that they purchase beef

steaks regularly. Participants (22.46%) responded that they regularly purchase them at a typical grocery store, such as Kroger or Winn Dixie, and 48.92% of participants purchase beef steaks most often in the Auburn/Opelika, AL area. Most participants (86.46%) cared where their beef steak was produced. Of those respondents, 44.91% consider the term "local" to mean produced in Alabama, 23.95% consider the term "local" to mean produced in Alabama and within 50 miles of where they live, and 11.38% consider the term "local" to mean produced in Alabama and within 25 miles of where they live. When asked where most of the meat they buy is produced, 22.68% of panelists responded Southeastern US and 16.49% responded Alabama. The percent of participants who agreed that limiting the portion size of beef steak they eat is important to them (32.64%) was greater than that of those who disagreed (21.24%). More respondents disagreed with the statement that they do not like small sized beef steaks (27.98%), and agreed that they would be willing to eat steaks from miniature cattle (36.46%). The results of the consumer portion demonstrate that the majority of consumers do not prefer to purchase beef steaks from miniature cattle versus standard cattle of the same age finished on both grain and forage resources. However, most participants believe it is important to limit the size of steak they eat, and were not opposed to consuming small sized beef steaks from miniature cattle.

Introduction

When developing a new product, it is important to develop an understanding of how consumers perceive products and how they make product choices based on their preferences or values (van Kleef et al., 2005). Consumer beef purchasing decisions are driven by quality and price. However, today's consumers are becoming increasingly

concerned with the environment, food safety, health and nutrition (Martin and Rogers, 2004). Changes in consumer demand have played a major role in the development of niche, or specialty, beef production systems. In turn, producers have worked to develop beef products such as grass-fed, organic, natural, and local beef as alternatives to conventional beef.

Miniature cattle production is a specialized niche market gaining popularity in the United States (Boden, 2008). This production system could potentially provide beef products that are of smaller proportion. Since the 1970s, portion sizes have been increasing in the United States (Ello-Martin et al., 2005). In 2002, Young and Nestle found that steaks exceeded USDA standard portions by 224%. By offering a broader range of portion sizes or promoting sensible portion sizes, food providers could improve the effect of portion size on food intake (Ello-Martin et al., 2005). Therefore, promotion of smaller, sensible portion sizes of beef, such as beef from miniature cattle, may be necessary to increase to increase representation of these products within the beef industry. Conventionally raised cattle are typically raised on pasture, or a forage-based diet, for the first few months of their lives, and then finished on a high energy, grain-based diet to achieve market weight. However, some consumers believe there could be benefits associated with forage-finished beef regarding health, environment, and animal welfare (McCluskey et al., 2005). Increased interest in forage-fed beef could provide an additional market for beef producers to meet the demands of changing consumer preferences. Previous research demonstrates that there is a market opportunity for alternative beef production systems (McCluskey et al., 2005; Cox et al., 2006; Umberger et al., 2009). Therefore, it may be possible to market alternative products such as beef

from miniature cattle finished on grain or forage resources, to capture a share of consumers that indicate a preference in specialty products and/or product attributes.

The objective of this study was to determine consumer desirability for beef from miniature cattle versus standard cattle of the same age finished on both grain and forage resources.

Materials and Methods

Animals

Crossbred standard cattle (n=7; 3 steers, 4 heifers) with initial weights of approximately 222 kg to 267 kg born January through February 2010 with 18.75% Brahman influence were acquired from Salacoa Valley Farms in Fairmount, GA, and crossbred miniature cattle (n=7; 3 steers 4 heifers) with initial weights of approximately 59 kg to 121 kg born March through May 2010 with 12.5% Brahman influence were acquired from the Auburn University College of Veterinary Medicine foundation herd. Cattle were housed at the Auburn University Beef Cattle Evaluation Center (PRN:2010-1802). Animals were placed on test November 22, 2010. Standard cattle (n=4; 2 steers, 2 heifers) and miniature cattle (n=4; 2 steers, 2 heifers) were allotted to a diet consisting of 77% sorghum sudan, 23% alfalfa powder (FOR, n=8) until ryegrass (*Lolium multiflorum*) forage was available at E.V. Smith Research Center Beef Unit in Shorter, AL on January 25, 2011. Standard cattle (n=4; 2 steers, 2 heifers) were then placed in a 2.02 hectare ryegrass paddock and miniature cattle (n=4; 2 steers, 2 heifers) were placed in a 1.01 hectare ryegrass paddock.

Standard Cattle (n=3; 1 steer, 2 heifers) and miniature cattle (n=3; 1 steer, 2 heifers) were allotted to a diet consisting of 25% grain (cracked corn, wheat midds, soy

hulls, dry distillers' grain, soybean meal, molasses, fat, vitamin premix, and limestone), 75% sorghum sudan (GRAIN, n=6) for the first three weeks of the experiment. Over a two week period, the GRAIN diet was adjusted to 30% grain, 40% grain, and then 50% grain for a formulation of 2.9 MCAL/kg ME to produce an average daily gain (ADG) of 1.47 to 1.59 kg per day. During the last 4 weeks on test, the GRAIN diet was increased to 77% grain, 23% sorghum sudan over a 2 week period, as a finishing diet.

Cattle were fed until an average back fat of approximately 0.76 cm, as determined by real time ultrasound (Aloka SSD-500V with 17.3 cm transducer, Hitachi Aloka Medical, Ltd., Wallingford, CT) was reached. While on feed, cattle weights and hip heights were collected every 28 days. Real time ultrasound measurements were also taken at the 28 day weigh periods to estimate average back fat thickness and ribeye area. The same UGC certified ultrasound technician was used each time to collect ultrasound carcass measurements. Once average back fat of 0.76 cm was reached, cattle were transported to Auburn University Lambert Powell Meats Laboratory where they were humanely harvested under USDA-FSIS inspection on April 26, 2011.

Consumer Survey

Consumers (n=196) from the southeastern United States were surveyed for beef preferences at an annual event, the Ag Roundup, at Auburn University, AL on November 19, 2011. The Ag Roundup is an annual homecoming tailgate event featuring an array of foods produced by Alabama farmers, as well as activities and informative displays from industry and university organizations. Consumers were presented with 7 packages of T-bone steaks (1 steak per package) that had information cards displaying

four different attributes (portion size, grain- or grass-fed, price, and traceability). They were asked to complete a written survey. The first portion of the survey asked consumers if they consume beef, and if they purchase beef to cook at home, as screening questions. The second portion included a conjoint analysis question, in which consumers were asked to rank the steaks in the order that they would prefer to purchase them. Below are the options offered:

- Option A: 9oz size, grain fed, traceable to farm, average price
- Option B: 9oz size, grass fed, traceable to processor, 10% above average price
- Option C: 9oz size, grain fed, traceable to country, 10% above average price
- Option D: 9oz size, grass fed, traceable to farm, 25% above average price
- Option E: 18oz size, grain fed, traceable to farm, 25% above average price
- Option F: 18oz size, grass fed, traceable to country, average price
- Option G: 18oz size, grass fed, traceable to processor, 10% above average price.

The next portion of the survey included questions regarding consumer preferences for both physical and credence attributes of beef to determine what attributes consumers believe are most important when purchasing beef. The final portion of the survey included purchasing behavior and socio-demographic variables. Participants in this study were asked to disclose what percentage of shopping they are responsible for in their household, as well as how often they purchase beef. Consumers were also asked to provide demographic data such as gender, ethnicity, age, income, level of education, and the number of children and adults present in the household to determine the demographic profile of the study population. Survey participants received either an Auburn University

Meat Science insulated cooler bag or a ten dollar gift certificate for beef at the completion of the survey.

Statistical Analysis

Data was analyzed using the FREQ procedure of SAS (SAS Institute, Inc., Cary, NC). Cross-tabs were performed for some variables of interest.

Results and Discussion

Consumer demographic information is presented in Table 4-1a and 4-1b. Some demographic groups were represented more than others due to the random recruitment of survey participants and location of the survey. Age groups between 18 and 65 years of age were well represented. The highest percentage of participants (20.94%) was from the 36-45 and 46-55 year age groups. However, Leick et al. (2011), found the majority of participants were between the ages of 20 and 29, when consumer recruitment was conducted on a college campus prior to a football game. More females participated in the survey than males (58.76% and 41.24%, respectively). These results are comparative to Sweeter et al. (2005), who found 58% of auction participants to be female, but differ from other studies (Kerth et al., 2007; Leick et al., 2011). Since the survey was conducted on a college campus, it was expected that race/ethnicity would be well distributed among participants, due to a diverse population. However, most participants identified themselves as white, and did not consider themselves Spanish, Hispanic, or Latino. Most participants were married (66.32%) with two adults in the household (65.07%), and did not have any children in their household. Approximately 68 percent of

survey participants had a four-year or graduate/professional degree. The majority of participants were employed full-time (62.18%), and 75.27 percent had a household income of $50,000 or greater. These groups may have been more heavily represented due to the number of alumni attending the event that day.

When consumers were asked to rank steak options in the order they would choose to purchase them, a greater percentage of respondents ranked 18oz steaks as their first choice in comparison to 9oz steaks. These results correspond with Sweeter et al. (2005), in which there was a trend of consumer preference for steaks with a larger longissimus muscle area (LMA) over those with a smaller LMA. Of the options with 18oz steaks, option E (18oz, grain-fed, traceable to farm, 25% above average price) was ranked as the first choice by 31.43% of respondents, option F (18oz, grass-fed, traceable to country, average price) was ranked first by 28.57% of respondents, and option G (18oz, grass-fed, traceable to processor, 10% above average prices) was ranked first by 16.43% of respondents (Table 4-2). In which, option E may have been ranked first more frequently due to the grain-fed production system used to produce the product, or because it was traceable to the farm. Of the options with a 9oz size T-bone, option A was ranked first more frequently than options B and C, which also had grain-fed and traceable to farm attributes. Some people who chose the larger portion size also commented that their two-person household would split the steak.

Over half of the participants responded that they are responsible for 76-100% of food shopping for their household. This information corresponds to Loureiro and Umberger (2007), who found the majority of respondents were the primary food shopper in the household. When asked how often they purchase beef steaks, 31.44% responded

that they purchase beef steaks regularly (Table 4-3). When purchasing beef steaks, 22.46% responded that they regularly purchase them at a typical grocery store, such as Kroger or Winn Dixie (Table 4-4), and 48.92% of participants purchase beef steaks most often in the Auburn/Opelika, AL area (Table 4-5).

Responses for consumer preference for production location are shown in Table 4-6. When participants were asked if they cared where their beef steak was produced, 86.46% responded yes. Of those respondents, 44.91% consider the term "local" to mean produced in Alabama, 23.95% consider the term "local" to mean produced in Alabama and within 50 miles of where they live, and 11.38% consider the term "local" to mean produced in Alabama and within 25 miles of where they live. When asked where most of the meat they buy is produced, 22.68% responded Southeastern US and 16.49% responded Alabama. Of participants who consider the term "local" to mean produced in the Southeastern US, 28.57% responded that most of the meat they buy is produced in the Southeastern US. Of participants who consider the term "local" to mean produced in Alabama, 23.60% responded that most of the meat they buy is produced in Alabama. These results demonstrate the misinformation of beef consumers. Beef production has become more specialized, with concentrations of feedlot cattle in Texas, Colorado, Nebraska, Kansas, Iowa, California and Oklahoma (EPA, 2009), and the top beef packers being located in Arkansas, Colorado, Kansas, Missouri, Minnesota, and Nebraska (Clause, 2011). Therefore, the majority of meat consumers buy is not produced in the Southeastern US or the state of Alabama. This indicates that there is a gap in knowledge between consumers and the animal industry.

Survey participants were also asked how strongly they agree or disagree with certain statements about credence or health attributes (Table 4-7). The percent of participants who agreed that limiting the portion size of beef steak they eat (32.64%) was greater than that of those who disagreed (21.24%). More participants responded that they disagreed with the statement that they do not like small sized beef steaks (27.98%), and agreed with the statement that they would be willing to eat steaks from miniature cattle (36.46%).

Implications

The results of this study conclude that the majority of consumers do not prefer to purchase beef steaks from miniature cattle versus standard cattle of the same age finished on both grain and forage resources. However, most participants believe it is important to limit the size of steak they eat, and were not opposed to consuming small sized beef steaks from miniature cattle. Therefore, miniature cattle production may be a niche market that can meet the needs of consumers who prefer smaller cuts of beef. More data should be collected on the economics of production of miniature cattle and consumer desirability.

Table 4-1a. Demographic description of survey participants.

Demographic	Percentage of participating consumers
Age	
17 & younger	3.14
18-25	17.28
26-35	14.66
36-45	20.94
46-55	20.94
56-65	16.23
66 & older	6.81
Gender	
Female	58.76
Male	41.24
Spanish, Hispanic, or Latino	0.52
Race	
Asian	5.21
Black or African American	2.60
White	89.58
Other	2.60
Education	
Less than 12th grade	3.11
High School or GED	4.15
Some college, no degree	13.47
2 year college degree	10.88
4 year college degree	32.12
Graduate or professional degree	36.27

Table 4-1b. Demographic description of survey participants.

Demographic	Percentage of participating consumers
Married	66.32
Number of children in household	
0 to 6 years	
0	81.73
1	10.58
2	5.77
4	1.92
7 to 17 years	
0	50.96
1	16.35
2	24.04
3	2.88
4	5.77
Number of adults in household	
18 to 64 years	
0	4.11
1	21.92
2	65.07
3	6.16
4	2.05
5	0.68
65 years or more	
0	90.68
1	2.54
2	6.78
Employment status	
Employed full-time	62.18
Employed part-time	9.84
Unemployed	3.11
Retired	9.84
Student	15.03
Household income	
Less than $10,000	3.76
$10,000 to $25,000	5.91
$25,000 to $50,000	15.05
$50,000 to $75,000	23.66
$75,000 to $100,000	25.81
$100,000 or more	25.81

Table 4-2. Percent of respondents ranking steak option in order of purchase preference.

Rank	Option A[a]	Option B[b]	Option C[c]	Option D[d]	Option E[e]	Option F[f]	Option G[g]
1	9.29	5.00	5.71	3.57	31.43	28.57	16.43
2	12.77	2.84	9.22	5.67	28.37	19.15	21.99
3	6.43	7.86	12.14	10.00	24.29	14.29	25.00
4	21.01	17.39	21.01	14.49	3.62	3.62	11.59
5	21.74	24.64	16.67	11.59	6.52	7.97	10.87
6	15.22	31.16	23.91	13.04	-	10.87	5.80
7	13.77	10.87	14.49	40.58	5.80	7.25	7.25

[a]Option A: 9oz size, grain fed, traceable to farm, average price
[b]Option B: 9oz size, grass fed, traceable to processor, 10% above average price
[c]Option C: 9oz size, grain fed, traceable to country, 10% above average price
[d]Option D: 9oz size, grass fed, traceable to farm, 25% above average price
[e]Option E: 18oz size, grain fed, traceable to farm, 25% above average price
[f]Option F: 18oz size, grass fed, traceable to country, average price
[g]Option G: 18oz size, grass fed, traceable to processor, 10% above average price

Table 4-3. Consumer beef purchasing behaviors.

Question	Percent
What percent of the food shopping do you do for your household?	
0-25%	13.33
26-50%	15.38
51-75%	16.41
76-100%	54.87
How frequently do you buy beef steak?	
Very Rarely	9.79
Rarely	14.43
Monthly	28.87
Regularly	31.44
Very Regularly	15.46

Table 4-4. Consumer beef purchasing behaviors.

Question	Percent
When you purchase beef steaks how often do you buy them at the following:	
At a typical grocery store such as Kroger and Winn Dixie	
Very Rarely	15.51
Rarely	21.93
Monthly	18.18
Regularly	22.46
Very Regularly	21.93
At a large specialty grocer such as Whole Foods and Earth Fare	
Very Rarely	56.12
Rarely	22.30
Monthly	10.07
Regularly	9.35
Very Regularly	2.16
At a small health/natural foods store or a food co-op	
Very Rarely	69.23
Rarely	14.62
Monthly	6.15
Regularly	7.69
Very Regularly	2.31
At a Farmer's Market	
Very Rarely	66.67
Rarely	20.45
Monthly	6.06
Regularly	4.55
Very Regularly	2.27
Directly from a producer's farm	
Very Rarely	67.91
Rarely	16.42
Monthly	2.24
Regularly	5.22
Very Regularly	8.21

Table 4-5. Consumer beef purchasing location.

Question	Percent
When you purchase beef steaks, where do you most often buy them?	
Auburn/Opelika, AL	48.92
Northern Region AL	21.02
Southeast Region AL	11.85
Central Region AL	7.55
Gulf Coast Region AL	3.77
Georgia	5.94
Florida	1.08
Texas	0.54

Table 4-6. Consumer preference for production location.

Question	Percent
Do you care where your beef steak is produced?	
Yes	86.46
No	13.54
What does the term "local" mean to you?	
US	3.59
Southeastern US	14.36
Alabama	45.64
Alabama & within 50 miles	24.62
Alabama & within 25 miles	10.77
I do not know	1.03
On average, where is most of the meat you buy produced?	
US	37.11
Southeastern US	22.68
Alabama	16.49
Alabama & within 50 miles	2.58
Alabama & within 25 miles	4.12
I do not know	17.01

Table 4-7. Percent of participants' response to statements.

	Percent of Respondents				
Statement	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
It would be easier to control portion size with beef steaks from miniature cattle	8.85	23.96	29.17	18.75	19.27
Limiting the portion size of the beef steak I eat is important to me	8.81	32.64	23.83	21.24	13.47
The next time I eat beef steak, I plan to choose a smaller cut of meat	3.66	24.61	27.23	30.37	14.14
If I ate beef steak from miniature cattle I would not tell my family	5.79	13.68	27.89	20.53	32.11
I do not like small sized beef steaks	13.99	19.69	22.80	27.98	15.54
Naming small framed cattle "miniature" is a bad idea	20.73	21.24	28.50	20.21	15.54
My family would not eat beef steaks from miniature cattle	5.73	13.57	26.56	31.77	22.40
Most Americans will enjoy eating steaks from miniature cattle	3.66	18.85	44.50	27.75	5.24
My family would think miniature cattle are pets rather than farm animals	14.66	25.13	24.08	21.47	14.66
I do what my family thinks I should do	6.25	19.79	30.73	25.00	18.23
Buying steaks from miniature cattle is a good way to control my serving size	5.21	22.40	33.33	19.79	19.27
My family is not concerned with the size of beef steaks that I eat	27.60	25.52	25.52	15.63	5.73
Most people who are important to me think I should eat smaller portions of beef steak	5.73	20.83	26.04	23.44	23.96
I would be willing to eat beef steak from miniature cattle	21.88	36.46	25.52	8.85	7.29
I think miniature cattle are pets rather than farm animals	7.33	16.75	27.23	20.94	27.75

References

Acevedo, N., Lawrence, J.D., & Smith, M. (2006). Organic, natural and grass-fed beef: profitability and constraints to production in the Midwestern U.S., Report. Ames, IA: Leopold Center for Sustainable Agriculture, Iowa State University.

American Hereford Association (2012). Frame scoring. http://hereford.org/node/315. Accessed on April 11, 2012.

Arango, J. A, & Van Vleck, L. D. (2002). Size of beef cows: early ideas, new developments. *Genetics and Molecular Research, 1*, 51-63.

Baggett, H.B., IV, Ward, C.E., & Childs, M.D. (2004). Effects of feeder cattle grades on performance and net return. *Journal of ASFMRA, 67*, 1-6.

Barkema, A., Drabenstott, M., & Welch, K. (1991). The quiet revolution in the U.S. food market. *Federal Reserve Bank of Kansas City Economic Review*, 25-42.

Beef Improvement Federation (2010). Guidelines for uniform beef improvement programs, ninth edition. http://www.beefimprovement.org/PDFs/guidelines/Guidelines-9th-Edition.pdf. Accessed on April 11, 2012.

Bertrand, A.R. (1980). Keynote address. In: Animal Agriculture: Research to Meet Human Needs in the 21st Century. p 307. Westview Press, Boulder, CO.

Berthiaume, R., Mandell, I., Faucitano, L., & Lafreniere, C. (2006). Comparison of alternative beef production systems based on forage finishing or grain-forage diets with or without growth promotants: 1. Feedlot performance, carcass quality, and production costs. *Journal of Animal Science, 84*, 2168-2177.

Bidner, T. D., Schupp, A. R, Mohamad, A. B., Rumore, N. C., Montgomery, R. E., Bagley, C. P., & McMillin, K. W. (1986). Acceptability of beef from angus-hereford or angus-hereford-brahman steers finished on all-forage or a high-energy diet. *Journal of Animal Science, 62*, 381-387.

Bidner, T. D., Schupp, A. R., Montgomery, R. E., & Carpenter, J. C., Jr. (1981). Acceptability of beef finished on all-forage, forage-plus-grain or high energy diets. *Journal of Animal Science, 53*, 1181-1187.

Block, H. C., McKinnon, J. J., Mustafa, A. F., & Christensen, D. A. (2001). Manipulation of cattle growth to target carcass quality. *Journal of Animal Science, 79*, 133-140.

Boden, D. W. R. (2008). Miniature cattle: for real, for pets, for production. *Journal of Agricultural & Food Information, 9*, 167-183.

Bowling, R. A., Smith, G. C., Carpenter, Z. L., Dutson, T. R., & Oliver, W. M. (1977). Comparison of forage-finished and grain-finished beef carcasses. *Journal of Animal Science, 45*, 209-215.

Breidenstein, B.B., Cooper, C.C., Cassens, R.G., Evans, G., & Bray, R.W. (1986). Influence of marling and maturity on the palatability of beef muscle. 1. Chemical and organoleptic considerations. *Journal of Animal Science, 27*, 1532.

Calkins, C.R., Duston, T.R., Smith, G.C., Carpenter, Z.L., & Davis, G.W. (1981). Relationship of fiber type composition to marbling and tenderness of bovine muscle. *Journal of Food Science*, *46*:708–715.

Camfield, P. K., Brown, A. H., Jr., Lewis, P. K., Rakes, L. Y., & Johnson, Z. B. (1997). Effects of frame size and time-on-feed on carcass characteristics, sensory attributes, and fatty acid profiles of steers. *Journal of Animal Science, 75*, 1837-1844.

Cartwright, T. C. (1979). Size as a Component of Beef Production Efficiency: Cow-Calf Production. *Journal of Animal Science, 48*, 974-980.

Clause, R. (2011). Commodity beef profile. http://www.agmrc.org/commodities__products/livestock/beef/commodity_beef_profile.cfm. Accessed on March 1, 2012.

Cox, R. B., Kerth, C.R., Gentry, J.G., Prevatt, J.W., Braden, K.W., & Jones, W.R. (2006). Determining acceptance of domestic forage- or grain-finished beef by consumers from three southeastern U.S. states. *Journal of Food Science, 71*, S542-S546.

Crouse, J. D., Koohmaraie, M., & Seidemann, S.D. (1991). The relationship of muscle fibre size to tenderness of beef. *Meat Science*, *30*:295–302.

Darby, K., Batte, M.T., Ernst, S., & Roe, B. (2008). Decomposing local: a conjoint analysis of locally produced foods. *American Journal of Agricultural Economics, 90*, 476-486.

Davis, C.G., & Lin, B.-H. (2005). Factors affecting U.S. beef consumption, report. Washington, D.C.: U.S. Department of Agriculture, Economic Research Service.

Dunn, J. L., Williams, S. E., Tatum, J. D., Bertrand, J. K., & Pringle, T. D. (2000). Identification of optimal ranges in ribeye area for portion cutting of beef steaks. *Journal of Animal Science, 78,* 966-975.

Ello-Martin,J.A., Ledikwe, J.H., & Rolls, B.J.. (2005). The influence of food portion size and energy density on energy intake: implications for weight management. *American Journal Clinical Nutrition, 82,* 236S-241S.

EPA. Background of beef production in U.S. (2009). http://www.epa.gov/agriculture/ag101/beefbackground.html. Accessed on March 1, 2012.

Fox, J.T., Reinstein, S., Jacob, M.E., & Nagaraja, T.G. (2008). Niche marketing production practices for beef cattle in the United States and prevalence of foodborne pathogens. *Foodborne Pathogens and Disease, 5*, 559-569.

Garcia, L.G., Nicholson, K.L., Hoffman, T.W., Lawrence, T.E., Hale, D.S., Griffin, D.B., Savell, J.W., VanOverbeke, D.L., Morgan, J.B., Belk, K.E., Field, T.G., Scanga, J.A., Tatum, J.D., & Smith, G.C. (2008). National Beef Quality Audit-2005: Survey of targeted cattle and carcass characteristics related to quality, quantity, and value of fed steers and heifers. *Journal of Animal Science, 86,* 3533−3543.

Garmyn, A. J., Hilton, G. G., Mateescu, R. G., & VanOverbeke, D. L. (2010). Effects of concentrate- versus forage-based finishing diet on carcass traits, beef palatability, and color stability in longissimus muscle from angus heifers. *Professional Animal Scientist, 26*, 579-586.

Garrett, W.N. (1980). Factors influencing energetic efficiency of beef production. *Journal of Animal Science, 51,* 1434.

Gilpin, G.L., Batcher, O.M., & Deary, P.A. (1965). Influence of marbling and final internal temperature on quality characteristics of broiled rib and eye of the round steaks. *Food Technology, 19,* 834.

Goss, J., Holcomb, R.B., & Ward, C.E. (2002). Factors influencing consumer decisions related to "natural" beef in the Southern Plains. *Journal of Food Distribution Research, 33*, 73-84.

Jekanowski, M.D., Williams II, D.R., & Schiek, W.A. (2000). Consumers' willingness to purchase locally produced agricultural products: an analysis of an Indiana survey. *Agricultural and Resource Economics Review, 29,* 43-53.

Kenney, J. & Fallert, D. (1989). Livestock hormones in the United States. *National Food Review, 12*, 21-24.

Kerth, C.R., Braden, K.W., Cox, R., Kerth, L.K., & Rankins Jr., D.L. (2007). Carcass, sensory, fat color, and consumer acceptance characteristics of angus-cross steers finished on ryegrass (*Lolium multiflorum*) forage or on a high-concentrate diet. *Meat Science, 75*, 324-331.

Kidwell, J.F. & McCormick, J.A. (1956). The influence of size and type on growth and development of cattle. *Journal of Animal Science, 15*, 109-118.

Klont, R. E., Brocks, L., and Eikelenboom, G. (1998). Muscle fibre type and meat quality. *Meat Science, (Suppl. 1) 49*:219–229.

Klosterman, E. W. (1972). Beef Cattle Size for Maximum Efficiency. *Journal of Animal Science, 34*, 875-880.

Klosterman, E.W. & Parker, C.F. (1976). Effect of breed and sex upon feed efficiency in beef cattle. Ohio Agricultural Research and Development Center Bulletin, 1088.

Ledward, D.A., Johnston, D.E., & Knight, M.K. (1992). The chemistry of muscle-based foods. Pp 128-139. The Royal Society of Chemistry, Thomas Graham House, Science Park, Cambridge, U.K.

Leick, C.M., Behrends, J.M., Schmidt, T.B., & Schilling, M.W. (2011). Consumer selection of constant-weight ribeye, top loin, and sirloin steaks. *Meat Science, 87*, 66-78.

Loureiro, M.L. & Umberger, W.J. (2007). A choice experiment model for beef: what US consumer responses tell us about relative preferences for food safety, country-of-origin labeling and traceability. *Food Policy*. *32*:496-514.

Lusk, J.L. & Fox, J.A. (2000). Consumer valuation of beef ribeye steak attributes. Paper presented at the American Agricultural Economics Association annual meeting, Tampa, Florida, August.

Maino, J.J., Linton, A.C., & Brinks, J. J. (1981). Postweaning growth and carcass characteristics of various frame size steers on forage systems. *Journal of Animal Science, 52*, 232-240.

Mandell, I. B., Buchanan-Smith, J. G., & Campbell, C. P. (1998). Effects of forage vs grain feeding on carcass characteristics, fatty acid composition, and beef quality in limousin-cross steers when time on feed is controlled. *Journal of Animal Science, 76*, 2619-2630.

Martin, J.M. & Rogers, R.W. (2004). Review: forage-produced beef: challenges and potential. *Professional Animal Scientist, 20*, 205-210.

Martinand, J. M., & Rogers, R. W. (2004). Review: forage-produced beef: challenges and potential. *Professional Animal Scientist, 20*, 205-210.

May, S.G., Mies, W. L., Edwards, J. W., Williams, F. L., Wise, J. W., Morgan, J. B., Savell, J. W., & Cross, H. R. (1992). Beef carcass composition of slaughter cattle differing in frame size, muscle score, and external fatness. *Journal of Animal Science, 70*, 2431-2445.

Maynard, L.J., Burdine, K.H., & Meyer, A.L. (2003). Market potential for locally produced meat products. *Journal of Food Distribution Research, 34*, 26-37.

McCarthy, F. D., Hawkins, D. R., & Bergen, W. G. (1985). Dietary Energy Density and Frame Size Effects on Composition of Gain in Feedlot Cattle. *Journal of Animal Science, 60*, 781-790.

McClusky, J.J., Wahl, T.I., Li, Q., & Wandshneider, P.R. (2005). U.S. grass-fed beef: marketing health benefits. *Journal of Food Distribution Research 36*, 1-8.

McKenna, D.R., Roebert, D.L., Bates, P.K., Schmidt, T.B., Hale, D.S., Griffin, D.B., Savell, J.W., Brooks, J.C., Morgan, J.B., Montgomery, T.H., Belk, K.E., & Smith, G.C.. National Beef Quality Audit-2000: survey of targeted cattle and carcass characteristics related to quality, quantity, and value of fed steers and heifers. *Journal of Animal Science, 80*, 1212-1222.

Melroe, T.A. & Loe, E.R. (2007). Definitions and descriptions: conventional, natural, and organic beef production and consumption, Extension Extra. South Dakota State University Cooperative Extension Service.

Mennecke, B. E., Townsend, A. M., Haye, D. J., & Lonergan, S. M. (2007). A study of the factors that influence consumer attitudes toward beef products using the conjoint market analysis tool. *Journal of Animal Science, 85*, 2639-2659.

Moloney, A.P, Keane, M.G., Dunne, P.G., Mooney, M.T., & Troy, D.J. (2008). Effect of concentrate feeding pattern in a grass silage/concentrate beef finishing system on performance, selected carcass and meat quality characteristics. *Meat Science, 79*, 355-364.

Nuernberg, K., Dannenberger, D., Nuernberg, G., Ender, K., Voigt, J., Scollan, N.D., Wood, J.D., Nute, G.R., & Richardson, R.I. (2005). Effect of a grass-based and a concentrate feeding system on meat quality characteristics and fatty acid composition of longissimus muscle in different cattle breeds. *Livestock Production Science, 94*, 137-147.

Organic Trade Association (2004). The OTA manufacturer survey. Available at http://www.ota.com/pics/documents/2004SurveyOverview.pdf, accessed October 31, 2011. Greenfield, MA.

Page, J. K., Wulf, D. M., & Schwotzer, T. R. (2001). A survey of beef muscle color and pH. *Journal of Animal Science, 79*, 678-687.

Pirog, R. (2004). Consumer perceptions of pasture-raised beef and dairy products: An internet study, Report. Ames, IA: Leopold Center for Sustainable Agriculture, Iowa State University.

Realini, C. E., Duckett, S. K., Brito, G. W., Dalla Rizza, M., & De Mattos, D. (2004). Effect of pasture vs. concentrate feeding with or without antioxidants on carcass characteristics, fatty acid composition, and quality of uruguayan beef. *Meat Science, 66,* 567–577.

Roberts, S. D., Kerth, C. R., Braden, K. W., Rankins, D. L., Jr., Kriese-Anderson, L., & Prevatt, J. W. (2009). Finishing steers on winter annual ryegrass (Lolium multiflorum Lam.) with varied levels of corn supplementation I: Effects on animal performance, carcass traits, and forage quality. *Journal of Animal Science, 87*, 2690-2699.

Roininen, K., Arvola, A., & Lahteenmaki, L. (2006). Exploring consumers' perceptions of local food with two different qualitative techniques: laddering and word association. *Food Quality and Preference, 17*,20-30.

Schroeder, J.W., Cramer, D.A., Bowling, R.A., & Cook, C.W. (1980). Palatability, shelflife and chemical differences between forage- and grain-finished beef. *Journal of Animal Science, 50,* 852-859.

Sofos, J.N. (2008). Challenges to meat safety in the 21st century. *Meat Science, 78*, 3-13.

Sweeter, K. K., Wulf, D. M., & Maddock, R. J. (2005). Determining the optimum beef longissimus muscle size for retail consumers. *Journal of Animal Science, 83*, 2598-2604.

Tatum, J. D., Klein, B. J., Williams, F. L., Jr., & Bowling, R. A. (1988). Influence of diet on growth rate and carcass composition of steers differing in frame size and muscle thickness. *Journal of Animal Science, 66*, 1942-1954.

Thonney, M. L., Heide, E. K., Duhaime, D. J., Nour, A. Y. M., & Oltenacu, P. A. (1981). Growth and feed efficiency of cattle of different mature sizes. *Journal of Animal Science, 53*, 354-362.

Troxel, T.R. (2005). Natural and organic beef. FSA3103. Available at http://www.uaex.edu/Other_Areas/publications/PDF/FSA-3103.pdf, accessed October 31, 2011. Little Rock, AR: University of Arkansas Cooperative Extension Service.

Tume, R.K., & Yang, A. (1996). Fat color in beef. *Meat Focus International*(March), 81.

Umberger, W.J., Boxall, P.C., & Lacy, R.C. (2009). Role of credence and health information in determining US consumers' willingness-to-pay for grass-finished beef. *Australian Journal of Agricultural and Resource Economics, 53*, 603-623.

Umberger, W.J., Feuz, D.M., Calkins, C.R., & Sitz, B.M. (2003). Country-of-origin labeling of beef products: U.S. consumers' perceptions. *Journal of Food Distribution Research, 34*, 103-116.

United States Standards for Livestock and Meat Marketing Claims, Grass (Forage) Fed Claim for Ruminant Livestock and the Meat Products Derived From Such Livestock; Notice, 72 Federal Register 199 (16 Oct. 2007), pp.58631-58637.

USDA-AMS. Grain fed diet clarification. http://www.ams.usda.gov/AMSv1.0/getfile?dDocName=STELPRDC5071196. Accessed Oct. 25,2011.

USDA-AMS. Grass fed marketing claim standards. http://www.ams.usda.gov/AMSv1.0/ams.fetchTemplateData.do?template=TemplateN&navID=GrassFedMarketingClaimStandards&rightNav1=GrassFedMarketingClaimStandards&topNav=&leftNav=GradingCertificationandVerfication&page=GrassFedMarketingClaims&resultType=&acct=lss. Accessed Oct. 25, 2011.

USDA –AMS. National Organic Program: Organic Standards. http://www.ams.usda.gov/AMSv1.0/ams.fetchTemplateData.do?template=TemplateN&navID=OrganicStandardsLinkNOPNationalList&rightNav1=OrganicStandardsLinkNOPNationalList&topNav=&leftNav=&page=NOPOrganicStandards&resultType=&acct=nopgeninfo. Accessed Oct. 25, 2011.

USDA-AMS. National Organic Program: What is Organic? http://www.ams.usda.gov/AMSv1.0/ams.fetchTemplateData.do?template=TemplateC&navID=NationalOrganicProgram&leftNav=NationalOrganicProgram&page=NOPConsumers&description=Consumers&acct=nopgeninfo. Accessed Oct. 25, 2011.

USDA-AMS. Naturally Raised Marketing Claims. http://www.ams.usda.gov/AMSv1.0/ams.fetchTemplateData.do?template=TemplateN&navID=NaturallyRaisedMarketingClaimStandards&rightNav1=NaturallyRaisedMarketingClaimStandards&topNav=&leftNav=GradingCertificationandVerfication&page=NaturallyRaisedMarketingClaims. Accessed Oct. 24, 2011.

USDA-FSIS. Fact Sheet: Country of Origin Labeling for Meat and Chicken. http://www.fsis.usda.gov/factsheets/COOL_Meat_and_Chicken/index.asp#.TrA2pKG3AS8.email. Accessed Nov. 1, 2011.

USDA-FSIS. Fact Sheet: Food Labeling. http://www.fsis.usda.gov/factsheets/meat_&_poultry_labeling_terms/index.asp. Accessed Oct. 25, 2011.

USDA-My Plate. Food Groups: Daily Recommendations. http://www.choosemyplate.gov/foodgroups/proteinfoods_amount_table.html. Accessed on Nov. 4, 2011.

Van Kleef, E., van Trijp, H.C.M ., & Luning, P. (2005). Consumer research in the early stages of new product development: a critical review of methods and techniques. *Food Quality and Preference, 16,* 181-201.

Warren, H. E., Scollan, N. D., Nute, G. R., Hughes, S. I., Wood, J. D. & Richardson, R. I. (2008). Effects of breed and a concentrate or grass silage diet on beef quality in cattle of 3 ages. II. Meat stability and flavor. *Meat Science, 78,* 270–278.

Washburn, L.E., Matsushima, J., Pearson, H.E. & Tom R.C. (1948). Nutrient utilization by compact and conventional type of shorthorn steers. *Journal of Animal Science, 7,* 127.

Woodward, R.P., Clark, R.T., & Cummings, J.N. (1942). Studies on large and small type Hereford cattle. Montana Agricultural Experiment Station Bulletin, 401.

Young, L. R., & Nestle, M. (2002). The contribution of expanding portion sizes to the US obesity epidemic. *American Journal of Public Health, 92*, 246-249.

Appendix A.

Sensory Panel Sample Sheet

Name_____ Date_____ Project_____

Sample Number	Initial Juiciness	Sustained Juiciness	Initial Tenderness	Sustained Tenderness	Flavor Intensity	Off Flavor	Off Flavor Descriptor

Juiciness	Tenderness	Flavor Intensity	Off Flavor	Off Flavor Descriptors
8=Extremely Juicy	8=Extremely Tender	8=Extremely Intense Beef	8=Extreme Off Flavor	8=Metallic
7=Very Juicy	7=Very Tender	7=Very Intense Beef	7=Intense Off Flavor	7=Salty
6=Moderately Juicy	6=Moderately Tender	6=Moderately Intense Beef	6=Very Off Flavor	6=Livery
5=Slightly Juicy	5=Slightly Tender	5=Slightly Intense Beef	5=Moderate Off Flavor	5=Grassy
4=Slightly Dry	4=Slightly Tough	4=Slightly Bland	4=Modest Off Flavor	4=Bitter
3=Moderately Dry	3=Moderately Tough	3=Moderately Bland	3=Small Off Flavor	3=Bloody
2=Very Dry	2=Very Tough	2=Very Bland	2=Slight Off Flavor	2=Rancid
1=Extremely Dry	1=Extremely Tough	1=Extremely Bland	1=No Off Flavor	1=Other - Explain

Appendix B.

Sample Consumer Survey

Consumer Preferences for Beef

Auburn University
Department of Animal Science and
Department of Agricultural Economics and Rural Sociology
Auburn, AL 36849

The purpose of this survey is to understand Alabama consumers' preferences when buying beef. We hope you will enjoy completing this survey about your beef preferences, and we greatly appreciate your participation.

Consumer Beef Steak Preferences

1. Do you consume beef?

_____Yes

_____No → *Your survey is complete. Thank you for your participation.*

2. Do you purchase beef to cook at home?

_____Yes

_____No → *Your survey is complete. Thank you for your participation.*

3. Please examine the beef steak options on the table and the accompanying cards.

If you were to purchase a steak today, please rank your most preferred option (1st choice) to your least preferred option (7th choice)?

_____1st choice

_____2nd choice

_____3rd choice

_____4th choice

_____5th choice

_____6th choice

_____7th choice

4. What percentage of the food shopping do you do for your household?

☐ 0-25%

☐ 26-50%

☐ 51-75%

☐ 76-100%

5. What does the term "local" mean to you?

_____Produced in the U.S.

_____Produced in the Southeastern U.S.

_____Produced in Alabama

_____Produced in Alabama and within 50 miles from where I live

_____Produced in Alabama and within 25 miles from where I live

_____ I do not know

6. How frequently do you buy beef steak?

- ☐ Very rarely (0 to 5 times a year)
- ☐ Rarely (6 to 11 times a year)
- ☐ Monthly (12 times a year)
- ☐ Regularly (2-3 times a month)
- ☐ Very regularly (4 or more times a month)

7. Do you care where your beef steak is produced?

- ☐ Yes
- ☐ No

8. When you purchase beef steaks, how often do you buy them at the following locations?

	Very rarely (0 to 5 times a year)	**Rarely (6 to 11 times a year)**	**Monthly (12 times a year)**	**Regularly (2 to 3 times a month)**	**Very regularly (4 or more times a month)**
At a typical grocery store such as Kroger and Win Dixie	☐	☐	☐	☐	☐
At a large specialty grocer such as Whole Foods and Earth Fare	☐	☐	☐	☐	☐
At a small health/natural foods store or a food co-op	☐	☐	☐	☐	☐
At a Farmers' Market	☐	☐	☐	☐	☐
Directly from a producer's farm	☐	☐	☐	☐	☐

9. When you purchase beef steaks, what city do you most often buy them in?

_____

10. On average, where is most of the meat you buy produced?

- ☐ The U.S.
- ☐ The Southeastern U.S.
- ☐ Alabama
- ☐ Alabama and within 50 miles from where I live
- ☐ Alabama and within 25 miles from where I live
- ☐ I do not know

10. Next, we would like to ask you some questions about beef cattle.

*Most beef comes from **"standard"** sized cattle. Adult beef cattle are typically 1,200 pounds and produce about 740 pounds of bone-in beef. A common 1 inch thick T-bone steak from a standard cow is between 1.0 and 1.5 pounds.*

***"Miniature"** is a type of beef cattle that is bred to have a smaller frame. Adult miniature cattle are typically 250 to 475 pounds produce about 130 to 250 pounds of bone-in beef. A common 1 inch thick T-bone steak from a miniature cow is between 0.4 and 0.75 pounds.*

	Strongly agree						**Strongly Disagree**
It would be easier to control portion size with beef steaks from miniature cattle.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
Limiting the portion size of the beef steak I eat is important to me.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
The next time I eat beef steak, I plan to choose smaller a cut of meat.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
If I ate beef steak from miniature cattle I would not tell my family.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
I do not like small sized beef steaks.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
Naming small framed cattle "miniature" is a bad idea.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
My family would not eat beef steaks from miniature cattle.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
Most Americans will enjoy eating steaks from miniature cattle.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
My family would think miniature cattle are pets rather than farm animals.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
I do what my family thinks I should do.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
Buying steaks from miniature cattle is a good way to control my serving size.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
My family is not concerned with the size of beef steaks that I eat.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
Most people who are important to me think I should eat smaller portions of beef steak.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
I would be willing to eat beef steak from miniature cattle.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
I think miniature cattle are pets rather than farm animals.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7

11. And now a few background questions to help us know if we've surveyed all different kinds of people in Alabama.

What month and year were you born?

_____MM

_____YYYY

12. What is your gender?

☐ Female

☐ Male

13. Are you Spanish, Hispanic or Latino?

☐ Yes

☐ No

14. Do you consider yourself . . . ? (feel free to select more than one)

☐ Asian

☐ Black or African American

☐ White

☐ Other (please specify)_____

15. What best describes your highest level of education?

☐ Less than 12^{th} grade

☐ High school or GED

☐ Some college, no degree

☐ 2 year college degree (Associate, Technical, etc.)

☐ 4year college degree (Bachelor's)

☐ Graduate or professional degree (Master's, Ph.D., M.B.A., etc.)

16. Are you married?

☐ Yes

☐ No

17. How many children live in your household?

- ☐ Number of children 0 to 6 years old
- ☐ Number of children 7 to 17 years old

18. How many adults, including yourself, live in your household?

- ☐ Number of adults 18 to 64 years
- ☐ Number of adults 65 years or more

19. While category best describes your current employment status?

- ☐ Employed full-time
- ☐ Employed part-time
- ☐ Unemployed
- ☐ Retired
- ☐ Student

20. Which category best describes your family's total income?

- ☐ Less than $10,000
- ☐ $10,000 to $25,000
- ☐ $25,000 to $50,000
- ☐ $50,000 to $75,000
- ☐ $75,000 to $100,000
- ☐ $100,000 or more

Thanks again for completing this survey!

If you have any additional thoughts about buying or consuming beef, please share them here.

Appendix C.
Sample Beef Option Cards

Option A	Option B
9oz size Grain fed Traceable to farm Average price	9oz size Grass fed Traceable to processor 10% Above Average price
Option C	**Option D**
9oz size Grain fed Traceable to Country 10% Above Average price	9oz size Grass fed Traceable to farm 25% Above Average price
Option E	**Option F**
18oz size Grain fed Traceable to farm 25% Above Average price	18oz size Grass fed Traceable to Country Average price

Option G
18oz size Grass fed Traceable to processor 10% Above Average price