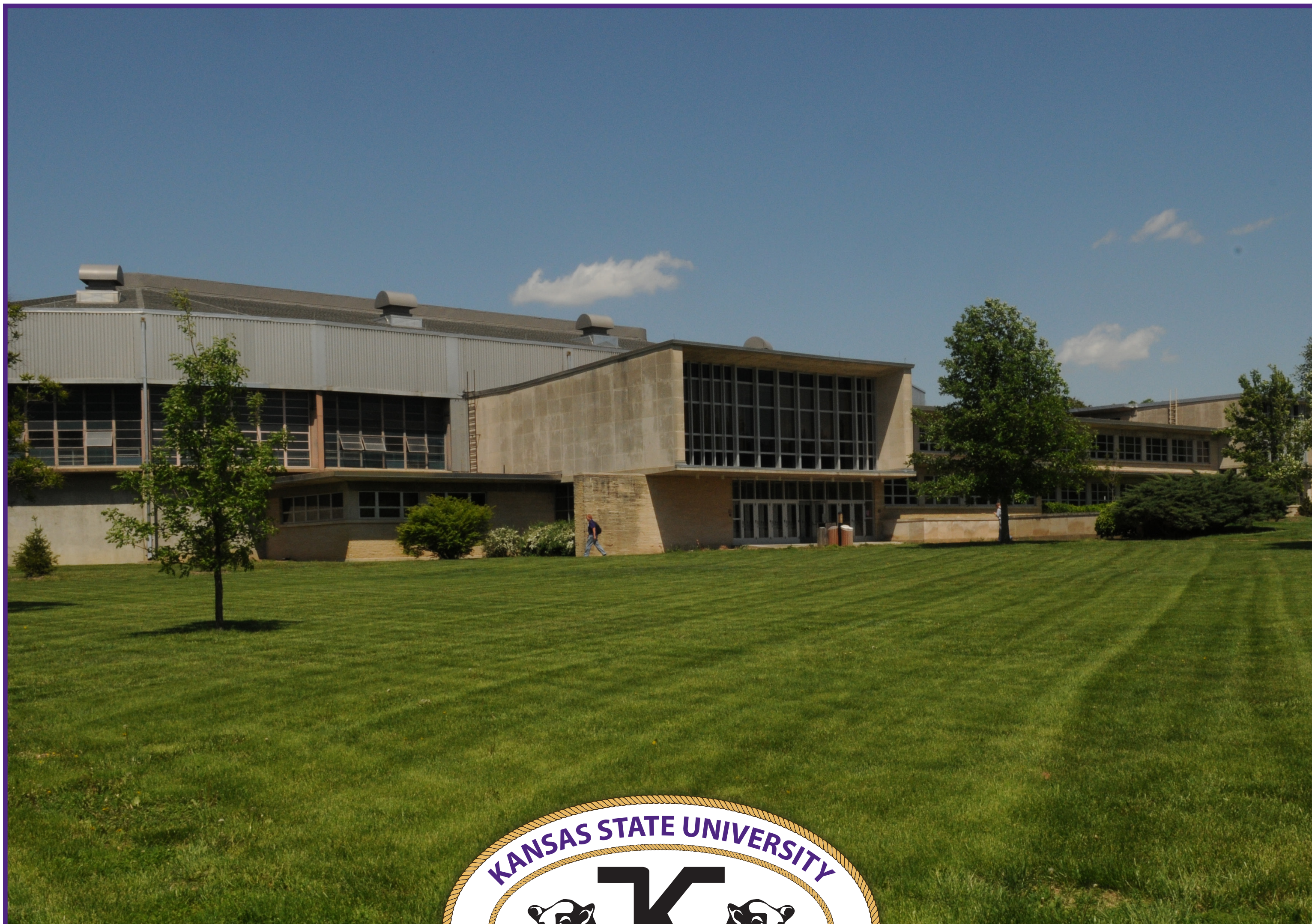

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Contents

Long-Term Effects of April, August, or October Prescribed Fire on Yearling Stocker Cattle Performance and Native Rangeland Plant Composition in the Kansas Flint Hills

Z.M. Duncan, A.J. Tajchman, J. Lemmon, W.R. Hollenbeck, D.A. Blasi, and K.C. Olson

Abstract

A six-year experiment was conducted between June 2018 and August 2023 to evaluate the effects of prescribed-fire season on stocker cattle growth performance and plant species composition in the Kansas Flint Hills. Eighteen pastures were grouped by watershed and each watershed was assigned randomly to one of three prescribed-fire treatments (n = 6 pastures per treatment): spring (April 11 ± 5.7 days), summer (August 25 ± 6.2 days), or fall (October 2 ± 9.0 days). Over five consecutive years, 1,939 yearling cattle [initial body weight (BW) = 619 ± 129.8 lb] were grazed for 90 days at a targeted density of 250 lb of live-weight per acre. Soil cover and plant species composition was measured annually beginning in June 2018 using a modified step-point technique. In addition, standing forage biomass was estimated in 2018, 2020, and 2022. Total BW gains and average daily gains were greater ($P \leq 0.03$) for calves grazing spring-burned pastures compared with calves grazing summer- or fall-burned pastures. Proportion of bare soil was greater ($P \leq 0.02$) while proportion of litter on the soil surface was lesser ($P \leq 0.01$) in the spring prescribed-fire treatment compared with the summer and fall prescribed-fire treatments. Standing forage biomass did not differ ($P = 0.58$) among fire regimes. In addition, basal cover of total grasses, native grasses, total forbs, and native forbs did not differ ($P \geq 0.24$) among prescribed-fire treatments. Conversely, basal cover of C3 grasses tended to be greater ($P = 0.06$), while basal cover of C4 grasses tended to be lesser ($P = 0.08$) in fall-burned pastures compared with spring-burned pastures. These data were interpreted to suggest that prescribed-fire timing had small influences on yearling stocker cattle growth performance and was associated with minor changes in rangeland plant composition.

Introduction

Flint Hills ranchers use spring-season prescribed fire on pastures to improve yearling stocker cattle weight gains, increase native warm-season grass production, and reduce encroachment of woody and invasive plant species. Although spring fire has been established as a standard practice in the Flint Hills community, there are challenges associated with burning during that time of the year. Strong winds and low relative humidity are common during this period and when combined with elevated fuel loads, can make fires difficult to control. When the number of days to safely conduct a burn are reduced, large amounts of rangeland are often burned when conditions allow. As a result, large volumes of smoke are produced in a relatively short period of time. Smoke produced from burning can travel to areas downwind of the Flint Hills and reduce air quality. In addition, spring-season prescribed fires do not control sericea lespedeza (*Lespedeza cuneata*). Sericea lespedeza is an invasive perennial legume that has degraded over

600,000 acres of native rangeland across the Kansas Flint Hills. Shifting prescribed-fire application from April to August or September reduced sericea lespedeza vigor and seed production in previous experiments. However, widespread adoption of growing season prescribed fires in the Flint Hills have been limited because burning pastures later in the year could have unknown major effects on the growth performance of stocker cattle during the next grazing season. The objective of our experiment was to determine if prescribed fire applied in April, August, or October influenced stocker cattle growth performance, plant community characteristics, or standing forage biomass accumulation in the Kansas Flint Hills over a 6-year period.

Experimental Procedures

A 6-year experiment was conducted at the Kansas State University Beef Stocker Unit from June 2018 to August 2023. Eighteen pastures were grouped by watershed and each watershed was assigned randomly to one of three prescribed-fire treatments ($n = 6$ pastures per treatment): spring (April 11 ± 5.7 days), summer (August 25 ± 6.2 days), or fall (October 2 ± 9.0 days). All burn treatments were applied prior to grazing in years 1, 2, 3, and 5 of the experiment; however, burn treatments were not applied in year 4 due to unfavorable burn conditions. At the start of the experiment, a permanent 328-ft transect was established within each pasture. Soil cover and plant species composition were measured alongside each transect using a modified step-point method. Pre-treatment measurements were recorded in June 2018 and annually in June thereafter. Standing forage biomass was determined in 2018, 2020, and 2022 by clipping vegetation within ten 0.82-ft^2 frames randomly placed at 33-ft intervals along each transect. After frames were placed, litter from the previous growing season was removed and all remaining plant material was clipped at a height of 0.39-in above the soil and dried in a forced-air oven (122°F; 96 hours).

A total of 1,939 yearling cattle [initial body weight (BW) = 619 ± 129.8 lb] were grazed over five consecutive growing seasons beginning in 2019. Calves were grazed for 90 days at a targeted density of 250 lb of live-weight per acre. Upon arrival, calves were held in earth-floor pens and limit-fed a growing diet until the start of the grazing season. Prior to grazing, calves were individually weighed and randomly assigned to one of 18 pastures. On the day grazing began, calves were individually weighed, treated for internal and external parasites, and allocated to their assigned pastures. Based on cattle availability, heifers were grazed in year 1 and steers were grazed in years 2 to 5. Steers received a growth-promoting implant. At the completion of the 90-day grazing period, calves were gathered and individual BW were immediately measured.

Results and Discussion

After five consecutive grazing seasons, total body weight gains (TBW) and average daily gains (ADG) were greater ($P \leq 0.03$; Table 1) for calves grazing spring-burned pastures compared with those grazing summer- or fall-burned pastures; however, TBW and ADG did not differ ($P = 0.55$) between calves grazing summer- or fall-burned pastures. As a result, TBW at the end of the 90-day grazing season were 10 and 14 lb lower for calves grazing summer- and fall-burned pastures compared with calves grazing spring-burned pastures, respectively. Differences in growth performance among prescribed-fire treatments may have been associated with differences in diet quality. Proportions of litter on the soil surface were greatest ($P \leq 0.04$; Table 2) in summer-burned pastures, intermediate ($P \leq 0.04$) in fall-burned pastures, and least ($P \leq 0.01$) in spring-burned pastures. Calves grazing summer- or fall-burned pastures may have consumed lesser quality regrowth from the previous growing season which could have contributed to reduced growth performance.

Proportions of bare soil were greater ($P \leq 0.02$) in spring-burned pastures compared with summer- and fall-burned pastures. Soil cover was measured annually in June; therefore, as the length of time between fire application and sampling increased, proportions of bare soil decreased while proportions of litter on the soil surface increased. Basal vegetation cover did not differ ($P = 0.19$) among prescribed-fire treatments and accounted for 12 to 13.3% of total area. Similarly, standing forage biomass accumulation did not differ ($P = 0.58$) among treatments.

Basal cover of total grasses and native grasses did not differ ($P \geq 0.24$) among prescribed-fire treatments; however, prescribed-fire timing tended to influence the relative basal cover of cool- and warm-season grasses. Basal cover of C3 grasses tended to be greater ($P = 0.06$) in fall-burned pastures, intermediate in summer-burned pastures, and least in spring-burned pastures. The trend in increased basal cover of C3 grasses may have been associated with differences in basal cover of sedges and Kentucky bluegrass. Basal cover of sedges was numerically greater in fall- and summer-burned pastures compared with spring-burned pastures. In addition, basal cover of Kentucky bluegrass was greater ($P < 0.01$) in the fall prescribed-fire treatment compared with the spring prescribed-fire treatment, whereas basal cover of Kentucky bluegrass in the summer prescribed-fire treatment was intermediate to and not different ($P \geq 0.11$) from the spring- or fall-prescribed-fire treatments. Conversely, basal cover of C4 grasses tended ($P = 0.08$) to be greatest in the spring-fire treatment, intermediate in the summer-fire treatment, and least in the fall-fire treatment. Basal cover of C4 tallgrasses did not differ ($P = 0.35$) among prescribed-fire treatments; however, basal cover of C4 mid- and short-grasses was greater ($P \leq 0.02$) in spring-burned pastures compared with summer- or fall-burned pastures. Increased basal cover of C4 mid- and short-grasses in spring-burned pastures likely contributed to the overall trend in increased basal cover of total C4 grasses.

Basal cover of total forbs and native forbs did not differ ($P \geq 0.43$) among spring, summer, or fall prescribed-fire treatments; however, basal cover of nectar producing forbs was greater ($P \geq 0.03$) in fall-burned pastures compared with spring- and summer-burned pastures. Increased basal cover of nectar producing forbs could have potential benefits to grassland-obligate invertebrates and the native birds that feed upon them. Conversely, basal cover of total shrubs tended ($P = 0.06$) to be greater in pastures burned in the summer and fall compared with pastures burned in the spring. The trend in increased basal cover of shrubs for the fall and summer prescribed-fire treatments was largely driven by numerical increases in basal cover of leadplant and New Jersey tea compared with the spring prescribed-fire treatment. In addition, basal cover of increaser shrubs (i.e., shrubs that tend to proliferate in response to grazing) tended ($P \leq 0.08$) to be greater in summer and fall prescribed-fire treatments compared with the spring prescribed-fire treatment. Although increaser shrubs tended to increase with summer and fall fire, basal cover of increaser shrubs in our experiment was low and represented less than 0.25% of total basal cover.

Implications

Shifting prescribed fire from April to August or October reduced yearling stocker cattle weight gains by 10 to 14 lb during a 90-day grazing season and was associated with small but benign changes in rangeland plant composition in the Kansas Flint Hills. When developing a plan to manage sericea lespedeza infestations, ranchers are encouraged to consider the cost associated with herbicides versus the costs associated with any reduction in growth performance.

Acknowledgments

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Table 1. Effects of prescribed-fire timing on stocker cattle growth performance in the Kansas Flint Hills

	Prescribed fire season			Standard error of the mean[1]	
Item	Spring	Summer	Fall		*P*-value
Initial BW, lb[2]	633	639	629	5.6	0.23
Final BW, lb	847[a]	842[a]	828[b]	5.5	0.01
Total BW gain, lb	213[a]	202[b]	199[b]	4.6	0.02
Average daily gain, lb/day	2.37[a]	2.24[b]	2.21[b]	0.052	0.02

[1]Mixed-model standard error of the mean (SEM) associated with comparison of treatment main-effect means.
[2]Body weight.
[a,b] Within rows, means with unlike superscripts differ ($P \leq 0.05$).

Table 2. Effects of prescribed-fire timing on forage biomass accumulation, soil cover, and plant species composition in the Kansas Flint Hills

Item	Prescribed-fire season			Standard error of the mean[1]	*P*-value
	Spring	Summer	Fall		
Forage biomass, lb/a	1756	1919	1972	220.7	0.58
Soil cover, % of total area					
Bare soil	66.0[a]	55.7[b]	59.8[b]	2.40	< 0.01
Litter cover	20.7[c]	32.3[a]	27.2[b]	2.33	< 0.01
Total basal vegetation cover	13.3	12.0	13.0	0.70	0.19
Basal cover, % of total basal vegetation cover					
Total grass cover	89.4	89.3	85.8	2.53	0.30
Native grass species	85.0	85.2	80.0	3.41	0.24
C3 grasses	19.2[z]	26.1[yz]	27.2[y]	3.44	0.06
Sedges	13.9	19.6	16.3	2.80	0.15
Kentucky bluegrass	2.0[a]	4.1[ab]	5.8[a]	1.25	0.02
C4 grasses	70.1[y]	63.2[yz]	58.7[z]	4.79	0.08
Tallgrasses	33.8	37.3	35.1	2.37	0.35
Mid-grasses	33.1[a]	25.0[b]	22.3[b]	3.73	0.02
Short-grasses	3.1[a]	0.8[b]	1.2[b]	0.83	0.03
Total forb cover	9.97	9.79	12.53	2.517	0.49
Native forb species	9.81	9.72	12.52	2.401	0.43
Nectar-producing forbs	1.54[b]	1.82[b]	2.71[a]	0.381	0.02
Total shrub cover	0.50[z]	1.20[y]	1.58[y]	0.438	0.06
Increaser shrubs[2]	0.02[z]	0.12[y]	0.24[y]	0.092	0.08

[1] Mixed-model standard error of the mean (SEM) associated with comparison of treatment main-effect means.
[2] Shrubs that tend to proliferate in response to grazing.
[a,b] Within rows, means with unlike superscripts differ ($P \leq 0.05$).
[y,z] Within rows, means with unlike superscripts tend to differ ($P \leq 0.10$).

Reducing Tick Populations Through Prescribed Burning

A. Salazar, H. Griese, V. Pickens, and C. Olds

Abstract
Ticks are one of the most important obligatory blood-feeding ectoparasites of livestock and humans. High tick burdens on cattle can result in decreased production, anemia, skin irritations, pruritus, and stress. In addition, ticks can transmit a wide variety of pathogens such as bacteria, protozoa, and parasites, which cause diseases in animals and humans. Tick control is difficult to achieve because a large proportion of the pest's life is spent off the animal host. Prescribed burning of grasslands has been suggested as a potential method to reduce tick abundance; however, the efficacy of prescribed burning as a mechanism for tick control in the Flint Hills is unknown. This study aimed to explore the effect of seasonal prescribed burning on the tick population in the Kansas Flint Hills. Ticks were collected from three pastures of each prescribed burn treatment: spring (April), summer (August), or fall (September), and non-burned pasture as a control treatment. All areas were burned annually for four years and grazed at an equal stocking density. Ticks were collected every other week from March to August using cloth dragging and baiting with dry ice. Ticks were identified morphologically utilizing a microscope and published keys of tick anatomy. Fewer ticks ($P < 0.0001$) were collected from fire-treated areas compared to unburned areas. Additionally, the season of the burn can potentially further impact tick populations with lower tick populations ($P = 0.0403$) observed in spring burned versus fall burned areas. The results of this study suggest that annual burning of grazing areas could be an effective method to effectively reduce tick abundance in cattle pastures.

Introduction
Worldwide, 80% of the cattle population is infected or at risk of tick-borne pathogens (Rochlin and Toledo, 2020; De Castro et al., 1997). In the U.S., ticks on livestock can cause devastating economic losses. According to the U.S. Department of Agriculture, the economic impact from an extended tick outbreak could be more than $1.2 billion, including control costs. Tick control has largely relied on the use of on-animal acaricides; however, chemical control has significant deleterious effects, including the generation of pesticide resistance, high levels of mammalian and environmental toxicity, and the killing of non-target organisms (Polito et al., 2013; De la Fuente et al., 2007). Alternative effective non-chemical methods for tick control are urgently needed. Prescribed burning of grazing areas has been suggested as an alternative method of tick control (Polito et al., 2013; Davidson et al., 1994). Long-term fire treatment can also significantly reduce tick abundance and could impact tick-borne pathogen prevalence (Gleim et al., 2019).

The efficacy of prescribed burning for tick control in different management systems and geographic regions needs to be further evaluated. Importantly, in areas where prescribed burning is already undertaken for other ecosystem benefits such as weed suppression and grass improvement, the season of burn becomes important. This study explored the effect of prescribed burning on the tick populations on native warm season grassland in the Kansas Flint Hills.

Experimental Procedures

This research project was conducted in the Kansas State University Beef Stocker Unit located west of Manhattan, KS. The grazing area was divided into 18 pastures with six pastures assigned to either a spring, summer, or fall burn. All pastures had been burned for four consecutive years (Figure 1). Spring pastures were burned in April, summer in August, and fall in September. Cattle were grazed between May and August and stocked at equal density. Three pastures in each burn treatment were selected for tick sampling and unburned sections that had not received any fire treatment. Ticks were collected every other week beginning in April and ending in August.

On every tick sampling day, humidity and temperature values were measured using a digital thermometer. Tick collections were performed each day between 8:30 a.m. to 12:00 p.m. Permanent sampling locations were selected to reduce microhabitat variation as a sampling bias. Drag and dry ice bait sampling methods were used to collect ticks in all life stages. For drag sampling procedures, flannel cloths measuring 39.4 × 39.4-in were pinned to a 47.24-in long, 1-in diameter wooden dowel on one side. The dowel was then tied at each end to approximately 59 inches of twine. The fabric flag was dragged as close to the ground as the vegetation would allow. The cloth was dragged over a 50 × 50 ft^2 area using a single pass. All ticks were removed from the fabric and stored in secured tubes. After dragging, dry ice (2.5 lb) was placed on a 39.4 × 39.4-in flannel cloth and left to sublime for 1 hour (Barré et al., 1997; Koch and McNew, 1981; Petry et al., 2010; Zimmerman et al., 1987) in the corner of the square close to trees for approximately an hour. Any ticks collected from the fabric, along with ticks collected from dragging, were stored at -4°F for a minimum of 24 hours to kill ticks. Ticks were counted and identified to species and life stage using microscopically identifiable features. All ticks were identified morphologically utilizing a microscope and published keys. Specimens were stored in microcentrifuge tubes at -4°F.

One-way ANOVA and Tukey's HSD post hoc comparison tests were performed on the number of ticks collected from each treatment area with a significance level of 0.05 ($P < 0.05$). Statistical analyses and plots were generated using GraphPad Prims (GraphPad Software, San Diego, CA).

Results and Discussion

A total of 341 adult ticks, 1,392 nymph ticks, and 234 larva ticks were collected from all study areas (Table 1). Three different tick species were identified: the lone star tick (*Amblyomma americanum*), the American dog tick (*Dermacentor variabilis*), and the Gulf Coast tick (*Amblyomma maculatum*). Lone star ticks are widely distributed across the eastern U.S. from central Texas, Oklahoma, and Kansas, and along the Atlantic coast north to Maine (Raghavan et al., 2019; Centers for Disease Control and Prevention, 2019). The American dog ticks display a broad distribution across the central and eastern U.S. and can also be found in regions of California (Centers for Disease Control and Prevention, 2019; Boorgula et al., 2020). Gulf Coast ticks are mostly found in the southern states such as southeast Kansas and Oklahoma (Centers for Disease Control and Prevention, 2019). Cumulatively, these ticks can transmit pathogens such as *Rickettsia* spp., *Ehrlichia* spp., *Francisella tularensis*, *Anaplasma marginale*, Bourbon virus, and Heartland virus that affect animals and humans (Hecht et al., 2019; Guizzo et al., 2022; Higuita et al., 2021). In states where these ticks predominate as significant vectors of human and animal pathogens, tick control methods are important in reducing the economic losses in beef production sectors.

In this study, ticks were collected from three individual pastures in each treatment group to form three biological replicates. There was no difference among the three pastures burned in spring ($P = 0.4133$) or fall ($P > 0.05$); however, ticks counts in three pastures burned in summer were different ($P = 0.0038$) from each other with one pasture supporting higher tick populations. This was likely due to the vegetation composition in the outlier, which had more wooded areas that are associated with increased presence of ticks. Characteristics observed in wooded habitats including higher humidity, less direct sunlight, and more vertebrate diversity promote tick survival, compared to prairie habitats with lesser woody plant populations (Polito et al., 2013; Bourdin et al., 2023).

Fewer ticks ($P < 0.0001$) were collected from fire-treated areas compared to non-burned control areas during the five months of sampling (Figure 2A). Studies suggest that the reduction of leaf litter cover in post-burned pastures reduces tick abundance (Gallagher et al., 2022; Allan, 2009). The decrease in plant litter may translate to lower soil temperature affecting the survival of ticks over winter (Gallagher et al., 2022). Fire treatment can also reduce environmental humidity and induce high temperatures which cause tick desiccation during dry periods (Gallagher et al., 2022). Together, changes in abiotic and biotic elements caused by prescribed burns, with direct killing of ticks, reduces tick populations.

Among seasonally burned areas, tick counts in fall pastures were higher ($P = 0.0403$) than summer and spring pastures, indicating that the time when fire was performed has an effect on the number of ticks (Figure 2B). The abundance of tick species was lower ($P = 0.0331$) in spring fire treatment areas compared to fall fire treatment. According to a study from areas in Missouri (Bouzek et al., 2013), the *A. americanum* life cycle takes a minimum of two years to complete. Overwintering adults and nymphs emerge in early March (spring), adults start laying eggs in late April, nymphal activity is observed from April to September, while larval activity begins in July until October. When correlating our population counts with the life cycle of *A. americanum*, spring-prescribed burning may be most effective for tick control because ticks are still undergoing overwintering stages and are within leaf litter and relatively immobile. In contrast, the tick counts were higher in summer and fall burned pastures because nymph and larvae stages feeding on small mammals can escape from fire effects. Strategically timing the prescribed fires to align with conditions that specifically target certain tick species at vulnerable periods during their life cycle is important to maximize the effects of prescribed burning for tick control.

Implications

Over time, annual burning of grazing areas can significantly reduce tick populations especially if burned in spring (April) and burning can offer an effective method for non-chemical tick control. Special attention needs to be paid to wooded areas as these areas act as refuges for ticks.

Acknowledgments

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Table 1. Number of *Amblyomma americanum*, *Dermacentor variabilis,* and *Amblyomma maculatum* ticks found following prescribed fire season and identified by life stages

	Number of larvae		Number of nymphs		Number of adults		
Prescribed fire season	***A. americanum***	***D. variabilis***	***A. americanum***	***D. variabilis***	***A. americanum***	***D. variabilis***	***A. maculatum***
Spring	0	0	4	0	2	1	0
Summer	0	0	33	0	27	1	0
Fall	0	0	86	0	26	4	1
Unburned	234	0	1269	0	245	35	1

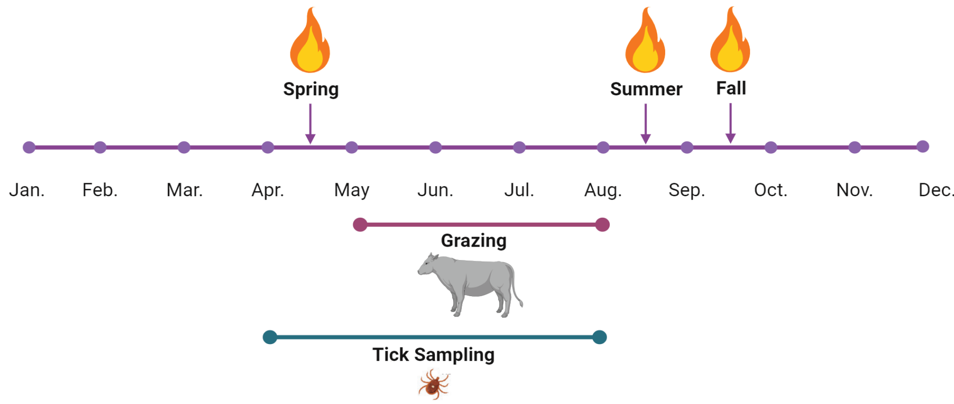

Figure 1. Schematic timeline of prescribed fire timing, cattle grazing period, and tick collection.

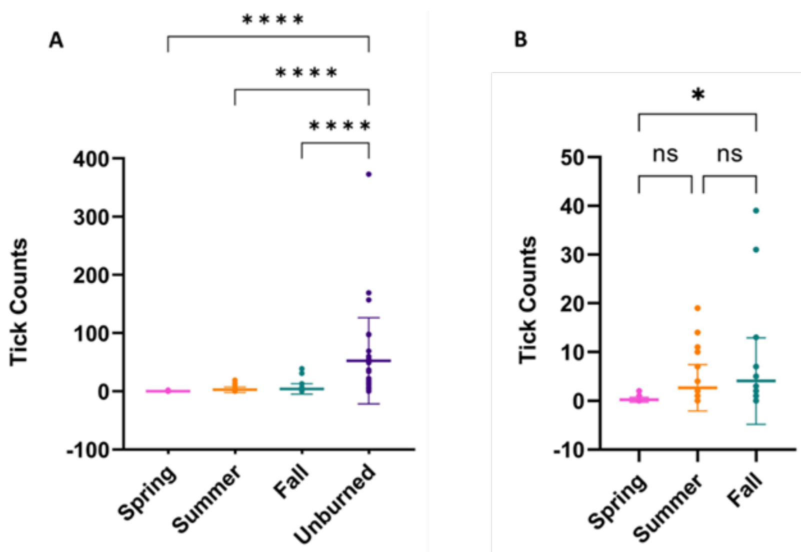

Figure 2. Effects of prescribed fire season treatments (spring, summer, fall, and unburned control) on tick counts.
A) Comparison between ticks collected from prescribed burned and unburned areas from each collection event. B) Comparison between the seasonal time of prescribed burn with relation to tick counts. Each dot represents the total number of ticks collected on each sampling day.
*$P < 0.05$. ****$P < 0.0001$. ns = not significant. Error bars show standard deviation.

The Effects of Seasonal Prescribed Burning on Flint Hills Dung Beetle (*Scarabaeinae)* Populations

H. Griese, A. Salazar, V. Pickens, and C. Olds

Abstract
Dung beetles (*Scarabaeinae*) provide essential services which promote the health and productivity of grasslands across the globe. The beetles move manure and dig tunnels, activities which improve soil drainage, aeration, and nutrient distribution.. In addition, dung beetles can also assist in managing insect pest species such as flies. Studies evaluating the effect of fire on dung beetle communities show mixed results and are often dependent on the geographic location of the study and the species of beetles present. This study aimed to determine if the season of prescribed burning impacted dung beetle communities on pastures grazed by cattle in the Flint Hills.

Introduction
True dung beetles are a family of specialized beetles which feed on manure and use it for larval rearing. Through the tunnels they excavate and the redistribution of manure into the tunnels, dung beetles improve soil drainage, aeration, and nutrient distribution (Nichols et al., 2008). In addition, dung beetles can also assist in managing insect pest species like face and horn flies (*Musca autumnalis* and *Haematobia irritans irritans* (Linnaeus), respectively). Both fly species require fresh intact bovine manure for larval development and studies have shown that dung beetles can reduce fly populations by 74% (Nichols et al., 2008). Horn flies are obligate blood feeding ectoparasites which cause significant stress in animals and production losses (Brewer et al., 2021). With increasing levels of pesticide resistance in multiple fly species in Kansas, non-pesticidal biological control options such as dung beetles can reduce selective pressure on fly populations by reducing the need for pesticide use. Three functional types of dung beetles (known as guilds) fill different niches in the ecosystem. Rollers build a compact ball of manure (brood balls), and roll it away from beetle competition at the manure pat. Tunnelers excavate soil below and adjacent to manure and bury it in the tunnels. The remnants of tunnelers can often be seen underneath a manure pat where small tunnels extend below the ground surface. Rollers and tunnelers are considered the most effective manure distributors (Nervo et al., 2014; Menéndez et al., 2016). Dwellers remain within the manure pat itself and larval development also occurs within the pat instead of in a brood ball below ground.

Prescribed burning is a practice used by many producers in the Great Plains involving the intentional burning of grassland to remove unwanted weeds and allowing the native grasses to grow back healthier (Prescribed Burning, 1999). The effect of burning on arthropod communities is often overlooked despite their major role in maintenance of healthy prairie landscapes. Studies evaluating the effect of fire on dung beetles often produces conflicting data. In the Mediterranean, dung beetle abundance (how many beetles are present) can be negatively affected by fire, but species diversity (which species are present) generally is not affected by burning (Palusci et al., 2021). In Brazil, rain forest beetles were negatively affected by fire (França et al., 2020) but not savannah (Nunes et al., 2019) and it is possible that dung beetles in fire-adapted landscapes are more tolerant of the effects of fire. A study conducted in Texas representing the Southern Great Plains showed no effect of burning on dung beetle populations (Smith et al., 2019). The Texas study carried out beetle collection one month after spring burning in March, so the effects of burning may not have been fully captured due to naturally occurring seasonal variation in species.

Like most insects, dung beetles undergo a dormant period over the winter and a reproductive period occurring during warmer months. Burning when beetles are most active could significantly impact beetle populations and should therefore be avoided. Populations of ticks and insects exist together in complex ecosystems. Fire treatment of Flint Hills warm season grassland significantly reduced the tick populations and should be considered as a method of reducing tick burdens without the need for pesticides. Spring burning was shown to reduce tick populations most effectively in our recent study (Salazar et al., 2024) and if tick control is a priority, spring burning should be performed. However, the effect of burn season on dung beetle populations is unknown. As dung beetles aid in horn fly control, without knowing seasonal burn effects on beetles, selecting spring burning for tick control could potentially negatively impact beetle populations. This study aimed to determine if the season of prescribed burning impacted dung beetle abundance on native warm season grassland in the Flint Hills

Experimental Procedures

This study was carried out over the 2023 grazing season from May 8 until August 15 at the Kansas State University Beef Stocker Unit. The facility has 1,120 acres divided into 18 pastures. Pastures were blocked with six pastures each burned in the spring (April), summer (August), and fall (October). Pastures have been burned annually for four consecutive years. Over the study period, pastures were grazed at an equal stocking density (246 lb/acre) ensuring equal availability of manure resources for beetles in each burn treatment area.

Dung beetle traps were set in three pastures from each burn treatment group and sampled biweekly from June 8 to August 15 resulting in a total of six trapping dates. One pitfall trap was placed in each pasture and traps placed a sufficient distance apart to not cause competition. Areas for trap deployment were selected to ensure similar topography, elevation, and overall vegetation structure. Dung beetles can fly long distances to search for manure (Smith et al., 2019), but we did not expect much travel between the pastures because manure supply was adequate.

Pitfall traps were constructed from clear 16-oz plastic drinking cups. Each trap was constructed using two cups with the outer cup containing a drainage hole drilled into the bottom. Matching holes were drilled on the sides of both cups to allow any rainwater to escape from the inside cup and prevent the trap from overflowing. Holes were dug in the ground deep enough for the stacked cups to be flush with the ground surface to allow beetles to crawl into the cup. Traps were baited with a 2.5 oz ball of swine manure wrapped in cheesecloth and attached to the inner cup rim with a binder clip. Swine manure is very attractive to dung beetles and provides a stronger attractant than any cattle manure in the surrounding area. Cups contained 3.4 oz. of water, 1 teaspoon of salt, and a drop of unscented dish soap to break the water surface tension. A visible post with a bright-colored ribbon was placed directly next to the trap for relocation. Traps were baited in the morning, and allowed to collect beetles for 24 hours, after which they were collected. Collected beetles were cleaned with water and identified using entomological dichotomous keys. Where possible, specimens were identified to the species but in some cases, genus level identifications were made.

The number of beetles collected from each burn treatment group were compared by one-way ANOVA and Tukey's HSD post hoc comparison tests. A collection point was considered to be different from the others if $P < 0.05$. All tests were performed using GraphPad Prism (Version 10 for Windows, GraphPad Software, Boston, MA). Weather data were retrieved from Kansas Mesonet Systems provided by Kansas State University.

Results and Discussion

A total number of 8,646 beetles were collected from nine traps representing at least eight *Scarabaeinae* species (Table 1). *Onthophagus* beetles were identified to the genus level, as some of the identifying characteristics were lost through sample degradation. Some Hister beetles were collected (n = 313) and although these are dung-associated dwelling beetles, they are not members of the *Scarabaeinae* family and were not included in the analysis. *Onthophagus* beetles were the most abundant species collected from all three burn treatment areas, representing over 85% of beetles caught. Although the most numerous, these beetles are also the smallest and not the most effective at manure removal compared to the other larger beetles (Nichols et al., 2018).

The largest numbers of beetles were collected from fall burned pastures (Figure 1) although this is due to the high number of *Onthophagus* beetles. Peak beetle numbers were found two weeks earlier following burning in spring pastures than in fall and summer. Critically, larger beetles from the roller and tunneler guilds were not different ($P > 0.05$) between spring, summer, or fall burned pastures. Season of fire treatment did not significantly impact the number of beetles or dung beetle species collected and choice of burn time can be made on other grounds without impacting beneficial beetles. Interestingly, there was a trend of more beetles being caught on days where the average precipitation for the preceding five days was higher (Figure 2). Further research should be carried out to determine the impact of abiotic climate conditions on dung beetle activity.

Implications

Burning in spring, summer, or fall did not impact dung beetle populations collected on native Flint Hills pasture. Time of burn can be chosen based on other desired outcomes without impacting the size of dung beetle populations.

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We appreciate the Kansas State University Beef Stocker Unit for the use of their facilities.

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Table 1. Number of dung beetles[1] collected from three pastures from each spring, summer, or fall burn treatment group

	Summer		Spring		Fall		
Species	**Average**	**SD[2]**	**Average**	**SD**	**Average**	**SD**	**Guild**
Canthon chalcites	23.8	5.8	22.9	5.8	17.2.0	4.3	Roller
Canthon viridis	1.0	0.0	1.0	0.0	1.0	0.0	Roller
Copris fricator	9.0	6.0	1.7	0.6	3.0	1.0	Tunneler
Dichotomius carolinus	1.7	0.3	1.0	0.0	2.0	0.3	Roller
Melanocanthon nigricornis	6.0	0.0	2.0	0.0	1.0	0.0	Roller
Onthophagus spp.	90.0	40.0	129.0	40.0	168.0	38.0	Tunneler
Phanaeus triangularis	2.0	1.0	1.0	0.0	1.2	1.0	Roller
Phanaeus vindex	2.5	0.5	2.2	0.6	1.6	0.3	Roller
Pseudocanthon perplexus	0.0	0.0	1.0	0.0	0.0	0.0	Roller

[1] Average caught in each trap.
[2] Standard deviation.

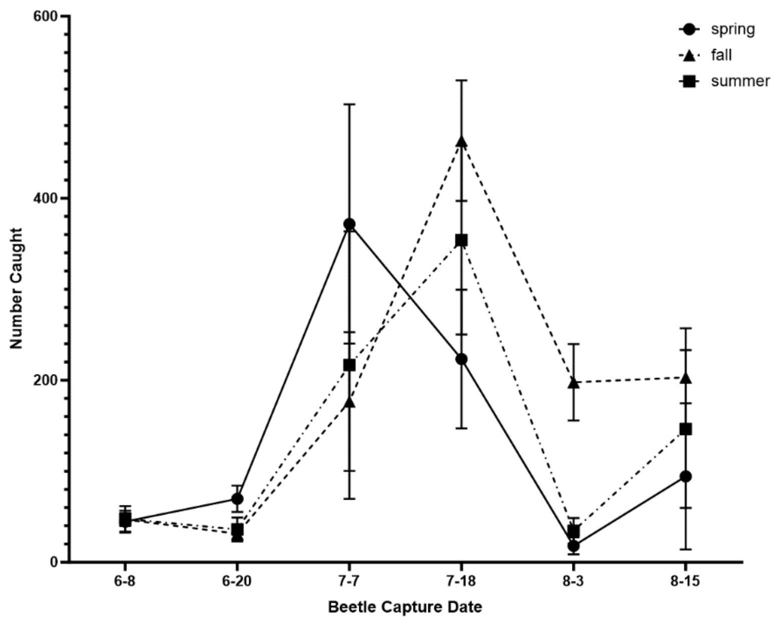

Figure 1. Average number of dung beetles caught on each sampling date with no differences ($P > 0.05$) between spring, summer, or fall treatments.

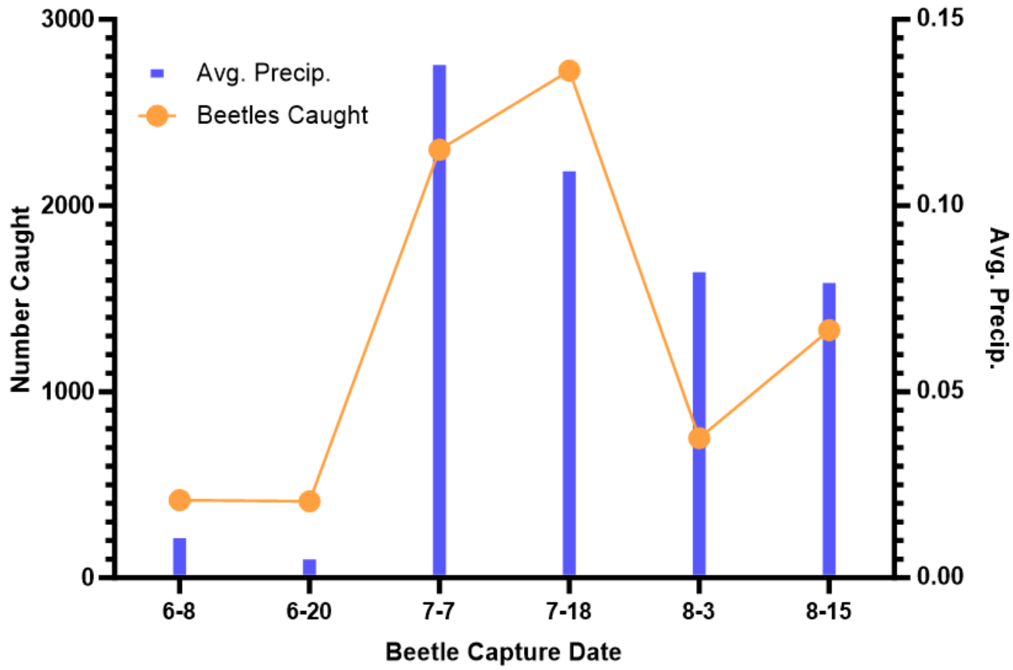

Figure 2. Average precipitation the week prior to beetle collection potentially influences the number of beetles caught.

Effects of Dietary Energy Concentration and Feed Intake on Growth Performance of Newly Received Growing Cattle Fed Diets Based on Corn and Corn Co-Products

C.D. Weir, Z.M. Duncan, W.R. Hollenbeck, S.P. Montgomery, T.J. Spore, and D.A. Blasi

Abstract
A 70-day growing study was conducted to determine the effects of feeding a high-roughage diet for *ad libitum* intake or a high-energy limit-fed diet at equal energy intakes on growth performance of newly received growing beef cattle. A total of 392 crossbred heifers [initial body weight (BW) = 605 ± 58 lb] were blocked by weight (4), stratified by individual arrival weight within block, and allocated to 1 of 8 pens. Pens were randomly assigned to 1 of 4 dietary treatments to provide 8 replications per treatment for a total of 32 pens. Experimental diets included a high-roughage diet fed for *ad libitum* intake (AL) or a limit-fed high-energy diet fed at 75% (LIM-80), or 85% (LIM-85) of *ad libitum* intake. Treatments were designed to equalize for energy intake between calves assigned to AL and LIM-75. At the conclusion of the 70-day feeding period, final body weights and average daily gains did not differ ($P \geq 0.37$) between AL and LIM-75. Dry matter intake was greater ($P > 0.01$) for calves fed for *ad libitum* intake compared with limit-fed calves. As a result, feed-to-gain was lesser for LIM-75, LIM-80, and LIM-85 compared with AL. Overall, limit-feeding a high-energy diet to newly received beef cattle improved feed efficiency compared with feeding a traditional high-roughage diet for *ad libitum* intake.

Introduction
Newly received growing beef cattle face numerous stressors such as marketing, commingling, transportation, and pathogen exposure. On arrival, feed intakes are often low, and calves fed traditional high roughage growing diets may not consume enough dry matter to meet energy and protein requirements. One strategy to circumvent low dry matter intakes is to limit feed a more energetically dense diet. Previous research conducted at the Kansas State Beef Stocker Unit demonstrated improvements in feed efficiency when cattle were limit-fed a high-energy diet based on corn and co-products compared with a traditional high-roughage growing diet fed for *ad libitum* intake (Spore et al., 2019). In that study, energy intake was not balanced across diets; therefore, the objective of this experiment was to determine if providing equal amounts of energy from a high-roughage diet fed for *ad libitum* intake or a high-energy limit-fed diet influenced growth performance of growing beef cattle.

Experimental Procedures
A total of 392 crossbred heifers [initial body weight (BW) = 605 ± 58 lb] were purchased from a single source in Deming, NM, and transported to the Kansas State University Beef Stocker Unit on May 26, 2023. Heifers were randomly assigned to pens containing 12 to 13 head and offered a 60 Mcal net energy for gain (NE_g) diet at

1% of BW [dry matter (DM) basis] until the following day. Upon arrival, calves were individually weighed using a hydraulic squeeze chute, assigned a visual identification tag, drenched with 10% albendazole (Valbazen; Zoetis, Kalamazoo, MI), and pour-on diflubenzuron (Clean Up 2; Elanco Animal Health, Greenfield, IN). Prior to arrival, heifers completed a Vac-45 vaccination protocol, so no additional vaccinations were administered.

Cattle were blocked into four weight groups (light, medium-light, medium-heavy, or heavy), stratified by individual arrival weight within block, and assigned to pens containing 12 to 13 head. Within block, pens were randomly assigned to one of four experimental diets: a high-roughage diet formulated to provide 45 Mcal NE_g per 100 lb of DM and fed for *ad libitum* intake (AL) or a high-energy diet formulated to provide 60 Mcal of NE_g per 100 lb of DM and fed at 75% (LIM-75), 80% (LIM-80), or 85% (LIM-85) of *ad libitum* intake. Each treatment was replicated eight times for a total of 32 pens. On day 0, cattle were individually reweighed to determine initial BW, assigned a pen tag, and sorted by pen.

Experimental diets are presented in Table 1. Diets were formulated to provide 45 or 60 Mcal NE_g per 100 lb of DM. All diets contained 40% wet corn gluten feed (DM basis; Sweet Bran; Cargill Animal Nutrition). To ensure monensin intake was similar across treatments, dry-rolled corn replaced proportions of supplement in limit-fed diets as feed offered was increased. Heifers were fed once daily at 7:00 a.m. using a Roto-Mix feed wagon (Model #414-14B; Roto-Mix, Dodge City, KS). Cattle fed for *ad libitum* intake were initially fed at 2.2% BW (DM basis). Feed refusals for cattle fed for *ad libitum* intake were weighed daily, and feed calls were adjusted so that 10% of DM fed the previous day remained at 6:30 a.m. Within block, feed intake of the two pens fed for *ad libitum* intake was averaged. Feed offered to limit-fed calves was then calculated within each weight block by multiplying average *ad libitum* intake by 75, 80, or 85%. As a result, energy intake was equal between heifers fed AL compared with heifers fed LIM-75. At the completion of the 70-day feeding period, calves were individually weighed.

Results and Discussion

Following the 70-day feeding period, final BW and average daily gains (ADG) did not differ ($P \geq 0.37$; Table 2) between AL and LIM-75. Among limit-fed calves, final BW and ADG were greater ($P < 0.01$) in LIM-85 compared with LIM-75, whereas final BW and ADG in LIM-80 was intermediate to and not different ($P \geq 0.37$) from LIM-75 or LIM-85. By design, DM intake was lower ($P < 0.01$) for LIM-75, LIM-80, and LIM-85 compared with AL. As a result, feed-to-gain was greater ($P \leq 0.02$) for calves fed for *ad libitum* intake compared with limit-fed calves; however, feed-to-gain did not differ ($P \geq 0.83$) among limit-fed calves. Similar weight gains between AL and LIM-75 suggest that restricting feed intake while maintaining energy intake does not negatively influence growth performance of newly received growing beef cattle.

Implications

The data presented suggest that higher energy rations limit-fed to cattle during the receiving period positively impact feed to gain conversion when compared to lower energy rations fed at the same net energy intake. From these conclusions, it can be predicted that producers can use this feeding technique to program gains based on forage cost and feeding period length to maximize feed utilization and minimize feed cost in their cattle.

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Table 1. Experimental diets

	Diet[1]			
Ingredient, % of dry matter	**AL**	**LIM-75**	**LIM-80**	**LIM-85**
Dry-rolled corn	14.38	40.50	40.97	41.38
Supplement[2]	5.63	7.50	7.03	6.62
Prairie hay	40.00	12.00	12.00	12.00
Sweet Bran[3]	40.00	40.00	40.00	40.00

[1] AL = High-roughage diet formulated to provide 45 Mcal net energy for gain (NE_g) per 100 lb of dry matter (DM) and fed for *ad libitum* intake; High-energy diet formulated to provide 60 Mcal of NEg per 100 lb of DM and fed at 75% (LIM-75), 80% (LIM-80), or 85% (LIM-85) of *ad libitum* intake.

[2] Pelleted supplement formulated to include (DM); 11.5% crude protein, 0.60% phosphorus, 4.7% salt, 0.80% potassium, 2.5% fat, and 307.2 g/ton monensin (Rumensin; Elanco, Greenfield, IN).

[3] Cargill Animal Nutrition (Blair, NE).

Table 2. Effects of dietary energy concentration and feed intake on growth performance of growing beef cattle

	Treatment[1]					
Item	**AL**	**LIM-75**	**LIM-80**	**LIM-85**	**SEM[1]**	***P*-value**
Number of pens	8	8	8	8		
Number of animals	98	98	98	98		
Body weight, lb						
Day 0	605	604	605	605	0.2	0.34
Day 70	805[a]	813[ab]	828[bc]	841[c]	6.4	< 0.01
Average daily gain, lb/day	2.86[a]	2.98[ab]	3.18[bc]	3.37[c]	0.090	< 0.01
Dry matter intake, lb/day	23.46[a]	17.37[b]	18.68[bc]	19.04[c]	0.557	< 0.01
Gain:Feed, lb/lb	0.12[a]	0.16[b]	0.16[b]	0.17[b]	0.010	0.02
Feed:Gain, lb/lb	8.26[a]	6.24[b]	6.38[b]	6.22[b]	0.517	0.04

[1] AL = High-roughage diet formulated to provide 45 Mcal net energy for gain (NE_g) per 100 lb of dry matter (DM) and fed for *ad libitum* intake. High-energy diet formulated to provide 60 Mcal of NEg per 100 lb of DM and fed at 75% (LIM-75), 80% (LIM-80), or 85% (LIM-85) of *ad libitum* intake.

[2] Standard error of the mean.

[a-c] Within rows, means with unlike superscripts differ ($P \leq 0.05$).

Post-Weaning Feed Intake and Performance of Bulls Developed in an Automated Feed Intake Management System

J.W.L. Banks, K.E. Fike, and J.M. Warner

Abstract
Two years of feed intake and performance data on spring born growing bulls (n = 77) developed in an automated feed intake system were analyzed and compared to predicted data from the BRANDS feed formulation software program (Iowa State University, Ames, IA). Each year bulls were weaned in the fall and they entered the Kansas State University Intake facility where they were fed a total mixed ration and the intake data were recorded by the Insentec feed intake system for 64 and 72 days for years one and two, respectively. A strong correlation ($P < 0.01$) for predicted and actual dry matter intake (DMI) was observed both years, with a weaker correlation ($r = 0.36$, $P = 0.03$) between the predicted and observed average daily gain (ADG) during the 2021–2022 test period. In year 2, a strong positive correlation ($r = 0.73$) was observed between actual and predicted ADG, suggesting that dietary differences may impact the accuracy with which gain is modeled. Feed intake trends over time were positive for both sets of bulls, but consumption increased at an increasing rate in 2022–2023. Ultimately, data indicated that DMI increases over time with advancing days on test during development in an individually fed intake system, and the day-to-day variation within the data set implies that animal intake is greatly impacted by factors such as individual behavior, management, and weather. The BRANDS formulation program appears to predict DMI more accurately than ADG.

Introduction
Post-weaning feed intake and its relationship to average daily gain (ADG) is critical given the significant impact feed costs have on developing virgin bulls. In typical production systems, bulls upon weaning are often managed in pen settings in which the overall intake of the contemporary group is measured, yet significant variation on an individual animal basis may occur. While systems exist allowing for individual feed consumption data to be recorded, much of the previous work in this area with growing beef cattle has been with steers. Likewise, performance of growing cattle can be predicted from nutrient requirements if feed intake is measured and dietary composition is known, and research evaluating this with pre- and peri-pubertal bulls post-weaning is limited. Our objectives were to: 1) report observed intake and performance data; 2) compare expected and observed dry matter intake (DMI) and ADG using modeled nutrient requirement equations; and 3) evaluate the change in individual DMI over time of weaned beef bull calves fed in an automated feed intake management system.

Experimental Procedures
Feed intake and performance data from purebred Angus, Hereford, and Simmental bull calves across two calf crops [birth years 2021 (n = 40) and 2022 (n = 37)] were utilized for this analysis. All calves were born at the Kansas State University Purebred

Beef Unit in the spring and raised at their dam's side grazing native Flint Hills range until weaning in September each year. At weaning, bulls initially had access to native prairie hay and a commercial creep feed for *ad libitum* consumption for approximately 2 weeks before being transitioned to a total mixed ration which was subsequently fed for 5–6 weeks. Following the weaning and diet transition period, bulls entered the Kansas State University Feed Intake Facility in mid-November each year. Intake test periods were November 11, 2021, through February 2, 2022 (83 days) and November 19, 2022, through January 30, 2023 (72 days) for years one and two, respectively. During the 2021–2022 test year, feed intake data were recorded for 64 days. During the study at the Feed Intake Facility, bulls were managed as a common group in earthen partially covered pens and fed in Insentec bunk module units allowing for individual feed intake data to be recorded. Ingredient composition of diets fed differed between years (Table 1). Bulls were individually weighed without feed or water restriction at the beginning and end of the test period to calculate ADG, with feed to gain ratio (F:G) subsequently calculated for each bull from average individual DMI.

Projected DMI and ADG were calculated for each group of bulls by year on an individual basis using the Growing Bull module of the Excel-based Beef Ration and Nutrition Decision Software (BRANDS) formulation program (Iowa State University, Ames, IA) used by K-State Research and Extension. Intake and performance equations incorporated into BRANDS are from the Nutrient Requirements of Beef Cattle 7th and 8th editions. Using actual initial and ending body weight (BW) for each bull, actual DMI of individual feedstuffs based on diet composition, and assumed average feedstuff composition values, projected DMI and ADG were retrospectively calculated to determine the accuracy of the program in predicting performance. In the 2021–2022 test year, two different diets were fed, but only diet 1 was used in the analysis as it was fed for the majority of the total days. All data were analyzed using SAS (SAS Institute Inc., Cary, NC) and the correlation procedures were used to evaluate the relationship between observed and projected DMI and ADG. P-values less than or equal to 0.05 were declared significant.

Results and Discussion

Initial BW was approximately 800 lb, and the ending BW were 1,080 lb and 1,063 lb for years 1 and 2, respectively (Table 2). Actual DMI for both years was slightly lower than predicted, with a greater standard deviation for 2022 (SD = 3.7) compared to 2021 (SD = 2.1; Table 2). Actual ADG for both years was notably greater than predicted (Table 2). Feed conversion was similar across the years. In 2021–2022, a strong positive correlation (r = 0.78, P < 0.01) was observed between actual and predicted DMI (Table 3). Likewise, there was a highly correlated (r = 0.84, significant (P < 0.01) relationship for observed and predicted DMI for 2022–2023 (Table 2). There was a moderate positive correlation (r = 0.36) between observed and predicted ADG in 2021–2022. There was also a strong relationship (r = 0.73, P < 0.01) between the observed and predicted ADG in year 2 (Table 3.). This difference in the relationships between actual and predicted ADG across years is likely related to how the BRANDS program handles metabolizable protein balance differences with different diets. The 2021–2022 bulls showed more deviance in the average group daily DMI from the best fit line (Figure 1), which is credited to variation in behavioral feeding patterns, inclement weather, or management. At day 50, the steep drop in intake is likely related to the change in diets that took place three days prior. The difference in the slopes of the DMI lines suggest the patterns of consumption over time were not uniform across different groups of bulls fed different diets. The 2022–2023 bulls (Figure 2) increased in DMI more gradually over time and the group daily DMI had less variance from the trend line, making for a more consistent feed intake pattern while on test. Individual feed intake, when measured on animals managed together in a group setting, appears to be greatly variable and this variation is undetected in pen-managed situations.

Implications

Data support that DMI increases over time as days of the test period increase for growing bulls in an individually fed intake system, and although significant day-to-day variation exists, the BRANDS formulation program appears to more accurately predict DMI than ADG.

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Table 1. Ingredient composition of diets by year, percent dry matter basis

Item	2021–2022[1]	2021–2022[2]	2022–2023
Corn silage	43.50	35.70	60.00
Wet corn gluten feed	21.75	25.00	25.00
Steam flaked corn	---	---	7.98
Dry rolled corn	23.00	10.00	---
Brome hay	9.46	22.15	---
Supplement	2.29	2.15	1.74
Omega 3 fatty acid supplement	---	5.00	5.28

[1]Fed from November 11 to December 29, 2021.
[2]Fed from December 30, 2021, to February 2, 2022.

Table 2. Actual and predicted bull performance means by year

	2021–2022			2022–2023		
Item	Actual	SD[1]	Predicted	Actual	SD	Predicted
Initial BW,[2] lb	800	107	---	805	119	---
Ending BW, lb	1080	118	---	1063	158	---
DMI,[2] lb/day	18.5	2.1	21.1	20.1	3.7	21.1
ADG,[2] lb	3.33	.57	1.66	3.59	0.89	2.32
F:G[2]	5.71	1.20	---	5.9	1.48	---

[1] Standard deviation.
[2] BW = body weight. DMI = dry matter intake. ADG = average daily gain. F:G = feed to gain ratio.

Table 3. Correlation coefficients for actual and predicted intake and gain of bulls by year

	2021–2022				2022–2023			
Item	Actual	Predicted	*r*	*P*-value	Actual	Predicted	*r*	*P*-value
DMI,[1] lb/day	18.5	21.1	0.78	< 0.01	20.1	21.1	0.84	< 0.01
ADG,[1] lb	3.33	1.66	0.36	0.03	3.59	2.32	0.73	< 0.01

[1] DMI = dry matter intake; ADG = average daily gain.

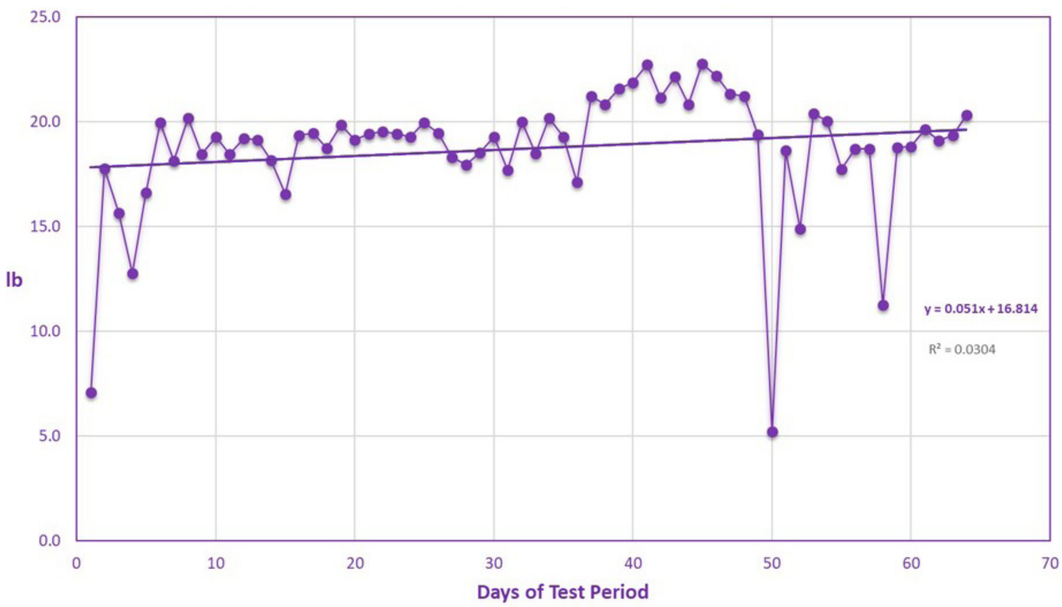

Figure 1. Average group daily dry matter intake for 2021–2022.

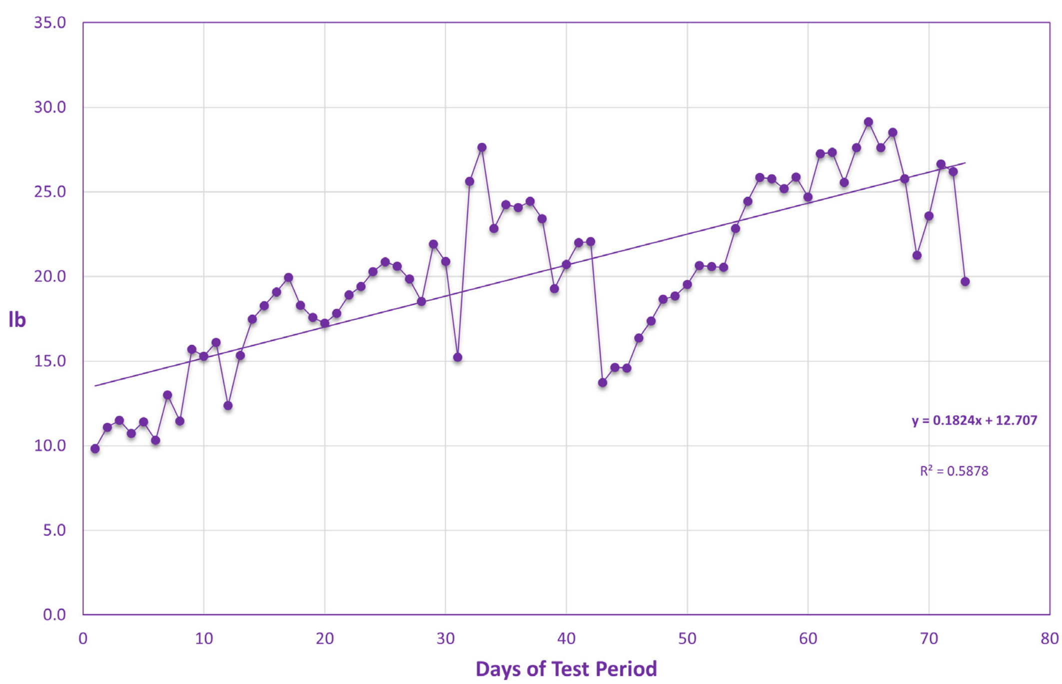

Figure 2. Average group daily dry matter intake for 2022–2023.

Comparing the Performance of Cattle Castrated Using Different Techniques Upon Arrival at the Feedlot

T. Blackwood, T.J. Spore, M.D. Kleinhenz, W.R. Hollenbeck, D.A. Blasi, and A.J. Tarpoff

Abstract
Ample evidence exists that male cattle intended for the beef production system should be castrated at or near birth. Producers insist on leaving male cattle intact until the feeding period as intact bulls will weigh more than steers; however, studies have shown that these bulls experience increased stress and weight loss at castration compared to cattle castrated at or near birth. The purpose of this study was to evaluate which castration technique would result in the least reduction of growth performance at the feedlot.

Introduction
The castration of male beef cattle is common practice and is done for a variety of practical reasons, including the reduction of aggression towards other animals and human handlers, improvement in meat quality and reduction of dark-cutting beef, and the elimination of instances of unwanted breeding (Booker et al., 2008; Coetzee, 2013; Coetzee et al., 2010). Many studies have been published pertaining to castration and have generally focused on age and timing, technique, pain, and pain management. The vast majority of studies have involved cattle aged from birth to weaning. These studies have demonstrated that the optimal age to castrate calves is at or near birth (Booker et al., 2008; Bretschneider, 2005; Rust et al., 2007). While the preferred technique remains a source of contention, there is some evidence that banding young cattle results in reduced chronic pain (Bretschneider, 2005).

While this has all been demonstrated many times over, some producers still insist on leaving cattle intact until they enter the feeding system under the pretense that the production of testosterone will result in increased weight gain. While intact bulls might weigh more than their castrated counterparts upon entry to the feedlot, they lose the weight benefit brought on by testosterone-induced secondary sex characteristics and will tend to perform equal to or worse than cattle that were castrated prior to entering the feeding system (Booker et al., 2008; Bretschneider, 2005; Fisher et al., 2001; Rust et al., 2007). Intact bulls continue to be sent to the feedlot despite this evidence, but there is little literature available that evaluates castration at the feedlot and its impact on growth performance. This study was conducted to evaluate this topic and attempt to provide an answer. The castration techniques evaluated included latex band, latex band with a split distal scrotum, burdizzo clamp, Henderson Tool, and a negative control group of intact bulls.

Experimental Procedures
Intact bulls were sourced from southeastern U.S. buying stations and received at the Kansas State University (K-State) Beef Stocker Unit (BSU) in the fall of 2020. The bulls were backgrounded at the K-State BSU to allow any health impacts from shipping

to not influence the outcome of the study. The cattle were vaccinated upon arrival, received vaccination boosters at day 28, and were pulled for health intervention on an as-need basis and treated per the K-State BSU's established treatment protocol.

In December 2020, 700-lb cattle were weighed individually and stratified by weight into treatment groups which consisted of latex band applied by a Callicarate Bander (No-Bull Enterprises, St. Francis, KS), latex band with the splitting of the distal scrotum via Newberry Knife, burdizzo clamp, Henderson Tool, and intact bulls (negative control). All cattle received their first dose of tetanus vaccination at this point and were affixed with an SCR ear tag (Allflex-Merk & Co., Inc., Rahway, NJ) which was numerically linked to individual ID ear tags and used to monitor rumination and movement every two hours. All cattle were castrated 21 days later according to their assigned treatment, except cattle assigned to the negative control group. All cattle received a booster of tetanus vaccination, and all cattle were administered a weight-appropriate dose of Banamine Transdermal (Merk Animal Health-Merk & Co., Inc., Rahway, NJ) per the K-State BSU protocol. Thermographic images of the scrotum were collected for every animal in the trial which allowed for a base scrotal temperature.

To monitor and compare the performance of each treatment group, individual weights were collected on days 7, 14, 21, 35, 49, and 56. The last few observations were moved to a bi-weekly schedule to reduce handling stress on the cattle in the study. Individual weights were averaged for each treatment group, for each weigh day. Thermographic images were collected at every weigh day so that the inflammation process of each treatment group could be monitored.

Results and Discussion

The average weights of the treatment groups did not differ when cattle were sorted before the study based on stratified weights ($P = 0.9998$). While the weights did spread due to differing metabolic demands of individuals, the treatment groups did not differ on average weight by day 0 ($P = 0.6383$). The average weights between treatment groups continued to be similar to each other on days 7, 14, and 21 ($P = 0.9961$, $P = 0.9119$, $P = 0.8851$, respectively). On day 35, the Henderson Tool group weighed less ($P = 0.0008$) than the other groups, while the other treatment groups remained similar in weight to each other. All treatment groups had similar weights on days 49 and 56 ($P = 0.7236$, $P = 0.7889$, respectively).

Average daily gain (ADG) was observed weekly, as well as on a day 0 to day 56 basis. Weekly ADG varied greatly throughout the study, most likely due to the inflammation and healing process of the different castration techniques. For ADG of the entire study period, no group was different from another; however, there was a trend ($P = 0.0643$) of the Henderson Tool group to have a lower ADG compared to all other groups.

The thermographic images obtained on day 0 demonstrated that all cattle were equal in scrotal temperature ($P = 0.4142$). Scrotal temperatures varied throughout the study. On a week-to-week basis, there were significant differences between treatment groups. The burdizzo group trended similarly to the control group throughout the study, while the band and band-cut groups had lower temperatures for the first portion of the study and then trended similarly to the control group near the end of the study.

The Henderson Tool group was significantly warmer in scrotal temperature than the control group for most of the study.

Data on rumination and movement were analyzed as a daily average per animal, and on a two-hour average across the entire study per animal. The individual animal averages were again averaged for each treatment group. This allowed for four data sets per treatment group: daily activity, daily rumination, hourly activity, and hourly rumination. Daily activity remained similar for all treatment groups, although cattle castrated using the Henderson Tool trended lower and the control group trended higher compared to the other groups (Figure 1). The control group trended higher for hourly activity, but all groups had a similar activity pattern. The Henderson Tool group trended lower in daily rumination and the control group trended higher than other groups (Figure 2). For hourly rumination, the Henderson Tool group trended higher than all other groups for much of the study period.

There was a major cold front during the study which may have contributed to the patterns of decreased weight gain during the middle of the study period. Aside from this cold period, the trend was that cattle treated with castration techniques which involved severing of the skin (Henderson Tool and band-cut), trended lower for weight gain compared to other treatment groups ($P = 0.0643$). While ADG was similar for all treatments, there was a trend with the control group of ADG = 3.35 lb/day, burdizzo = 3.05 lb/day, band = 2.98 lb/day, band-cut = 2.63 lb/day, and Henderson Tool = 2.53 lb/day. The trend in ADG is possibly explained by increased thermographic values of the Henderson Tool group compared to the control for days 7 to day 35. On day 21, the thermographic values of the Henderson Tool group were similar to the control. The increased thermographic values demonstrated persistent inflammation, yielding a decrease in weight gain compared to other groups.

By day 56, the burdizzo group had a similar ADG for the entire study period compared to the control. Therefore, this would appear to be an option for castrating cattle of this weight class; however, the use of the burdizzo is physically taxing on the operator and requires two people to operate the clamp arms for a successful crush of the spermaticord. This method was deemed to be a wholly impractical method of castrating cattle of this weight class. Based on ADG, using a band appears to be a better option compared to band-cut and the Henderson Tool, which trended lower in ADG compared to banding. The thermographic data show the band group and band-cut group to have lower scrotal temperatures compared to the control for much of the study. This could be explained by reduced blood flow to the scrotum resulting in a lower tissue temperature. As the scrotum sloughed off the body, the minimum temperature observed was a result of frostbite to tissue that had no blood flow and resulted in a lower average temperature than the control. The inflammatory period appears to not have had a major impact on ADG compared to the control, while the inflammatory period for the Henderson Tool group appears to have been detrimental to ADG.

The trend of cattle treated with the Henderson Tool performing worse than other treatment groups is further supported by the decreased activity time compared to other treatment groups (Figure 1), and the increased rumination time (Figure 2). The increase in observed rumination time is likely teeth grinding as a pain response, more so than actual rumination. Cattle castrated using the Henderson Tool appeared uncomfortable for most of the study.

The idea that banded cattle performed better than surgically castrated cattle is not uncommon (Rust et al., 2007). Splitting of the distal scrotum resulted in decreased performance compared to an intact scrotum, which conflicts with the only other study comparing these methods known to the authors at the time of this study (Theurer et al., 2019). This study would agree with previous research conducted on younger calves that banding is a superior castration method compared to surgical methods in terms of long term ADG (Bretschneider, 2005; Meléndez et al., 2017; Rust et al., 2007). Banding appears to be the technique that results in the least detrimental effects on ADG for intact cattle entering the feedlot. That said, this study was limited in scope in terms of the number of cattle per treatment group (roughly 10 head) and the time of year (the study was done once in the year and during an abnormally cold period). Because of these results, further research on castration's impact on feedlot performance is warranted. Cattle treated with surgical techniques seem to do worse, so increasing the head count of treatment groups and reducing the number of treatment groups would be a valid future study.

Implications

Given the scope of this study, the results indicate that the best way to castrate cattle entering the feedlot would be banding, as surgical techniques decrease performance and the burdizzo is not practical for cattle of this size.

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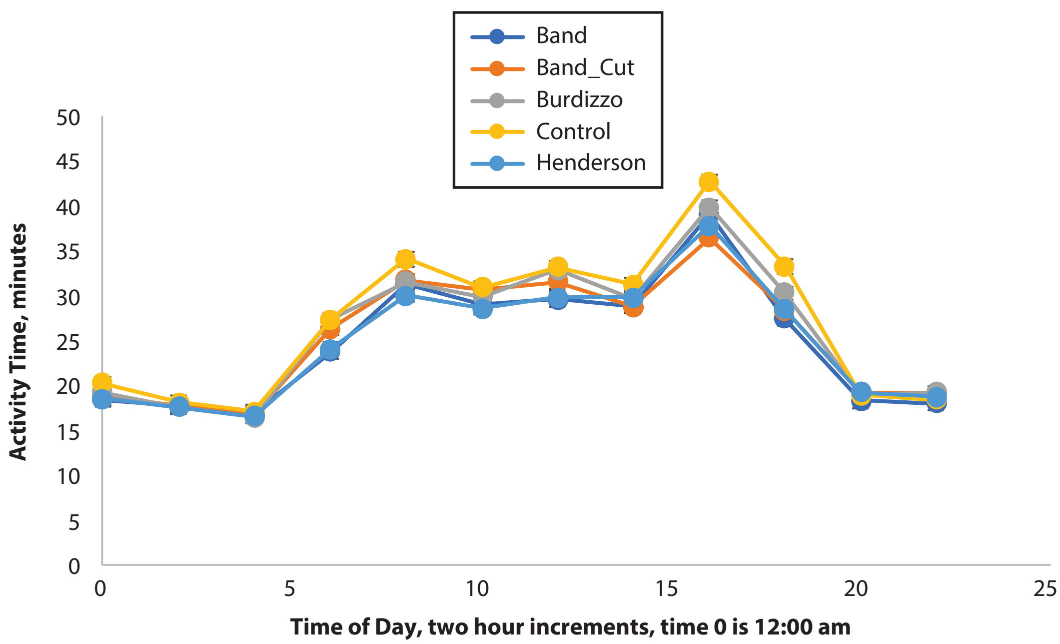

Figure 1. Activity time (minutes) in two-hour increments averaged over every other day for 56 days for all treatment groups.

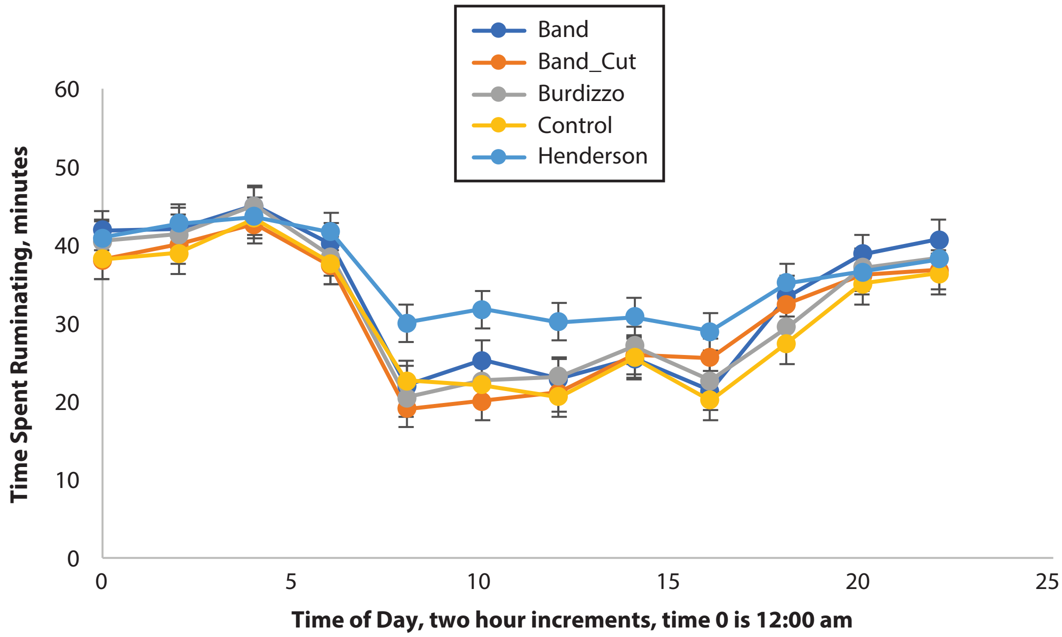

Figure 2. Time spent ruminating (minutes) in two-hour increments averaged over every other day for 56 days for all treatment groups.

Restricting Bunk Space Allotments to 6 or 10 Inches has Minimal Impact on Growth Performance in Limit-Fed Receiving Cattle

W.C. Ellis, Z.M. Duncan, M.S. Grant, W.R. Hollenbeck, E.C. Titgemeyer, and D.A. Blasi

Abstract

A 56-day experiment was conducted to determine the effects of bunk space allotment on growth performance of limit-fed growing cattle. Three-hundred thirty-two crossbred heifers [initial body weight (BW) = 659 ± 34.2 lb] were blocked by origin, stratified by arrival BW, and assigned to pen within block. Pens were randomly allocated to one of four treatments, providing either 6, 10, 14, or 18 inches of bunk space per head for a total of four pens per treatment (16 total pens). Heifers were limit-fed at 2.0% of BW daily [dry matter (DM) basis] for 56 days. Individual BW were measured at the start and end of the feeding period. Pens weights were measured weekly and used to adjust feed delivered for the following week. At the completion of the feeding period, final BW did not differ ($P = 0.23$) among treatments. In addition, average daily gain, DM intake, and feed-to-gain ratio did not differ ($P \geq 0.16$) among calves allotted 6, 10, 14, or 18 in of bunk per head. Overall, bunk allotments of 6 to 18 in of bunk per head had minimal impact on growth performance of limit-fed growing heifers.

Introduction

Limit feeding a high-energy diet based on corn and corn co-products can improve feed efficiency, reduce manure output, and improve health detection in growing cattle (Spore et al., 2019). One concern associated with limit-fed diets is the potential need to increase bunk allotments to allow all cattle to eat at one time. Current industry recommendations for growing cattle fed once a day are 18 to 22 in of bunk per head (FASS, 2020); however, we recently reported that growth performance of limit-fed steers allotted 10 to 25 in of bunk per head did not differ following a 58-day receiving period (Duncan et al., 2022). An additional concern associated with reducing bunk allotments for limit-fed cattle is that aggressive cattle will consume a majority of the feed provided and less aggressive cattle will not have the opportunity to consume their intended allocation. Overconsumption by aggressive calves and underconsumption by non-aggressive calves will potentially create differences in growth performance within the pen. In our previous experiment, the overall variation in average daily gain (ADG) within pen was not influenced by bunk allotment; however, pens only contained 12 to 14 head. Increasing the head count within a pen could potentially increase competition at the feed bunk and increase variation in weight gains within the pen. In addition, much of the work evaluating the effects of bunk allotments on growth performance of limit-fed cattle has been done in pens containing fewer than 14 head; therefore, the objective of the study was to determine if bunk allotments of 6, 10, 14, or 18 in per head in pens containing 18 to 28 head impacts growth performance of growing calves limit-fed a high-energy diet based on corn and corn co-products.

Experimental Procedures

A total of 332 crossbred heifers [initial body weight (BW) = 659 ± 34.2 lb] were purchased in Texas, Kansas, and Missouri and shipped to the Kansas State University Beef Stocker Unit between March 1, 2023, and March 10, 2023. Heifers were blocked by origin (3 blocks) and stratified by individual arrival BW to pens within block. Two blocks were stratified across four pens (19 to 28 head per pen), and one block was stratified across eight pens (18 head per pen). Within block, pens were randomly assigned to one of four bunk allotment treatments: 6, 10, 14, or 18 in of bunk space per heifer. Overall, there were four pens per treatment and a total of 16 pens. Bunk ends were measured and marked with movable concrete bunk dividers. In addition, panels were fastened along the bunk line in each pen to control where cattle could access the bunks. Pens were identical in size (60 × 50 ft) with a packed soil floor, a concrete bunk apron (60 × 12 ft), and one automatic water tank.

Upon arrival, heifers were individually weighed off the truck (day -1), assigned a visual identification tag, and allotted to pens of equal headcount. Following initial processing, heifers were offered prairie hay at 1% of BW [dry matter (DM) basis], had *ad libitum* access to water, and were allowed to stand overnight. The following day (day 0) calves were individually weighed, treated for internal (Valbezen; Zoetis, Kalamazoo, MI) and external (Clean-Up II; Elanco, Greenfield, IN) parasites, and assigned a pen tag. When processing was complete, heifers were allocated to their respective treatment pens. On day 1, cattle were fed the experimental diet (Table 1) at 1.5% of the average pen BW (DM basis). The following day, cattle were stepped up to 2% of BW daily (DM basis) where they remained for the duration of the experiment. Pen weights were measured weekly (days 0, 14, 21, 28, 35, 42, 49, and 56) and were used to adjust weekly feed calls. Calves were fed once daily beginning at 7:00 a.m. using a Roto-Mix feed wagon (Model #414-14B; Roto-Mix, Dodge City, KS) for a 56-day period. At the completion of the 56-day receiving period, heifers were individually weighed.

Results and Discussion

At the conclusion of the 56-day receiving period, final BW did not differ ($P = 0.23$; Table 2) among calves allotted 6, 10, 14, or 18 in of bunk per head. In addition, ADG, DM intake, and feed-to-gain ratio did not differ ($P \geq 0.16$) among treatments. Although we did not observe a statistical difference, ADG were numerically lower for calves allotted 14 in of bunk per head compared with those allotted 6, 10, or 18 in of bunk per head ($P \leq 0.13$). The overall incidence of respiratory morbidity and mortality in our experiment was low. In total, five calves were treated once for bovine respiratory disease: one from the 6-in treatment, one from the 18-in treatment, and three from the 14-in treatment. Additionally, one calf from the 14-in treatment was treated a second time for respiratory illness 4 days after the initial treatment. Numerically greater morbidity in the 14-in treatment could have potentially contributed to reduced growth performance. On average, the three calves treated for respiratory disease in the 14-in treatment gained 0.13 lb/day. If these animals were not included in the analysis, ADG for the 14-in treatment increases from 2.18 to 2.23 lb/day. We observed a quadratic effect ($P = 0.05$) of bunk allotment on the standard deviation of ADG within pens. Overall, within-pen variation in ADG was greater for pens allotted 14 in of bunk per head compared with pens allotted 6, 10, or 18 in of bunk per head. Taken together, it appears that in limit-fed growing heifers in pens of 18 to 28 calves, bunk space allotment can be reduced to as little as 6 to 10 in with minimal impact on performance.

Implications

These data suggest that bunk allotments as low as 6 inches per head do not reduce the growth performance of limit-fed growing cattle during a 56-day receiving period.

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Table 1. Experimental diet

Item	% of Dry matter (DM)
Ingredient	
Corn, dry rolled	39.5
Supplement[1]	7.5
Sweet bran[2]	40.0
Prairie hay, chopped	13.0
Nutrient analysis[3]	
DM, % as is	76.6
Organic matter	65.0
Crude protein	14.8
Neutral detergent fiber	25.7
Acid detergent fiber	9.5

[1] Supplement pellet formulated to contain (DM basis) 11.5% crude protein, 0.60% phosphorus, 4.7% salt, 0.80% potassium, 2.5% fat, and 307.2 g/ton monensin (Rumensin; Elanco, Greenfield, IN).
[2] Cargill Corn Milling (Blair, NE).
[3] Nutrient analysis by SDK Labs (Hutchinson, KS).

Table 2. Effects of bunk space allotment of growth performance and health of limit-fed growing heifers[1]

	Treatment, in					P-value[3]		
Item	**6**	**10**	**14**	**18**	**SEM[2]**	**Linear**	**Quadratic**	**Cubic**
Number of pens	4	4	4	4				
Number of animals	82	82	83	83				
Morbidity, head [4]	1	0	3	1				
Mortality, head	1	1	0	0				
BW, lb								
Day 0	657	655	655	654	1.75	0.09	0.72	0.42
Day 56	794	788	778	789	7.23	0.29	0.14	0.28
Average daily gain, lb/day	2.43	2.37	2.18	2.40	0.116	0.48	0.12	0.17
Standard deviation of average daily gain, lb/day	0.58	0.68	0.86	0.64	0.10	0.30	0.05	0.18
DM intake, lb/day	14.51	14.54	14.46	14.51	0.069	0.70	0.88	0.30
Feed:Gain, lb/lb	6.02	6.14	6.69	6.07	0.303	0.46	0.12	0.12

[1] Heifers were allotted 6, 10, 14, or 18 in of bunk per head and limit-fed at 2.0% of body weight (BW) daily [dry matter (DM) basis] for 56 days.
[2] Standard error of the mean.
[3] *P*-value associated with linear, quadratic, or cubic effects of bunk allotment.
[4] Number of animals treated for bovine respiratory disease.

Kansas State University Feedlot Boot Camp and Teaching Program: Growing Student Interest and Engagement in the Feedlot Industry

D.M. Stock, P. Anderson,[1] and K.E. Fike

Abstract
From 2019 through 2023, 95 Kansas State University College of Agriculture undergraduate students participated in the annual K-State Feedlot Boot Camp and Teaching Program. The program aims to develop students' knowledge, skills, and professional relationships in feedlot management to help meet the critical need for trained professionals in the feedlot industry. Student knowledge of feedlots prior to the Boot Camp ranged from little to no experience with feedlots to being raised on beef cow-calf or feedlot operations. The program begins with a 4-day comprehensive "Boot Camp" at Western Kansas feedlots which includes on-site feedlot experiences and discussions about topics such as cattle health, feeding and nutrition, feedlot design and maintenance, and the business of cattle feeding. An evening networking dinner brings students and feedlot managers together to facilitate students gaining internship and full-time employment with feedlots. Following the Boot Camp, students share individual presentations on relevant industry topics. Presentations are recorded and shared with feedlot managers to further engagement between students and feedlot managers. Later in the semester students also participate in a half-day animal health and cattle processing experience at a feedlot near K-State to provide additional insight and experience with feedlot health management. From surveys following the completion of the Boot Camp portion of the program, more than 96% (91/95) of student participants agreed with the statement, "My interest in pursuing an internship and (or) career in the feedlot industry grew as a result of this Boot Camp." Approximately 45% of students participated in feedlot internships or entered full-time jobs working in a feedlot within the six months after completing the Boot Camp program.

Introduction
Beef cattle ranching and farming, including feedlots and dual-purpose ranching, are collectively the number one employer within the Kansas agriculture industry, contributing approximately $8.7 billion to the economy of the state of Kansas (Kansas Department of Agriculture, 2020). However, managing the workforce and hiring new qualified employees is a major challenge for many Kansas feedlots. In 2021, "A competitive and competent workforce to meet the diverse and technical needs of the beef industry in Kansas," and "Talent development and educational training opportunities for students preparing for careers in the beef industry," were outlined as a high-priority outcome in the Kansas 2021 Ag Summit beef sector document (Kansas Department of Agriculture, 2021).

Spearheaded by Midwest PMS, LLC and through collaboration between other feedlot stakeholders, including allied industry, feedlot owners/managers, and Kansas State

[1] Pete Anderson, Midwest PMS LLC, Leawood, KS.

University, the K-State Feedlot Boot Camp and Teaching Program was developed. The program's overarching goal is to develop students' knowledge, skills, and professional relationships in feedlot management to help meet the critical need for trained professionals in the feedlot industry. Specific objectives are to:

- Train students in aspects of feedlot management through a 4-day hands-on, comprehensive "Boot Camp" at western Kansas participating feedlots.
- Enhance students' likelihood of participating in a feedlot internship experience.
- Cultivate students' vision of potential career paths within the feedlot and beef cattle industry.

Experimental Procedures

Undergraduate students in the College of Agriculture at Kansas State University have had the opportunity to apply to participate in the K-State Feedlot Boot Camp and Teaching Program from 2019 through 2023. The entirety of the program from the student perspective can be partitioned into the following components:

1. Information Session and Application – fall semester
2. Feedlot Boot Camp Session – January
3. Post-Boot Camp Activities and Expectations – spring semester
4. Feedlot Internship Participation

During the Feedlot Boot Camp session, students were transported to Garden City, KS, for the 4-day hands-on comprehensive training. The Boot Camp included both classroom instruction and hands-on experiences at Reeve Cattle Company, Inc., Poky Feeders, Finney County Feedyard, and Fairleigh Feedyard. Topics addressed included cattle health and nutrition, feedlot design and maintenance, commodity handling, and low-stress cattle handling. A networking dinner was held during the Boot Camp to bring students and feedlot managers together to facilitate students gaining internship and full-time employment opportunities with feedlots.

Following the Boot Camp, students shared individual presentations about industry topics that are recorded and shared with feedlot managers to further engagement between students and feedlot managers. In April, students also participated in a half-day cattle processing experience at a feedlot near Kansas State University to provide additional experience with feedlot health management. Students who completed the Boot Camp, cattle processing experience, and a feedlot internship could earn a $2,500 scholarship to be applied toward their tuition the following semester.

Results and Discussion

A total of 163 undergraduate students applied to participate in the program in its first five years (2019 - 37; 2020 - 41; 2021 - 23; 2022 - 30; 2023 - 32). Of those applicants, 95 were selected to participate (2019 - 20; 2020 - 21; 2021 - 18; 2022 - 19; 2023 - 17). In surveys following the completion of the Boot Camp portion of the program, over 96% (91/95) of student participants agreed with the statement, "My interest in pursuing an internship and (or) career in the feedlot industry grew as a result of this Boot Camp" (Figure 1). Approximately 45% of participants proceeded to participate in feedlot internships or entered full-time jobs working in a feedlot six months after completing the Boot Camp (Figure 2).

Jenna Hlavaty, 2020 participant and now head of Animal Health and Processing at Cimarron Crossing Feeders near Cimarron, KS, shared that "The Feedlot Boot Camp program is the major reason that I earned a feedlot internship right after Boot Camp and have since been on a career path in the feedlot industry." Nicole Stafford, 2021 participant, stated, "If it was not for the Feedlot Boot Camp, I wouldn't have gotten [cattle handling] experience with Tiffany's [Cattle Company] as well as a want to pursue feedlot consulting after vet school! The Boot Camp really opened up my eyes to so many possibilities for my future, and I'm excited to pursue this track!" A 2023 participant, Ethan Kunkel, noted, "The opportunity created by the Feedlot Boot Camp is next to none. The Feedlot Boot Camp gave me the foundation to have an excellent summer internship at Foote Cattle Company and learn about a part of the cattle industry that I did not know much about. I highly recommend applying to be a part of this opportunity." Jenna, Nicole and Ethan's experiences highlight the value of this program in growing the vision students have for feedlot career opportunities as well as facilitating professional relationships to enable their visions to become reality.

Implications

The Feedlot Boot Camp program has made progress in growing student interest and awareness of career opportunities in the feedlot industry and fostering communication between employers and prospective employees.

Acknowledgments

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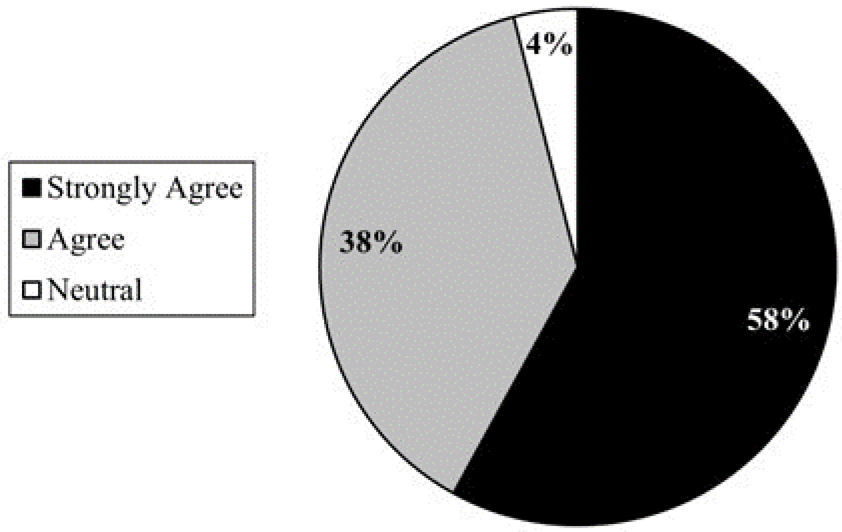

Figure 1. Post-Boot Camp survey "My interest in pursuing an internship and/or career in the feedlot industry grew as a result of this Boot Camp."

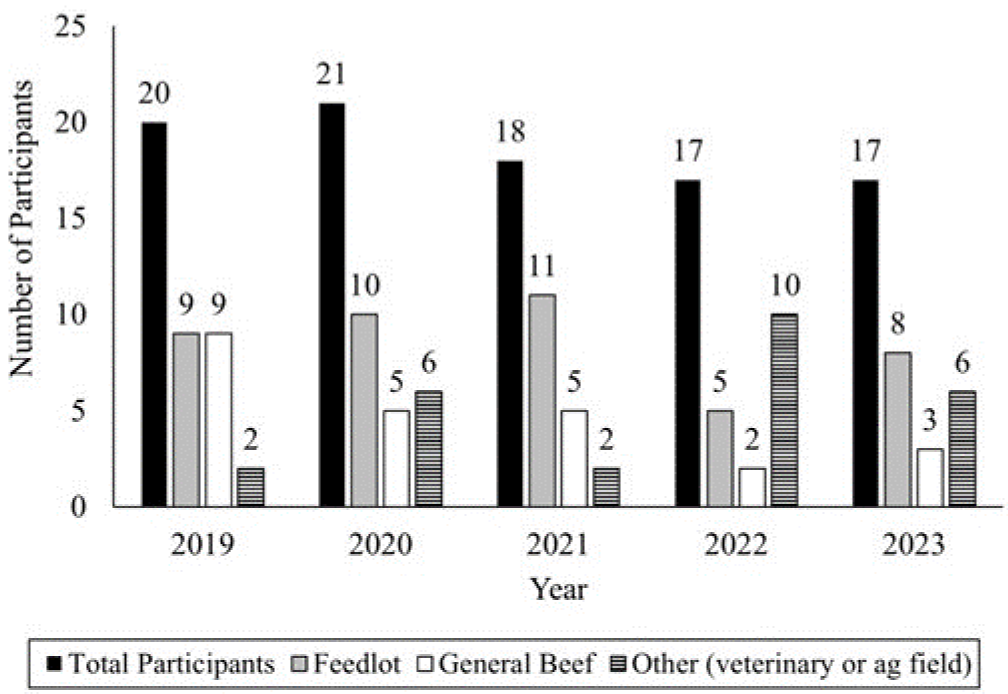

Figure 2. Students' internship or job path six months after the Boot Camp.

Supplementation of Methionine or Choline Did Not Improve Health or Growth Performance in High-Risk, Newly Received Beef Heifers

M.S. Grant, D.A. Blasi, and E.C. Titgemeyer

Abstract

Methionine and choline supplementation can improve health and immune function in transition dairy cattle. Our objective was to determine if supplemental methionine or choline improves health or growth performance in high-risk, newly received beef heifers. In a 3-year experiment, 1,440 crossbred beef heifers [480 per year; 493 ± 9.8 lb initial body weight (BW); Tennessee origin] were received in 15 truckloads (blocks; five per year) in October 2020, 2021, and 2022. Heifers were weighed individually upon arrival. On the day following arrival, cattle were stratified within block by arrival weight to one of eight pens containing 12 heifers each. Cattle (40 pens/year; 120 total pens) were limit-fed at 2.2% of BW for 60 days. Pens were assigned to one of five treatments: control; 5 g/day methionine (8.33 g/day Smartamine M; Adisseo USA Inc., Alpharetta, GA; ruminally protected methionine product); 15 g/day methionine (25 g/day Smartamine M); 1.17 g/day choline (26 g/day ReaShure; Balchem Corp., Montvale, NJ; ruminally protected choline product); or 3.5 g/day choline (78 g/day ReaShure). Treatments were top-dressed at feeding daily. In each year, there were eight pens/treatment for a total of 24 pens/treatment across three years. Pen weights were measured weekly to adjust feed offered the following week. Individual BW were measured on days 0, 14, and 60. Dry matter intake was not affected by treatment ($P = 0.48$). We observed minor differences among treatments for final BW, average daily gain, and gain:feed, but none of the treatments were different from control. Overall prevalence of respiratory morbidity and mortality were 28.1% and 0.72%, respectively. No treatment differences were detected for first, second, or third respiratory morbidity or mortality ($P \geq 0.30$). Overall, supplementation with methionine or choline did not affect health or growth performance of high-risk, newly received heifers.

Introduction

Methionine and choline are methyl group sources, and their supplementation improves health and immune function in transition dairy cows. High-risk receiving cattle are also subjected to a wide variety of stressors, such as commingling, transportation, disease exposure, and low feed intake. Because methionine and choline supplementation help to mitigate stress-induced immune responses in dairy cows, we hypothesized it would provide similar benefits to receiving cattle. Recent work suggested that supplemental methionine may decrease inflammation in newly received beef heifers. The objective of this trial was to evaluate the ability of supplemental methionine or choline to improve health and growth performance of receiving cattle.

Experimental Procedures

In a 3-year experiment, a total of 1,440 crossbred beef heifers [480 per year; average initial body weight (BW) 493 ± 9.8 lb] were purchased from auction markets in Tennessee and transported to the Kansas State University Beef Stocker Unit, Manhattan, KS, in 15 truckloads (five truckloads per year) in October 2020, October 2021, and October 2022. Heifers were blocked by load (15 total blocks; five per year) and stratified by individual arrival BW within a block to pens containing 12 heifers each. Pens were randomly assigned to one of five treatments: control (no added methionine or choline); 5 g/day available methionine (8.33 g/day Smartamine M; Adisseo USA Inc., Alpharetta, GA; ruminally protected methionine product); 15 g/day available methionine (25 g/day Smartamine M); 1.17 g/day available choline (26 g/day ReaShure; Balchem Corp., Montvale, NJ; ruminally protected choline product); or 3.5 g/day available choline (78 g/day ReaShure). A common experimental diet (Table 1) was offered at 2.2% of BW daily (dry matter basis). Treatments were top-dressed at feeding daily.

On arrival, heifers were weighed individually and assigned an individual ear tag. Heifers were placed in pens, offered prairie hay at 1% of BW and *ad libitum* access to water, and were allowed to stand overnight. The next day (day 0), heifers were vaccinated for viral and clostridial pathogens, treated for internal and external parasites, received Draxxin (2.5 mg tulathromycin/kg BW; Zoetis Inc., Parsippany, NJ), and were allocated to pens. On day 14, heifers were revaccinated for viral respiratory diseases. Individual BW were measured at initial processing (day 0), revaccination (day 14), and at trial conclusion (day 60). Pen weights were measured using a pen scale on day 0 and weekly from days 14 to 60. Weekly pen weights were used to calculate feed offered for the following week. Heifers were fed once daily at 7:00 a.m. using a Roto-Mix feed wagon (Model 414-14B; Roto-Mix LLC., Dodge City, KS) for 60 days.

Throughout the trial, heifers were observed twice daily for clinical signs of respiratory illness. Respiratory illness was treated as follows: first treatment was florfenicol, second treatment was enrofloxacin, and third treatment was oxytetracycline. Heifers requiring a third treatment were declared as chronic and removed from the experiment.

Results and Discussion

Performance data are presented in Table 2. Dry matter intake did not differ among treatments ($P \geq 0.30$), largely because cattle were limit-fed. We observed tendencies for an overall effect of treatment on day 60 final BW, average daily gain (ADG), and gain:feed ($P \leq 0.10$). On day 60, calves supplemented with 15 g/day methionine were heavier than calves supplemented with 5 g/day methionine, 1.17 g/day choline, or 3.5 g/day choline ($P \leq 0.03$). In addition, calves provided 15 g/day methionine had greater ADG and improved feed efficiency compared with calves provided 1.17 g/day choline, or 3.5 g/day choline ($P \leq 0.03$). Despite this, none of the treatments differed from control for final BW, ADG, and gain:feed ($P \geq 0.12$), suggesting overall minimal performance effects.

Health data are presented in Table 2. No differences were detected among treatments for first, second, or third respiratory morbidity or mortality ($P \geq 0.30$). Across the three-year experiment, first treatment morbidity averaged 28.1% and mortality averaged 0.72%. Incidence of first respiratory morbidity differed among the three years

($P < 0.001$) and was 21.5% in year 1, 9.3% in year 2, and 53.5% in year 3. On average, first treatment respiratory morbidity occurred at 18 days on trial.

Implications

Overall, supplemental methionine or choline did not improve growth performance or health of high-risk, newly received beef heifers.

Acknowledgments

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Table 1. Experimental diet fed to newly received beef heifers

Ingredient	% of Dry matter
Corn, dry rolled	39.5
Wet corn gluten feed[1]	40.0
Prairie hay, chopped	13.0
Supplement[2]	7.5

[1] Sweet Bran, Cargill Corn Milling, Blair, NE.

[2] Supplement pellet formulated to contain (dry matter basis) 8.5% calcium, 0.64% phosphorus, 0.76% potassium, 5.0% salt, and 307 grams/ton monensin (Rumensin; Elanco, Greenfield, IN).

Table 2. Effects of supplemental methionine or choline on growth performance and health of newly received heifers

Item	Control	Methionine, grams/day		Choline, grams/day		SEM[1]	Treatment *P*-value
		5	15	1.17	3.5		
Number of pens	24	24	24	24	24	–	–
Number of heifers[2]	279	278	278	282	280	–	–
Body weight, lb							
Day 0	492	492	494	494	494	2.0	0.26
Day 60	642[ab]	639[b]	646[a]	639[b]	632[b]	4.6	0.09
Average daily gain, lb/day							
Days 0 to 60	2.51[ab]	2.45[ab]	2.56[a]	2.43[b]	2.40[b]	0.075	0.09
Dry matter intake, lb/day							
Days 0 to 60	12.1	12.0	12.1	12.1	12.0	0.07	0.48
Gain:feed, lb/lb							
Days 0 to 60	0.208[ab]	0.204[ab]	0.212[a]	0.201[b]	0.201[b]	0.0058	0.10
Morbidity, %							
Treated once	23.8	24.1	22.6	23.1	27.6	4.15	0.71
Treated twice	4.9	6.7	4.4	4.9	7.2	1.78	0.30
Treated thrice	1.2	1.3	1.4	0.5	0.8	0.65	0.52
Mortality, %	0.6	0.6	0.6	0.9	0.9	0.54	0.97
Days to							
First treatment	19	18	17	21	17	–	–
Second treatment	21	24	18	25	20	–	–
Third treatment	18	33	28	42	26	–	–

[1] Standard error of the mean.
[2] Performance data from dead and chronic heifers were removed from analysis.
[a,b] Within row, means without a common superscript differ, $P \leq 0.05$.

GreatO⁺ Supplementation Leads to Greater Proportions of Omega-3 Fatty Acids in the Small Intestines of Holstein Steers

R.L. Thorn and J.S. Drouillard

Abstract
Omega-3 fatty acids are essential to produce various signaling hormones and cellular structures. NBO3 technologies in Manhattan, KS, has developed an extruded blend of flaxseed and microalgae known as GreatO$^+$, which is utilized in various livestock diets. Flaxseed and microalgae contain high levels of omega-3 fatty acids, which are essential nutrients. We hypothesized that supplementation of GreatO$^+$ would lead to greater proportions of omega-3 fatty acids reaching the small intestines of cattle and allow greater absorption. Dry matter intake (DMI) increased for cattle supplemented with GreatO$^+$ ($P < 0.01$), while water intake was not affected ($P = 0.89$). Cattle fed GreatO$^+$ had a lower ruminal acetate:propionate ratio ($P = 0.02$) and tended to have higher concentrations of propionate ($P = 0.09$) and butyrate ($P = 0.08$) within the rumen compared to cattle fed the control diet. Higher amounts of fatty acids, including α-linolenic acid ($P < 0.01$), were present in the duodenum of cattle supplemented with GreatO$^+$ compared to the control group. This allows steers supplemented with GreatO$^+$ to absorb greater amounts of these fats.

Introduction
Omega-3 fatty acids are essential nutrients in cattle and are used as components of cellular membranes and signaling molecules involved in growth, reproduction, and immunity. Diets commonly fed to cattle in confinement often lack sufficient omega-3 fats due to the more significant usage of cereal grains, which have higher proportions of omega-6 fats. This diet creates an imbalance in the omega-6 to omega-3 fatty acid ratio which can lead to exaggerated inflammation and lower reproductive performance in cattle. Challenges with supplementation of omega-3 fats include the costs of producing omega-3 fats as well as transformation of the omega-3 fatty acids to saturated fatty acids through ruminal biohydrogenation. GreatO$^+$ (NBO3, Manhattan, KS) is a microalgae and flaxseed extruded product containing approximately nine percent omega-3 fat and has been used to supplement essential fats in livestock diets. This study aimed to determine if supplementation of GreatO$^+$ affected apparent ruminal and total tract flow of fatty acids, volatile fatty acid concentrations, dry matter intake (DMI), and water intake.

Experimental Procedures
This study utilized 12 ruminal and duodenal fistulated steers in a cross-over design. Each steer was blocked by weight and assigned to one of two treatments, resulting in six replications per treatment in each of the two periods. These treatments included a control diet without supplemental omega-3 fatty acids and a treatment diet consisting of GreatO$^+$ inclusion at 10% of the diet DM. Two consecutive feeding periods were utilized, which included a 15-day adaptation interval and a four-day sampling interval. Feed was dispensed in each bunk at 10:00 a.m. each day. Titanium dioxide was used as

an internal marker to calculate the apparent flow of fatty acids to the small intestines and feces. Titanium dioxide (15 g) was placed in the rumen of each steer 15 minutes before feeding, starting on day 10 of the feeding period. Feed and water intake data were collected each time the animal consumed feed or water using the Insentec Roughage Intake Control system (Hokofarm Group, Emmeloord, Netherlands). Ruminal, duodenal, and fecal contents were collected over the four-day sampling interval, with collection times being advanced every eight hours each day to obtain digest or fecal samples every two hours during a 24-hour period. Ruminal contents were strained through four layers of cheesecloth, and ruminal fluid pH was measured. After pH was measured, a 4-mL ruminal fluid sample was collected and vortexed with 25% w/v meta-phosphoric acid before the sample was frozen. Volatile fatty acid (VFA) and long-chain fatty acid concentrations were analyzed using gas chromatography, and titanium concentrations were analyzed using light spectroscopy.

Results were analyzed using the Mixed procedure of SAS version 9.6 (SAS Inst. Inc., Cary, NC). Dry matter intake and water intake data were analyzed with DMI, and water intake was used as fixed effect with repeated measurements by day. Steer was used as the random effect. Volatile fatty acid concentrations and pH data were analyzed as fixed effects with hour as the repeated measurement and steer as the random effect. Ruminal flow and total tract flow were analyzed using the Proc Mixed procedure of SAS, with treatment and period interaction used as fixed effects and steer as the random effect. A significant effect was declared when $P \leq 0.05$ and a tendency of an effect if $0.05 < P < 0.10$.

Results and Discussion

GreatO^{+} supplementation effects on DMI, water intake, VFA concentrations, and apparent amounts of fatty acids consumed and appearing in the duodenum and feces are presented in Figures 1 and 2, and Tables 2 and 3, respectively. Compared to cattle fed the control diet, those fed GreatO^{+} had greater DMI ($P < 0.01$), but not water intake ($P = 0.48$). Ruminal acetate concentrations were not affected by treatment ($P = 0.19$); however, there were greater concentrations of propionate ($P = 0.03$) in ruminal fluid from cattle supplemented with GreatO^{+} compared to animals fed the control diet. Cattle fed GreatO^{+} had lower acetate:propionate ratios ($P < 0.01$) compared to steers fed the control diet. Greater amounts of omega-3 fatty acids were present in the duodenum of cattle fed GreatO^{+} compared to cattle consuming the control diet. Higher amounts of omega-3 in the small intestines leads to the possibility that more omega-3 fat could be absorbed in the intestine of cattle fed GreatO^{+} compared to cattle fed the control diet.

Implications

Cattle supplemented with GreatO^{+} had greater amounts of fatty acid presented to the small intestines. Increased absorption of omega-3 fat in the small intestines could lead to greater incorporation of these essential fats in tissue and milk.

Acknowledgments

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Table 1. Diet composition [% dry matter basis (DM)]

Item	Control	GreatO+
Steam-flaked corn	31.30	23.87
Alfalfa hay	15.00	15.00
Corn silage	50.00	50.00
GreatO+	-	10.00
Soybean meal, dehulled	2.57	-
Supplement[1]	1.13	1.13
Nutrient composition, calculated, %		
Crude protein, % of DM	11.51	11.51
Net energy for maintenance, Mcal/lb	0.84	0.86
Net energy for gain, Mcal/lb	0.55	0.57
Omega-3 fatty acid, % of diet	0.18	1.12
Ether extract, % of DM	2.58	4.24
Major fatty acid composition of diet, %		
C16:0	0.43	0.51
C18:0	0.07	0.14
C18:1n9c	0.56	0.89
C18:1n7c	0.02	0.03
C18:2n6c	1.21	1.42
C18:3n3	0.18	1.12
C20:5n3	0.00	0.00

[1] Supplement was formulated to provide 1,000 IU/lb of vitamin A; 10 ppm of copper; 30 ppm of zinc; 20 ppm of manganese; 0.5 ppm of iodine; 0.1 ppm of selenium; and 0.15 ppm of cobalt in the total diet DM.

Table 2. Volatile fatty acid (VFA) concentrations

	Treatment			*P*-value[2]		
Item	Control	GreatO+	SEM[1]	Treatment	Hour	Treatment × hour
VFA, mM						
Acetate	95.7	95.6	5.95	0.995	<0.01	0.19
Propionate	29.6	31.9	2.60	0.33	<0.01	0.03
Butyrate	14.4	14.0	1.62	0.76	<0.01	0.04
Total VFA	142.3	144.0	9.90	0.86	<0.01	0.12
Acetate: propionate ratio	3.4	3.0	0.20	0.10	<0.01	<0.01

[1] Standard error of the mean.
[2] $P \leq 0.05$ is considered statistically different.

Table 3. Apparent amounts of fatty acid present in the duodenum and feces

Item	Nutrient intake			Nutrient to duodenum			Nutrient in feces		
	Control	GreatO+	SEM[1]	Control	GreatO+	SEM	Control	GreatO+	SEM
Fatty acid, g									
C16:0	47.4[a]	61.6[b]	2.3	33.7[a]	47.4[b]	2.1	8.5[a]	12.9[b]	0.53
C18:0	7.7[a]	16.9[b]	0.5	108.9[a]	203.2[b]	11.4	24.3[a]	63.6[b]	3.48
C18:1n9c	61.8[a]	107.4[b]	3.6	9.3[a]	17.5[b]	1.0	2.8[a]	6.1[b]	0.32
C18:1n7c	2.2[a]	3.6[b]	0.1	1.7[a]	2.0[b]	0.1	0.3[a]	0.4[b]	0.02
C18:2n6c	133.4[a]	171.5[b]	6.4	9.3[a]	11.3[a]	0.9	3.4[a]	5.0[b]	0.41
C18:3n3	19.9[a]	135.3[b]	3.9	1.6[a]	6.3[b]	0.5	0.6[a]	3.5[b]	0.27
C20:5n3[‡]	ND	ND	ND	ND	ND	ND	ND	ND	ND

[1] Standard error of the mean.
[a,b] Values with common superscript letters within a row and nutrient site are not statistically different ($P > 0.05$).
[‡] ND: Not detected.

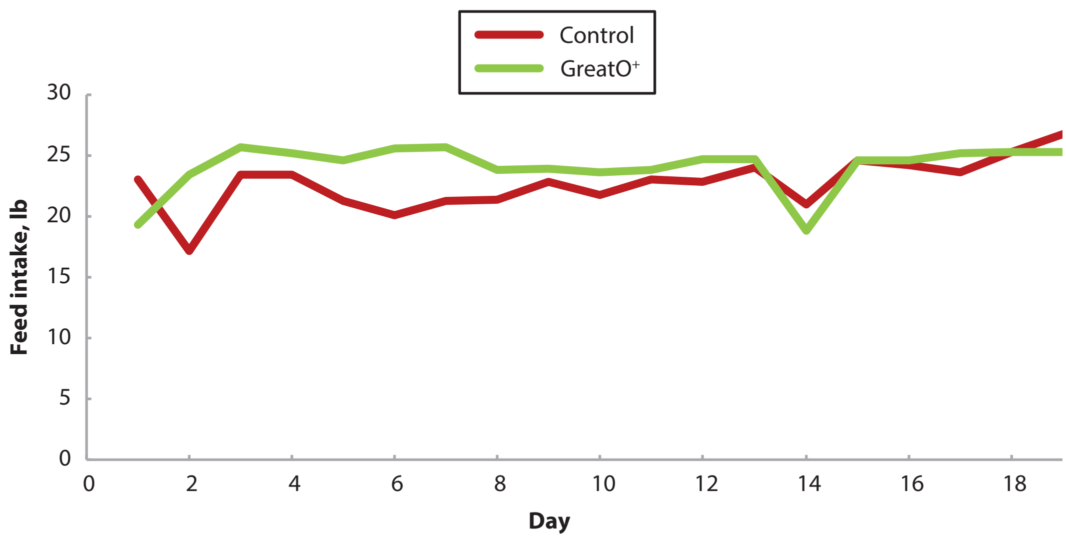

Figure 1. Dry matter intake.
Treatment $P = 0.40$
Day $P < 0.01$
Treatment × hour $P < 0.01$
Standard error of the mean = 1.68

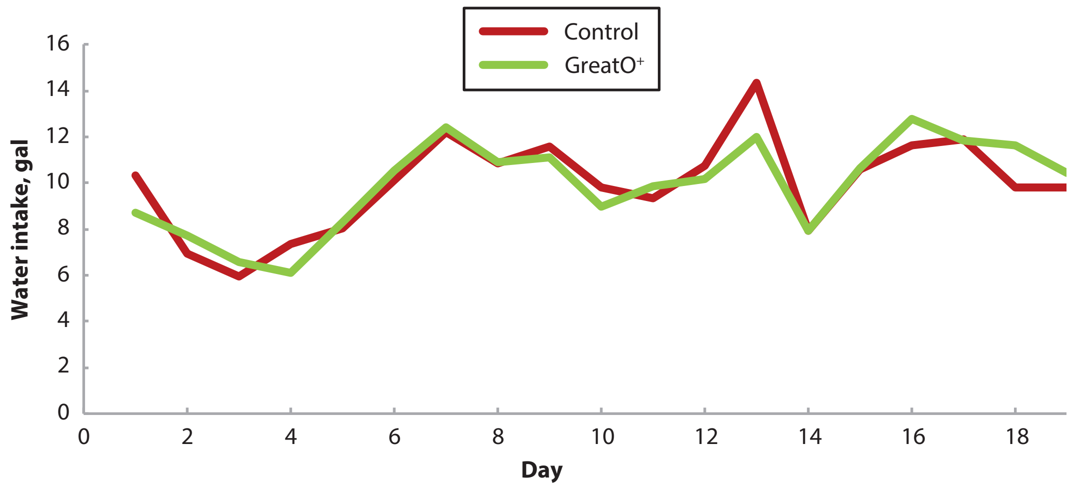

Figure 2. Water intake.
Treatment *P* = 0.97
Day *P* < 0.01
Treatment × hour *P* = 0.48
Standard error of the mean = 1.09

A Novel Approach of Using Electrostatic Field to Reduce Thawing Time and Improve Frozen Beef Quality

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Abstract

The objective of this study was to evaluate the impact of applying an electrostatic field (EF) on thawing characteristics, such as thawing speed and purge loss, as well as its impact on quality attributes during subsequent aging and retail display of beef. Beef striploins from both sides of 12 USDA Choice carcasses were frozen and then thawed under 4 kV treatments: EF-0 (control), EF-2.5, EF-5, and EF-10. Within each treatment, half were thawed at 32°F (inside cooler) and half at 35.6°F (outside cooler). After reaching 30.2°F, striploins were weighed with the purge collected to assess purge loss and purge protein content, swabbed for microbial content, and then fabricated into steaks. After samples were collected for histological analysis, steaks were assigned to either 0 or 14 days of aging and then retail displayed for 0 or 7 days. During retail display, steaks were evaluated for discoloration and objective color measurements. Upon completion, steaks were analyzed for Warner-Bratzler shear force (WBSF), sarcomere length, myofibrillar protein degradation, lipid oxidation, and pH. It was found that all EF treatments increased purge loss in the outside cooler location and EF did not improve thawing speed, with the EF-10 samples taking longer to thaw ($P < 0.05$). There was also a trend that EF-10 samples in the outside cooler location had increased muscle fiber spacing ($P = 0.09$). All EF voltages reduced aerobic plate counts compared to the control. Samples aged for 0 days under EF-5 showed more discoloration than the other treatments ($P < 0.05$), and samples aged 14 days under EF-2.5 and EF-5 showed less discoloration than EF-0 and EF-10 ($P < 0.05$). The EF-10 samples showed a reduction in WBSF, but there was no impact of EF on sarcomere length and myofibrillar protein degradation ($P > 0.05$). The EF-10 treatment samples also showed an increase in pH in the outside cooler location ($P < 0.05$).

Introduction

Freezing is a common method of cold chain management to extend the shelf-life of beef. However, the thawing process of frozen beef usually results in increased purge loss due to cell membrane damage from the ice crystal formation and is thus viewed as an inferior product compared to fresh beef. Therefore, the beef industry is actively seeking new technologies with the goal of mitigating the negative impacts of freezing. Electrostatic field (EF) assisted thawing is an emerging technology that relies upon applying an alternating current EF during thawing, which functions by oscillating the positive and negative ions in the ice crystals and thus potentially breaks apart the existing ice crystals into smaller and more uniform ice crystals. Based on this existing knowledge, we hypothesized that the EF thawing process reduces the physical damage of the cellular

[1] Cargill, Wichita, KS.

structure as the ice crystals gradually and uniformly reduce in size throughout the frozen meat.

Experimental Procedures

Striploins from both sides of USDA Choice carcasses (n = 12) were collected and portioned into four equal parts (n = 48). Portions were vacuum packaged and frozen at -40°F for 14 days and randomly assigned to one of four EF thawing treatments (Figure 1): 0 kV voltage (control), 2.5 kV voltage (EF-2.5), 5 kV voltage (EF-5), and 10 kV voltage (EF-10). Within each EF treatment, half of the striploin portions were thawed at 32°F (inside cooler) and half at 36°F (outside cooler), representing two areas within the cooler used in this study. Internal temperatures were recorded throughout the thawing process, and the thawing process was considered complete when all striploin portions reached 30.2°F. After thawing, striploin portions were weighed and purge was collected for microbial and protein analysis, and portions were fabricated into steaks. One steak was immediately cored parallel to muscle fiber direction for later histological analysis to assess muscle fiber damage. The remaining steaks were vacuum packaged and subjected to either 0 or 14 days of aging. After the designated aging, steaks were placed on Styrofoam trays, overwrapped with polyvinyl chloride, and placed in a coffin-style retail case for a designated 0 or 7 days of retail display. Steaks were evaluated daily for objective color as well as subjective evaluation of discoloration by trained panelists. After completion of each designated aging and display period, steaks were utilized for Warner-Bratzler shear force (WBSF), sarcomere length, lipid oxidation (TBARS), pH, and myofibrillar protein degradation analysis.

Results and Discussion

There was an increase in purge loss for all EF samples regardless of voltages compared to the control samples in the outside cooler location ($P < 0.05$; Table 1). Furthermore, application of EF did not reduce thawing times ($P > 0.05$; Figure 1), with EF-10 samples taking longer to reach the targeted 30°F than the rest of the treatments ($P < 0.05$). All EF treatments in the outside cooler location reduced the purge aerobic plate count ($P < 0.01$; Table 1). The EF-10 had lower WBSF ($P < 0.05$; Figure 2) compared to the control. The EF-10 samples from the outside cooler location tended to have greater muscle fiber spacing compared to the other EF treatments ($P = 0.09$; Table 1). There were no differences found for troponin-T degradation, sarcomere length and purge protein concentrations ($P > 0.05$; data not shown). For the 0-day aged samples, EF-5 on day 7 resulted in more discoloration than the rest of the treatments ($P < 0.05$; Table 2). Interestingly, when looking at the 14-day aged samples, EF-5 as well as EF-2.5 had less discoloration than the control and EF-10 ($P < 0.05$; Table 2). When looking at the impact of EF on a* (redness), EF-5 had higher a* values (more redness) than control samples and EF-2.5 on days 4 and 5 of retail display ($P < 0.05$; Figure 3). Lipid oxidation increased over display time as expected ($P < 0.05$; data not shown); however, none of the EF applications or aging periods altered the lipid oxidation of the samples ($P > 0.10$). The EF-10 treatment samples showed an increase in pH in the outside cooler location compared to the control samples ($P < 0.05$).

Implications

Overall, the application of EF during thawing did not reduce purge loss and thawing times, but the EF-10 treatment yielded a more tender product, which could likely be explained by the oscillating ions from the voltage elevating the muscle structural damage. Application of a moderate EF intensity showed potential to be used as a color stabilizer during retail display without affecting other characteristics such as lipid oxidation, particularly for EF-5. Along with the impacts on meat color preservation, future research should investigate the impact of EF thawing as an antimicrobial intervention as well as a color stabilizer.

Acknowledgments
The authors appreciate the Beef Checkoff for funding this project.

Table 1. Interaction of electrostatic field treatments on thawing traits × location[1]

		Location			
	Treatment	**Inside**	**Outside**	**SEM[3]**	***P*-value**
Purge loss (%)	0 kV	1.27^{aB}	1.45^{bB}	0.31	< 0.05
	2.5 kV	0.94^{aB}	2.51^{aA}		
	5 kV	1.38^{aB}	2.50^{aA}		
	10 kV	1.14^{aB}	3.26^{aA}		
APC log CFU purge	0 kV	2.00^{bB}	2.38^{aA}	0.12	< 0.05
	2.5 kV	2.44^{aA}	1.78^{bcB}		
	5 kV	2.27^{abA}	1.66^{cB}		
	10 kV	2.25^{abA}	1.98^{bcA}		
Muscle fiber spacing[2] (µm)	0 kV	11.75^{aA}	10.76^{aA}	0.84	0.09
	2.5 kV	9.66^{aA}	9.40^{aA}		
	5 kV	10.39^{aA}	9.96^{aA}		
	10 kV	9.92^{aB}	13.03^{aA}		
pH	0 kV	5.68^{aA}	5.62^{bA}	0.03	< 0.05
	2.5 kV	5.64^{aA}	5.64^{abA}		
	5 kV	5.67^{aA}	5.64^{abA}		
	10 kV	5.65^{aA}	5.65^{aA}		

a-c Least square means within columns without common superscript differ ($P < 0.05$).
A-B Least square means within respective rows within a measurement without common superscript differ ($P < 0.05$).
[1] Location regarding cooler placement: inside (32°F), outside (36°F).
[2] Average of 60 spaces were measured between muscle fibers.
[3] Standard error of mean of the least square means.

Table 2. Interaction of electrostatic field treatments × aging × display on discoloration[1]

Treatment[2]	kV Treatment	Day 0	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	SEM[4]	*P*-value
Discoloration: 0 days aging	0 kV	0.08^{bA}	0.03^{bA}	0.04^{bA}	0.13^{bA}	0.75^{bA}	1.40^{bA}	1.86^{abB}	3.36^{abcB}	1.51	< 0.05
	2.5 kV	0^{bA}	0^{bA}	0.17^{bA}	0.36^{bA}	0.57^{bA}	1.35^{bA}	1.89^{abB}	6.00^{aB}		
	5 kV	0.25^{cA}	0.24^{cA}	0.15^{cA}	0.56^{cA}	0.43^{cA}	1.43^{cA}	6.35^{bA}	15.26^{aA}		
	10 kV	0.08^{bA}	0.08^{bA}	0.06^{bA}	0.40^{bA}	0.50^{bA}	1.00^{bA}	2.05^{abB}	3.35^{abB}		
Discoloration: 14 days aging	0 kV	0.03^{gA}	0.93^{gA}	4.61^{fgA}	19.97^{eAB}	43.47^{dA}	63.10^{bcA}	80.03^{bA}	89.69^{aA}	6.89	< 0.05
	2.5 kV	0^{eA}	1.10^{eA}	9.41^{deA}	31.67^{cA}	42.86^{bcA}	49.40^{abA}	53.22^{aB}	56.35^{aB}		
	5 kV	0^{cA}	0.61^{cA}	0.78^{cA}	1.97^{ceB}	4.78^{ceB}	12.42^{cdB}	32.90^{bC}	53.74^{aB}		
	10 kV	0.02^{dA}	0.44^{dA}	0.46^{dA}	1.29^{deB}	4.46^{deB}	25.64^{cB}	56.33^{bB}	80.65^{aA}		

[1] Trained panelists score from 0–100 line scale; 0 = no discoloration and 100 = complete discoloration.
[2] a-h Least square means within rows without common superscript differ ($P < 0.05$).
[3] A-C Least square means within columns of aging treatment without common superscript differ ($P < 0.05$).
[4] Standard error of the mean (largest) of the least square means.

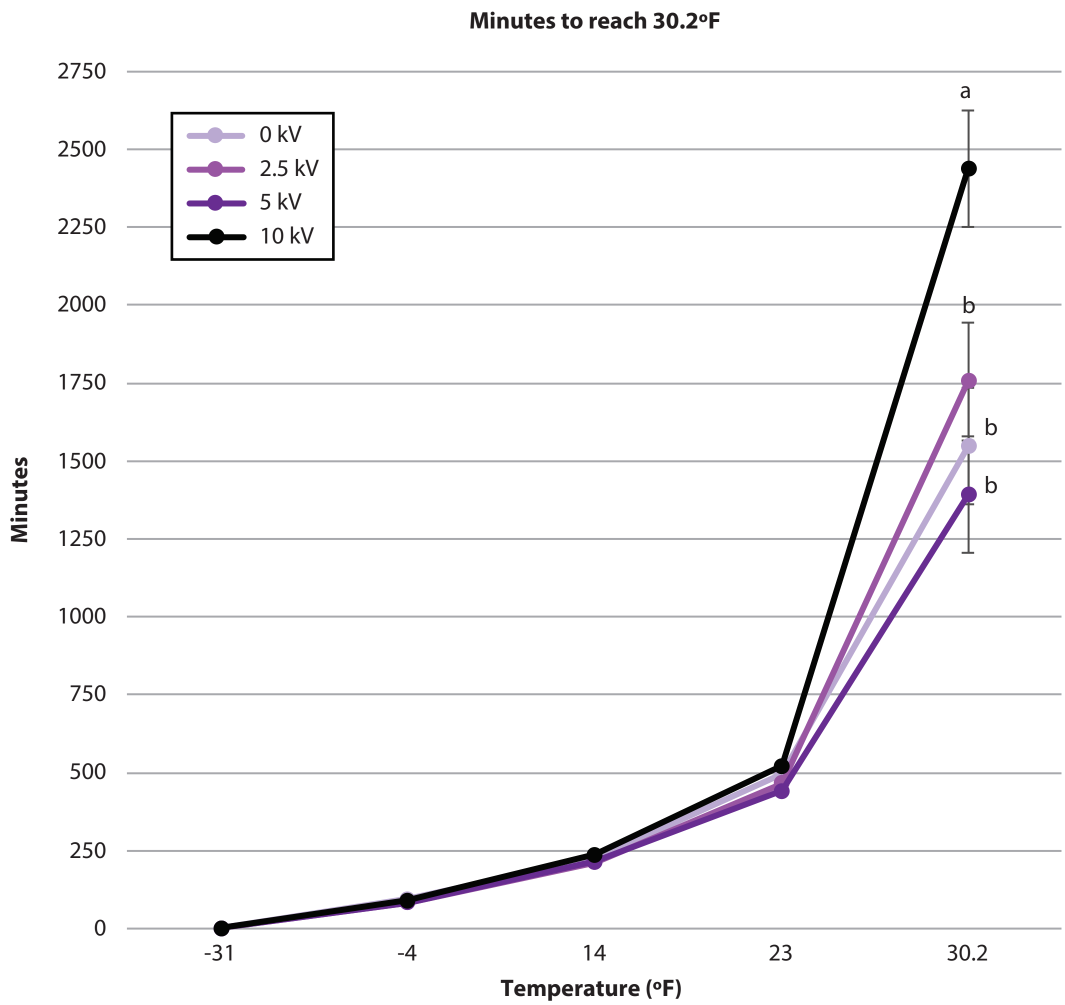

Figure 1. Thawing speed (minutes) of electrostatic field treatments until thawed temperature (30.2°F).

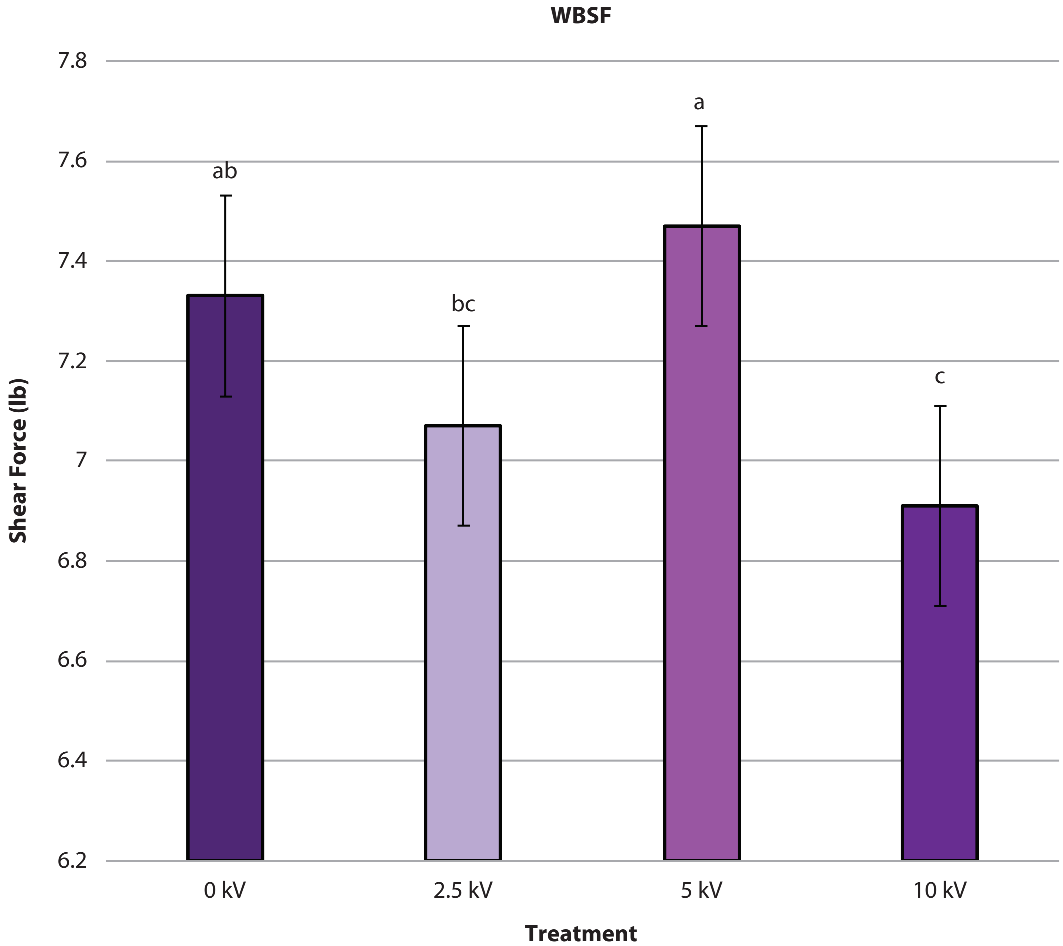

Figure 2. Warner-Bratzler shear force (WBSF) values of samples from electrostatic field thawing treatments.

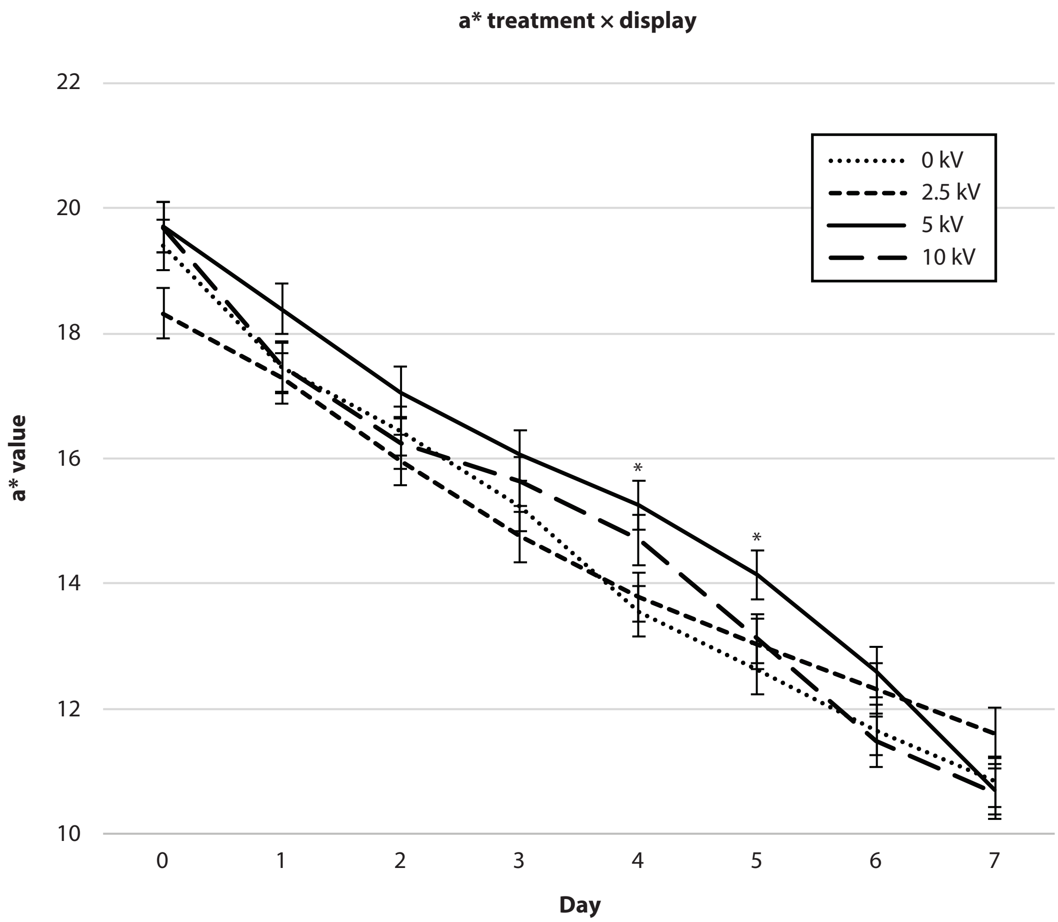

Figure 3. a* values (redness) of samples from the electrostatic field thawing treatments during 7 days of retail display.

Evaluation of Thawing Curves of Beef Strip Loin Steaks Using Various Thawing Methods

L.M. Frink, L.K. Decker, E.S. Beyer, M.D. Chao, M.D. Zumbaugh, J.L. Vipham, and T.G. O'Quinn

Abstract
The objective of this study was to evaluate and determine the thawing rate and time of strip steaks thawed using methods that are recommended by the U.S. Department of Agriculture and those commonly used by consumers. Strip loins were collected from a beef packing facility, cut, and vacuum packaged at Kansas State University, then frozen at -40°F prior to further research. In this study, four different methods of thawing were utilized. Two methods were USDA-approved: thawing in a refrigerator (REF) and in cold water (CW); while the other two methods evaluated are commonly used by consumers: thawing on the countertop (CT) and in hot water (HW). As steaks were thawed, temperatures were recorded over different periods of time to track the thawing time and rate of thawing in the different environments. In this study, thawing time differed by method ($P < 0.05$; HW > CT > CW > REF). Additionally, thawing rates showed similar results ($P < 0.05$; HW > CT > CW < REF). However, CW and REF were similar ($P > 0.05$) in terms of thawing rate. In conclusion, consumers and restaurants should take into consideration thawing rate and times to determine the best method of thawing for strip steaks and should strongly consider using CW and REF to eliminate food safety concerns.

Introduction
In the meat industry, where products are mass produced, freezing is a crucial method to ensure a safe, preserved product in stores and in households for consumption. The process and time used to thaw beef varies and has been largely unstudied. However, thawing time and rate can play a large role in meat quality (Eastridge and Bowker, 2011). For example, drip loss can occur in steaks due to the rupturing of ice crystals formed during the freezing process (Eastridge and Bowker, 2011). Thawing is the final stage of chilling when meat is expected to return to a similar quality as fresh, never-frozen product. However, thawing may affect meat quality due to ice crystal reformation throughout the thawing process (Eastridge and Bowker, 2011). Consumers often choose the quickest and most efficient thawing methods, leading to thawing on countertops or in hot water as opposed to many of the slower USDA-approved methods. Therefore, the purpose of this study was to compare the thawing rate and time of strip steaks thawed using different thawing methods and to evaluate the speed and rate of different thawing methods.

Experimental Procedures
Beef strip loins (Institutional Meat Purchase Specifications #180) were collected from a beef processing plant and brought to Kansas State University. At the university, the strip loins were fabricated into approximately 1-in thick steaks. The steaks were then vacuum-packaged and frozen at -40°F until utilized for the study. Four different

thawing methods were utilized in this study. Two methods were USDA-approved: thawing in a refrigerator (REF) and in cold water (CW); while the other two methods evaluated are commonly used by consumers: thawing on the countertop (CT) and in hot water (HW). Temperature probes (Q-Series Type K, American Fork, UT) were placed at the geometric center of the cut. Prior to the study, pilot studies were completed for each method to determine the approximate time the product would take to thaw. All steaks were thawed until the center reached a temperature of 32°F. Steaks assigned to REF were held at constant temperatures of 35.6–37.4°F in a refrigerator. Steak designated to CW were placed in individual containers with water held at a constant temperature of 35.6–37.4°F. To maintain the temperature of water, the containers were placed in the refrigerator throughout the thawing process. Steaks allocated to CT were thawed in plastic trays at 62.6–68°F for approximately 5 hours, or until the internal temperature reached 32°F. Steaks assigned to HW were placed in a water bath set at 104°F. In order to maintain consistent temperature for HW, a sous vide machine was used. Temperature probes were connected to temperature data loggers. Every 30 minutes, REF and CW temperatures were recorded for 24 hours or until 32°F was reached. The CT temperatures were recorded every 10 minutes for 5 hours or until 32°F was reached. The HW temperatures were recorded every 30 seconds and steaks were removed when internal temperatures reached 32°F. Data were analyzed as a completely randomized design.

Results and Discussion

Thawing time differed ($P < 0.05$) among treatments in this study (HW < CT < CW < REF), ranging from 10 minutes to 14 hours and 42 minutes (Table 1 and Figure 1). Additionally, thawing rates differed ($P < 0.05$) among treatments with a similar trend (HW < CT < CW < REF), ranging from 33.46°F per minute to 32.01°F per minute. The CW temperatures differed ($P < 0.05$) from REF until 5 hours prior to the thaw point, at which point the temperatures were similar ($P > 0.05$) for the remaining thawing period. Moreover, REF steaks were warmer ($P < 0.05$) than CW steaks from 13 to 5 hours prior to the thaw point. In the final 5 hours, CW and REF steaks were similar ($P > 0.05$) in temperature. Among all treatments, CT steaks were the coldest ($P < 0.05$) from 5 to 2 hours prior to the thaw point. However, in the final 2 hours, CT steaks were at similar ($P > 0.05$) temperatures as CW and REF. Due to the short period of thawing time and the observed rapid thawing rate, HW samples were the coldest ($P < 0.05$) in the final 10 minutes prior to thaw point.

Implications

Various methods can be used to thaw meat; however, this study evaluated approximate thawing rates and times for the four most common methods. Consumers can estimate the amount of time needed to thaw a steak and plan ahead of time to do so with the safest method possible.

Acknowledgments

This project was funded by the National Cattlemen's Beef Association.

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Table 1. Least squares means for thawing rate, time, and temperatures (°F) at times prior to thawed of strip loin steaks thawed using various methods

Time prior to thawed[1]	Hot water	Countertop	Cold water	Refrigerator	*P*-value	SEM[2]
Thaw rate[3]	1.46[a]	0.504[b]	0.018[c]	0.126[c]	< 0.01	32.16
Thaw time[4]	10.3[a]	264.0[b]	637.5[c]	882.0[d]	< 0.01	51.26
0:00	32.54	32.36	32.0	32.18	0.21	32.18
0:05	24.98	---	---	---		33.49
0:10	25.52[a]	31.28[b]	---	---	< 0.01	32.76
0:30	---	30.2	30.56	33.62	0.31	32.22
1:00	---	29.66	29.84	30.02	0.47	32.2
1:30	---	29.12[a]	29.48[ab]	29.84[b]	0.29	32.18
2:00	---	28.58[a]	29.3[b]	29.84[b]	< 0.01	32.22
2:30	---	27.5[a]	29.12[b]	29.66[b]	< 0.01	32.31
3:00	---	26.06[a]	29.12[b]	29.66[b]	< 0.01	32.45
3:30	---	24.8[a]	28.94[b]	29.48[b]	< 0.01	32.59
4:00	---	22.46[a]	28.76[b]	29.48[b]	< 0.01	32.65
5:00	---	16.88[a]	28.22[b]	29.12[b]	< 0.01	33.93
6:00	---	---	27.68[a]	28.94[b]	0.01	32.31
7:00	---	---	27.5[a]	28.76[b]	< 0.01	32.31
8:00	---	---	26.96[a]	28.58[b]	< 0.01	34.2
9:00	---	---	26.24[a]	28.04[b]	< 0.01	32.4
10:00	---	---	23.72[a]	27.14[b]	< 0.01	32.7
11:00	---	---	21.74[a]	26.6[b]	< 0.01	32.63
12:00	---	---	21.2[a]	26.24[b]	< 0.01	32.99
13:00	---	---	19.4[a]	25.16[b]	0.01	33.76
14:00	---	---	---	22.64		32.63
15:00	---	---	---	20.3		32.41

[1](hours:minutes).
[2]Standard error of the mean (largest) of the least square means.
[3]Degrees / minutes to reach 32°F.
[4]Minutes to reach 32°F.
[abc]Least square means in the same row without a common superscript differ ($P < 0.05$).

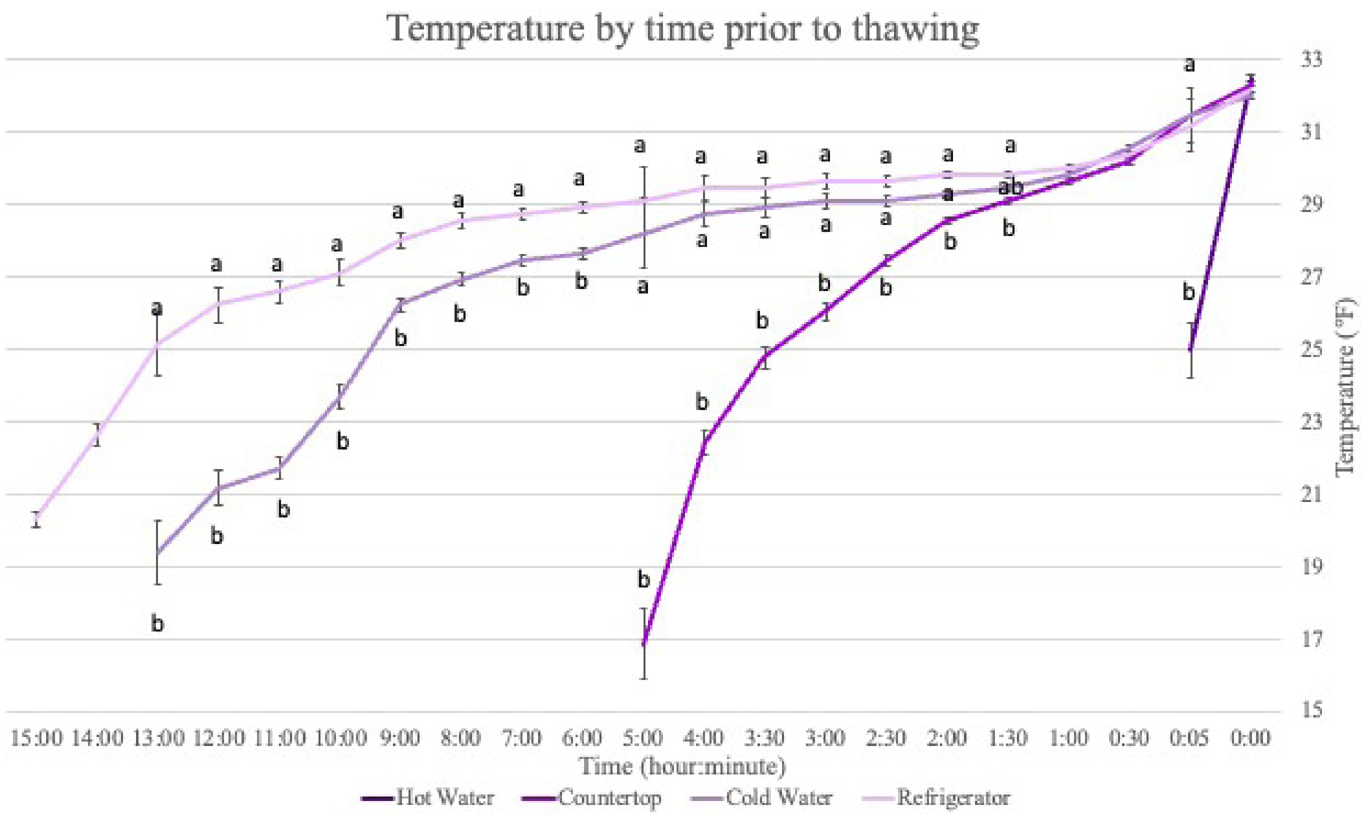

Figure 1. Thaw curves of various thawing methods where time equals hours until thawed.

The Effects of Thawing Methods on Trained Sensory Evaluation of Beef Palatability Traits and Instrumental Measurements of Quality

L.K. Decker, E.S. Beyer, M.D. Chao, M.D. Zumbaugh, J.L. Vipham, and T.G. O'Quinn

Abstract

While the impact of freezing beef is well studied among published literature, thawing has not received the same level of attention. The objective of the current study was to evaluate six thawing methods for palatability: the four USDA approved thawing methods (thawing in a refrigerator, cold water, microwave, and cooking from a frozen state), as well as two methods commonly used by consumers (thawing in hot water and on the counter). Paired Low Choice strip loins (n = 15) were collected from a beef packing facility. The paired loins were fabricated into 1-in steaks and blocked into six blocks of four steaks. Each block was assigned a different thawing method, and each steak within the block a test. The samples were then aged 21 days and frozen. Fifteen trained panels were performed, with 8 panelists consuming 6 samples from the same loin. Each steak was cooked to a peak temperature of 160°F on clamshell style grills. Data were analyzed as a completely randomized block design. Steaks thawed in a microwave and cooked from frozen were less tender ($P < 0.05$) than steaks thawed in cold water or in a refrigerator, while steaks cooked from frozen were rated higher ($P < 0.05$) for beef flavor intensity than all other methods. Moreover, steaks thawed in a microwave had lower ($P < 0.05$) a* (redness) and b* (yellowness) values than steaks thawed in a refrigerator, cold water, and hot water. Steaks thawed in a microwave had a higher ($P < 0.05$) thaw loss, cook loss, and total moisture loss than steaks thawed in a refrigerator, cold water, and on the counter. The thawing method utilized has a minimal impact on palatability. However, increases in moisture loss can have a negative economic impact. Therefore, consumers should utilize whichever thaw method they prefer, keeping food safety as the highest priority.

Introduction

Freezing, and thus the thawing process, has been utilized for meat preservation for decades. The importance and prevalence for freezing has only increased as demand for meat export to Asian countries continues to rise (Ren et al., 2022; USDA, 2023). Moreover, the effects of freezing on meat quality has been widely investigated. There is evidence that ice crystal formation causes damage to muscle fibers, which causes an increase in tenderness and reduction of juiciness ratings of frozen samples (Rahelić et al., 1985; Kim et al., 2015; Beyer, 2023). However, published literature exploring the effect of thawing method on beef quality is more limited. There are studies that look at one or two thawing methods compared to thawing in a refrigerator, and even still, few of those studies have a trained or consumer sensory panel component, or a complete array of instrumental quality measures. Moreover, the USDA has established four thawing methods defined as safe: thawing in a refrigerator, cold water, microwave, and cooking from a frozen state. Still, consumers commonly utilize other methods to thaw meat, such as thawing on a counter and in hot water (Benli, 2015). Therefore, the purpose of the current study was to evaluate six common thawing methods and to assess quality attributes using a trained panelist evaluation and a wide array of instrumental quality measures.

Experimental Procedures

Paired Low Choice strip loins (n = 15) were collected from a midwestern packing facility and transported to the Kansas State University Meat Laboratory. On day 11 of aging, loins were fabricated into 1-in thick steaks. Each pair of loins was sectioned into six equal blocks, and those blocks assigned to one of six thaw methods. Each steak was assigned a 4-digit ID, a test, then vacuum packaged and aged an additional 10 days prior to freezing (-4°F), for a total of 21 days of aging. Thaw methods consisted of the four USDA-approved thaw methods: refrigerator (REF), cold water (CW), microwave (MIC), cooking from frozen (COOK), and two methods commonly used by consumers: countertop (CT) and hot water (HW). Steaks assigned to REF were thawed in a refrigerator at 34–37°F for 24 hours prior to cooking. Steaks assigned to CW were thawed in individual containers of 34–37°F water for 24 hours prior to cooking. COOK steaks were cooked immediately upon removal from the freezer, while still in a frozen state. The CT steaks were thawed at ambient temperature (68°F) for 5 hours. The HW steaks were thawed in a sous vide machine set to 104°F for 20 minutes (± 2 minutes). The MIC steaks were microwaved at 50% power for 3.5 minutes, flipped, and repeated in a retail microwave. Steaks were cooked to a final peak temperature of 160°F on clamshell-style grills, with temperature being monitored throughout the cooking process. Fifteen sensory panels were performed by eight trained panelists, with each panelist evaluating one sample from each treatment from the same loin. The samples were rated on a 100-point line scale with anchors at 0 (extremely dry/tough/bland/none), 50 (neither dry nor juicy, tough nor tender), and 100 (extremely juicy/tender/abundant/intense). Moreover, analyses were performed for slice shear force (SSF), Warner-Bratzler shear force (WBSF), expressible moisture, internal instrumental cooked color, thaw loss, cook loss, and total moisture loss. Data were analyzed as a completely randomized block design.

Results and Discussion

As a whole, thawing method had a minimal impact on palatability. There were no ($P > 0.05$) differences among thawing methods for initial juiciness, sustained juiciness, connective tissue, pressed juice percentage, L* (lightness), lipid oxidation, WBSF and SSF (Table 1). For myofibrillar tenderness, COOK steaks were tougher ($P < 0.05$) than REF and CW. Also, MIC and COOK steaks were lower ($P < 0.05$) than CW and REF steaks for overall tenderness, while all other treatments were similar ($P > 0.05$). COOK steaks were rated higher ($P < 0.05$) than all other treatments for beef flavor intensity. MIC steaks had lower ($P < 0.05$) cooked a* (redness) and b* (yellowness) values than REF, HW, and CW steaks, while CT samples had higher ($P < 0.05$) values than COOK and MIC. MIC steaks had the highest ($P < 0.05$) cook loss, followed by COOK ($P < 0.05$), with all other treatments being similar (MIC > COOK > CT = HW = CW = REF). The MIC and HW had a higher ($P < 0.05$) thaw loss than CW, CT, and REF (MIC = HW > CW = CT = REF). Moreover, MIC, COOK, and HW steaks had a higher ($P < 0.05$) percent total moisture loss than REF, CW, and CT. This increase in total moisture loss and thaw loss could indicate a total economic loss of steaks thawed using these methods. Lastly, COOK steaks had higher ($P < 0.05$) cooked expressible moisture than CT, CW, and REF.

Implications

These results show that consumers and food service establishments may use whichever thawing method is the most economical and convenient for them, as it does not impact eating quality, although food safety should be the upmost concern.

Acknowledgments

This project was funded by the National Cattlemen's Beef Association.

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Table 1. Least square means for Warner-Bratzler shear force (WBSF), slice shear force, cooking characteristics, and instrumental cooked color of frozen beef strip loin steaks thawed using various thaw methods

	Countertop[1]	Cook from frozen[2]	Cold water[3]	Hot water[4]	Microwave[5]	Refrigerator[6]	*P*-value	SEM[7]
L*	56.7	55.0	56.0	55.3	55.5	55.9	0.16	0.6
a*	21.3[a]	18.2[bc]	20.4[ab]	20.3[ab]	16.4[c]	20.5[ab]	0.02	1.1
b*	19.2[a]	17.7[bc]	18.9[ab]	18.7[ab]	16.9[c]	18.9[ab]	< 0.01	0.5
Slice shear force, lb	32.0	34.4	33.1	32.4	34.2	32.6	0.78	0.7
WBSF, lb	7.9	7.9	7.7	7.5	8.4	8.2	0.15	0.1
Cook loss, %[8]	15.0[c]	18.1[b]	14.6[c]	14.4[c]	19.4[a]	15.4[c]	< 0.01	0.5
Thaw loss, %[9]	1.2[b]	---	0.9[b]	3.7[a]	4.2[a]	0.8[b]	< 0.01	0.4
Total loss, %[10]	16.1[b]	18.3[a]	15.4[b]	18.1[a]	19.4[a]	16.0[b]	< 0.01	0.8
PJP[11]	13.7	13.5	14.7	14.8	15.2	13.8	0.23	0.0
Moisture, %	69.3[ab]	---	69.6[a]	69.7[a]	68.8[b]	69.8[a]	0.04	0.4
Fat, %	9.0[a]	---	8.1[ab]	8.1[ab]	9.0[a]	7.5[b]	0.04	0.5
Malonaldehyde/kg[12]	0.2	---	0.2	0.2	0.2	0.2	0.61	0.0
Expressible moisture, %	7.9[b]	10.1[a]	7.9[b]	8.9[ab]	8.8[ab]	8.3[b]	0.03	0.5
WHC, %[13]	92.2[a]	89.9[b]	92.1[a]	91.1[ab]	91.2[ab]	91.7[a]	0.03	0.5

[abc]Least squares means in the same row without a common superscript differ ($P < 0.05$).
[1]Thawed at 63–68°F for approximately 5 hours, or until internal temperature reached 32°F.
[2]Cooked immediately upon removal from the freezer while still in a frozen state.
[3]Thawed in individual plastic containers of 36–37°F water for 24 hours.
[4]Thawed in 104°F water for 20 minutes (±2 minutes) utilizing a sous vide machine to maintain water temperature.
[5]Microwaved in a retail microwave at 50% power for 180 seconds, rotated, and microwaved for an additional 180 seconds, microwaving for an additional 30–60 seconds if not completely thawed.
[6]Thawed at 36–37°F in open air in a refrigerator.
[7]Standard error of the mean (largest) of the least square means.
[8]Cook loss percentage = [(raw weight – cooked weight) / raw weight] × 100.
[9]Thaw loss percentage = [(steak in package – raw steak weight – dried package weight) / raw steak weight] × 100.
[10]Total loss = [(steak in package – dried package weight – cooked weight) / raw steak weight] × 100.
[11]Pressed juice percentage.
[12]mg of malonaldehyde/kg of meat.
[13]Water holding capacity.

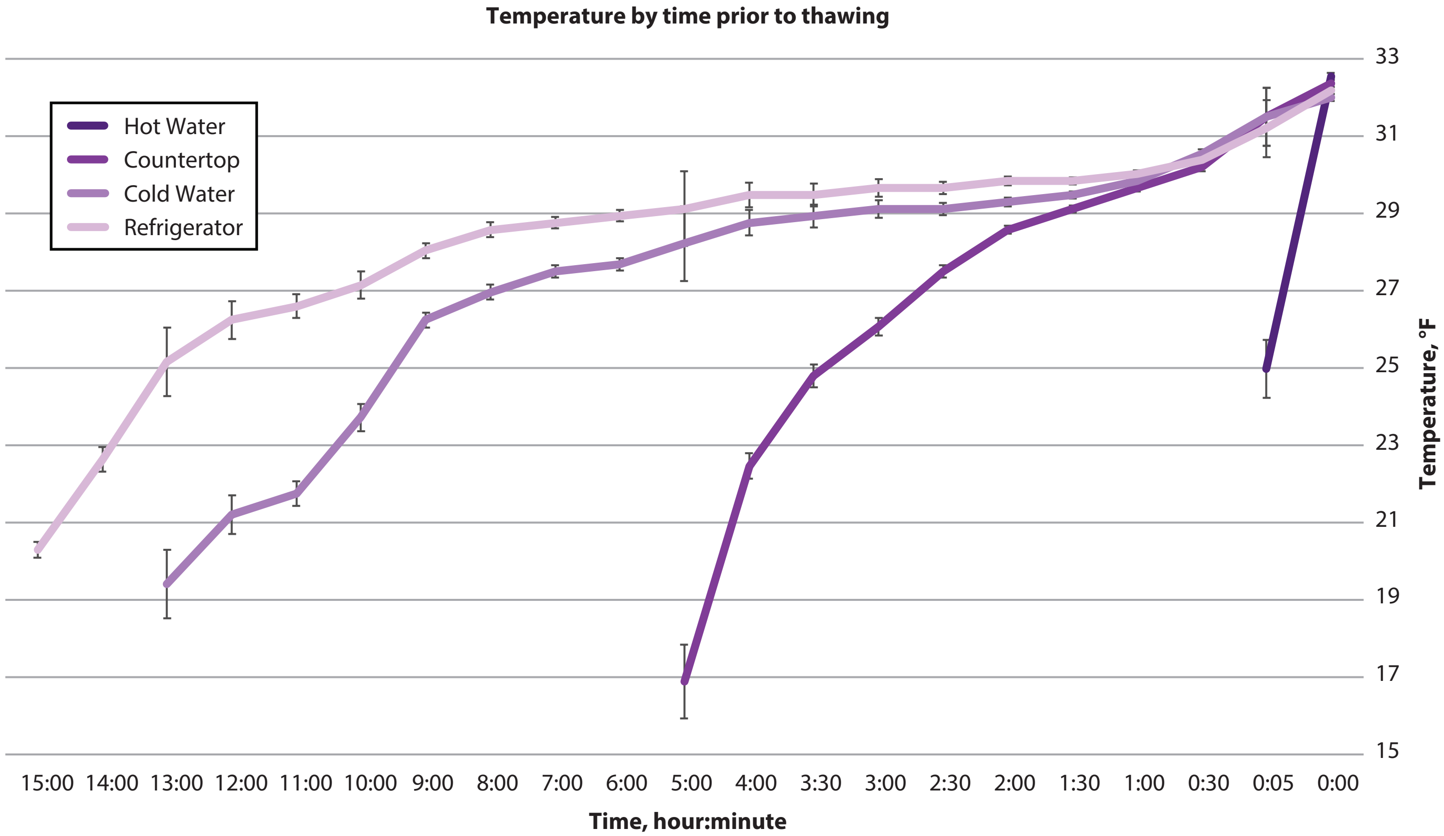

Figure 1. Temperature by time prior to thawing.

The Effects of Thawing Method on Consumer Palatability Ratings of Beef Strip Loin Steaks

S.L. Witberler, L.K. Decker, E.S. Beyer, M.D. Zumbaugh, M.D. Chao, J.L. Vipham, and T.G. O'Quinn

Abstract

The objective of this study was to determine palatability differences in beef strip loin steaks among various U.S. Department of Agriculture approved thawing methods and those commonly utilized by consumers. Paired Low Choice beef strip loins were collected and fabricated into six sections. Each section was fabricated into 1-in steaks and assigned one of six thawing methods including: countertop, cook from frozen, cold water, hot water, microwave, and refrigerator. Steaks were cooked to a peak internal temperature of 160°F and samples were fed to consumers to evaluate juiciness, tenderness, flavor liking, overall liking, acceptability of palatability traits, and perceived level of quality. Results of consumer sensory evaluation indicated that there were no differences ($P > 0.05$) among the six thaw methods for juiciness, tenderness, and flavor liking. However, all treatments had an average rating of at least 57 for overall liking, indicating a high level of eating satisfaction. For all thaw methods, at least 82% of steaks were rated as overall acceptable. Additionally, for all thaw methods, consumers rated at least 79.1% of steaks acceptable for juiciness, tenderness, and flavor liking. Furthermore, thaw method did not have an impact ($P > 0.05$) on the perceived level of quality of samples. Therefore, consumers should use whichever thawing method is most convenient or best suits their needs.

Introduction

Beef is often frozen in the U.S. to help preserve and extend shelf life. In 2022, the USDA reported that the U.S. exported $11.7 billion of beef (USDA, 2023). Exported beef is commonly frozen to preserve quality and ease in transportation. In many instances, beef is thawed before cooking, but it is unknown how beef palatability is impacted by thawing method. There is evidence that thawing method impacts properties such as water holding capacity, thawing loss, and cooking loss (Zahir, 2021). Also, there is evidence that trained panelists rate myofibrillar tenderness lower ($P < 0.05$) in frozen steaks rather than thawed steaks (Obuz and Dikeman, 2003). However, there has been limited consumer research done evaluating various thawing methods and the impact on beef palatability. The objective of this study was to determine palatability differences in beef strip loin steaks among various USDA approved thawing methods and those commonly utilized by consumers.

Experimental Procedures

Paired Low Choice beef strip loins (Institutional Meat Purchase Specifications #180) were collected from a Midwest commercial processing facility (n = 15 pairs). Each pair was fabricated into six sections and cut into 1-in steaks. Each section was assigned one of the six different thawing methods. Thawing methods included: countertop, cook from frozen, cold water, hot water, microwave, and refrigerator. Steaks thawed on the countertop were thawed at 62-68°F for 5 hours. Cook from frozen steaks were cooked immediately after removal from the freezer while still frozen. Steaks thawed in cold water were placed in 35-37°F water for 24 hours. Steaks thawed in hot water were placed in a sous vide machine with 104°F water for 20 minutes (±2 minutes). Microwaved steaks were placed in a retail microwave at 50% power for 3 minutes, rotated, and microwaved for 3 minutes. Steaks thawed in the refrigerator were placed in a 35-37°F refrigerator for 24 hours. Steaks were cooked to an internal peak temperature of 160°F measured with a temperature probe placed in the geometric center of the steak. Consumers were given 0.39-in × 0.39-in samples which they evaluated for juiciness, tenderness, flavor liking, and overall liking, attribute acceptability, and perceived level of quality (premium quality, better than everyday quality, everyday quality, or unsatisfactory quality) and reported their responses using a Qualtrics survey. Samples were rated on a 100-point scale with 0 indicating dry, tough, or dislike extremely, and 100 indicating extremely juicy, extremely tender, or like extremely. Consumers also answered demographic questions and self-reported information about their beef consumption. Data were analyzed as a completely randomized block design.

Results and Discussion

For beef demographic data, consumers reported that the most important beef palatability trait was flavor with 56.7% of consumers indicating it as the most important. Tenderness was rated as the most important by 33.3% of consumers. Additionally, consumers reported the trait they experienced the most variability with was tenderness. Results of consumer sensory evaluation indicated that there were no differences ($P > 0.05$) among the six thaw methods for juiciness, tenderness, flavor, and overall liking (Table 1). However, all treatments had an average rating of at least 57 for overall liking, indicating a high level of eating satisfaction. For all thaw methods, at least 82% of steaks were rated as overall acceptable. Additionally, for all thaw methods, consumers rated at least 79.1% of steaks acceptable for juiciness, tenderness, and flavor liking. Furthermore, thaw method did not have an impact ($P > 0.05$) on the perceived level of quality of samples.

Implications

Thawing method did not impact juiciness, tenderness, flavor liking, or overall liking, and therefore consumers should use whichever thawing method is most convenient or best suits their needs.

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Table 1. Least squares means for consumer sensory evaluation of palatability characteristics[1] and percentage of samples rated as acceptable of frozen beef strip loin steaks using various thaw methods

Trait	Countertop[2]	Cook from frozen[3]	Cold water[4]	Hot water[5]	Microwave[6]	Refrigerator[7]	*P*-value	SEM[8]
Juiciness	60.8	59.2	65.5	58.1	56.8	57.1	0.28	2.9
Tenderness	60.6	56.9	63.8	60.8	56.8	57.6	0.38	2.8
Flavor	61.8	62.7	62.3	60.5	56.1	62.2	0.19	2.1
Overall liking	62.6	60.8	65.9	61.6	57.0	62.7	0.18	2.4
Juiciness acceptability	82.6	81.8	92.0	80.9	79.1	80.0	0.17	4.2
Tenderness acceptability	82.2	79.9	87.9	91.6	80.6	81.5	0.12	3.9
Flavor acceptability	87.4	87.4	91.1	87.4	84.8	85.7	0.80	3.5
Overall acceptability	85.2	82.6	95.2	86.3	87.4	83.7	0.13	4.0

[1]Sensory scores: 0 = extremely dry/tough/dislike extremely; 50 = neither dry nor juicy/neither tough nor tender/neither like nor dislike; 100 = extremely juicy/tender/like extremely.
[2]Thawed at 62-68°F for approximately 5 hours.
[3]Cooked immediately upon removal from the freezer while still in a frozen state.
[4]Thawed in individual plastic containers of 35-37°F water for 24 hours.
[5]Thawed in 104°F water for 20 minutes (±2 minutes).
[6]Microwaved in a retail microwave at 50% power for 3 minutes, rotated, and microwave for an additional 3 minutes.
[7]Thawed at 35-37°F in open air in a refrigerator.
[8]SEM (largest) of the least square means.

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