Effects of feeding cattle calcium hydroxide treated corn stover during backgrounding on carcass characteristics and beef quality

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ABSTRACT

Sixty-seven purebred Angus steers (initial mean BW 197 kg.) were used to evaluate the effects of calcium hydroxide treated corn stover in backgrounding diets and a common finishing phase. Steers were randomly assigned to 1 of 4 dietary treatments: untreated corn stover (CON), corn stover treated with 50% DM water (H_2O); 50% DM, water and calcium hydroxide treated corn stover ($Ca(OH)_2$); grazing on a turnip cover crop (CC) for 29 days before adapted to ad libitum alfalfa haylage diet fed in feed bunks for remaining 20 d of backgrounding. Steers were fed individually using a Calan system for 49 days. All diets were formulated on a dry matter (DM) basis to contain 30% corn stover, 15% alfalfa haylage, 25% dried distillers grains with solubles, 25% dry rolled corn, and 5% supplement containing monensin. Upon completion of dietary treatments, steers were fed a common feedlot diet for 240 days. Steers were then harvested at a commercial abattoir, and carcass characteristics were recorded 48 hours postmortem. Strip loins and shoulder clods (IMPS #180 and #114) from the right side of the carcass were collected. All primals were transported to the University of Minnesota Meat Laboratory for further evaluation. Strip loins were fabricated into 2.54 cm steaks at 96 hours postmortem. Strip loin steaks were used to evaluate vacuum purge, cook loss, and Warner-Bratzler shear force (WBSF), color scores, as well as consumer acceptability. Shoulder clods were processed to ground beef for evaluation of subjective and objective color scores as well as Thiobarbituric Acid Reactive Substances (TBARS). Portions of ground beef were then processed into bologna to be evaluated for objective and subjective color as well as consumer acceptability. Dietary treatment had no effect on carcass characteristics including hot carcass weight (HCW) (P = 0.694), ribeye area (REA) (P = 0.259), 12th rib backfat (P = 0.780), marbling score (P = 0.845), USDA Yield Grade (P = 0.890), and USDA Quality Grade (P = 0.877). Although purge loss (P = 0.884) and cook loss (P = 0.149) were not affected by treatment, WBSF values were lower for CC than CON (1.6 v 2.23kg respectively; P = 0.001). Lean color scores for fresh steaks were affected by dietary treatment (P = .004). On day 5, CC (5.34) was less bright cherry red than CON (5.66; P = .017) and H_2O (5.76; P = .001). On day 7, CC (4.92) was less bright cherry red than CON (5.22; P = .032) and H_2O (5.29; P = .007). Overall desirability scores for fresh steaks differed (P = .011) among dietary treatments with H_2O being more desirable than CC on day 5 (5.35 v 4.93; P = .023) and $Ca(OH)_2$ was more desirable than CC on day 6 (5.36 v 4.98; P = .047). Discoloration scores for fresh steaks varied among treatments (P = .003). On day 5, CC (10.02) was more discolored than H2O (10.30; P = .019) and $Ca(OH)_2$ (10.32; P = .016). On day 6, steaks from CC were more discolored than H_2O steaks (9.27 v 9.57; P = .013). Day 7 fresh steak discoloration scores shows that CC (9.13) was more discolored than CON (9.42; P = .027), H_2O (9.5; P = .003), and $Ca(OH)_2$ (9.42; P = .024). Yellowness (b*) color values for ground beef varied among treatments (P = .025). Ground beef lean color as assed by a trained panel was affected by dietary treatment (P < .001). On day 0, H_2O (6.77) was less bright cherry red than CON (7.06; P = .022) and $Ca(OH)_2$ (7.13 P = .006). On day 1, CON (6.91) was more bright cherry red than H_2O (6.51; P = .012) and CC (6.52; P = .017). On day 2, CON (6.12) was more bright cherry red than H_2O (5.7; P = .006) and CC (5.7; P = .007). On day 3, CON (5.32) was brighter than CC (4.72; P < .001) and $Ca(OH)_2$ (4.98; P = .029), and H_2O was brighter than CC (5.1 v 4.72; P = .005). On day 4, CC (3.47) was less bright red than H_2O (3.90; P < .001) and CON (3.84; P = .006). Desirability scores were affected by dietary treatment (P < .001). On Day 0, H_2O (7.16) ground beef samples were less desirable than CON (7.39; P = .032) and $Ca(OH)_2$ (7.44; P = .016). On day 1, CON (7.21 was more desirable than H_2O (6.74; P = .005) and CC (6.77; P = .009). On day 2, CON (6.32) was more desirable than H_2O (5.80; P < .001) and CC (5.68; P < .001), and CC was less desirable than $Ca(OH)_2$ (5.68 v 6.04; P = .031). On day 3, CON (5.36) was more desirable than H_2O (4.93; P = .004), CC (4.54; P < .001) and $Ca(OH)_2$ (4.71; P < .001); H_2O was more desirable than CC (4.93 vs 4.54; P = .006). On day 4, CC (3.00) was less desirable than CON (3.46; P = .001) and H_2O (3.44; P = .016). On day 5, $Ca(OH)_2$ (2.14) was less desirable than CON (2.44; P = .039) and H_2O (2.43; P = .016). Discoloration scores for ground beef was affected by dietary treatment (P < .001). On day 2, H_2O was more discolored than $Ca(OH)_2$ (8.55 v 9.29; P = .039). On day 3, CON (8.83) was less discolored than H_2O (8.09; P = .028), CC (7.39; P < .001) and $Ca(OH)_2$ (7.59; P < .001); H_2O was less discolored than CC (8.09 v 7.39; P = .028). On day 4, H_2O was less discolored than CC (6.3 v 5.68; P = .034). In regards to steak sensory, no differences were found in flavor liking (P = 0.102), juiciness (P = 0.375), or off-flavor (P = 0.313). Differences were found in overall liking (P = 0.008) with CC being more liked than CON (P = 0.013) and $Ca(OH)_2$ (P = 0.019). Texture liking was affected by dietary treatment

($P < 0.001$), with CC higher than CON ($P < 0.001$), H_2O ($P = 0.021$), and $Ca(OH)_2$ ($P < 0.001$). Toughness scores were also affected by dietary treatment ($P < 0.001$) with CC having the lowest values compared to CON ($P < 0.001$), H_2O ($P = 0.015$), and $Ca(OH)_2$ ($P < 0.001$). For bologna sensory, no differences among dietary treatments were found for overall liking ($P = 0.610$), flavor liking ($P = 0.707$), texture liking ($P = 0.828$), juiciness ($P = 0.371$), and off-flavor ($P = 0.716$). A difference in toughness was found ($P = 0.011$) with H_2O being more tough than $Ca(OH)_2$ ($P = 0.008$). It was concluded that the use of calcium hydroxide treatment of corn stover in backgrounding diets of beef calves does not affect carcass characteristics or moisture loss, but does affect fresh and further processed beef characteristics. Although there were differences found among dietary treatments for meat characteristics, these differences do not appear to be large enough from a practical stand point to make a recommendation against the feeding of alkali-treated corn stover during calf backgrounding.

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CHAPTER 1.

REVIEW OF LITERATURE

INTRODUCTION

The United States is home to the world's largest fed-cattle industry, and in turn, is the world's largest producer of beef (USDA, 2015a). However, the number of livestock producers in the United States has decreased and caused a shift towards more specialized production practices (USDA, 2012). This decrease in stockmen and women has brought about the need to implement production practices that are more cost effective (USDA, 2012).

Feed costs generally make up about 60% of expenses for cattle feeding operations (DiCostanzo, 2015). According to the National Agriculture Statistic Service, grazing fees in 2014 averaged $19.90 per animal unit, up $1.60 from 2013. Land prices have also been at all-time highs with pasture and crop land averaging $1,200 and $4,000/acre respectively (NASS, 2014c). Labor is also a large cost to cattle producers. The number of workers willing to labor in the agricultural field has been on a steady decline since the 1950's (NASS, 2014b). The decreasing supply of people willing to work in agriculture has also created a need for higher wages for those willing to stay in or enter the industry. In 2014, the average pay rate for farm workers was $12 per hour (NASS, 2014b).

Other costs incurred by cattle producers include veterinary costs, fuel, repairs, implants, and yardage. The average breakeven cost for a Minnesota cattle producer who is backgrounding cattle is $0.86/pound with feed to gain efficiency and average daily gain being the biggest factors influencing the bottom line (DiCostanzo, 2015).

The size of the United States' cattle herd reached an all-time low in 2014 (USDA, 2015b). However, the 2015 herd is up 1% to 89.9 million head of cattle (NCBA, 2015). With the production of almost 90 million cattle and increasing input costs for producers, the need for economical feed is of increasing importance among cattle producers.

Growing Cattle

The amount of growth an animal can achieve within its lifetime is affected by many factors. According to Oddy et al., (2001), an animal's growth is heavily influenced by its genetic potential. Genetics can influence body composition, growth potential, and pattern of development (Oddy et al., 2001). Perry and Thompson (2005) determined that genetics play a very large role in influencing meat quality.

One of the most important aspects of growth when discussing feedlot cattle is muscle growth. Muscle growth is achieved by greater amounts of protein synthesis than protein degradation which can be affected by genotype, nutrition, and age (Oddy et al., 2001). Early in life, muscle and bone grow much faster than fat (Perry and Thompson, 2005). However, this growth rate can be manipulated by nutrition (McGregor et al., 2012). The nutritional quality of the feedstuffs in the diet influences the body weight gain throughout the growing and finishing phases (Lippke, 2002; Perry and Thompson, 2005; McCurdy et al., 2010).

Backgrounding

After weaning, there are two approaches to growing cattle to market weight. The first method is backgrounding which is a usually a two to six month period of grazing or feeding high quality forage to weaned calves to increase frame size before transferring the calves to the feedlot (Rasby, et al., 1994; Klopfenstein et al., 1999a; SAFRR, 2003; McCurdy et al., 2010). Backgrounding allows cattle to gain muscle and bone mass without substantial gains in fat (Rasby et al., 1994). This allows for producers to manage a group of calves that are more uniform in weight and carcass composition (Vaage, et al., 1998). Additionally, use of various management practices can manipulate body composition or weight of calves to fit into specific markets (Block et al., 2001).

Ideally, cattle that are small to moderate framed are the best candidates for backgrounding (SAFRR, 2003). Cattle that are large framed, are generally not backgrounded due to the possibility of having a carcass that is too heavy at an adequate backfat thickness for proper marbling (Drake, 2015). If a small framed animal was to be put directly into a feedlot, it has a higher chance of producing a very low carcass weight (Drake, 2015). McCurdy et al. (2010) found that backgrounding steers produced heavier body weights at slaughter compared to calf-fed steers.

There are many benefits to backgrounding. By keeping calves in the same area in which they were born, cow/calf producers can utilize local feed options, increase the value of their investment in their calves, and keep a calf supply readily available for feedlots in the area (SAFRR, 2003). Calves that are sold at an 800 to 900 pound body weight have much less price variability than calves sold in the 500 to 600 pound range (SAFRR, 2003). This lack of variability can improve producers' bottom line by providing a more stable breakeven price.

Backgrounding has not been found to hinder carcass traits such as marbling, flavor, or juiciness (Vaage et al., 1998; Klopfenstein et al., 1999a; Loken, et al., 2009).

Loken et al. (2009) found that backgrounding diets formulated for high gain or low gain did not affect dry matter intake, gain to feed efficiency, or average daily gain during the finishing period. In contrast, Vaage et al. (1998) found that backgrounded steers had a longer time on feed to reach a desired backfat thickness before slaughter compared to calf-fed steers.

In addition to less price variability, backgrounding cattle can allow feedlots to utilize compensatory gain (Klopfenstein et al., 1999a) which occurs after an animal has been feed restricted for a period of time. The longer an animal is feed restricted, the greater the amount of compensatory gain there will be (McGregor et al., 2012). Knoblich et al., (1997) found that compensatory gain allowed steers that had been feed restricted to finish at the same time as steers fed ad libitum. McGregor et al. (2012) stated that the use of compensatory gain reduces feed costs and overall production costs. However, compensatory gain does have some drawbacks. In a study comparing cattle that were fed a diet to maintain body weight for 154 to 190 days with cattle fed full feed diets, the cattle on restricted diets had a lower efficiency of converting protein to body tissue and utilized more dietary protein than their full feed counterparts (Fox et al., 1972). Cattle that are heavier-muscled at the time of feed restriction are less efficient at converting feed and will have less compensatory gain than cattle of the same age that are smaller framed and carry less body condition (Rasby et al., 1994; Klopfenstein et al., 1999b). Yearlings that have been feed restricted tend to be much more aggressive eaters than calves who have been backgrounded for a few months, which makes them more susceptible to acidosis and would hinder their ability to achieve compensatory gain (Klopfenstein et al., 1999a). One of the biggest drawbacks with utilizing compensatory gain is that it is difficult to predict (Klopfenstein et al., 1999b). Therefore, producers must pay attention to their cattle to decide when to stop restricting feed and when to allow an ad libitum consumption to begin.

British breeds are more suitable to use when practicing compensatory gain methods as was demonstrated by McGregor et al. (2012) who found that steak tenderness from British breeds was not affected by feed restriction, however tenderness was detrimentally affected in Continental breed cattle.

Feedlot managers generally prefer to purchase calves that have been backgrounded because the feedlot will have a higher turnover, less sickness, and the calves generally have developed the ability to put on consistent gains (SAFRR, 2003).

Calf-feeding

Upon arrival at the feedlot, cattle can have a variety of weights, ages, and nutritional backgrounds (Klopfenstein et al., 1999a). Since cattle are shipped to commercial abattoirs in groups, this can mean that cattle can be different sizes at finishing, detrimentally affecting yield and quality grades (Klopfenstein et al., 1999a). When a calf is taken directly from weaning to a feed lot, they are categorized as a "calf-fed". Calf-feds are placed directly on a high concentrate diet (Reuter and Beck, 2013). When calves arrive at the feedlot, they are given a receiving diet that is higher in forages than concentrates to acclimate to bunk feeding and to allow the rumen to adjust to the new diet (Watson et al., 2015). McCurdy et al. (2010) found that calf-fed steers grew faster than backgrounded steers with higher average daily gains during the growing phase, but then had lower average daily gains than backgrounded steers during the finishing phase. Despite the differences in growth rates, calf-feds and yearlings had similar carcass characteristics when they were grown to a similar end point and slaughtered at similar backfat thickness (Klopfenstein et al., 1999a).

Corn Stover

In 2015, 89.2 million acres of corn were planted across the United States, down from about 97 million acres in 2012 (NASS, 2014d). In 2014, the average yield of corn planted was 171 bushels per acre (NASS, 2014d) which translated to a record high 14.2 billion bushels of corn produced (NASS, 2014d). Despite the decline in number of acres planted, there is still a relatively under-utilized product that is left on the fields every year. That product is corn stover; the stalks, leaves, and cobs left in the field after corn harvest (Koundinya, 2009). Corn stover is the largest quantity of crop residue in the United States measuring between 196 million and 220 million tons annually (Graham et al., 2007; Glassner et al., 1998). According to Graham et al. (2007), the amount of grain produced annually directly determines the amount of collectible corn stover. In 2007, about 64.2 million dry tons of corn stover was collectable, of which 62% came from Iowa, Minnesota, and Illinois (Graham et al., 2007). However, corn stover does not need to be collected to be of use to cattle producers. When left on the field, one cow can be sustained for 30-45 days on one acre of corn stover (DeDecker and Gould, 2014).

Corn stover is a low cost forage (Watson et al., 2015). The price of corn stover ranges between $18-45 per bale depending on if it is purchased or baled off of land already owned by the cattle producer (Edwards, 2014). Even though corn stover is an acceptable feed source for both growing and finishing cattle, it is a very low quality forage (Watson et al., 2015). Digestibility of corn residues is generally around 50% (Klopfenstein, 1978), and one third of the protein content of average quality hay (DeDecker and Gould, 2014). Russell et al., (2011) found that as harvest of corn gets later, the nutritional value of the stover decreases. Crude protein and non-structural carbohydrates within the plant decrease while the fibrous components increase (Russell et al., 2011). Russell et al. (2011) also noted that as the grain yields increase, the non-structural carbohydrates within the stalk decreases. The reason corn stover is not very digestible is because corn stover is 15-20% lignin, which is an indigestible material found in corn stalks (Koundinya, 2009). The digestible portion of corn stover, cellulose and hemicellulose, is found in close association with the lignin which further inhibits the digestibility of stover (Mansfield et al., 1999).

In addition to low digestibility, corn stover is not very palatable due to its high dry matter content. Watson et al. (2015) found that high inclusion rates of corn stover in diets were a limiting factor for intake. Studies have evaluated whether the palatability and digestibility of corn stover could be increased by the addition of water to dry stalks. Ndlovu and Manyame (1989) found that dry mater intake increased after a 24 hour soak of corn stover in water. Water can be used to cause swelling of the structures within the cell wall (Ndlovu and Manyame, 1989). However, lignin limits swelling, and therefore limits cellulose accessibility (Mansfield et al., 1999).

Alkaline Treatment of Corn Stover

As previously mentioned, corn stover is a readily available feed source with limited digestibility (Klopfenstein, 1978). In addition to corn stover, studies have been conducted to evaluate the digestibility of husklage, wheat straw, oat straw, barley straw, rice straw, grass straw, and milo residue (Klopfenstein, 1978). Improving digestibility can create more uses for low quality forages (Watson et al., 2015). One of the most common areas of study on this subject is the addition of alkaline treatments directly to the stover. Alkaline treatments can break the bonds that hold lignin and cellulose or hemicellulose together to increase the digestibility of cellulose or hemicellulose without changing cellulose content (Klopfenstein, 1978). Treating corn stover with 5% CaO can increase dry matter and fiber digestibility (Duckworth, 2013). The addition of alkaline sources can increase the pH of stover from between 6.5-8.5 to about 12.5 (Schroeder, 2012). In addition to pH, time, temperature, and oxidative treatment all affect the improvement of digestibility (Kim, 2003). The four chemical treatments that are most commonly used are NaOH, $Ca(OH)_2$, KOH, and NH_4OH (Klopfenstein, 1978). The use of calcium oxide and calcium hydroxide are preferred over sodium oxide to reduce the amount of sodium loading on both the environment and the animals especially when the pH of the rumen may be lowered due to other feedstuffs (Haddad et al., 1995).

Alkaline treatment levels are generally between 3-5% (Klopfenstein, 1978). At this treatment level, the cost per ton to treat is about $20-30 (Combs, 2015). The amount of time it takes for the whole alkaline reaction to occur is about 5-7 days (Combs, 2015).

Including treated corn stover in feedlot diets can result in increased fiber digestibility while not detrimentally affecting ADG, feed efficiency, or ribeye area (Chapple, 2015). There is some discrepancy about whether or not inclusion of forage will affect marbling scores. Chapple (2015) determined there would be no decrease in marbling score with the inclusion of treated corn stover, but Russell et al. (2011) found that higher forage diets will decrease marbling scores in finished carcasses. The inclusion of treated corn stover produces different effects in growing and finishing diets (Watson et al., 2015). While there were no negative effects in feedlot diets, Watson et al. (2015) determined that treated corn stover is not always an economical inclusion in growing diets. Despite the findings of Watson et al. (2015), Shreck et al., (2014) found that an inclusion of 5% CaO on corn stover in a growing diet for steer calves increased average daily gain (ADG) 1.9% and body weight 3.2% resulting in significantly improved ADG and feed to gain. In a finishing study, cattle fed a diet with 20% inclusion of corn stover had significantly greater body weight, ADG, gain to feed efficiency, and hot carcass weight while marbling scores were not affected (Shreck et al., 2012). Steers fed a diet including corn stover treated at 5% on a dry matter basis of CaO and then wetted to 50% dry matter (DM) experienced higher live body weight, feed efficiency, ADG, 12th rib backfat, and hot carcass weight (Shreck et al., 2015). Fifteen percent of the intended grain inclusion of a finishing diet can be replaced with 5% CaO treated 50% DM corn stover without hindering live performance of feedlot cattle (Shreck et al., 2013). Russell et al. (2011) found that treating corn silage with CaO increased ADG, acid detergent fiber (ADF) and neutral detergent fiber (NDF) digestibility, and gain to feed compared to untreated corn silage and untreated baled corn stalks. USDA Yield Grade was significantly increased for carcasses from cattle fed treated corn silage and control diets compared to untreated silage and baled corn stalks (Russell et al., 2011). However, hot carcass weights did not differ between carcasses from cattle fed treated and untreated corn silage (Russell et al., 2011). Shreck et al. (2012), Russell et al. (2011), and Duckworth (2013) all concluded that there was no change in muscle score and ribeye area for carcasses from cattle fed corn stover.

Distillers Grains

Distillers grains are a by-product of corn from ethanol production (Gordon et al., 2002). Distillers grains are produced by combining the non-fermentable by-products of alcohol production (Kingsley et al., 2010). The production of distillers grains involves many steps. The starch is removed from the grain of choice and fermented using yeast to produce alcohol. Then, the fermented product is subjected to various process that are intended to remove the alcohol and water from the mash. The large particles are then removed from the stillage and can be sold as dried distillers grains. The stillage can then go through other processes to produce a thick syrup-like byproduct sold as condensed distillers solubles. Dried distillers grains can be combined with the condensed distillers solubles to produce dried distillers grains with solubles (DDGS; Stock et al., 1999). Distillers grains have higher concentrations of fiber, fat, and protein than the grain that was used to produce them due to the removal of starch during fermentation (Gordon et al., 2002).

Prices of corn have increased, which is challenging producers to adapt traditional production practices (Arias et al., 2012). Because of this, cattle producers have begun supplementing cattle diets with various forms of distillers grains. These co-products can be used for either energy or protein sources within the diet (Nuñez et al., 2014; Watson et al., 2015). However, since no two ethanol plants are the same, there is a large amount of variability in the chemical and physical properties of distillers grains (Kingsley et al., 2010). Therefore, cost, feeding value, and impact on carcass quality are all important factors in determining whether or not to include distillers grains in feeding programs (Aldai et al., 2010).

Distillers grains have not been found to be detrimental to carcass characteristics (Kelzer et al., 2011). There have been many studies to determine the effects of including various levels of distillers grains in feedlot diets. A majority of the literature agrees that distillers grains can be beneficial to both feedlot performance and feed costs. Many studies keep inclusion rates of distillers grains between 40% and 60%, however, there is no consensus over what the optimum inclusion rate of distillers grains should be in feedlot diets.

Watson et al. (2015) determined that the optimum supplementation rate was 1% of body weight for growing calves. A 25% inclusion rate was found to improve ADG and feed efficiency without having any negative carcass characteristics (Arias et al., 2012). Depenbusch et al., (2009) found that increasing the inclusion of DDGS above 15% decreased ADG, DMI, and body weight. Gunn et al., (2009) found that up to a 40% inclusion did not affect feedlot performance, but a 50% inclusion decreased feedlot performance. Gain increased as supplementation of dried distillers grains with solubles increased in a study conducted by Watson et al. (2015). Interestingly, dry matter intake decreased linearly with increasing inclusion of dried distillers grains with solubles (Felix et al., 2012). Arias et al. (2012) and Johnston (2014) found that including distillers grains in feedlot diets increased hot carcass weight.

There are a few challenges associated with feeding high levels of distillers grains. Gunn et al. (2009) found that increasing inclusion of DDGS in diets from 25-50%

decreased marbling scores, USDA Quality Grades, and color stability of ground beef during a retail display period. The amount of DDGS included in the diet is limited by the high concentrations of sulfur, oil, and protein within the feed (Russell et al., 2011). In a study conducted by Felix et al., (2012), increased levels of DDGS increased the dietary concentration of sulfates and lowered rumen pH. This created an unsuitable environment for rumen microbes and hindered the ability to digest fiber (Felix et al., 2012; Nuñez et al., 2014).

Cover Crops/Turnips

Cover crops are secondary crops used to break up soil compaction, manage soil erosion, grazing, and to improve the quality of crop residues (Mousel, 2012). The use of a cover crop can also reduce labor costs by extending the grazing season (Smart and Pruitt, 2015). There are many different types of forages that can be used as a cover crop including brassicas, cereals, legumes, summer annuals, and annual grasses (Mousel, 2012). One of the more common brassicas used in the upper Midwest is the turnip because it is highly digestible, cold tolerant, and has a high harvest efficiency (Mousel, 2012; Smart and Pruitt, 2015). Additionally, turnips are very high in protein (Lardy and Anderson, 2009). Unfortunately, turnips are not very drought resistant so use is limited to areas that receive adequate amounts of rain (Kinder, 2004).

Cattle can be grazed about 60 days after seeding of turnips but should be introduced to grazing slowly over the course of 3-5 days to prevent illness (Lardy and Anderson, 2009; Koch 2015). Grazing too early can result in small tubers that increase the risk of choking (Kinder, 2004). Turnips should only make up at the most 75% of an animal’s diet (Kinder, 2004). Failure to keep an alternate feed source accessible for the grazing cattle can result in bloat, hypothyroidism, atypical pneumonia, nitrate poisoning, polioencephalomalacia (Kinder, 2004).

MEAT QUALITY

Sensory Analysis

Customers at the retail case perceive meat quality to be defined by the characteristics that they deem desirable (Warner et al., 2010). The primary factors consumers are able to detect are color, odor, flavor, texture, and toughness (Oddy et al., 2001). A consumer study conducted by Reicks et al., (2011) determined that the most important factors customers consider when choosing a meat product are flavor, juiciness, and tenderness. These factors received 8.7, 8.6, and 8.2 on a 10 point scale respectively (Reicks et al., 2011). These three traits are what make up the general concept of palatability. The generalization of these three characteristics into palatability is known as the halo effect. The halo effect implies that a decrease in tenderness, juiciness, or flavor can lead to in a decrease liking of the other characteristics (Roeber et al., 2000). However, all three of these aspects can be manipulated by the consumer through cooking processes, seasoning, and the final temperature of the product after cooking, known as the degree of doneness (Lorenzen et al., 2003; Claborn et al., 2011). Miller et al, (2001) found that 78% of consumers would purchase steaks if they were guaranteed to be tender and be willing to pay higher price for this product. Therefore, research has been conducted to determine how to produce steaks with the highest palatability before they reach the customer.

Tenderness

With the willingness of consumers to purchase more steaks for a premium rate for a tender product, it is no surprise that there has been a large push for determining how ante mortem factors influence tenderness. Tenderness is affected by the structure of muscle fibers and the amount of collagen within the muscle and it is perceived by consumers as the force required to chew the product (Oddy et al., 2001). One of the most difficult obstacles to overcome with dealing with tenderness issues is that tenderness is variable among and within muscles of the same animal (Rhee et al., 2004). The consumer threshold for tenderness is between the shear force values of 3.6-4.6 kilograms (Shackelford et al., 1991). In another study, Miller et al, (2001) determined that consumers could detect increases in tenderness as shear force values decreased and they made the transition of calling a product tough or tender at a shear force value between 4.3-4.9kg. In contrast, a study conducted by Savell and Sitka (2007) did not find a correlation between WBSF values and tenderness ratings. This suggest that there may not be a single shear force value to determine tenderness and that shear force ratings for tenderness should be dependent on what muscle is being evaluated (Savell and Sitka, 2007).

Research has also been conducted on backgrounding diets on carcass tenderness. Loken et al. (2009) evaluated the differences in off flavor, tenderness, flavor, and juiciness among steaks from cattle fed backgrounding diets designed for either high gain of 1.25 kg/d or low gain of .91 kg/d. They found no significant differences in any of those sensory attributes between the two diets. Perry and Thompson, (2005) obtained similar results; finding no difference of shear force values based on the ADG during the backgrounding period. However, as already mentioned, cattle that are backgrounded may be slaughtered at a more advanced age due to the slower growth rate during their growing phase. A study conducted by Klopfenstein et al. (1999a) concluded that calf-fed cattle were significantly more tender than backgrounded cattle. Regardless of this finding, it is important to note that just because the shear force values were higher for backgrounded cattle, does not mean that the steaks from the backgrounded cattle were "tough" (Klopfenstein et al., 1999a). In that same study, Klopfenstein et al. (1999a) also noted that the time of year that gain occurs does not influence carcass quality.

Influences of Diets on Carcass Characteristics

Oddy et al. (2001) suggests that the nutrition an animal is subjected to can influence the carcass characteristics.

Gill et al., (2008) evaluated the effects of feeding diets with varying levels of corn or sorghum distillers grains to feedlot cattle. The results indicated that shear force, juiciness and flavor were not affected by a 15% inclusion of either type of distillers grains (DGs) in place of steam flaked corn. In contrast to the lack of differences in palatability characteristics, Gill et al. (2008) did find that steaks from cattle fed some form of distillers grains produced brighter color scores than the control diet. The most significant results found from the study conducted by Gill et al. (2008) were found within the fat characteristics. The steaks from the corn distillers grain steers had higher levels of conjugated linoleic acid (CLA) than steaks from steers fed sorghum distillers grains. Also, both diets produced steaks with higher CLA levels than the control diet. Moreover, the addition of distillers grains to the diet increased the proportion of 18:2 trans-10 cis-12 CLA compared to the steam flaked corn diet. The trans-10 cis-12 isomer of CLA has been shown to possibly inhibit lipogenesis. Despite the differences in CLA among diets, fatty acid proportions were not affected until they were grouped by structure. The fat from steers fed DGs contained higher levels of polyunsaturated fatty acids (PUFA; Gill et al., 2008; He et al., 2014). The higher levels of PUFA within the meat made it more susceptible to oxidation and reduced color stability (de Mello Jr. et al., 2008). In a similar study, WDGS were shown to increase PUFA and CLA cis-9 trans-11 CLA levels (de Mello Jr. et al., 2008)

Leupp et al., (2009) conducted a study to determine how including 30% DDGS into a feedlot diet would affect meat quality. The data showed that steaks from steers fed DDGS were juicier and more flavorful than steaks from steers fed the control diet.

Depenbusch et al. (2009) fed 6 levels of DDGS to feedlot heifers. Results from that study concluded that beef flavor intensity was the greatest for steaks from heifers fed 45% and 60% DDGS. Depenbusch et al. (2009) also observed that color brightness decreased in a linear fashion as the inclusion of DDGS in the diet increased. In agreement with Gill et al., (2008) CLA levels increased as the inclusion rate of DDGS increased within the diets of the heifers. Depenbusch et al. (2009) also observed that WBSF values decreased as DDGS inclusion rates increased

Kinman et al., (2011) conducted a study with 5 different diets including various levels of DDGS, WDGS, or steam flaked corn. The results of this study concluded that tenderness was not affected by the inclusion level or type of distillers grains that were fed (Kinman et al., 2011).

Aldai et al. (2010) fed feedlot cattle various levels of DDGS as part of a finishing diet. Results of this study concluded that the inclusion of DDGS in the diet decreased WBSF values and produced brighter colored steaks.

Klopfenstein et al. (1999a) conducted a study comparing backgrounded cattle during various times of the year to cattle who were placed in the feedlot immediately after weaning. The carcass characteristics of the cattle did not have many differences. Consumer panels results for juiciness and flavor did not differ between backgrounded yearlings and calf-feds slaughtered at similar backfat thicknesses.

CONCLUSION

With the increasing costs of beef production, the search for economical feeding and management practices is more important than ever. The abundance of corn stover is a great opportunity to utilize a low cost feed source to cheaply add pounds onto backgrounded cattle without sacrificing long term gain or carcass quality. The addition of calcium hydroxide to corn stover used as a feed source can help producers maximize the nutritional qualities of an otherwise low quality feedstuff to aid in lowering inputs and maximizing profit throughout the backgrounding phase of growth.

CHAPTER 2.

EFFECTS OF FEEDING CATTLE CALCIUM HYDROXIDE TREATED CORN STOVER DURING BACKGROUNDING ON CARCASS CHARACTERISTICS AND BEEF QUALITY

INTRODUCTION

The United States is home to the largest fed-cattle industry, which produces the most beef in the world (USDA, 2015a). In recent years, we have seen an upward trend in beef prices while 2014 saw a record high value of U.S. cattle and calf production topping out at $60.8 billion (USDA, 2015c). However, with the increase in cattle prices also came the increase in labor and land costs, with pasture and cropland prices reaching all-time highs in 2014 (NASS 2014b, NASS 2014c). These increases have been spurred by a rise in corn prices. With high land prices and low profit margins, farmers are attempting to utilize all parts of their crops including the stover which left on the ground after harvesting corn. While corn stover is a great bedding material for animals, it is relatively low quality when used as a feed source. The digestibility of corn residues is around 50 percent while the protein content is one third that of average quality hay (Klopfenstein, 1978; DeDecker and Gould, 2014; Watson et al, 2015). Due to the high dry matter content in corn stover, it is not very palatable when fed at a high percentage of the diet (Watson et al, 2015). Studies have been conducted to correct the low dry matter content in corn stover by adding water to stalks (Ndlovu and Manyame, 1989). However, the high lignin content limited swelling within the stalk and, by extension, limited cellulose accessibility (Mansfield et al, 1999). In attempt to break down the bonds holding lignin and the digestible components of corn stover, several studies have incorporated an alkaline treatment of corn stover prior to baling, wrapping or ensiling (Klopfenstein, 1978; Haddad et al., 1995; Kim, 2003; Schroeder, 2012). The use of an alkali treatment on corn stover increased nutrient availability (Chapple, 2015). Studies have demonstrated no effects on ribeye area or marbling score (Shrek et al., 2012; Duckworth, 2013; Watson et al., 2015). Russell et al., (2011) observed a decrease in marbling score with diets containing 20% DM corn stover or calcium oxide treated corn stover compared to a control diet that was absent of stover. Despite the plethora of research involving alkali-treated corn stover in cattle diets, a vast majority of the research has been done on the finishing phase of beef cattle, and little work has been done on its effect on fresh and processed meat quality.

In addition to the incorporation of alkaline-treated corn stover, a negative control group was added to this study. This treatment group was put out to graze on a cover crop of turnips for the duration of the backgrounding study.

Therefore, it is the objective of this study to determine the effects of feeding alkali-treated corn stover to steer calves during the backgrounding phase of production on carcass and further processed meat characteristics.

MATERIALS AND METHODS

Dietary Treatments

Animal management procedures were approved by the University of Minnesota Animal Care and Use Committee (1409-31794A). Sixty-seven purebred Angus steers (initial mean body weight 197 kg) were randomly assigned to 1 of 4 dietary treatments. The first treatment group of 16 steers was assigned to be backgrounded on a turnip cover crop (CC) for 29 days before being brought into a dry lot and adapted to an ad libitum alfalfa haylage diet for the remaining 20 days of the study. The remaining 3 dietary treatment groups of 17 steers were assigned to diets including corn stover. Cattle were trained to use a Calan gate system (American Calan, Inc., Northwood, NH) for two weeks. All diets, with exception to the CC treatment, were formulated on a dry matter (DM) basis to contain 30% corn stover, 15% alfalfa haylage, 25% dried distillers grains with solubles, 25% dry rolled corn, and 5% supplement. A diet containing untreated corn stover served as the control treatment (CON). The other diets included corn stover treated with 50% DM water (H_2O) or 50% DM water and 6% DM of calcium hydroxide ($Ca(OH)_2$). A vitamin and mineral supplement containing monensin was administered to all cattle to meet dietary requirements. Upon completion of the backgrounding phase, the steers were moved to University of Minnesota's Beef Research and Education Complex located at UMore Park (Rosemount Research and Outreach Center) in Rosemount, MN. They were fed a common finishing diet for 240 days.

Carcass Data Collection

Upon completion of the common finishing phase, cattle were transported to a commercial abattoir (Greater Omaha Packing Company Inc., Omaha, NE) and slaughtered when the average backfat of the group reached 1.02 cm as assessed visually. Forty-eight hours postmortem, carcasses were evaluated for hot carcass weight (HCW), ribeye area (REA), and 12th rib backfat by plant personnel. Marbling score, USDA Quality Grade, and USDA Yield Grade were collected by a USDA grader and recorded.

Fresh Beef Fabrication and Collection

Fresh beef primals were fabricated 48 hours postmortem by plant personnel according to Institutional Meat Purchasing Specifications (IMPS). Strip loins (IMPS #180) and shoulder clods (IMPS #114) were removed from the right side of the carcass and identified individually by tags that were cross-referenced to live animal identification numbers. The strip loins and shoulder clods were vacuum sealed and transported to the Andrew Boss Laboratory of Meat Science (ABLMS) on the St. Paul campus of the University of Minnesota. Shoulder clods were inspected for seal integrity, resealed if necessary, placed in a blast freezer at -20 ^oC and stored until further evaluation. Strip loins were processed immediately after arriving at ABLMS at 96 hours postmortem.

Strip Loin Preparation and Backfat Color

Strip loins were faced on the anterior end perpendicular to the length of the loin. Steaks were serially cut to 2.54 cm thick (automatic slicer, MHS Schneidetechnik GMBH, Abstatt, Germany). The first steak was designated for drip loss analysis, the second and third for shelf-life, the fourth and fifth for sensory analysis, the sixth and seventh for Warner-Bratzler shear force (WBSF) and cook loss analysis. A 50 g backfat sample was collected from the anterior end of each loin before cutting steaks. Six objective color readings (L*, a*, b*; Hunter Lab Miniscan EZ model 4500S, Reston, VA) were taken from each loin. The samples were then vacuum packaged, frozen, and stored at -20 ^oC.

Moisture Loss

Strip loins were evaluated for vacuum purge loss after transport and before fabrication. Loins were weighed before opening the packaging. Then the package was opened, and the loin removed. The loin and packaging were patted dry and weighed separately.

Vacuum Purge Loss (VPL) % = [(Initial weight - dry weight - package weight) / Initial weight] * 100

Cook loss was measured on steaks to be used for Warner-Bratzler Shear Force.

Warner-Bratzler Shear Force (WBSF)

Two serially cut steaks from each loin were weighed (Ohaus Navigator XL, Parsippany, NJ) wrapped in aluminum foil and cooked (Whirlpool RF263CXTB, Benton Harbor, MI) at 177 ^{o}C to an internal temperature of 71 ^{o}C when measured with a temperature probe (Thermoworks Super-Fast Thermopen, American Fork, UT) at the geometric center of the steak. Steaks were allowed to cool to room temperature where they were then re-weighed to calculate percentage cook loss.

Cook Loss % = [(raw weight - cooked weight) / raw weight] * 100

The steaks were then refrigerated at 2 ^{o}C for 24 hours, and then tempered to room temperature 25^{o} C. Steaks were trimmed to include only the *longissimus dorsi* muscle. Six cores measuring 1.27 cm in diameter were removed from the steaks using a hand corer in a parallel angle to the fiber direction within the steak. All 6 cores were sheared perpendicular to fiber direction using a texture analyzer with a WBSF attachment set to a test speed of 100 mm/min (Shimatzu Texture Analyzer, Model: EZ-SX, Kyoto, Japan). The average of all 6 cores was taken as a representation of entire loin tenderness.

Fresh Steak Retail Shelf Life

Duplicate steaks designated for retail display were placed on polystyrene trays with polyvinylchloride (PVC) overwrap (oxygen transmission rate 1400 cc/m2) and stored under cool white fluorescent lighting (Sylvania H968, 100w, 2, 640 LUX) at 2 ^{o}C for seven days. Objective color values (CIE, L*, a*, and b*) were taken every 24 hours at three locations on each steak (Hunter Lab Miniscan EZ model 4500S, Reston, VA).

Subjective color scores of lean color, surface discoloration, and overall acceptability were evaluated by a trained panel (n=10). Panelists evaluated the samples daily for seven days. Lean color was scored on a scale of 1 to 8 with 1 being extremely brown and 8 being extremely bright, cherry red. Surface discoloration was evaluated on a scale of 1 to 11 with 1 being 91-100% discoloration and 11 being 0% discoloration. Overall acceptability was evaluated on a scale of 1 to 8 with 1 being extremely undesirable and 8 being extremely desirable (AMSA, 2012).

Steak Sensory Evaluation

One hundred thirty panelists were recruited by the University of Minnesota Food Science and Nutrition Sensory Center to participate in fresh beef sensory evaluation. Panelists were untrained, at least 18 years of age, had no food allergies, and consumed beef at least twice per month. The University of Minnesota Institutional Review Board approved the procedures used for utilizing human subjects for consumer panel evaluation of sensory attributes. Panelists were compensated for their time.

Steaks were thawed at 2 °C for 48 hours. Once thawed, steaks were individually wrapped in aluminum foil and cooked to an internal temperature of 71° C, as measured by a temperature probe (Pyrex Professional Acurite Thermometer; Racine, WI) placed in the geometric center of the steak, in a standard kitchen oven (General Electric® Range, JAS02; Fairfield, CT) heated to 177°C. The *longissimus dorsi* muscle was then removed from the steak, cut into cubes (1cm X 1cm X 2.54cm), and transferred into double boilers to keep the samples warm before distribution to the panelists.

Panelists were allotted 2 pieces of each sample distributed in lidded 60 ml plastic cups. The panelists were asked to consume one piece of steak and evaluate it for overall liking, liking of flavor, and liking of texture. Panelists were then asked to consume the second piece of steak and rate the toughness, juiciness, and off flavor intensity of the sample. The scales available to the panelists were 120 point Labeled Affective Magnitude (LAM) scales for ratings for "liking" labeled from *strongest dislike imaginable* on the far left and *strongest like imaginable* on the far right, and 20 point unlabeled scales for ratings for intensity with the far left representing *none* and the far right representing *extremely* for off flavor, toughness, and juiciness.

Shoulder Clod Preparation

Shoulder clods were removed from frozen storage and held at 2 °C for 7 days. Clods (whole and untrimmed) were ground twice (Hobart 4156, Hobart Corporation, Troy, OH) through a 0.375 cm plate.

Ground Beef Retail Shelf Life

One sample of ground beef (225 g) per clod was placed on a polystyrene tray with polyvinylchloride (PVC) overwrap (oxygen transmission rate 1400 cc/m^2) and stored under cool white fluorescent lighting (Sylvania H968, 100w, 2, 640 LUX) at 2 ^{o}C for seven days. Objective color values (CIE, L*, a*, and b*) were taken every 24 hours at six locations on each sample (Hunter Lab Miniscan EZ model 4500S, Reston, VA). Thirteen trained panelists were used to evaluate subjective color scores using the scale previously outlined for steak shelf life.

Bologna Preparation

Samples of ground clod from 3 animals per treatment were combined to create an 11.34 kg meat block. The meat block was then mixed with a commercial seasoning blend (Bologna SCTP, Newly Wed Food, Chicago, IL), 1.13 kg ice, 30 g sodium tripolyphosphate, and 30 g sodium nitrite cure (Heller's Modern Cure #47688, Newly Wed Food, Chicago, IL). The mixed meat block was placed into a bowl chopper (Alipina, PB 80-890-II Gossau S G Switzerland, Speed setting 2, 3-knife head with Alipina tangential form blades) and emulsified until batter reached 10 ^{o}C. The batter was then stuffed (Handtmann VF-608, Albert Handtmann Maschimen Fabrik GmbH & Co., Biberach, Germany) into inedible collagen casings (Bologna 10.8 cm Walsrober Casings, Mar/Co Sales, Burnsville, MN). The bologna was then placed into a commercial smokehouse (ALKAR 1000 Food Processing Oven, ALKAR RapidPak-Inc., Lodi, WI) and cooked to an internal temperature of 65.5 ^{o}C as measured by thermocouple placed into the geometric center of the bologna stick. Upon the completion of the cook cycle, the bologna was removed from the smokehouse and cooled at 2 ^{o}C for 12 hours. Bologna was then sliced (Globe Slicer, Model 400, Globe Slicing Machine Co, Inc., Stanford, CT) 4 mm thick with a diameter of 11.5 cm.

Composition of Ground Beef and Bologna

Ground beef and bologna composition was determined using a CEM Smart Trac (CEM Corporation, Matthews, NC). A 4-gram sample was weighed and analyzed for moisture, fat, and solids. The CEM Smart Trac utilizes Nuclear Magnetic Resonance (NMR) to measure energy output of fat molecules when magnetic waves are passed through the sample (CEM, 2016). Microwaves were used to dry the sample and determine moisture content, NMR is used to determine the fat, and the results are presented as a percentage of a whole.

Bologna Retail Shelf Life

Two slices of bologna from each batch were used for evaluation of retail shelf life. Slices were individually packaged on polystyrene trays placed into a vacuum seal bag (3 ml standard barrier, Bunzl PD, North Kansas City, MO), and sealed. Samples were stored in refrigerated temperatures (2 ^{o}C) under cool white fluorescent lighting (Sylvania H968, 100 w, 2, 640 LUX) for 14 days.

Subjective color was evaluated every other day for 10 days. A group of 11 trained consumer panelists evaluated the bologna for cured lean color, surface discoloration, and overall acceptability. Lean color was measured on a score of 1 to 8 with 1 representing extremely dark red or brown and 8 representing light pinkish cured color. Surface discoloration was a scale of 1 to 11 with 1 meaning 91 to 100%

discoloration and 11 meaning 0% discoloration. Overall acceptability was a scale of 1 to 8 with 1 being extremely undesirable and 8 being extremely desirable (AMSA, 2012). Objective color (CIE, L*, a*, and b*) was taken every other day for 14 days at six separate locations on each slice using a Hunter Lab Miniscan EZ (model 4500S, Reston, VA).

Bologna Sensory Evaluation

One hundred twenty-six panelists were recruited by the University of Minnesota Food Science and Nutrition Sensory Center to participate in bologna sensory evaluation. Panelists were untrained, at least 18 years of age, had no food allergies, and consumed beef at least twice per month. The University of Minnesota Institutional Review Board approved the procedures used for utilizing human subjects for consumer panel evaluation of sensory attributes. Panelists were compensated for their time.

Slices of bologna (average diameter 10.8 cm) were divided into eight pieces. Panelists received two pieces of each of the four dietary treatments. Samples were stored in refrigerated conditions. Panelists were asked to consume one piece of bologna and evaluate it for overall liking, liking of flavor, and liking of texture. Panelists were then asked to consume the second piece of bologna and rate the toughness, juiciness, and off flavor intensity of the sample. The scale available to the panelists was a 120-point labeled affective magnitude (LAM) scale for ratings for “liking” labeled from *strongest dislike imaginable* on the far left and *strongest like imaginable* on the far right, and 20-point scale for ratings for intensity with the far left representing *none* and the far right representing *extremely* for off flavor, toughness, and juiciness.

Thiobarbituric Acid Reactive Substances (TBARS)

A 10-gram sample of ground beef was collected from each ground beef batch at 0 and 7 days. Samples were vacuum packaged, frozen (-20 ^{o}C), and stored until thiobarbituric acid reactive substances (TBARS) analysis could be carried out. Thiobarbituric acid assay (method adapted from Witte et al., 1970; Kuntapanit, 1978) was used to evaluate and measure secondary lipid oxidation of each sample. Testing was performed at University of Arkansas (Fayetteville, AR). Testing on each sample was done in duplicate using procedures outlined in Appendix A and measured with a spectrophotometer (Spectronic 20+, Spectronic Instruments, Inc.) at 533 nm. Results were expressed as malondialdehyde equivalents (mg/kg)

Statistical Analysis

Data were analyzed using the PROC MIXED procedure of SAS (SAS Inst, Inc., Cary, NC. Version 9.3). Color data were analyzed using PROC GLM procedure of SAS. Experimental unit was the individual animal and the model included dietary treatment as a fixed effect. An alpha value of 0.05 was used to indicate significance, and an alpha value of less than 0.1 indicated a trend within the data. For data with a significant P-value, ANOVA and corrections for multiple comparisons were evaluated using the PDIFF function within LSMEANS. When evaluating color data, dietary treatment, day, and dietary treatment by day were included as fixed effects and day was evaluated as a repeated measure. Moisture, fat, and protein composition of bologna and ground beef was determined, and fat content was used as a covariate for color analysis but was not found to affect color data.

RESULTS AND DISCUSSION

Carcass Data

No differences (P > 0.05) were found between dietary treatments in HCW, ribeye area, 12th rib backfat thickness, USDA Yield Grade, USDA Quality Grade, or marbling score (Table 2). The absence of significant difference in hot carcass weight is contradictory to research by Shrek et al., (2012), Shreck et al., (2015), and Russell et al., (2011) who found increases in HCW in dietary treatments containing alkali components; these studies were conducted with alkali treatments during the finishing phase. However, those same studies also found no differences in marbling score and ribeye area which was similar to the results of the current study. Schroeder et al., (2014) evaluated the effects of feeding calcium oxide-treated distillers grains during the finishing phase and found no differences in carcass traits among treatment groups.

Moisture loss

There were no differences (P > 0.05) between treatments for vacuum purge loss or cook loss (Table 3). These results are not surprising as water-holding capacity (WHC) is generally altered by a change in muscle pH. While pH was not measured in this study, there was no incidence of dark, firm, and dry lean tissue that would suggest an increased pH compared to the pH of normal meat. Another factor that can influence WHC within cuts of meat is cutting the whole muscle into steaks (Alberle et al., 2001). Since all of the steaks were treated the same including the way they were cut, it was expected for the cook loss and vacuum purge loss values to be similar.

Warner Bratzler Shear Force (WBSF)

Warner-Bratzler Shear Force was affected by dietary treatment ($P<0.001$; Table 3). Steaks from the cover crop treatment yielded steaks that had lower WBSF values than the control group ($P = 0.007$; 1.6 v 2.23 kg) and the water treatment ($P = 0.004$; 1.6 v 2.24 kg). There was a trend ($P = 0.069$; 1.79 v 2.24) for the $Ca(OH)_2$ treatment group to be more tender than the H_2O treatment group means. However, with mean tenderness values ranging from 1.6 to 2.24 kilograms of force, all treatments fall well below the tough-tender threshold of 3.6 to 4.9 kilograms (Shackelford et al., 1991; Miller et al., 2001).

The average daily gain (ADG) for the CC (2.13) group during the backgrounding phase was lower than CON (2.9; $P < .001$), H_2O (3.29; $P < .001$), and $Ca(OH)_2$ (2.99; $P < .001$ Nenn et al., 2016 unpublished). In agreement with the current study, research conducted by McGregor et al., (2012) and Hornick et al., (1998) found that cattle with a higher ADG also had higher shear force values. In contrast, Loken et al., (2009) and Perry and Thompson (2005) found no differences in shear force values in relation to ADG.

Fresh Steak Retail Shelf Life

Lean color scores for fresh steaks were affected by dietary treatment ($P = .004$). On day 5, CC (5.34) was less bright cherry red than CON (5.66; $P = .017$) and H_2O (5.76; $P = .001$). On day 7, CC (4.92) was less bright cherry red than CON (5.22; $P = .032$) and H_2O (5.29; $P = .007$). Overall desirability scores for fresh steaks differed ($P = .011$)

among dietary treatments with H_2O being more desirable than CC on day 5 (5.35 v 4.93; P = .023) and $Ca(OH)_2$ was more desirable than CC on day 6 (5.36 v 4.98; P = .047). Discoloration scores for fresh steaks varied among treatments (P = .003). On day 5, CC (10.02) was more discolored than H2O (10.30; P = .019) and $Ca(OH)_2$ (10.32; P = .016). On day 6, steaks from CC were more discolored than H_2O steaks (9.27 v 9.57; P = .013). Day 7 fresh steak discoloration scores shows that CC (9.13) was more discolored than CON (9.42; P = .027), H_2O (9.5; P = .003), and $Ca(OH)_2$ (9.42; P = .024). Objective L* (Figure 4), a* values (Figure 5), and b* values (Figure 6) did not differ among dietary treatments ($P > 0.05$).

Steak Sensory Evaluation

Flavor liking, juiciness, and off-flavor were not affected by dietary treatment (P = 0.102, P = 0.375, P = 0.313, respectively; Table 7). Overall liking scores were affected by dietary treatment (P = 0.008). Scores for the cover crop treatment were higher than the control (P = 0.013; 76 v 70) and calcium hydroxide (P = 0.019; 76 v 70) groups. Texture liking was different among dietary treatments ($P < 0.001$). Scores were higher for cover crop than the control ($P < 0.001$; 77 v 65), calcium hydroxide ($P < 0.001$; 77 v 63), and water (P = 0.021; 77 v 69) treatment groups. Additionally, the cover crop treatment was found to be the least tough ($P < 0.001$) compared to control ($P < 0.001$; 8 v 10), calcium hydroxide ($P < 0.001$; 8 v 11), and water (P = 0.015; 8 v 10) treatments. Sensory toughness results indicated that the cover crop treatment was the least tough of the four treatments agreed with the results obtained from WBSF. Differences in overall liking, texture liking, and tenderness conflict with results obtained by Loken et al., (2009).

These authors found no differences in tenderness, juiciness, flavor, or off-flavor. A study by Roeber et al., (2000) found a high correlation between tenderness and overall liking which may explain why the panelist ratings in the current study were both higher. When evaluating eating experiences, the entire eating experience must be taken into account. This implies that a decrease in tenderness, juiciness, or flavor can lead to a decrease in the liking of other characteristics (Roeber et al., 2000). Therefore, the increased tenderness found in the CC treatment group may have caused the increase in texture liking and overall liking.

Color Evaluation of 12th Rib Backfat

No differences in backfat color (Table 4) occurred in L* (P = 0.907), a*(P = 0.059), or b* (P = 0.288) values. Kim et al., (2014) found similar results when evaluating subjective backfat color of Hanwoo heifers. No differences were expected among dietary treatments in fat color because fat color can be influenced by genotype, sex, and age, all of which were very similar among dietary treatments (Muir et al., 1998). Diet can also affect fat color, however, the duration of the study where the steers were fed different diets was brief. Also, there was a relatively long period of time after the trial diets that the steers were fed a common diet which may have helped to alter fat color to a more common color among dietary treatments.

Ground Beef Retail Shelf Life

There were no L* or a* (Figures 10 and 11) color differences among dietary treatments during the 7-day ground beef trial (P > .05). Color differences were observed for b* values among ground beef samples ($P = .025$; Figure 12). Ground beef lean color (Figure 7) as assed by a trained panel was affected by dietary treatment ($P < .001$). On day 0, H_2O (6.77) was less bright cherry red than CON (7.06; $P = .022$) and $Ca(OH)_2$ (7.13 $P = .006$). On day 1, CON (6.91) was more bright cherry red than H_2O (6.51; $P = .012$) and CC (6.52; $P = .017$). On day 2, CON (6.12) was more bright cherry red than H_2O (5.7; $P = .006$) and CC (5.7; $P = .007$). On day 3, CON (5.32) was brighter than CC (4.72; $P < .001$) and $Ca(OH)_2$ (4.98; $P = .029$), and H_2O was brighter than CC (5.1 v 4.72; $P = .005$). On day 4, CC (3.47) was less bright red than H_2O (3.90; $P < .001$) and CON (3.84; $P = .006$). Desirability scores (Figure 8) were affected by dietary treatment ($P < .001$). On Day 0, H_2O (7.16) ground beef samples were less desirable than CON (7.39; $P = .032$) and $Ca(OH)_2$ (7.44; $P = .016$). On day 1, CON (7.21 was more desirable than H_2O (6.74; $P = .005$) and CC (6.77; $P = .009$). On day 2, CON (6.32) was more desirable than H_2O (5.80; $P < .001$) and CC (5.68; $P < .001$), and CC was less desirable than $Ca(OH)_2$ (5.68 v 6.04; $P = .031$). On day 3, CON (5.36) was more desirable than H_2O (4.93; $P = .004$), CC (4.54; $P < .001$) and $Ca(OH)_2$ (4.71; $P < .001$); H_2O was more desirable than CC (4.93 vs 4.54; $P = .006$). On day 4, CC (3.00) was less desirable than CON (3.46; $P = .001$) and H_2O (3.44; $P = .016$). On day 5, $Ca(OH)_2$ (2.14) was less desirable than CON (2.44; $P = .039$) and H_2O (2.43; $P = .016$). Discoloration scores (Figure 9) for ground beef was affected by dietary treatment ($P < .001$). On day 2, H_2O was more discolored than $Ca(OH)_2$ (8.55 v 9.29; $P = .039$). On day 3, CON (8.83) was less discolored than H_2O (8.09; $P = .028$), CC (7.39; $P < .001$) and $Ca(OH)_2$ (7.59; $P < .001$); H_2O was less discolored than CC (8.09 v 7.39; $P = .028$). On day 4, H_2O was less discolored than CC (6.3 v 5.68; $P = .034$). It is unclear why the trained panel was able to detect differences among treatment for both fresh steaks and ground beef when the colorimeter was not. It is possible that location on the display table could have influenced the results of the trained panel. It is worth noting that while samples were not specifically randomized in regards to their display position, there could have been unintentional groupings of treatments on the table. Due to the high volume of samples, sensory fatigue could have played a role in panel results.

Composition of Ground Beef and Bologna

Percentage of moisture, fat, and protein in ground beef samples varied among treatments ($P = 0.011$, $P = .003$, and $P = 0.005$ respectively; Table 5). Moisture content was higher for CON than CC and $Ca(OH)_2$ ($P = 0.015$; 60.04 v 56.58%, and $P = 0.026$; 60.04 v 56.81% respectively). Fat content was lower for CON (22.14%) than H_2O (25.46%), CC (26.30%), and $Ca(OH)_2$ (25.46%) ($P = 0.045$, $P = 0.014$, $P = 0.004$ respectively). Protein content was higher for CON (17.81%) and CC (17.57%) than $Ca(OH)_2$ (16.5%) ($P = 0.011$ and $P = 0.043$ respectively).

Moisture, fat, and protein content of bologna samples was also variable among treatments ($P = 0.032$, $P = 0.008$, and $P = 0.007$ respectively; Table 6). Moisture levels were higher for CON than $Ca(OH)_2$ ($P = 0.030$; 59.26 v 55.08%). Fat levels were lower for CON (22.44%) and H_2O (26.63%) than $Ca(OH)_2$ (28.57%) ($P = 0.007$ and $P = 0.028$ respectively). The levels of protein within each treatment were higher for CON (18.30%) and H_2O (17.78%) than $Ca(OH)_2$ (16.35; $P < 0.001$ and $P = 0.006$ respectively). These results were unexpected based on the lack of differences in USDA Yield Grade and USDA Quality Grade. However, when fat percentage was evaluated as a covariate of ground beef and bologna color no differences were found compared to results obtained without the fat covariate. This leads us to believe that while the percentages of moisture, fat, and solids may be statistically different, they are still not practically different and do not affect other aspects of meat quality.

Bologna Retail Shelf Life

The trained panel did not detect differences in cured lean color (P = 0.195; Figure 13), discoloration (P = 0.999; Figure 15), or desirability (P = 0.628; Figure 14). Additionally, no differences were found in L* (P = .763; Figure 16), a* (P = .076; Figure 17), or b* (P = .084; Figure 18).

Bologna Sensory Evaluation

Dietary treatment did not affect overall liking (P = 0.610), texture liking (P = 0.828), flavor liking (P = 0.707), juiciness (P = 0.371), or off flavor (P = 0.716) (Table 8). However, panelists found differences (P = 0.011) in toughness; finding the water treated corn stover treatment to be more tough than the calcium hydroxide group (6.7 v 5.1; P = 0.008). Bologna is an emulsified product. Therefore, the difference in toughness was an unexpected phenomenon. However, Johnston et al., (2014) also found increased toughness in bologna samples when evaluating differences between cattle of the breeds fed distillers grains. At this point, further research is needed to explore the reasoning behind increased toughness in bologna products.

Thiobarbituric Acid Reactive Substances (TBARS)

Dietary treatment affected TBARS value on day 0 ($P = 0.003$) but not on day 7 ($P = 0.830$). On day 0, $Ca(OH)_2$ was lower than CC (0.491 v 0.681 mg/kg; $P = 0.001$). It is unclear as to why the TBARS values on day 0 was significant while the values for day 7 were not. Additional analysis of the fatty acid profile may lead to a more accurate hypothesis of the cause of varying differences. However, we did expect the TBARS values to increase from day 0 to day 7 due to the increased likelihood of oxidation of the ground beef product under cool fluorescent lighting and the presence of oxygen.

CONCLUSION

The use of calcium hydroxide treatment in backgrounding diets of beef calves does not affect carcass characteristics or moisture loss, but does affect fresh beef and further processed beef characteristics. Although there were differences found among dietary treatments for meat characteristics, these differences do not appear to be large enough from a practical stand point to make a recommendation against the feeding of alkali-treated corn stover during calf backgrounding.

Table 1. Dietary treatment by percent of diet DM in diets of cattle fed treated corn stover during backgrounding

	Stover Treatment*			
	CON	$Ca(OH)_2$	H_2O	CC
Corn Stover (%)	30.9	27.5	25.7	-
Alfalfa Haylage (%)	16.1	17.4	17.6	44.9
Dry Rolled Corn (%)	23.9	24.9	25.7	25.0
DDGS (%)	23.7	24.6	25.3	25.0
Supplement (%)[1, 2]	5.4	5.6	5.7	5.1

* Treatments: CON = fed untreated corn stover, $Ca(OH)_2$ = fed calcium hydroxide treated corn stover, H_2O = fed water treated corn stover, CC = fed no corn stover

[1] Supplement formulated to provide 234 mg monensin/hd/d (Rumensin, Elanco Animal Health, Greenfield, IN)

[2] MYCO CURB (Kemin, Des Moines, IA) added to supplement to reduce mold concentration.

Table 2. Beef carcass data of cattle fed treated corn stover during backgrounding

	Stover Treatment*					
	CON	$Ca(OH)_2$	H_2O	CC	SEM	P-Value
Hot Carcass Wt., kg	409	413	395	402	5.42	0.694
REA, sq. cm	87.49	83.75	83.21	83.78	0.86	0.259
12th rib backfat, cm	1.59	1.69	1.52	1.62	0.05	0.780
Yield Grade[1]	3	3	3	3	0.09	0.890
Quality Grade[2]	3	3	3	3	0.13	0.877
Marbling Score[3]	623	655	639	636	12.54	0.850

[1] Yield Grade: 1 to 5 where 1 = high yielding carcasses and 5 = low yielding carcasses

[2] Quality Grade: 1 = Se, 2 = Ch^-, 3 = Ch^o, 4 = Ch^+, 5 = Pr^-

[3] Marbling Score: 400 = Se, 500 = Ch^-, 600 = Ch^o, 700 = Ch^+, 800 = Pr^-

* Treatments: CON = fed untreated corn stover, $Ca(OH)_2$ = fed calcium hydroxide treated corn stover, H_2O = fed water treated corn stover, CC = fed no corn stover

Table 3. Vacuum purge, cook loss, and Warner-Bratzler Shear Force (WBSF) of cattle fed treated corn stover during backgrounding

	Stover Treatment*					
	CON	$Ca(OH)_2$	H_2O	CC	SEM	P-Value
Purge ,%	0.88	0.82	0.81	0.80	0.04	0.884
Cook Loss, %	20.46	21.62	20.54	21.93	0.28	0.149
WBSF, kg	2.23^{a}	1.79^{ab}	2.24^{a}	1.6^{b}	0.07	0.001

[ab] Different letters within each row denote significant differences

* Treatments: CON = fed untreated corn stover, $Ca(OH)_2$ = fed calcium hydroxide treated corn stover, H_2O = fed water treated corn stover, CC = fed no corn stover

Table 4. Twelfth rib fat color of cattle fed treated corn stover during backgrounding

	Stover Treatment [1]					
	CON	$Ca(OH)_2$	H_2O	CC	SEM	P-Value
L*	74.69	74.73	74.91	74.61	0.15	0.907
a*	0.37	0.89	0.58	0.74	0.07	0.059
b*	4.75	5.45	4.35	4.65	0.21	0.288

[1] Treatments: CON = fed untreated corn stover, $Ca(OH)_2$ = fed calcium hydroxide treated corn stover, H_2O = fed water treated corn stover, CC = fed no corn stover

Table 5. Ground beef composition of cattle fed treated corn stover during backgrounding

	Stover Treatment*					
	CON	$Ca(OH)_2$	H_2O	CC	SEM	P-Value
Moisture, %	60.04^{a}	56.81^{b}	57.89^{ab}	56.58^{b}	0.409	0.011
Fat, %	22.14^{a}	26.87^{b}	25.46^{b}	26.30^{b}	0.503	0.003
Protein, %	17.81^{a}	16.50^{b}	16.88^{ab}	17.57^{a}	0.147	0.005

^{ab} Different letters within each row denote significant differences

* Treatments: CON = fed untreated corn stover, $Ca(OH)_2$ = fed calcium hydroxide treated corn stover, H_2O = fed water treated corn stover, CC = fed no corn stover

Table 6. Bologna composition of cattle fed treated corn stover during backgrounding

	Stover Treatment*					
	CON	$Ca(OH)_2$	H_2O	CC	SEM	P-Value
Moisture, %	59.26^a	55.08^b	58.59^{ab}	58.03^{ab}	0.578	0.032
Fat, %	22.44^a	28.57^b	23.63^a	24.63^{ab}	0.758	0.008
Protein, %	18.30^a	16.35^c	17.78^{ab}	17.34^b	0.214	<0.001

^{ab} Different letters within each row denote significant differences

* Treatments: CON = fed untreated corn stover, $Ca(OH)_2$ = fed calcium hydroxide treated corn stover, H_2O = fed water treated corn stover, CC = fed no corn stover

Table 7. Fresh steak sensory characteristics[1] of cattle fed treated corn stover during backgrounding

	Stover Treatment*					
	CON	$Ca(OH)_2$	H_2O	CC	SEM	P-Value
Overall Liking	70^a	70^a	72^{ab}	76^b	0.786	0.008
Flavor Liking	72	72	70	75	0.776	0.102
Texture Liking	65^a	63^a	69^a	77^b	0.979	<0.001
Toughness	10^a	11^a	10^a	8^b	0.206	<0.001
Juiciness	7	7	7	8	0.192	0.375
Off-flavor	4	4	5	5	0.186	0.313

^{ab} Different letters within each row denote significant differences

* Treatments: CON = fed untreated corn stover, $Ca(OH)_2$ = fed calcium hydroxide treated corn stover, H_2O = fed water treated corn stover, CC = fed no corn stover

[1] Characteristics indexed in Appendix B

Table 8. Bologna sensory characteristics[1] of cattle fed treated corn stover during backgrounding

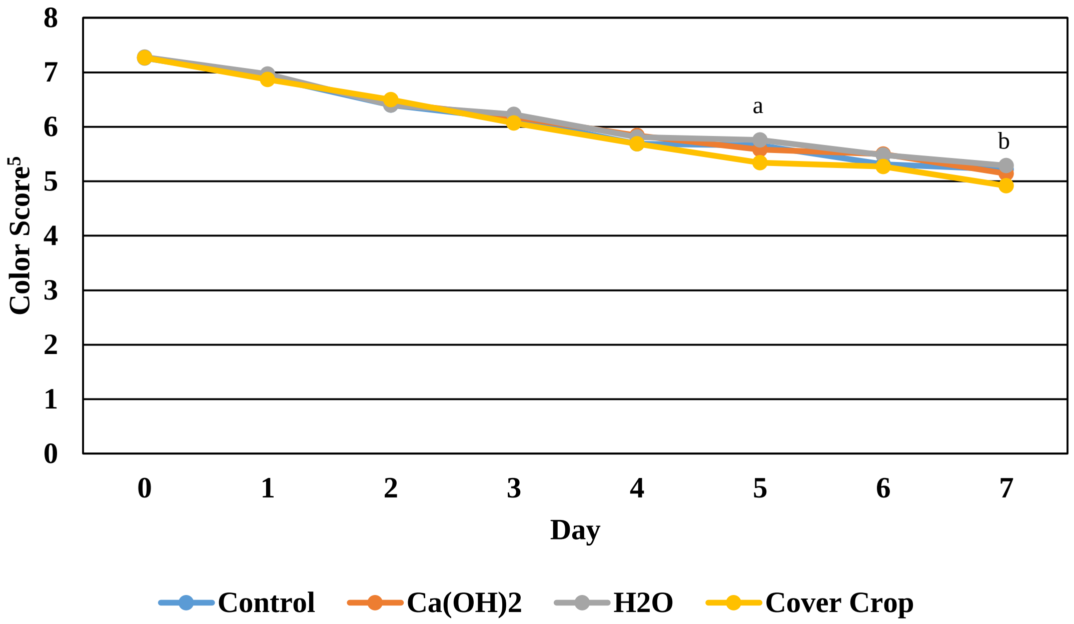
	Stover Treatment*					
	CON	$Ca(OH)_2$	H_2O	CC	SEM	P-Value
Overall Liking	76	78	76	76	0.674	0.610
Flavor Liking	76	77	75	76	0.728	0.707
Texture Liking	75	75	77	75	0.692	0.828
Toughness	6.0^{ab}	$5.1a^{a}$	6.7^{b}	6.3^{ab}	0.184	0.011
Juiciness	9	9	8	9	0.180	0.371
Off-flavor	5	5	5	5	0.199	0.716

^{ab} Different letters within each row denote significant differences

* Treatments: CON = fed untreated corn stover, $Ca(OH)_2$ = fed calcium hydroxide treated corn stover, H_2O = fed water treated corn stover, CC = fed no corn stover

[1] Characteristics defined in Appendix B

Figure 1. Lean color scores of fresh steaks from cattle fed treated corn stover during backgrounding



[a] Cover crop differs from control (P = .017) and H2O (P = .001)

[b] Cover crop differs from control (P = .032) and H2O (P = .007)

Treatment effect (P = .004)

[1] Control diet contains untreated corn stover

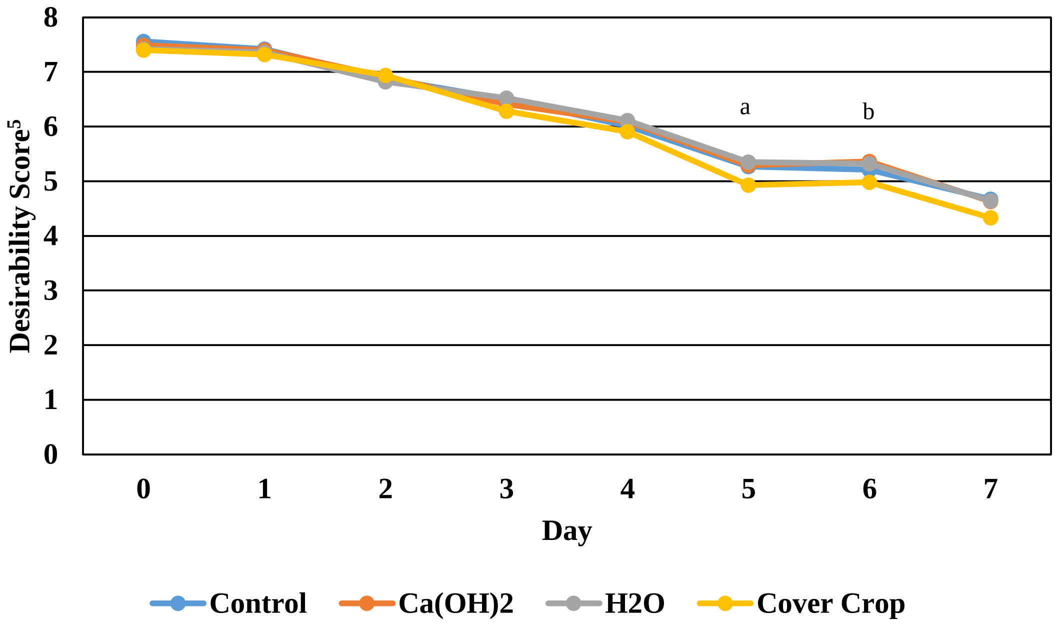
[2] Ca(OH)2 diet contains corn stover treated with calcium hydroxide

[3] H2O dietary treatment contains corn stover treated with water

[4] Cover Crop dietary treatment contains no corn stover

[5] Color Score: 1 = extremely brown, 2 = very brown or green, 3 = moderately brown or green, 4 = slightly brown or green, 5 = slightly bright cherry red, 6 = very bright cherry red, 7 = very bright cherry red, 8 = extremely bright cherry red

Figure 2. Desirability scores in fresh steaks of cattle fed treated corn stover during backgrounding



[a] H2O differs from cover crop (P = .023)

[b] Cover crop differs from Ca(OH)2 (P = .047)

Treatment effect (P = .011)

[1] Control diet contains untreated corn stover

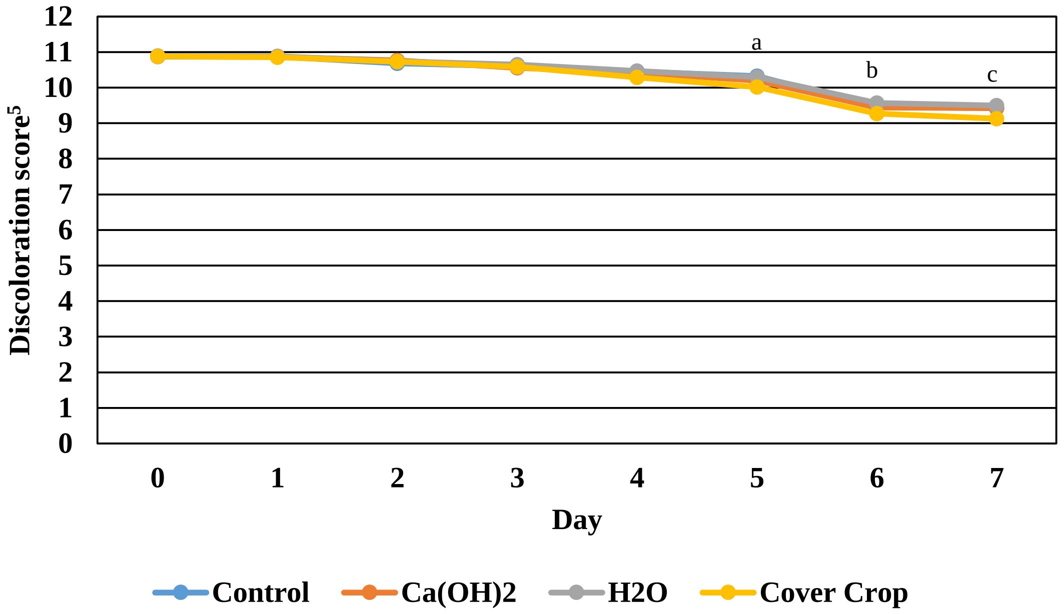
[2] Ca(OH)2 diet contains corn stover treated with calcium hydroxide

[3] H2O dietary treatment contains corn stover treated with water

[4] Cover Crop dietary treatment contains no corn stover

[5] Desirability Score: 1 = extremely undesirable, 2 = very undesirable, 3 = moderately undesirable, 4 = slightly undesirable, 5 = slightly desirable, 6 = moderately desirable, 7 = very desirable, 8 = extremely desirable

Figure 3. Discoloration scores in fresh steaks of cattle fed treated corn stover during backgrounding



[a] Cover crop differs from H2O (P = .019) and Ca(OH)2 (P = .016)

[b] H2O differs from cover crop (P = .013)

[c] Cover crop differs from control (P = .027), Ca(OH)2 (P = .024), and H2O (P = .003)

Treatment effect (P = .003)

[1] Control diet contains untreated corn stover

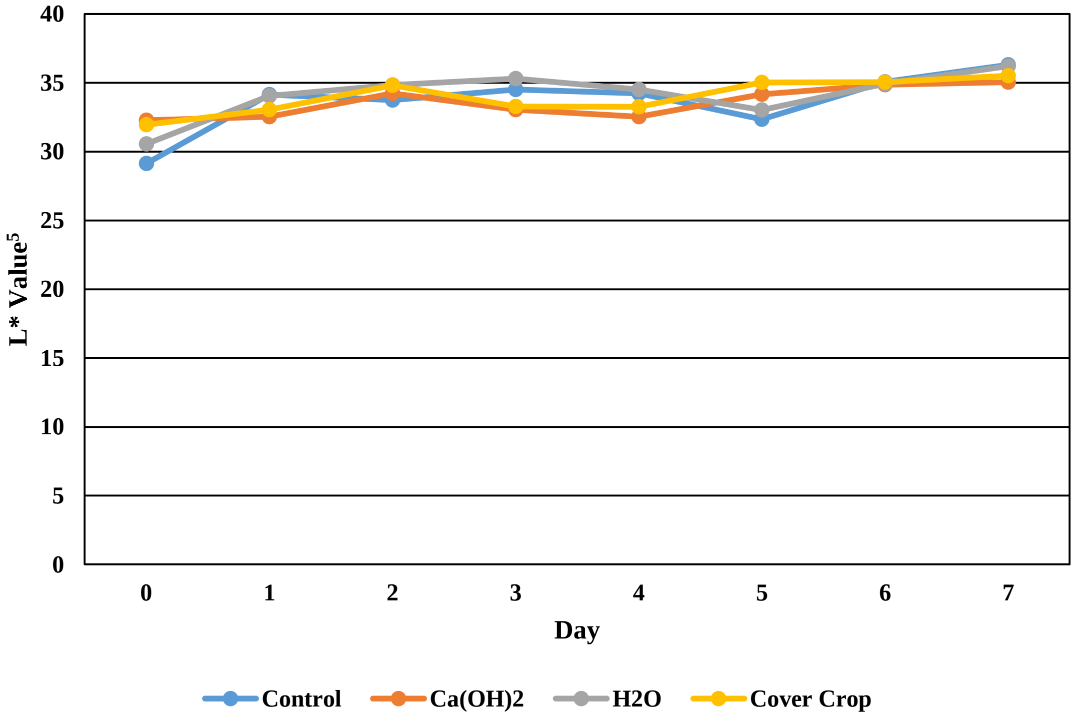
[2] Ca(OH)2 diet contains corn stover treated with calcium hydroxide

[3] H2O dietary treatment contains corn stover treated with water

[4] Cover Crop dietary treatment contains no corn stover

[5] Discoloration Score: 1 = 91 to 100% discolored, 2 = 81 to 90% discolored, 3 = 71 to 80% discolored, 4 = 61 to 70% discolored, 5 = 51 to 60% discolored, 6 = 41 to 50% discolored, 7 = 31 to 40% discolored, 8 = 21 to 30% discolored, 9 = 11 to 20% discolored, 10 = 1 to 10% discolored, 11 = 0% discolored

Figure 4. Lightness (L*) values in fresh steaks of cattle fed treated corn stover during backgrounding



Treatment effect (P = .829)

[1]Control diet contains untreated corn stover

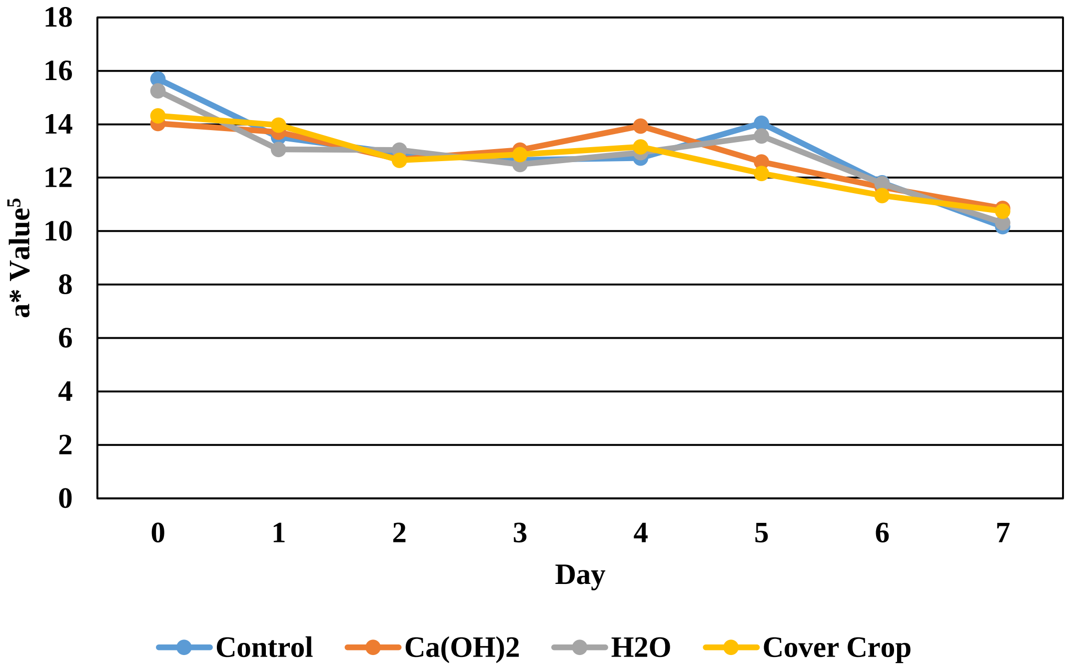
[2] Ca(OH)2 diet contains corn stover treated with calcium hydroxide

[3] H2O dietary treatment contains corn stover treated with water

[4] Cover Crop dietary treatment contains no corn stover

[5] L* value: 0 = black, 100 = white

Figure 5. Redness (a*) values in fresh steaks of cattle fed treated corn stover during backgrounding



Treatment effect (P = .902)

[1]Control diet contains untreated corn stover

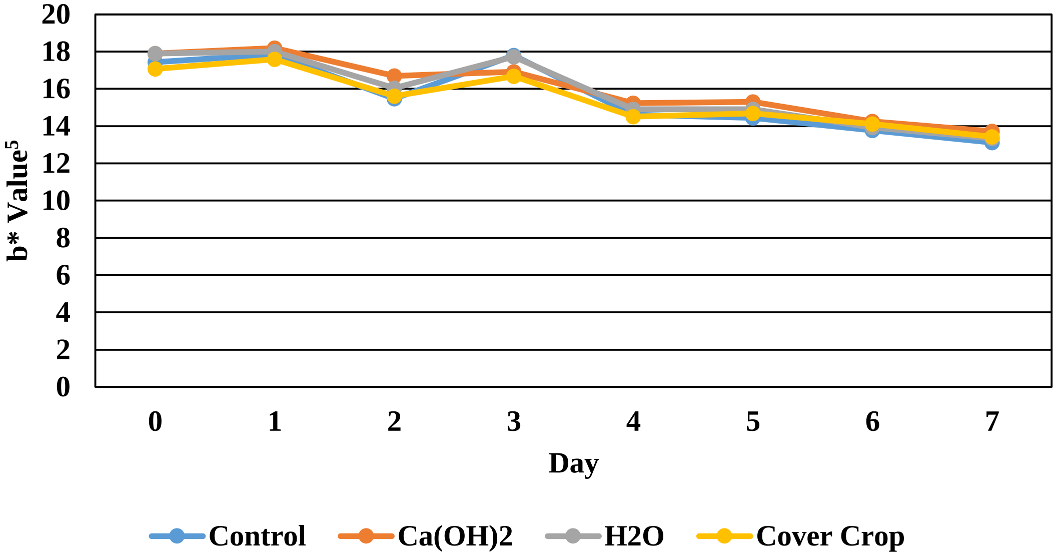
[2] Ca(OH)2 diet contains corn stover treated with calcium hydroxide

[3] H2O dietary treatment contains corn stover treated with water

[4] Cover Crop dietary treatment contains no corn stover

[5] a* value: -a = green, +a = red

Figure 6. Yellowness (b*) values in fresh steaks of cattle fed treated corn stover during backgrounding



Treatment effect (P = .219)

[1] Control diet contains untreated corn stover

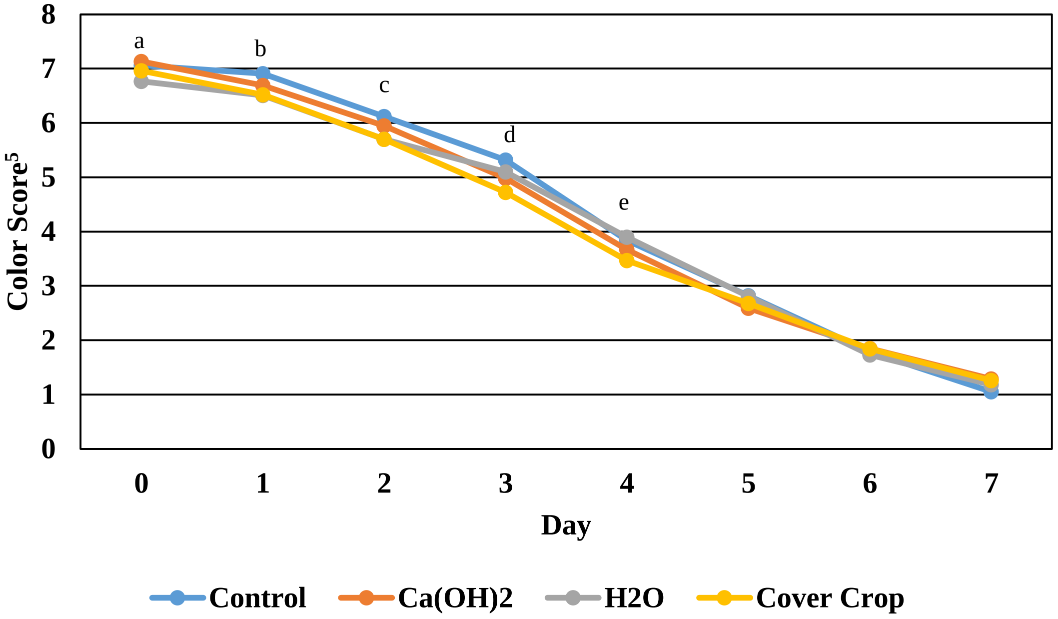
[2] Ca(OH)2 diet contains corn stover treated with calcium hydroxide

[3] H2O dietary treatment contains corn stover treated with water

[4] Cover Crop dietary treatment contains no corn stover

[5] b* Value: -b = blue, +b = yellow

Figure 7. Lean color scores in ground beef of cattle fed calcium corn stover during backgrounding



[a] H2O differs from control (P = .022) and Ca(OH)2 (P = .006)

[b] Control differs from H2O (P = .012), cover crop (P = .017)

[c] Control differs from H2O (P = .006) and cover crop (P = .007)

[d] Control differs from cover crop (P < .001) and Ca(OH)2 (P = .029); H2O differs from cover crop (P = .005)

[e] Cover crop differs from H2O (P < .001) and control (P = .006)

Treatment effect (P < .001)

[1]Control diet contains untreated corn stover

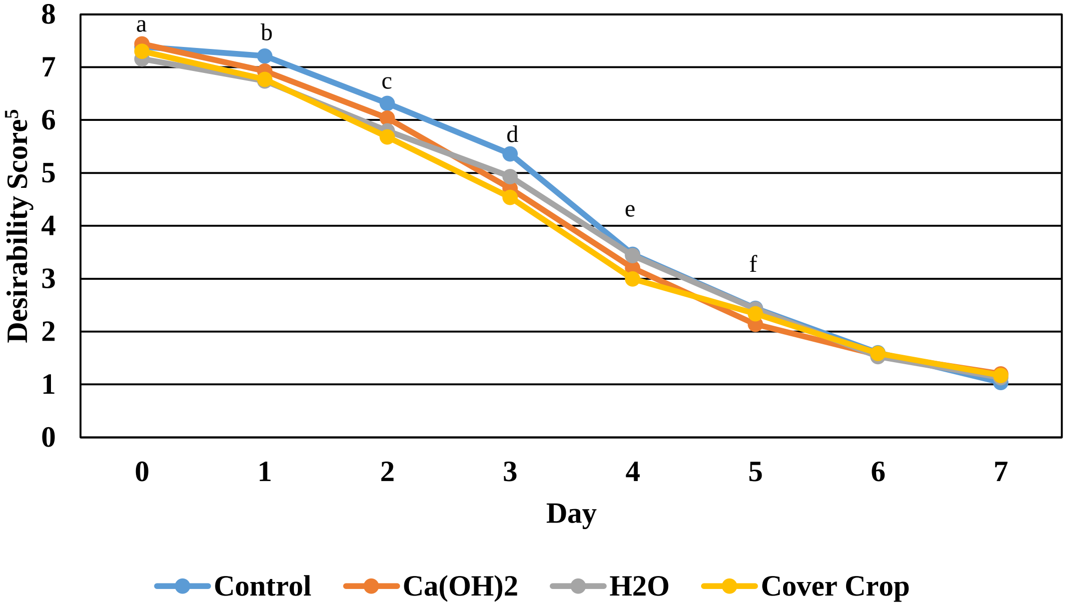
[2] Ca(OH)2 diet contains corn stover treated with calcium hydroxide

[3] H2O dietary treatment contains corn stover treated with water

[4] Cover Crop dietary treatment contains no corn stover

[5] Color Score: 1 = extremely brown, 2 = very brown or green, 3 = moderately brown or green, 4 = slightly brown or green, 5 = slightly bright cherry red, 6 = very bright cherry red, 7 = very bright cherry red, 8 = extremely bright cherry red

Figure 8. Desirability scores in ground beef of cattle fed treated corn stover during backgrounding



[a] H2O differs from control (P = .032) and Ca(OH)2 (P = .016)

[b] Control differs from H2O (P = .005) and cover crop (P = .009)

[c] Control differs from H2O (P < .001) and cover crop (P < .001); cover crop differs from Ca(OH)2 (P = .031)

[d] Control differs from H2O (P = .004) cover crop (P < .001) and Ca(OH)2 (P < .001); H2O differs from cover crop (P = .006)

[e] Cover crop differs from control (P = .001) and H2O (P < .001)

[f] Ca(OH)2 differs from control (P = .039) and H2O (P = .016)

Treatment effect (P < .001)

[1] Control diet contains untreated corn stover

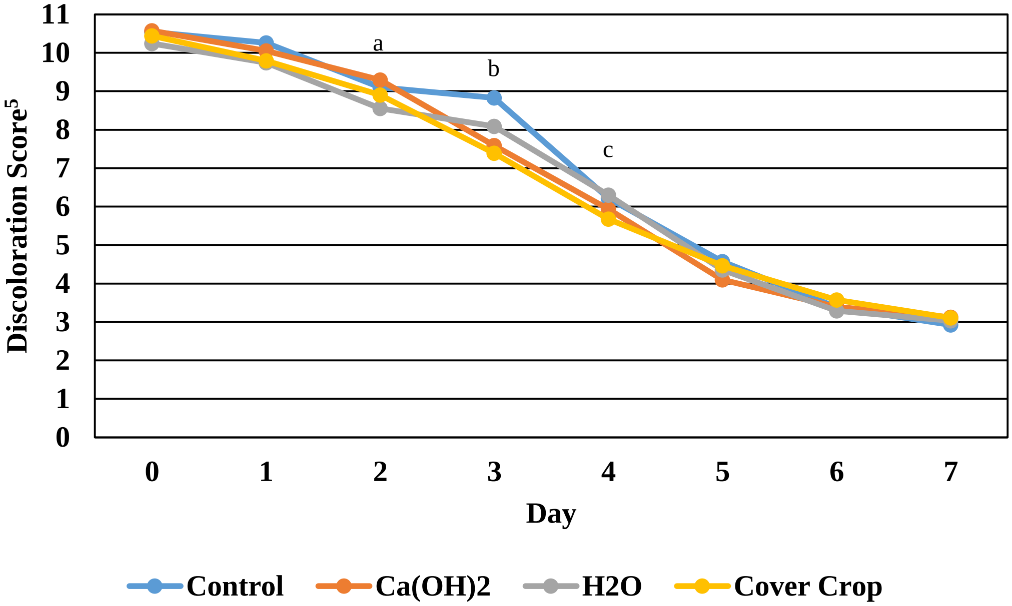
[2] Ca(OH)2 diet contains corn stover treated with calcium hydroxide

[3] H2O dietary treatment contains corn stover treated with water

[4] Cover Crop dietary treatment contains no corn stover

[5] Desirability Score: 1 = extremely undesirable, 2 = very undesirable, 3 = moderately undesirable, 4 = slightly undesirable, 5 = slightly desirable, 6 = moderately desirable, 7 = very desirable, 8 = extremely desirable

Figure 9. Discoloration scores in ground beef of cattle fed treated corn stover during backgrounding



[a] H_2O differs from $Ca(OH)_2$ ($P = .039$)

[b] Control differs from H_2O ($P = .028$), cover crop ($P < .001$), and $Ca(OH)_2$ ($P < .001$); H_2O differs from cover crop ($P = .028$)

[c] H_2O differs from cover crop ($P = .034$)

Treatment effect ($P < .001$)

[1] Control diet contains untreated corn stover

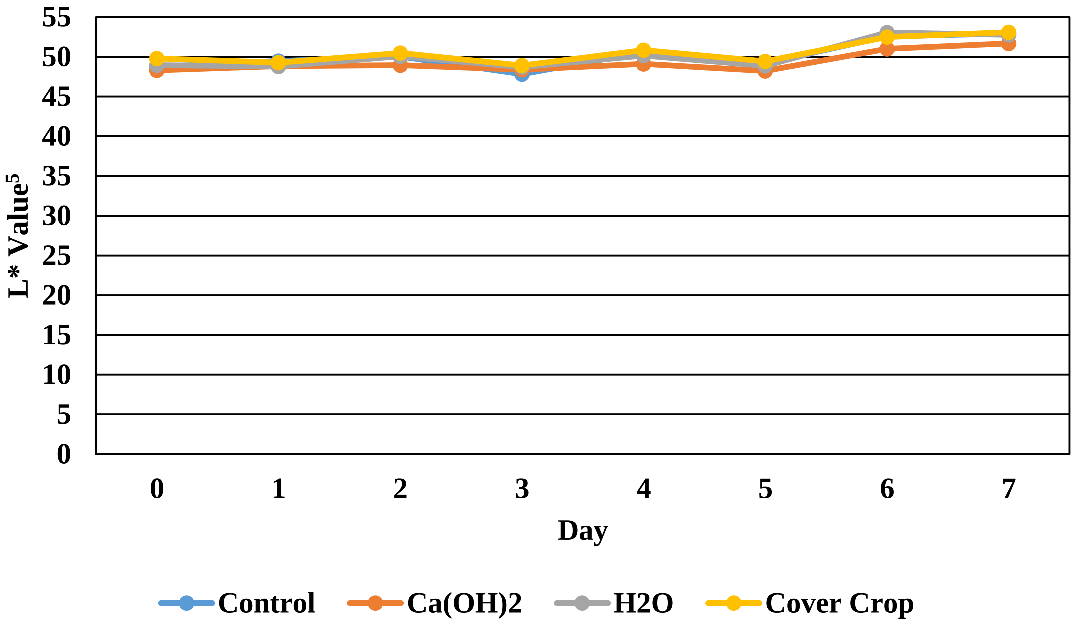
[2] $Ca(OH)_2$ diet contains corn stover treated with calcium hydroxide

[3] H_2O dietary treatment contains corn stover treated with water

[4] Cover Crop dietary treatment contains no corn stover

[5] Discoloration Score: 1 = 91 to 100% discolored, 2 = 81 to 90% discolored, 3 = 71 to 80% discolored, 4 = 61 to 70% discolored, 5 = 51 to 60% discolored, 6 = 41 to 50% discolored, 7 = 31 to 40% discolored, 8 = 21 to 30% discolored, 9 = 11 to 20% discolored, 10 = 1 to 10% discolored, 11 = 0% discolored

Figure 10. Lightness (L*) values in ground beef of cattle fed treated corn stover during backgrounding



Treatment effect (P = .446)

[1] Control diet contains untreated corn stover

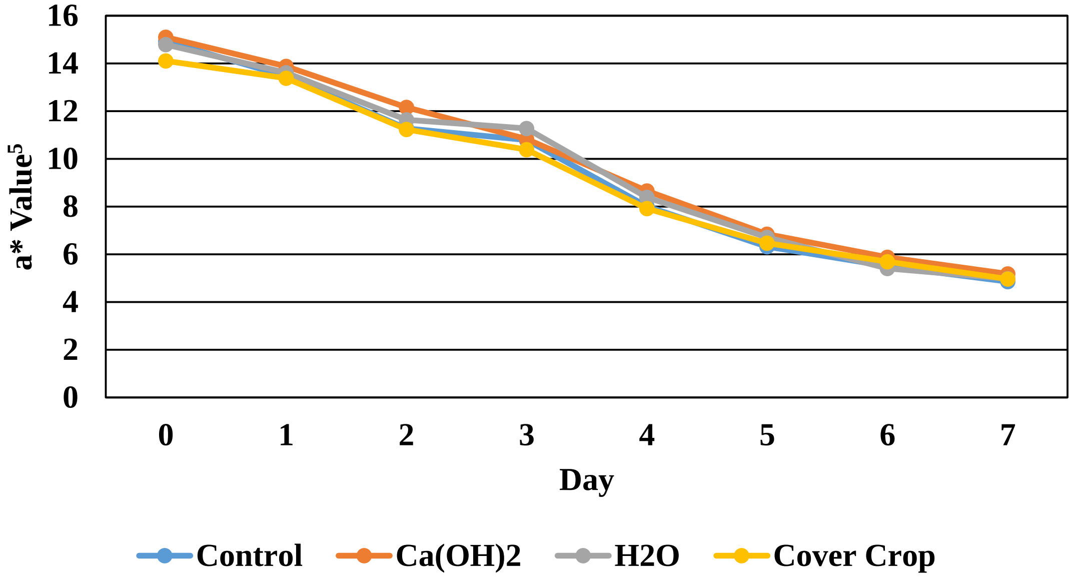
[2] Ca(OH)2 diet contains corn stover treated with calcium hydroxide

[3] H2O dietary treatment contains corn stover treated with water

[4] Cover Crop dietary treatment contains no corn stover

[5] L* value: 0 = black, 100 = white

Figure 11. Redness (a*) values in ground beef of cattle fed treated corn stover during backgrounding



Treatment effect (P = .285)

[1] Control diet contains untreated corn stover

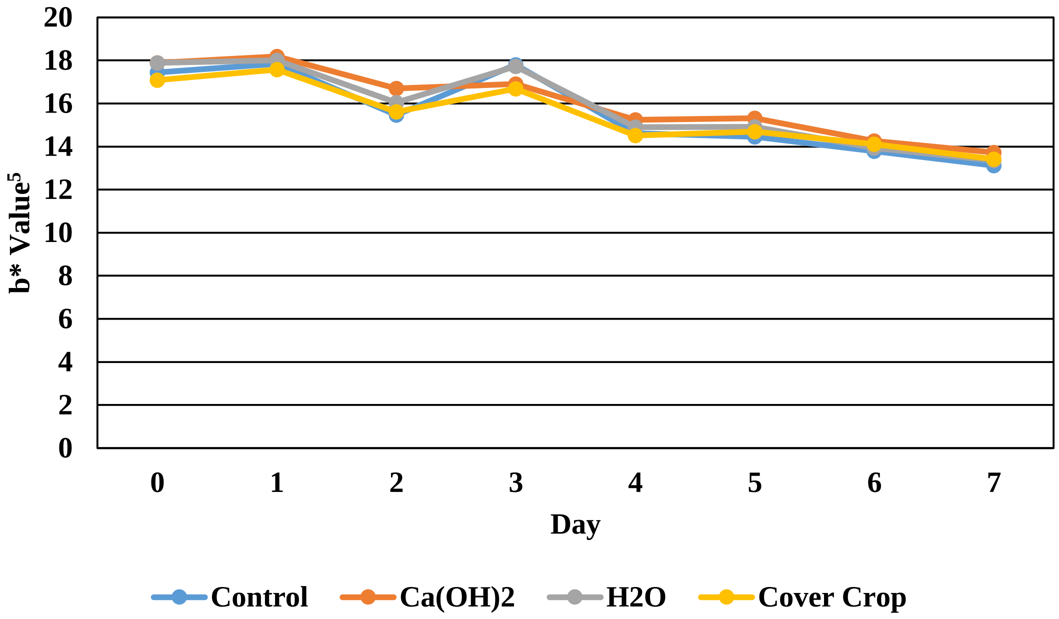
[2] Ca(OH)2 diet contains corn stover treated with calcium hydroxide

[3] H2O dietary treatment contains corn stover treated with water

[4] Cover Crop dietary treatment contains no corn stover

[5] a* Value: -a = green, +a = red

Figure 12. Yellowness (b*) values in ground beef of cattle fed treated corn stover during backgrounding



Treatment effect (P = .025)

[1] Control diet contains untreated corn stover

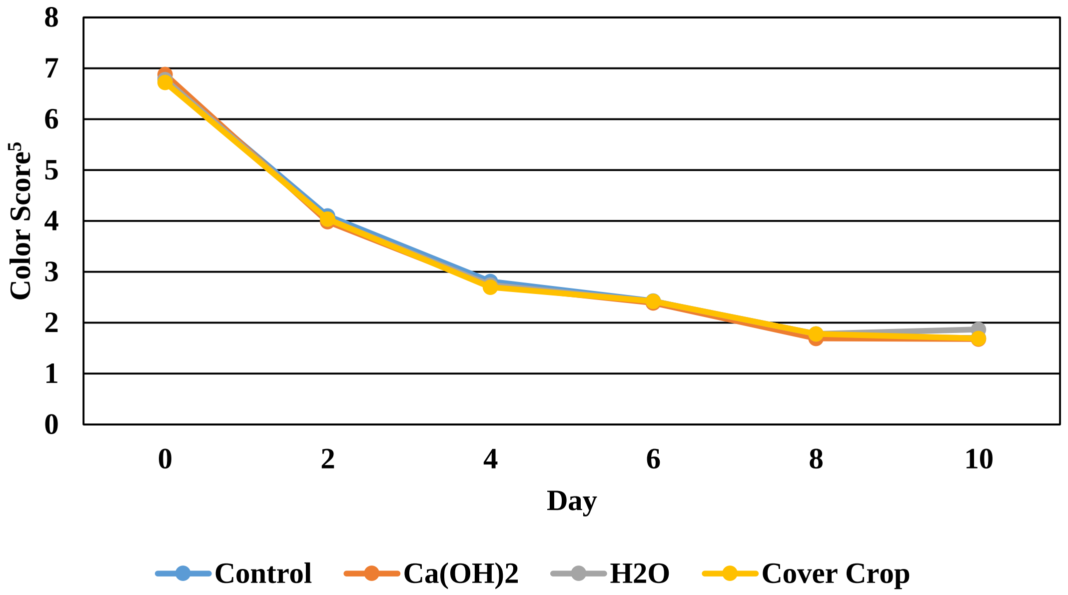
[2] Ca(OH)2 diet contains corn stover treated with calcium hydroxide

[3] H2O dietary treatment contains corn stover treated with water

[4] Cover Crop dietary treatment contains no corn stover

[5] b* Value: -b = blue, +b = yellow

Figure 13. Lean color scores in bologna of cattle fed treated corn stover during backgrounding



Treatment effect (P = .195)

[1]Control diet contains untreated corn stover

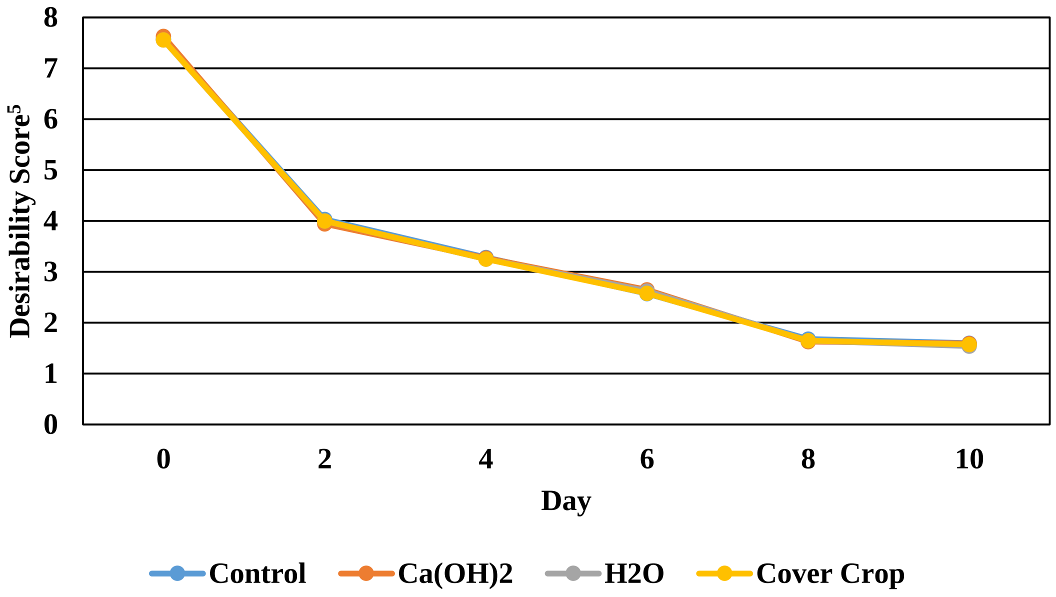
[2] Ca(OH)2 diet contains corn stover treated with calcium hydroxide

[3] H2O dietary treatment contains corn stover treated with water

[4] Cover Crop dietary treatment contains no corn stover

[5] Color Score: 1 = very dark red cured color, 2 = moderately dark red cured color, 3 = slightly dark red cured color, 4 = reddish-pink cured color, 5 = pinkish-red cured color, 6 = slight pinkish red color, 7 = pinkish cured color, 8 = light pinkish cured color

Figure 14. Desirability scores in bologna of cattle fed treated corn stover during backgrounding



Treatment effect (P = .628)

[1] Control diet contains untreated corn stover

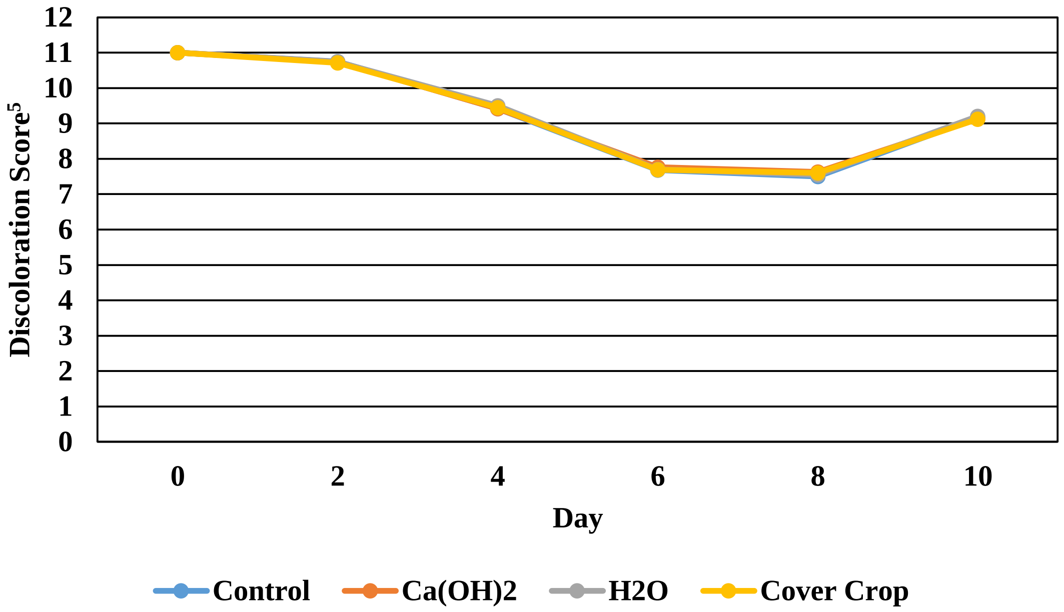
[2] Ca(OH)2 diet contains corn stover treated with calcium hydroxide

[3] H2O dietary treatment contains corn stover treated with water

[4] Cover Crop dietary treatment contains no corn stover

[5] Desirability Score: 1 = extremely undesirable, 2 = very undesirable, 3 = moderately undesirable, 4 = slightly undesirable, 5 = slightly desirable, 6 = moderately desirable, 7 = very desirable, 8 = extremely desirable

Figure 15. Discoloration scores in bologna of cattle fed treated corn stover during backgrounding



Treatment effect (P = .999)

[1]Control diet contains untreated corn stover

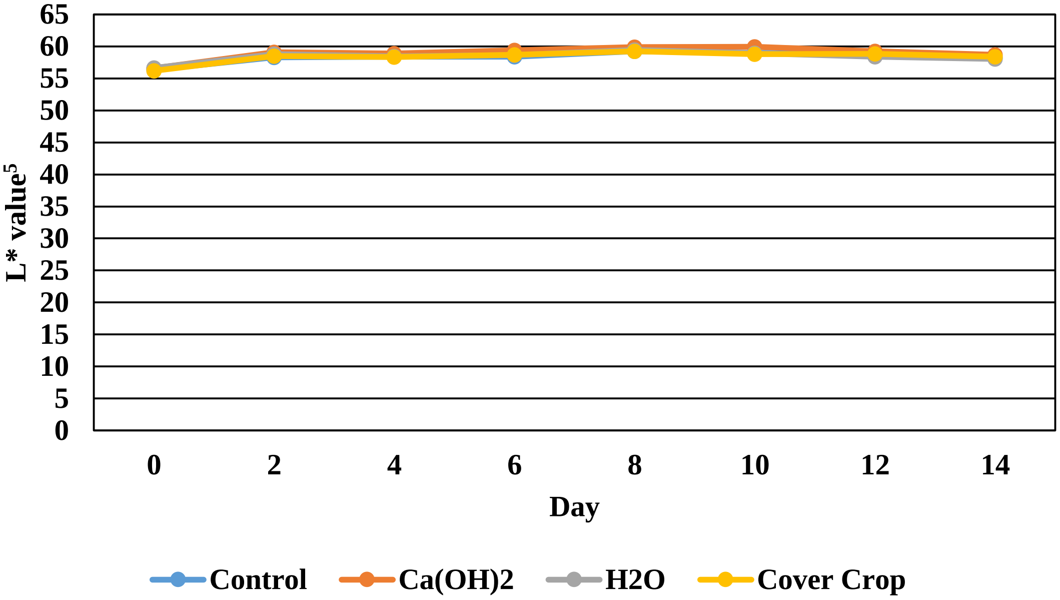
[2] Ca(OH)2 diet contains corn stover treated with calcium hydroxide

[3] H2O dietary treatment contains corn stover treated with water

[4] Cover Crop dietary treatment contains no corn stover

[5] Discoloration Score: 1 = 91 to 100% discolored, 2 = 81 to 90% discolored, 3 = 71 to 80% discolored, 4 = 61 to 70% discolored, 5 = 51 to 60% discolored, 6 = 41 to 50% discolored, 7 = 31 to 40% discolored, 8 = 21 to 30% discolored, 9 = 11 to 20% discolored, 10 = 1 to 10% discolored, 11 = 0% discolored

Figure 16. Lightness (L*) values in bologna of cattle fed treated corn stover during backgrounding



Treatment effect (P = .763)

[1] Control diet contains untreated corn stover

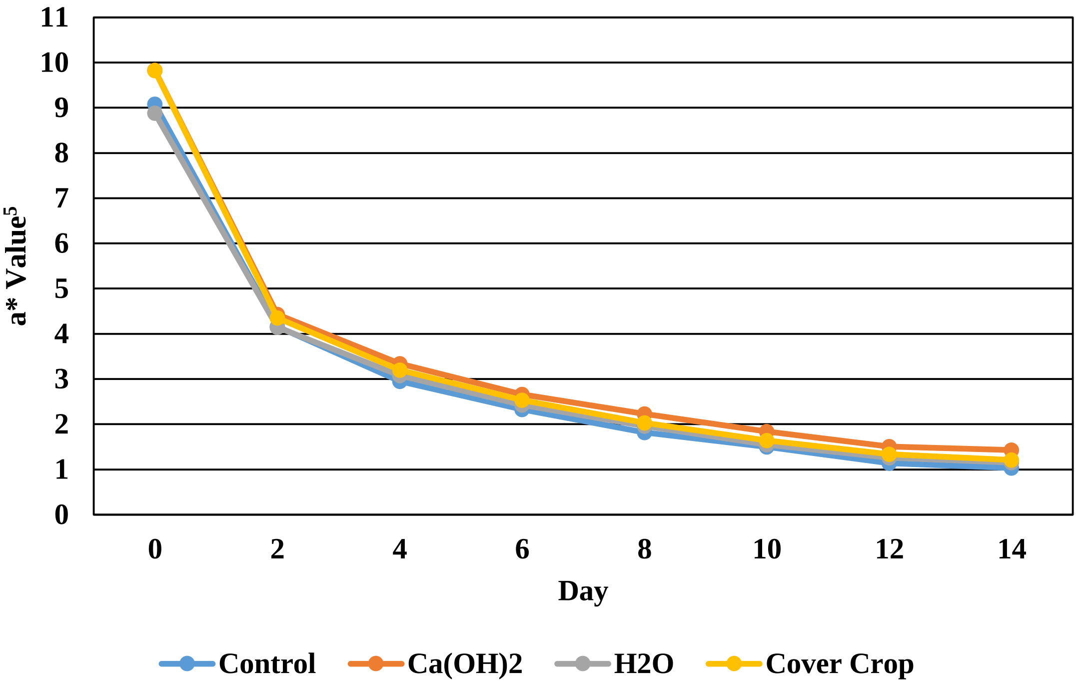
[2] Ca(OH)2 diet contains corn stover treated with calcium hydroxide

[3] H2O dietary treatment contains corn stover treated with water

[4] Cover Crop dietary treatment contains no corn stover

[5] L* value: 0 = black, 100 = white

Figure 17. Redness (a*) values in bologna of cattle fed treated corn stover during backgrounding



Treatment effect (P = .076)

[1] Control diet contains untreated corn stover

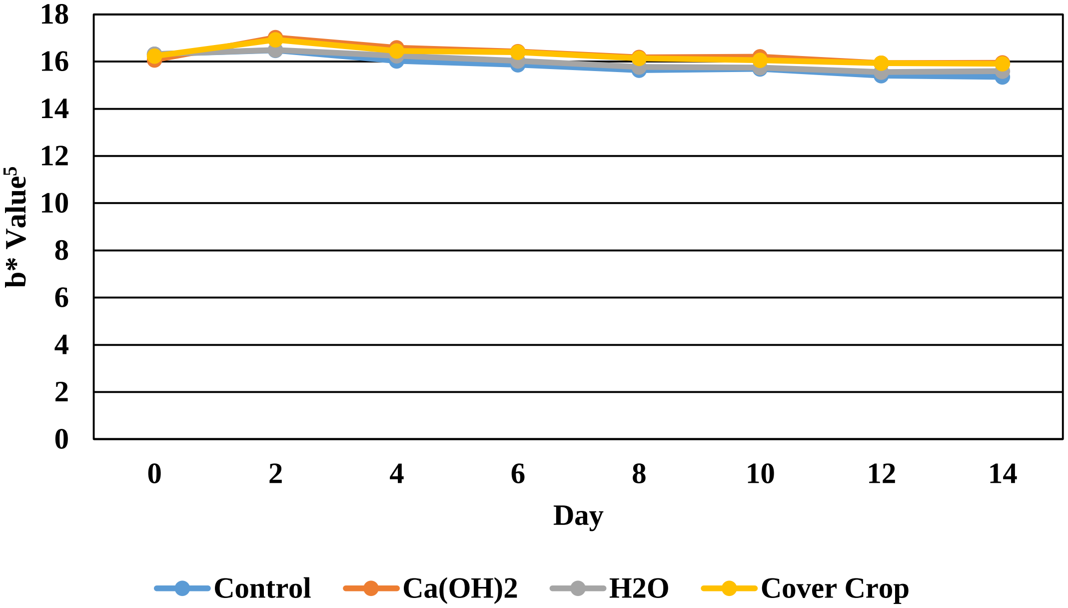
[2] Ca(OH)2 diet contains corn stover treated with calcium hydroxide

[3] H2O dietary treatment contains corn stover treated with water

[4] Cover Crop dietary treatment contains no corn stover

[5] a* Value: -a = green, +a = red

Figure 18. Yellowness (b*) values in bologna of cattle fed treated corn stover during backgrounding



Treatment effect (P = .084)

[1] Control diet contains untreated corn stover

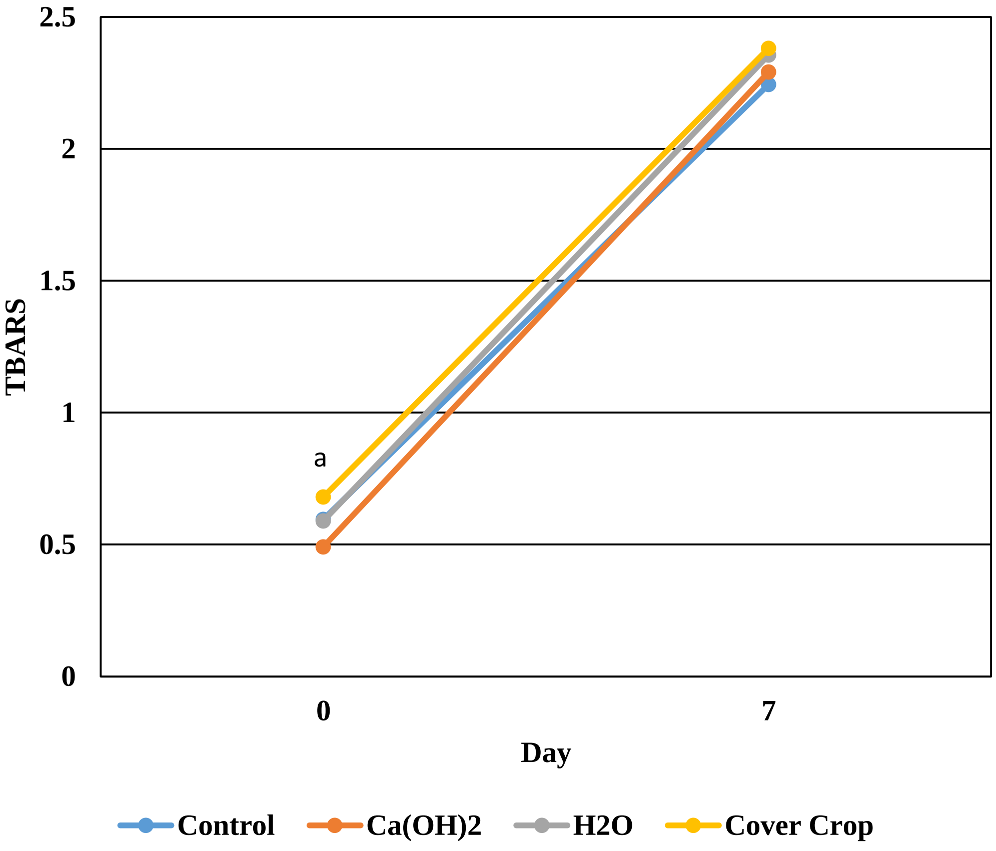
[2] Ca(OH)2 diet contains corn stover treated with calcium hydroxide

[3] H2O dietary treatment contains corn stover treated with water

[4] Cover Crop dietary treatment contains no corn stover

[5] b* Value: -b = blue, +b = yellow

Figure 19. Thiobarbituric acid reactive substances (TBARS) measured pre and post-retail color display in ground beef samples of cattle fed treated corn stover during backgrounding*



[a] CC differs from $Ca(OH)_2$ ($P < .001$)

* Day 0 ($P = 0.003$), Day 7 ($P = 0.830$)

[1] Control diet contains untreated corn stover

[2] Ca(OH)2 diet contains corn stover treated with calcium hydroxide

[3] H2O dietary treatment contains corn stover treated with water

[4] Cover Crop dietary treatment contains no corn stover

BIBLIOGRAPHY

Aldai, N., Aalhus, J.L., Dugan, M.E.R., Robertson, W.M., McAllister, T.A., Walter, L.J., & McKinnon, JJ. (2010). Comparison of wheat- versus corn-based dried distillers' grains with solubles on meat quality of feedlot cattle. *Meat Science, 84*(3), 569-577. doi: http://dx.doi.org/10.1016?j.meatsci.2009.10.014

AMSA. (2012). Meat Color Measurement Guidelines. Champaign, IL: American Meat Science Association.

Arias, R.P., Unruh-Snyder, L.J., Scholljergerdes, E.J., Baird, A.N., Johnson, K.D., Buckmaster, D., Lemenager, R.P., & Lake, S.L. (2012). Effects of feeding corn modified wet distillers grains plus solubles co-ensiled with direct-cut forage on feedlot performance, carcass characteristics, and diet digestibility of finishing steers. *J. Anim. Sci., 90(10),* 3574-3583. doi:10.2527/jas.2011-4502

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

CEM Corporation. (2016) SMART Trac II - Moisture & Fat Analysis Technology.

Chapple, W. (2015). Effects of feeding treated corn stover and distillers grains to beef cattle on performance, carcass traits, digestibility, and ruminal metabolism. *University of Illinois Extension.*

Claborn, S.W., Garmyn, A.J., Brooks, J.C., Rathmann, R.J., Ramsey, C.B., Thompson, L.D., & Miller, M.F. (2011). Consumer evaluation of the palatability of USDA Select, USDA Choice, and Certified Angus Beef strip loin steaks from retail markets in Lubbock, Texas, U.S.A. *Journal of Food Quality 34*:425-434.

Combs, D. (2015). Alkali-treated corn stover for ruminants: Research update. *University of Wisconsin-Madison.*

Covington, R.C., Tuma, H.J., Grant, D.L, & Dayton, A.D. (1970). Various chemical and histological characteristics of beef muscle as related to tenderness. *J. Anim. Sci. 30:*203-206.

de Mello Jr., A.S., Jenschke, B.E., & Calkins, C.R. (2008). Influence of feeding wet distillers grains on fatty acid composition of beef. *Nebraska Beef Cattle Reports.* Paper 45.

DeDecker J., and Gould, K. (2014). Maximizing the value of corn stover. *Michigan State University Extension. http://www.agweb.com/Maximizing_the_Value_of_Corn_Stover_NAA_University_News_Release-university-news-release/?print=y*

Depenbusch, B.E., Coleman, C.M., Higgins, J.J., & Drouillard, J.S., (2009). Effects of increasing levels of dried corn distillers grains with solubles on growth performance, carcass characteristics, and meat quality of yearling heifers. *J. Anim. Sci. 87(8)*:2653-2663. doi: 10.2527/jas.2008-1496

DiCostanzo, A. (2015). Economics of backgrounding cattle. *University of Minnesota Extension Stocker Backgrounder Nutrition Management Lesson 6.*

Drake, D.J. (2015). *Understanding and Improving Beef Cattle Carcass Quality.* University of California Division of Agriculture and Natural Resources.

Duckworth, M.J. (2013). Effects of feeding CaO treated modified wet distillers grains with solubles or corn stover to cattle on performance, carcass characteristics, and ruminal metabolism (*Master's Thesis) Retrieved from http://hdl.handle.net/2142/46690*

Edwards, W. (2014). Estimating a value for corn stover. *Ag Decision Maker*.

Felix, T.L., Murphy, T.A., & Loerch, S.C. (2012). Effects of dietary inclusion and NaOH treatment of dried distillers grains with solubles on ruminal metabolism of feedlot cattle. *J. Anim. Sci 90*:4951-4961. doi: 10.2527/jas2011-4736

Fox, D.G., Johnson, R.R., Preston R.L., Dockerty, T.R., & Klosterman, E.W., (1972). Protein and energy utilization during compensatory growth in beef cattle. *J. Anim. Sci. 34(2),* 310-318.

Gill, R.K., VanOverbeke, D.L., Depenbusch, B., Drouillard, J.S., & DiCostanzo, A. (2008). Impact of beef cattle diets containing corn or sorghum distillers grains on beef color, fatty acid profiles, and sensory attributes. *J. Anim. Sci 86(4),* 923-935. doi: 10.2527/jas.2007-0244

Glassner, D.A., Hettenhaus, J.R., & Schechinger, T.M. (1998). Corn Stover Collection Project. *BioEnergy '98: Expanding BioEnergy Partnerships p.1100-1110.*

Gordon, C.M., Drouillard, J.S., Phebus, R.K., Hachmeister, K.A., Dikeman, M.E., Higgins, J.J., & Reicks, A.L. (2002). The effect of Dakota Gold®-brand dried distillers grains with solubles of varying levels on sensory and color characteristics of ribeye steaks. *Cattlemen's Day* (pp.72-74).

Graham, R.L., Nelson, R., Sheehan, J., Perlack, R.D., & Wright, L.L. (2007). Current and potential U.S. corn stover supplies. *Agronomy Journal 99*:1-11. doi:10.2134/agronj2005.0222

Gunn, P.J., Weaver, A.D., Lemenager, R.P., Gerrard, D.E., Claeys, M.C., & Lake, S.L. (2009). Effects of dietary fat and crude protein on feedlot performance, carcass characteristics, and meat quality in finishing steers fed differing levels of dried distillers grains with solubles. *J. Anim. Sci. 87*:2882-2890. doi: 10.2527/jas.2008-1521

Haddad, S.G., Grant, R.J., & Klopfenstein, T.J. (1995). Digestibility of alkali-treated wheat straw measured in vitro or in vivo using Holstein heifers. *J. Anim. Sci. 73*:3258-3265.

He, M.L., McAllister, T.A., Hernandez-Calva, L.M., Aalhus, J.L., Dugan, M.E.R., & McKinnon, J.J. (2014). Effect of dietary inclusion of triticale dried distillers grain and oilseeds on quality and fatty acid profile of meat from feedlot steers. *Meat Science 97*:76-82. doi: http://dx.doi.org/10.1016/j.meatsci.2014.01.008

Hornick, J.L., Van Eenaeme, C., Clinquart, A., Diez, M., and Istasse, L. (1998) Different periods of feed restriction before compensatory growth in Belgian Blue bulls: I. animal performance, nitrogen balance, meat characteristics, and fat composition. *Journal of Animal Science 76*:249-259.

Johnston, J.E. (2014). Impact of using reduced-fat distillers grains in beef feedlot diets on carcass and meat quality (Master's Thesis). Retrieved from the University of Minnesota Digital Conservancy, http://hdl.handle.net/11299/169991.

Kelzer, J.M., Popowski, J.M., Bird, S., Cox, R.B., Crawford, G.I., & DiCostanzo, A. (2011). Effects of including low fat, high protein dried distillers grains in finishing diets on feedlot performance and carcass characteristics of beef steers. *2011 University of Minnesota Beef Report Publication BR-1104.*

Kim, S.H. (2003). Lime pretreatment and enzymatic hydrolysis of corn stover. Doctoral dissertation, Texas A&M University. Texas A&M University. Available electronically from http : / /hdl .handle .net /1969 .1 /2208.

Kim, Y., Park, J., Lee, Y., Lee, M., Oh, Y., Choi, D., Kwak, W. (2014). Effects of a by-product feed-based silage diet on the performance, blood metabolites, and carcass characteristics of Hanwoo heifers (a field study). Res. Opin. Anim. Vet. Sci., 4(12): 654-662.

Kinder, C.A. (2004). Growing and utilizing turnips as forages. *Proceedings, Idaho Alfalfa and Forage Conference, 24-25.*

Kingsley, A.R.P., Ileleji, K.E., Clementson, C.L., Garcia, A., Maier, D.E., Stroshine, R.L., & Radcliff, S. (2010). The effect of process variables during drying on the physical and chemical characteristics of corn dried distillers grains with solubles (DDGS)-Plant scale experiments. *Bioresource Technology 101*:193-199. doi: 10.1016/j/biortech.2009.07.070

Kinman, L.A., Hilton, G.G., Richards, C.J., Morgan, J.B., Krehbiel, C.R., Hicks, R.B., Dillwith, J.W., & VanOverbeke, D.L. (2011). Impact of feeding various amounts of wet and dry distillers grains to yearling steers on palatability, fatty acid profile, and retail case life of longissimus muscle. *J. Anim. Sci. 89*:179-184. doi: 10.2527/jas.2010-3137

Klopfenstein, T. (1978). Chemical treatment of crop residues. *J. Anim. Sci. 46(3)*, 841-848.

Klopfenstein, T.J., Cooper, R., Jordon, D.J., Shain, D., Milton, T., Calkins, C.R., & Rossi, C. (1999a). Effects of backgrounding and growing programs on beef carcass quality and yield. *Faculty Papers and Publications in Animal Science.* Paper 550.

Klopfenstein, T.J., Jordon, D.J., Rush, I.G., & Milton, T. (1999b). Predicting amount of compensatory gain. *Nebraska Beef Cattle Reports.* Paper 412.

Knoblich, H.V., Fluharty, F.L., & Loerch, S.C. (1997). Effects of programmed gain strategies on performance and carcass characteristics of steers. *J. Anim. Sci. 75*:3094-3102. doi: http://jas.fass.org/content/75/12/3094

Koch, D.W. (2015). Brassicas for Fall Grazing. *University of Wyoming Extension Department of Plant Sciences.*

Koundinya, V. (2009). Corn Stover. *Agricultural Marketing Resource Center.* http://www.agmrc.org/renewable_energy/corn-stover/

Kuntapaint, C. 1978. Beef muscle and adipose lipid deterioration as affected by nutritional regime, vacuum aging, display and carcass conditioning. Ph.D. dissertation. Kansas State University. Pg. 117.

Lardy, G. and Anderson, V. (2009). Alternative feeds for ruminants. *North Dakota State University Extension AS-1182.*

Leupp, J.L., Lardy, G.P., Bauer, M.L., Karges, K.K., Gibson, M.L., Caton, J.S., & Maddock, R.J. (2009). Effects of distillers dried grains with solubles on growing and finishing steer intake, performance, carcass characteristics, and steak color and sensory attributes. *J. Anim. Sci. 87(12),* 4118-4124. doi: 10.2527/jas.2009-2149

Lippke, H. (2002). Forage & grazing lands estimation of forage intake by ruminants on pasture. *Crop Sci. 42*:869-872.

Loken, B.A., Maddock, R.J., Stamm, M.M., Schauer, C.S., Rush, I., Quinn, S., & Lardy, G.P. (2009). Growing rate of gain on subsequent feedlot performance, meat, and carcass quality of beef steers. *J. Anim. Sci. 87*:3791-3797. doi: 10.2527/jas.2009-1853

Lorenzen, C.L., Miller, R.K., Taylor, J.F., Neely, T.R., Tatum, J.D., Wise, J.W., Buyck, M.J., Reagan, J.O., & Savell, J.W. (2003). Beef Customer Satisfaction: Trained sensory panel ratings and Warner-Bratzler shear force values. *J. Anim. Sci. 81*:143-149.

Mansfield, S. D, Mooney, C, & Saddler, J. N. (1999). Substrates and enzyme characteristics that limit cellulose hydrolysis. *Biotechnology Progress 15(5),* 804-816. doi: 10.1021/bp9900864

McCurdy, M.P., Horn, G.W., Wagner, J.J., Lancaster, P.A., & Krehbiel, C.R. (2010). Effects of winter growing programs on subsequent feedlot performance, carcass characteristics, body composition, and energy requirements of beef steers. *J. Anim. Sci. 88*:1564-1576. doi: 10.2527/jas.2009-2289

McGregor, E.M., Campbell, C.P., Miller, S.P., Purslow, P.P., & Mandell, I.B. (2012). Effect of nutritional regimen including limit feeding and breed on growth performance, carcass characteristics, and meat quality in beef cattle. *Can. J. Anim. Sci. 92*:327-341. doi: 10.4141/CJAS2011-126

Miller, M.F., Carr, M.A., Ramsey, C.B., Crockett, K.L., & Hoover, L.C. (2001). Consumer thresholds for establishing the value of beef tenderness. *J. Anim. Sci. 79:*3062-3068.

Mousel, E. (2012). Incorporating Cover Crops into Forage Systems. *University of Minnesota Extension North Central Research and Outreach Center.*

P. D. Muir , J. M. Deaker & M. D. Bown (1998) Effects of forage- and grain-based feeding systems on beef quality: A review, *New Zealand Journal of Agricultural Research*, 41:4, 623-635, DOI: 10.1080/00288233.1998.9513346

NASS. (2014a). *Charts and Maps.* Economics. Grazing Fees. http://www.nass.usda.gov/Charts_and_Maps/Grazing_Fees/index.asp

NASS. (2014b). *Charts and Maps.* Economics. Farm Labor. http://www.nass.usda.gov/Charts_and_Maps/Farm_Labor/index.asp

NASS. (2014c). Charts and Maps. Economics. Land Values. http://www.nass.usda.gov/Charts_and_Maps/Land_Values/index.asp

NASS. (2014d). Charts and Maps. Economics. Field Crops. http://www.nass.usda.gov/Charts_and_Maps/Field_Crops/index.asp

National Cattlemen's Beef Association (NCBA). (2015). Beef Industry Statistics.

Ndlovu, L.R. and Manyame, Z. (1989). Hydration as a means of improving utilization of maize stover fed to steers. *Proceedings of the fourth annual workshop held at the Institute of Animal Research, Mankon Station, Bamenda, Cameroon.*

Nuñez, A.J.C., Felix, T.L., Lemenager, R.P., & Schoonmaker, J.P. (2014). Effect of calcium oxide inclusion in beef feedlot diets containing 60% dried distillers grains with solubles on ruminal fermentation, diet digestibility, performance, and carcass characteristics. *J. Anim. Sci. 92:*3954-3965. doi: 10.2527/jas2013-7501

Oddy, V.H., Harper, G.S., Greenwood, P.L., & McDonagh, M.B. (2001). Nutritional and developmental effects on the intrinsic properties of muscles as they relate to the eating quality of beef. *Australian Journal of Experimental Agriculture 41:*921-942. doi: 10.1071/EA00029

Perry, D. and Thompson, J.M. (2005). The effect of growth rate during backgrounding and finishing on meat quality traits in beef cattle. *Meat Science 69*:691-702. doi: 10.1016/j.meatsci.2004.10.020

Pobiner, B. (2013) Evidence for Meat-Eating by Early Humans. Nature Education Knowledge 4(6):1

Rasby, R.J., Rush, I.G., & Stock, R. (1994). G4-1228 Wintering and Backgrounding Beef Calves. *Historical Materials from University of Nebraska-Lincoln Extension*. Paper 308.

Reicks, A.L., Brooks, J.C., Garmyn, A.J., Thompson, L.D., Lyford, C.L., & Miller, M.F. (2011). Demographics and beef preferences affect consumer motivation for purchasing fresh beef steaks and roasts. *Meat Science 87*:403-411. doi: 10.1016/j.meatsci.2010.11.018

Reuter, R.R. and Beck, P.A. (2013). Southern Section Interdisciplinary Beef Cattle Symposium: Carryover effects of stocker cattle systems on feedlot performance and carcass characteristics. *J. Anim. Sci. 91*:508-515. doi: 10.2527/jas2012-5527

Rhee, M.S., Wheeler, T.L., Shackelford, S.D., & Koohmaraie, M. (2004). Variation in palatability and biochemical traits within and among eleven beef muscles. *J. Anim. Sci. 82*:534-550.

Roeber, D.L., Cannell, R.C., Belk, K.E., Miller, R.K., Tatum, J.D., & Smith, G.C. (2000). Implant strategies during feeding: Impact on carcass grades and consumer acceptability. *J. Anim. Sci. 78*:1867-1874.

Russell, J., Loy, D., Anderson, J., & Cecava, M. (2011). Potential of chemically treated corn stover and modified distiller grains as a partial replacement for corn grain in feedlot diets. *Iowa State University Animal Industry Report 2011.* A.S. Leaflet R2586.

Saskatchewan Agriculture, Food and Rural Revitalization (SAFRR). (2003). Backgrounding Beef Cattle in Saskatchewan. *Livestock Development Branch.*

Savell, J.W. and Sitka, L. (2007). Identification of Threshold Levels for Warner-Bratzler Shear Force of Beef Value Cuts. *National Cattlemen's Beef Association*

Schroeder, J.W. (2012). Ammoniation and adding hydrated lime can improve low-quality forages. *Dairy Focus: Improve Low-quality Forages.* North Dakota State University Extension Services.

Shackelford, S.D., Morgan, J.B., Cross, H.R., & Savell, J.W. (1991). Identification of threshold levels for Warner-Bratzler Shear Force in beef top loin steaks. *Journal of Muscle Foods 2(4),* 289-296. doi: 10.1111/j.1745-4573.1991.tb004161.x

Shreck, A.L., Nuttelman, B. L., Schneider, C.J., Burken, D.B., Maken, C.N., Griffin, W.A., Erickson, G.E., & Klopfenstein, T.J., (2014). Alkaline treated wheat straw or corn stover fed to growing calves. *Nebraska Beef Cattle Reports.* Paper 781.

Shreck, A.L., Nuttelman, B.L., Griffin, W.A., Klopfenstein, T.J., & Cecava, M.J. (2012). Chemical treatment of low-quality forage to replace corn in cattle finishing diets. *Nebraska Beef Cattle Reports.* Paper 690.

Shreck, A.L., Nuttelman, B.L., Harding, J.L., Griffin, W.A., Erickson, G.E., Klopfenstein, T.J., & Cecava, M.J. (2015). Digestibility and performance of steers fed low quality crop residues treated with calcium oxide to partially replace corn in distillers grains finishing diets. *J. Anim. Sci. 93*:661-671. doi: 10.2527/jas2013-7194

Smart, A.J. and Pruitt, R.J. (2015). Rye and turnips to extend the grazing season for weaned calves. *Beef 2006-11 South Dakota State University Department of Animal and Range Sciences.*Stock, R., Lewis, J.M., Klopfenstein, T.J., & Milton, C.T. (1999). Review of new information on the use of wet and dry milling feed by-products in feedlot diets. *Faculty Papers and Publications in Animal Science.* Paper 555.

USDA. (1997). United States Standards for Grades of Carcass Beef.

USDA. (2003). Agriculture Fact Book. Washington, DC. *U.S. Government Printing Office.*

USDA. (2012). Crop and Livestock Practices-Overview. http://www.ers.usda.gov/topics/farm-practices-management/crop-livestock-practices.aspx

USDA. (2014). Inspection and Grading of Meat and Poultry: What Are the Differences? http://www.fsis.usda.gov/wps/portal/fsis/topics/food-safety-education/get-answers/food-safety-fact-sheets/production-and-inspection/inspection-and-grading-of-meat-and-poultry-what-are-the-differences_/inspection-and-grading-differences

USDA. (2015a). Cattle and Beef-Overview. http://www.ers.usda.gov/topics/animal-products/cattle-beef.aspx

USDA. (2015b). Livestock and Meat Domestic Data-Overview. http://www.ers.usda.gov/data-products/livestock-meat-domestic-data/interactive-chart.aspx

USDA (2015c). Cattle and Beef-Statistics & Information. http://www.ers.usda.gov/topics/animal-products/cattle-beef/statistics-information.aspx

Vaage, A.S., McCartney, D.H., McKinnon, J.J., & Bergen, R.D. (1998). Effect of prolonged backgrounding on growth performance and carcass composition of crossbred beef steers. *Canadian Journal of Animal Science 78(3)*, 359-367.

Warner, R.D., Greenwood, P.L., Pethick, D.W., & Ferguson, D.M. (2010). Genetic and environmental effects on meat quality. *Meat Science 86*:171-183. doi: 10.016/j.meatsci.2010.04.042

Watson, A.K., MacDonald, J.C., Erickson, G.E., Kononoff, P.J., & Klopfenstein, T.J. (2015). Forages and Pastures Symposium: Optimizing the use of fibrous residues in beef and dairy diets. *J. Anim. Sci. 93* doi:10.2527/jas2014-8780. doi: 10.2527/jas2014-8780

Witte, V.C., Krause, G.F., & Bailey, M.E., 1970. A new extraction method for determining 2-thiobarbituric acid values for pork and beef during storage. *Journal of Food Science,* 35, 582-585.

APPENDIX A

TBARS Procedure

1. Weigh out 2.0 g (1.95 to 2.05g) of minced meat into a labeled 50 ml disposable centrifuge tube. Record the exact weight of the sample.
2. Add 8 ml of prepared phosphate buffer to the tube.
3. Add 2 ml of TCA to the tube, and homogenize for 20 to 30 seconds.
4. Filter the homogenate through a Whatman (No. 4) filter paper, collecting the clear filtrate into labeled tubes.
5. Remove 2 ml of the sample filtrate and place into labeled glass test tube. Prepare duplicate tubes for each samples at this point.
6. Prepare three "Blank" tubes, using 2 ml of distilled-deionized water.
7. Prepare one "Standard" tube, using 2 ml of phosphate buffer.
8. Add 2 ml of TBA to each tube including the blanks and standard.
9. Cover the tubes with aluminum foil and place into hot water bath for 20 minutes.
10. Remove the tubes from hot water bath and place into ice water bath for 15 minutes.
11. Read absorbance by 533 nm.
12. Multiply absorbance by 12.21.
13. Report TBARS as mg/kg of maldonaldehyde.

Standard

1,1,3,3 tetraethoxypropane (TEP)

Stock standard solution

(0.02M Solution) .44g (0.5 ml) to 100 ml of distilled water (2 x 10^{-5} moles/ml)

Working standard solution

Dilute 0.5 ml of TEP stock standard to 500 ml (2 x 10^{-8} moles/ml)

Standards for standard curve

Dilute each of the following amounts of TEP working solution in 50 ml volumetric flasks with distilled water

References

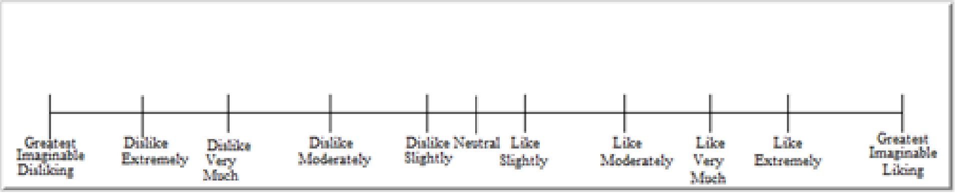
Kuntapaint, C. 1978. Beef muscle and adipose lipid deterioration as affected by nutritional regime, vacuum aging, display and carcass conditioning. Ph.D. dissertation. Kansas State University. Pg. 117.

Witte, V.C., Krause, G.F., & Bailey, M.E., 1970. A new extraction method for determining 2-thiobarbituric acid values for pork and beef during storage. *Journal of Food Science,* 35, 582-585.6

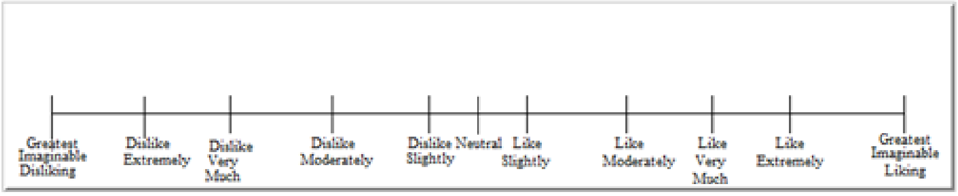
APPENDIX B

Sensory Evaluation of Bologna and Fresh Steaks

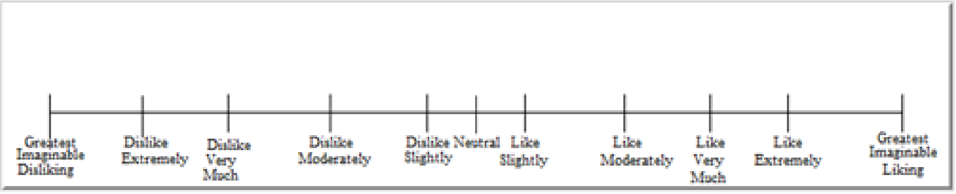
Overall Liking



Flavor Liking



Texture Liking



Reference Caption	Point Value
Greatest imaginable disliking	0
Dislike extremely	13
Dislike very much	25
Dislike moderately	39.5
Dislike slightly	53
Neutral	60
Like slightly	67
Like moderately	81
Like very much	93
Like extremely	104
Greatest imaginable liking	120

Toughness

None

Extremely Tough

Juciness

None

Extremely Juicy

Off Flavor

None

Extremely Intense