TENDERNESS AND SENSORY ATTRIBUTES OF PASTURE VERSUS GRAIN FED BEEF AGED 14 AND 28 DAYS

By

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CHAPTER I

INTRODUCTION

Consumer interest in pasture versus grain fed beef has been on the rise in recent years. This interest could be sparked by public concerns of beef management techniques and processing impacts on the nutrition and safety of their food, as well as the environmental impact of each management type. In past years, consumers desired beef with good taste, convenience, nutrition, variety, and price; however, today, consumers want all of those benefits plus they want product produced humanely and in a sustainable, environmentally friendly manner. Even with consumers peaked interest in pasture fed beef, the amount of pasture fed beef has not drastically increased. Smith (2015) reported in the years 2004-2007 grass fed beef production was less than 0.1% of the industry and in 2014 grass fed beef made up 0.07% of beef production, while grain fed beef was at 91% and 93.72%, respectively; the remaining percentages were made up of natural, never ever, NHTC, and organic beef.

In the U.S., it is common to background cattle in the stocker stage on forage before sending them to a feedlot to be finished on a greater energy, grain based diet. Conventionally finished cattle are typically in the feedlot for 100 to 200 d, or 3 to 6 mo, before slaughter (Umberger et al., 2002). Finishing cattle in this manner allows for more intramuscular fat to deposit in the meat, while also giving the meat a flavor more

common to consumers in the U.S. grain fed beef production differs from pasture fed, because grass fed cattle are grown solely on forages.

Even though there is only a select group of people who prefer it in the U.S., in other countries grass fed beef is very popular, because of varying climates grass fed beef is the predominant feeding regime (Sitz et al., 2005). There is certainly a niche market for grass fed beef, as there are particular groups of consumers that prefer it. Pasture fed beef has received attention from health conscious consumers. Consumers who thought grass fed beef was safer to consume were 12.1% more likely to choose it (Umberger et al., 2009b). Some producers also have had peaked interest in pasture fed beef production. Certain producers want to be able to capitalize on the niche market, while others were looking for alternatives to the high grain prices that struck during times of drought, and in some areas it may be the more viable, profitable option. Depending on the climate, pasture feeding may be the more affordable option, especially when it is efficiently managed. Grass fed beef typically receives a premium at market, because of the additional input costs (Martin and Rogers, 2004). These additional costs could be caused by increased processing costs, longer production times, feeding season limitations, and more complex marketing schemes needed to target the niche customers. Consumers would have to be willing to pay at least a 10% premium for grass fed beef to offset production costs (Umberger et al., 2009b).

Research has shown consumer's preference of beef depends on 3 sensory components, which include tenderness, flavor, and juiciness (Killinger et al., 2001). Pasture fed beef has been documented as having a strong, grassy off-flavor when compared to grain fed beef (Xiong et al,, 1996; Garmyn et al., 2010). The overall liking

and flavor was ranked much greater in conventionally raised beef (Bjorklund et al., 2013). Grass fed steaks were also rated less tender and juicy by panelists when compared to grain fed steaks (Sitz et al., 2005).

The objective of this study was to evaluate the effects of different feeding regimes and postmortem aging times on palatability traits.

CHAPTER II

REVIEW OF LITERATURE

Grass Fed Beef

Grass fed beef is a product from cattle who have only been allowed to eat forages throughout their entire life. Historically, packers have discriminated against grass fed beef due to the yellow fat color and the darker, purple color of the lean (Mandell et al., 1998; French et al., 2001; Martin and Rogers, 2004; Realini et al., 2004). The color differences shown in grass fed beef are typically undesirable to consumers. Forage fed cattle are typically older at slaughter because it takes the cattle longer to attain the same body weight and degree of finish as compared to cattle fed a concentrate diet (Martin and Rogers, 2004). Berry et al. (1988) found carcasses obtained from alfalfa fed cattle had significantly less backfat than did concentrate fed cattle. Grass fed beef typically has less marbling, because these cattle are not receiving a high energy grain based diet (Mandell et al., 1998).

Umberger et al. (2009b) found, on average, consumers believe the nutritional value, eating quality, and food safety of grass fed beef to be greater than that of conventional beef by values of 54.6%, 48.3%, and 40.0%, respectively. Consumers who

thought grass fed beef was safer to consume than grain fed beef were 12.1% more likely to choose grass fed beef (Umberger et al., 2009b).

A premium would be needed for grass fed beef to remain profitable to produce. In order for producers to continue raising grass fed cattle, they will need to target those customers who are willing to pay premiums for grass fed beef. Consumers would have to be willing to pay at least a 10% premium more than grain fed beef in order for production to remain economically feasible for producers (Umberger et al., 2009b). This extra cost occurs because of the extended time it takes for grass fed cattle to reach their desirable end point. Grass fed cattle typically have lower live weights, carcass weights, and dressing percentages as shown in the studies by Davis et al. (1981) and Xiong et al. (1996).

More often than not feed costs are the greatest expenses for producers. In the right area, where the weather is beneficial to grass production, grass fed beef could be a more reliable, cheaper resource for producers. In certain areas of the U.S., grass feeding cattle would be a more sustainable option. Areas with adequate rainfall, good climates, and high cow-calf numbers would allow opportunity for producers to capitalize on grass feeding beef (Martin and Rogers, 2004). As grain prices fluctuate, the interest in feeding cattle on grass increases (Sapp et al., 1999). Grass fed beef is very popular in many other countries such as, Australia, Canada, New Zealand, and Brazil. In these countries, grass fed beef is the more predominate way of raising beef. For instance, the climate of Western Canada and other parts of North America promote the production of barley and other forages over concentrate grains. This would explain why barley is the primary energy source for cattle in these regions of the world (Jeremiah et al., 1998; Sitz et al.,

2005). Japan is also known for beef finished on barley (Miller et al., 1996). This article also states it is common to find enhanced flavor differences between cattle on a high barley diet versus a high energy grain.

Consumers are demanding products from local, natural, organic, and grass fed operations. Grass fed beef provides an alternative to consumers as they become more concerned about the origins of their food (Bjorklund et al., 2013). It is important for agriculturalists to capitalize on what consumers want. As people have begun to evaluate purchasing decisions, based on food origins, pasture fed beef has become an appealing alternative to many consumers (Steinberg et al., 2010). Health conscious consumers are particularly more interested in pasture fed beef (Steinburg et al., 2009).

Grain Fed Beef

Grain fed beef, otherwise known as conventionally raised beef, is the common form of beef in the U.S. Grain fed beef is the product from cattle who are finished on a high concentrate diet, typically including corn and other grains. Many consumers, particularly in the U.S., have become accustomed to the taste of grain fed beef and prefer the taste of conventionally raised beef (Daley et al., 2010). Grain fed beef typically has more marbling, a brighter, cherry red color of lean, and a whiter fat color (Mandell et al., 1998). Around 85% of the beef sold through retail outlets in the U.S. is grain fed (Feuz et al., 2004).

Most grain fed cattle are finished in a feedlot where hundreds to thousands of cattle are present in a single location. Cattle are typically fed in the feedlot for 100 to 200 d, or 3 to 6 mo, prior to slaughter (Umberger et al., 2002). Finishing cattle in this manner allows cattle to gain weight faster because of the higher energy intake (Martin and

Rogers, 2004). Cattle typically gain 1.1 to 1.8 kg per day while in the feedlot. By feeding cattle in large quantities, production costs are typically reduced, ultimately resulting in a lower product cost for the consumer.

When analyzing the carcass differences between pasture fed and grain fed beef, multiple differences have been found. Concentrate fed cattle, both live and carcass, have been found to be heavier weight than pasture fed cattle (Larick et al., 1987; Mandell et al., 1998; Realini et al., 2004; Garmyn et al., 2010). Carcasses have also had greater fat depth, ribeye area, and more degree of finishing in concentrate fed cattle (Realini et al., 2004). Garmyn et al. (2010) found grain fed cattle to have a greater percentage of KPH fat, a higher USDA calculated YG, and more visual marbling than forage finished cattle. Larick et al. (1987) also found grain fed cattle to have a larger ribeye area, more 12^{th} rib backfat, and more marbling. However, contrasting results from Miller et al. (1996) found no differences in HCW, ribeye area, KPH fat, or YG.

Research has shown that increasing the energy of the diet correlates to improved carcass quality, and ultimately, tenderness of meat (Larick et al., 1987). Finishing diet type impacts carcass characteristics, specifically fat deposition effects (Garmyn et al., 2010). Grain fed cattle typically have increased amounts of intramuscular fat and backfat, as well as increased carcass weight (Larick et al., 1987; Mandell et al., 1998; French et al., 2001; Realini et al., 2004; Garmyn et al., 2010). Concentrate fed cattle have also been shown to have increased ribeye area when compared to pasture fed cattle (Realini et al., 2004). However, Miller et al. (1996) found there to be no difference in carcass weight, ribeye area, or in final yield grade when comparing a barley diet with a corn fed diet, but

indeed found a difference in preliminary yield grade, final live weights, and increased marbling in concentrate fed cattle.

Additionally, grain feeding has more versatility, because it can be done year round, whereas grass feeding cattle has limitations due to changes in seasons of the year and peak grass production time. Grain feeding has allowed a greater turnover in cattle, because cattle are able to be sent to market at a younger age (Martin and Rogers, 2004).

Consumers who are involved in agriculture typically have preconceived notions as to which type of beef they would prefer to consume. Some of these opinions are based on knowledge of taste, while others could be influenced by price or belief. Umberger et al. (2009b) stated, "Consumers currently or previously involved in production agriculture were 14.2% less likely to prefer grass fed beef."

Palatability and Sensory

It has been proven a consumer's preference is largely impacted by the palatability of beef, including aspects such as tenderness and flavor (Xiong et al., 1996; Campo et al., 1999; Steinburg et al. 2009). Research on feeding regimes has been conducted in numerous studies to indicate whether or not there is indeed a difference between different feeding types.

Tenderness differences between grass fed and grain fed cattle have produced mixed results in previous studies. Concentrate fed cattle have been shown to have lower Warner-Bratzler (WBS) values (Berry et al., 1988; Sapp et al., 1999; Garmyn et al., 2010; Bjoeklund et al., 2013). These tenderness differences could be linked to a number of factors, which could include the age of the cattle. Often, forage fed cattle are older at the time of slaughter, because it takes them longer to reach their desired endpoint. Even with

the age impact being accounted for, Garmyn et al. (2010) still found a difference in tenderness. However, Realini et al. (2004), Mandell et al. (1998) and Berry et al. (1988) found no differences in tenderness when comparing pasture versus grain fed beef shear force values of the same age of cattle. There were also no differences in cooking or palatability attributes found by Jeremiah et al. (1998).

Cattle on high concentrate diets have a greater amount of marbling which results in increased palatability and flavor of the meat (Miller et al., 1996). There have been numerous studies, by both trained and untrained panelists, done to test the difference in palatability, flavor, juiciness, and overall ratings of grass fed and grain fed beef. Palatability ratings for grain fed beef were much higher as reported by Davis et al. (1981), Berry et al. (1988), Umberger et al. (2002), and Sitz et al. (2005).

Berry et al. (1988) and Garmyn et al. (2010) reported increased sensory tenderness values for initial and overall tenderness in the grain fed beef; however, other trained panels found there to be no differences in tenderness or in connective tissue (Sapp et al., 1999). Loins from grass fed steaks were reported as less tender and less desirable in flavor when compared to grain fed beef (Davis et al., 1981).

Sitz et al. (2005) utilized grain fed beef from the U.S. aged for 8 to 11 d, barley fed beef from Canada aged 24 d, and grass fed beef from Australia aged 67 to 73 d. Flavor, juiciness, tenderness, and overall acceptability were rated higher in grain fed beef (Sitz et al., 2005). In this study, samples were matched by WBS values. This allowed consumers to place focus on the flavor of the beef and, to no surprise, the largest sensory difference found was flavor (Sitz et al., 2005). Marbling scores did differ between feeding regimes; grain fed having increased marbling (Sitz et al., 2005). This, along with

the different aging times, could correlate to the sensory differences that were noted (Sitz et al., 2005). Consumers frequently noted off-flavors and off-odors in the Australian beef; Sitz et al. (2005) noted these differences could have been impacted by the extended period of aging. Campo et al. (1999) found that aging does influence the occurrence of off-flavors in grass fed beef; and Xiong et al. (1996) found that aging for 10 d alone caused off-flavors to double. Surprisingly, the consumers still rated the Australian beef to be the toughest and rated concentrate fed beef to be the most tender, even though WBS values did not differ (Sitz et al., 2005).

Flavor largely impacts what consumers want to purchase. If something does not taste appealing to a consumer they are less likely to buy. There have been distinguishable differences in flavor amongst forage fed and grain fed beef. Concentrate fed cattle had a greater beef flavor intensity, less grass or cow flavor intensity, and a greater painty or fishy flavor than the grass fed cattle (Garmyn et al., 2010). Garmyn et al. (2010) linked this more intense beef flavor to increased marbling of concentrate fed beef. A greater bloody, livery, and metallic aftertaste was found in samples from barley fed cattle when compared to corn fed animals, as well as an increased beef flavor in the corn fed cattle (Jeremiah et al., 1998). Miller et al. (1996) found no significant differences in palatability or in flavor differences between barley and corn finished beef, but noted there was more livery, bloody, and metallic aftertastes in barley fed cattle. Berry et al. (1988) found concentrate fed cattle to have an increased juiciness rating and increased beef flavor. Sapp et al. (1999) also found increased juiciness in grain fed beef and linked the differences to more marbling. Overall liking and flavor for conventional beef was much higher than that of grass fed beef (McCurdy et al., 1981; Bjorklund et al., 2013). Xiong et

al. (1996) and Mandell et al. (1998) found there was less beef flavor, along with more off-flavor in pasture fed cattle. Panelists rated grass fed beef as slightly unacceptable, regardless of aging times (Xiong et al., 1996).

Flavor has been shown to be more desirable, having less off-flavors in grain fed beef (Davis et al., 1981; Larick et al., 1987; Berry et al., 1988; Sitz et al., 2005). McCurdy et al. (1981) found that feeding regimes had a greater impact on muscles from less tender cuts, than on the more tender cuts such as the rib. The sensory differences consumers and trained panelists found could be linked to what the panelists are accustomed to. People in the U.S. are not typical consumers of grass fed beef for the most part, and can typically distinguish the differences between the two finishing types.

Aging

Aging and tenderness correlations have been evaluated in multiple studies. Increased tenderness through aging corresponds with proteolytic changes in myofibrillar proteins (Xiong et al., 1996). As stated by Campo et al. (1999), "Texture is the most influential factor in meat throughout aging, especially tenderness." Postmortem aging could be a very valuable tool for increased consumer satisfaction (Steinburg et al., 2009).

Realini et al. (2004) found pasture fed beef had a greater impact on tenderness and more extensive aging than did grain fed beef. The pasture fed beef was 1 kg and 0.6 kg lower in WBS values than grain fed beef at 7 d and 14 d, respectively (Realini et al., 2004). Sapp et al. (1999) and French et al. (2001) reported increased aging times correlated to an improvement in WBS values, as well as, increased sensory values of tenderness, texture, flavor, juiciness, chewiness, and acceptability.

Xiong et al. (1996) found aging to increase the off-flavors noted in grass fed beef. In grain fed beef aged longer there was no difference detected in flavor, unlike the grass fed beef. Tenderness was the main aspect effected by aging, increasing the tenderness in all treatment types. Juiciness also increased with aging times (Xiong et al., 1996). In this study, aging did not improve the organoleptic traits of grass fed beef, but it did increase acceptability of grain fed beef. Campo et al. (1999) detected differences in beef at d 1, 3, 7, 10, 14, and 21 postmortem, and they found with increased aging, and particularly at d 21, the liver odor intensity significantly increased.

Economics

Consumer demand for grass fed beef has spiked over recent years. This demand increase could be caused by a number of factors, some of which include: grass fed cattle being the more environmentally friendly option, consumers believe it is the more humane way to raise cattle, and they are interested in the additional health benefits it may provide. In 2002, there were around 50 beef producers raising grass fed beef, today there are more than 2,000 (K. Cross, 2011, cooking light, U.S., personal communication). This niche market has increased in size over recent years, however, in the grand scheme, the market, in general, is still very small making up for around 3% or less of total beef sales in the U.S. (K. Cross, 2011, cooking light, U.S., personal communication). Most producers see opportunity for this niche market, however, many remain hesitant due to the increased operating costs, marketing availability, shortage of processors, and continued questioning in the taste, palatability, and consistency of the grass fed beef products. It is important for producers to be able to offset the additional production costs by targeting specific customers who value the grass fed products and are willing to pay the extra value.

Consumers' willingness to pay is perhaps as important to the industry as any other factor. Consumers must be willing to buy what producers are offering. There are multiple factors that affect consumer's decision making, some of which include: flavor, juiciness, palatability, and overall acceptability of a product. Feuz et al. (2004) found as steaks became less tender, consumers ratings for all other factors (flavor, juiciness, tenderness, and overall acceptability) tend to decline. As these ratings declined, the consumers' willingness to pay for extra value also declined. An increase of only 1 kg in WBS led to a significant decrease in what consumers were willing to pay, decreasing the product's value by $0.52/kg ($0.24/lb) for steak (Feuz et al., 2004). This same study compared consumers' willingness to pay for beef raised conventionally in the U.S., Australian grass-fed beef, and Canadian barley-fed beef, as well as comparing aging methods. The U.S. grain fed beef had much higher ratings than the Australian or Canadian raised beef (Feuz et al., 2004). Marbling and tenderness levels had a significant impact on the consumers' preferences.

Demographics of people and location affect who purchases grass fed or grain fed beef. Women in large urban areas with relatively lower incomes and fewer children were most likely to pay a premium for grass fed products, working couples over 45 y old who had no children living at home were 12% and 16% more likely to pay a premium for ground beef and rib eye steaks, respectively, and people who perceived grass fed beef to be the healthy option were willing to pay more (Umberger et al., 2009a). However, on the other end of the spectrum, consumers who spend a majority of their income on grocery purchases, along with price sensitive consumers were less willing to pay the extra fee to

purchase grass fed beef. In 2009b, Umberger found older consumers or consumers who had children were less willing to purchase the more expensive grass fed beef.

Umberger et al. (2002) and Killinger et al. (2004) conducted studies which allowed consumers to decipher what they would be willing to pay for grass fed beef and grain fed beef. The studies were conducted in Chicago and San Francisco. Umberger et al. (2002) used steaks with similar tenderness values in order for consumers to solely focus their attention to the flavor of the meat. On average, consumers were willing to pay a premium of 30.6% more for grain fed beef. There were 62% of the panelists who were willing to pay $3.55 more per kg ($1.61/lb) for the corn fed beef, 23% were willing to pay a premium of $3.00 more per kg ($1.36/lb) for the grass fed beef, and 15% were indifferent (Umberger et al., 2002). Consumers rated domestic or corn fed steaks higher for juiciness, tenderness, flavor, and overall acceptability, and they were willing to pay more for the grain fed beef (Killinger et al., 2004). Killinger et al. (2004) found 61.5% of panelist were willing to pay more for grain fed beef, 19.7% were willing to pay more for grass fed beef, and the rest were indifferent. Sitz et al. (2005) found consumers were willing to pay more for conventionally raised beef than either Australian or Canadian forage fed beef.

These studies prove consumers have different taste preferences, some consumers prefer the flavor of grass fed beef, while others prefer the grain fed beef flavor. The study also indicates there is indeed a taste distinction between each kind. Additionally, it shows consumers are willing to pay a premium for beef containing the flavor characteristics they desire (Killinger et al., 2004).

Conclusion

In conclusion, consumers demand different types of beef based on what they are accustomed to, what they are willing to pay, and what they believe is healthy. Studies of grass fed and grain fed beef have mixed results, but one thing remains constant; flavor differences are noted. For grass fed producers, consistency of product could be an important factor when marketing their product to consumers. Grass fed beef provides producers with a unique niche market, but for producers to continue making profit it will be important to market the forage fed cattle to the right consumers. The increase in consumer demand proves the need for more research to be conducted on grass fed versus grain fed beef to determine if it is truly the product consumers believe it is and to determine if it will be effective for farmers to produce.

CHAPTER III

TENDERNESS AND SENSORY ATTRIBUTES OF PASTURE VERSUS GRAIN FED BEEF AGED 14 AND 28 DAYS

ABSTRACT

The objective of this study was to evaluate the effects of different feeding regimes and postmortem aging times on palatability traits. All cattle were on forage diets during the entire stocking period. For finishing, cattle were randomly assigned to either a conventional grain based diet or pasture finished on alfalfa. Conventionally finished cattle were fed for 94 d, and alfalfa cattle were on pasture for either 88 or 130 d. Average age of cattle at slaughter was 18.2 mo for concentrate fed and 18.9 mo for alfalfa finished. Strip loins (n = 107) were cut into 11, 2.54 cm thick steaks and vacuum packaged. The data were analyzed using the Mixed Procedure of SAS. Carcasses from concentrate finished cattle had a higher ($P < 0.05$) calculated yield grade, higher ($P < 0.05$) marbling scores, and were ($P < 0.05$) fatter than pasture fed cattle. There was no difference ($P > 0.05$) in ribeye area or KPH fat percentage between the feeding regimes. Protein and collagen percentages were not different ($P > 0.05$) between treatments. Grain fed beef had more fat ($P < 0.05$) and less moisture ($P < 0.05$) content than pasture fed

beef. When comparing all treatment types, 14 d grain and grass fed steaks had the lowest WBS values. There was an interaction ($P < 0.05$) between aging and feeding regimes for palatability traits. Grain fed beef, 14 and 28 d, was ranked higher for juiciness than grass fed beef at 14 and 28 d aging. The 28 d grass fed beef samples were rated as the least tender by panelists, while the 28 d grain fed beef samples were ranked as the most tender. Panelists rated grass fed beef to have less beef flavor and more grass off-flavor than grain fed beef at both 14 and 28 d. There was no difference ($P > 0.05$) in connective tissue amount between the aging and feeding regimes. The results indicate there is no difference in tenderness of grass fed versus grain fed steaks found by instrument; however, trained panelists could detect a difference in tenderness, juiciness, and flavor.

INTRODUCTION

Consumer interest in pasture versus grain fed beef has been on the rise in recent years. This interest could be sparked by public concerns of beef management techniques and processing impacts on the nutrition and safety of their food, as well as the environmental impact of each management type. In past years, consumers desired beef with good taste, convenience, nutrition, variety, and price; however, today, consumers want all of those benefits plus they want product produced humanely and in a sustainable, environmentally friendly manner. Even with consumers peaked interest in pasture fed beef, the amount of pasture fed beef has not drastically increased. Smith (2015) reported in the years 2004-2007 grass fed beef production was less than 0.1% of the industry and in 2014 grass fed beef made up 0.07% of beef production, while grain fed beef was at 91% and 93.72%, respectively.

In the U.S., it is common to background cattle in the stocker stage on forage before sending them to a feedlot to be finished on a greater energy, grain based diet. Conventionally finished cattle are typically in the feedlot for 100 to 200 d, or 3 to 6 mo, before slaughter (Umberger et al., 2002). Finishing cattle in this manner allows for more intramuscular fat to deposit in the meat, while also giving the meat a flavor more common to consumers in the U.S. grain fed beef production differs from pasture fed, because grass fed cattle are grown solely on forages.

Even though there is only a select group of people who prefer it in the U.S., in other countries grass fed beef is very popular, because of varying climates grass fed beef is the predominant feeding regime (Sitz et al., 2005). There is certainly a niche market for grass fed beef, as there are particular groups of consumers that prefer it. Pasture fed beef has received attention from health conscious consumers. Consumers who thought grass fed beef was safer to consume were 12.1% more likely to choose it (Umberger et al., 2009b). Some producers also have had peaked interest in pasture fed beef production. Certain producers want to be able to capitalize on the niche market, while others were looking for alternatives to the high grain prices that struck during times of drought, and in some areas it may be the more viable, profitable option. Depending on the climate, pasture feeding may be the more affordable option, especially when it is efficiently managed. Grass fed beef typically receives a premium at market, because of the additional input costs (Martin and Rogers, 2004). These additional costs could be caused by increased processing costs, longer production times, feeding season limitations, and more complex marketing schemes needed to target the niche customers. Consumers

would have to be willing to pay at least a 10% premium for grass fed beef to offset production costs (Umberger et al., 2009b).

Research has shown consumer's preference of beef depends on 3 sensory components, which include tenderness, flavor, and juiciness (Killinger et al., 2001). Pasture fed beef has been documented as having a strong, grassy off-flavor when compared to grain fed beef (Xiong et al,, 1996; Garmyn et al., 2010). The overall liking and flavor was ranked much greater in conventionally raised beef (Bjorklund et al., 2013). Grass fed steaks were also rated less tender and juicy by panelists when compared to grain fed steaks (Sitz et al., 2005).

The objective of this study was to evaluate the effects of different feeding regimes and aging periods on tenderness and consumer palatability.

METHODOLOGY

Cattle Management and Study Treatments

All procedures involving animals during the study were approved by the Institutional Animal Care and Use Committee. Animals were handled in a manner consistent with institutional regulations and standards set forth by the Guide for the Care and Use of Agricultural Animals in Agricultural Research and Teaching (FASS, 1999).

Cattle used in this experiment were finished at the USDA research station in El Reno, OK. All cattle were on forage diets during the entire stocking period. For finishing, cattle were randomly assigned to either a conventional grain based diet or pasture finished on alfalfa. Feed ingredients for grain fed cattle (% DM basis) consisted of 82.4% corn, 8.85% alfalfa hay, 3.0% cottonseed meal, 5.0% cane molasses, and 0.75% calcium

carbonate. Pasture raised cattle grazed regrowth alfalfa after first hay cutting and then grazed regrowth of subsequently grazed or hayed alfalfa areas. Conventionally finished cattle were fed for 94 d, and alfalfa cattle were on pasture for either 88 or 130 d.

The cattle were comprised of multiple different breeds. The breeds consisted of an Angus dam with an Angus or Red Angus sire, high percentage Angus dam with an Angus sire, F1 dam to Charolais sire, Red Angus dam to Red Angus sire, or old, large framed cows sired by Charolais or Angus bulls. There were both heifers and steers utilized in this experiment. The cattle ranged from 17-20 mo of age when slaughtered.

Slaughter

The pasture fed cattle were randomly assigned to 1 of 2 slaughter dates, at either 88 or 130 d. The first round of pasture fed cattle, fed to d 88, were slaughtered the same day as the conventional cattle fed to d 94. The second round of pasture fed cattle were slaughtered at 130 d. Cattle were slaughtered at a commercial beef processing facility in Amarillo, TX.

Strip Loin Preparation

After slaughter, strip loins (n = 107) were transported to the West Texas A&M campus, held for 7 to 10 d postmortem then transported to Oklahoma State University. Upon arrival at Oklahoma State University, strip loins were fabricated into 11, 2.54 cm thick steaks using a gravity slicer (model SE-12, Bizerba USA, Inc., Sandston, VA). From the rib end, steaks were numbered before individually being vacuum packaged. Steaks were then aged for either 14 or 28 d at 4ºC. At the end of each aging time, steaks were frozen at -20ºC. In each analysis, the same steak number from each loin was used to reduce anterior-posterior variation.

Proximate Analysis

Proximate analyses were conducted to determine the chemical percentages of protein, fat, moisture, and collagen of each strip loin. From the rib end, the eleventh steak was used for proximate analysis. The steaks used were aged for 14 d. Steaks were thawed at 4ºC for approximately 24 h. All exterior fat and connective tissue were removed before proximate analysis. Each sample was coarse ground through a table top grinder (Big Bite Grinder, 4.5 mm, fine grind, LEM). The ground samples were then tightly packed into a 140-mm sample cup before analysis and were analyzed using the NIR. Proximate analyses were conducted using an AOAC approved near infrared spectrophotometer (FoodScan Lab Analyzer, Serial No. 91753206, Foss, NIRsystems Inc., Slangerupgade, Denmark, 2014).

Instrumental Tenderness Analysis

From the rib end, the third steak was used for Warner-Bratzler (WBS) 14 d, the fourth steak was used for Slice Shear (SS) 14 d, the seventh steak was used for SS 28 d, and the eighth steak was used for WBS 28 d. Steaks were thawed at 4ºC for approximately 24 h before cooking. The steaks used for WBS and SS were cooked in an XLT Impingement Oven (model 3240-TS, BOFI Inc., Wichita, KS) at 200ºC to an internal temperature of 68ºC and allowed to temper to 71ºC. Temperatures were measured as the steaks exited the oven, if they had not yet reached 68ºC they were returned to the conveyor until they reached 68ºC. After cooking, WBS steaks were cooled at 4ºC for 18 h. Steaks were allowed to reach room temperature before coring. Six cores (1.27 cm in diameter), which were done by hand, were taken from the middle of the steak parallel to longitudinal orientation of muscle fibers so shearing action was perpendicular

to the longitudinal orientation of muscle fibers. For SS, the final temperature of steaks was recorded. The lateral of each steak was removed while still hot, a 1 cm thick, 5 cm long slice was cut parallel to the muscle fibers. A Warner-Bratzler Meat Shear fixture was used for WBS and a Flat Shear Blade was used for SS, these blades were attached to an Instron Universal Testing Machine (Model 5943, Instron Corporation, Norwood, MA). The crosshead speed was 200 mm/min and software utilized was Bluehill 3. Maximum load (kg) was recorded for each core or slice and the mean maximum load was calculated for the 6 WBS cores.

Trained Sensory Panel

Panelists were trained for evaluating tenderness, juiciness, connective tissue, specific flavor attributes prior to the panel (Cross et al., 1978). At least 7 panelists were seated for each session and evaluated no more than 15 samples per session (IRB approval number AG1511). From the rib end, the fifth steak was used for 14 d sensory and the sixth steak was used for 28 d sensory. Steaks were thawed at 4ºC for approximately 24 h before cooking and were cooked in an XLT Impingement Oven (model 3240-TS, BOFI Inc., Wichita, KS) at 200ºC to an internal temperature of 68ºC. Steaks were cut into 1-cm^3 pieces, 2 cubes were included in each sample cup, assigned a number at random and placed in warmers with hot packs to maintain temperature through sensory evaluation. Samples were evaluated under red lighting and panelists were provided deionized water and salt free crackers to cleanse the palette in-between samples. Panelists were asked to evaluate initial and sustained juiciness (15 = extremely juicy, 0 = extremely dry), initial and overall tenderness (15 = extremely tender, 0 = extremely tough), connective tissue (15 = abundant connective tissue, 0 = no connective tissue), beefy/brothy flavor (15 =

strong presence, 0 = no presence), and grassy off-flavor (15 = strong presence, 0 = no presence). Panelists recorded information using SIMS 2000 software, and the scale of 0 to 15 was a continuous scale.

Statistical Analysis

Least square means and SE were generated using the MIXED procedure of SAS (SAS 4.3; SAS Inst., Cary, NC). For instrumental tenderness and proximate analysis, the individual animals tag number served as the random effect. In trained panel analysis, the panelist was used as the random effect. For all analyses, when a significant F-test was identified ($P < 0.05$), least square means were separated using a pairwise t-test (PDIFF option).

RESULTS AND DISCUSSION

Carcass Characteristics

Results of carcass characteristics are presented in Table 1. Carcasses from cattle finished on concentrate diet had a higher ($P < 0.05$) calculated yield grade (YG), higher ($P < 0.05$) marbling scores, and were fatter ($P < 0.05$) than pasture fed cattle. Results agree with previous findings by Realini et al. (2004) and Larick et al. (1987) who both found grain fed cattle to have more fat depth. Additionally, Garmyn et al. (2010) found grain fed cattle to have a greater numerical YG. Lastly, Realini et al. (2004), Larick et al. (1987), and Garmyn et al. (2010) all found grain fed cattle to have more marbling. There was no difference ($P > 0.05$) in ribeye area or KPH fat percentage between the feeding regimes. Similarly, Miller et al. (1996) found no differences between grass and grain fed cattle in ribeye area or KPH fat percentage.

The final live weights and HCW were heavier ($P < 0.05$) in concentrate fed cattle. This is similar to findings of other researchers, where both live and HCW were heavier from concentrate fed cattle (Larick et al., 1987; Mandell et al., 1998; Realini et al., 2004; Garmyn et al., 2010). The ADG from June to kill date was different between the feeding types, concentrate fed cattle had a higher ($P < 0.05$) ADG. Pasture fed cattle were older ($P < 0.05$) at the time of slaughter, based on their months of age.

Pasture fed cattle had 14.49% dark cutters, while grain fed beef produced 2.70%. For pasture fed beef, 6 carcasses were 1/3 dark cutter, 3 carcasses were 2/3 dark cutter, and 1 carcass was full dark cutter. For grain fed beef, the dark cutter (n = 1) was 2/3s dark. These results align with previous findings where grass fed beef had a darker, purple color of the lean (Mandell et al., 1998; French et al., 2001; Martin and Rogers, 2004; Realini et al., 2004).

Proximate Analysis

Results of the treatment effect on proximate composition are displayed in Table 2. Protein and collagen percentages were not different ($P > 0.05$) between treatments. However, fat and moisture percentages were different ($P < 0.05$) between feeding regimes. Grain fed beef had more fat and less moisture content than pasture fed beef. This compares to other studies where moisture was inversely related to fat content (O'Quinn et al., 2012; Corbin et al., 2015). Similar to these results, Xiong et al. (1996) found moisture content was higher in pasture fed beef than in grain fed beef. O'Quinn et al. (2012) found as the USDA quality grades decreased, the fat level would also decrease.

Instrumental Tenderness

Results of the treatment and aging interaction effect on instrumental tenderness are displayed in Table 3. When comparing all 4 treatment types, 14 d grain and grass fed steaks had the lower WBS values than 28 d grain and grass fed steaks. This is not typical of aging times, but the average WBS values in this study were well below the 3.5 kg tenderness threshold. The effect aging has on tenderness differs from results found by Sapp et al. (1999) and French et al. (2001), who both found increased aging times to improve WBS values. Numerical SS values were not different ($P > 0.05$). Similarly, Realini et al. (2004), Mandell et al. (1998), and Berry et al. (1988) all found no difference in tenderness when comparing pasture versus grain fed beef shear force values. While there was not a difference ($P > 0.05$), SS results showed aging grass fed beef to have a greater impact on tenderness (having the larger reduction in SS value) than aging of grain fed beef. This is similar to the results of Realini et al. (2004).

Tenderness classes for WBS were established following protocol developed by Miller et al. (2001). Tenderness classes for SS were developed following guidelines by Wheeler et al. (2004). The percentages and actual numbers across the tenderness classes of tender, intermediate, and tough are displayed in Table 4 for WBS and Table 5 for SS. For WBS, pasture fed 14 d had 95.6% tender, 4.4% intermediate, and 0% tough, while pasture fed 28 d had 81.2% tender, 14.5% intermediate, and 4.3% tough. For WBS, grain fed 14 d had 97.3% tender, 2.7% intermediate, and 0% tough, and grain fed 28 d had 89.2% tender, 5.4% intermediate, and 5.4% tough. For SS, pasture fed 14 d had 56.5% tender, 36.2% intermediate, and 7.3% tough, while 28 d pasture fed had 58.0% tender, 37.7% intermediate, and 7.3% tough. For SS, grain fed 14 d had 56.8% tender, 43.2%

intermediate, and 0% tough, and grain fed 28 d had 56.8% tender, 35.1% intermediate, and 8.1% tough.

Trained Sensory Analysis

Results of treatment and aging interaction effect on sensory traits are displayed in Table 3. There was an interaction between feeding type and days aged ($P < 0.05$) in both initial and sustained juiciness. Grain fed beef, 14 and 28 d, was ranked higher for initial juiciness than grass fed beef at 14 and 28 d aging. Steaks aged 14 d and from cattle fed grain had the highest ($P < 0.05$) sustained juiciness scores, followed by 14 d pasture fed and 28 day grain fed. Berry et al. (1988) and Sapp et al. (1999) also found concentrate fed cattle to have an increased juiciness ratings.

While no difference in tenderness of pasture fed versus grain fed steaks were found by WBS or SS, there was an interaction ($P < 0.05$) in both initial and overall tenderness. The 28 d grass fed beef samples were rated as the least tender ($P < 0.05$) but statistically similar to 14 d pasture fed, while the 28 d grain fed beef samples were ranked the most tender. Increased sensory tenderness values for initial and overall tenderness in grain fed beef were also found by consumer panels conducted by Berry et al. (1988) and Garmyn et al. (2010). Panelists did not detect differences in connective tissue amount. These results compare to Sapp et al. (1999) who also found no difference in connective tissue amount.

There was a difference ($P < 0.05$) between aging and feeding groups in beef and grass flavor. Panelists rated grass fed beef aged 28 d to have the least ($P < 0.05$) beef flavor and the most ($P < 0.05$) grass off-flavor. Additionally, 14 d aged grass fed steaks had more ($P < 0.05$) grass-off flavor than 14 or 28 d aged grain fed steaks. Grain fed

steaks were rated similar ($P > 0.05$) by panelists for beef flavor and grassy flavor. This corresponds to previous findings where concentrate fed cattle had a greater beef flavor intensity and less grass off-flavor (Larick et al., 1987; Xiong et al., 1996; Mandell et al., 1998; Garmyn et al., 2010). Palatability ratings for grain beef were more acceptable as reported by Davis et al. (1981), Berry et al. (1988), Umberger et al. (2002), and Sitz et al. (2005). Sitz et al. (2005) utilized grain fed beef from the U.S. aged for 8 to 11 d, barley fed beef from Canada aged 24 d, and grass fed beef from Australia aged 67 to 73 d. The largest sensory difference identified in this study was flavor; however, juiciness, tenderness, and overall acceptability were also rated greater for grain fed beef (Sitz et al., 2005). Sitz et al. (2005) did note the additional off-flavor in the Australian beef could have been caused by the extended aging period. Campo et al. (1999) also found that aging influences the occurrence of off-flavors in grass fed beef. Xiong et al. (1996) found aging for 10 d alone caused off-flavors to nearly double in grass fed beef; however, in grain fed beef that was aged, there was no detectable flavor difference.

IMPLICATIONS

Consumers are becoming more concerned about the origins of their food, grass fed beef could provide a niche market for those consumers. Pasture feeding may provide more variety to the beef industry and be a viable option in many locations, as long as producers can make profit and the product can satisfy the consumer's needs. There were no instrumental differences in tenderness between feeding regimes. However, grain fed steaks were rated by trained panelists as more tender, more juicy, and more desirable in flavor, having a stronger beef flavor and less detectable grassy-off flavor than pasture fed

beef. Consumers in the United States have grown accustomed to the flavor of concentrate fed beef, and the flavor profile of grass fed beef is not as desirable. Although this study demonstrates the sensory characteristics of pasture fed beef are less desirable, there are still consumers who prefer to purchase grass fed beef, based on personal preferences.

Table 1. LS means ± SEM for carcass characteristics comparisons of grain and pasture fed cattle (n = 107)

Item	Grain fed	Pasture fed	*P*-value
Yield grade	2.20[a] ± 0.07	1.79[b] ± 0.05	< 0.05
Marbling score[z]	40.89[a] ± 0.96	34.62[b] ± 0.67	< 0.05
Fat thickness, cm[y]	0.71[a] ± 0.07	0.52[b] ± 0.05	< 0.05
Ribeye area, cm^2	79.94 ± 1.83	75.95 ± 1.27	0.08
KPH fat percentage	1.97 ± 0.04	1.92 ± 0.03	0.21
HCW, kg	306.38[a] ± 4.94	270.97[b] ± 3.42	< 0.05
June to kill ADG, kg	1.37[a] ± 0.04	1.01[b] ± 0.02	< 0.05
Slaughter weight, kg	531.55[a] ± 7.60	478.76[b] ± 5.27	< 0.05
Age, mo	18.23[b] ± 0.14	18.95[a] ± 0.09	< 0.05

[ab]LS means within a row that do not have common superscript differ ($P < 0.05$).
[y]Fat thickness measured between the 12th and 13th ribs.
[z]Marbling Score- 10= practically devoid; 20= traces; 30= slight; 40= small; 50= modest; 60= moderate; 70= slightly abundant; 80= moderately abundant

Table 2. LS means ± SEM for proximate composition of grain fed and pasture fed beef (n = 107)

Trait	Grain fed	Pasture fed	*P*-value
Protein, %	22.32 ± 0.10	22.52 ± 0.07	0.12
Fat, %	6.78[a] ± 0.32	5.45[b] ± 0.23	< 0.05
Moisture, %	68.85[b] ± 0.24	70.26[a] ± 0.18	< 0.05
Collagen, %	1.94 ± 0.06	2.05 ± 0.05	0.17

[ab]LS means within a row that do not have common superscript differ ($P < 0.05$).

Table 3. LS means ± SEM sensory analysis traits stratified by diet and days of age (n = 107)

	Grain fed		Pasture fed	
Item	14 d	28 d	14 d	28 d
Initial juiciness[1]	$9.31^{a} \pm 0.22$	$9.40^{a} \pm 0.22$	$9.11^{b} \pm 0.21$	$8.80^{c} \pm 0.21$
Sustained juiciness[1]	$9.36^{a} \pm 0.24$	$9.00^{c} \pm 0.24$	$9.16^{b} \pm 0.24$	$8.84^{d} \pm 0.24$
Initial tenderness[2]	$9.80^{ab} \pm 0.24$	$10.02^{a} \pm 0.24$	$9.66^{bc} \pm 0.24$	$9.57^{c} \pm 0.24$
Overall tenderness[2]	$9.85^{ab} \pm 0.29$	$10.07^{a} \pm 0.29$	$9.69^{bc} \pm 0.28$	$9.59^{c} \pm 0.28$
Connective tissue[3]	0.15 ± 0.40	0.09 ± 0.04	0.08 ± 0.03	0.11 ± 0.03
Beef flavor[4]	$8.20^{a} \pm 0.40$	$8.12^{ab} \pm 0.40$	$7.92^{b} \pm 0.40$	$7.20^{c} \pm 0.40$
Grassy flavor[4]	$0.59^{c} \pm 0.20$	$0.86^{c} \pm 0.20$	$1.29^{b} \pm 0.18$	$2.74^{a} \pm 0.18$
Warner-Bratzler shear, kg	$1.94^{b} \pm 0.12$	$2.62^{a} \pm 0.12$	$2.12^{b} \pm 0.09$	$2.67^{a} \pm 0.09$
Slice shear, kg	15.00 ± 0.92	15.84 ± 0.92	15.96 ± 0.67	15.70 ± 0.67

[abc]LS means within a row that do not have common superscript differ ($P < 0.05$).

[1]0 = extremely dry; 15 = extremely juicy

[2]0 = extremely tough; 15 = extremely tender

[3]0 = no connective tissue; 15 = abundant connective tissue

[4]0 = no presence; 15 = strong presence

Table 4. Percentages for Warner-Bratzler values across tenderness classes (n = 107)

	Pasture fed				Grain fed			
	14 d (%)	14 d (n)	28 d (%)	28 d (n)	14 d (%)	14 d (n)	28 d (%)	28 d (n)
Tender[1]	95.6 %	66	81.2 %	56	97.3 %	36	89.2 %	33
Intermediate[1]	4.4 %	3	14.5 %	10	2.7 %	1	5.4 %	2
Tough[1]	0 %	0	4.3 %	3	0 %	0	5.4 %	2

[1]Tender = WBS less than 3.5 kg, intermediate = WBS from 3.5 to 4.5 kg, tough = WBS over 4.5 kg.

Table 5. Percentages for Slice Shear values across tenderness classes (n = 107)

	Pasture fed				Grain fed			
	14 d (%)	14 d (n)	28 d (%)	28 d (n)	14 d (%)	14 d (n)	28 d (%)	28 d (n)
Tender[1]	56.5 %	39	58.0 %	40	56.8 %	21	56.8 %	21
Intermediate[1]	36.2 %	25	37.7 %	26	43.2 %	16	35.1 %	13
Tough[1]	7.3%	5	4.3 %	3	0 %	0	8.1 %	3

[1]Tender = SS less than 15 kg, intermediate = SS from 15 to 27 kg, tough = SS over 27 kg.

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APPENDICES

All procedures involving human test subjects were approved by the Oklahoma State University Institutional Review Board.

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VITA

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Candidate for the Degree of

Master of Science

Thesis: TENDERNESS AND SENSORY ATTRIBUTES OF PASTURE VERSUS GRAIN FED BEEF AGED 14 AND 28 DAYS

Major Field: Animal Science

Biographical:

Education: Completed the requirements for the Master of Science in Animal Science at Oklahoma State University, Stillwater, Oklahoma in May 2016; completed the requirements for the Bachelor of Science in Animal Science at Oklahoma State University, Stillwater, Oklahoma in 2014; Completed the requirements for the Associate of Science in Animal Science at Redlands Community College, El Reno, Oklahoma in 2012; Graduated from Mulhall-Orlando High School, Mulhall, Oklahoma in 2010.

Experience: Intern for Sure Champ at the Oklahoma Youth Expo, March 2013; Graduate Research Assistant at Oklahoma State University, 2014-2016; Employee at Pfeiffer Farms

Professional Memberships: American Meat Science Association, American Angus Association, Oklahoma Cattlemen's Association