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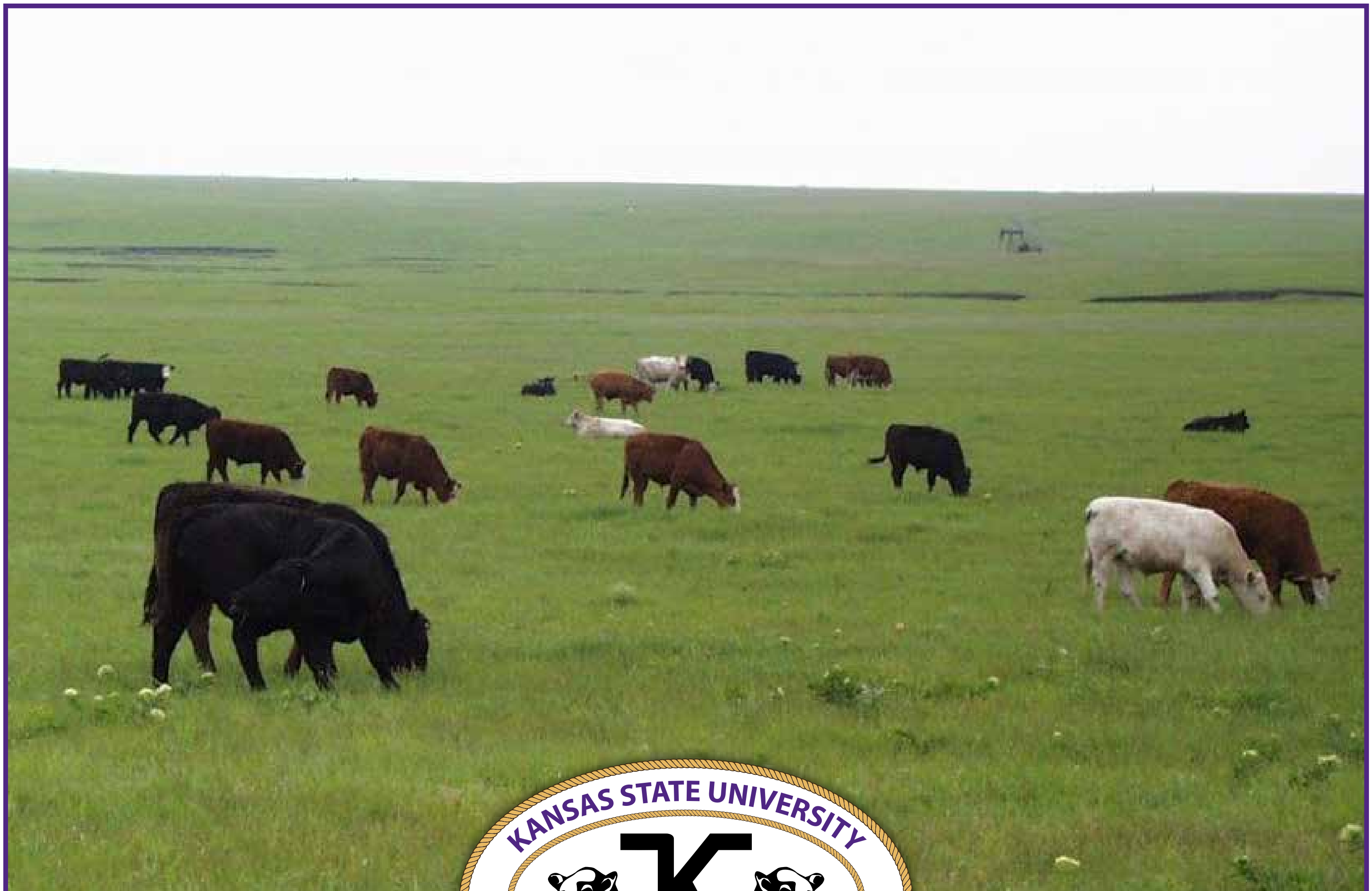

Cattlemen's Day 2017

Beef Cattle Research

K-State Research and Extension

Kansas State University Agricultural Experiment Station and Cooperative Extension Service

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Effects of Growing-Season Prescribed Burning on Vigor of Sericea Lespedeza in the Kansas Flint Hills: I. Suppression of Seed Production and Canopy Dominance

J.A. Alexander, W.H. Fick, J. Lemmon, G.A. Gatson, G.W. Preedy, and K.C. Olson

Introduction

Sericea lespedeza (*Lespedeza cuneata*) is a highly fecund noxious weed in Kansas and surrounding states. Individual plants are capable of producing greater than 1,000 seeds annually. Vigorous seed production allows sericea lespedeza to rapidly infiltrate native and cultivated grasslands; seed can be transported great distances via farm machinery and the alimentary canal of wild and domestic herbivores. In Kansas alone, sericea lespedeza infests more than 700 square miles of pasture, primarily in the Flint Hills region. The resulting damage to native habitats for wildlife and pasture quality for domestic herbivores has been devastating.

The predominant grazing management practice in the Kansas Flint Hills involves annual spring burning in April followed by intensive grazing with yearling beef cattle for a relatively short period from late April to August. During seasonal grazing, 40 to 60% of annual graminoid production is removed and grazing lands then remain idle for the remainder of the year. Under this prevailing management practice, invasion by sericea lespedeza into the tallgrass prairie biome has steadily increased. Oklahoma State University researchers speculated that dormant-season, spring fires may stimulate sericea lespedeza seed germination by scarifying seeds cast the previous fall. Previous research reported that application of growing season fire at 3 year intervals decreased the rate of sericea lespedeza invasion. Therefore, the objective of our study was to evaluate the effects of annual prescribed burning applied during the growing season on vigor of sericea lespedeza infesting native tallgrass range.

Key words: sericea lespedeza, prescribed burning, growing season

Experimental Procedures

A 125-acre native tallgrass pasture located in Geary Co., KS was used for our study. The site was historically grazed during the winter and spring by beef cattle; moreover, the infestation of sericea lespedeza on the site was problematic for the 20-year period preceding our study. The study site was divided along watershed boundaries into 9 fire-management units (12 ± 6 acres). Unit boundaries were delineated by mowing firebreaks (≈ 20 ft wide) around each perimeter. Units were assigned randomly to 1 of 3 prescribed-burning times (n = 3 / treatment): early spring (April 1), mid-summer (August 1), or late summer (September/1). Prescribed burns were carried out on or near target dates when appropriate environmental conditions prevailed: surface wind speed = 10 to 15 mph; surface wind direction = steady and away from urban areas; mixing height greater than 1800 feet; transport wind speed = 8 to 20 mph; relative humidity = 40 to 70%; ambient temperature = 75 to 100°F; and Haines index 4 or less. All prescribed burning activities were carried out with the permission of Geary Co. Emergency Services, Junction City, KS (permit no. 348).

Forage biomass, sericea lespedeza frequency, sericea lespedeza crown maturity, and sericea lespedeza stem height were measured along a single, permanent 100-yd transect in each fire-management unit (100 × 12-in^2 plot points/transect). Transects were laid out on a southwest-to-northeast gradient; transect ends were marked using steel fence posts. Transects were read on average dates July 19 and October 10. A 100-yd measuring tape was stretched from the southwestern end to the northeastern end of each transect. At 3-ft intervals along each transect, biomass was measured using a visual obstruction technique. In addition, a 12 × 12-in plot was projected on the eastern side of transects at each point of measurement. Within the plot, presence of sericea lespedeza was noted (e.g., yes or no). If sericea lespedeza was present, stem height and crown maturity of the sericea lespedeza plant closest to the 3-ft interval on the measuring tape was recorded. Stem height was measured in inches from the surface of the soil to its maximum length by manually holding the sericea lespedeza stem erect. Crown maturity was evaluated visually; sericea lespedeza plant crowns containing any senescent material or multiple stems were judged to be old growth (> 1 year old), whereas sericea lespedeza plant crowns without evidence of senescence or with single-stem crowns were judged to be new growth (< 1 year old).

A total of 100 mature sericea lespedeza plants were collected adjacent to permanent transects in each burn-management unit immediately after the first killing frost (approximately November 1). Plants were clipped at ground level and placed into a labeled paper bag. Bagged samples were dried using a forced-air oven. Individual plants in each sample were defoliated by hand. Resulting seeds, chaff, and stems were also separated by hand. The total amount of seed recovered from each sample was weighed to the nearest milligram. Seed weight was converted to seed count, assuming a density of 770 seeds/gram. Average seed production was calculated by dividing the number of seeds by the number of sericea lespedeza plants in each sample (n = 100).

Results and Discussion

Forage biomass, sericea lespedeza maximum stem height, and crown maturity were influenced by treatment and measurement date (treatment × time, $P \leq 0.01$; Table 1). Forage biomass was not different ($P \geq 0.81$) between treatments on July 19, indicating that burning during the latter half of the growing season did not harm forage productivity in subsequent years. As expected, forage biomass on spring-burn treatments was greatest ($P \leq 0.01$) on October 10; however, forage regrowth on mid-summer and late summer burn treatments was significant. All burn management units had greater than 3,600 lb of forage dry matter/acre before seasonal plant dormancy occurred. We concluded that

post-fire regrowth was sufficient to prevent erosion and soil-moisture loss during the dormant season.
Maximum stem height of sericea lespedeza and the proportion of mature sericea lespedeza crowns were not different ($P \geq 0.78$) between treatments on July 19 (Table 1). On October 10, stem height and proportion of mature crown did not change ($P \geq 0.22$) on spring burn treatments from the initial measurement on July 19. In contrast, burning in mid-summer or late summer reduced ($P \leq 0.04$) sericea lespedeza stem height and the proportion of mature sericea lespedeza crowns on October 10 compared to spring burning.

Canopy frequency of sericea lespedeza was greatest ($P < 0.01$) on spring-burn treatments (49.9% of plots) and least on mid-summer (31.4%) and late summer burn treatments (20.3%; Table 1). Incidence of plant canopies with multiple sericea lespedeza crowns was not different ($P = 0.13$) between treatments.

Whole-plant dry matter weight of sericea lespedeza at dormancy, total seed weight per sericea lespedeza plant, and seed production per sericea lespedeza plant were greatly diminished ($P < 0.01$) on mid-summer and late summer burn treatments compared to spring-burn treatments (Table 2). Whole-plant dry matter weight of individual sericea lespedeza plants on the spring-burn treatment was 8.6-fold and 24.3-fold heavier than sericea lespedeza plants on the mid-summer and late summer burn treatments, respectively. Seed production in areas treated with mid-summer fire was less than 5% of that in areas treated with spring fire. In areas treated with late-summer fire, seed production was 0.07% that of areas treated with spring fire.

We interpreted these data to indicate that prescribed burning during the growing season had strong suppressive influences on vigor and reproductive capabilities of individual sericea lespedeza plants.

Implications

Compared to traditional spring, dormant-season burning, burning during the summer months resulted in significant decreases in canopy dominance and seed production by sericea lespedeza. Growing-season prescribed burning is an inexpensive and comprehensive means to control sericea lespedeza propagation and invasion. At the time of this writing, prescribed burning in the Kansas Flint Hills had a cash cost of less than $1 USD/acre, whereas fall application of herbicide was estimated to cost between > $18 USD/acre. This manuscript presents the results of 3 years of a 4-year experiment.

Table 1. Effects of prescribed-burn timing of native tallgrass rangeland on forage biomass and canopy frequency, crown maturity, and stem height of sericea lespedeza (SL; *Lespedeza cuneata*)

Evaluation date	Prescribed-burn timing	Forage biomass, dry matter lb/a	Plant canopies containing SL, % of total	SL maximum stem height, in.	Incidence of multiple SL stems, % of SL-containing plant canopies	Mature SL crowns, % of SL-containing plant canopies
July 19	Early spring (April 01)	4,436[c]	47.9[a]	21.4[a]	72.3	92.8[a]
	Mid-summer (August 01)	4,401[c]	33.9[a, b]	21.5[a]	70.3	92.3[a]
	Late summer (September 1)	4,228[c]	27.1[b, c]	21.7[a]	62.4	94.6[a]
October 10	Early spring (April 01)	14,488[a]	52.0[a]	23.5[a]	84.1	91.4[a]
	Mid-summer (August 01)	6,490[b]	29.0[b, c]	9.2[b]	63.9	29.4[b]
	Late summer (September 1)	3,603[c]	13.6[c]	6.9[b]	63.5	12.3[c]
	Standard error*	865.3	9.16	1.72	10.82	8.23
	P–treatment	< 0.01	< 0.01	< 0.01	0.13	< 0.01
	P–time	< 0.01	0.37	< 0.01	0.72	< 0.01
	P–treatment × time	< 0.01	0.40	< 0.01	0.49	< 0.01

* Mixed-model standard error associated with comparison of treatment × time means.

a,b,c Means within a column with unlike superscripts are different (P≤0.05).

Table 2. Effects of prescribed-burn timing of native tallgrass rangeland on whole-plant dry matter weight and seed production by sericea lespedeza (SL; *Lespedeza cuneata*) as measured at plant dormancy

Item	Early spring burn (April 1)	Mid-summer burn (August 1)	Late-summer burn (September 1)	Standard error*	P-value†
Whole-plant dry matter weight, mg/plant	3,954[a]	460[b]	163[b]	561.1	< 0.01
Total seed weight, mg/plant	924[a]	42[b]	1[b]	153.1	< 0.01
Seeds, number/plant	710.8[a]	32.6[b]	0.5[b]	117.82	< 0.01

* Mixed-model standard error associated with comparison of treatment main effect means.

† Treatment main effect.

a,b Means within a row with unlike superscripts are different (P≤0.05).

Effects of Growing-Season Prescribed Burning on Vigor of Sericea Lespedeza in the Kansas Flint Hills: II. Plant-Species Composition

J.A. Alexander, W.H. Fick, J. Lemmon, G.A. Gatson, G.W. Preedy, and K.C. Olson

Introduction

Fire has, for centuries, been a key force for sustainability of native ecosystems in the Kansas Flint Hills. Prior to the arrival of European settlers, prescribed and wild fires occurred at less than 3-year intervals in the tallgrass prairie region. As a result, native tallgrass plant communities adapted to fire at regular intervals and plant-species composition became stable on a geologic time scale.

Currently, prescribed fire is used in the Kansas Flint Hills as a treatment for control of woody-stemmed invasive species such as eastern red cedar, honey locust, and roughleaf dogwood. These fires are generally applied in March and April and have become an integral part of the most common grazing management practice in the Kansas Flint Hills: annual spring burning in April followed by intensive grazing with yearling beef cattle for a relatively short period of time from late April to early August. Annual burning reportedly results in 0.2 to 0.3 lb of additional daily weight gain for yearling cattle when used in that way. In contrast, prescribed and wild fires during the pre-settlement era were not concentrated during any particular season of the year.

Use of prescribed burning that is limited to a short interval during the spring has coincided with a steady increase of an invasive, non-woody, perennial legume known as sericea lespedeza (*Lespedeza cuneata*). Introduced into North America during the late 19th century, sericea lespedeza has proven highly adaptable to Flint Hills soils and climate. Prolific seed production appears to be the primary means of invasion. Seeds of sericea lespedeza are not wind-borne but are easily transported via the digestive tract of tannin-resistant herbivores and via machinery.

Until recently, control of sericea lespedeza has relied heavily on costly, repeated application of herbicides, which has not checked the spread of the plant. We previously reported that prescribed burning during the months of August and September had strong suppressive effects on stand vigor and seed production of sericea lespedeza at a greatly reduced cost compared with herbicide. Questions remain, however, about the effects of growing-season prescribed burning on non-target plant species and soil cover. Therefore, the objective of this study was to evaluate the effects of growing-season prescribed fire on soil cover and populations of native grasses, forbs, and shrubs.

Key words: sericea lespedeza, prescribed burning, growing season

Experimental Procedures

A 125-acre native tallgrass pasture located in Geary Co., KS, was used for our study. The site was historically grazed during the winter and spring by beef cattle; moreover, the infestation of sericea lespedeza on the site was problematic for the 20 year period preceding our study. The study site was divided along natural watershed boundaries into 9 fire-management units (12 ± 6 acres). Unit boundaries were delineated by mowing firebreaks (≈ 20 ft wide) around each perimeter. Units were assigned randomly to 1 of 3 prescribed-burning times (n = 3 / treatment): early spring (April 1), mid-summer (July 30), or late summer (September 1). Prescribed burns were carried out on or near target dates when appropriate environmental conditions prevailed (surface wind speed = 10 to 15 mph; surface wind direction = steady and away from urban areas; mixing height greater than 1800 ft; transport wind speed = 8 to 20 mph; relative humidity = 40 to 70%; ambient temperature = 75 to 100°F; and Haines index ≤ 4). All prescribed burning activities were carried out with the permission of Geary Co. Emergency Services, Junction City, KS (permit no. 348). Fires were applied during 2014, 2015, and 2016.

Plant species composition and soil cover were measured along permanent 100-yd transects in each fire-management unit. Transects were laid out on a southwest-to-northeast gradient; transect ends were marked using steel fence posts. Composition and cover were assessed in mid-July for 3 consecutive years using a modified step-point technique. One hundred points adjacent to each transect were evaluated for bare soil, litter cover, or basal plant area (percent of total area). Plants were identified by species, and basal cover of individual species was expressed as a percentage of total basal plant area.

Results and Discussion

Bare soil, litter cover, and basal vegetation cover, expressed as a percent of total land area, were not different ($P \geq 0.38$) among treatments and averaged 40.3, 49.0, and 10.7%, respectively (Table 1). Cover values were indicative of normal, healthy soils and tallgrass plant communities. Total grass cover, major warm season grass species cover, total forb cover, and total shrub cover were not influenced ($P \geq 0.36$) by the timing of prescribed burning. We interpreted these data to indicate that prescribed burning during April, August, or September produced similar effects on soil cover and plant species composition.

Prior to our study, basal sericea lespedeza cover on all burn management units was not different ($P \leq 0.52$) between treatments (Table 1). Sericea lespedeza basal cover trended ($P = 0.18$) downward over the 3-year course of our study and averaged 4.89, 3.46, and 1.55% for April, August, and September prescribed burns, respectively. In addition, basal area of Baldwin's ironweed and western ragweed were greater ($P \leq 0.01$) on areas burned in April than those burned in August.

Smooth sumac basal cover was lesser (P=0.04) in areas treated with prescribed fire in August than those treated with prescribed fire in April; moreover, roughleaf dogwood basal cover was lesser (P=0.04) in areas treated with prescribed fire in August and September than those treated with prescribed fire in April. Treatments had no effect ($P \leq 0.50$) on basal cover of buckbrush or leadplant; however, New Jersey tea basal cover (a preferred diet component for beef cattle) was greater (P=0.04) in areas treated with prescribed fire in August and September than those treated with prescribed fire in April.

Implications

In contrast to published reports involving herbicide application, control of sericea lespedeza using growing-season prescribed burning did not result in measurable collateral damage to non-target plant species. Growing-season prescribed burning decreased basal cover of undesirable plants such as Baldwin's ironweed, western ragweed, smooth sumac, and roughleaf dogwood compared with conventional spring burning. In contrast, soil cover, grass basal cover, and forb basal cover were not affected by the timing of prescribed burning. Herbicide control of sericea lespedeza is known to be expensive (≈ $18 USD/acre annually) and tedious and can negatively affect non-target plant species. In contrast, growing season prescribed burning costs less than $1 USD/acre and strongly hindered vigor and seed production of sericea lespedeza and tended to decrease basal cover of sericea lespedeza in our study.

Table 1. Effects of prescribed-burn timing of native tallgrass rangeland on graminoid basal cover, forb basal cover, occurrence of bare soil and litter cover during the middle of the growing season

Item	Early spring burn (April 1)	Mid-summer burn (July 30)	Late-summer burn (September 1)	Standard error*	P-value†
Bare soil, % of total area	40.4	42.2	38.2	10.12	0.92
Litter cover, % of total area	49.3	47.9	49.9	10.09	0.98
Basal vegetation cover, % of total area	10.3	9.9	11.9	1.48	0.38
Total grass cover, % of total basal cover	84.4	86.2	88.0	2.71	0.44
Major warm-season grasses‡, % of total basal cover	55.2	51.2	55.6	5.53	0.69
Total forb cover, % of total basal cover	13.7	11.8	9.6	2.83	0.36
Total shrub cover, % of total basal cover	1.87	1.94	2.44	0.605	0.60
Western ragweed, % of total basal cover	3.34[a]	1.20[b]	1.15[b]	0.844	0.02
Baldwin's ironweed, % of total basal cover	0.78[a]	0.23[b]	0.49[a, b]	0.217	0.06
Sericea lespedeza, % of total basal cover	4.89	3.46	1.55	1.753	0.18
Smooth sumac, % of total basal cover	0.34[a, b]	0.14[b]	0.44[a]	0.113	0.04
Roughleaf dogwood, % of total basal cover	0.19[a]	0.05[b]	0.02[b]	0.065	0.04
Leadplant, % of total basal cover	0.80	1.19	1.38	0.490	0.50
New Jersey tea, % of total basal cover	0.00[a]	0.19[b]	0.01[c]	0.081	0.04
Buckbrush, % of total basal cover	0.48	0.35	0.50	0.209	0.74

* Mixed-model standard error associated with comparison of treatment main effect means.
† Treatment main effect.
‡ Combined basal cover of big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyium scoparium*), indiangrass (*Sorghastrum nutans*), and sideoats grama (*Bouteloua curtipendula*).
abc Means within row having unlike superscripts differ ($P \leq 0.05$).

Horn Fly Control and Growth Implants are Effective Strategies for Heifers Grazing Flint Hills Pasture

S.S. Trehal, J.L. Talley[1], K.D. Sherrill[1], T.J. Spore, R.N. Wahl, W.R. Hollenbeck, and D.A. Blasi

Introduction

Horn flies (*Haematobia irritans* (L.)) are considered the most important external parasite that negatively affects pasture-based beef systems with losses estimated to exceed $1 billion annually to the U.S. beef industry. Control strategies have relied heavily on insecticide applications to control horn flies and are implemented when the economic threshold of 200 flies/animal have been exceeded. When horn fly populations are maintained below 200 flies/animal by treating them with insecticides then the level of stress annoyance behaviors such as leg stomping, head throwing, and skin twitching decreases while grazing increases. While most stocker operators utilize some type of fly control these are rarely used as a single pharmaceutical technology to aid in performance of the animals. Additional pharmaceutical technologies are utilized in combination of others, with the use of de-wormers and implants showing the largest impact with performance of stockers. The objective of this study was to compare a commercial injectable insecticide, LongRange, to an insecticidal ear tag for horn fly control and determine the impact of weight performance on stockers when fly control technologies were used in combination with implants versus no implants.

Key words: horn fly, implants, LongRange

Experimental Procedures

Crossbred stockers (n = 301; 587.82 ± 35.36 lb) were randomized by their initial weight across 15 pastures. Pastures were randomly assigned to three different treatment groups: 1) insecticide ear tag administered at 1 tag/animal (Corathon, 15% coumaphos and 35% diazinon; Bayer Healthcare LLC Animal Health Division, Shawnee Mission, KS); 2) LongRange injectable administered at 1 mL/110 lb body weight (1 mL contains 50 mg eprinomectin, Merial Limited, Duluth, GA); and 3) untreated control group. Within each treatment group, equal number of animals were randomly given either: Ralgro (36 mg zeranol; Merck Animal Health, Madison, NJ), Revalor-G (40 mg of trenbolone acetate and 8 mg estradiol; Merck Animal Health, Madison, NJ), or no implant. Stocking rates were based on pasture size (average: 253.58 ± 5.16 lb/acre).

[1] Department of Entomology and Plant Pathology, Oklahoma State University.

Individual animals were weighed and fecal samples were taken from four randomly selected animals per pasture on days 0 and 90. Fly counts began 2 weeks after initial treatment and continued on a weekly basis until the end of the study. Fifteen to 20 animals were randomly selected per pasture, and pictures were taken of one side of each animal using a DSLR digital camera with a telephoto zoom lens. Pictures were uploaded to a grid system where flies were counted by a trained observer. The study was designed as a randomized complete block with weekly analysis of horn fly populations.

Weight data, fecal egg counts, and fly counts were analyzed using the PROC GLM procedure with a preceding PROC UNIVARIATE for normality in SAS 9.4 (SAS Institute, Cary, NC). The fecal egg count data were not normally distributed so a PROC GLIMMIX procedure with pre-planned comparisons was conducted for the internal worm burden. Mean separation tests were conducted using LSMEANS with an $\alpha = 0.05$.

Results and Discussion

Eight weeks after treatment application the horn fly population increased to more than the economic threshold of 100 flies/side for all treatment groups with LongRange exhibiting a lower number of horn flies (112.01 ± 15.33 flies) than the untreated animals (175.68 ± 14.82 flies) (P=0.01; Figure 1). Interestingly, the extended release of eprinomectin for LongRange, which occurs for ~75 days post-treatment, could be seen 10 weeks after treatment with a significantly lower horn fly population (115.75 ± 22.92 flies/side) than both the Corathon tag group (256.17 ± 23.41 flies/side) and the untreated control group (319.88 ± 23.24 flies/side; P<0.001; Figure 1). LongRange provided adequate control of horn flies for 10 weeks and the Corathon tag provided control up to 8 weeks post-treatment. Overall, the application of fly control strategies demonstrated a decrease in horn fly populations in comparison to untreated animals, with LongRange providing 2 additional weeks of control when compared to the Corathon tag. The two products used in this study represent different delivery systems with the application of LongRange also targeting internal parasites. The internal parasite burden was low during this study and no differences were detected in fecal egg counts in both May (P=0.44) and August (P=0.08; Table 1). However, when a pharmaceutical technology can address both internal and external parasites then the breakeven price of not utilizing a product such as LongRange could increase dramatically. Weight performance (average daily gain) from the stockers was different in groups with no fly control or no implant compared to those with both a fly control and implant combined (P=0.002; Table 2). Stockers given the combination of both LongRange and Revalor-G exhibited the greatest average daily gain (1.60 lb) which was greater than the average daily gain of stockers with no fly control and no implant (1.23 lb) (Table 1). The 0.37 lb increase in daily performance demonstrates that these two technologies (fly control and implants) have an additive effect on weight gains, and all combinations of either a fly tag or LongRange with an implant were significantly higher than not implementing either (P=0.002; Table 1).

Implications

The use of LongRange as a fly control technique adequately controlled horn flies up to 10 weeks and exhibited the highest weight performance in stockers when used in combination with Revalor-G.

Table 1. Internal parasite fecal egg count at initiation and end of grazing season

	Eggs per gram	
	May[a]	August
Control	0.67	1.59
LongRange	0.50	0.47
Corathon Fly Tag	1.17	1.72
P-value	0.44	0.08

[a]All cattle administered Safeguard late March 2016.

Table 2. Performance response to fly control treatments with different implant measures in crossbred stockers

	Weight performance, lb (± SE[1])			
Treatment[1]	Day 0 weight	Day 90 weight*	Weight gain*	Average daily gain*
No fly / No implant	584.72 (5.88)	695.03[c] (7.56)	110.31[d] (5.67)	1.23[d] (0.06)
No fly / Ralgro	587.19 (5.80)	704.81[bc] (7.46)	117.62[cd] (5.60)	1.31[cd] (0.06)
No fly / Revalor-G	580.49 (5.80)	708.16[abc] (7.46)	127.68[bc] (5.60)	1.42[bc] (0.06)
LongRange / No implant	595.24 (6.05)	721.18[ab] (7.78)	125.94[bcd] (5.84)	1.40[bcd] (0.06)
LongRange / Ralgro	583.18 (6.05)	717.76[ab] (7.78)	134.59[ab] (5.84)	1.50[ab] (0.06)
LongRange / Revalor-G	583.89 (5.88)	728.06[a] (7.56)	144.17[a] (5.67)	1.60[a] (0.06)
Fly tag / No implant	602.00 (6.55)	727.45[a] (8.43)	125.45[bcd] (6.32)	1.39[bcd] (0.07)
Fly tag / Ralgro	591.47 (6.44)	724.33[ab] (8.28)	132.87[abc] (6.22)	1.48[abc] (0.06)
Fly tag / Revalor-G	585.39 (6.67)	720.71[ab] (8.58)	135.32[ab] (6.43)	1.50[ab] (0.07)
P-value[2]	0.3009	0.0310	0.0023	0.0023

[1]SE=standard error.
[1]No Fly = no fly control; No Implant = no implant; Ralgro and Revalor-G (Merck Animal Health, Madison, NJ); LongRange (Merial Limited, Duluth, GA); Fly Tag = 1 Corathon Tag (Bayer Animal Health Division, Shawnee Mission, KS).
[2]Observed significance levels for weight performance for all treatments.
*Weight performance within the same column with different superscripts are significantly different $\alpha = 0.05$.

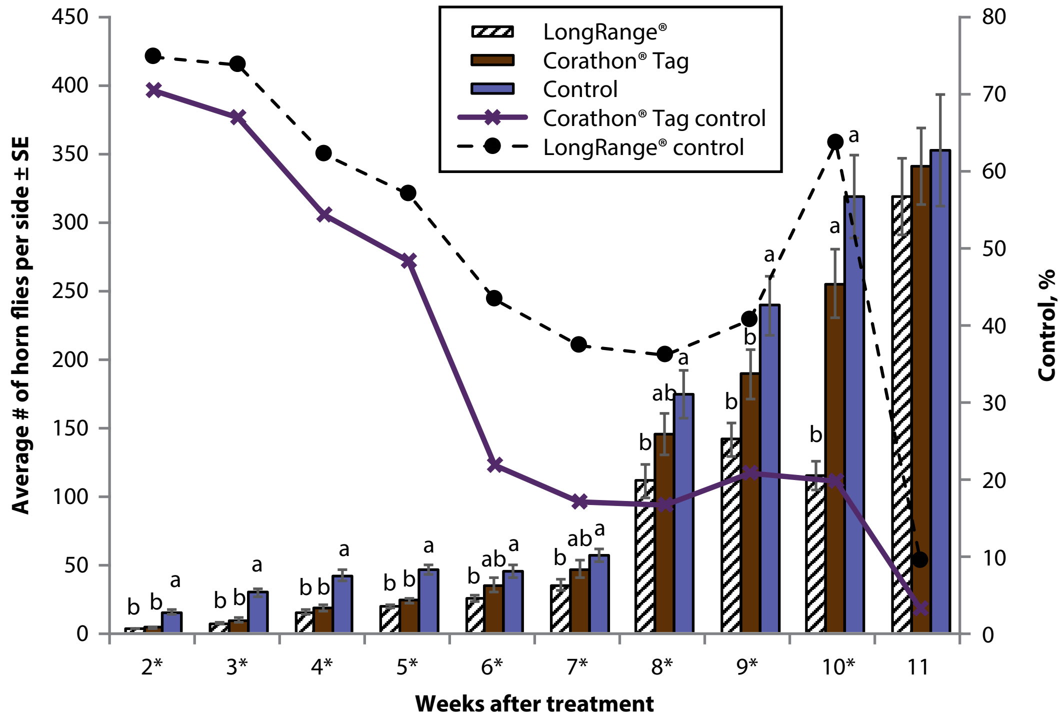

Figure 1. Horn flies per side (bars) and % control from LongRange or Corathon ear tag (lines). *Bars with different letters are significantly different $\alpha = 0.05$.

Zelnate on Arrival Could Decrease the Likelihood of Subsequent Pulls in Suspect Bovine Respiratory Disease Complex Cases

T.J. Spore, S.P. Montgomery, G.A. Hanzlicek, W.R. Hollenbeck, R.N. Wahl, J.E. Sears[1], and D.A. Blasi

Introduction

Antimicrobial metaphylaxis is an important tool used for the prevention of Bovine Respiratory Disease Complex; a disease with a large economic impact that typically affects newly-weaned beef calves that are marketed and transported a distance from their origin.

There are questions involving the potential benefit of Zelnate, a novel non-antibiotic technology designed to activate an animal's natural immunity to fight Bovine Respiratory Disease Complex, being used either solely or in combination with metaphylaxis at the time of initial processing of high risk calves. More knowledge is also needed regarding the possible effects of repeated use of Zelnate when subsequent therapy is required in individual Bovine Respiratory Disease Complex cases. The objective of this study was to evaluate the effectiveness of Zelnate when used as part of an antimicrobial metaphylaxis treatment or when used in combination with an antibiotic when a calf is diagnosed with Bovine Respiratory Disease Complex.

Key words: Zelnate, high risk, bovine respiratory disease

Experimental Procedures

During a four-day period (October 6-9, 2015) three semi-loads containing 283 head of high-risk cross-bred heifers (520 ± 39 lb) were purchased from sale barns in Tennessee and Alabama, assembled at a Dickson, Tennessee order buyer facility, and shipped to the Kansas State University Beef Stocker Unit. After initial processing the animals were placed in temporary pens with each truck representing six pens with free access to native grass hay and water through automatic waterers. The morning after arrival, calves were vaccinated for common clostridial and viral diseases (Pyramid 5 + Presponse, Vetmedica, St. Joseph, MO; Excede, Zoetis, Parsippany, NJ; Vison 7 with Somnus, Merck Animal Health, Madison, NJ); dewormed (Safeguard, Merck Animal Health, Madison, NJ); treated for flies (Permectrin CDS; Bayer, Shawnee Mission, KS); and implanted with a mild growth implant (Revalor IH, Merck Animal Health, Madison,

[1] Bayer Health Care, LLC, Animal Health.

NJ). One half of the calves also received 2 ml intramuscular of Zelnate (Bayer Healthcare, Animal Health Division, Shawnee Mission, KS) at this time. Calves were blocked by load and initially assigned to six pens based on arrival weight. To maintain similar weights between initial treatments (receiving Zelnate or not at arrival), after animals were sorted by weight, the heaviest animal in the pen was assigned group no Zelnate and the next heaviest group received Zelnate at initial processing. This procedure was replicated through each pen to standardize weights between arrival groups. A second population of treatments was generated based on rectal temperature as the animals were visually pulled for illness. Calves that had a rectal temperature of greater than or equal to 104°F at first pull received Baytril 100 (Bayer Healthcare, Animal Health Division, Shawnee Mission, KS) (Bovine Respiratory Disease, no Zelnate at pull) or Baytril 100 and Zelnate (Bovine Respiratory Disease, Zelnate at pull). Similarly, calves that did not have a rectal temperature of 104°F were either not treated at all (respiratory observed, no Zelnate) or administered only Zelnate (respiratory observed, Zelnate). The combination of treatment group on arrival and treatment at first pull for illness yielded eight possible treatments for cattle that were pulled and two for cattle that were never pulled. All animals enrolled in the study were fed an identical diet once daily at approximately 7:00 a.m. (Table 1). Feed bunks were checked once daily and adjustments made in delivery to ensure feed bunks were slick at the next feeding. All calves were checked at least once daily to assess animal health. Performance data were analyzed using standard T-test for mean comparison and ANOVA in StatPlus (Version 6; AnalystSoft Inc.). Health data were analyzed using proportion comparisons of morbidity in Stata 12 (StataCorp., 2011).

Results and Discussion

The results from the study are below in Tables 2, 3, 4, and 5. The administration of Zelnate upon arrival had no statistical effect on initial pull (P=0.92) or average daily gain (P=0.34). Although there were no statistical differences in morbidity 2 (second pull) between any of the treatments, calves that received Zelnate on arrival but not at first treatment for suspect cases of Bovine Respiratory Disease Complex (Zelnate at arrival, respiratory observed, no Zelnate at pull) appeared to be less likely to experience subsequent pulls compared to those animals receiving Zelnate only at treatment for Bovine Respiratory Disease Complex (no Zelnate at arrival, respiratory observed, Zelnate at pull) (P=0.06). Furthermore, average daily gain of calves that received Zelnate on arrival and not as a component of Bovine Respiratory Disease Complex therapy (Zelnate at arrival, no Zelnate at pull) appeared to be higher; however, the difference was not statistically significant (P=0.8).

Implications

These results suggest that Zelnate used only in combination with metaphylaxis on arrival and not as a component of Bovine Respiratory Disease Complex treatment could decrease the likelihood of additional pulls in suspect Bovine Respiratory Disease Complex cases. Additional research opportunities may exist in addressing the effectiveness of Zelnate used as pre-shipping treatment, particularly as calves are loaded on trucks at the order buyer/auction market facilities prior to transportation.

Table 1. Experimental diet fed

Experimental diet	% of dry matter
Ingredient	
Dry rolled corn	28.13
Control supplement	5.63
Steep	10.00
Alfalfa hay	17.50
Prairie hay	17.50
Corn germ meal	11.25
Distillers dried grains	10.00
Total	100.00
Calculated nutrient content	
Dry matter, %	81.8
Protein, %	16.92
Calcium, %	0.80
Phosphorus, %	0.52
Salt, %	0.28
Potassium, %	1.20
Magnesium, %	0.25
Fat, %	3.40
Acid detergent fiber, %	18.22
Net energy gain, Mcal/cwt	48.68

Table 2. Proportion of calves initially pulled for illness from each treatment

Arrival treatment	1st pull rate	P-value
No Zelnate	39%	0.92
Received Zelnate at initial processing	39%	

Table 3. Healthy cattle performance

Arrival treatment	Final average daily gain, lb	P-value
No Zelnate	3.23	0.34
Received Zelnate at initial processing	3.27	

Table 4. Proportion of calves pulled twice from each treatment combination

Bovine Respiratory Disease cases	2nd pull rate
No Zelnate at arrival / no Zelnate at first pull	35%
No Zelnate at arrival / Zelnate given at first pull	54%
Zelnate at arrival / no Zelnate at first pull	44%
Zelnate at arrival / Zelnate given at first pull	33%
Respiratory observed, no fever cases	2nd pull rate
No Zelnate at arrival / no Zelnate at first pull	44%[ab]
No Zelnate at arrival / Zelnate given at first pull	50%[a]
Zelnate at arrival / no Zelnate at first pull	11%[b]
Zelnate at arrival / Zelnate given at first pull	36%[ab]

[ab] Means in a column with uncommon superscripts differ.

Table 5. Morbid cattle performance

Arrival treatment/pull treatment	Final average daily gain, lb	P-value
No Zelnate at arrival / no Zelnate at first pull	2.73	0.80
No Zelnate at arrival / Zelnate given at first pull	2.46	
Zelnate at arrival / no Zelnate at first pull	2.86	
Zelnate at arrival / Zelnate given at first pull	2.71	

Route of *Mannheimia haemolytica* and *Pasteurella multocida* Vaccine Administration Does Not Affect Health or Performance of Receiving Heifers

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Introduction

Light weight stocker calves often experience health problems shortly after arrival to feeding facilities. Preventative health programs are routinely administered to calves upon arrival to reduce the incidence of Bovine Respiratory Disease. The major route of vaccine administration in cattle is via injection through either intramuscular or subcutaneous routes. Several products have been introduced that utilize the intranasal route of vaccine administration. There are several reasons why intranasal vaccine administration may be more beneficial: 1) Intranasal vaccine administration alleviates concerns that injections pose for Beef Quality Assurance programs. 2) Intranasal vaccine administration may be less stressful on the animal. 3) Intranasal vaccine administration delivers the vaccine to the site of infection in the case of respiratory pathogens, and may provide a different adaptive immune response to the vaccine.

The objective of this study was to determine the effects of route of administration of the *Mannheimia haemolytica* and *Pasteurella multocida* fractions of the vaccine regimen on receiving cattle growth performance, health, and mortality.

Key words: intranasal vaccine, health, stocker

Experimental Procedures

A total of 388 cross-bred heifers (497 ± 32 lb) were purchased from sale barns in MO and TN and received in 4 truckloads to the Kansas State University Beef Stocker Unit. Two truckloads were received on March 23, one truckload was received on March 30, and one truckload was received on April 2, 2016. Cattle were weighed immediately after coming off the truck, individually identified with an ear tag, and an ear notch sample was taken for testing of persistent infection with Bovine Viral Diarrhea Virus. Three animals tested positive and were excluded from the experiment. Other exclusion criteria

[1] Merck Animal Health, Summit, NJ.

included the presence of active disease, injury, or disparities in body weight relative to the other animals from the truckload.

The day following arrival, all cattle were weighed again and given their respective investigational vaccines and Vision 7 Somnus (Merck Animal Health, Madison, NJ), Ivomec Plus (Merial, Duluth, GA), Safe-Guard (Merck Animal Health, Madison, NJ) and Exede (Zoetis, Parsippany, NJ). This weight served as the initial weight for the experiment.

Truckload served as the blocking factor and cattle within a truckload were stratified by arrival weight and randomly assigned to pens of 11 to 13 head. Pens were then randomly assigned to one of 2 treatments with 16 pens per treatment. Treatments consisted of Vista Once SQ (Merck Animal Health, Madison, NJ) given subcutaneously at initial processing or Vista 5 SQ (Merck Animal Health, Madison, NJ) given subcutaneously plus Once PMH IN (Merck Animal Health, Madison, NJ) administered intranasally at initial processing.

Diets were provided in quantities to ensure *ad libitum* intake. Body weights were captured at initial processing, during revaccination (day 14), and at completion of the study, which was day 47 for blocks 1 and 2 and day 45 for blocks 3 and 4. All calves were observed daily for any signs of sickness or lameness. If any signs were observed, cattle were pulled from their pens and a rectal temperature was taken. If a temperature of 104°F or higher was found, antibiotics were administered according to the Kansas State University Beef Stocker Unit health protocol. Diagnosis of non-bovine respiratory diseases (lameness, pink eye, etc.) was treated according to the health protocol.

During the course of the trial, 1 animal from the Vista Once SQ group was found dead in the pen from bronchopneumonia. Additionally, 4 heifers were removed for mycoplasma infections or injury. Of these animals, 2 were in the Vista Once SQ group and 2 were in the Vista 5 SQ plus Once PMH IN group. These animals were excluded from the analysis. Data were analyzed as a randomized complete block design using the MIXED procedure of SAS (version 9.3; SAS Institute, Cary, NC). Pen was the experimental unit. In the model, treatment was a fixed effect and block was a random effect. Treatment differences were considered significant at P-value less than 0.05 and tendencies at P-value less than 0.10.

Results and Discussion

The effects of route of vaccine administration are shown in Table 1. Overall, the cattle performed well on feed between all treatments. There were no differences in body weight gain, average daily gain, feed intake, feed efficiency, morbidity, or mortality during the receiving trial. Morbidity and mortality were lower than anticipated in this class of cattle.

Implications

Route of vaccine administration in cattle experiencing a low disease challenge did not impact performance or health measurements.

Table 1. Performance and health of cattle vaccinated with VISTA Once SQ given subcutaneously or VISTA 5 SQ given subcutaneously together with ONCE PMH-IN administered intranasally

Item	Vista 5 SQ and Once PMH IN	Vista Once SQ	SEM[1]	P-value
Initial weight, lb	498	499	1.3	0.77
14-Day performance				
Body weight, lb	534	531	2.8	0.39
Dry matter intake, lb	10.8	11.0	0.13	0.36
Average daily gain, lb	2.53	2.32	0.196	0.29
Gain:feed	0.232	0.212	0.0181	0.25
45-Day performance				
Final weight, lb	593	593	3.9	0.96
Dry matter intake, lb	11.9	12.0	0.13	0.50
Average daily gain, lb	2.06	2.05	0.083	0.83
Gain:feed	0.174	0.171	0.0069	0.66
Health				
1st Pulls	4.1%	3.6%	0.17	0.73
2nd Pulls	0.01%	0.01%	0.008	0.55
Mortality	0%	0.005%	0.0064	1.00

[1]SEM=Standard error of the mean.

Intermittent Feeding of Tylan Reduces Use of In-Feed Antibiotics While Still Controlling Incidence of Liver Abscesses in Finishing Steers

H.C. Muller, R.G. Amachawadi, H.M. Scott, and J.S. Drouillard

Introduction

Liver abscesses are a cause of concern for many feedlots across the country as they lead to a decrease in feedlot performance of finishing cattle as well as a decrease in the final carcass value. Loss in carcass value is due to not only the abscessed liver being condemned, but also due to trim loss associated with the condemned liver. The macrolide drug tylosin phosphate is the drug of choice for metaphylactic treatment of liver abscesses in feedlot cattle. The Food and Drug Administration approved the drug for over-the-counter use, however, from January 2017 all medically important (used in human health) antibiotics that are to be fed in production animal diets will require a veterinary feed directive. The objective of the veterinary feed directive program is to decrease the use of medically important antibiotics in animal production. These veterinary feed directives are similar to a prescription and will encourage the use of the drug in accordance to FDA-guidelines associated with that drug. Macrolide antibiotics are considered medically important and will need a veterinary feed directive. Therefore, it is imperative to look at different methods to control liver abscesses in feedlot cattle. Various studies have noted that macrolide antibiotics (such as tylosin phosphate) are effective against pathogens for moderate to prolonged periods after initial use. The purpose of this study was to determine whether feeding tylosin phosphate periodically throughout the finishing period will have a comparable effect on decreasing liver abscesses as when we would feed tylosin phosphate continuously through the finishing period.

Key words: macrolide antibiotics, liver abscesses, feedlot cattle

Experimental Procedures

Three-hundred-twelve crossbred steers (908 ± 15 lb) were blocked according to their initial body weight in a randomized complete block design with 3 treatments and 8 replicates per treatment. These treatments included a negative control group where animals received a basal diet containing no tylosin phosphate throughout the trial period, a positive control group where animals were fed a basal diet containing tylosin phosphate throughout the trial period and a periodic group where animals were fed a basal diet containing tylosin phosphate for the transition period (first 21-day period) and then thereafter received tylosin phosphate for 1 week after a 2-week period without tylosin phosphate. This 1-week on, 2-week off pattern was repeated until the end of the feeding period. This feeding strategy also allowed for a 2-week withdrawal period of tylosin phosphate prior to the harvest date. Animals were randomly assigned to a treatment group within each block. Total mixed ration diets (Table 1) were fed once daily for a 119-day period. Steers were housed in one of 24 dirt-surfaced pens with each pen holding 13 animals. Twenty-four hours after arrival at the feedlot, steers were individually weighed, randomly assigned to pens, vaccinated with Ultrabac 7/Somnubac and Bovishield Gold 5 (Zoetis Animal Health, Florham Park, NJ), and received a pour-on treatment for parasites (Permectin CDS, Bayer, Leverkusen, Germany). At the start of the study, steers were implanted with Component TE-200 with Tylan (Elanco Animal Health, Indianapolis, IN). Pens were weighed after 119 days and average daily gain, dry matter intake and efficiency of gain were determined for each pen. After the 119-day feeding period steers were shipped approximately 280 miles to a commercial abattoir where liver abscess scores were assessed using the Elanco liver abscess scoring system. U.S. Department of Agriculture quality and yield grades, backfat thickness, ribeye area and marbling scores were obtained using camera images (VBG 2000, E+V Technology GmbH & Co. KG, Oranienburg, Germany) at the abattoir. Data were analyzed using the MIXED procedure of SAS version 9.2 (SAS Inst. Inc., Cary, NC) with treatment as a fixed effect, block as the random effect and pen as the experimental unit. The effect of the treatment on feedlot performance and carcass characteristics was evaluated using linear contrasts.

Results and Discussion

Feedlot performance and carcass performance are summarized in Tables 2 and 3, respectively. There were no differences ($P \geq 0.207$) observed in final body weight, average daily gain, dry matter intake or feed efficiency between the positive control, negative control and the periodic treatment group. Similarly, there were no differences ($P \geq 0.257$) between the groups with respect to hot carcass weight, dressed yield, ribeye area, backfat thickness, or quality and yield grades. However, there was a difference ($P = 0.022$) among treatments with respect to marbling scores when the positive control group was compared to the other 2 treatments. Percentage total liver abscesses ($P = 0.007$) was greater for the negative control group when compared to the positive control and periodic tylosin feeding groups (Figure 1). There was also a difference between the negative and positive control group for liver abscesses scored moderate ($P = 0.026$). However, there was no difference between the positive control group (continuous tylosin feeding) and the periodic feeding of tylosin for the total liver abscesses or any of the severity scores. This suggests that tylosin has a prolonged effect on liver abscess-causing pathogens after an initial dose, and therefore can be used for on-again off-again periods during the finishing phase and still reduce liver abscesses to the same extent as when feeding tylosin throughout the finishing period. By using this periodic feeding of tylosin we reduced the use of in-feed antibiotics by 60%.

Implications

Feeding tylosin phosphate during the transition period and then for a pattern of 1-week after a 2-week period without feeding tylosin, decreases the use of in-feed antibiotics by 60% while maintaining the same low incidence of liver abscesses as when tylosin is fed continuously throughout the finishing period.

Table 1. Diet composition

Item	No Tylan	Tylan
Steam-flaked corn	57.68	57.67
Corn gluten feed	30.00	30.00
Corn silage	10.00	10.00
Supplement[1]	2.32	2.33
Nutrient composition (dry matter basis), calculated[2]		
Crude protein, %	14.37	14.37
Net energy maintenance, Mcal/lb	0.97	0.97
Net energy gain, Mcal/lb	0.67	0.67
Neutral detergent fiber, %	18.65	18.65
Calcium, %	0.71	0.71
Phosphorus, %	0.49	0.49
Salt, %	0.25	0.25
Tylosin, g/ton	0.00	9.00

[1]Contains limestone, salt, urea, trace mineral/vitamin premix to provide (on a total diet dry matter basis) 0.15 ppm cobalt, 10 ppm copper, 0.50 ppm iodine, 20 ppm manganese, 0.10 ppm selenium, 30 ppm zinc, 1000 IU/lb vitamin A and 7 IU/lb vitamin E, 30 g/ton Rumensin and, in the case of the Tylan diet, 9 g/ton Tylan.
[2]Calculated based of Nutrient Requirements of Beef Cattle (7th Revised Edition, 2000) values.

Table 2. Effect of tylosin feeding strategy on feedlot performance

	Treatment				
Item	No Tylan	Tylan	Intermittent Tylan	SEM[1]	P-value
Initial body weight, lb	904.40	908.19	908.04	14.79	0.401
Final body weight, lb	1383.16	1397.62	1379.21	10.69	0.229
Average daily gain, lb	4.51	4.61	4.43	0.18	0.207
Dry matter intake, lb/day	23.99	24.69	23.92	1.15	0.278
Gain:feed	0.188	0.186	0.186	0.003	0.752
Feed:gain	5.32	5.38	5.38	0.003	0.752

[1]SEM=standard error of the mean.

Table 3. Effect of Tylosin feeding strategy on carcass characteristics

	Treatment				
Item	No Tylan	Tylan	Intermittent Tylan	SEM[1]	P-value
Hot carcass weight, lb	836.63	843.51	836.74	6.11	0.512
Dressed yield, %	60.48	60.30	60.67	0.21	0.257
Backfat thickness, in.	0.49	0.50	0.49	0.03	0.860
Ribeye area, $in.^2$	13.75	13.84	13.81	0.20	0.921
Marbling score[2]	455	429	458	12	0.022
USDA Prime, %	0.97	0	1.92	1.37	0.377
High choice, %	27.25	16.66	23.03	5.76	0.182
Low choice, %	47.73	56.76	53.72	6.91	0.413
Select, %	24.27	25.74	18.27	5.90	0.401
Sub-select[3], %	0	0	0.97	0.80	0.373
Overall USDA yield grade	2.56	2.60	2.54	0.11	0.847
Yield grade 1, %	4.85	1.97	3.85	2.86	0.595
Yield grade 2, %	39.81	40.59	43.27	6.92	0.870
Yield grade 3, %	49.52	52.46	48.08	7.36	0.831
Yield grade 4, %	5.83	4.95	4.81	3.12	0.939

[1]SEM=standard error of the mean.
[2]Marbling score determined by computer imaging system (VBG 2000, E+V Technology GmbH & Co. KG, Oranienburg, Germany). Small (400-499).
[3]Consists of carcasses grading standard and commercial carcasses.

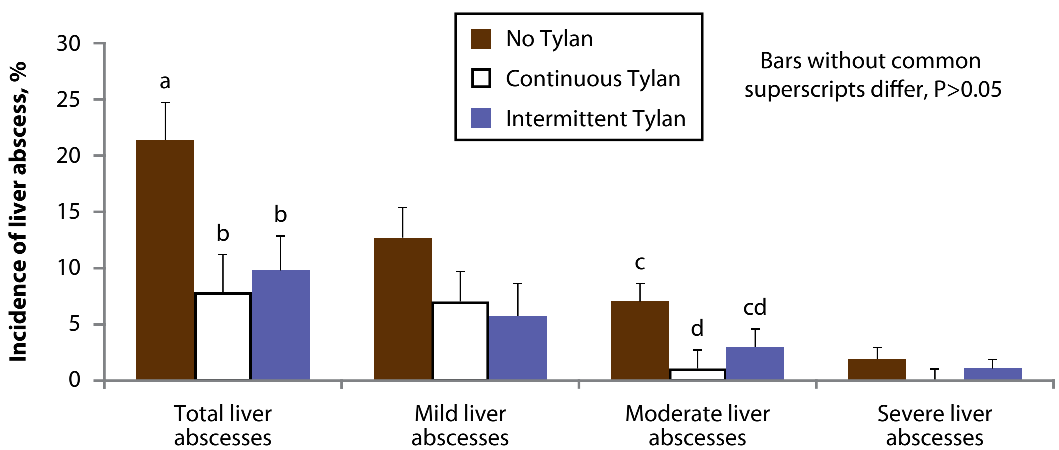

Figure 1. Tylan feeding strategy and incidence of liver abscesses.

Producer Opinions on Antibiotic Use in the Beef Industry

T.L. Lee, C.D. Reinhardt, E.F. Schwandt, and D.U. Thomson

Introduction

Antibiotic use in the beef industry is of increasing interest to consumers and has become a point of discussion for producers, veterinarians, and professional scientists in recent years. With the vast amount of information available on the internet and social media, consumers are becoming more knowledgeable about beef production practices and the use of antibiotics in the food animal industries. Furthermore, scientists have devoted a large amount of time and money to research to investigate consumer opinions and perspectives about management practices used in food animal production. However, many of these investigations fail to include the opinions and perspectives of the producers who raise these animals. Therefore, the objective of this survey was to explore producer practices and opinions on antibiotic use and antibiotic resistance in the beef industry.

Key words: antibiotics, beef cattle, antibiotic resistance

Experimental Procedures

Survey participants were recruited through popular public and private websites and magazines relating to beef cattle production. All producers with access to these resources were encouraged to participate, and provided a link to the survey. The survey was available from September 10 to October 15, 2015. All participants remained anonymous.

The survey consisted of 26 questions addressing demographics, producers' relationships with their veterinarians, antibiotic use on the producers' operations, and producer opinions on antibiotic use, antibiotic resistance, and consumer perceptions of antibiotic use in the beef industry. Data were collected using Kansas State University's web-based survey system, and downloaded into Microsoft Excel for summary and analysis.

Results and Discussion

Two hundred and sixty surveys were submitted from producers in 48 states, and 1 province in Canada (Table 1). Cow-calf production units were most commonly reported, followed by stocker, backgrounder, and finishing operations (Table 2). Producers were instructed to select all types of operations that apply to their production unit, therefore the sum of percentages shown is greater than 100% (Table 2).

Veterinary oversight is increasingly important, as federal and state regulations increase in the United States. Eighty-five percent of participants indicated that they use veterinary services regularly, for a number of reasons; however, only 23% stated that they have a written, documented, and signed veterinary-client-patient relationship with their veterinarian (Figure 1). This could indicate that a valid veterinary-client-patient relationship exists, but producers and veterinarians simply do not have written documentation of its existence. Such documentation will likely become common in the future, as increased federal and state regulation of feed-grade antibiotics will require written proof that the veterinary-client-patient relationship exists.

When asked about the frequency of use of antibiotics on their operations, producers indicated that injectable antibiotics are rarely utilized, and oral antibiotics are used once per month or never (Figure 2). The most frequent use of antibiotics on the farm, ranch, or feedyard are for treatment of Bovine Respiratory Disease, foot rot, and pinkeye. Most antibiotics used by the producers surveyed are bought directly from a veterinarian. Ninety-three percent of respondents reported that they always follow label directions when using antibiotics, and 95% reported that if they do not follow label directions, they consult a veterinarian before doing so. All but one producer indicated that withdrawal times are always followed when an antibiotic is administered to an animal; however, in a subsequent question, the same producer indicated that he/she thought it important that withdrawal times are always followed when antibiotics are used.

Ninety-one percent of survey participants indicated that Beef Quality Assurance is an important industry resource for guidance on antibiotic use and prevention of residues. The use of industry resources and guidelines on the use of antibiotics is increasingly important as more federal and state regulations are put into effect, including the implementation of the Veterinary Feed Directive. When asked about producer awareness of this new rule, 81% of participants indicated that they were familiar with the legislation. Producers were asked their opinions on the new rule, and 70 respondents expressed a negative attitude toward the law, 46 respondents indicated a positive attitude, and 56 were either indifferent or expressed mixed opinions.

Finally, survey questions asked about producers' opinions on antibiotic use and resistance in the beef industry, and their opinions on consumers' perceptions of antibiotic use in the industry. Producers were asked "Do you believe that resistance to antibiotics is an issue in the beef industry?" Sixty-six percent of respondents reported disagreement (answering 0 to 5 on a 0 to 10 scale), while 33% reported agreement (Figure 3). In a subsequent question, asking, "How much do you believe antibiotic use in the beef industry contributes to antibiotic resistance in the general (human and livestock) population?," 88% reported little or not at all, while 12% expressed the opposite opinion (Figure 4). Producers were also asked questions about consumer knowledge and perceptions of the beef industry, and 98% of producers reported that they did not think that consumers are knowledgeable about antibiotic use in the beef industry. Perceived consumer opinions varied, but generated mostly negative remarks.

Implications

This survey shows that beef producers are willing to share information about their production systems and management strategies, including their use of antibiotics. The survey provides valuable insight into the practices and opinions of producers in the beef industry. While survey data inherently have limitations, the information provided here adds to the body of knowledge about management practices and antibiotic use in the beef industry, and helps provide producers a voice in the scientific community.

Table 1. Location of survey participants by region in the United States and Canada to evaluate producer practices and opinions on antibiotic use and antibiotic resistance in the beef industry

Region	Number of respondents
Northeast (Maine, New Hampshire, Vermont, Delaware, Rhode Island, New York, Massachusetts)	1
Mid-Atlantic (Pennsylvania, New Jersey, Maryland, West Virginia, Virginia)	30
Southeast (Kentucky, Tennessee, North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana)	50
Great Lakes (Ohio, Michigan, Indiana, Illinois, Wisconsin, Minnesota)	28
Central (Missouri, Iowa, North Dakota, South Dakota, Nebraska, Kansas, Arkansas, Oklahoma)	96
Southwest (Texas, New Mexico, Arizona)	12
Mountain (Colorado, Wyoming, Montana, Idaho, Utah, Nevada)	18
Pacific West (California, Oregon, Washington)	11
Alaska and Canada	3
No response	11
Total surveys accessed	260

Table 2. Type of production operation reported by survey participants in the United States and Canada to evaluate producer practices and opinions on antibiotic use and antibiotic resistance in the beef industry

Operation type	Number of responses	% respondents[1]
Cow/calf operation	218	88%
Stocker operation	46	19%
Backgrounder/grower yard	35	14%
Finishing yard	51	21%

[1]Participants were instructed to select all operation types that applied to their production unit.

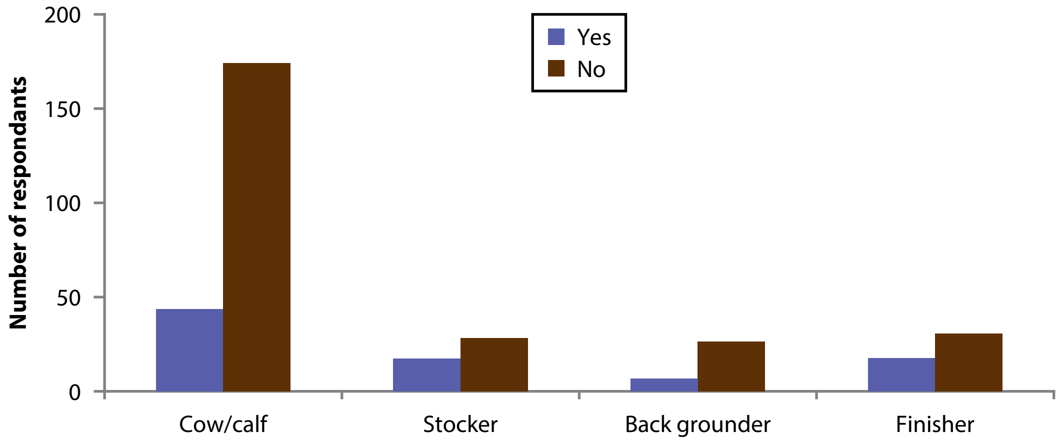

Figure 1. Documentation of valid veterinary-client-producer relationship by operation type for survey participants in the United States and Canada.

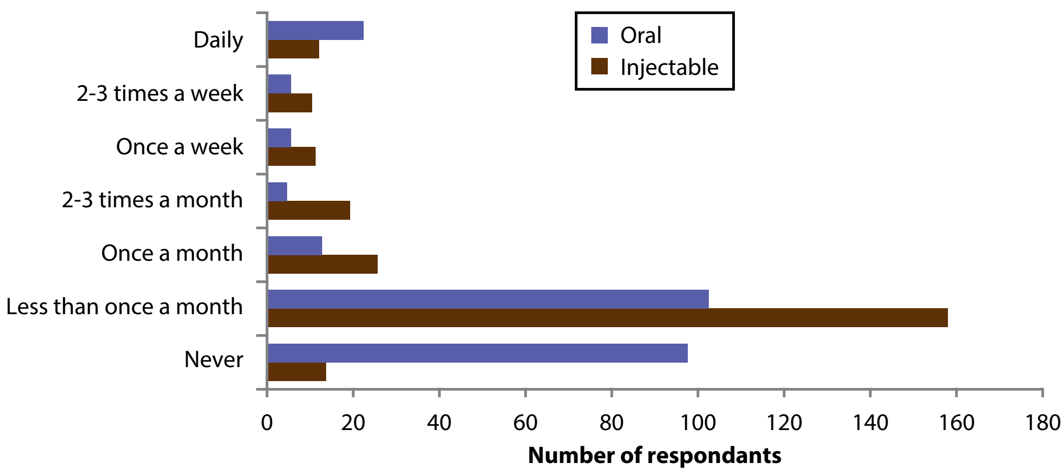

Figure 2. Frequency of use of oral and injectable antibiotics by survey participants in the United States and Canada.

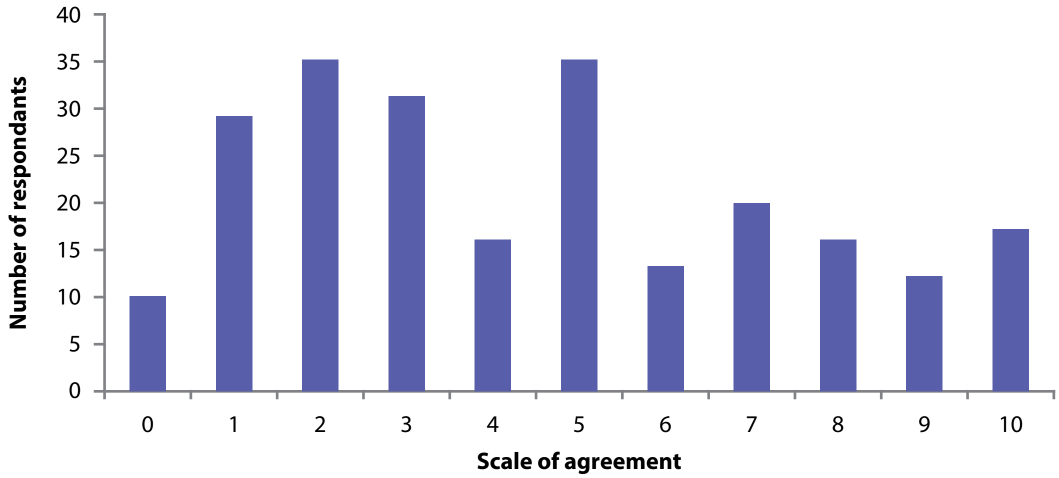

Figure 3. Results of the question, "On a scale of zero to ten, with zero being 'Strongly Disagree' and ten being 'Strongly Agree' do you believe that resistance to antibiotics is an issue in the beef industry?"

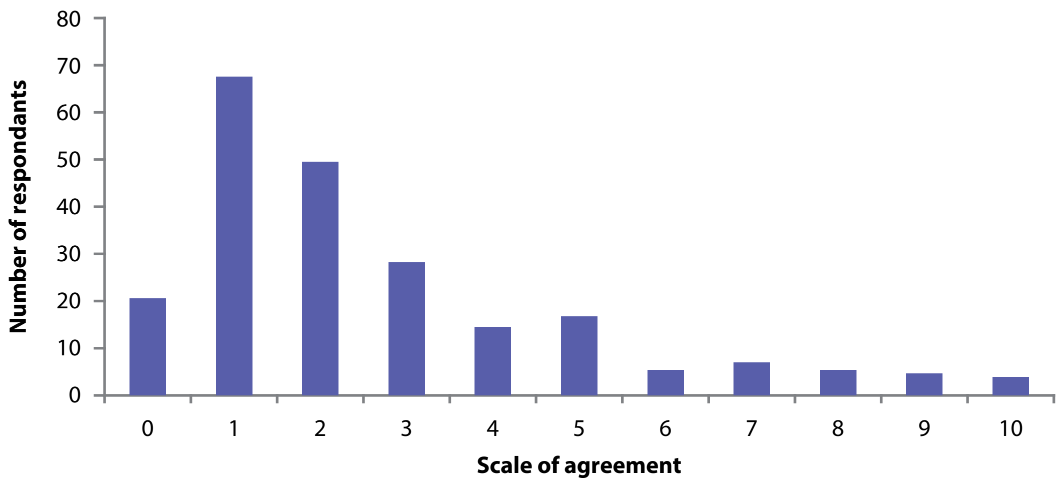

Figure 4. Results of the question "On a scale of zero to ten, with zero being 'Not At All' and ten being 'Contributes A Lot,' how much do you believe antibiotic use in the beef industry contributes to resistance in the general (human and livestock) population?"

Antioxidant Feeding Does Not Impact Incidence or Severity of Liver Abscesses

H.C. Muller, C.L. Van Bibber-Krueger, and J.S. Drouillard

Introduction

Liver abscesses are a large source of economic loss in feedlot cattle. Not only do liver abscesses lead to a decrease in feedlot performance, but these livers are condemned in the abattoir and can also lead to a further decrease in carcass value due to trim loss. Tylosin phosphate is a metaphylactic macrolide drug that effectively decreases the occurrence of liver abscesses. The drug is approved by the Food and Drug Administration for over-the-counter use. However, in January 2017 the FDA will require a veterinary feed directive for medically important antibiotics (antibiotics that are used in human health) used in production animal feed. Macrolides are one class of antibiotic that will require a veterinary feed directive. A drug that is accompanied by a veterinary feed directive will require it to be used within the regulations that the FDA has set for the specific drug. This new directive is to encourage the animal production industry to use less medically important antibiotics. It is therefore important to look at alternatives to control liver abscesses in feedlot cattle. Various studies have shown that α-tocopherol acetate increases the humoral response and that ascorbate increases mononuclear lymphocyte counts. These antioxidants are also known to maintain the integrity and structure of ruminal papillae, thereby inhibiting pathogenic bacteria that lead to the formation of liver abscesses from gaining access to the portal blood and then eventually the liver. The objective of this study was to evaluate the impact of antioxidants on feedlot performance, carcass characteristics, and incidence and severity of liver abscesses in finishing heifers.

Key words: antioxidant, liver abscesses, feedlot cattle

Experimental Procedures

A total of 392 crossbred heifers (1,060 ± 20.81 lb) were blocked by previous treatment in a randomized complete block design with 2 treatments and 14 replicates per treatment. Heifers were randomly assigned to one of 2 treatments. These treatments included a negative control group that contained 10 IU/lb α-tocopherol acetate, and a treatment group that contained 100 IU/lb vitamin E and 0.25 g/lb vitamin C. On the first day of the trial heifers were individually weighed and assigned to one of 28 dirt-surfaced pens with 14 animals per pen. They were vaccinated with Bovishield Gold 5 (Zoetis Animal Health, Florham Park, NJ) and Ultrabac 7 Somnubac (Zoetis), implanted with Component TE-200 with Tylan (Elanco Animal Health, Indianapolis, IN), and received Standguard (Elanco) as a pour-on treatment. Total mixed ration diets (Table

1) were provided and animals were fed once daily for 95 days. Animals were weighed after 95 days and average daily gain, dry matter intake, and efficiency of gain was determined for the feeding period. Animals were then shipped approximately 276 mi. to a commercial abattoir for harvest. At the abattoir, hot carcass weight, ribeye area, backfat thickness, U.S. Department of Agriculture quality and yield, and marbling scores were obtained using a camera images. Liver abscesses were scored using the Elanco liver abscess scoring system. Data were analyzed using the MIXED procedure of SAS version 9.2 (SAS Inst. Inc., Cary, NC) with treatment, previous treatment, and interaction as fixed effects. There was no interaction between the backgrounding treatment and the finishing treatment. Pen was the experimental unit and block as random effect. A significant effect was declared when P value < 0.05.

Results and Discussion

Feedlot performance and carcass performance are summarized in Tables 2 and 3, respectively. No differences were observed between the 2 treatments for final body weight or average daily gain. There was, however, a tendency (P=0.083) for a decrease in dry matter intake when the antioxidant group was compared to the control group and this translated into a tendency for an improvement in feed efficiency (P=0.074). The only differences that were observed between treatments with respect to carcass characteristics were that the control group had a greater percentage of carcasses that had a yield grade of 1 (P=0.016) and the antioxidant group had a greater percentage of carcasses that had a yield grade of 3 (P=0.024). There were no differences observed for incidence and severity of liver abscesses between the 2 groups (Figure 1).

Implications

Feeding antioxidants tend to improve the efficiency of gain, however, feeding antioxidants did not affect the incidence and severity of liver abscesses.

Table 1. Diet composition (dry matter basis)

Item	Percentage of dry matter
Steam-flaked corn	60.10
Wet corn gluten feed	30.00
Alfalfa hay	8.00
Supplement[1]	1.90
Nutrient composition (dry matter basis), calculated[2]	
Crude protein, %	14.12
Neutral detergent fiber, %	19.44
Calcium, %	0.70
Phosphorus, %	0.48
Potassium, %	0.70
Net energy for maintenance, Mcal/lb	0.97
Net energy for gain, Mcal/lb	0.67

[1]Formulated to provide the following added nutrient levels: 0.3% salt, 1.49% limestone, 0.05% potassium chloride, 2200 IU/kg vitamin A, 22 IU/kg α-tocopherol acetate, 0.15 mg/kg vobalt, 10 mg/kg copper, 20 mg/kg manganese, 30 mg/kg zinc, 0.10 mg/kg selenium, and 300 mg/d monensin. α-tocopherol acetate was added to the supplement to provide 220 IU/kg α-tocopherol acetate and crystalline ascorbic acid was added to the supplement at a rate of 550 mg/kg for the antioxidant treatment.
[2]Calculated based on Nutrient Requirements of Beef Cattle (7th Revised Edition, 2000) values.

Table 2. Feedlot performance of heifers fed different levels of antioxidants

	Treatment			
Item	Control	Antioxidant	SEM[1]	P-value
Initial body weight, lb	1060	1062	20.94	0.831
Final body weight, lb	1324	1327	16.98	0.663
Average daily gain, lb	2.82	2.89	0.17	0.702
Dry matter intake, lb/day	23.50	22.73	1.06	0.083
Gain:feed	0.120	0.126	0.003	0.074
Feed:gain	8.33	7.94	---	0.074

[1]SEM = standard error of the mean.

Table 3. Carcass performance of finishing steers fed different levels of antioxidants

	Treatment			
Item	Control	Antioxidant	SEM[1]	P-value
Hot carcass weight, lb	828.94	828.94	13.47	0.603
Dressed yield, %	62.82	62.91	0.300	0.643
Backfat thickness, in.	0.58	0.61	0.03	0.284
Ribeye area, in.^{2}	14.58	14.49	0.13	0.604
Marbling score[2]	508	506	11	0.831
USDA Prime, %	9.56	7.28	2.18	0.346
High Choice, %	31.61	35.04	4.78	0.474
Low Choice, %	35.70	38.96	5.59	0.559
Select, %	18.12	13.18	4.29	0.145
Sub-select[3], %	5.65	8.13	1.50	0.466
Overall USDA yield grade	2.48	2.56	0.06	0.306
Yield grade 1, %	12.26	3.37	3.06	0.016
Yield grade 2, %	38.83	42.20	3.89	0.538
Yield grade 3, %	36.79	47.40	4.90	0.024
Yield grade 4, %	10.61	6.40	2.29	0.074
Yield grade 5, %	0.89	0	0.43	0.162

[1]SEM = standard error of the mean.
[2]Marbling score determined by computer imaging system (VBG 2000, E+V Technology GmbH & Co. KG, Oranienburg, Germany). Modest (500-599).
[3]Consists of carcasses grading standard and commercial carcasses.

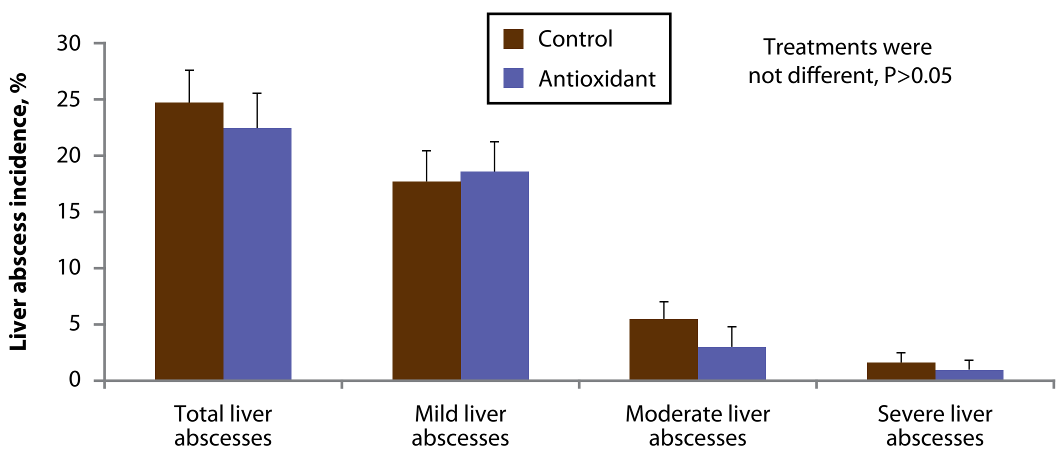

Figure 1. Effect of antioxidants on liver abscess incidence.

Decline in Brahman Breed Influence of Beef Calf Lots Marketed by Video Auction from 1995 to 2015

E.D. McCabe, M.E. King, K.E. Fike, K.L. Hill[1], G.M. Rogers[2], and K.G. Odde

Introduction

Brahman cattle are widely known for their ability to tolerate hot and humid climates as well as for their insect and parasite resistance. An estimated 40% of all beef cows in the United States are located in the southern region, which has a relatively hot climate. Historically, many of these beef cows have had at least some Brahman influence. The opportunity to evaluate potential changes in the influence of the Brahman breed on beef calves produced in the United States was available through lots of beef calves marketed through a video auction service. The objective was to characterize the potential change in the percentage of lots of beef calves with Brahman influence among calves originating from various regions of the United States marketed through summer video auctions from 1995 through 2015.

Key words: beef calves, Brahman influence, video auctions

Experimental Procedures

Information describing factors about lots sold through a livestock video auction service (Superior Livestock Auction, Fort Worth, TX) was obtained from the auction service in an electronic format. These data were collected for lots of beef calves offered for sale during summer sales from 1995 through 2015.

The breed of lots of beef calves were categorized as English, English crosses, English-Continental crosses, or Brahman influenced. The Cochran-Armitage trend test was used to determine the presence of an increasing or decreasing trend in the percentage of lots with Brahman influence over time with a $P \leq 0.05$ considered significant.

[1] Merck Animal Health, Kaysville, UT.

[2] Grassy Ridge Consulting, Aledo, TX.

To determine potential regional differences of Brahman influence percentage in lots of beef calves marketed, the United States was divided into seven regions:

1. West Coast (Alaska, California, Hawaii, Idaho, Nevada, Oregon, Utah, and Washington);
2. Rocky Mountain/North Central (Colorado, Iowa, Illinois, Indiana, Michigan, Minnesota, Montana, North Dakota, Nebraska, South Dakota, Wisconsin, and Wyoming);
3. South Central (Arizona, Kansas, Missouri, New Mexico, and Oklahoma);
4. Texas (Texas);
5. Coastal (Alabama, Florida, Georgia, Louisiana, Mississippi, and South Carolina);
6. Sub-Coastal (Arkansas, Kentucky, North Carolina, Tennessee, Virginia, and West Virginia); and
7. Northeast (Connecticut, Delaware, Massachusetts, Maryland, Maine, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, and Vermont).

The Northeast region was excluded from this study due to few lots representing this region.

Results and Discussion

The data analyzed were collected from 171 summer livestock video auctions from 1995 through 2015. There were 80,574 lots (9,685,247 total calves) used in the analyses. There was a decrease ($P<0.0001$) in percentage of lots with Brahman influence in the United States during the 21 years (Figure 1). Percentage of lots with Brahman influence decreased ($P<0.0001$) in four regions: West Coast (CA, ID, NV, OR, UT, and WA); Rocky Mountain/North Central (CO, IA, IL, IN, MI, MN, MT, ND, NE, SD, WI, and WY); South Central (AZ, KS, MO, NM, and OK); and Texas (TX).

There was no change ($P=0.30$; $P=0.07$, respectively) in percentage of lots with Brahman influence originating from the Coastal (AL, FL, GA, LA, MS, and SC) and Sub-Coastal (AR, KY, NC, TN, VA, and WV) regions (Figure 2). We expect the relative stability in percentage of lots with Brahman influence in the Coastal and Sub-Coastal regions is likely due to producers' continued value of the breed for its adaptability to the warmer climates of these regions.

Across the 21 years of this study, between 14 and 29% of lots of beef calves marketed in summer sales through this video auction service had Brahman influence. Specifically in the Coastal region, between 89 and 98% of all lots of beef calves marketed from 1995 to 2015 had Brahman influence.

Of the 80,574 lots marketed via summer video auctions from 1995 through 2015, 68,870 lots sold. Of the sold lots, Brahman influenced lots had average price discounts of \$4.28/cwt and \$3.09/cwt when compared with English crosses and English-Continental crosses lots, respectively. During the 21 years, the smallest discount for Brahman influenced lots compared with English crosses lots was in 1996 at \$1.93/cwt and when compared with English-Continental crosses lots, in 1997 at \$1.45/cwt. The greatest price discount for BR lots was in 2014 at \$7.01/cwt and \$5.11/cwt compared with English crosses and English-Continental crosses lots, respectively.

Implications

The percentage of lots of beef calves with Brahman influence marketed via summer video auctions appears to be decreasing in the United States. However, it has remained unchanged in the Coastal and Sub-Coastal regions where Brahman influenced calves are adapted to the warmer, more humid climates. The decision to utilize the Brahman breed is a decision made by producers, likely evaluates trade-offs of cattle performance and value to best fit their operation.

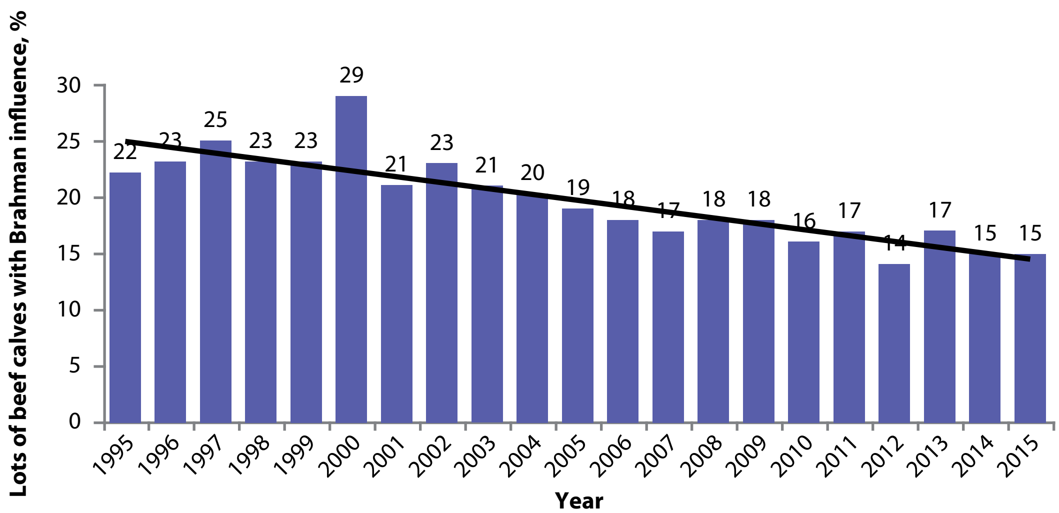

Figure 1. Percentage of lots of beef calves with Brahman influence decreased in the United States from 1995 through 2015 (P<0.0001).

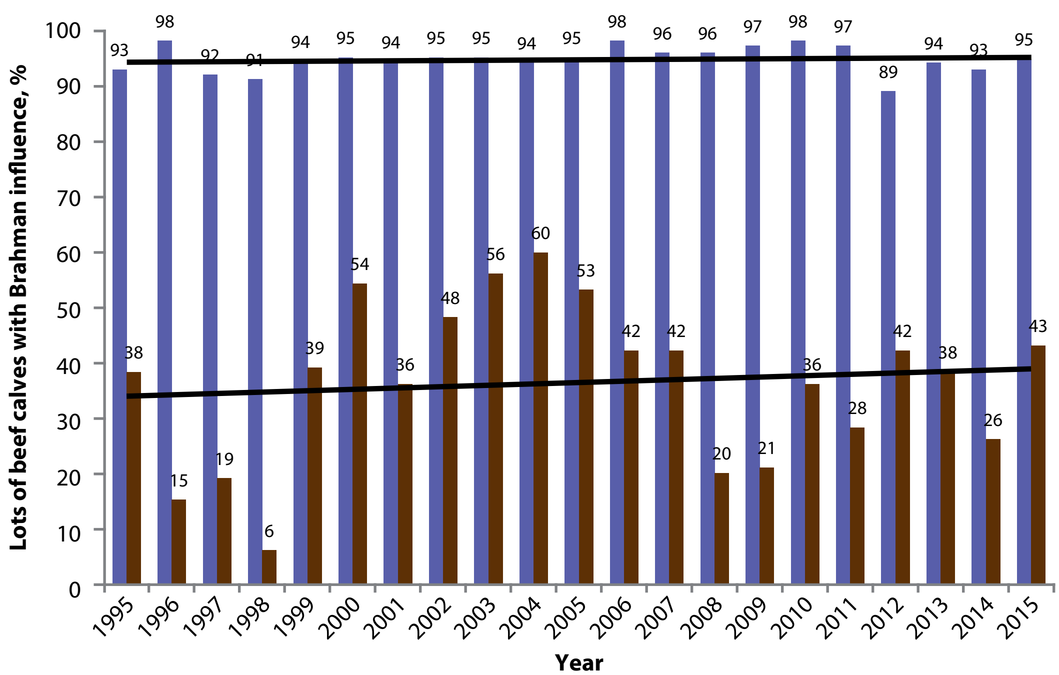

Figure 2. Percentage of lots of beef calves with Brahman influence from 1995 through 2015. The percentage of lots of beef calves with Brahman influence from the Coastal region did not significantly change (▪) (P=0.30). The percentage of lots of beef calves with Brahman influence from the Sub-coastal region did not significantly change (▪) (P=0.07).

Survey of Cattle Feedlot Facilities in the High Plains Region of the United States

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Introduction

Defining the appropriate dimensions and type of feeding facilities for feedlot cattle fed in outdoor pens is important because the characteristics of these facilities have a significant impact on the performance, welfare, and health of cattle housed in those facilities, as well as a considerable impact on the final cost of the project. Although multiple sources can be found in the literature that provide recommendations with regard to design of facilities to be used in outdoor feeding facilities for feedlot cattle, there are no published data that describe the dimensions and type of feeding facilities currently used by the feedlot industry in outdoor feeding operations. Thus, the objective of this survey was to obtain descriptive data regarding outdoor cattle feeding facilities currently used by feedlots in the High Plains region of the United States.

Key words: feedlot, facilities, survey

Experimental Procedures

Feedlots were randomly selected from an existing database provided by Zinpro Corporation that contained contact information for 358 feedlots located in 6 states in the High Plains (Texas, Kansas, Nebraska, Oklahoma, New Mexico, and Colorado), with a minimum one-time capacity of 5,000 cattle. An equal proportion of feedlots from each state was randomly selected from the database, and a final list of 247 feedlots was used to send an individual electronic invitation to participate in the study. The survey was conducted during summer of 2015 with a total of 43 respondents completing this survey. The survey was divided into 4 categories: general information, shipping and receiving area, cattle feeding pens, and hospital area.

Results and Discussion

Sixty percent of the participating feedlots were finishing feedlots, whereas 40% were a combination of growing/backgrounding and finishing operations. Out of the 43 feedlots completing the survey (Table 1), 84% of feedlots provided their geographical location of which 31% of feedlots were located in Nebraska, 22% in Kansas, 22% in Texas, 14% in Colorado, 8% in Oklahoma, and 3% in Wyoming. The largest percentage of feedlots surveyed were more than 20 years old (88%), 9% were 10 to 20 years old, and

[1] Zinpro Corporation, Eden Prairie, MN, 55344.

2% were 5 to 10 years old. The age of the most recent addition to the feedlot was fewer than 5 years old for 33% of feedlots, 5 to 10 years old for 33% of feedlots, and greater than 10 years old for 33% of feedlots. Only 2% of feedlots reported to not have any additions within the designated time frames. The feedlot footprint of 26% of feedlots occupied fewer than 100 ac, 47% of feedlots occupied 100 to 500 ac, and 28% of feedlots occupied more than 500 ac for their facilities. The closest packing plant was within 50 mi for 54% of these feedlots, 51 to 150 mi for 41% of feedlots, and 151 to 300 mi for 5% of feedlots. An emergency power source was located on site for 84% of feedlots, while 16% of feedlots did not report having an emergency power source.

Fifty-three percent of feedlots reported having designated alleys for shipping cattle at their facilities; whereas, 47% of feedlots did not have designated shipping alleys. Of the feedlots that utilize shipping alleys, 48% of feedlots had unsurfaced alleys, while 43% of feedlots had a concrete surface in their shipping alley. Forty percent of feedlots only had 1 loading/unloading chute, 47% of feedlots had 2 to 3 loading/unloading chutes, 12% of feedlots had 4 to 5 loading/unloading chutes, and 2% of feedlots reported having more than 5 loading/unloading chutes. Thirty-three percent of feedlots used their truck scale as a pen-scale for weighing cattle, while 67% did not use their truck scale as a pen-scale. Ninety-five percent of feedlots had dedicated pens for receiving cattle in their facilities. Out of 42 feedlots, 10% of feedlots allowed fewer than 50 ft^2/animal of pen space in receiving pens, 31% of feedlots allowed 50 to 100 ft^2/animal in receiving pens, 24% of feedlots allowed 101 to 150 ft^2/animal in receiving pens, 19% of feedlots allowed 151 to 200 ft^2/animal in receiving pens, and 17% of feedlots allowed more than 200 ft^2/animal of pen space in receiving pens. More than 50% of these feedlots allowed an average of 100.2 ft^2 per animal in receiving pens. The average number of cattle housed per pen in receiving pens was 116.4. Fewer than 50 cattle/pen were housed by 3% of feedlots in receiving pens, 15% of feedlots housed 50 to 75 cattle/pen, 33% of feedlots housed 76 to 100 cattle/pen, 13% of feedlots housed 101 to 125 cattle/pen, 18% of feedlots housed 126 to 150 cattle/pen, 8% of feedlots housed 151 to 175 cattle/pen, 3% of feedlots housed 176 to 200 cattle/pen, and 8% of feedlots housed more than 200 cattle/pen. Newly arrived cattle remained fewer than 7 days in receiving pens for 74% of participating feedlots, 7 to 14 days in receiving pens for 12% of feedlots, 15 to 21 days in receiving pens for 7% of feedlots, and more than 21 days in receiving pens for 7% of feedlots. Only 5% out of 43 participating feedlots used shades in receiving pens with 95% not using shades in receiving pens. Long-stem hay feeders were used by 42% of feedlots in their receiving pens, while 58% of feedlots did not use long-stem hay feeders in receiving pens. All feedlots had water tanks in their receiving pens and all but 2 feedlots utilized automatic filling water tanks. A majority of feedlots surveyed indicated concrete as the flooring in receiving facilities (72%) with others indicating unsurfaced floors (21%) or another type of flooring. Out of the 31 feedlots that reported to have concrete flooring in their receiving facilities, 48% of feedlots had a grooved surface on their concrete floors, 45% had a hatch/diamond surface, 3% feedlot had a smooth surface, and 3% of feedlot had other type of flooring.

Ninety-five percent of feedlots had 1 to 3 processing barns in their facilities. Most feedlots (88%) had individual animal scales in their processing facilities. A majority of feedlots (72%) had curved snakes in their processing facilities. With regard to the sides of the snake, 67% participating feedlots had V-slant sides on their snake, 19% of feedlots had adjustable sides on their snake, and 14% of feedlots had straight sides on their snake. Thirty percent feedlots brought fewer than 10 cattle to the tub or Bud Box at one time, 35% of feedlots brought 11 to 15 cattle, 30% of feedlots brought 16 to 20 cattle, and 5% of feedlots brought 21 to 25 cattle at one time to the crowding tub or Bud Box. Eighty-eight percent of feedlots mentioned concrete as the type of flooring in processing facilities, 9% of feedlots had a different type of flooring, and 2% of feedlots had unsurfaced floors in its processing facilities. Out of the 38 feedlots that had concrete floors in their processing facilities, 57% of feedlots had a grooved surface, 30% had a hatch/diamond surface, 11% had a smooth surface, and 3% had a different surface. Ninety-five percent of feedlots indicated they had sorting pens in their facilities; whereas, only 5% of feedlots did not have sorting pens. Out of the 39 feedlots with sorting pens in their facilities, 43% of feedlots had hydraulically operated sorting pens and 57% of feedlots had manually operated sorting pens. Twenty-six percent of feedlots had fewer than 3 dedicated sorting pens, 57% of feedlots had 3 to 6 dedicated sorting pens, 14% of feedlots had 7 to 10 dedicated sorting pens, and only 2% of feedlots had more than 10 dedicated sorting pens. Water tanks were reported to be present in sorting pens for 73% of feedlots; whereas, 27% did not have water tanks in their sorting pens.

Sixty-eight percent of surveyed feedlots allowed 151 ft^2 to more than 200 ft^2 per animal of pen space for high-health-risk cattle during the receiving period. Bunk space allowances in feedlots for high-health-risk cattle during the starting period varied, with 2% of feedlots allowing 6 to 8 in./animal, 56% of feedlots allowing 9 to 12 in./animal, 35% of feedlots allowing 13 to 17 in./animal, and 7% of feedlots allowing more than 18 in. of bunk space per animal. Five percent of feedlots had the top section of feed bunks fewer than 20 in. wide, 46% of feedlots had feed bunks 21 to 25 in. wide, 34% of feedlots had feed bunks 26 to 30 in. wide, and 15% of feedlots had feed bunks 31 to 35 in. wide. In regard to the cattle-side height of the feed bunk, 2% of feedlots had feed bunks fewer than 10 in. high, 45% of feedlots had feed bunks 10 to 15 in. high, 38% of feedlots had feed bunks 16 to 20 in. high, and 14% of feedlots had feed bunks more than 20 in. high. Thirty-nine percent of feedlots used flat bottom feed bunks, 39% used round bottom feed bunks, and 22% of feedlots had a combination of both in their finishing pens. All surveyed feedlots used concrete aprons by the feed bunk. Twenty-seven percent of surveyed feedlots had 6 to 10 ft wide concrete aprons; whereas, 56% of feedlots had wider aprons at 11 to 16 ft wide. Ground/well water was the primary water source for all of the 43 participating feedlots. Water supply was routinely tested for water quality parameters by 86% of participating feedlots while 14% of feedlots did not routinely test their water supply. Of the 37 feedlots that tested their water supply, 33% of feedlots tested once every year, 28% of feedlots tested twice every year, and 39% of feedlots tested more than twice every year. Forty-nine percent of feedlots had the water supply located in the pen, 44% of feedlots had the water supply located in the fence line, and 7% of feedlots had the water supply located in the bunk line.

Ninety-five percent of feedlots had concrete aprons by the water tank in finishing pens and 5% of feedlots did not have concrete aprons by the water tank in finishing pens. Out of the 39 feedlots that had concrete aprons by the water tank, 3% of feedlots had concrete aprons fewer than 5 ft wide, 36% of feedlots had concrete aprons 5 to 8 ft wide, 31% of feedlots had concrete aprons 9 to 12 ft wide, 11% of feedlots had concrete aprons 13 to 16 ft wide, 11% of feedlots had concrete aprons 17 to 20 ft wide, and 8%

of feedlots had concrete aprons wider than 20 ft by the water tank in their finishing pens. Continuous flow water tanks were used in finishing pens by 74% of participating feedlots, 12% of feedlots used heated water tanks in their finishing pens, and 14% of feedlots had a different type of water tank. Water tanks in finishing pens were cleaned or checked at a frequency of fewer than once every week by 7% of participating feedlots, at least once every week by 60% of feedlots, 2 times every week by 14% of feedlots, 3 to 4 times every week by 7% of feedlots, and on a daily basis by 12% of feedlots. Soil was used as the pen surface in finishing pens by 100% of feedlots. Fifty percent of feedlots used metal rods or posts for fencing, 39% of feedlots used cable for fencing, and 11% of feedlots used wood posts or rails for fencing in finishing pens. Seventy-one percent of feedlots utilized mounds in their finishing pens, from which 92% of feedlots had 1 to 2 mounds per finishing pen, 4% of feedlots had 2 to 3 mounds per finishing pen, and 4% of feedlots had 1 mound in small pens and 2 to 3 mounds in large pens. Also, 34% of feedlots had mounds that connected with the concrete apron by the feed bunk in finishing pens, and mounds in 66% of feedlots did not connect with the concrete apron by the feed bunk. Windbreaks were used by 43% of feedlots that responded to this survey. Out of the 7 feedlots that used shades in finishing pens, 50% of these feedlots provided a coverage of 10 to 25 ft^2 per animal of shade. Out of 41 respondents, 39% of feedlots used sprinklers in finishing pens for heat stress or dust control and 61% did not use sprinklers in finishing pens. Forty-one feedlot managers responded to questions regarding the width of feeding alleys, from which 5% of feedlots had feeding alleys fewer than 15 ft wide, 12% of feedlots had feeding alleys 15 to 20 ft wide, 22% of feedlots had feeding alleys 21 to 25 ft wide, 17% of feedlots had feeding alleys 26 to 30 ft wide, and 44% of feedlots had feeding alleys more than 30 ft wide. Out of 40 responding feedlots, 82% of feedlots had drover's alleys and 18% of feedlots did not have drover's alleys associated within finishing pens.

Approximately 2/3 of feedlots that participated in this survey provided a dedicated hospital facility. Twenty-nine percent feedlots reported that the hospital doctoring facility was the same as their processing facility and 5% of feedlots reported a different setup; one feedlot had both setups and the other feedlot doctored and returned cattle back to their home pen the same day. Nearly all of the feedlots surveyed had dedicated hospital pens for cattle to recover from injury or disease. Approximately half of the feedlots provided shades in their hospital pens. Out of 40 respondents, 13% of feedlots allowed fewer than 50 ft^2/animal of pen space in hospital pens, 23% of feedlots allowed 51 to 100 ft^2/animal, 38% of feedlots allowed 101 to 150 ft^2/animal, 15% of feedlots allowed 151 to 250 ft^2/animal, and 13% of feedlots allowed more than 250 ft^2/animal of pen space in hospital pens. All of the feedlots in our survey had water tanks in hospital pens, with the majority being automatically filled water tanks. Long-stem hay feeders were used in hospital pens by 46% of the feedlots surveyed.

Implications

Expanding, planning, or building cattle feeding facilities should take into account both published recommendations and practical experience to obtain the facility design that will better fit individual feedlot needs. This paper provides a thorough description of outdoor cattle feeding facilities in the High Plains region in the United States to serve as a benchmark for those looking to build a new facility or enhance an existing cattle feedlot.

Table 1. Descriptive data about cattle feedlot facilities of participating feedlots

Item	≤ 20,000 cattle	> 20,000 cattle	Number of responses	Percent of responses
One-time full capacity (cattle) of feedlot	20	23	43	100
Tub or Bud-Box in processing barn				
Tub	15	17	32	74%
Bud-Box	3	5	8	19%
Space allowance (ft^2/animal) in finishing pens				
50 to 100	1	3	4	10%
101 to 250	12	15	27	66%
> 250	6	4	10	24%
Bunk space (in./animal) in finishing pens				
6 to 9	6	10	16	38%
10 to 12	12	11	23	55%
Water space (in./animal) in finishing pens				
< 3	5	5	10	24%
3 to 6	5	6	11	27%
Don't know	10	9	19	46%
Use of shade in finishing pens				
Yes	4	3	7	17%
Greatest distance (yd; 1 mi=1,760 yd) from feeding pen to loadout				
< 440	3	0	3	7%
440 to 880	5	8	13	32%
880 to 1,320	8	4	12	29%
1,320 to 1,760	3	7	10	24%
> 1,760	0	3	3	7%

Differences in Efficacy Between Gamithromycin, Tilmicosin, and Tulathromycin as Metaphylactic Treatments in High Risk Calves for Bovine Respiratory Disease

T. Miller, M. E. Hubbert[1], E.F. Schwandt, D.U. Thomson, and C.D. Reinhardt

Introduction

The cost of Bovine Respiratory Disease to the beef industry due to death, poorer conversions, and therapy is estimated to cost more than $3 billion per year. Identifying and mitigating Bovine Respiratory Disease in cattle can be difficult due to the increased susceptibility for Bovine Respiratory Disease in high risk cattle. One management option to minimize an outbreak of respiratory disease is the use of metaphylaxis, the mass treatment of a group of calves to reduce the incidence and adverse effects of respiratory disease on high risk animals. Criteria used to determine the necessity of metaphylactic treatment against Bovine Respiratory Disease in feedlots can be based on several factors depending on feedlot preference; however, the primary criteria often considered are: a known history of no previous vaccinations, overall appearance of cattle, source of cattle, Bovine Respiratory Disease in calves received from same source previously, long shipping distance, season of the year, and light arrival weight.

The objective of this study was to compare the efficacy of treating newly received, high-risk feedlot calves with gamithromycin, tulathromycin, and tilmicosin as metaphylactic treatments on health and performance characteristics.

Key words: bovine respiratory disease, cattle, metaphylactic treatment

Experimental Procedures

Cross-bred heifer calves (n = 572; initial body weight 404 ± 27.4 lb) were used in a randomized complete block design to evaluate the effects of three different metaphylactic treatments for Bovine Respiratory Disease in high risk calves upon arrival at the feedlot. Cattle originated from the Southeastern United States and were shipped approximately 700 mi. to the research center. Cattle were delivered in five individual loads over a 17-day period and were identified as high-risk due to being light-weight calves

[1] New Mexico State University, Las Cruces, NM.

from a sale barn origin, co-mingled, and long truck haul (>8 hours on the truck). Each load (114 to 120 animals per load) was unloaded and heifers were weighed individually before being placed in an arrival pen. Cattle received free-choice long-stemmed hay, a minimal amount (<1.0 lb/head as fed) of starter ration, and *ad libitum* access to water for the first 24 to 48 hours.

After a 24 to 48 hour rest, heifers were individually weighed, vaccinated with Bovishield Gold 5, Inforce 3, and were given Dectomax (Zoetis Animal Health, Florham Park, NJ), Valbazen (Zoetis Animal Health, Florham Park, NJ), and Synovex C (Zoetis Animal Health, Florham Park, NJ). Horns (for heifers with horns) were tipped to approximately 1 in. diameter. Each animal received an individual identification ear tag and a tag identifying treatment assignment. Heifers were housed by treatment in soil-surfaced pens (40 × 115 ft, with 36 ft bunk line; 19 to 20 animals/pen) with approximately 22 in. of bunk space per animal. Water was supplied to each pen with a bunk line continuous flow water tank.

Within each arrival group, heifers in groups of three were randomly assigned to receive one of the three metaphylactic treatments during processing. Administrators of metaphylactic treatments were blinded to treatment. The selected antibiotic was injected subcutaneously in the neck per label dosage and site of administration recommendations. The treatments administered consisted of one of the three following antibiotics: 1) tulathromycin (1.13 mg/lb; 192 calves); 2) tilmicosin phosphate (5.99 mg/lb; 193 calves); or 3) gamithromycin (2.72 mg/lb; 194 calves). Cattle were randomized into 5 blocks with 3 treatment groups within each block and 10 replicates per treatment. Thirty pens were filled with approximately 19 to 20 heifers. Individual weights were recorded on day 0 and pen weights recorded at the end of the trial on days 56 to 60. Pen served as the experimental unit.

Heifers were initially fed a receiving diet composed of 20% dry-rolled corn, 57% wet corn gluten feed, 18% ground corn stalks, and 5% of a supplement containing decoquinate. Dietary energy concentrations were increased through day 28 using a 2-ration (starter diet and grower diet) transition system. The grower diet was composed of 30% ground corn, 52% wet corn gluten feed, 13% ground corn stalks, and 5% of a supplement containing lasalocid. Feed was delivered to the bunks twice daily by way of an auger mixer wagon. Throughout the feeding period, cattle were offered feed *ad libitum* with an attempt to minimize the amount of feed left over before the next feeding period.

Individual animal health was assessed daily throughout the study. Clinical monitoring of study heifers was performed at the same time each day by trained animal health personnel that were blinded to treatments. Any animal pulled with a combined score ≥ 3 and a rectal temperature ≥ 104°F was treated with ceftiofur crystalline free acid, according to label directions, with a 5-day post-treatment interval so that no retreatment was allowed until 5 days following the original treatment. Any animal removed from the pen for treatment with a combined score ≥ 3 and a rectal temperature < 104°F was treated with enrofloxacin, according to label directions, and a 3-day post-treatment moratorium. Any animal removed from the pen for treatment with a combined score < 3 was not treated and was returned to its home pen. Any animal removed from the pen for treatment a second time was treated with ceftiofur crystalline free acid as the second treatment; however, if the animal received ceftiofur crystalline free acid as its first treatment, then enrofloxacin was used as the second treatment. Sick animals were returned to their home pen following treatment. Animals were removed from the study if severe clinical morbidity prior to expiration of the assigned moratorium occurred.

Average daily gain, average daily feed intake, morbidity, and mortality measurements were evaluated on a pen means basis as a randomized complete block design and analyzed using the PROC MIXED procedure of SAS (SAS Institute, Inc., Cary, NC). Treatment was included in the model as a fixed effect; pen was the experimental unit for all measures. Average daily gain and feed efficiency were calculated on both deads in and deads out basis across treatment groups. Means were generated with the LSMEANS statement and separated using the PDIFF function when the F-statistic was significant ($P<0.05$). Morbidity, mortality, and retreatments were analyzed as percentage of the pen using a Wilcoxon Rank-Sum Test.

Results and Discussion

A total of 7 animals were removed from the study: two were removed due to lameness, three were removed due to animal welfare concerns based on severe clinical morbidity prior to expiration of the assigned moratorium, and two were removed due to suspected neurological symptoms.

Heifer performance results are presented in Table 1. There were no differences between treatments for dry matter intake or feed:gain ($P>0.05$) during the experimental period. Heifers administered tulathromycin had greater average daily gain compared to gamithromycin treated heifers. There were no differences in average daily gain between gamithromycin and tilmicosin treated heifers ($P>0.05$). There were no differences in average daily gain or dry matter intake between the tulathromycin and tilmicosin treated heifers.

Calves that received tulathromycin had reduced ($P<0.05$) morbidity rates compared to those that received tilmicosin and gamithromycin (Table 2). No differences were found in morbidity between tilmicosin-treated calves and gamithromycin-treated calves ($P>0.05$). Mortality rates were low across all treatment groups and there were no treatment differences ($P>0.05$) for mortality or second treatment rate. Calves treated with tulathromycin were 0.36 and 0.40 times as likely to get sick compared to tilmicosin-treated calves and gamithromycin-treated calves, respectively.

Implications

There are differences between antimicrobials with respect to effectiveness in suppressing bovine respiratory disease when used as a mass medication immediately upon arrival.

Table 1. Least squares means illustrating the effects of metaphylactic treatments on newly received, high-risk feedlot calves on animal performance

	Treatment[1]			
Item[2]	Tulathromycin[3]	Tilmicosin[3]	Gamithromycin[3]	SEM[4]
Initial weight, lb	403.5	402.7	405.1	3.295
Final weight, lb	553.0	544.3	540.1	8.283
Dry matter intake, lb	12.52	12.28	11.99	0.198
Average daily gain, lb				
Deads in	2.54[a,x]	2.36[a,b,y]	2.25[b,x,y]	0.105
Deads out	2.62[a]	2.48[a,b]	2.36[b]	0.089
Feed:gain				
Deads in	4.96	5.29	5.43	0.257
Deads out	4.82	5.01	5.10	0.165

[1]Tulathromycin (1.13 mg/lb); Tilmicosin (5.99 mg/lb); and Gamithromycin (2.72 mg/lb).
[2]Least squares treatment means.
[3]Means within a row without a common superscript of a,b,c are different ($P<0.05$) or a common superscript of x, y, or z have a tendency ($P<0.10$).
[4]Standard error of the least squares mean.

Table 2. Comparative health effects of metaphylactic treatments on newly received, high-risk feedlot calves on mortality, morbidity, and retreatments

	Treatment[1]					
Item	Tulathromycin	Tilmicosin	Gamithromycin	Risk ratio	95% confidence interval	P-value
Number of cattle	192	193	194			
Mortality	2 (1.0%)		3 (1.5%)	0.67	-3.34-2.34	0.72
	2 (1.0%)	3 (1.6%)		0.67	-3.36-2.31	0.71
		3 (1.6%)	3 (1.5%)	1.01	-2.81-2.86	0.99
Morbidity						
1st treatment	10 (5.2%)		25 (12.8%)	0.40	9.30-19.95	0.05
	10 (5.2%)	28 (14.6%)		0.36	-0.17-10.48	0.02
		28 (14.6%)	25 (12.8%)	1.13	7.47-18.11	0.62
2nd treatment	0 (0.0%)		3 (1.5%)	-	-3.79-0.79	0.19
	0 (0.0%)	5 (2.6%)		-	-4.85-0.27	0.03
		5 (2.6%)	3 (1.5%)	1.68	-1.23-3.35	0.35

[1] Tulathromycin (1.13 mg/lb), Tilmicosin (5.99 mg/lb), and Gamithromycin (2.72 mg/lb).

Prevalence of Horns in a Pen Does Not Affect Incidence of Carcass Bruising in Feedlot Cattle

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Introduction

Disbudding and dehorning are two common practices done to remove horns from cattle to prevent injury to handlers and other cattle and to reduce bruising of carcasses. Bruised carcasses result in substantial reduction in profit due to trim loss, increased sanitation risk, and loss in time on the rail during processing. Previous research has indicated that cattle with horns increased hide damage of cohorts and caused injury to handlers. Cattle with horns cause circular shaped bruises that lead to trim loss due to bruising. Cattle with tipped horns do not have a lower bruising rate than cattle with intact horns. The objective of this study was to evaluate the effect of horn prevalence within groups of slaughter animals and the incidence of bruising on the carcasses of those same cattle.

Key words: bruising, cattle, horns

Experimental Procedures

Carcasses from beef cattle (n = 4,287; 27 lots) originating from 13 different feedlots in Texas and Kansas were observed at a commercial abattoir in Southwest Kansas. The population included steers, heifers, and a combination of Holstein and beef breeds. Observations were made during 3 separate days and data collections took place during February, March, and December of 2014.

All cattle were evaluated for presence or absence of horns, and horns were measured for length and diameter, and carcasses were subsequently evaluated for presence and location of bruising after the hides had been completely removed. Measurements included the length of the longest horn from base to tip and the tip-to-tip distance between the tips of both horns. Prevalence of horns was determined by dividing the total number of horned cattle within each lot by the total number of all cattle in the same lot. Bruise location and severity were scored on each carcass (Figure 1). If a carcass had multiple bruises in multiple regions, each individual bruise location and severity was recorded. If multiple bruises were found in one region, only the most severe bruise was recorded.

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For bruises that occurred along the dividing line of 2 regions, the region that contained the majority of the bruise, subjectively determined, was recorded. Prevalence of bruising within a lot was determined by dividing the number of cattle in a lot with bruises by the total number of cattle in the lot. Lot number, horns (yes or no), and harvest date data were evaluated as categorical responses using the GLIMMIX procedure of SAS (SAS Institute, Inc., Cary, NC) and a binomial distribution was assumed. The Link = Logit option of the model statement and the ILINK option of the LSMEANS statement were used to calculate the likelihood ± SEM. A simple linear regression using the PROC REG procedure of SAS was used to evaluate the prevalence of bruises vs. the prevalence of horns. Lot was the experimental unit and significance was determined at $P \leq 0.05$.

Results and Discussion

Out of 4,287 cattle, 7.7% of the animals had horns (Table 1). The average lot prevalence of cattle with horns was 6% across all 27 lots of cattle and ranged from 0 to 26.5%. The average length of the longest horn was 4.4 in. with a range of 1.2 to 11 in. and the average distance from tip-to-tip was 15.6 in. with a range of 5.5 to 25.6 in.

Bruising prevalence of carcasses was 55.2% with a range of 0 to 98% (Table 1). The distribution of bruises over the carcasses showed the dorsal midline was the most frequently bruised portion with 61.8% of all bruises occurring in Regions 2, 5, and 8 (Figure 1). Region 5 was the most frequently bruised region, accounting for 33.6% of bruises recorded (Figure 2). The remaining bruises were distributed throughout the left side (Regions 3, 6, and 9) and right side (Regions 1, 4, and 7) of the carcasses (19.5 and 18.6%, respectively). Severity of bruises were classified as minor (38.8%), moderate (35.6%), and severe (25.6%) and the distribution of severity by location on the carcass indicated that the most severe bruises were in region 9 (Figure 2). Results from these data indicate a poor relationship (adjusted $R^2 = 0.09$; Figure 3) between prevalence of bruising and prevalence of horns within a lot. However, bruising prevalence and horn prevalence were significantly influenced by feedyard origin ($P<0.05$; Figure 4) suggesting that bruising could be occurring due to other factors such as, facility design, cattle handling, and trailer type.

Implications

Contrary to most published data reporting an increased prevalence of bruising in groups of horned cattle, the current study did not find a relationship between the prevalence of horned cattle within a lot and subsequent prevalence of carcass bruising within those same lots. Most importantly, the authors would like to reemphasize the most prevalent location of bruises within these data being along the top of the animals' backs indicating other likely sources of bruising. Further research to evaluate animal handling facility design, cattle trailer design, and animal handling practices that may contribute to bruising is needed.

Table 1. Descriptive statistics of bruised and horned carcasses by lot (n = 27) for 4,287 beef cattle harvested at a single packing plant in Southwest Kansas

Item	Average	Minimum	Maximum	Standard deviation
Horned carcasses, %[1]	7.7	0	26.5	7.4
Bruised carcasses, %[2]	55.2	0	98.0	23.2

[1] Percentage of cattle with horns per lot.
[2] Percentage of bruised carcasses per lot.

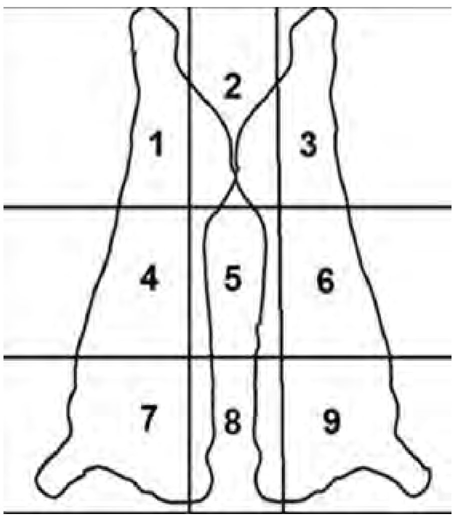

Figure 1. The Harvest Audit Program carcass diagram used to determine location of bruises for 4,287 beef cattle harvested at a single packing plant in southwest Kansas. 1 = right hind limb, 4 = right barrel, 7 = right forelimb. On the midline of the carcass, 2 = midline tailhead, 5 = midline thoracic cavity, 8 = midline shoulder and top of neck, and on the left side of the carcass, 3 = left hind limb, 6 = left barrel, and 9 = left forelimb.

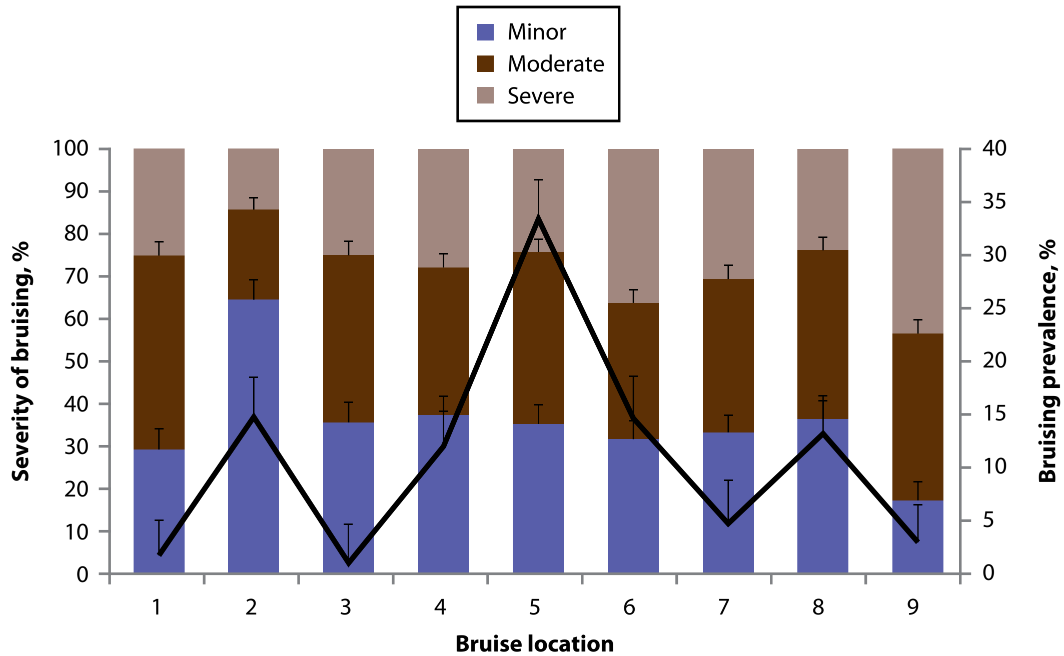

Figure 2. Severity of bruises by region of the carcass for 4,287 beef cattle harvested at a single packing plant in southwest Kansas. The percentage of the most severe bruises by location follow Harvest Audit Program definitions. Severity of bruises by bruise location were defined as: Minor bruises were ≤ 2.0 in.; Moderate bruises were 2.0 to 5.98 in.; Severe bruises were ≥ 5.98 in.

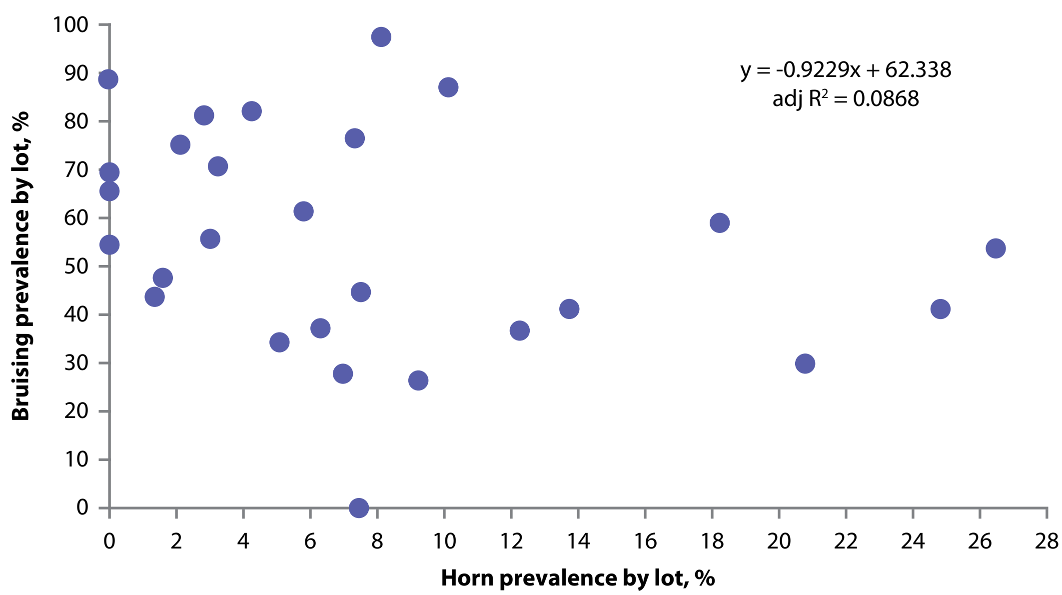

Figure 3. Simple linear regression model comparing the relationship between the prevalence of bruising and prevalence of horns for 4,287 beef cattle harvested at a single packing plant in southwest Kansas. (Standard error of the least squares mean = 12.033.)

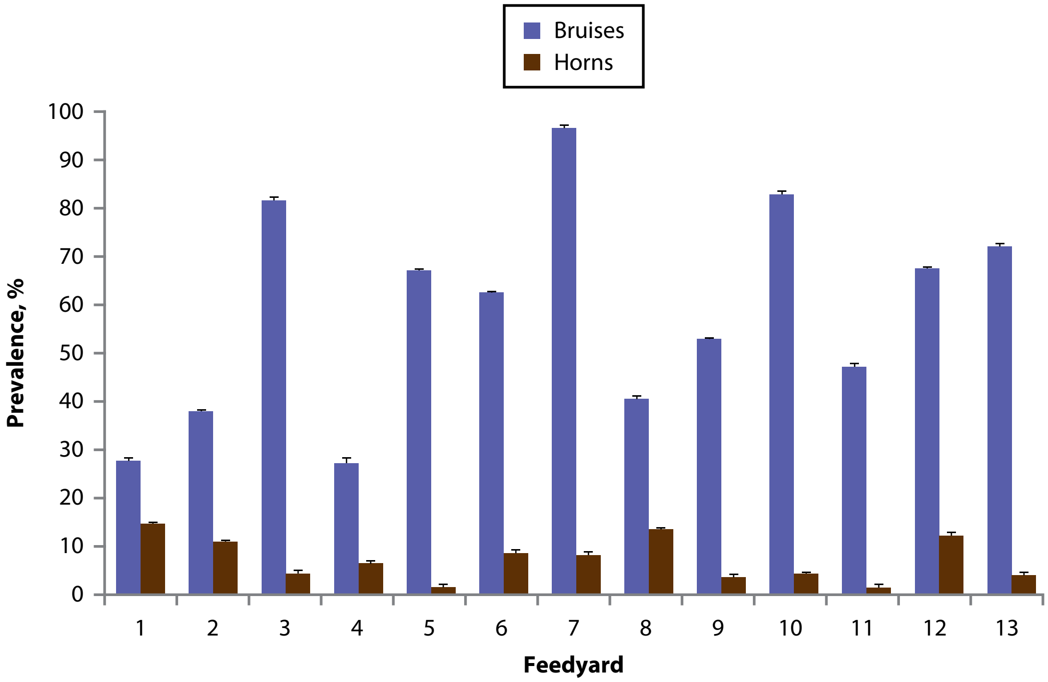

Figure 4. Prevalence of bruises and horns by feedyard for 4,287 beef cattle harvested at a single packing plant in southwest Kansas. (Standard error of the least squares mean = 0.609; P<0.05.)

Twenty-four Hour Holter Monitoring in Finishing Cattle Housed Outdoors

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Introduction

Ambulatory electrocardiogram monitoring, in the form of Holter monitoring, has been used in human and veterinary medicine for decades as an aid in the diagnosis and determination of appropriate therapy of heart rhythm disturbances. Within veterinary medicine, Holter monitors have been primarily used in companion animal species, yet little attention has been given to food animal species. Moreover, the heart rhythm in clinically normal cattle fed high concentrate diets and housed outdoors in confined dry-lot facilities has not been previously reported. In order to properly identify pathologic arrhythmias in cattle, the normal rhythm and arrhythmia prevalence in healthy cattle should be defined. Most prior reports of arrhythmia in cattle have been recordings of relatively shorter duration and in animals that were hospitalized or being handled for various reasons. Therefore, the objective of this study was to determine normal Holter monitor registrations including heart rate, rhythm, number of ventricular premature complexes, and atrial premature complexes in unrestrained finishing Angus steers.

Key words: cattle, electrocardiogram, Holter

Experimental Procedures

Twenty-seven (1,116 ± 12.1 lb) 15- to 17-month-old Angus steers were evaluated by clinical examination, complete blood count, and serum biochemical analysis. Cattle were determined to be disease-free based on normal physical examinations and blood count and serum chemistries. In addition, tissue histopathology was determined to be normal following euthanasia (27 days after Holter recordings). A lightweight Holter monitor was used in an outdoor environment. The steers were received from a commercial feeding facility in southwest Kansas. Steers were selected from a larger group based on weight uniformity and condition. Steers were adapted to a standard commercial finishing diet prior to shipment. Upon arrival, steers were weighed, identification recorded, placed in a pen with *ad libitum* access to grass hay/fresh water. Steers were reacclimated to the finish diet over 10 days. After 10 days, steers were placed into six dirt floor pens with feed bunks containing an individual animal feeding system. Steers were stratified by weight and randomly assigned to one of six pens. Pens were divided into two blocks of three pens. Study day was separated by 5 calendar days between the

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two blocks. Pens were approximately 59 × 11.8 ft and each contained five gated feed bunks and was equipped with water tanks. Approximately, 26.9 ft^2 of shade was provided per animal. Steers were individually fed twice daily. Blood samples for serum chemistry and complete blood count were collected on all study animals on days 11 and 16 for blocks 1 and 2, respectively. All samples were processed within 3 hours of sampling. Serum was submitted to the Kansas State University Veterinary Diagnostic Laboratory for analysis of serum chemistry panel. Complete blood counts were analyzed using a hematology analyzer. Sample frequency was 180 samples per second. Each registration had recorded three leads. Silver/silver chloride electrodes were applied to five vertically aligned locations just caudal to the forelimbs. The software identified individual heart beats as normal, abnormal, or artifact. Portions of the recording marked as artifact were excluded from the analysis. After evaluation, software output results were compiled into hourly intervals.

All data were analyzed using a generalized linear mixed model method accounting for repeated measures with steer as the repeated effect. The random effects included were block and pen. Degrees of freedom were calculated using the Kenward-Rogers method. The final model was inspected using QeQ plots and residual plots vs. predicted values.

Results and Discussion

Serum biochemistry analysis and complete blood count were within normal reference limits on all steers enrolled in the study. All steers accepted the Holter monitor and harness after a short adjustment period. The heart rate was calculated every hour with the mean heart rate of 66.8 to 16.4 beats per minute. Heart rates ranged from 20 to 102 beats per minute with a median and mode of 68 beats per minute. Mean heart rate throughout the day showed an increasing heart rate from 6:00 a.m. and peaking at 8:00 a.m., which was associated with feeding time. Heart rate decreased following feeding and remained somewhat stable until decreasing into the mid to low 60 beats per minute range after 8:00 p.m. This is similar to the pattern that has been previously reported in cattle, dogs, cats, horses, and humans.

Atrial premature complexes occurred in 23 out of 27 (85.2%) cattle, of which 100% of all events were singlets. Atrial premature complex occurrence ranged from 0 to 5 complexes per animal per hour. Median and mode were 0 atrial premature complex/hour. Ventricular premature complexes occurred in four (14.8%) steers. Rate of ventricular premature complex occurrence ranged from 0 to 3 complexes per animal per day. Median and mode were 0 ventricular premature complex/day. A total of 14 ventricular premature complexes were recorded during this study, of which nine occurred in a single steer. In addition to atrial premature complexes and ventricular premature complexes, simple second degree atrioventricular block was noted in 5 out of 27 (18.5%) cattle in this study (Figure 4). All second degree atrioventricular blocks were suggestive of hypervagotonia.

Implications

Based on the data from this study, atrial premature complexes are common, ventricular premature complexes are uncommon, and simple second degree atrioventricular block is a variable arrhythmia noted in clinically normal cattle. In addition, instances of simple second degree atrioventricular block noted in the steers in this study were likely secondary to hypervagotonia. Cattle heart rhythms follow patterns similar to other species with slower rates during the evening and night hours, with higher rates in the morning and declining into the afternoon.

Table 1. Summary of laboratory data in normal steers

Analyte	Average	Range
Albumin, g/dL	3.6	2.9 - 3.9
Bicarbonate, mEq/L	25	17 - 28
Calcium, mg/dL	10.0	9.5 - 10.6
Chlorine, mEq/L	97	94 - 100
Creatinine, mg/dL	1.1	0.8 - 1.3
Globulin, g/dL	3.7	3.1 - 5.4
Glucose, mg/dL	43	17 - 66
Hematocrit, %	40.3	33.6 - 47.3
Lactate, mg/dL	4.3	1.8 - 9.6
Phosphorus, mg/dL	7.9	6.0 - 9.9
Potassium, mEq/L	5.7	4.7 - 7.7
Sodium, mEq/L	142	138 - 145
White blood count, K/uL	10.75	6.14 - 15.07
Neutrophils	3.17	0.48 - 6.16
Lymphocytes	5.38	2.62 - 9.86
Monocytes	1.65	0.78 - 3.42

Figure 1. Picture of Holter monitor apparatus applied to steer.

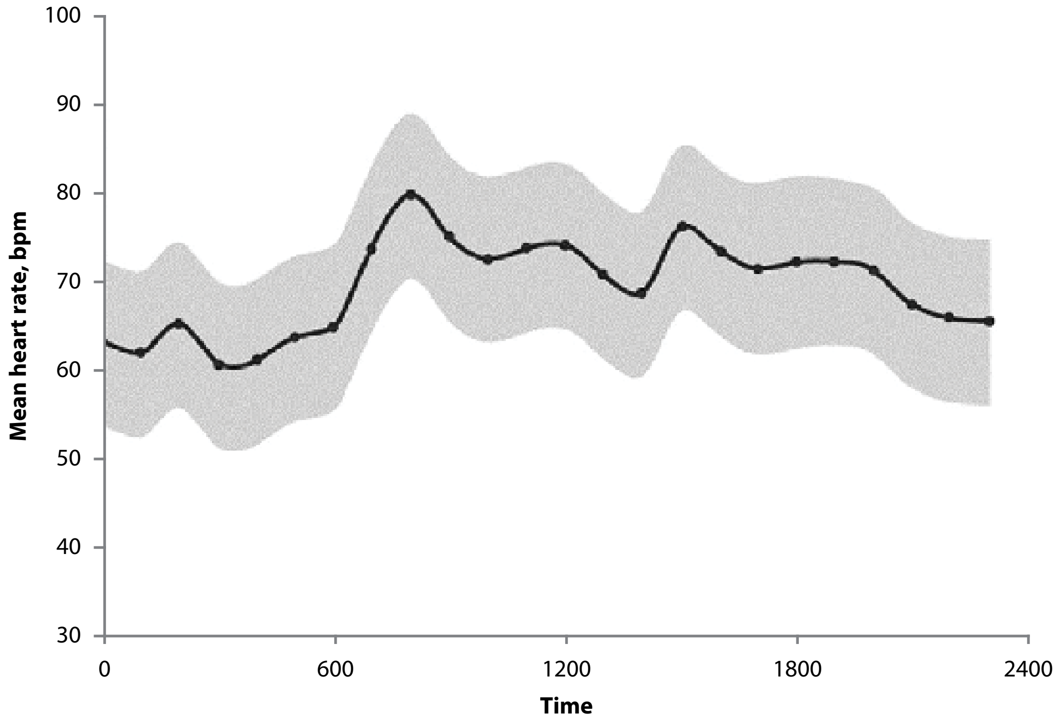

Figure 2. Mean heart rate and 95% confidence interval over 24 hours for finishing steers equipped with Holter monitor apparatus.

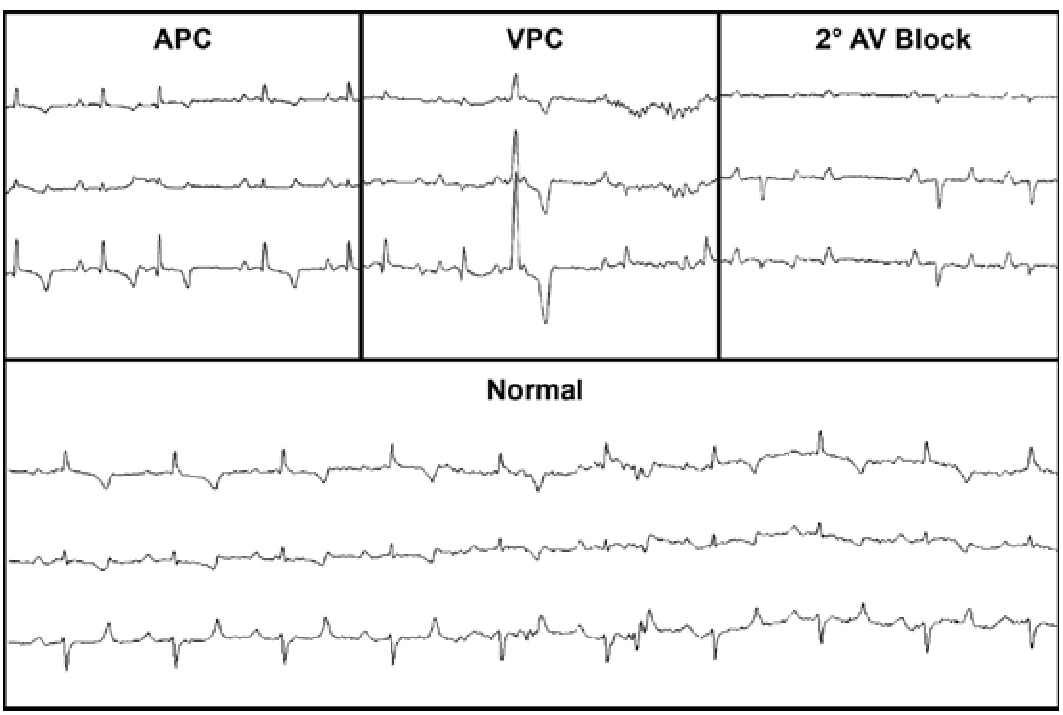

Figure 3. Representative atrial premature complex, ventricular premature complex, and low magnification Holter recordings in normal finishing steers.

Water Intake in Growing Beef Cattle

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Introduction

Water is an essential part of livestock and human diets and is often thought of as an inexpensive, readily available renewable natural resource. However, the amount of competition between humans, wildlife, feed production, and livestock for high-quality water is increasing, not only from the effects of drought but from the pressure of a growing global population (Nardone et al., 2010). With limited resources available for production agriculture, there is a need to identify and select for efficient animals that can produce more product with fewer inputs. Although some work has been done in dairy cattle, very little data is available on individual animal water intake in modern beef cattle (Brew et al., 2011). The majority of the water intake data available in growing beef cattle is derived from dividing the total amount of water drunk in a pen divided by the number of animals in that pen (Sexson et al., 2010; Mader and Davis, 2004). Data derived from groups are not generally useful for the purposes of genetic evaluation, which aims to quantify individual animal variation in a trait for selection. However, in order to practice selection on a large scale, parameters for collecting phenotypic data must be established. The objectives of this study were to measure daily water intake on a large number of beef steers and to estimate the number of test days necessary to collect accurate water intake phenotypes.

Key words: water intake, beef cattle, test length

Experimental Procedures

Feed and water intake was measured on 459 crossbred steers using an Insentec system at the Oklahoma State University Willard Sparks Beef Research Unit. Steers were fed in four groups during a three-year period (group 1 from May to August 2014, group 2 from November 2014 to March 2015, group 3 from May to August 2015, and group 4 June to October 2016). Steers were individually weighed every 14 days and gain was calculated using a regression of full body weight over time to account for differences in fill. Individual daily feed and water intake records were collected over a 70-day period in accordance with test length guidelines for feed intake and gain published by the Beef Improvement Federation (2010). Within each group, steers were blocked by weight

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(low and high) at the beginning of the study and randomly assigned to one of four pens containing approximately 30 steers per pen. Each pen provided 2007.47 ft^2 of shade and included an Insentec system containing six feed bunks and 1 water bunk. Steers were fed a growing diet throughout the study that consisted of 15% cracked corn, 51.36% wet corn sweet bran, 28.44% prairie hay, and 5.20% supplement on a dry matter basis. The mean dry matter was ~73.5% and mean gross energy of composited samples was ~128,270.3 cal/oz on a dry matter basis (data on group 1-3 only). Groups 1-3 steers were managed using a standard slick bunk feed call procedure and group 4 was offered *ad libitum* feed intake. All groups had *ad libitum* access to water. Intake records were filtered for reasonableness using parameters for feed and water bunk starting weight, ending weight, and duration. Records collected on weigh dates, days where equipment malfunctioned, or other days where *ad libitum* water access was compromised were treated as missing data points to maintain data quality. Average intakes for each animal were computed for increasingly large test durations (7, 14, 21, 28, 35, 42, 49, 56, 63, or 70 days) with a minimum of 3 days of intake per week to determine the optimum test duration for water intake in this dataset. Water intake was adjusted for differences in body size by reporting it as a percent of mid-test body weight. A general linear model with group as a fixed effect was fit in SAS (SAS Inst. Inc., Cary, NC; version 9.4) to determine whether intakes were significantly different between groups. Phenotypic correlations were generated using SAS 9.4 for each shortened test period as compared to the full 70-day test. Depending on the desired stringency of data collection, minimum test duration can be determined when both the Pearson and Spearmen correlations were above 0.90, 0.95, or 0.99 for water intake.

Results and Discussion

The average intake across all groups was approximately 88.77 lb/day, which was approximately 9.334% of their body weight. Cattle that were fed during the summer months had a significant ($P<0.0001$) increase in water intake when compared to cattle fed during the winter (10.03% of body weight vs. 6.90% of body weight, respectively). Cattle fed during the summer months that were managed on the slick bunk procedure had lower water intakes ($P<0.0008$) than cattle that had access to *ad libitum* feed during the summer months (9.67% of body weight vs. 10.76% of body weight, respectively). However, with only one group at a larger initial body weight representing *ad libitum* intake, it is not clear how much of this difference might be due to differences in feed regimen, differences in genetic potential for water intake, or changing metabolic water requirements as body weight increases. Mader and Davis (2004) reported daily water intakes of 7.89% of mid-test body weight per day (~10 gallons) for finishing steers based on pen water intake data extrapolated to individual animals during the summer with similar temperature humidity index measures, which were lower then our estimates for the same time of year (groups 1, 3, and 4). Brew et al. (2011) reported daily water intake of 7.92 gallons (66.10 lb) per day during the winter using a GrowSafe system to collect individual water intakes. This result was consistent with our intakes collected during the same season (group 2).

Our results indicate that minimum test durations for collection of water intake phenotypes should be 35, 49, or 56 days if the desired phenotypic correlation is either 0.90, 0.95, or 0.99, respectively. While no other minimum test duration recommendations exist for water intake, the minimum test duration for water intake in our data is similar to the minimum test duration for feed intake as reported by the Beef Improvement Federation (35-42 days; 2010). These data suggest that water and feed intake can be collected simultaneously, which would allow concurrent collection of both phenotypes without significantly extending test duration.

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Table 1. Daily water intake for beef cattle (n = 459) during a three year period

		Water intake (% mid-test body weight/day)[1]				Daily water intake (gal)			
Group[2]	N	Mean	STD[3]	Min	Max	Mean	STD[3]	Min	Max
1	118	10.79[a]	1.97	5.84	16.45	10.70	2.12	5.68	17.51
2	115	6.90[b]	1.13	4.46	11.89	7.21	1.44	3.69	11.53
3	117	8.55[c]	1.42	5.95	13.18	9.47	1.75	6.27	15.64
4	106	10.76[a]	2.86	7.67	22.92	12.98	3.43	8.47	26.79
All	456	9.34	2.58	4.46	22.92	10.66	2.37	6.27	26.79

[1]Daily water intake as a percent of mid test body weight (lb).
[2]Daily water intakes were taken for group 1 summer 2014, group 2 winter 2014, group 3 summer 2015, group 4 summer 2016, and all is the average of the four groups.
[3]Standard deviation.
[abcd]Means within a column that do not have common superscripts differ ($P<0.05$).

Feeding a Novel Trace Mineral at Lower Levels to Grazing Stocker Cattle Does Not Impair Performance

C.S. Weibert, W.R. Hollenbeck, S.B. Laudert[1], J.D. Kubick, and D.A. Blasi

Introduction

When grazing stocker cattle on native Flint Hills pasture, optimizing growth rate is important in determining overall profitability. The correct selection of mineral supplements is an important decision that can be used to help promote overall productivity during a grazing season.

Key words: trace minerals, stocker, grazing

Experimental Procedures

A 90-day grazing study was conducted at the Kansas State University Beef Stocker Unit starting in May 2015 to determine the consumption and growth resulting from a trace mineral supplement that contained zinc, copper, and manganese either in a sulfate or a hydroxy form. All heifers used in this study (n = 276; 645 lb) were previously involved in a receiving study that focused on the source of trace mineral supplement from sulfate, organic (Availa 4) or hydroxy (IntelliBond) zinc, copper, and manganese. Heifers from the receiving treatments were equally assigned to the grazing treatments. Off-test weights collected at the conclusion of the receiving study were used to randomly assign animals to grazing treatments. Heifers were assigned to two grazing treatments with seven pasture replicates randomly allocated to treatment. All calves were tagged, dewormed with LongRange (Merial Limited, Duluth, GA) for control of internal and external parasites, and sorted to their pre-assigned paddock groups. All pastures were stocked at 230 lb of beef per acre.

The sulfate treatment consisted of a standard free-choice mineral formulated with sulfate forms of zinc, copper, and manganese. The hydroxy treatment consisted of a free-choice mineral formulated with the hydroxy forms of zinc, copper, and manganese at a 40% reduction in level (Table 1). Calf intake was targeted at 4 oz per head daily. The two treatments were provided throughout the duration of the trial.

On a weekly basis, mineral feeders were weighed to determine consumption. The collected data were used to calculate the previous week's intake of mineral. The mineral

[1] Micronutrients USA LLC, Indianapolis, IN.

in the feeder of each paddock was checked weekly for manure, water, or other foreign matter that could interfere with normal supplement consumption. Bull Master feeders (Mann Enterprises, Inc., Waterville, KS) were used for mineral delivery in all paddocks. When inclement weather was forecasted, rubber flap covers on all feeders were closed to minimize exposure to moisture. All flaps were reopened immediately after the threatening storm event. If mineral intake was beyond target, the feeder was moved further away from the primary water source. All calves were inspected multiple times throughout the week for pinkeye, lameness, and other ailments. If diagnosed with foot rot or pinkeye, cattle received Bio-Myocin 200. Data were analyzed using the MIXED procedure (SAS Inst. Inc., Cary, NC). Data were arranged in a randomized block design, with pen serving as the experimental unit for growth and health outcomes as impacted by treatment. In the model, the fixed effects were treatment and pasture while the random effects were pasture × treatment, pasture, and animal identification number.

Results and Discussion

Performance and health results are presented in Table 2. There were no significant differences in average daily gain or mineral intake during the 90-day grazing trial. Heifer daily gains based on previous years' research results were sub-par, which was likely the result of fleshiness obtained during the receiving phase and subsequent body size when introduced to pasture.

Implications

Providing a free-choice mineral using hydroxy form of trace minerals (copper, zinc, and manganese) provides comparable performance when formulated at 40% of a sulfate trace mineral based supplement.

Table 1. Nutrient composition of free-choice trace minerals

	Treatment[a]	
Item	Sulfate trace mineral	IntelliBond trace minerals[b]
Calcium, %	18.0	18.0
Phosphorus, %	3.5	3.5
Salt, %	21.8	21.8
Magnesium, %	1.0	1.0
Selenium, ppm	26.0	26.0
Copper, ppm	1400	840
Manganese, ppm	3000	1800
Zinc, ppm	4000	2400
Vitamin A, IU/lb	100,000	100,000
Vitamin D, IU/lb	10,000	10,000
Vitamin E, IU/lb	100	100
S-Methoprene, mg/lb	47.6	47.6
Chlortetracycline, g/ton	2800	2800

[a]Sulfate trace minerals supplied by copper, manganese, and zinc sulfate. IntelliBond trace minerals supplied by IntelliBond copper, manganese, and zinc. All other nutrients supplied by identical sources.
[b]Formulated at a 40% reduction of the sulfate form of copper, zinc, and manganese.

Table 2. Performance data for cattle supplemented with sulfate or hydroxy trace minerals while grazing Flint Hills pasture

Item	Sulfate	Hydroxy	Standard error	P-value
Pastures, number	7	7		
Animals on trial, number	119	121		
Grazing days, number	90	90		
Initial weight, lb	645	645	1.32	0.7755
Final weight, lb	736	740	5.33	0.6062
Grazing average daily gain, lb/day	1.03	1.06	0.053	0.6563
Mineral intake, oz/day	3.84	3.84	0.207	0.9779

Evaluation of Trace Mineral Sources on Newly Arrived Stocker Cattle

C.S. Weibert, W.R. Hollenbeck, S. B. Laudert[1], J.D. Kubick, and D.A. Blasi

Introduction

Light weight stocker calves experience variable degrees of physiological and psychological stressors as they are assembled from various marketing points and transported to their destination. Susceptibility to disease in young, long hauled calves is greatly enhanced and the consequence of sickness is a major cause for poor production outcomes. Enhanced nutritional trace mineral programs that contain zinc, copper, and manganese from organic or hydroxy sources may be more efficacious as a means of minimizing disease or realizing improved performance than the sulfate form of these respective trace minerals.

Key words: trace minerals, stocker, drylot

Experimental Procedures

A total of 283 crossbred heifers (initial body weight = 511 ± 29 lb) were blocked by weight and randomly assigned to one of 3 treatments with 6 pens per treatment (18 pens with 15 heifers each). Treatments consisted of supplemental zinc (360 mg/day), copper (125 mg/day), and manganese (200 mg/day) from sulfate, organic complexes (Availa® 4, Zinpro Corp., Eden Prairie, MN), or hydroxy (Intellibond®, Micronutrients, Indianapolis, IN) trace mineral sources fed during a 45 day receiving and backgrounding period (Table 1).

Diets were fed once daily. Unconsumed feed was removed from the bunk, weighed, and a subsample was dried as needed to determine actual feed intake. Body weights were captured at initial processing, during revaccination (day 14), and at completion of the study at day 45. All calves were observed daily for signs of sickness or lameness. If any signs were observed, cattle were pulled from their pens and a rectal temperature was taken. If a temperature of 104°F or higher was found, antibiotics were administered according to the Kansas State University Beef Stocker Unit health protocol. Diagnosis of non-bovine respiratory diseases (lameness, pink eye, etc.) was treated according to the health protocol. The trial was conducted as a randomized complete block design. Statistical analyses were conducted using the MIXED procedure of SAS (version 9.4; SAS Institute, Cary, NC). Data were arranged in a randomized incomplete block design, with pen serving as the experimental unit for growth and health outcomes as impacted

[1] Micronutrients USA LLC, Indianapolis, IN.

by treatment. In the model, the fixed effects were treatment and lot number while the random effects were lot × treatment, pen, and animal ID. Treatment differences were considered significant at P-value less than 0.05 and tendencies at P-value less than 0.10.

Results and Discussion

The effects of source of zinc, copper, and manganese on heifer performance are shown in Table 2. Overall, the cattle performed well on feed among all treatments. There were no significant differences in body weight gain, average daily gain, feed intake, or feed efficiency during the 45 day receiving and growing trial.

Implications

Trace mineral source did not affect total weight gain, average daily gain, feed efficiency or morbidity during the receiving and subsequent growing phase of stocker calves in this particular trial.

Table 1. Basal diet composition of heifers fed a trace mineral supplement

Item, % dry matter basis	Basal diet	Hydroxy	Organic	Control
Dry rolled corn	19.38			
Wet corn gluten feed	40.00			
Alfalfa hay	17.50			
Trace mineral premix[1]	5.63			
Prairie hay	17.50			
Analyzed nutrient composition[2]				
Dry matter, %		73.04	73.22	73.27
Crude protein, %		17.14	17.49	17.26
Acid detergent fiber		16.75	17.39	17.56
Net energy gain, Mcal/lb		0.48	0.47	0.47
Calcium, %		0.68	0.61	0.63
Phosphorus, %		0.60	0.61	0.62
Potassium, %		1.27	1.29	1.32
Magnesium, %		0.36	0.35	0.36
Copper, ppm		10.51	9.13	9.64
Manganese, ppm		37.07	35.47	39.00
Molybdenum, ppm		0.73	0.80	0.73
Zinc, ppm		52.93	52.70	53.73

[1] Formulated to provide 150 mg/day Rumensin (Elanco Animal Health, Greenfield, IN) and to contain the following nutrient levels: 28,000 IU/lb vitamin A; 31 IU/lb vitamin E; 170 ppm added copper; 510 ppm added zinc; 340 ppm added manganese; 2.63 ppm added selenium; 2.5% salt; 4.7% calcium; and 9.4% crude protein from sulfate, organic, and hydroxy mineral sources for the elements of zinc, copper and manganese.
[2] SDK Laboratories, Hutchinson, KS.

Table 2. Performance data for cattle supplemented with sulfate, organic complexes, or hydroxy trace minerals

Item	Sulfate	Organic	Hydroxy	Standard error	P-value
Pens, number	8	8	8		
Animals on trial, number	94	93	89		
Days on feed	45	45	45		
Initial weight, lb	511	511	510	2.26	0.9362
Revaccination weight, lb	582	578	579	3.03	0.7276
Final shrunk weight, lb	645	645	641	6.84	0.7778
Receiving period average daily gain, lb/day	2.97	3.00	2.94	0.11	0.9053
Bovine respiratory disease pull rate, % per treatment	0.81	1.66	2.02		0.4333
Day 14 dry matter intake, lb/day	12.18	12.38	11.91	0.36	0.6754
Day 14 feed:gain, lb dry matter feed/lb gain	2.38	2.53	2.36	0.098	0.4061
Day 14 gain:feed, lb gain/lb dry matter feed	0.425	0.398	0.427	0.016	0.3897
Overall dry matter intake, lb/day	16.36	16.61	16.15	0.503	0.8134
Overall feed:gain, lb dry matter feed/lb gain	5.53	5.54	5.51	0.164	0.9895
Overall gain:feed, lb gain/lb dry matter feed	0.182	0.181	0.182	0.005	0.9786

Feeding Nucleotides with Corn Germ Meal or Dried Corn Distillers Grains Does Not Promote Growth Performance of Receiving and Growing Calves

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Introduction

Corn germ meal is often used in swine and poultry diets, but very little information exists on the effects on beef cattle and on newly arrived stressed cattle. When formulating receiving and growing diets, calf health and stress are important factors to consider. Including nucleotides, an immune-boosting feed additive may aid in gastrointestinal health of an animal and furthermore improve growth performance. The objective of these experiments was to determine: 1) the effects of corn germ meal in comparison to dried corn distillers grains on growth performance and 2) the effects of nucleotides on growth performance, by receiving and growing cattle.

Key words: receiving and growing diet, nucleotide, corn germ meal

Experimental Procedures

Crossbred heifers (n = 213, initial body weight = 576 lb) were shipped from three separate sources (Searcy, AR; Snook, TX; and Melbourne, AR) to the Beef Stocker Unit in Manhattan, KS, to determine the feeding value of corn germ meal in comparison with dried corn distillers grains and to evaluate the effects of nucleotides on receiving stocker cattle health and performance (Experiment 1). The heifers were blocked by source, stratified by arrival weight within each block and assembled into 11 or 12 head per pen. Pens were randomly assigned one of six treatments: 1) corn germ meal with 0 g/heifer daily nucleotides (corn germ meal 0); 2) corn germ meal with 2 g/heifer daily nucleotides (corn germ meal 2); 3) corn germ meal with 4 g/heifer daily nucleotides (corn germ meal 4); 4) dried corn distillers grains with 0 g/heifer daily nucleotides (dried corn distillers grains 0); 5) dried corn distillers grains with 2 g/heifer daily nucleotides (dried corn distillers grains 2); and 6) dried corn distillers grains with 4 g/heifer daily nucleotides (dried corn distillers grains 4) (Table 1). Heifers were fed once daily and feed samples of each diet were collected weekly from each bunk and stored for later analysis. Heifers were individually weighed on day 0, 28, 56, 84, and 85. A second experiment

[1] ADM Animal Nutrition, Inc., Quincy, IL.
[2] Agri-Trails Coop, Tampa, KS.

was conducted to follow up on the effects of nucleotides on receiving stocker cattle health and performance (Experiment 2). Brahman × Hereford crossbred heifers (n = 240, initial body weight = 590 lb) were blocked by weight, stratified by weight within each block, and randomly assigned to one of three treatments from the previous experiment; dried corn distillers grains 0, dried corn distillers grains 2, and dried corn distillers grains 4. Calves were fed once daily. Feed samples of each diet were collected weekly from each bunk and stored for later analysis. Heifers were individually weighed on days 0, 28, 56, and 57 (completion of trial).

Results and Discussion

In Experiment 1, inclusion of corn germ meal at 24.5% on a dry matter basis was similar to dried corn distillers grain diets containing 22.0% dried corn distillers grains for dry matter intake ($P \geq 0.19$), average daily gain ($P \geq 0.57$), and gain:feed ($P \geq 0.34$) (Table 2). There were no linear ($P \geq 0.15$) or quadratic ($P \geq 0.28$) effects of nucleotides on the growth performance of growing and receiving beef heifers. Likewise, in Experiment 2, there was no difference (linear or quadratic) in dry matter intake (all $P \geq 0.43$), average daily gain ($P \geq 0.18$), or gain:feed ($P \geq 0.26$) by nucleotide inclusion level over the 56 day feeding period (Table 3).

Implications

These experiments indicate that corn germ meal yielded similar growth performance to dried corn distillers grains. There was no effect of nucleotides on the growth performance of receiving and growing calves in these experiments.

Table 1. Composition of diets (% of dry matter) containing corn germ meal, dried distillers grains and a nucleotide additive fed during Experiments 1 and 2

	Corn germ meal			Dried corn distillers grains		
	Nucleotide additive, g/day					
Item	0	2	4	0	2	4
Ingredient						
Cracked corn	25.5	25.5	25.5	29.0	29.0	29.0
Corn germ meal	24.5	24.5	24.5	-	-	-
Dried distillers grains	-	-	-	22.0	22.0	22.0
Prairie hay	18.0	18.0	18.0	10.7	10.7	10.7
Alfalfa hay	13.0	13.0	13.0	22.8	22.8	22.8
Corn steep liquor	7.0	7.0	7.0	7.0	7.0	7.0
Corn gluten meal	4.0	4.0	4.0	0.5	0.5	0.5
Limestone	1.5	1.5	1.5	1.5	1.5	1.5
Mineral supplement[1]	1.0	1.0	1.0	1.0	1.0	1.0
Nucleotide additive[2]	5.5	5.5	5.5	5.5	5.5	5.5
Composition, analyzed (Experiment 1)						
Dry matter, %	77.4	77.5	77.6	76.4	77.0	76.5
Crude protein, % of dry matter	18.3	18.9	18.1	18.9	18.7	19.4
Ether extract, % of dry matter	2.6	2.7	2.6	4.1	4.1	4.4
Calcium, % of dry matter	0.96	0.94	1.00	1.12	1.08	0.99
Phosphorus, % of dry matter	0.51	0.53	0.50	0.55	0.54	0.57
Composition, analyzed (Experiment 2)						
Dry matter, %				75.0	74.7	74.9
Crude protein, % of dry matter				20.2	19.5	20.0
Ether extract, % of dry matter				3.9	3.9	3.8
Calcium, % of dry matter				1.22	1.27	1.23
Phosphorus, % of dry matter				0.58	0.56	0.56

[1] Mineral supplement was supplemented to contain (dry matter basis) 18.7% calcium, 4.14% phosphorus, 0.24% magnesium, 0.43% potassium, 26.88% sodium chloride, 10.62% sodium, 16.38% chloride, 1.43% sulfur, 399.41 ppm fluorine, 35.66 ppm cobalt, 177.79 ppm iodine, 775.26 ppm iron, 6516.67 ppm manganese, and 4018.94 ppm zinc.

[2] Nucleotide additive was formulated to provide 0, 2, or 4 g/heifer daily when dry matter intake was 8.2 kg/d. At this inclusion level, the nucleotide provides 0 g/kg dietary dry matter, 0.242 g/kg dietary dry matter, and 0.489 g/kg dietary dry matter.

Table 2. Effects of corn germ meal and dried corn distillers grains and the addition of a nucleotide additive on beef heifer gain, intake and efficiency (Experiment 1)

	Corn germ meal			Dried corn distillers grains				P-value				
	Nucleotide additive[1], g/day											
Item	0	2	4	0	2	4	SEM	BP[2]	NA-L[3]	NA-Q[4]	BP×NA-L[5]	BP×NA-Q[6]
Days on feed	84	84	84	84	84	84						
Initial body weight, lb	578	577	575	577	576	576	35	0.78	0.20	0.72	0.41	0.91
Final body weight, lb	784	777	784	770	791	721	15	0.88	0.33	0.72	0.32	0.23
Dry matter intake, lb												
day 0 to 28	17.1	16.4	17.3	16.9	17.0	17.2	2.0	0.76	0.66	0.28	0.83	0.31
day 28 to 56	21.0	19.7	20.5	19.8	20.8	20.6	1.6	0.96	0.84	0.77	0.42	0.26
day 56 to 84	24.2	23.6	24.0	22.0	22.5	23.6	2.1	0.19	0.58	0.65	0.44	0.94
day 0 to 84	20.7	19.8	20.5	19.6	20.1	20.4	1.8	0.55	0.65	0.56	0.45	0.48
Average daily gain, lb												
day 0 to 28	3.00	3.04	3.22	2.93	3.28	3.31	0.35	0.57	0.15	0.80	0.71	0.48
day 28 to 56	2.87	2.64	2.71	2.49	2.76	2.71	0.22	0.65	0.90	0.97	0.38	0.43
day 56 to 84	1.39	1.41	1.41	1.37	1.52	1.41	0.20	0.83	0.85	0.72	0.99	0.75
day 0 to 84	2.45	2.38	2.49	2.29	2.56	2.51	0.18	0.88	0.28	0.70	0.39	0.25
Gain:feed												
day 0 to 28	0.17	0.19	0.19	0.18	0.20	0.19	0.02	0.47	0.15	0.41	0.99	0.87
day 28 to 56	0.14	0.13	0.13	0.13	0.13	0.13	0.01	0.64	0.96	0.78	0.56	0.72
day 56 to 84	0.06	0.06	0.06	0.06	0.07	0.06	0.01	0.59	0.96	0.55	0.72	0.66
day 0 to 84	0.12	0.12	0.12	0.12	0.13	0.12	0.01	0.34	0.41	0.28	0.93	0.45

[1] Nucleotide (NA); PSB Complex, DSS Global, Chicago, IL.
[2] BP indicates byproduct effect.
[3] NA-L indicates nucleotide additive linear effect.
[4] NA-Q indicates nucleotide additive quadratic effect.
[5] BP × NA-L indicates byproduct × nucleotide additive linear effect.
[6] BP × NA-Q indicates byproduct × nucleotide additive quadratic.

Table 3. Effects of the addition of a nucleotide additive to diets containing dried distillers grains on beef heifer gain, intake, and efficiency

	Nucleotide additive, g/day				P-value	
Item	0	2	4	SEM	Linear	Quadratic
Days on feed	56	56	56			
Initial body weight, lb	589	591	590	15.3	0.49	0.54
Final body weight, lb	713	714	706	3.8	0.42	0.29
Dry matter intake, lb/day						
day 0 to 28	19.1	19.2	18.5	0.48	0.46	0.51
day 28 to 56	19.7	19.4	19.0	0.57	0.44	0.96
day 0 to 56	19.4	19.3	18.7	0.48	0.43	0.73
Average daily gain, lb						
day 0 to 28	3.15	2.98	2.89	0.132	0.18	0.85
day 28 to 56	1.26	1.43	1.26	0.132	0.96	0.23
day 0 to 56	2.20	2.20	2.07	0.066	0.23	0.36
Gain:feed						
day 0 to 28	0.165	0.155	0.157	0.0054	0.26	0.40
day 28 to 56	0.084	0.112	0.093	0.0173	0.72	0.28
day 0 to 56	0.114	0.115	0.111	0.0031	0.54	0.58

[1]PSB Complex, DSS Global, Chicago, IL.

Receiving Stocker Cattle Performance is Similar With Either Corn or Sorghum Wet Distillers Grains

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Introduction

Distillers grains are an excellent energy and protein feed source for beef cattle. Corn distillers grains have been fed to beef cattle for many years, but sorghum distillers grains are becoming more popular and may be more cost effective than corn. Sorghum is very comparable to corn in terms of energy, but has a higher crude protein value. All distillers grains are available in a wet and dry form. The moist texture of wet distillers grains can help to reduce sorting at the bunk and appears to improve intake in young calves. The objective of this study was to evaluate the effect of corn and sorghum wet distillers grains on performance and digestibility of receiving stocker calves.

Key words: corn wet distillers grains, sorghum wet distillers grain, receiving stocker cattle

Experimental Procedures

Crossbred steers (n = 263, 644 lb initial body weight) were obtained from a single source in central Texas. Steers were organized in a generalized randomized complete block design, blocked by truck (n = 4), and stratified by weight within block. Steers were assigned to one of four treatments: 1) cracked corn with wet corn distillers grains; 2) cracked corn with wet sorghum distillers grains; 3) rolled sorghum with corn wet distillers grains; or 4) rolled sorghum with sorghum wet distillers grains. This procedure had 24 pens of equal size and used 6 pens per treatment. Upon arrival, calves were weighed, tagged, and allowed to rest overnight with free-choice access to brome hay and water. The day after arrival all calves were dewormed and vaccinated for respiratory and clostridial diseases. Calves received Dectomax (Zoetis, Florham, NJ), Excede (Zoetis, Florham, NJ), and Vision 8 with SRUR (Merck Animal Health, Duluth, GA). On day 7, steers were administered a modified-live vaccine, Bovi-Shield Gold (Zoetis, Kalamazoo, MI) for protection against infectious bovine rhinotracheitis. On day 21, steers were revaccinated against respiratory disease with Pyramid 5 (Boehringer Ingelheim, St. Joseph, MO).

Diets (Table 1) were mixed and fed daily for a total of 90 days. Steers were fed a common diet consisting of wet corn gluten feed, cracked corn, alfalfa hay, grass hay, and supplement from days 83 to 90 to equalize gut fill. The amount of feed delivered to each pen was recorded daily and total mixed feed samples were collected weekly. Steers were weighed on days 0 (initial processing), 21, 40, 83, and 90. Steer health was monitored daily. If body temperature was between 103°F and 104.5°F and the steer had visual signs of suffering from a respiratory disease, the animal was administered Bio-Mycin 200 (Boehringer Ingelheim Vetmedica, Inc. St. Joseph, MO) per label instructions. If the body temperature exceeded 104.5°F, the animal was administered Resflor Gold (Intervet Inc. Roseland, NJ) per label instructions.

Results and Discussion

Overall, there were no differences in diet consumption across treatments ($P \geq 0.25$; Table 2). From days 0 to 83, average daily gain was not different for corn vs. sorghum wet distillers grains ($P \geq 0.10$) or for corn vs. sorghum grain ($P \geq 0.35$). In terms of feed efficiency, all steers converted feed similarly regardless of treatment ($P \geq 0.22$). Corn and sorghum wet distillers grains appear to be similar in the nutrients allocated to the growth of the animal. There were differences observed on days 83 to 90 among grain type or wet distillers grain type. However, during this period a common diet was fed to the steers to equalize gut fill and the results from this week are not comparable to the period the steers were on the treatment diets.

Implications

Sorghum wet distillers grains can be fed at the same level as wet corn distillers grains to growing stocker steers and will produce similar responses in terms of gain, intake, and efficiency. The slight differences observed in the digestibility study did not affect the performance of the steers. Overall, sorghum wet distillers grains are a viable alternative to wet corn distillers grains to feed cattle in the receiving and growing yard.

Table 1. Composition of diets and distillers grains fed

	Cracked corn		Rolled sorghum			
Item	Wet corn distillers grain	Wet sorghum distillers grain	Wet corn distillers grain	Wet sorghum distillers grain	Wet corn distillers grain	Wet sorghum distillers grain
Ingredient, % dry matter						
Corn	25.36	25.36	0	0		
Sorghum	0	0	25.36	25.36		
Corn wet distillers grains	30.00	0	30.00	0		
Sorghum wet distillers grains	0	30.00	0	30.00		
Alfalfa hay	17.50	17.50	17.50	17.50		
Prairie hay	17.50	17.50	17.50	17.50		
Supplement[1]	9.64	9.64	9.64	9.64		
Composition, % dry matter						
Dry matter, %	95.7	95.1	95.7	95.6	93.5	89.3
Ash	11.4	9.6	11.0	9.6	23.4	6.8
Neutral detergent fiber	40.8	34.0	36.4	34.5	36.1	34.6
Acid detergent fiber	19.8	17.0	17.3	18.0	10.9	16.8
Crude protein	19.0	20.0	19.3	19.6	29.7	33.1
Starch	12.5	12.9	12.0	14.4	2.5	4.3
Fat	5.5	5.4	5.5	5.1	11.7	11.0
Calcium	0.92	0.97	0.92	0.91	0.01	0.08
Phosphorus	0.90	0.89	0.92	0.90	1.07	0.94

[1]Supplement ingredients: Monensin 220mg/kg, processed grain by-products, calcium carbonate, magnesium, mica, salt, zinc sulfate, sodium selenite, copper sulfate, manganous oxide, manganese sulfate, ferrous sulfate, zinc oxide, thiamine mononitrate, vitamin E supplement, vitamin A supplement, ethylenediamine dihydroiodide, vitamin D3 supplement, cobalt carbonate, ferrous carbonate, and calcium iodate; manufactured by Cargill Animal Nutrition, Minneapolis, MN.

Table 2. Effects of wet corn or sorghum distillers grains with corn or sorghum grain on gain, intake, and efficiency in crossbred Angus steers

	Cracked corn		Rolled sorghum			P-value		
Item	Wet corn distillers grain	Wet sorghum distillers grain	Wet corn distillers grain	Wet sorghum distillers grain	SEM[1]	Grain	Wet distillers grain type	Grain × Wet distillers grain type
Number of pens	6	6	6	6				
Number of animals[2]	66	66	66	66				
Days on feed	90	90	90	90				
Initial body weight, lb	651	640	640	645	7.02			
Final body weight, lb	955	957	946	959	6.16			
Dry matter intake, lb/day								
days 0 to 21	17.80	17.62	17.58	17.67	0.59	0.88	0.94	0.82
days 21 to 40	25.61	26.69	25.83	26.91	0.92	0.81	0.25	0.99
days 40 to 83	33.11	31.57	32.54	32.14	1.52	0.99	0.47	0.67
days 83 to 90[2]	24.35	25.54	23.94	26.95	1.32	0.65	0.06	0.4
days 0 to 90	27.57	26.77	27.02	27.30	1.08	0.99	0.79	0.57
Average daily gain, lb								
days 0 to 21	3.56	3.87	3.96	3.67	0.24	0.68	0.95	0.23
days 21 to 40	4.33	4.44	4.31	4.51	0.20	0.95	0.46	0.82
days 40 to 83	3.39	3.21	3.28	3.15	0.11	0.35	0.1	0.82
days 83 to 90[3]	0.18[a]	0.99[a]	0.79[a]	2.27[b]	0.40	0.03	0.01	0.43
days 0 to 90	3.37	3.45	3.48	3.48	0.07	0.37	0.49	0.69
Gain:Feed								
days 0 to 21	0.20	0.22	0.23	0.21	0.01	0.72	0.93	0.22
days 21 to 40	0.17	0.17	0.17	0.17	0.01	0.8	0.83	0.74
days 40 to 83	0.10	0.1	0.1	0.1	0.01	0.32	0.38	0.84
days 83 to 90[3]	0.01[a]	0.04[a]	0.03[a]	0.08[b]	0.02	0.03	0.02	0.56
days 0 to 90	0.12	0.13	0.13	0.13	0.01	0.59	0.64	0.48

[a,b,c,d] Within a row least squares means without a common superscript differ ($P \leq 0.05$).

[1] SEM = standard error of the mean.

[2] For treatment corn grain/ corn wet distillers grains initial n = 66, final n = 65: steer died from breaking leg in chute.

[3] Days 83-90 steers were fed a common diet to equalize gut fill of 28.5% corn grain, 30% wet corn gluten feed, 17.5% alfalfa, 17.5% bromegrass hay, and 6.43% supplement, dry matter basis.

High Energy Digestible Fiber-based Diets Improve Efficiency in Growing Heifers

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Introduction

An inherent challenge of long hauled, highly stressed calves is decreased feed intake upon destination arrival. Highly stressed, newly received stocker calves not consuming adequate amounts of energy are prone to a variety of disorders such as Bovine Respiratory Disease Complex and decreased performance throughout the feeding period. One mechanism that can be used to increase energy intake upon arrival is to make the diet more energy dense. Often times, this is accomplished by the addition of cereal grains high in fermentable carbohydrate including starch. Unfortunately, this has also been linked to increasing morbidity due to metabolic disorders. The goal of this study was to analyze the effects of limit-fed diets containing increasing amounts of energy from highly digestible fiber in by-product feeds on health and performance of newly received stocker calves.

Key words: wet corn gluten feed, health, limit-feeding

Experimental Procedures

Four loads, containing 370 crossbred heifers assembled from Tennessee and Alabama sale barns and combined at a Dickson, TN order buyer facility (initial body weight = 491 ± 37 lb) were received at the Kansas State University Beef Stocker Unit in the summer of 2016. On arrival cattle were weighed and given an individual animal identification number. The following morning cattle were vaccinated against common viral and clostridial diseases (Pyramid 5 + Presponse, Vetmedica, St. Joseph, MO; Baytril 100, Bayer Healthcare, Animal Health Division, Shawnee Mission, KS; Vison 7 with Somnus, Merck Animal Health, Madison, NJ) and dewormed (Safeguard, Merck Animal Health, Madison, NJ). Each load represented a block that was stratified by weight and randomly assigned to 8 pens. Pens were randomly assigned to one of 4 treatments with 8 pens per treatment (10-13 heifers per pen). The 4 treatments supplied 45, 50, 55, and 60 Mcals net energy for gain/100 lb of feed. The 45 treatment was provided *ad libitum* and the other 3 were fed at decreasing levels based on the intake of 45 treatment as follows: 50 treatment fed at 95%, 55 treatment at 90%, and 60 treatment at 85%. All treatments were formulated to contain 40% wet corn gluten feed on a dry matter basis (Table 1).

Treatments were fed each morning at approximately 7:00 a.m. Before feeding each day, all bunks containing refusals were cleaned and their contents weighed. Actual dry matter consumption was calculated for the control group to dictate feed delivery to the other treatments as described above. The duration of the trial was 55 days including a 14-day gut fill equalization period in which the 45 treatment diet was fed to all animals. Animals were weighed on days 0, 14, 27, 41, and 55. Performance and health data were analyzed in the MIXED procedure of SAS (version 9.3; SAS Institute, Cary, NC) with the fixed effect of dietary treatment and the random effect of block. The pen was the experimental unit.

Results and Discussion

The effects of energy density of the diets and intake are shown in Table 2. Overall, cattle performed similarly on all treatments and there were no differences in morbidity or mortality. However, interactions were detected between dietary treatment and efficiency of feed conversion since the animals performed similarly on varying levels of dry matter intake.

Implications

Limit feeding high-energy diets based primarily on highly digestible fiber from by-product feeds such as wet corn gluten can offer a more efficient approach to feeding newly received calves without increasing morbidity or mortality. The possibility of decreased step-up or transition diets traditionally used to adapt feeder calves to a higher-energy finishing ration on entry to the feedlot could offer additional benefit since these calves would presumably be adapted to a higher-energy ration beforehand.

Table 1. Experimental diets

	Treatment[1]			
	100% dry matter basis			
Ingredient	45/100	50/95	55/90	60/85
Dry-rolled corn	8.57	19.08	28.50	38.82
Low-energy supplement	6.43	6.92	7.50	8.18
Alfalfa hay	22.50	17.00	12.00	6.50
Prairie hay	22.50	17.00	12.00	6.50
Wet corn gluten feed	40.00	40.00	40.00	40.00
Total	100.00	100.00	100.00	100.00
Calculated nutrient content				
Dry matter, %	73.5	73.2	72.9	72.6
Protein, %	16.39	15.94	15.52	15.07
Calcium, %	0.91	0.86	0.82	0.79
Phosphorus, %	0.53	0.54	0.55	0.56
Salt, %	0.32	0.35	0.38	0.41
Potassium, %	1.39	1.24	1.11	0.96
Magnesium, %	0.26	0.25	0.24	0.24
Fat, %	2.89	2.99	3.08	3.18
Acid detergent fiber, %	21.41	17.62	14.17	10.38
Net energy main, Mcal/cwt	73.21	79.08	84.34	90.09
Net energy gain, Mcal/cwt	45.28	50.40	55.01	60.06

[1]First number is net energy for gain in Mcal/100 lb dry matter. Second number is dry matter intake as percent of 100.

Table 2. Effects of dietary net energy for gain and intake on newly arrived heifer performance and health

	Treatment[1]				
Item	45/100	50/95	55/90	60/85	SEM[2]
Day 0 body weight, lb	490	493	490	491	5.37
Day 14 body weight, lb	539[b]	528[b,c]	520[b,c]	515[c]	8.70
Day 27 body weight, lb	555[b]	555[b]	549[b,c]	545[c]	9.35
Day 41 body weight, lb	590	591	585	586	7.27
Day 55 body weight, lb	614	617	616	623	8.21
Day 14 average daily gain, lb/day	3.48[b]	2.48	2.15	1.70	0.33
Day 27 average daily gain, lb/day	2.40[b]	2.29[b,c]	2.20[b,c]	2.00[c]	0.22
Day 41 average daily gain, lb/day	2.44	2.39	2.31	2.31	0.13
Day 55 average daily gain, lb/day	2.26	2.25	2.29	2.40	0.11
Day 14 dry matter intake, lb/day	10.60[b]	10.07[b,c]	9.70[c]	9.00[d]	0.62
Day 27 dry matter intake, lb/day	12.24[b]	11.34[c]	10.85[c,d]	10.14[d]	0.54
Day 41 dry matter intake, lb/day	13.67[b]	12.60[c]	11.92[c,d]	11.25[d]	0.50
Day 55 dry matter intake, lb/day	14.51[b]	13.51[c]	12.88[c,d]	12.51[d]	0.46
Day 14 feed:gain	3.16	4.60	4.72	9.18	1.93
Day 27 feed:gain	5.19	5.06	5.19	5.29	0.41
Day 41 feed:gain	5.67	5.32	5.31	4.91	0.32
Day 55 feed:gain	6.48[b]	6.11[b,c]	5.65[c,d]	5.22[d]	0.22
Day 14 gain:feed	0.329[b]	0.241[b,c]	0.225[c]	0.182[c]	0.0333
Day 27 gain:feed	0.197	0.201	0.202	0.196	0.0158
Day 41 gain:feed	0.179[b]	0.189[b,c]	0.195[b,c]	0.206[c]	0.0105
Day 55 gain:feed	0.156[b]	0.166[b,c]	0.178[c,d]	0.192[d]	0.0064
Day 14 intake as % of body weight	2.06[b]	1.97[b,c]	1.92[c]	1.79[d]	0.09
Day 27 intake as % of body weight	2.34[b]	2.16[c]	2.09[c,d]	1.96[d]	0.08
Day 41 intake as % of body weight	2.53[b]	2.32[c]	2.22[c,d]	2.09[d]	0.07
Day 55 intake as % of body weight	2.63[b]	2.43[c]	2.33[c,d]	2.25[d]	0.06

[1]First number is net energy for gain in Mcal/100 lb dry matter. Second number is dry matter intake as percent of 100.
[2]SEM=standard error of the mean.
[bcd]Means within a row with uncommon superscripts differ ($P<0.05$).

Supplemental Zinc Sulfate Interacts with Optaflexx in Feedlot Heifers

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Introduction

Optaflexx is a beta-adrenergic agonist, and is fed to cattle during the final 28 to 42 days on feed to improve growth rate and feed efficiency. Beta-adrenergic agonists are repartitioning agents that stimulate muscle deposition at the expense of fat deposition. Zinc is a trace mineral element that functions as an important component of many enzyme systems, including those associated with nucleic acid synthesis and metabolism of proteins and carbohydrates, thus making it an essential nutrient for growth. The purpose of this study was to evaluate growth, carcass characteristics, and plasma urea nitrogen concentrations in finishing heifers supplemented with Optaflexx at 0 or 200 mg/animal daily, in the presence of 30 or 100 ppm supplemental zinc. We hypothesized that feeding Optaflexx could increase requirements for dietary zinc, and that additional zinc supplementation could increase the growth response to Optaflexx.

Key words: feedlot cattle, Optaflexx, zinc sulfate

Experimental Procedures

One hundred fifty-six crossbred heifers (initial body weight = 1,162 ± 14.6 lb) were blocked by weight and randomly assigned within block to one of 4 treatments for a 43-day feeding trial. Factors (Table 1) consisted of: 1) supplemental zinc (as zinc sulfate) fed at 30 or 100 ppm of diet dry matter; and 2) Optaflexx fed to provide 0 or 200 mg/animal daily of active ingredient (ractopamine hydrochloride). Heifers were allocated to 52 partially covered, concrete surfaced pens with 3 heifers/pen (13 pens per treatment). Optaflexx was fed for 42 days, then removed from the diet until cattle were harvested on day 43. Heifers were fed finishing diets once daily to allow *ad libitum* access to feed. Two heifers per pen were randomly selected for blood collection, and on days 0 and 36 blood was drawn by jugular venipuncture and processed by centrifugation to recover plasma. Plasma was placed into 5-mL plastic tubes and stored frozen until analysis of plasma urea nitrogen. Final body weights (gross body weight × 0.96) were determined immediately before transporting cattle to a commercial abattoir (Tyson Fresh Meats) in Holcomb, KS. Hot carcass weights and incidence and severity of liver abscesses were recorded the day of harvest. After approximately 32 hours of refrigeration, marbling score, 12th-rib fat thickness, ribeye area, and U.S. Department of Agriculture yield grade were obtained from camera images, and USDA quality grade and incidence and severity of dark cutting beef were determined by a USDA grader. Data were analyzed using the MIXED procedure of SAS (SAS Inst. Inc., Cary, NC; version 9.4). The model included fixed effects of zinc, Optaflexx, and the interaction between zinc and Optaflexx, the random effect was block, and the experimental unit was pen. A P value of ≤ 0.05 was declared significant.

Results and Discussion

Effects of zinc and Optaflexx on feedlot performance are presented in Table 2. Zinc supplementation did not interact with Optaflexx supplementation for final body weight, dry matter intake, or feed efficiency ($P \geq 0.24$). Supplementing Optaflexx increased final body weight by 18.5 lb ($P=0.02$) and increased average daily gain by 9% ($P<0.01$), but did not affect feed intake ($P=0.63$). This resulted in a 10% improvement in feed efficiency ($P<0.01$). Increasing supplemental zinc from 30 to 100 ppm of the diet tended to decrease average daily gain ($P=0.07$), but did not affect final body weight, feed intake, of feed efficiency ($P \geq 0.12$). Effects of zinc and Optaflexx on carcass characteristics are presented in Table 3. Zinc × Optaflexx interactions were observed for ribeye area ($P<0.01$) and yield grade ($P=0.01$), in which case heifers supplemented 100 ppm zinc and no Optaflexx had decreased ribeye area ($P<0.01$) and increased yield grade ($P<0.05$) compared to other treatments. This effect was no longer evident with addition of Optaflexx to the diet. A tendency for a zinc × Optaflexx interaction for dressing percentage ($P=0.08$) also was observed, in which heifers supplemented 30 ppm zinc in combination with Optaflexx tended to have decreased dressing percentage compared to heifers supplemented 100 ppm zinc in combination with Optaflexx. No other interactions were detected for carcass traits ($P \geq 0.11$). Hot carcass weight increased approximately 11 lb with Optaflexx supplementation, but dressing percentage, incidence of liver abscesses, 12th rib fat thickness, marbling score, or quality grade were not affected by addition of Optaflexx to the diet ($P \geq 0.13$). Results suggest Optaflexx increased lean tissue deposition, but did not affect deposition of carcass fat. Zinc supplementation did not affect incidence of liver abscesses, 12th rib fat thickness, marbling score, or quality grade ($P>0.15$). There were no zinc × Optaflexx × day ($P=0.26$), zinc × Optaflexx ($P=0.62$), or zinc × day ($P=0.98$) interactions observed for plasma urea nitrogen concentration (Figure 1). There was a tendency for Optaflexx × day interaction ($P=0.08$), in which plasma urea nitrogen concentration tended to decrease with Optaflexx supplementation by day 36 compared to day 0. Increased supplemental zinc did not affect plasma urea nitrogen concentration ($P=0.25$). No effect of zinc on plasma urea nitrogen concentration would be expected due to the lack of an effect of zinc supplementation on hot carcass weight and ribeye area. Plasma urea nitrogen concentration increased day 36 compared to day 0 ($P<0.01$), possibly indicating an increased rate of protein degradation compared to protein synthesis towards the end of finishing.

Implications

Supplementing increased concentrations of zinc sulfate to finishing heifers had little impact on feedlot performance and plasma urea nitrogen concentration; however, muscle and fat deposition may be altered when fed in combination with Optaflexx.

Table 1. Diet and nutrient composition (dry matter basis)

	No Optaflexx		Optaflexx	
	30 ppm zinc	100 ppm zinc	30 ppm zinc	100 ppm zinc
Ingredients, %				
Steam-flaked corn	58.90	58.88	58.90	58.88
Wet corn gluten feed	30.00	30.00	30.00	30.00
Ground alfalfa hay	7.00	7.00	7.00	7.00
Vitamin/mineral premix[1]	0.11	0.11	0.11	0.11
Limestone	1.49	1.49	1.49	1.49
Salt	0.30	0.30	0.30	0.30
Optaflexx mix[2]	-	-	2.20	2.20
Ground corn	2.20	2.20	-	-
Zinc sulfate	-	0.02	-	0.02
Calculated nutrient composition[3]				
Crude protein, %	14.08	14.08	14.08	14.08
Calcium, %	0.69	0.69	0.69	0.69
Phosphorus,%	0.48	0.48	0.48	0.48
Neutral detergent fiber,%	19.03	19.03	19.03	19.03
Zinc (total diet), ppm	61.90	131.90	61.90	131.90

[1]Formulated to provide; 300 mg/day monensin (Elanco Animal Health, Greenfield, IN); 1,000 IU/lb vitamin A; 10 IU/lb vitamin E; 10 ppm added copper; 30 ppm added zinc; 20 ppm added manganese; 0.5 ppm added iodine; 0.10 ppm added selenium; and 0.15 ppm cobalt.
[2]Optaflexx was fed 42 days and formulated to provide 200 mg/animal daily mixed in a ground corn carrier, then removed from the diet until cattle were harvested on day 43.
[3]Calculated from NRC (2000) values for individual ingredients.

Table 2. Feedlot performance of heifers fed 0 or 200 mg/animal daily Optaflexx and supplemented 30 or 100 ppm zinc[1]

	No Optaflexx		Optaflexx			P-value		
Item	30 ppm zinc	100 ppm zinc	30 ppm zinc	100 ppm zinc	SEM	Zinc	Optaflexx	Zinc × Optaflexx
Initial weight, lb[2]	1,162	1,160	1,161	1,164	14.58	0.85	0.75	0.47
Final weight, lb[2]	1,337	1,330	1,359	1,345	14.09	0.17	0.02	0.58
Average daily gain, lb	4.07	3.97	4.63	4.20	0.14	0.07	< 0.01	0.24
Dry matter intake, lb/day	24.84	24.84	25.05	24.23	0.43	0.32	0.63	0.32
Feed:gain	6.11	6.25	5.41	5.77	0.19	0.12	< 0.01	0.39

[1]Optaflexx (Elanco Animal Health, Greenfield, IN) was fed for 42 days, then removed from the diet until cattle were harvested on day 43.
[2]Calculated as: gross body weight × 0.96.

Table 3. Carcass traits of heifers receiving 0 or 200 mg/animal daily Optaflexx and 30 or 100 ppm zinc as zinc sulfate[1,2]

	No Optaflexx		Optaflexx			P-value		
Item	30 ppm zinc	100 ppm zinc	30 ppm zinc	100 ppm zinc	SEM	Zinc	Optaflexx	Zinc × Optaflexx
Carcass weight, lb	849	842	856	857	8.96	0.50	0.03	0.43
Dressed yield, %	63.54	63.33	62.97	63.71	0.26	0.33	0.74	0.08
Liver abscess, %	43.6	30.8	30.8	23.1	7.71	0.19	0.19	0.74
Ribeye area, in.^{2}	15.49[a]	14.21[b]	15.14[a]	15.36[a]	0.24	0.03	0.07	< 0.01
12th-rib fat, in.	0.55	0.62	0.57	0.52	0.04	0.78	0.32	0.11
USDA yield grade	2.3[b]	2.9[a]	2.5[b]	2.3[b]	0.14	0.14	0.14	0.01
Marbling score[3]	521	523	509	485	18.71	0.48	0.13	0.41
Prime, %	5.13	5.13	7.69	5.13	3.63	0.72	0.72	0.72
Choice, %	74.36	64.10	61.54	66.67	7.18	0.72	0.48	0.29
Select, %	10.25	23.08	15.38	20.51	6.24	0.16	0.84	0.54
Sub-Select,[4] %	5.13	2.56	2.56	5.13	2.63	1.00	1.00	0.34
Dark cutters, %	5.13	5.13	12.82	2.56	4.63	0.22	0.53	0.22

[a,b]Within a row, means without a common superscript are different (P<0.05).
[1]Optaflexx (Elanco Animal Health, Greenfield, IN) was fed for 42 days, removed from the diet until cattle were harvested on day 43.
[2]Following 32 hours of refrigeration, 12th rib fat thickness, ribeye area, and USDA yield grade were obtained from camera images provided by the abattoir, and USDA quality grade and incidence and severity of dark cutting beef were determined by a certified USDA grader.
[3]Marbling scores were determined by camera images (VBG 2000, E+V Technology GmbH & Co. KG, Oranienburg, Germany) provided by the abattoir; Small=400 to 499; Modest=500 to 599.
[4]Includes carcasses that graded standard or commercial.

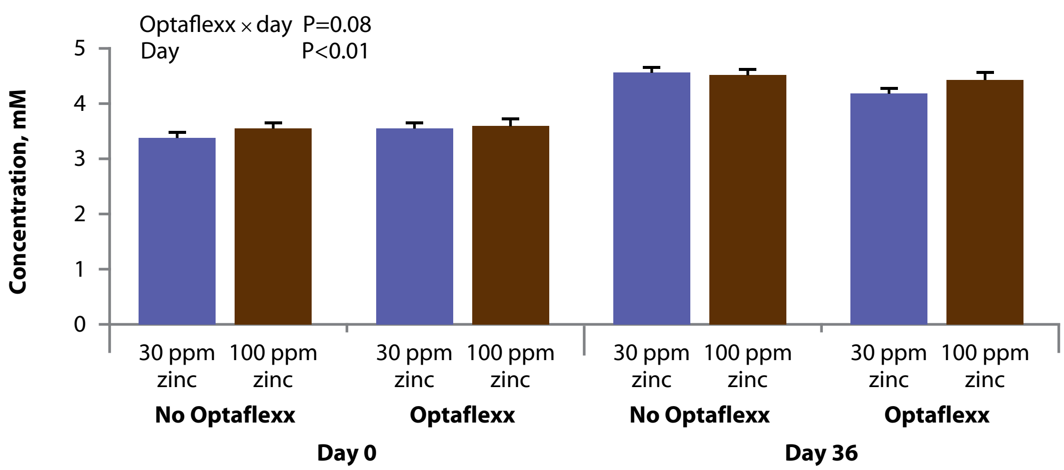

Figure 1. Plasma urea nitrogen concentration of finishing heifers supplemented 30 or 100 ppm zinc as zinc sulfate in combination with Optaflexx at 0 or 200 mg/animal daily.

Particle Size of Dry-rolled Corn Affects Starch Digestibility but Not Feedlot Performance

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Introduction

Dry-rolling corn is a common practice in feedlots located in the Midwestern and Northern Plains regions of the United States. Optimizing total digestive tract starch utilization in diets containing dry-rolled corn is essential for maximizing efficiency. However, recommendations often suggest that grain be coarsely cracked to avoid producing an excessive amount of fine material that could potentially increase the rate of fermentation, reduce rumen pH, and cause digestive disturbances.

Wet distillers byproducts may be effectively used as a protein and energy source for feedlot finishing cattle and can replace a portion of the dry-rolled corn in the diet. The average geometric mean particle size of dry-rolled corn across all feedyards (n = 31) was 0.179 ± 0.035 in. with a range of 0.085 to 0.269 in. The objective of this study was to evaluate the effects of dry-rolled corn particle size on animal performance, carcass traits, and starch digestibility in feedlot finishing diets containing 20% wet distillers grains on a dry matter basis.

Key words: dry rolled corn, feedlot, particle size

Experimental Procedures

Cross-bred yearling steers (n = 360; initial body weight = 871 ± 79.0 lb) were used in a randomized complete block design to evaluate the effects of dry-rolled corn particle size in diets containing 20% wet distillers grains on feedlot performance, carcass characteristics, and starch digestibility.

Steers were individually weighed on 2 consecutive days and were divided into 9 weight block replicates, each consisting of 40 steers, and randomly allocated to one of 4 treatments. Steers were housed in 10-head feedlot pens where they received their dietary treatment throughout the duration of the study. Each pen measured 20 × 131 ft, contained a 73.2 ft^2 concrete feeding apron, 20 ft of bunk space, and each 2 adjacent pens shared a common continual flow water fountain. Pen was used as the experimental unit.

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Dietary treatments were coarse dry-rolled corn (0.192 in.), medium dry-rolled corn (0.148 in.), fine dry-rolled corn (0.093 in.), and steam-flaked corn (27 lb/bu). All diets contained 20% wet distillers grains (dry matter basis) and were formulated to meet or exceed National Research Council (2000) requirements for growing-finishing beef cattle. Steers were transitioned to the finishing diet over a 23-day period following arrival using a series of 4 diets including: starter (days 1-7), step-1 (days 8-14), step-2 (days 15-23), finisher without ractopamine hydrochloride (days 24-113), and finisher with ractopamine hydrochloride (days 114-142). Steam-flaked corn was used in the starter and step-up diets and all diet changes during the step-up program were simultaneous for all pens and all treatments. Optaflexx was fed to all treatments the final 29 days in the feedlot at 13.65 mg/lb dry matter basis, providing approximately 300 mg/head/day.

Particle size analysis was conducted weekly on dry-rolled corn samples. The average particle size within each sample is described as the geometric mean particle size and log normal standard deviation represents the range of particle size within each sample.

Fecal samples were analyzed for moisture, dry matter, and total starch content at the Kansas State University Ruminant Nutrition Laboratory using enzymatic hydrolysis. Samples were analyzed in duplicate and those samples which differed in total starch content between duplicates by 5% or greater were re-analyzed. Duplicates were averaged.

Two mature cross-bred steers (body weight ≥ 1,598 lb), fitted with rumen cannula were fed gradually decreasing amounts of low-quality mixed grass hay and increasing amounts of the steam-flaked corn based finishing diet over a 14 day adaptation period followed by *ad libitum* amounts of the steam-flaked corn based finishing diet for an additional 7 days prior to the start of the *in situ* study. A 0.035 oz sample of unmasticated steam-flaked corn, coarse dry-rolled corn, medium dry-rolled corn, and fine dry-rolled corn samples were placed into separate Dacron bags and sealed. Four bags per time period (0, 2, 4, 8, 12, and 24 hours) per steer (n = 2) were used. All samples were suspended in the rumen at times appropriate for the desired incubation time interval and removed simultaneously. Upon removal, all samples were hand-washed individually for approximately 20 seconds per bag under a continuous stream of luke-warm tap water. Samples that were not incubated were washed using the same procedure and were used to determine the amount of sample that was washed out.

Washed *in situ* bags were dried for 48 hours at 140°F in a forced-air oven to determine *in situ* dry matter disappearance. Residual corn samples were removed from the bags, composited by time period, ground with a mortar and pestle, and frozen. A subsample was weighed and analyzed for starch disappearance at the Kansas State University Ruminant Nutrition Laboratory using enzymatic hydrolysis. Samples were analyzed in duplicate and if samples differed in total starch between duplicates by 5% or greater they were re-analyzed. Duplicates were averaged.

Fecal starch, feedlot performance, and continuous carcass data were analyzed on a pen mean basis and dry rolled corn particle size data were analyzed on a collection mean basis as a randomized complete block design using PROC MIXED of SAS (version 9.3, SAS Institute, Cary, NC). Treatment was used as a fixed effect and pen as a random effect. Average daily dry matter intake for each week was evaluated using MIXED model procedures with treatment, week, and treatment × week included in the model as fixed effects. Quality grade (Low Choice and greater versus Select and lower) and yield grade (yield grade 1, 2, or 3 versus yield grade 4 and 5) data were evaluated as categorical responses using PROC GLIMMIX of SAS and assuming a binomial distribution. Significance was determined at $P \leq 0.05$. Treatment means were separated using orthogonal contrasts if the effect for treatment approached significance. Contrasts of interest were steam-flaked corn versus dry-rolled corn and the linear and quadratic effects of decreasing particle size among the dry-rolled corn treatments.

Results and Discussion

Final body weight and average daily gain were not affected by treatment ($P>0.05$; Table 1). Dry matter intake was greater and gain:feed was lower ($P<0.05$) for steers fed dry-rolled corn versus steam-flaked corn. There was a linear decrease ($P<0.05$) in dry matter intake in the final 5 weeks on feed with decreasing dry-rolled corn particle size (Figure 1). Fecal starch decreased (linear, $P<0.01$) as dry-rolled corn particle size decreased (Table 2). *In situ* starch disappearance was lower for dry-rolled corn versus steam-flaked corn ($P<0.05$) and increased linearly ($P<0.05$) with decreasing particle size at 8 and 24 hours (Figure 2). Reducing dry-rolled corn particle size did not influence growth performance but increased starch digestion and influenced dry matter intake of cattle on finishing diets. No differences ($P>0.10$) were observed among treatments for any of the carcass traits measured (data not shown). Results indicate improved ruminal starch digestibility, reduced fecal starch concentration, and reduced dry matter intake with decreasing dry-rolled corn particle size in feedlot diets containing 20% wet distillers grains on a dry matter basis.

Implications

These results indicate improved ruminal starch digestibility, reduced fecal starch concentration, and reduced dry matter intake with decreasing dry-rolled corn particle size in feedlot diets containing 20% wet distillers grains on a dry matter basis. A better understanding of dry-rolled corn particle size on the influence of feedlot performance with the addition of various levels of wet distillers grains is needed. Based on these data, feeding finely processed corn in diets containing 20% wet distillers grains appears to be acceptable in binding fines and improving homogeneity of diet. Reduced dry matter intake with decreasing dry-rolled corn particle size towards the end of the finishing period could have potentially been associated with a sub-acute acidotic event, but the reason is not clear.

Table 1. Least squares means illustrating the effect of dry-rolled corn particle size on feedlot performance in yearling steers fed diets containing 20% wet distillers grains (dry matter basis)

	Treatment[1]						Probability>F		
							Steam-flaked corn vs dry-rolled corn	Dry-rolled corn	
Item[2]	Coarse dry-rolled corn	Medium dry-rolled corn	Fine dry-rolled corn	Steam-flaked corn	SEM[3]	Treatment effect[4]		Linear	Quadratic
Initial weight, lb	840	840	840	840	20.7	0.76	0.58	0.50	0.49
Day 17 weight, lb[6]	908	926	922	917	4.4	0.06	0.99	0.08	0.07
Final weight, lb[6]	1,404	1,411	1,402	1,413	9.9	0.81	0.60	0.87	0.42
Finish period									
Average daily gain, lb	4.37	4.25	4.21	4.32	0.088	0.61			
Dry matter intake, lb	12.31	12.15	12.17	11.50	0.256	0.11	0.02	0.68	0.77
Gain:feed[6]	0.162	0.159	0.158	0.171	0.0035	0.05	< 0.01	0.43	0.84
Calculated net energy for maintenance[7]	88.9	88.5	88.0	93.5	1.35	0.03	< 0.01	0.69	0.97
Calculated net energy for gain[7]	59.3	59.0	58.6	63.4	1.19	0.03	< 0.01	0.69	0.97
Dry matter intake last 5 weeks, lb	27.78	27.56	26.94	24.85	0.476	< 0.01	< 0.01	< 0.01	0.15
Overall									
Average daily gain, lb[5]	4.34	4.41	4.32	4.41	0. 075	0.80	0.58	0.50	0.49
Dry matter intake, lb[5]	26.06	25.79	25.86	24.56	0.514	0.14	0.02	0.77	0.78
ca Final body weight, lb[8]	1,400	1,415	1,404	1,408	10.1	0.74	0.088	0.076	0.26
ca Average daily gain, lb[8]	4.32	4.41	4.34	4.39	0.077	0.79	0.83	0.82	0.29
Gain:feed[5]	0.168	0.171	0.168	0.180	0.0030	0.03	< 0.01	0.87	0.47
Calculated net energy for maintenance[7]	90.0	91.0	90.0	94.9	1.23	0.02	< 0.01	0.99	0.55
Calculated net energy for gain[7]	60.4	61.2	60.3	64.7	1.08	0.02	< 0.01	0.99	0.55

[1] Coarse dry-rolled corn (0.192 in.); medium dry-rolled corn (0.148 in.); fine dry-rolled corn (0.093 in.); steam-flaked corn (27 lb/bu).
[2] Least squares treatment mean.
[3] Standard error of the least squares mean.
[4] Treatment as a fixed model effect.
[5] Initial body weight used as a covariate, P<0.10.
[6] Day 17 body weight used as a covariate, P<0.10.
[7] Calculated from performance, Mcal/100 lb diet dry matter.
[8] Carcass adjusted for average dressing percent 66.0%.

Table 2. Least squares means illustrating the effect of dry-rolled corn particle size on fecal starch content in yearling steers fed diets containing 20% wet distillers grains (dry matter basis)

Item[2]	Treatment[1]					Probability>F[4]			
							Steam-flaked corn versus dry-rolled corn	Dry-rolled corn	
	Coarse dry-rolled corn	Medium dry-rolled corn	Fine dry-rolled corn	Steam-flaked corn	SEM[3]	Treatment effect		Linear	Quadratic
Fecal starch	13.92	10.41	7.64	2.12	0.594	< 0.01	< 0.01	< 0.01	0.66

[1] Coarse dry-rolled corn (0.192 in.); medium dry-rolled corn (0.148 in.); fine dry-rolled corn (0.093 in.); steam-flaked corn (27 lb/bu).
[2] Percentage of dry matter.
[3] Standard error of the least squares mean.
[4] Treatment effect; steam-flaked vs dry-rolled corn; dry-rolled corn linear; dry-rolled corn quadratic.

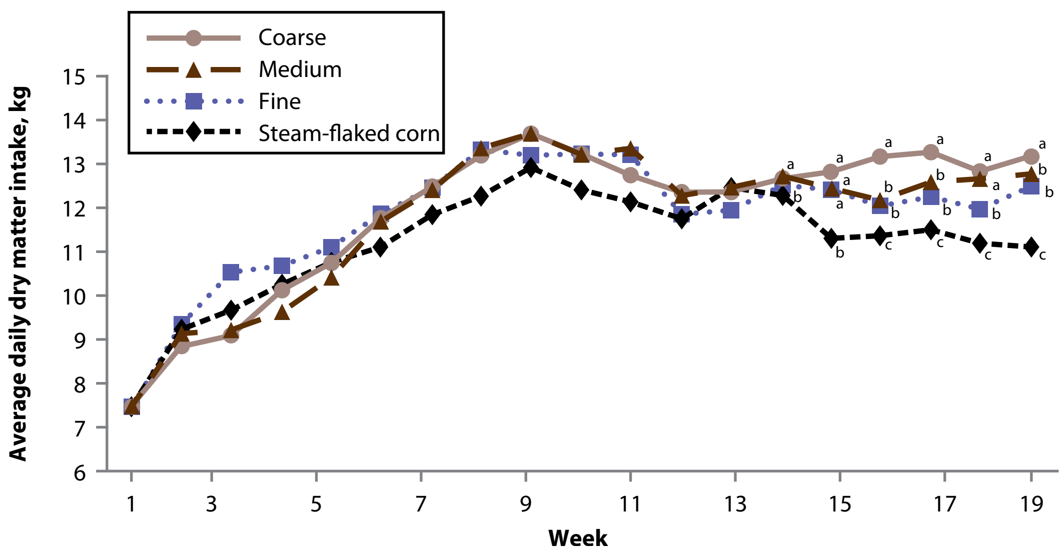

Figure 1. Weekly average daily dry matter intake by treatment for cattle fed coarse dry-rolled corn (0.192 in.); medium dry-rolled corn (0.148 in.); fine dry-rolled corn (0.093 in.); steam-flaked corn (27 lb/bu). Treatment by week interaction was significant (P<0.05). For any given week, means without a common superscript are different (P<0.05). Standard error of the least squares mean = 0.501.

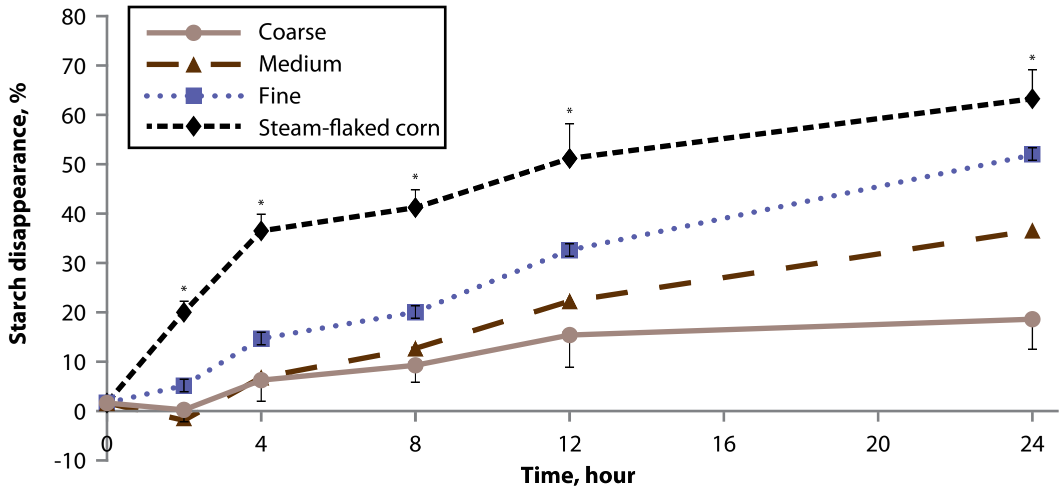

Figure 2. The disappearance of starch from Dacron bags suspended in the rumen for 0, 2, 4, 8, 12, or 24 hours. Treatments were coarse dry-rolled corn (0.192 in.); medium dry-rolled corn (0.148 in.); fine dry-rolled corn (0.093 in.); steam-flaked corn (27 lb/bu). Treatment ($P<0.01$), time ($P<0.01$), and the treatment by time interaction ($P<0.01$) effects for *in situ* starch disappearance were significant. After 24 hours incubation, *in situ* starch disappearance was approximately 18.0, 36.2, 52.0, and 63.1% (Standard error of the least squares mean = 5.44) for the coarse, medium, and fine dry-rolled corn, and steam-flaked corn treatments, respectively (*steam-flaked corn vs. dry-rolled corn, $P<0.05$; † dry-rolled corn linear, $P<0.05$).

Flake Density, Roll Diameter, and Flake Moisture All Influence Starch Availability of Steam-Flaked Corn

E.F. Schwandt, M.E. Hubbert[1], D.U. Thomson, C. Vahl, S.J. Bartle, and C.D. Reinhardt

Introduction

Steam-flaked corn is commonly fed in feedlot finishing diets because steam-flaking improves starch availability and nutrient utilization, thus improving the overall feeding value of corn. In most operations which utilize steam-flaked corn, grain is processed to a pre-determined flake density by setting the rolls to a specific separation distance and using tension to hold rolls together. Flaked grain is most often produced to a bulk density between 24 and 32 lb/bu, with a common recommendation of 27 lb/bu for corn; however, flake density among steam-flakers within a single mill and among feedlots can vary greatly. Flaking to a similar density using 2 flakers does not ensure similar starch availability.

The degree of starch gelatinization or starch availability of steam-flaked corn can be estimated using analytical procedures such as enzymatic hydrolysis, gas production, and steam-flaked corn gelatinization methods. Routinely evaluating starch availability is used as a quality control method to standardize the steam-flaking process to ensure within-day and day-to-day manufacturing consistency. The concentration of readily available starch in steam-flaked corn is indicative of the rate of starch fermentation in the rumen. When starch is too readily available and is fermented at an excessively rapid rate, acid can accumulate in the rumen, reducing ruminal pH, and ultimately resulting in increased prevalence of digestive disturbances.

Factors that contribute to variation between feedlot operations with respect to steam-flaked corn quality include type and dimensions of flaking equipment, grain type, grain variety and moisture content, roll wear, and steam-flaking procedures. Sampling and handling procedures contribute to precision of results; therefore, sampling procedures need special attention, and consistency must be evaluated when attempting to determine starch availability of steam-flaked corn.

The objective of this study was to evaluate starch availability of steam-flaked corn comparing roll dimensions and steam-flaked corn flake densities among flaking systems and feedyards and to provide information on the equipment utilized, steam-flaked corn

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flaking procedures, and to define current manufacturing practices of steam-flaking in commercial feedlot operations.

Key words: flake density, starch availability, steam-flaked corn

Experimental Procedures

Commercial feedlots (n = 17) which regularly steam-flake grain in their operations were selected for inclusion in this study. Data were collected from August through October 2015. Each individual roll set (n = 49) within each feedlot was considered the observational unit; samples were collected during normal operating procedures after the mill had been in operation for a minimum of 2 hours.

Steam-conditioned whole corn samples were most commonly collected directly above the rolls located at the peg feeder. Investigators were unable to collect steam-conditioned grain from 2 flakers. Flaker design dictated that steam-conditioned corn samples from 14 flakers be collected below the rolls with the rolls separated and temporarily not in operation. Steam-flaked corn was collected directly below the rolls and across the entire length of the roll using a shovel. Flake density was measured 3 separate ways using a hand-held density tester: 1) measured by yard personnel using the feedyard's quart cup hand-held density tester under their normal operating procedures (Yard flake density); 2) measured by the investigator using the same procedure at every yard: steam-flaked corn sample was taken directly below the rolls using a shovel and immediately allowed to fall freely into the quart cup to over-fill, then steam-flaked corn was leveled off with a strike off stick in a zig-zag motion across the rim of the cup, and weighed (Hot flake density); and 3) measured by the investigator using the same procedure at every yard: steam-flaked corn sample was taken directly below the rolls using a shovel, immediately spread out on a clean, flat surface (thickness of approximately 1.2 in.), allowed to cool for 15 minutes, gently swept into a dust pan and allowed to freely fall into the quart cup to over-fill, then steam-flaked corn was leveled off with a strike off stick in a zig-zag motion across the rim of the cup, and weighed (Cooled flake density). Steam-flaked corn was collected directly below the rolls and across the entire length of the roll, immediately spread out onto a clean, flat surface (thickness of approximately 1.2 in.), allowed to cool for 15 minutes, gently swept into a dust pan, funneled into a 1.23 L plastic cylinder, leveled off with a strike off stick, and weighed (Volumetric). Flake Color Index System analysis was conducted on cooled steam-flaked corn samples from each roll set. The ground sample of steam-flaked corn used for the Flake Color Index System measurement was subsequently submitted for total starch and available starch using enzyme hydrolysis. Cooled steam-flaked corn samples were also analyzed for flake thickness. Twenty-five whole, intact flakes from each set of rolls were measured at the center of the flake, using a micrometer and thickness (mm) was recorded; average thickness values for each roll set were used in this analysis and were representative of spacing between rolls. Roll corrugations were measured by evaluating the number of grooves per inch from various whole flakes from each sample and roll corrugations were reported as either round-bottom vee or Stevens profile.

Data were analyzed as a multiple linear regression using the PROC MIXED procedure of SAS (SAS Institute, Inc., Cary, NC). Pearson's correlation coefficients (r) were determined for each pair of continuous variables considered for potential use as independent variables in the multiple linear regression model using PROC CORR of SAS to determine potential collinearity ($r \geq 0.70$; $P<0.10$). For pairs of variables which were determined to be collinear, only 1 variable was selected to be tested in the regression model for significance. Manual forward selection was used to fit a regression model to the response variables and determine significant ($P<0.10$) explanatory variables. The ultimate model statement included starch availability measured using enzymatic hydrolysis as a response variable, and cooled flake density, steam-flaked corn moisture, and roll diameter ($P<0.10$) were used as fixed effects. Flaker was considered the experimental unit and feedyard and flaker within feedyard were used as random effects. The final significant variables were analyzed using the PROC REG procedures and PCORR2 function of SAS to determine partial R^2. A simple linear regression using the REG procedure of SAS was used to evaluate the following variables: Hot flake density vs. Yard flake density, Hot flake density vs. Cooled flake density, Yard flake density vs. Enzymatic, Flake thickness vs. Hot flake density, and Flake thickness vs. Cooled flake density.

Results and Discussion

Consulting nutritionists (n = 7) suggested names of feedlots (n = 17) to participate in this survey. Each individual flaker (n = 49) was considered an independent observational unit. Roll size varied considerably between feedyards. The most prevalent roll size was 24 × 48 in. (24.5%). Roll diameter ranged from 18 to 36 in., and roll length ranged from 24 to 68 in. In addition to roll size, the ratio of length to diameter was also reported and averaged 1.9 with a range of 1.33 to 2.33.

Flake density measured by yard personnel averaged 27.5 lb/bu; hot flake density averaged 27.7 lb/bu; and cooled flake density measured by the investigator was 24.1 lb/bu. Differences between Yard flake density and Hot flake density measurements were attributed to some yards sifting out fines prior to measuring hot flake density. Flake density measurements taken by the investigator were completed the same way at all feedyards. Roll corrugations ranged from 14 to 16 grooves per inch and were reported by mill personnel as either round-bottom vee or Stevens Tooth profile. Most feedyards assessed roll wear by physically evaluating flake quality and by looking at changes in enzymatic starch availability. Roll wear was not assessed in this survey and could have had an impact on the results of the analysis. Average flake thickness across all flakers was 1.76 mm with a range of 1.22 to 2.45 mm. Enzymatic hydrolysis starch availability values ranged from 37 to 65% with an average of 51%. The median starch availability value was 51% and the mode was 46%. All feedyards routinely submitted samples to commercial laboratories for starch availability analysis using the enzymatic hydrolysis method. Most of the feedyards surveyed submitted weekly (66.7%) samples, while the remaining feedyards submitted monthly (33.3%) samples. Two feedyards also routinely evaluated starch availability using the Flake Color Index System.

Significant ($P<0.10$) variables contributing to the final multiple linear regression model using Enzymatic as the dependent variable were: steam-flaked corn moisture, cooled flake density, and roll diameter (Enzymatic = 119.72 - (1.22 × steam-flaked corn moisture) - (2.42 × cooled flake density) + (0.47 × roll diameter); $R^2 = 0.5276$; $P<0.10$).

Implications

Manufacturing equipment and quality control measures vary greatly across commercial feedyards in the United States. Within each feedyard, each roll set should be managed as an individual unit given that no two units are the same. Each roll set is unique in roll wear, roll gap, mill load, steam cabinet temperature, retention time, etc. All of these variables can influence steam-flaked corn production capacity and quality. This study has identified cooled flake density, steam-flaked corn moisture, and roll diameter to be significant variables contributing to enzymatic starch availability in commercial feedyards located in the United States.

Table 1. Multiple linear regression coefficient estimates for variables related to changes in enzymatic starch availability of steam-flaked corn in 17 commercial feedyards surveyed in Nebraska, Kansas, Colorado, Texas, New Mexico, Arizona, and California

Variable	Estimate	Standard error	P<F	Partial R^2
Intercept	119.72	10.974	< 0.01	
Cooled flake density, kg/L[1]	-2.42	0.379	< 0.01	0.4764
Steam-flaked corn moisture, %	-1.22	0.441	0.02	0.1456
Roll diameter, cm	0.47	0.244	0.06	0.0749

[1]Cooled flake density was measured by the same investigator after cooling.

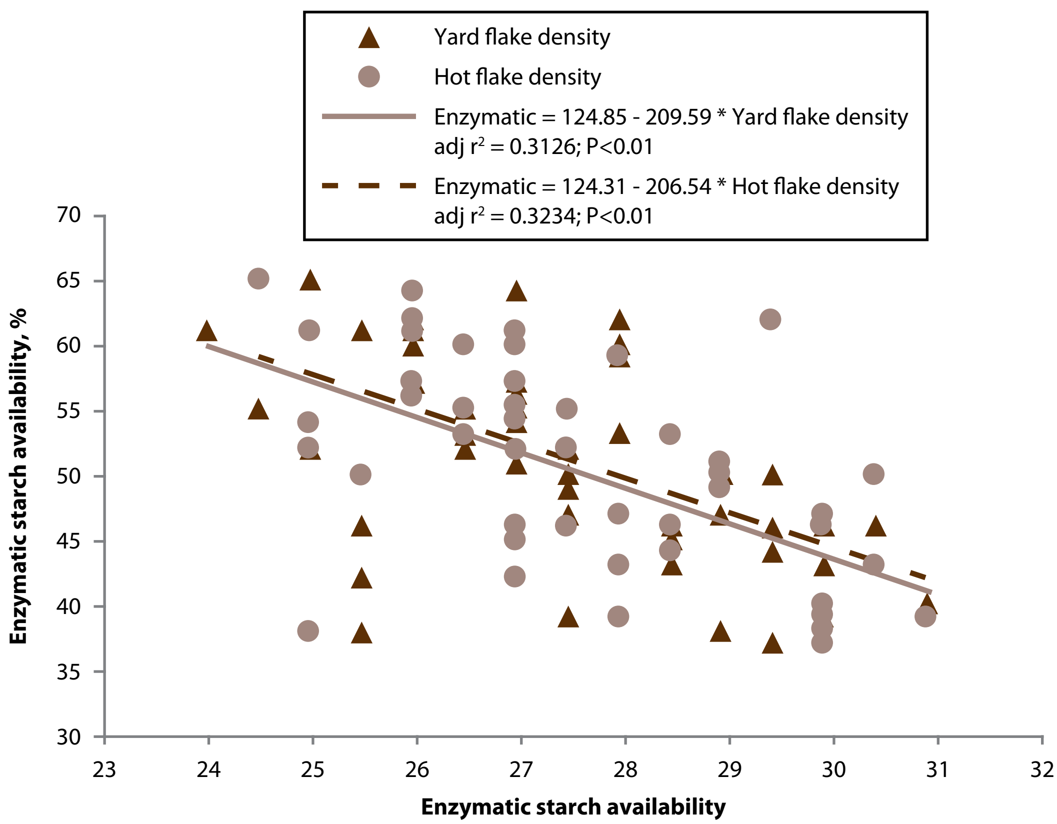

Figure 1. Simple linear regression model comparing the relationships between enzymatic starch availability (Enzymatic) and yard personnel flake density and Enzymatic and investigator flake density for 17 commercial feedyards surveyed in Nebraska, Kansas, Colorado, Texas, New Mexico, Arizona, and California. (Standard error of the mean = 2.188.)

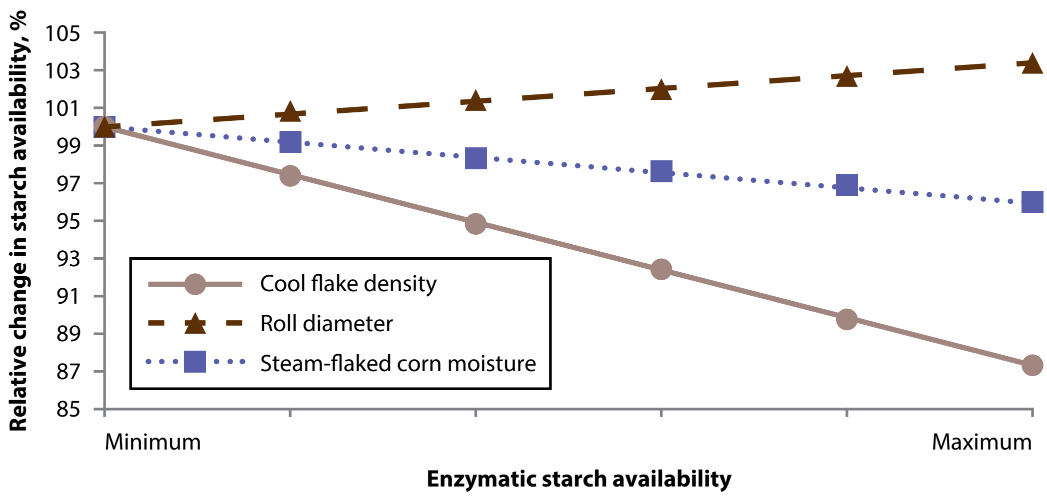

Figure 2. Multiple linear regression equation illustrating the relative effects of starch availability for the complete range of values within dataset for significant variables: Cooled flake density, roll diameter, and steam-flaked corn moisture for 17 commercial feedyards surveyed in Nebraska, Kansas, Colorado, Texas, New Mexico, Arizona, and California. (Enzymatic = 119.72 - (1.22 × steam-flaked corn moisture) - (2.42 × cooled flake density) + (0.47 × roll diameter) All variables but one were held constant at the mean of the data collected, and values for the third variable were entered from the minimum to the maximum values within the dataset. Then, the relative effect of each change was calculated as:

$$\frac{\text{change in starch availability}}{\text{original starch availability}} \times 100$$

A Survey of Dry Processed Corn Particle Size and Fecal Starch in Midwestern U.S. Feedlots

E.F. Schwandt, D.U. Thomson, S.J. Bartle, and C.D. Reinhardt

Introduction

Optimizing grain processing practices in cattle feeding operations is critical to reaching maximum feed utilization efficiency. An increased degree of grain processing has consistently shown improved dry matter and starch digestibility; however, it exists with conflicting results on improving performance in finishing cattle. These inconsistencies are likely due to diet composition, such as roughage and co-product level, that could offset the effects of reduced particle size on rate of fermentation thus reducing the risk of digestive dysfunction.

Finishing diets are commonly formulated with processed grain to increase utilization of starch and improve animal performance. Processing methods including steam-flaking, grinding, or dry-rolling improve total tract starch digestibility compared with that of whole grain. When dry-rolling corn for finishing cattle, recommendations often suggest that grain be coarsely processed, or cracked to prevent production of an excessive quantity of fine material that could potentially result in an increased rate of fermentation, reduced rumen pH, and digestive disturbances. However, previous research has reported that inclusion of dried distillers grains in finishing diets may influence optimal grain processing method. Grinding corn to a finer particle size when the grain is fed in combination with distillers grains may result in improved total tract starch utilization without causing reduced ruminal pH and digestive disturbances.

The objective of this survey was to provide the feedlot industry with an indication of average particle size distribution from current manufacturing practices of dry processed corn, fecal starch content, and co-product and roughage inclusion levels in Midwestern feedlots.

Key words: dry rolled corn, feedlot, particle size

Experimental Procedures

Feedlots (n = 35) were asked to participate in a survey to evaluate dry-rolled corn processing practices, processed corn particle size distribution, and fecal starch content in finishing cattle. Feedlots were located in the central United States, including Kansas, Nebraska, South Dakota, Minnesota, Colorado, and Iowa. Samples of dry processed corn and finishing diet were collected from each feedlot, along with samples of freshly voided feces collected from 3 pens of finishing cattle with samples collected from 3 animals per pen with a total of 9 samples per feedlot composited. The survey was conducted from November 2013 through March 2014. Sample collection included a dry processed corn sample, diet sample, and fecal samples. Dry processed corn samples were collected from the ground corn storage pile. Grain samples (~17 oz) were typically collected from 3 locations in the pile from approximately 5.9 in. deep. If corn was ground directly into the mixer truck (n = 2), the sample was collected in the mixer truck during loading. Diet samples (~17 oz) were collected across 5 locations in the bunk immediately after feeding. Diet samples (n = 5 per pen) were placed in a 20 quart bucket, hand-mixed, and poured onto a clean concrete surface. Piles were quartered, and 2 aliquots of diet were sub-sampled from 2 opposite quarters, placed in a plastic bag and frozen. Diet samples were analyzed at a commercial lab for moisture, dry matter, crude protein, acid detergent fiber, neutral detergent fiber, fat, calcium, phosphorus, potassium, and magnesium.

Fecal samples were collected from 3 pens of cattle per feedlot which were consuming the finishing diet. Samples were collected from 3 animals per pen, composited, and frozen, for a total of 9 composited samples per feedlot. Cattle were required to be transitioned to a finishing diet for a minimum of 5 days prior to taking fecal samples so fecal starch wasn't influenced by step-up diets. Fecal samples were analyzed for moisture, dry matter, and total starch. Dry processed corn samples were analyzed for particle size distribution.

Formulated diet composition was provided by nutritionists (Table 1; one from each feedyard; n = 32). Dry processed corn was the primary energy source in all operations involved in this survey. In addition, there were other sources of starch, such as earlage, high moisture corn, and corn silage in most of the feedlots surveyed, which compromised the ability to determine any relationship between fecal starch and dry-rolled corn particle size. Co-products were in the form of wet distillers grain, wet corn gluten feed, and modified wet distillers grains. Roughage sources included ground hay (Conservation Reserve Program, brome, prairie, or mixture), corn silage, corn stalks, and wheat straw.

All data were entered and tabulated in a Microsoft Excel spreadsheet. Mean, standard deviation, and minimum and maximum values were calculated using spreadsheet formulas.

Results and Discussion

Average particle size of dry processed corn, including dry-rolled and hammermill-ground corn across all operations (n = 35) was 0.166 ± 0.050 in. with a range of 0.046 to 0.269 in. (Table 2). Dry-rolled corn average particle size (n = 31) was 0.179 ± 0.035

in. with a range of 0.085 to 0.269 in. Hammermill-ground corn (n = 4) average particle size was 0.072 ± 0.046 in. with a range of 0.046 to 0.140 in. Fecal starch content averaged 19.0 ± 6.5% with a range of 7.0 to 36.6%. Diet composition was evaluated for co-product (27.8 ± 13.4%) roughage concentration (8.9 ± 2.0%) and neutral detergent fiber concentration (19.3 ± 4.3%). The nutrient analysis of the diets is shown in Table 3.

Implications

Results from this survey provide the industry with a greater understanding of the degree of processing that is currently practiced and the resulting fecal starch concentration, and diet formulation. Research in the area of dry-rolled corn particle size in finishing feedlot diets and its influence on feedlot performance and carcass characteristics is needed. These results do not directly compare dry-rolled corn particle size and fecal starch concentration, but the combined results suggest that dry-rolled corn particle size may affect total tract starch digestion. Diets formulated with a higher co-product level could include more finely processed grain in the diet. Co-products fed at higher levels could dilute the concentration of rapidly fermentable starch found in finely processed grain, thus achieving greater total tract starch digestion without affecting rumen function.

Table 1. Ingredient use in Midwestern U.S. finishing cattle diets[1]

Item	Number of feedlots	Feedlots, %
Grain		
Corn	32	100
Earlage	8	25
High moisture corn	8	25
By-product		
Wet distillers grains	15	47
Wet corn gluten feed	17	22
Modified wet distillers grains	10	31
Roughage		
Ground hay[2]	20	63
Corn silage	12	38
Corn stalks	7	22
Wheat straw	4	13

[1]Values from 32 feedlots located in the central United States.
[2]Ground hay sources consist of Conservation Reserve Program, brome, prairie, or a mixture of hay source.

Table 2. Dry processed corn particle size of Midwestern U.S. finishing cattle diets[1]

Item	Mean	Standard deviation	Range	
			Minimum	Maximum
Dry-rolled				
Geometric mean diameter (in.)	0.179	0.035	0.085	0.269
Hammermill				
Geometric mean diameter (in.)	0.072	0.046	0.046	0.140
Overall				
Geometric mean diameter (in.)	0.166	0.050	0.046	0.269
Fecal starch, %[2]	19.0	6.5	7.0	36.6

[1]Overall values from 35 feedlots located in the central United States.
[2]Fecal starch values obtained from 34 feedlots.

Table 3. Diet nutrient analysis (% of dry matter) of Midwestern U.S. finishing cattle diets[1]

Item	Mean	Standard deviation	Range	
			Minimum	Maximum
Crude protein, %	14.84	1.91	9.85	19.17
Fat, %	5.08	0.92	2.90	7.48
Phosphorus, %	0.44	0.11	0.25	0.63
Calcium, %	0.86	0.23	0.31	1.38
Potassium, %	0.87	0.12	0.31	1.05
Magnesium, %	0.22	0.04	0.12	0.61
Roughage, %[2]	8.9	2.0	5.3	15.6
By-product, %[2]	27.8	13.4	0.0	51.0
Neutral detergent fiber, %[2]	19.3	4.3	11.2	27.5

[1]Values from 32 feedlots located in the central United States.
[2]Roughage, by-product, and neutral detergent fiber values from 32 feedlots located in the central United States.

Length of Aging has Greater Effect than Lactic Acid Treatment on Color Stability of Beef Chuck Muscles

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Introduction

Lactic acid spray washes are widely used as an antimicrobial intervention in the beef industry. Sprays are typically applied to the exterior of carcasses and subprimal cuts to reduce or eliminate potential pathogenic bacteria. While the efficacy of these washes has been proven, other questions remain about their effect on color attributes of meat when applied to subprimal cuts. The objective of this study was to determine the effect of a lactic acid subprimal wash on the color stability of beef chuck rolls.

Key words: beef chuck muscles, lactic acid, color stability

Experimental Procedures

Twenty-four beef chuck rolls (Institutional Meat Purchase Specifications 116A) were transported to the Kansas State University Meat Laboratory from a commercial abattoir, denuded, and randomly assigned to a control water treatment or 3.6% lactic acid (1.9 pH) antimicrobial spray treatment. After treatment, each chuck roll was cut into four pieces with each piece being randomly assigned to an aging period of 3, 14, 21, or 28 days with every aging period represented within a chuck roll, and stored in the dark at 35-39°F. All chuck pieces were vacuum packaged in high barrier film and instrumental lightness (L*), redness (a*), and yellowness (b*) color readings were taken throughout the aging period. On the final day of each aging period, the chuck roll pieces were removed from the vacuum packages and cut into 1 in steaks, placed on foam trays with moisture absorbent pads, overwrapped with polyvinyl chloride film, and displayed under fluorescent lighting in a 7-day simulated retail display. A trained color panel evaluated redness and discoloration of the *complexus* and *serratus ventralis* of each steak daily. Panelists assigned scores for redness of both muscles using a 6-point scale: 0 = light pinkish-red, 20 = cherry red, 30 = dull red, 40 = slightly dark red, 50 = dark red, and 60 = very dark red. Panelists also assigned scores for discoloration directly representative of the percentage of surface discoloration. Instrumental L*, a*, and b* were recorded on each day of simulated retail display.

Results and Discussion

External L*, a*, and b* values for chuck rolls treated with water and lactic acid are shown in Table 1. The external color of beef chuck rolls from the water treatment became lighter ($P<0.05$) from days 0 to 14 indicated by an increase in L* values. The lightness of the lactic acid treatment did not change throughout the aging period. An aging by treatment interaction ($P<0.05$) was observed for external a* values. The water treatment had a redder ($P<0.05$) external color than the lactic acid treatment throughout the aging period as indicated by higher a* values. The water treatment showed a decrease in a* values from day 0 to days 21 and 28, getting less red. An aging by treatment interaction ($P<0.05$) was observed for external b* values. The water treatment maintained lower ($P<0.05$) b* values throughout the aging period, meaning the water treatment was less yellow than the lactic acid treatment regardless of aging time.

Redness scores for the *complexus* and *serratus ventralis* from chuck rolls from both treatments are shown in Table 2. Panelists reported lower ($P<0.05$) redness scores for the *complexus* muscles from the lactic acid treatment on day 0, indicating a duller red compared to the slightly dark red *complexus* muscles from the water treatment. Redness scores for the *serratus ventralis* muscle from the water treatment increased ($P<0.05$) from days 0 to 21 and remained constant for the remainder of the aging period. Redness scores for the lactic acid treatment increased ($P<0.05$) from days 21 to 28. It is important to note that these increases in redness scores indicate the *serratus ventralis* got darker, transitioning from a dull red to a slightly dark red.

Percent discoloration scores for the *complexus* and *serratus ventralis* from chuck rolls from both treatments are shown in Table 3. An aging by treatment interaction ($P=0.02$) was observed for discoloration of the *complexus* and *serratus ventralis* muscles. Panelist reported higher discoloration scores for the *complexus* muscles from the lactic acid treatment at day 28 compared to day 0. Panelist discoloration scores for the *serratus ventralis* increased from days 0 to 14 and then remained constant for both the water and lactic acid treatments. These increases in discoloration scores indicate a greater percentage of surface discoloration after the day 0 aging period.

Instrumental L*, a*, and b* values for the *complexus* and *serratus ventralis* muscles from chuck rolls from both treatments are shown in Table 4. Instrumental L* values for the *complexus* muscle increased ($P<0.05$) from day 0 to day 14 and remained constant throughout the remainder of the aging period for both the water and lactic acid treatments. This indicates that the *complexus* muscle for both treatments became lighter over the 28-day aging period. Instrumental L* values for the *serratus ventralis* muscle from the water treatment increased ($P<0.05$) from day 21 to day 28. Instrumental L* values for the *serratus ventralis* from the lactic acid treatment increased ($P<0.05$) from day 0 to day 14. This indicates that both treatments became lighter throughout the aging period, with the lactic acid treatment becoming lighter at a greater rate. Instrumental a* values for the *complexus* muscle decreased ($P<0.05$) from day 0 to day 14 for both the water and lactic acid treatments. This decrease in a* value means that both water and lactic acid treatments became less red over time. Similarly, instrumental a* values for the *serratus ventralis* decreased ($P<0.05$) from day 0 to day 14 (Figure 4) for both water and lactic acid treatments. This decrease in a* value indicates that the *serratus ventralis* for both the water and lactic acid treatments became less red over time. Instrumental b* values for the *complexus* muscle decreased ($P<0.05$) from days 0 to 14 for both treatments. This indicates that the *complexus* became less yellow over time. Instrumental b* values for the *serratus ventralis* also decreased ($P<0.05$) from days 0 to 14 for both treatments. This decrease indicates that the *serratus ventralis* also became less yellow over time.

Beef chuck rolls treated with water had a redder external color than chuck rolls treated with lactic acid throughout the aging period. During simulated retail display, aging time appeared to be the greatest factor in color stability. This is shown by the color panel reporting darker red colored *complexus* and *serratus ventralis* muscles with a higher percentage of discoloration after the day 0 aging period. This is further supported by the decrease in instrumental a* values for both treatments after the day 0 aging period, indicating a less red product.

Implications

The application of lactic acid washes negatively impacts the color of the treated chuck roll surface, resulting in a less red external color. However, the treatment does not impact the redness or discoloration of steaks cut from treated chuck rolls. Length of aging, not exterior antimicrobial treatment, has the greatest effect on color stability of beef chuck muscles under retail display conditions.

Table 1. Mean external lightness (L*), redness (a*), and yellowness (b*) values for beef chuck rolls treated with water or lactic acid and aged in a vacuum package at 35-39°F for up to 28 days

	Aging time				
Color attribute	Day 3	Day 14	Day 21	Day 28	SEM[1]
L*[2]					
Water	33.1^{by}	35.3^{ay}	35.1^{ay}	35.6^{ay}	0.692
Lactic acid	34.3^{ay}	35.9^{ay}	34.8^{ay}	35.5^{ay}	0.692
a*[3]					
Water	19.5^{ay}	18.7^{aby}	18.2^{by}	18.2^{by}	0.48
Lactic acid	16.8^{az}	15.9^{bz}	16.6^{az}	16.9^{az}	0.48
b*[4]					
Water	10.6^{bz}	11.4^{az}	10.8^{abz}	9.9^{bz}	0.477
Lactic acid	14.4^{by}	15.7^{ay}	15.2^{aby}	15.5^{ay}	0.477

[1]Standard error of the mean.
[2]L* lightness (0 = black, 100 = white).
[3]a* redness/greenness (positive values = red, negative values = green).
[4]b* yellowness/blueness (positive values = yellow, negative values = blue).
[ab]Means within a row with different superscripts differ ($P<0.05$).
[yz]Means within a column with different superscripts differ ($P<0.05$).

Table 2. Mean redness scores for the *complexus* and *serratus ventralis* muscles from beef chuck rolls treated with water or lactic acid and aged in a vacuum package at 35-39°F for up to 28 days

	Aging time				
Redness[1]	Day 3	Day 14	Day 21	Day 28	SEM[2]
complexus					
Water	60.3^{ax}	62.6^{ax}	61.4^{ax}	63.0^{ax}	2.31
Lactic acid	55.2^{ay}	59.8^{ax}	56.9^{ax}	59.9^{ax}	2.31
serratus ventralis					
Water	55.3^{bx}	66.7^{ax}	67.4^{ax}	62.8^{ax}	2.31
Lactic acid	54.6^{bx}	60.2^{abx}	60.5^{aby}	64.5^{ax}	2.31

[1]Redness color scale: 0 = light pinkish-red, 20 = cherry red, 40 = dull red, 60 = slightly dark red, 80 = dark red, and 100 very dark red.
[2]Standard error of the mean.
[ab]Means within a row with different superscripts differ (P<0.05).
[yz]Means within a column, within a muscle with different superscripts differ (P<0.05).

Table 3. Mean percent discoloration scores for the *complexus* and *serratus ventralis* muscles from beef chuck rolls treated with water or lactic acid and aged in a vacuum package at 35-39°F for up to 28 days

	Aging time				
Discoloration[1]	Day 3	Day 14	Day 21	Day 28	SEM[2]
complexus					
Water	37.8^{az}	39.5^{az}	37.2^{az}	43.1^{az}	3.41
Lactic acid	36.9^{bz}	45.5^{abz}	43.6^{abz}	46.1^{az}	3.41
serratus ventralis					
Water	32.7^{bz}	39.1^{az}	38.2^{az}	43.7^{az}	3.41
Lactic acid	33.9^{bz}	45.1^{az}	43.9^{az}	45.9^{az}	3.41

[1]Percent discoloration.
[2]Standard error of the mean.
[ab]Means within a row with different superscripts differ (P<0.05).
[z]Means within a column, within a muscle with different superscripts differ (P<0.05).

Table 4. Mean lightness (L*), redness (a*), and yellowness (b*) values for the *complexus* and *serratus ventralis* muscles from beef chuck rolls treated with water or lactic acid and aged in a vacuum package at 35-39°F for up to 28 days

	Aging time				
Color Attribute	Day 3	Day 14	Day 21	Day 28	SEM[1]
complexus					
L*[2]					
Water	34.7[by]	39.0[ay]	39.1[ay]	39.8[az]	0.821
Lactic acid	36.0[by]	40.2[ay]	39.9[ay]	41.9[ay]	0.821
a*[3]					
Water	28.4[ay]	24.2[by]	22.3[by]	23.4[by]	0.734
Lactic acid	27.9[ay]	22.8[by]	21.0[by]	23.2[by]	0.734
b*[4]					
Water	28.4[ay]	23.8[by]	21.3[cy]	24.1[by]	0.685
Lactic acid	26.9[ay]	23.5[by]	21.0[cy]	24.9[by]	0.685
serratus ventralis					
L*[2]					
Water	36.5[by]	38.3[bz]	37.1[bz]	43.2[ay]	0.821
Lactic acid	36.7[by]	40.9[ay]	40.9[ay]	42.3[ay]	0.821
a*[3]					
Water	29.3[ay]	22.3[by]	21.5[by]	23.5[by]	0.734
Lactic acid	28.9[ay]	22.7[by]	20.9[by]	23.1[by]	0.734
b*[4]					
Water	29.1[ay]	20.2[cz]	18.9[cy]	23.3[by]	0.685
Lactic acid	28.9[ay]	22.2[cy]	20.0[cy]	24.0[by]	0.685

[1]Standard error of the mean.
[2]L* lightness (0 = black, 100 = white).
[3]a* redness/greenness (positive values = red, negative values = green).
[4]b* yellowness/blueness (positive values = yellow, negative values = blue).
[ab]Means within a row with different superscripts differ ($P<0.05$).
[yz]Means within a column, within a muscle with different superscripts differ ($P<0.05$).

Steak Location Within the *Semitendinosus* Muscle Impacts Metmyoglobin Accumulation on Steaks During Retail Display

K.J. Phelps, T.G. O'Quinn, T.A. Houser, and J.M. Gonzalez

Introduction

Beef color is a major attribute consumers utilize to make purchasing decisions. It is estimated poor color shelf-life of beef steaks costs the meat industry more than $1 billion annually. Shelf-life color is influenced by a balance of two biochemical processes within steaks: metmyoglobin reducing ability and oxygen consumption. Steaks that exhibit a greater metmyoglobin reducing and a reduced oxygen consumption are typically characterized as more color stable. Characteristics of the muscle fiber or muscle cell are what determine the properties of a steak. Commonly, muscles with more oxidative fibers have an elevated oxygen consumption and reduced metmyoglobin reducing ability. The *Semitendinosus* muscle or eye of round possesses a divergent muscle fiber isoform distribution based on the location steaks are fabricated. The objective of this study was to examine effects of steak location on muscle fiber type distribution and metmyoglobin accumulation of *Semitendinosus* steaks.

Key words: color stability, muscle fiber type, *Semitendinosus*

Experimental Procedures

Twenty *Semitendinosus* muscles (Institutional Meat Purchase Specifications 171C) purchased from a commercial abattoir were wet aged in a vacuum bag for 22 days at 35°F. Progressing from the proximal to distal end, each *Semitendinosus* was fabricated into twelve 1-in thick steaks. Steaks 1-4 were designated proximal, 5-8 were designated middle, and 9-12 were designated distal, with steaks 1, 6, and 12 utilized for fiber type analysis. Remaining steaks within each location were randomly assigned to 0, 4, or 9 days of simulated retail display. Steaks were placed on Styrofoam trays with an absorbent pad and overwrapped with poly-vinyl chloride film. Steaks were displayed in coffin-style retail cases set to 35°F under continuous fluorescent light. Day-0 and -4 steaks were utilized for metmyoglobin reducing ability and oxygen consumption analyses conducted according to procedures described by the American Meat Science Association. Day-9 steaks were subjected to daily objective surface discoloration measurements using a Hunter Lab Miniscan EZ and subjective steak surface discoloration analyses utilizing a visual panel of 8 panelists per day. On day 9 these steaks were also subjected to metmyoglobin reducing ability and oxygen consumption analyses.

Results and Discussion

To evaluate changes in discoloration of *Semitendinosus* steaks during display, metmyoglobin accumulation of *Semitendinosus* steaks was measured instrumentally over the course of 9-day simulated retail display. There was a location × day interaction (P<0.01) for surface metmyoglobin percentage (Figure 1). On day 0 of display, proximal steaks had less surface metmyoglobin than the other locations (P<0.01), which were not different (P=0.51). On day 1, middle steaks had more metmyoglobin than the other locations (P<0.04), but distal steaks and proximal steaks did not differ (P=0.70). From day 2 to 6, middle steaks had more metmyoglobin than steaks from other locations (P<0.01), which did not differ (P>0.17). On day 7 of display, middle steaks tended to have more metmyoglobin than steaks from other locations (P<0.09), which did not differ (P=0.65). On day 8 and 9, middle steaks had more metmyoglobin than proximal steaks (P<0.02), and distal steaks did not differ from the two locations (P>0.15).

In addition to measuring metmyoglobin accumulation using an instrument, a visual panel was used assess the amount of discoloration on *Semitendinosus* steaks. There was a location × day interaction (P<0.01) for visual panel percent discoloration scores (Figure 2). No differences in panel percent discoloration scores were found between muscle locations on day 0 (P=1.00); however from day 1 to 5, middle steaks had more discoloration than proximal and distal steaks (P<0.04), which did not differ (P>0.12). From day 6 to 8, middle steaks had more discoloration than proximal steaks (P<0.05), and steaks from both locations did not differ from distal steaks (P>0.16). On day 9, proximal steaks had less discoloration than middle and distal steaks (P<0.03), which did not differ (P=0.72).

Accumulation of metmyoglobin on the surface of steaks is a balance of two biochemical processes within the steaks, metmyoglobin reducing ability and oxygen consumption. There was a location × day interaction (P<0.01) for metmyoglobin reducing ability, (Figure 3). There was no location × day interaction (P=0.33) for oxygen consumption indicating that only metmyoglobin reducing ability was driving metmyoglobin accumulation the surface of the *Semitendinosus* steaks. On day 0 and 4 of display, proximal and distal steaks had greater metmyoglobin reducing ability than middle steaks (P<0.01), but were not different (P=0.33) from one another. At day 9 of display, all locations possessed the same metmyoglobin reducing ability (P>0.51). At the end of display all locations also did not differ in surface metmyoglobin which corresponds to the reducing ability at the end of display.

Because muscle fiber type determines characteristics of a steak, the muscle fiber type distribution was examined across the locations of the *Semitendinosus* (Figure 4). Location affected percentage of all 3 fiber types (P<0.01). There were fewer type I fibers in proximal steaks than the other two locations (P<0.01), and middle steaks tended to have more type I fibers (P=0.10) than distal steaks. Proximal steaks had more (P<0.01) type IIA fibers than the middle location, and tended to have more (P=0.07) type IIA fibers than distal steaks. Steaks from proximal and middle locations did not differ (P=0.72) in type IIX fiber percentage, but did possess more type IIX fibers than the distal steaks ($P<0.01$).

Implications

Throughout most of display, middle steaks accumulated more surface metmyoglobin than proximal and distal steaks, which was also detected by a visual panel. Steaks from the middle location possessed less metmyoglobin reducing ability compared to the other two locations on days 0 and 4 of display. Reduced metmyoglobin reducing ability and discoloration may be due to the middle location tending to possess less type IIA fibers. Based on these data, retailers selling steaks from the *Semitendinosus* need to be conscious that steaks from the middle of the muscle discolor faster. Retailers may want to display steaks from this location during times when the case is turning over more quickly.

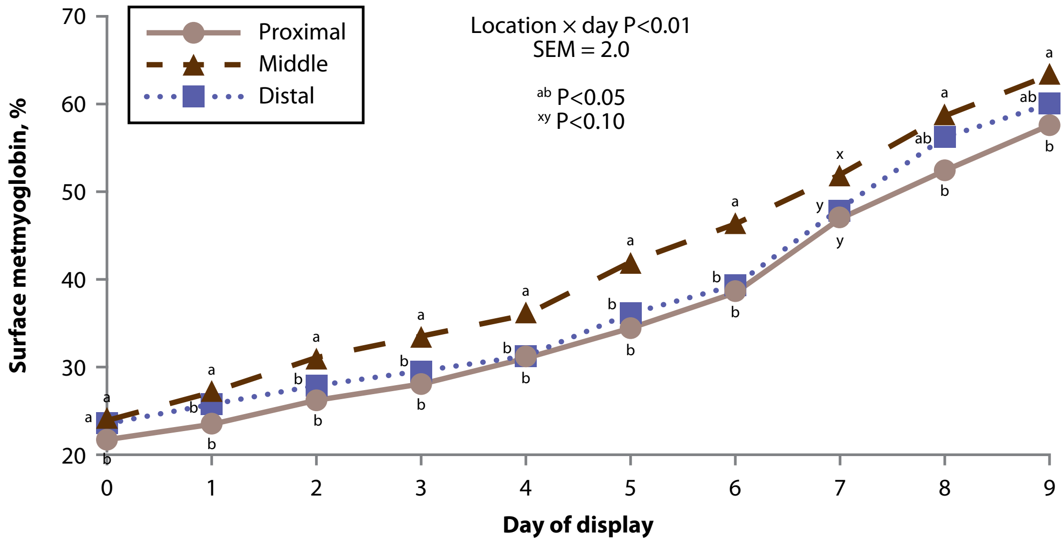

Figure 1. Surface metmyoglobin percentage of *Semitendinosus* steaks under simulated retail display captured using a Hunter Lab Miniscan.

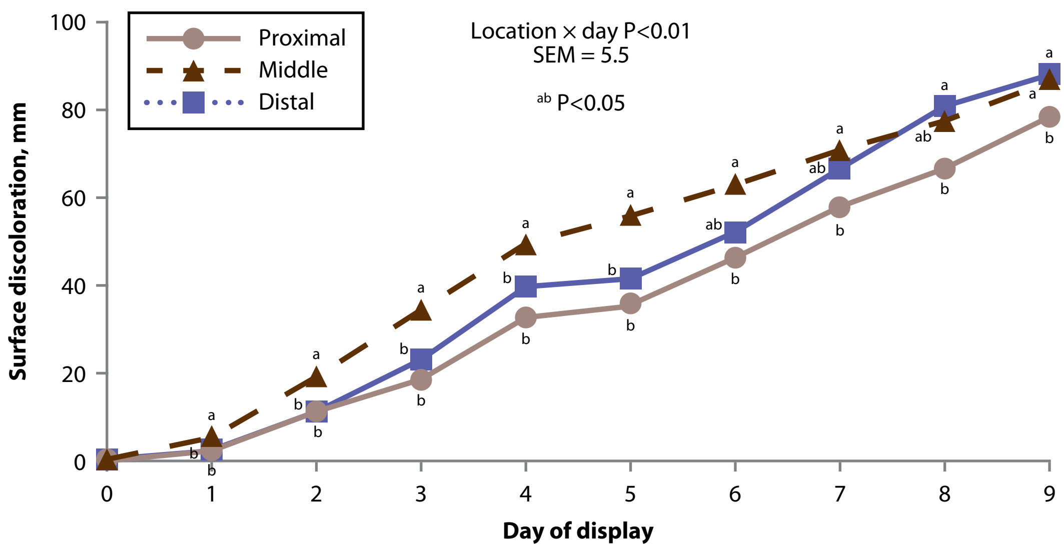

Figure 2. Surface discoloration percentages as observed by a visual panel; 0 mm = 0% discoloration; 100 mm = 100% discoloration.

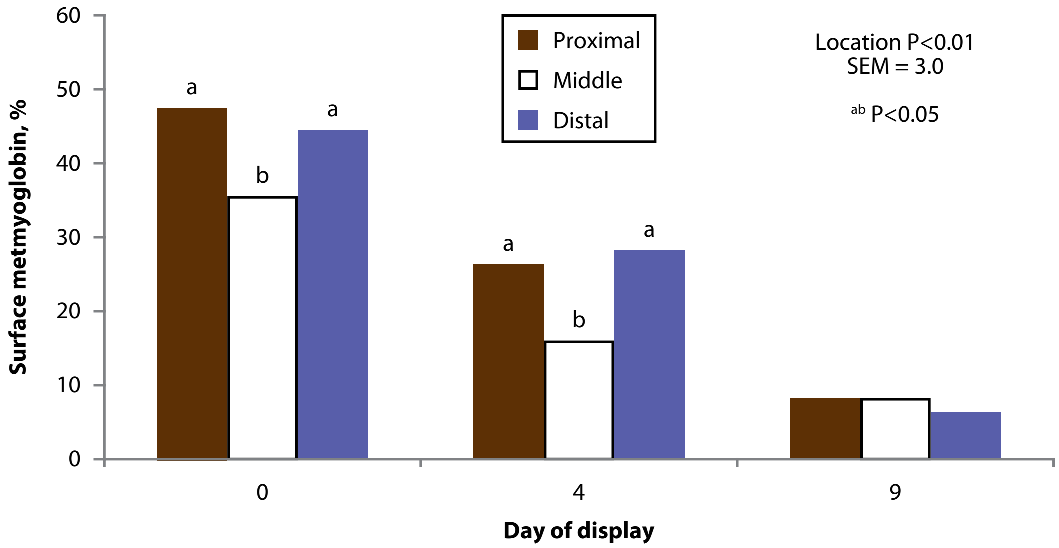

Figure 3. Metmyoglobin reducing ability of *Semitendinosus* steaks on day 0, 4 and 9 of simulated retail display.

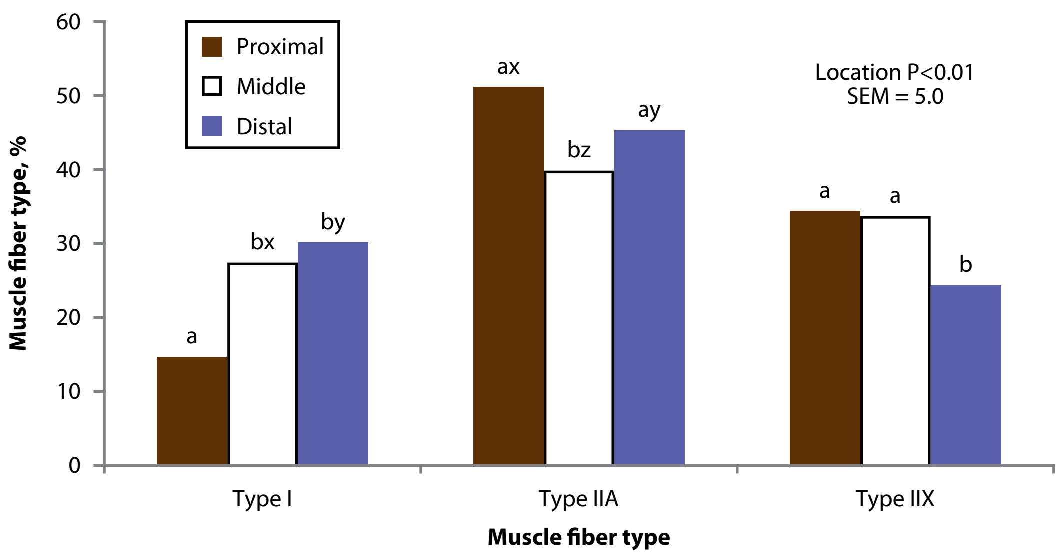

Figure 4. Muscle fiber type distribution of the proximal, middle, and distal locations within the *Semitendinosus*.

[ab]Within fiber type, means without common superscripts are different ($P<0.05$).

[xy]Within fiber type, means without common superscripts tend to be different ($P<0.10$).

Brahman Genetics Negatively Impact Protein Degradation and Tenderness of *Longissimus Lumborum* Steaks, but do Not Influence Collagen Cross-Linking

K.J. Phelps, D.D. Johnson[1], M.A. Elzo,[1] C.B. Paulk[2], and J.M. Gonzalez

Introduction

Beef tenderness is an important factor contributing to consumer eating satisfaction of beef products. Tenderness is dependent on several factors including: breed-type, postmortem age time, myofibrillar muscle protein degradation, and collagen content. During the past 30 years, numerous studies have indicated steaks from cattle with a greater percentage of Brahman genetics are tougher than steaks from *Bos taurus* cattle. The cause of tougher steaks is commonly attributed to Brahman cattle having a greater calpastatin activity which inhibits calpains, the enzymes responsible for myofibrillar protein degradation during the postmortem aging process. Some researchers have reported calpastatin activity was poorly correlated to tenderness of steaks from Brahman cattle. Others have reported sensory panelists indicated steaks from cattle with increasing percentages of Brahman genetics have an increase in the amount of connective tissue or collagen. Additionally, researchers have reported an increase in expression of genes that play a role in cross-linking of collagen which decreases collagen solubility. Due to these findings, we hypothesized steaks from cattle with greater Brahman genetics have more collagen cross-links and therefore a less soluble collagen fraction. The objective of this study was to evaluate the effect of Brahman genetics on protein degradation, collagen cross-linking, and meat tenderness of strip loin steaks.

Key words: Brahman, collagen, tenderness

Experimental Procedures

Steers (n = 131) from the University of Florida Multi-breed Herd born in 2012 and 2013 were classified into four breed categories. The four breed categories were Angus in which steers had 26/32nd or greater of Angus genetics (100% Angus/0% Brahman), Brangus in which steers had 20/32nd Angus genetics (62.5% Angus/32.5% Brahman), Half-Blood in which steers had 14/32 to 18/32nd Angus genetics (50% Angus/50% Brahman), and Brahman in which steers had 0/32 to 9/32nd Angus genetics (0% Angus/100% Brahman). All steers were weaned at 210 days of age and reared under

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the same conditions until harvest. Steers were harvested at a common compositional endpoint of 0.5 in. of back fat over the 12th/13th rib. Following a 24-hour chill time, a 3 in. thick loin roast extending from the 13th rib towards the posterior end of the loin was collected from each carcass and wet-aged 14 days in a vacuum bag at 35°F. After aging, three 1 in. steaks were fabricated from each roast. Steak one was utilized for objective tenderness analysis by Warner-Bratzler shear force, steak two was utilized for trained sensory panel analysis, and steak three was used to measure myofibrillar protein degradation and collagen characteristics. Steaks utilized for Warner-Bratzler shear force were cooked on open-hearth grills (Model 450-A, Farberware, Yonker, NY) to an internal temperature of 160°F, cooled overnight at 35°F, and 6, 1 in. cores were removed perpendicular to the muscle fiber and sheared once. Sensory panel steaks were cooked in a similar manner as described above, but were then cut into 1 in. cubes and presented to trained sensory panel. Sensory panelists evaluated steaks for tenderness, juiciness, beef flavor, connective tissue amount tissue (1 = extremely tough, extremely dry, extremely bland, abundant; 8 = extremely tender, extremely juicy, extremely intense, none, and off-flavor (1 = extremely intense; 6 = none). Protein degradation analyses consisted of Western Blot quantification (Figure 1) of degradation products of desmin (38 kDa band) and troponin-T (36, 34, and 30 kDa band). Collagen cross-links were extracted by acid hydrolysis and the hydroxylysyl pyridinoline cross-link was quantified utilizing a commercial ELISA kit. The perimysial collagen fraction was extracted from the muscle, samples were dried, and subjected to differential scanning calorimetry to determine the peak temperature at which the perimysial collagen melts.

Results and Discussion

Because of the well documented body of literature on Brahman genetic influence on cooked meat characteristics, objective and subjective measures were evaluated (Table 1). As the percentage of Brahman genetics increased, strip loin steak thaw loss increased, but there was no effect ($P=0.14$) on cook loss. In agreement with data from previous literature, as the percentage of Brahman genetics increased Warner-Bratzler shear force increased (linear, $P<0.01$), indicating that increasing Brahman genetics decreases tenderness of steaks. Further, as percentage Brahman genetics increased, sensory panel scores of strip loin steak tenderness, connective tissue, and juiciness decreased (linear, $P<0.01$), indicating that steaks were tougher, had more connective tissue, and were less juicy. Brahman genetics had no effect on beef flavor or off-flavor scores ($P>0.35$).

Tenderness is influenced by two distinct components, myofibrillar protein degradation and collagen solubility. Steaks from steers with a greater percentage of Brahman genetics had decreased intensity of 38 kDa desmin, 34 kDa troponin-T, and 30 kDa troponin-T degradation bands (Table 2; linear, $P<0.03$). In contrast to these results, increasing Brahman genetics increased (linear, $P=0.04$) intensity of 36 kDa degraded troponin-T band. Decreased intensity of the desmin degradation band and the two smaller troponin-T degradation bands, and increased intensity of the troponin-T 36 kDa band signifies less myofibrillar protein degradation in steaks from steers with a greater percent of Brahman genetics. This decrease in myofibrillar protein degradation is likely driving the decreases in objective tenderness and sensory panel tenderness of steaks from steers with a greater percentage of Brahman genetics. Sensory panelists also detected increases in the amount of collagen within strip loins steaks as the percentage of Brahman genetics increased. There was no effect ($P=0.14$) of Brahman genetics on amount of the hydroxylysyl collagen crosslink, but as Brahman genetics increased, peak temperature to melt perimysial collagen from steaks tended (linear, P=0.07) to increase. Although there was no difference in the collagen crosslink measured, it is probable there may be other crosslinks that are increased in steaks from steers with greater Brahman genetics. This may be a cause of the increased melting temperature of the perimysial collagen.

Implications

As in most published literature, as the percentage of Brahman genetics increased, steak tenderness decreased. This decrease in tenderness is likely caused by a decrease in myofibrillar protein degradation, but is not caused by the amount of the hydroxylysyl pyridinoline crosslink. However, it does appear the increase in connective tissue detected by panelists in steaks from steers with greater Brahman genetics may be because the collagen was not as soluble due to a tendency for increased melting temperature of the perimysial collagen. Further research is needed to elucidate the cause of the heat stability of collagen from steaks of steers with greater Brahman genetics.

Table 1. The effect of Angus and Brahman genetics on objective and subjective measures of cooked meat tenderness of strip loin steaks wet-aged 14 days postmortem

	Angus/Brahman,[1] %					P-value	
Item	100/0	62.5/32.5	50/50	0/100	SEM	Linear	Quadratic
Objective measures							
Shear force, lb	37.22	38.23	40.78	43.46	2.47	0.01	0.86
Thaw loss, %	1.07	1.99	1.51	2.14	0.70	0.01	0.44
Cooking loss, %	15.73	13.80	15.39	14.21	1.43	0.14	0.54
Subjective measures[2]							
Tenderness	6.30	5.69	6.05	5.30	0.18	0.01	0.81
Juiciness	6.27	5.92	5.99	5.84	0.12	0.01	0.22
Beef flavor	5.75	5.70	5.87	5.68	0.09	0.56	0.35
Connective tissue	6.76	6.49	6.64	6.11	0.21	0.01	0.49
Off-flavor	5.86	5.85	5.85	5.87	0.05	0.84	0.73

[1] Steers (n = 131) were classified into 4 categories based on percentage of Angus and Brahman genetics. The breed groups were: 100% Angus/0% Brahman, 62.5% Angus/37.5% Brahman (Brangus), 50% Angus/50% Brahman, and 0% Angus/100% Brahman.
[2] Tenderness, juiciness, beef flavor, and connective tissue (1 = extremely tough, extremely dry, extremely bland, abundant; 8 = extremely tender, extremely juicy, extremely intense, none). Off-flavor (1 = extremely intense; 6 = none).

Table 2. The effect of Angus and Brahman genetics on protein degradation and collagen characteristics of strip loin steaks wet-aged 14 days postmortem

	Angus/Brahman,[1] %					P-value	
Item	100/0	62.5/32.5	50/50	0/100	SEM	Linear	Quadratic
Protein degradation[2]							
Intact desmin 55 kDa band	0.96	0.86	0.81	1.05	0.34	0.51	0.11
Degraded desmin 38 kDa band	1.42	1.27	0.97	0.76	0.69	0.01	0.89
Intact troponin-T 40 kDa band	1.30	0.94	1.01	1.11	0.44	0.34	0.04
Degraded troponin-T 36 kDa band	0.79	0.94	0.93	2.03	0.53	0.04	0.47
Degraded troponin-T 34 kDa band	0.74	0.70	0.46	0.19	0.41	0.01	0.30
Degraded troponin-T 30 kDa band	1.40	1.54	1.39	0.94	0.78	0.03	0.13
Collagen							
Collagen crosslink[3]	1644	1719	1747	1408	156	0.14	0.14
Perimysial collagen[4]	131.3	121.2	135.3	143.8	4.9	0.07	0.17

[1] Steers (n = 131) were classified into 4 categories based on percentage of Angus and Brahman genetics. The breed groups were: 100% Angus/0% Brahman, 62.5% Angus/37.5% Brahman (Brangus), 50% Angus/50% Brahman, and 0% Angus/100% Brahman.
[2] Protein degradation data measured in arbitrary units.
[3] Hydroxylysyl pyridinoline crosslink measured in ng/g tissue.
[4] Peak differential scanning calorimetry melting temperature in °F.

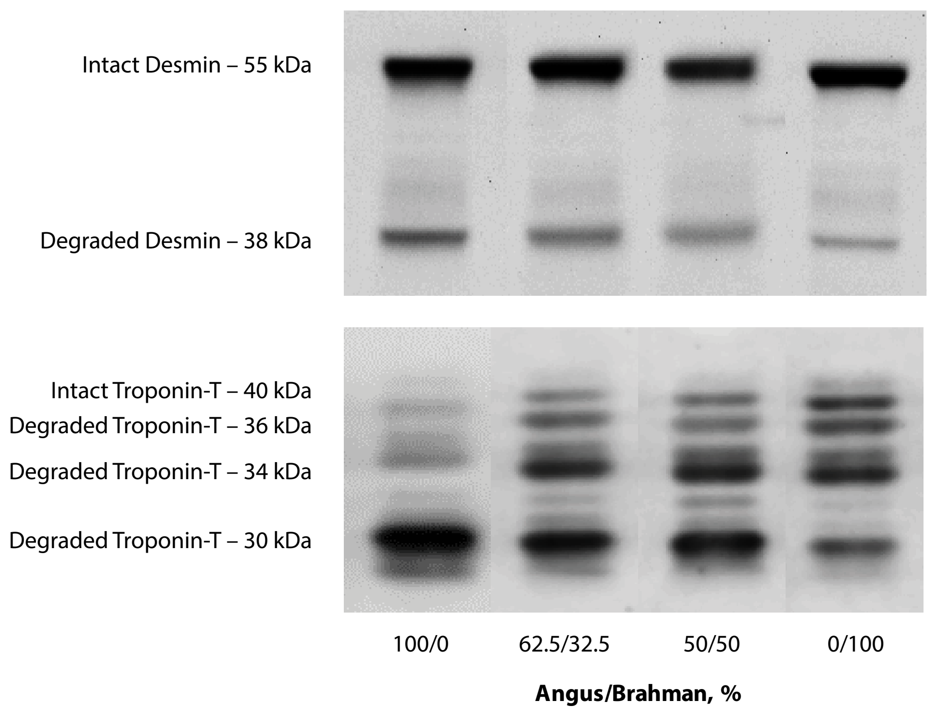

Figure 1. Representive western blots of desmin and troponin-T degradation of strip loin steaks from Angus (100% Angus/0% Brahman), Brangus (62.5% Angus/32.5% Brahman), Half-Blood (50% Angus/50% Brahman), and Brahman (0% Angus/100% Brahman) steers.

Tenderness, Juiciness, and Flavor Contribute to the Overall Consumer Beef Eating Experience

L.N. Drey and T.G. O'Quinn

Introduction

Overall beef palatability can be attributed to three primary traits, tenderness, juiciness, and flavor, as well as the interaction among these traits (Smith and Carpenter, 1974). Multiple authors have worked to identify which of these palatability traits contributes the most to overall eating satisfaction and have historically identified tenderness as the most important palatability trait (Savell et al., 1987; Miller et al., 1995a; Savell et al., 1999; Egan et al., 2001). Overall eating quality of beef steaks may excel at one or even two of these traits, yet fail to meet consumer eating expectations due to the unsatisfactory level of another trait. Conversely, a steak may be deemed acceptable by consumers primarily due to the outstanding level of a single trait despite the lower and even unacceptable levels of one or both of the other traits. To date, no comprehensive study has evaluated this interaction among palatability traits and assessed the relative risk of an unacceptable overall eating experience associated with the failure of a single or combination of palatability traits. It was the objective of this report to combine consumer palatability data collected during the past five years as a result of a series of trials that have evaluated the palatability traits of a diverse set of treatments in order to evaluate the relative contribution of tenderness, juiciness, and flavor to overall consumer eating satisfaction.

Key words: consumer, palatability, marbling

Experimental Procedures

Data from 11 consumer studies conducted within the past five years were selected for this report. Within each study, the same 100 mm line scales were used for consumer evaluation of steak tenderness, juiciness, flavor, and overall liking. Scales were anchored as extremely tough/dry/dislike extremely at the 0 end point and extremely tender/juicy/like extremely at the 100 end point. Additionally, consumers rated each trait as either acceptable or unacceptable (yes/no), providing definitive consumer perceptions of steak acceptability for each trait. All samples used in these studies were cooked using similar dry-heat grilling procedures. Collectively, these studies used more than 1,800 beef consumers from multiple regions of the United States and included 1,505 unique samples resulting in more than 12,000 individual consumer observations. The raw data from all studies were compiled as a single dataset. The average sensory score for each palatability trait was determined for each sample by averaging across the individual consumer ratings for the sample. A multivariate regression model was constructed using the sample means to determine the relative contribution of tenderness, juiciness, and flavor to consumer overall liking scores. Sample overall liking scores were used as the dependent variable and consumer tenderness, juiciness, and flavor liking scores as well as their interactions were used as explanatory variables. A step-wise selection procedure was used for inclusion of variables in the regression model. All variables that entered the model were significant ($P<0.05$) and had to remain significant ($P<0.05$) to be included in the final regression model. Additionally, the intercept was highly non-significant ($P>0.70$) and was therefore excluded from the model. The odds and relative risk of an unacceptable overall eating experience were determined based on the acceptability of the three individual sensory traits.

Results and Discussion

The final beef palatability model determined was:

Consumer overall liking = (0.42 × tenderness) + (0.07 × juiciness) + (0.48 × flavor)

This model accounted for greater than 99% of the variation ($R^2>0.99$) in consumer overall liking scores. This provides clear evidence that the linear combination of tenderness, juiciness, and flavor accounts for practically all of the variation in overall consumer eating satisfaction. The interaction terms among the three traits never entered the model, as they were non-significant ($P>0.05$). This indicates that the effects of tenderness, juiciness, and flavor on overall eating satisfaction are not dependent upon the level of the other traits.

Table 1 provides the estimates for the likelihood of overall palatability failure based on the failure/acceptance of the other traits. Odds ratios represent the relative increase in the odds of an event occurring (overall palatability failing) due to another event (unacceptable rating for tenderness, juiciness, or flavor). For example, in Table 1, the odds of overall palatability failing when tenderness is acceptable is 1 in 10 (10% chance), whereas the odds of overall palatability failing when tenderness is unacceptable is 2.2 to 1 (69% chance). Therefore, the odds ratio is 20.8 (odds when tenderness is unacceptable / odds when tenderness is acceptable). So the odds of overall palatability failing when tenderness is unacceptable is 20.8 times higher than when tenderness is acceptable. The relative risk is the increased risk of an event occurring (overall unacceptable) due to another event (unacceptable tenderness). Thus, the likelihood of unacceptable overall palatability is 7.2 times higher when tenderness is unacceptable. With respect to flavor, only 1 in 15 (6.7% chance) steaks fail for overall palatability when flavor is also acceptable; however, this increases to 3.3 to 1 (76% chance) when flavor is unacceptable. The odds of overall palatability failing when flavor is unacceptable are 49 times higher than when flavor is acceptable, and overall palatability failure is 12.3 times more likely due to unacceptable flavor. For juiciness, 1 in every 9 steaks (11% chance) are unacceptable overall when juiciness is acceptable compared to close to 2 out of every 3 (66% chance) when juiciness is unacceptable. This indicates overall palatability is 6.5 times more likely to fail when juiciness is unacceptable, with the odds of failure 17.1 times greater due to juiciness failure. When more than one palatability trait fails, the odds of overall palatability failure increase dramatically. Most notably, when tenderness and flavor are both unacceptable, the odds of overall palatability failing are 516.5 times greater than when both traits are acceptable, with overall palatability more than 46 times more likely to fail when both traits are unacceptable. When juiciness fails in combination with tenderness or flavor, the odds of overall palatability failure are increased 92 and 294 times, respectively. Lastly, when all three traits are acceptable, only 1 in every 93 steaks (~1% chance) are unacceptable overall. However, when all three traits fail, the odds of failure increase almost 2,000 times to more than a 95% chance and the likelihood of overall failure is 89.5 times more likely.

Table 2 provides the percentage of A maturity, grain-finished strip loin steaks of various U.S. Department of Agriculture quality grades cooked to a medium degree of doneness rated as acceptable by consumers. More than 91% of USDA Prime samples were rated acceptable for all traits other than flavor, representing a greater percentage than all lower grading beef. Conversely, almost 25% of Select beef failed to meet consumer expectations for all palatability traits, and had a similar percentage of samples rated unacceptable for all traits, other than flavor, as Standard. These results differ from previous authors who have evaluated the probability of an unsatisfactory eating experience based on quality grade. A study by Smith et al. (2008) compiled results from 14 previous works and determined the probability of an unsatisfactory eating experience for Prime to be 1 in 33 (3%), Premium Choice to be 1 in 10 (10%), Low Choice to be 1 in 6 (16%), Select to be 1 in 4 (25%), and Standard to be 1 in 2 (50%). The observed differences between the current work and that of Smith et al. (2008) is likely the result of the differences in study types used for the analyses. Smith et al. (2008) included studies in their analyses that were comprised of trained sensory panelists. Trained panels are designed in order to evaluate sensory traits as objectively as possible. Because of this, the data from trained sensory panelists should not be interpreted the same as results from consumer panelists who assess samples based on their own individual biases and interpretations. It is also interesting to note that Premium Choice (upper 2/3 of Choice grade) had a greater portion of samples rated acceptable overall than Low Choice, however a similar percentage of samples rated acceptable for each palatability trait. This advantage in overall palatability and demand by consumers is reflected in the premiums garnered by the wholesale cut prices of this category over commodity Choice products (USDA, 2016a).

Implications

These results indicate the importance and impact of tenderness, juiciness, and flavor on overall eating experience as well as the significant impact of even single palatability trait failure on eating experience.

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Table 1. Odds of an unacceptable eating experience based on tenderness, juiciness, and flavor acceptability

Palatability trait	Odds when trait is acceptable[1]	Odds when trait is unacceptable[2]	Odds ratio[3]	Relative risk[4]
Tenderness	1 in 10	2.2 to 1	20.8	7.2
Juiciness	1 in 9	1.9 to 1	17.1	6.5
Flavor	1 in 15	3.3 to 1	49.0	12.3
Tenderness and juiciness	1 in 15	6.3 to 1	92.0	13.5
Tenderness and flavor	1 in 50	10.3 to 1	516.5	46.8
Juiciness and flavor	1 in 35	8.3 to 1	293.7	32.4
Tenderness, juiciness, and flavor	1 in 93	21.5 to 1	1989.1	89.5

[1]Odds of overall eating experience failing when individual palatability trait is rated acceptable.
[2]Odds of overall eating experience failing when individual palatability trait is rated unacceptable.
[3]Relative increase in odds of unacceptable eating experience when trait is rated unacceptable (i.e. odds of failure are X times greater than when trait is acceptable).
[4]Increased risk of unacceptable eating experience when trait is unacceptable (i.e. overall unacceptable rating is X times more likely than when trait is acceptable).

Table 2. Percentage of grain-finished strip loin steaks of various USDA quality grades cooked to a medium degree of doneness rated as acceptable by consumers

USDA Quality Grade	Tenderness	Juiciness	Flavor	Overall liking
Prime	95.14[a]	92.42[a]	88.11[a]	91.37[a]
Premium Choice	86.61[b]	84.97[b]	85.44[ab]	86.83[b]
Low Choice	86.31[b]	83.33[b]	83.83[b]	83.08[c]
Select	77.30[c]	75.96[c]	75.38[c]	74.75[d]
Standard	74.53[c]	67.99[d]	72.29[c]	72.04[d]
SEM[1]	1.81	1.94	1.86	1.86
P-value	< 0.01	< 0.01	< 0.01	< 0.01

[abcd]Means in the same column lacking a common superscript differ ($P<0.05$).
[1] SEM = standard error of the mean.

Marbling Texture Does Not Affect Consumer Preference of Beef Strip Loin Steaks

K.R. Vierck, J.M. Gonzalez, T.A. Houser, E.A.E. Boyle, and T.G. O'Quinn

Introduction

In the beef industry, U.S. Department of Agriculture quality grades and marbling levels have long been associated with beef palatability and eating experience. Marbling score and maturity are the two major components of USDA quality grade. Traditionally, marbling texture has not been considered a factor of marbling score; however, there are often discernments at both the packer and retail level, as more than 75% of branded beef programs supervised by USDA-AMS have a specification of fine or medium textured marbling (USDA, 2015). Additionally, in some cases, fine and medium textured steaks are graded higher than their coarse counterparts, which results in a loss of possible premiums for producers and packers. There is very little research evaluating marbling texture and its effect on palatability and eating experience.

Key words: marbling, consumer, palatability

Experimental Procedures

Top Choice (Modest^{00} – Moderate^{100} marbling), Low Choice (Small marbling), and Select strip loins (n = 117; 39/quality grade; Institutional Meat Purchase Specifications #180) were procured from a Midwestern beef processor. Strip loins were selected according to USDA Marbling Texture reference cards (USDA-AMS-LS-SB-02) and required at least 75% of the marbling to meet the standard (fine, medium, or coarse) for the particular group. Thirteen strip loins were selected per each marbling treatment within each quality grade. Strip loins were then transported to the Kansas State University Meat Laboratory where they were fabricated into 1-in. steaks, vacuum packaged and then aged for 21 days prior to freezing at -40°F.

Prior to panel sessions, steaks were thawed at 39°F for 24 hours. Steaks were prepared to a medium degree of doneness (160°F) on clamshell grills (Cuisinart Griddler Deluxe, Cuisinart, East Windsor, NJ). Prior to serving, steaks were cut into 0.4 in cubes, with 3 cubes immediately served to 7 consumer panelists. Untrained consumer panelists (n = 104) evaluated nine samples, one from each treatment, for tenderness, juiciness, flavor liking, and overall liking on a 3.93-in. line scales, which were verbally anchored at end and midpoints. Additionally, consumers rated each steak as either acceptable or unacceptable for each trait. Consumers were also asked to visually appraise each steak through a digital survey (Qualtrics, Provo, UT) on electronic tablets (HP Steam, HP, Palo Alto, CA). Pictures of each steak were edited to 1 × 2.5 in. dimensions of the center of the steak to remove any external fat, or ribeye area differences and color made uniform across all images. Consumers rated the desirability of the appearance of each steak as well as how likely they were to purchase the steak pictured, with verbal anchors at each end and midpoints of a scale. Data were analyzed as a completely randomized design with a 3 × 3 factorial arrangement, with quality grade, marbling texture, and quality grade × texture interaction serving as fixed effects as well as included panel number as a random effect and steak peak temperature as a covariate.

Results and Discussion

There were no quality grade × texture interactions ($P>0.05$) for all of the traits evaluated (Table 1). Marbling texture had no effect on palatability traits ($P>0.05$). Consumers rated all treatment groups (fine, medium, and coarse) as similar ($P>0.05$) for tenderness, juiciness, flavor liking, and overall liking. Furthermore, when asked to rate each sample as acceptable or unacceptable for each palatability trait, consumers found a similar ($P>0.05$) percentage of samples from each texture treatment acceptable (Table 2). Consumers rated Low Choice steaks as similar ($P>0.05$) to Top Choice steaks for all palatability traits evaluated. Low Choice steaks were rated higher ($P<0.05$) than Select for tenderness, flavor liking, and overall liking scores; however, they were similar ($P>0.05$) to Select for juiciness ratings. Moreover, both Top Choice and Low Choice were rated greater ($P<0.05$) for flavor liking than Select samples. A similar trend was observed when consumers were asked to rate samples as acceptable or unacceptable. No differences ($P>0.05$) were found among quality grades for the percentage of samples rated acceptable for tenderness, juiciness, and overall liking, with greater than 83% of samples rated acceptable for each trait. However, a lower percentage ($P<0.05$) of Select samples were rated acceptable for flavor than either Top Choice or Low Choice.

When asked to visually rate steaks on desirability of appearance, consumers rated steaks from each marbling texture treatment as similar ($P>0.05$). Moreover, steaks from each quality grade were found to be similar in terms of desirability of appearance ($P>0.05$). Additionally, when asked to rate how likely they were to purchase each steak, consumers rated each marbling texture treatment as similar ($P>0.05$). Likewise, there were no significant differences ($P>0.05$) between quality grades when asked to rate how likely they were to purchase the steak. This indicates that when external fat and color are not a factor in a purchasing decision, the amount of marbling or texture of the marbling does not play a role in beef purchases.

Implications

These results indicate there are no significant palatability differences between marbling texture types when fed to consumers. This implies coarse marbled beef should not be discriminated against for grading or purchasing decisions at the packer and wholesale level. Additionally, this would allow more cattle to be sorted into branded programs, which could increase profits at both the wholesale and retail level. These results indicate consumers do not have a preference for quality grades or marbling textures when external fat, muscling, and color do not play a role in the selection process.

Table 1. Least squares means for consumer panel ratings[1] of grilled beef strip loin steaks of varying USDA quality grades and marbling texture treatments (n = 104)

Treatment	Tenderness	Juiciness	Flavor liking	Overall liking
Marbling texture				
Fine	66.6	63.8	65.0	67.7
Medium	63.0	60.9	62.1	64.2
Coarse	63.7	61.9	63.3	64.9
SEM[2]	2.2	2.2	1.8	1.8
P-value	0.29	0.53	0.35	0.22
Quality grade				
Top Choice[3]	64.6[ab]	63.2	64.3[a]	66.1[ab]
Low Choice	67.5[a]	63.7	66.3[a]	68.3[a]
Select	61.2[b]	59.6	59.8[b]	62.4[b]
SEM	2.2	2.2	1.8	1.8
P-value	0.04	0.24	0.01	0.02
Quality grade × texture				
P-value	0.51	0.46	0.78	0.62

[1]Sensory scores: 0 = Extremely tough/dry/dislike flavor, 100 = Extremely juicy/tender/like flavor.
[2]SE (largest) of the least squares means.
[3]USDA marbling score of Modest^{00}-Moderate^{100}.
[ab]Least squares means in the same main effect (quality grade or marbling texture) without a common superscript differ ($P<0.05$).

Table 2. Percentage of beef strip loin steaks of varying USDA quality grade and marbling texture treatments rated acceptable for tenderness, juiciness, flavor, and overall liking (n = 104)

Treatment	Tenderness acceptability	Juiciness acceptability	Flavor acceptability	Overall acceptability
Marbling texture				
Fine	87.9	86.4	87.5	88.5
Medium	86.0	85.7	85.8	85.0
Coarse	86.6	83.7	85.1	85.2
SEM[1]	2.7	2.6	2.4	2.5
P-value	0.78	0.63	0.68	0.38
Quality grade				
Top Choice[2]	85.8	84.7	87.6[a]	87.5
Low Choice	89.2	87.6	88.7[a]	87.8
Select	85.2	83.4	81.4[b]	83.2
SEM	2.8	2.6	2.8	2.7
P-value	0.29	0.35	0.03	0.20
Quality grade × texture				
P-value	0.59	0.50	0.38	0.40

[1]SE (largest) of the least squares means.
[2]USDA marbling score of Modest^{00}-Moderate^{100}.
[ab]Least squares means in the same main effect (quality grade or marbling texture) without a common superscript differ ($P<0.05$).

Coarse Marbled Beef is Juicier and More Flavorful Than Fine or Medium Marbled Beef

K.R. Vierck, J.M. Gonzalez, T.A. Houser, E.A.E. Boyle, and T.G. O'Quinn

Introduction

Beef palatability and eating experience is driven primarily by U.S. Department of Agriculture quality grade and marbling levels. Beef USDA quality grade consists of both marbling levels and maturity. Conventionally, marbling texture has not been a consideration of quality grades. Currently, only one study has assessed the effects of marbling texture on beef palatability. Despite this, preferences for fine or medium marbling exist with both packers and retailers, as approximately 75% of branded beef programs under the supervision of USDA-AMS require fine or medium textured marbling, which equates to losses of premiums for packers and producers (USDA, 2016). The objective of the study was to evaluate the effects of marbling texture on trained sensory panel ratings of beef strip loin steaks of varying USDA quality grades and marbling textures.

Key words: marbling, palatability, trained sensory panel

Experimental Procedures

Strip loins from three quality grades, Top Choice (Modest^{00} – Moderate^{100} marbling), Low Choice (Small marbling), and Select (n = 117; 39/quality grade), were obtained from a Midwestern beef processor. To select the strip loins, the USDA Marbling Texture reference card (USDA-AMS-LS-SB-02) was used as a guide to visually sort loins into fine, medium, and coarse textured groups. To qualify into a texture group, at least 75% of the marbling had to meet the standard of fine, medium, or coarse textured marbling. For each quality grade, 13 strip loins were selected and transported refrigerated to the Kansas State University Meat Laboratory. Strip loins were then fabricated into 1 inch steaks, vacuum packaged, and aged for 21 days before freezing at -20°F.

Steaks were thawed prior to each sensory panel session at 39°F for 24 hours. After thawing, steaks were prepared to a medium degree of doneness (160°F) on clamshell grills (Cuisinart Griddler Deluxe, Cuisinart, East Windsor, NJ). After cooking, steaks were sliced into 0.4 in. cubes with 2 cubes served to 8 member panels. Panelists were trained according to the AMSA guidelines for sensory evaluation and evaluated samples for initial and sustained juiciness, myofibrillar tenderness, connective tissue amount, overall tenderness, beef flavor intensity, as well as off-flavor intensity on continuous line scales on electronic tablets (Toshiba Encore 2, Toshiba, Tokyo, Japan) using a digital survey (Qualitrics, Provo, UT). Each line scale was anchored at both ends and at midpoints with descriptive terms (0 = extremely dry/tough/none/unbeef-like/bland, 100 = extremely juicy/tender/abundant/beef-like/intense).

Results and Discussion

There were no quality grade × texture interactions ($P>0.05$) for all traits evaluated (Table 1). Panelists rated coarse marbled steaks higher than medium marbled steaks for initial juiciness ($P<0.05$), but rated both as similar to initial juiciness of fine marbled steaks ($P>0.05$). However, coarse marbled steaks were rated higher ($P<0.05$) for sustained juiciness and beef flavor intensity compared to both fine and medium marbled steaks. Fine and medium steaks were rated as similar ($P>0.05$) for sustained juiciness. All marbling texture treatments were rated as similar ($P>0.05$) for myofibrillar tenderness, connective tissue amount, and off-flavor intensity.

Top Choice steaks were rated higher for both initial and sustained juiciness ($P<0.05$) than Select steaks for both initial and sustained juiciness, but were similar to Low Choice steaks ($P>0.05$). Furthermore, panelists rated all quality grades similar ($P>0.05$) for myofibrillar tenderness, connective tissue amount, overall tenderness, and off-flavor intensity. However, Top Choice and Low Choice steaks were similar ($P>0.05$) and more intense in beef flavor ($P<0.05$) than Select steaks.

Implications

These results indicate steaks with coarse textured marbling are juicier and have an increased beef flavor when compared to fine and medium textured steaks. This indicates coarse marbled beef should not be discriminated against and should be included in branded beef programs, as it improves eating experience when compared to both fine and medium textured steaks. Furthermore, this would allow for increasing profits for both the packer and wholesaler.

Table 1. Least squares means for trained panel ratings[1] of grilled beef strip loin steaks of varying USDA quality grades and marbling texture treatments

Treatment	Initial juiciness	Sustained juiciness	Myofibrillar tenderness	Connective tissue amount	Overall tenderness	Beef flavor intensity	Off-flavor intensity
Marbling texture							
Fine	61.4[ab]	49.5[b]	74.1	8.8	70.8	39.6[b]	1.7
Medium	60.3[b]	48.5[b]	71.5	8.2	68.4	38.5[b]	1.4
Coarse	65.5[a]	54.5[a]	73.6	9.2	69.8	42.6[a]	1.8
SEM[2]	1.8	2.0	1.6	0.7	1.6	1.1	0.7
P-value	0.04	0.03	0.17	0.55	0.53	0.01	0.88
Quality grade							
Top Choice[3]	65.8[a]	55.16[a]	74.7	8.3	71.5	42.2[a]	2.0
Low Choice	62.4[ab]	50.6[ab]	73.3	8.2	69.9	40.5[a]	1.3
Select	59.1[b]	46.7[b]	71.2	9.8	67.6	38.0[b]	1.6
SEM	1.8	2.0	1.6	0.7	1.6	1.1	0.7
P-value	0.01	0.003	0.34	0.22	0.18	0.01	0.67
Quality grade × Texture							
P-value	0.33	0.38	0.83	0.81	0.89	0.85	0.18

[1]Sensory scores: 0 = Extremely dry/tough/none/unbeef-like/bland, 100 = Extremely juicy/tender/abundant/beef-like/intense.
[2]Standard error (largest) of the least squares means.
[3]USDA marbling score of Modest^{00}-Moderate^{100}.
[abcd]Least squares means in the same main effect (quality grade or marbling texture) without a common superscript differ ($P<0.05$).

Angus Ground Beef Has Higher Overall Consumer Acceptability than Grass-Fed Ground Beef

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Introduction

Ground beef is considered one of the major sources of animal protein in the U.S., accounting for approximately 40% of beef consumption per capita (USDA, 2011). Consumers' concern about animal welfare, sustainable production, and low fat products has influenced purchasing decisions, resulting in an increased demand for grass-fed ground beef (U.S. Department of Agriculture, Agricultural Marketing Service, 2007). Grass-fed cattle are fed natural based forages or grass-hay, thus resulting in a higher deposition of omega-3 fatty acids in meat. Meat from grain-fed cattle has a lower omega-3 content due to the saturated and monounsaturated fatty acid profile found in a grain based diet. Additionally, grass-fed ground beef contains three times more omega-3 fatty acids than traditional grain-fed ground beef; however, there is no evidence to support that grass-fed ground beef is a healthier choice for consumers than traditional ground beef (Smith, 2013). Several studies have looked at the flavor profile between grass-fed and grain-fed beef in order to identify whether the omega-3 fatty acids found in grass-fed ground beef play a key role on consumer flavor acceptability. A high content of omega-3 fatty acids accelerates oxidization of meat, and consequently causes potential adverse effects on meat palatability traits. Consumer sensory evaluation was conducted to evaluate consumer palatability ratings of grass-fed ground beef in comparison to Angus and commodity ground beef.

Key words: ground beef, consumer, palatability

Experimental Procedures

Fresh grass-fed ground beef, Angus ground beef, and commodity 80/20 ground beef were obtained from local retail stores and a commercial meat processing facility. For each treatment 14 different production lots were used, and each lot contained five lb of ground beef. Upon arrival, the chubs were stored in a -40°F freezer for up to 14 days. All ground beef chubs were then thawed for 5 days at 35 to 39°C. Ground beef patties from all treatments were manually formed into 4 oz patties using a stainless steel and acrylic template, crust frozen, vacuum packaged with 2 patties per package, and stored frozen at -40°F for 8 days. Any remaining product was vacuum packaged and refrozen at -40°F for moisture, fat, and protein determination within one week.

Frozen ground beef patties were thawed for 2 days prior to cooking for consumer sensory panels. Patties were cooked to an initial internal temperature of 160°F using a clam shell grill (Cuisinart, East Windsor, NJ) and then held for approximately 5 minutes to allow for a post-cook rise in temperature to 165°F. Internal temperature was monitored using thermocouples. Following cooking, ground beef patties were cut into 4 wedge-shaped pieces, and then immediately served on paper plates to panelists. A total of 98 consumers evaluated ground beef patties for tenderness, juiciness, flavor liking, texture liking, and overall liking using continuous 100 point line scales on an electronic tablet, with anchors at each end and the midpoint. In addition, consumers rated each sample as either acceptable or unacceptable for each sensory trait assessed.

Results and Discussion

Moisture, fat, and protein content of commodity, grass-fed, and Angus ground beef used in this study was similar ($P>0.05$) as shown in Table 1. Consumers tended to rate grass-fed ground beef about 4% and 6% lower ($P=0.06$) for flavor and texture liking, respectively, than Angus and commodity ground beef (Table 2). Angus and commodity ground beef were rated higher ($P<0.01$) for overall liking compared to grass-fed ground beef. Consumers found tenderness and juiciness palatability ratings to be similar ($P>0.05$) for all three types of ground beef.

Overall, consumers preferred ($P<0.05$) Angus ground beef, with an overall acceptability of 94.9% compared to grass-fed ground beef with an overall acceptability of 82.5%, while commodity ground beef had similar ($P>0.05$) overall acceptability of 91.8% to Angus and grass-fed ground beef (Table 3). Consumers indicated no difference ($P>0.05$) for tenderness acceptability, juiciness acceptability, and texture acceptability among the three ground beef treatments. Commodity ground beef had the highest ($P<0.05$) flavor acceptability, while Angus and grass-fed ground beef had similar ($P>0.05$) acceptability percentages for flavor.

Implications

Angus and commodity ground beef were liked overall more than grass-fed ground beef, and Angus ground beef was more acceptable overall to consumers than grass-fed ground beef. Additionally, consumer's acceptability for ground beef flavor was higher for commodity ground beef than grass-fed ground beef. Ground beef palatability and acceptability are influenced by the source and diet of the beef.

Table 1. Moisture, fat, and protein content of Angus, commodity, and grass-fed ground beef

Treatment	Fat	Moisture	Protein
Angus	19.8[a]	61.5[a]	18.0[a]
Commodity	19.8[a]	61.6[a]	17.6[a]
Grass-fed	15.7[a]	64.7[a]	18.7[a]
SEM[1]	1.4	1.1	0.34
P-value	0.16	0.12	0.15

[a]Least squares means for the same product in the same column lacking a common superscript differ (P<0.05).
[1]Pooled standard error of the least squares means.

Table 2. Consumer (n = 98) palatability ratings[1] for Angus, commodity, and grass-fed ground beef

Treatment	Tenderness	Juiciness	Flavor liking	Texture liking	Overall liking
Angus	64.7	69.7	59.9	63.2	65.3[a]
Commodity	66.5	68.0	61.2	61.6	66.2[a]
Grass-fed	64.0	65.9	54.1	57.2	56.4[b]
SEM[2]	2.1	1.9	2.1	2.1	2.1
P-value	0.57	0.40	0.06	0.06	< 0.01

[ab]Least squares means in the same column lacking a common superscript differ (P<0.05).
[1]Sensory scores: 0 = not tender/juicy, dislike flavor/texture/overall extremely; 50 = neither tough nor tender, neither dry nor juicy, or neither like or dislike flavor/texture/overall; 100 = very tender/juicy, like flavor/texture/overall extremely.
[2]Pooled standard error of the least squares means.

Table 3. Percentage of Angus, commodity, and grass-fed ground beef samples considered acceptable for palatability traits by consumers (n = 98)

Treatment	Tenderness acceptability	Juiciness acceptability	Flavor acceptability	Texture acceptability	Overall acceptability
Angus	91.6	92.4	83.3[ab]	90.0	94.9[a]
Commodity	84.7	91.4	90.6[a]	83.8	91.8[ab]
Grass-fed	84.7	87.4	73.9[b]	83.8	82.5[b]
SEM[1]	4.1	3.8	4.4	4.8	4.1
P-value	0.26	0.46	0.02	0.28	0.03

[ab]Least squares means in the same column lacking a common superscript differ (P<0.05).
[1]Standard error (largest) of the least squares means.

Bulls Are More Efficient Than Steers with Similar Meat Quality

D.U. Thomson, M.E. Youngers[1], E.F. Schwandt, S.J. Bartle, M. Siemens[2], J.C. Simroth, and C.D. Reinhardt

Introduction

Bull breeding soundness evaluations are often performed as a critical component of beef cow herd management to ensure that herd bulls have adequate semen quality, are physically capable of enduring the breeding season, and to determine the serving capacity per bull. Currently, there are approximately 30.3 million beef cows and 2.1 million bulls in the U.S. Depending on the breeding soundness evaluation failure rate, there are likely several hundred thousand bulls which will enter the beef market annually and a portion will be young bulls with the potential to be fed and sold to produce saleable meat of choice or select quality grade.

Castration of male cattle is a common procedure that is practiced world-wide, but is more common in the U.S. than in many countries. Behavioral benefits from castration include reduced aggressiveness and sexual activity by reducing testosterone levels. In addition, castrated animals maintain a lower muscle pH post-harvest producing fewer "dark cutters." Bulls have greater feeding performance and efficiency than steers. However, a bull's ability to gain efficiently and produce a leaner carcass, with more value to the packer and retailer, is overshadowed by the perception that meat from bulls is less tender than meat from steers.

Castration methods and the age at castration influence the potential stress on the animal, resulting in concerns regarding animal welfare and animal performance; therefore, castration of post-pubertal bulls to improve meat quality should be re-evaluated. The objective of this study was to evaluate the effects of castration and the use of growth promotion technologies in post-pubertal bulls on feeding performance, carcass traits, and meat quality characteristics compared to intact post-pubertal bulls.

Key words: bulls, carcass, meat quality

Experimental Procedures

The study was conducted at Kansas State University from June through August of 2014. Purebred Red Angus and Black Angus bulls (n = 30; initial body weight =

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1,336 ± 25.1 lb; average age = 16 months) were used in a randomized complete block design to evaluate the effects of castration of post-pubertal bulls on feeding performance, carcass traits, and meat quality characteristics.

Bulls were individually weighed and vaccinated with Pyramid 5 (Vetmedica, St. Joseph, MO) and Cavalry 9 (Merck Animal Health, Madison, NJ) and received Cydectin pour-on (Vetmedica, St. Joseph, MO). Twenty-four of the 30 purebred bulls were selected based on body weight uniformity. Bulls were blocked by breed, stratified by weight, and randomly assigned to treatment and pen, so that breed distribution was similar among pens. Treatments included: intact (n = 12) or castrated with addition of growth-promoting technologies (n =12). There were 4 animals per pen. Cattle were fed in a Calan Gate individual animal feeding system in 6 outdoor dirt-floor pens approximately 20 × 4 ft. Cattle were acclimated to the pens and Calan Gate feeders for 26 days prior to trial initiation.

On study day 0 all cattle were weighed prior to feeding. Animals assigned to the castrated treatment were subsequently castrated using a Callicrate bander (St. Francis, KS) and implanted with 120 mg of trenbolone acetate and 24 mg of estradiol implant. The last 28 days of feeding, the castrated cattle were fed 1 lb/day of a pellet containing 300 mg/lb ractopamine hydrochloride beta-adrenergic agonist to provide 300 mg/head/day of ractopamine hydrochloride. Cattle in the intact treatment were not implanted and were fed a similar amount of a placebo pellet the last 28 days on feed. The placebo and beta-adrenergic agonist pellet consisted of corn, alfalfa meal, and liquid molasses.

Cattle were fed a dry-rolled corn-based total mixed finishing diet for 62 days (Table 1). Diet samples were taken from each individual bunk and mixed together into one complete sample and submitted on a monthly basis to evaluate nutrient composition. Feed was delivered daily by 8:00 a.m., with residuals collected and weighed prior to feed delivery. On day 35, the beta-adrenergic agonist or placebo pellet was introduced and fed for the remaining 28 days. On day 63, cattle were transported approximately 1,000 miles to a commercial abattoir. During the 3 hour lairage, animals from the same treatment were penned together to avoid any potential pre-harvest stress due to mixing of bulls and steers.

Thirty-six hours post-mortem longissimus muscle samples 2 in. thick were taken from the left and right side of each carcass at the 12th rib for Warner-Bratzler shear force and sensory panel evaluation. Trained personnel evaluated carcasses and provided data for quality and yield grades using the United States Standards for Grades of Carcass Beef, longissimus muscle area using video image analysis camera, back-fat thickness, and marbling scores. Longissimus samples were aged in the vacuum sealed packaged for 14 days postmortem at 39°F.

Data were analyzed using the GLIMMIX procedures of SAS with treatment included as a fixed effect and breed included as a random effect; initial body weight was used as a covariate. Means were generated with the LSMEANS statement and separated using the DIFF function when the F-statistic was significant ($P<0.05$).

Results and Discussion

Cattle in the intact treatment had greater average daily gain and gain:feed (P=0.02; Table 2) compared to cattle in the castrated treatment. There was no difference in dry matter intake between treatments (P=0.90).

No differences (P>0.05) were observed between treatments for hot carcass weight, yield grade, quality grade, marbling score, dressing percent, or back-fat thickness (Table 3). Cattle in the intact treatment had greater longissimus muscle area than cattle in the castrated group (P<0.05).

Animals in the intact treatment tended (P≤0.10) to have greater Warner Bratzler shear force and less desirable overall tenderness, but there were no differences in any other sensory assessments (Table 4).

Implications

Results from this study suggest that carcass traits, growth parameters, and meat quality characteristics were not improved by castrating post-pubertal bulls. These results strongly suggest that intact bulls should remain intact to eliminate animal welfare concerns arising from castration and castration-induced stress, leading to poorer performance when meat quality is similar between post-pubertal bulls and steers.

Table 1. Ingredient composition of study diet to evaluate the effects of castration on post-pubertal male cattle on growth, feed efficiency, and meat quality characteristics

Ingredient[1]	% of dry matter
Dry-rolled corn	58.5
Dried distillers grains plus solubles	21.5
Cottonseed hulls	12.3
Molasses, cane	2.5
Supplement pellet[2]	5.2
Chemical composition, dry matter basis	
Dry matter, %	86.6
Crude protein, %	13.8
Calcium, %	0.90
Phosphorus, %	0.45

[1]Diet fed without ractopamine hydrochloride from days 1-62.

[2]Contained ground corn (90.0%), alfalfa meal (6.0%), and E-Z Glo molasses (4.0%); castrated treatment pellet contained 300 mg/lb ractopamine hydrochloride added to the feed bunk at 1.0 lb per animal daily; intact treatment pellet contained the same ingredients with no ractopamine hydrochloride.

Table 2. Least squares means illustrating the effects of castration on growth, feed efficiency, and dry matter intake in 16 month old post-pubertal bovine males

	Treatment[2]			
Item[1]	Intact	Castrated	Probability>F	SEM[3]
Initial weight, lb	1324	1340	0.65	3.5
Final weight, lb	1551	1516	0.30	55.7
Average daily gain, lb	4.07	3.19	0.02	0.46
Dry matter intake, lb	34.76	34.98	0.90	2.29
Gain:feed	0.12	0.09	0.02	0.012

[1]Least squares treatment mean.
[2]Intact post-pubertal male bovine or castrated via banding of post-pubertal male bovine.
[3]Standard error of the least squares mean.

Table 3. Least squares means illustrating the effects of castration on carcass characteristics in post-pubertal bovine males

	Treatment[2]			
Item[1]	Intact	Castrated	Probability>F	SEM[3]
Hot carcass weight, lb	981	955	0.36	19.3
Dressing percentage	63.74	63.73	0.99	0.7
Longissimus muscle area, in.^{2}	16.6	15.0	< 0.01	0.57
12th rib fat depth, in.	0.41	0.40	0.85	0.04
Yield grade[4]	2.73	3.08	0.15	
Quality grade[5]	Low Choice	Low Choice	0.34	
Marbling score[6]	502	502	0.98	

[1]Least squares treatment mean.
[2]Intact post-pubertal male bovine or castrated via banding of post-pubertal male bovine.
[3]Standard error of the least squares mean.
[4]USDA yield grade calculated from carcass measurements.
[5]Quality grade reported as USDA Low Choice.
[6]Marbling score units: 400 = Small^{00}, 500 = Modest^{00}.

Table 4. Least squares means illustrating the effects of castration on post-pubertal bovine males on Warner-Bratzler shear force and sensory panel analysis of longissimus steaks

	Treatment[2]			
Item[1]	Intact	Castrated	Probability>F	SEM[3]
Juiciness[4]	5.22	5.03	0.29	0.13
Overall tenderness[5]	5.26	5.53	0.07	0.10
Beef flavor intensity[6]	5.27	5.24	0.86	0.21
Connective tissue amount[7]	5.93	6.22	0.15	0.41
Myofibrillar tenderness[8]	5.23	5.42	0.45	0.18
Off flavor intensity[9]	7.66	7.63	0.81	0.22
Warner-Bratzler shear force, lb/0.5 in.[2]	10.56	9.46	0.10	0.46

[1]Least squares treatment mean.
[2]Intact post-pubertal male bovine or castrated via banding of post-pubertal male bovine.
[3]Standard error of the least squares mean.
[4]8 = Extremely juicy, 7 = very juicy, 6 = moderately juicy, 5 = slightly juicy, 4 = slightly dry, 3 = moderately dry, 2 = very dry, 1 = extremely dry.
[5]8 = Extremely tender, 7 = very tender, 6 = moderately tender, 5 = slightly tender, 4 = slightly tough, 3 = moderately tough, 2 = very tough, 1 = extremely tough.
[6]8 = Extremely intense, 7 = very intense, 6 = moderately intense, 5 = slightly intense, 4 = slightly bland, 3 = moderately bland, 2 = very bland, 1 = extremely bland.
[7]8 = None, 7 = practically none, 6 = traces, 5 = slight, 4 = moderate, 3 = slightly abundant, 2 = moderately abundant, 1 = abundant.
[8]8 = Extremely tender, 7 = very tender, 6 = moderately tender, 5 = slightly tender, 4 = slightly tough, 3 = moderately tough, 2 = very tough, 1 = extremely tough.
[9]8 = None, 7 = practically none, 6 = traces, 5 = slight, 4 = moderate, 3 = slightly abundant, 2 = moderately abundant, 1 = abundant.

Relationship Between Trauma Sustained at Unloading and Carcass Bruise Prevalence in Finished Cattle at Commercial Slaughter Facilities

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Introduction

Bruising in cattle can be an indicator of poor animal welfare, as well as a significant cause of economic loss due to decreased carcass value. Previous literature suggests sources of trauma causing bruising in beef carcasses include horn prevalence, rough transport conditions, cattle handling techniques, cattle temperament, and vehicle design; however, evidence of correlations between such trauma and actual carcass bruising is limited. The objective of this study was to evaluate the relationship between trauma sustained at unloading and carcass bruise prevalence in finished cattle at commercial slaughter facilities.

Key words: animal welfare, bruising, finished cattle

Experimental Procedures

Whole lots of finished beef cattle were observed at commercial slaughter facilities in July and August of 2015. All cattle in a lot were observed by a trained observer during unloading at the slaughter facility. The observer noted all potentially traumatic events between the animals and the trailer during unloading. Traumatic events were categorized by location in which they occurred (back, shoulder, rib, or hip).

A second trained observer evaluated the same animals' carcass (hide off) to determine bruise prevalence, location, and size. The Harvest Audit Program Bruise Scoring System was used to evaluate carcass bruising. Using this system, the carcass is divided into a grid of 9 sections (Figure 1), and each section represents a location on the carcass. Bruise size was recorded as Small (<2 in. in diameter), Medium (2-6 in. in diameter), or Large (>6 in. in diameter). Bruise color was used as an exclusion factor. Yellow bruises were presumed to be over 24 hours old, therefore were recorded, but not included in the statistical analysis.

[1] Cargill Meat Solutions, Wichita, KS.

Results and Discussion

A total of 9,860 head in 75 lots were observed for traumatic events and carcass bruising. Approximately 20.4% of animals in each lot experienced traumatic events. Average carcass bruising prevalence by lot was 68.2%. More than half of the bruising observed occurred along the dorsal midline, or topline, of the carcasses (Figure 2, Table 1). Of the bruises observed, 28.6% were considered Small, 41.8% were considered Medium, and 29.6% were considered Large.

There was a significant correlation observed between traumatic events and carcass bruising ($P<0.05$). When broken down by location, the only significant correlation between traumatic events and carcass bruising was found in the dorsal midline, or topline, location ($P<0.05$).

Implications

Bruising prevalence found in the current study is higher than results of other studies in the United States. Most bruising occurs along the dorsal midline, or topline, of the carcasses, where trim has the most economic impact. In addition, trauma at unloading is positively correlated with bruises found on carcasses at commercial slaughter facilities. More research is needed to determine where trauma is most likely to occur during the transport process, and the economic and welfare implications of bruising will be key drivers in the process of gleaning such information.

Table 1. Location of carcass bruising

Location	Mean, %	SEM[1]
Left side	26.5	1.10
Midline	53.5	1.12
Right side	20.0	1.04

[1]SEM=Standard error of the mean.

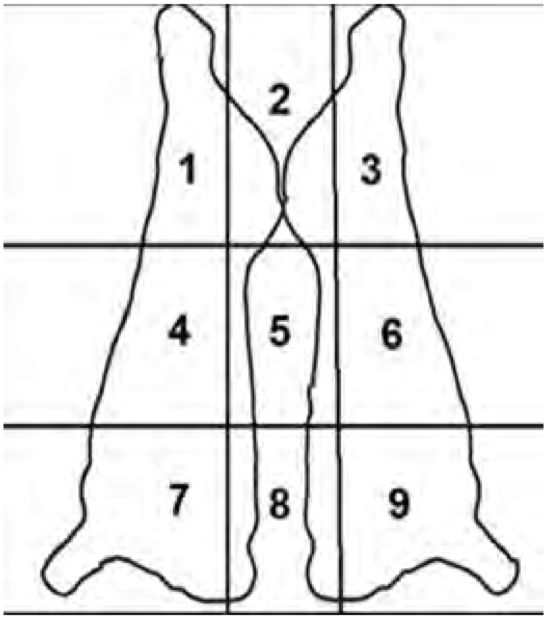

Figure 1. Nine-section grid used in the Harvest Audit Bruise Scoring System to determine location of carcass bruising.

Figure 2. Example of carcass bruising observed along the dorsal midline of finished cattle carcass.

Liver Abscess Severity at Slaughter Does Not Affect Meat Tenderness and Sensory Attributes in Commercially Finished Beef Cattle Fed Without Tylosin Phosphate

E.J. McCoy, T.G. O'Quinn, E.F. Schwandt, C.D. Reinhardt, and D.U. Thomson

Introduction

Liver abscesses are a significant problem in the United States' cattle feeding industry, costing the industry an estimated $15.9 million annually in liver condemnation, trim losses, and reduced carcass weights and quality grades. Recent reported incidence rates of liver abscesses at slaughter range from 10 to 20%. Liver abscess incidence may be influenced by a number of factors including: breed, gender, diet, days on feed, cattle type, season, and geographical location. Liver abscesses typically occur secondary to rumen insults caused by acidosis or rumenitis. It has been proposed that pathogens associated with liver abscess formation enter the blood stream through damaged rumen epithelium and are transported to the liver through the portal vein where they cause infection, manifested as liver abscesses. Severe liver abscesses have been linked to reduction in hot carcass weight, dressing percentage, yield grade, longissimus muscle area, and marbling scores of carcasses when compared to those with normal livers. However, the effect of liver abscesses on meat tenderness and sensory attributes has not been previously investigated.

Key words: cattle, liver abscesses, meat tenderness

Experimental Procedures

Strip loin steaks from carcasses (n = 119) were used in a 3 × 2 factorial treatment arrangement in a completely randomized design to evaluate the interactive effects of liver score and U.S. Department of Agriculture quality grade on meat tenderness and sensory attributes. Cattle originated from the same commercial feedlot and were fed common diets that did not contain tylosin phosphate. All carcasses utilized in this study were from cattle that were slaughtered on a single day at a commercial abattoir in northwest Texas and carcasses were selected after lungs and livers were scored. Only carcasses with healthy, normal lung scores were utilized to avoid any potential effects on tenderness or sensory attributes caused by respiratory disease.

Liver and lung scores were evaluated and recorded by trained university observers at harvest. Livers were scored as 0 = no abscesses, A- = 1 to 2 abscesses with diameter less than 0.77 in., A = 2 – 4 abscesses with diameter between 0.77 and 1.57 in., A+ = 1 abscess with diameter greater than 1.57 in. or more than 4 small abscesses, A+/AD = A+ criteria with adhesions to the body cavity. For this study, 0 represented the normal liver population, A- and A represented the mild liver abscess population, and A+, and A+ with adhesions represented the severe liver abscess population.

Quality grades of USDA Low Choice and Select and liver abscess scores of normal, mild, and severe were used for this study. Steaks from a total of 119 carcasses were collected and consisted of the following: 22 Low Choice-normal; 20 Low Choice-mild; 20 Low Choice-severe; 21 Select-normal; 20 Select-mild; and 16 Select-severe. Carcasses were chilled for approximately 36 hours post-mortem and all steaks were cut from the carcasses on a single day. Strip loin steaks were cut approximately 2.5 in. thick from the left side of the carcass at the 13th rib by a trained abattoir employee. Steaks were individually bagged and identified before being transported back to Manhattan, Kansas on ice. Steaks were vacuum-packaged, aged at 37 ± 1.8°F for 14 days post mortem. Steaks were stored for 48 hours at –4°F then faced and cut into two 1 in. steaks.

Warner Bratzler shear force and slice shear force were conducted according to the American Meat Science Association Research Guidelines for cookery, sensory evaluation, and instrumental tenderness measurements of meat. Steaks were randomized using a random number generator and thawed for 24 hours at 37°F. Steaks were weighed before and after cooking to calculate cook loss. Before cooking, a 30 gauge copper/constantan thermocouple was inserted into the geometric center of each steak. Steaks were cooked on clamshell grills (Cuisinart Griddler Deluxe, Cuisinart, East Windsor, NJ) set to 350°F that had been sprayed with nonstick cooking spray. Internal temperatures were monitored until an internal temperature of 150°F was reached, with a target endpoint temperature of 160°F. Once maximum rise in temperature was reached, thermocouples were removed and steaks were cut for slice shear force using a slice shear force kit. An Instron testing machine (Model 5569, Instron Corp., Norwood, MA) was used in combination with a slice shear blade (crosshead speed of 19.67 in./minute). After slice shear force, the remaining portion of the steak was cooled overnight at 37°F and used for Warner Bratzler shear force. Six 0.5 in. cores, parallel to the muscle fiber orientation, were removed and sheared on the Instron testing machine with a v-blade (G-R Manufacturing Co., Manhattan, KS; crosshead speed of 250 mm/min). The values of the 6 cores were averaged to obtain a single Warner Bratzler shear force value for each steak.

Panelists were trained over a series of training sessions with a minimum number of 3 trainings attended. Trainings were attended during a 5 day period. Characteristics on which panelists were trained included initial juiciness, sustained juiciness, myofibrillar tenderness, connective tissue, overall tenderness, beef flavor intensity, and off-flavor intensity. Anchors were provided at each training session and were used to set the 100 point scales.

Steak samples for sensory analysis were stratified by liver score and USDA quality grade and randomly assigned to one of 20 sensory panels so that each panel had one steak from each treatment combination. Six samples were evaluated per panel with a maximum of two panels per day. Steaks were prepared in the same manner as described above for Warner Bratzler shear force and slice shear force.

Immediately after peak temperature was reached, steaks were cut into uniform 0.5 × 0.5 × 1 in. cubes and placed into a metal double boiler to remain warm until served. Panels consisted of 20 sessions with 7 to 9 trained panelists per panel session. Panelists were seated in individual sensory analysis booths lit with red and green incandescent light to mask any color differences. Unsalted crackers, apples, and deionized, distilled water were provided as palette cleansers. Digital tablets (Toshiba Encore 2, Toshiba, Tokyo, Japan) were used to record sensory data on each steak with each category having a continuous line scale from 0 to 100 on which to mark a score. Qualtrics analytics software (Qualtrics, Provo, UT) was used to record and summarize data.

Sensory panel, Warner Bratzler shear force, and slice shear force data were analyzed using the GLIMMIX procedure of SAS. Sensory panel data were averaged within each steak and averages were used for analysis. Quality grade, liver score, and their interactions were analyzed as fixed effects and panel number was used as a random effect. Warner-Bratzler shear force and slice shear force data were analyzed with quality grade, liver score, and their interaction as fixed effects, and peak temperature used as a covariate. A Kenward-Roger adjustment was applied to the degrees of freedom. Significance was determined at $P<0.05$.

Results and Discussion

There were no quality grade × liver abscess score interactions for initial or sustained juiciness, connective tissue amount, overall tenderness, beef flavor identify, or off flavor ($P>0.05$). There was a quality grade × liver abscess score interaction for myofibrillar tenderness ($P<0.05$). Choice steaks did not differ in myofibrillar tenderness between liver abscess scores, but Select-mild steaks had greater myofibrillar tenderness than both the Select-normal and Select-severe groups ($P<0.05$). Low Choice Steaks had greater initial and sustained juiciness, and overall tenderness, and had less connective tissue than the Select steaks ($P<0.05$). There were no differences among liver abscess scores for any of the sensory panel traits ($P>0.05$).

There was no quality grade × liver abscess score interaction for Warner Bratzler shear force, slice shear force, or cook loss ($P>0.05$). There was also no effect of quality grade or liver abscess score on Warner Bratzler shear force, slice shear force, or cook loss ($P>0.05$).

Implications

Results from this study indicate that liver abscesses present at the time of slaughter do not have an effect on beef tenderness or sensory analysis characteristics in cattle fed in commercial feedlots without tylosin phosphate. Tenderness is an important trait for beef consumers, therefore, it is desirable for the beef industry and consumers alike that liver abscesses do not affect meat tenderness. Further research on liver abscess prevention is still warranted due to the decrease in profit caused by severe liver abscesses.

Table 1. Least squares means of effect of liver abscess score on Warner-Bratzler shear force, slice shear force, and cook loss for USDA Low Choice and Select beef strip loin steaks

Treatment	Warner Bratzler shear force, lb	Slice shear force, lb	Cook loss, %
Quality Grade			
Select	9.99	62.77	15.96
Low Choice	9.30	59.37	16.03
SEM[1]	0.29	2.84	0.29
P-value	0.09	0.39	0.87
Liver abscess score[2]			
None	9.77	63.98	16.42
Mild	9.57	58.84	15.57
Severe	9.59	60.43	16.00
SEM[1]	0.37	3.57	0.37
P-Value	0.91	0.52	0.21
Quality grade × liver abscess			
P-value	0.38	0.61	0.15

[ab] Means with different superscripts differ at the P≤0.05 significance level.
[1]Standard error of the least squares mean.
[2]None: healthy liver, no abscess; Mild: abscess less than 0.77 in diameter to 4 abscesses less than 1.57 in diameter; and Severe:1 abscess greater than 1.57 in diameter or greater than 4 small abscesses.

Table 2. Least squares means of effects of liver abscess score on sensory analysis panel items for USDA Low Choice and Select beef strip loin steaks

Treatment	Initial juiciness[1]	Sustained juiciness	Myofibrillar tenderness	Connective tissue amount	Overall tenderness	Beef flavor identity	Off flavor
Quality Grade							
Select	55.11[a]	46.20[a]	57.51[a]	17.05[a]	53.96[a]	47.05	0.91
Low Choice	59.06[b]	49.58[b]	62.41[b]	13.89[b]	58.81[b]	48.39	0.60
SEM[2]	1.42	1.26	1.53	1.38	1.65	0.87	0.31
P-value	0.01	0.01	0.02	0.03	0.03	0.27	0.38
Liver abscess score[3]							
None	57.83	48.18	59.84	15.24	56.62	48.39	0.84
Mild	56.50	47.62	60.84	14.84	57.20	47.67	0.61
Severe	56.93	47.86	59.21	16.33	55.33	47.10	0.81
SEM[2]	1.61	1.45	1.90	1.60	2.05	1.10	0.37
P-value	0.71	0.94	0.81	0.70	0.79	0.68	0.85
Quality grade × liver abscess							
P-Value	0.37	0.66	0.03	0.06	0.08	0.10	0.65

[ab] Means with different superscripts differ at $P \leq 0.05$ significance level.

[1]Sensory Scores: 0 = Extremely dry/tough/none/bland; 100 = Extremely juicy/tender/abundant/intense; 50 = neither dry nor juicy, neither tough nor tender.

[2]Standard error of the least squares mean.

[3]None: healthy liver, no abscess; Mild: 1 abscess less than 0.77 in diameter to 4 abscesses less than 1.57 in diameter; and Severe: 1 abscess greater than 1.57 in diameter or more than 4 small abscesses.

Biological Variability and Chances of Error

Variability among individual animals in an experiment leads to problems in interpreting the results. Animals on treatment X may have higher average daily gains than those on treatment Y, but variability within treatments may indicate that differences in production between X and Y were not the result of treatment alone. Statistical analysis allows us to calculate the probability that such differences are from treatment rather than chance.

In some of the articles herein, you will see the notation $P<0.05$. That means the probability of the differences resulting from chance is less than 5%. If two averages are said to be significantly different, the probability is less than 5% that the difference is from chance, or the probability exceeds 95% that the difference resulted from the treatments applied.

Some papers report correlations or measures of the relationship between traits. The relationship may be positive (both traits tend to get larger or smaller together) or negative (as one trait gets larger, the other gets smaller). A perfect correlation is one (+1 or -1). If there is no relationship, the correlation is zero.

In other papers, you may see an average given as 2.5 ± 0.1. The 2.5 is the average; 0.1 is the standard error. The standard error is calculated to be 68% certain that the real average (with an unlimited number of animals) would fall within one standard error from the average, in this case between 2.4 and 2.6.

Using many animals per treatment, replicating treatments several times, and using uniform animals increase the probability of finding real differences when they exist. Statistical analysis allows more valid interpretation of the results, regardless of the number of animals. In all the research reported herein, statistical analyses are included to increase the confidence you can place in the results.

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Cargill Corn Milling (Sweet Bran), Blair, Nebraska
Cargill Meat Solution, Wichita, Kansas
Cattlemen's Beef Board, Centennial, Colorado
Certified Angus Beef, Wooster, Ohio
Elanco Animal Health, Indianapolis, Indiana
Electrostatic Spraying Systems, Inc., Watkinsville, Georgia
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Kenny Knight, Lyons, Kansas
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Micronutrients USA LLC, Indianapolis, Indiana
MS Biotec, Wamego, Kansas
National Cattlemen's Beef Association, Centennial, Colorado
National Fish and Wildlife Foundation, Washington, DC
NBO3 Technologies, Manhattan, Kansas
New Generation Supplements, Belle Fourche, South Dakota
Porter Farms, Reading, Kansas
Pratt Feeders, Pratt, Kansas
R&R Machine Works, Inc., Dalhart, Texas
R.W. Leighton, Quinter, Kansas
Rezac Land & Cattle Company, St. Marys, Kansas
Roto-Mix, Scott City, Kansas
Select Sires, Inc., Plain City, Ohio
USDA National Institute of Food and Agriculture, Washington, DC
Zinpro Corporation, Eden Prairie, Minnesota
Zoetis Animal Health, Whitehouse Station, New Jersey

Livestock and Meat Industry Council Inc

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