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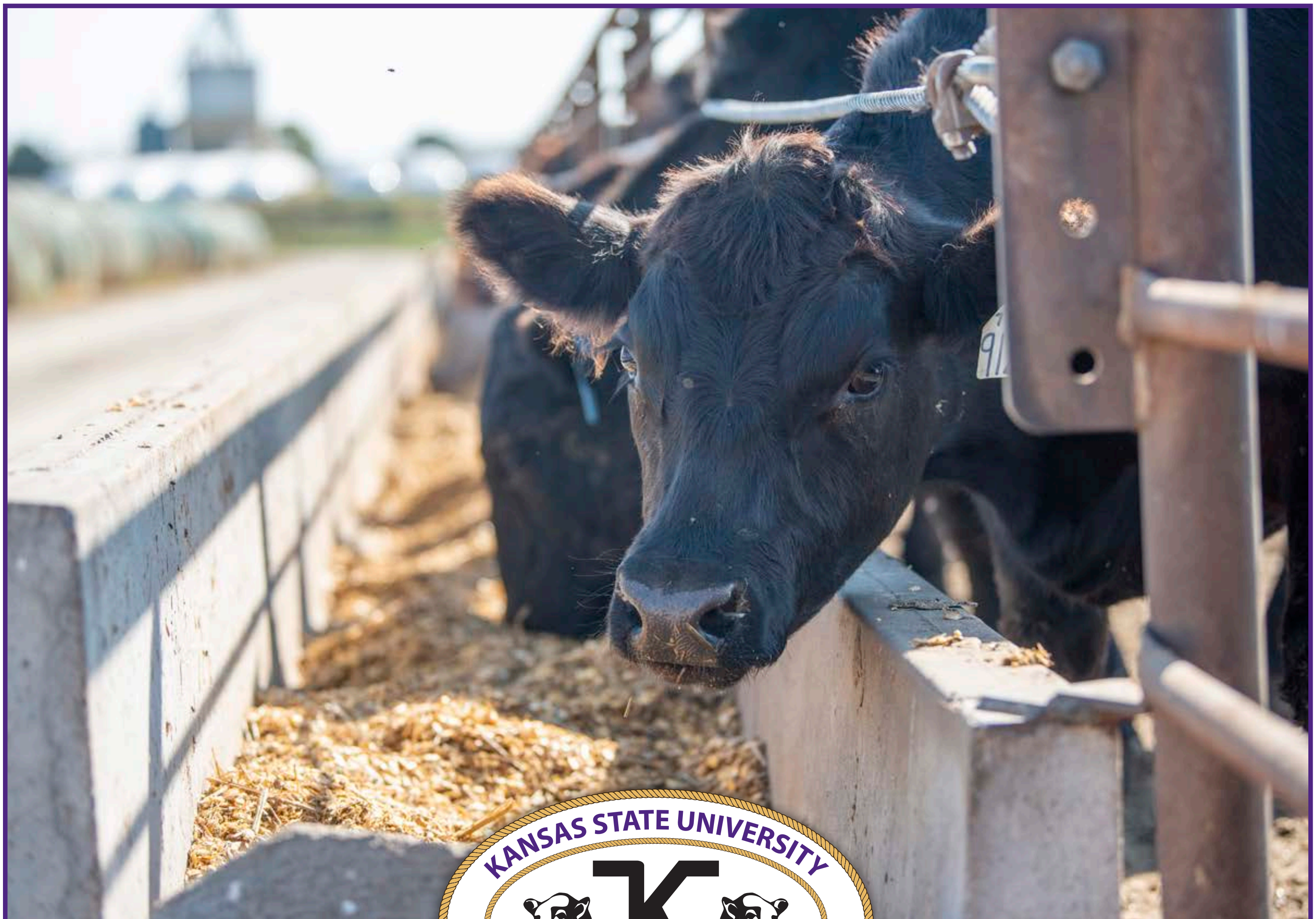

CATTLEMEN'S DAY 2021

BEEF CATTLE RESEARCH

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KANSAS STATE UNIVERSITY AGRICULTURAL EXPERIMENT STATION AND COOPERATIVE EXTENSION SERVICE

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Effects of Late Summer Prescribed Fire on Botanical Composition, Soil Cover, and Forage Production in Caucasian Bluestem-Infested Rangeland in the Kansas Smoky Hills: Year 2 of 4

M.P. Ramirez, A.J. Tajchman, Z.M. Duncan, J. Lemmon, and KC Olson

Abstract

Introduced old-world bluestem species (*Bothriochloa ischaemum* and *Bothriochloa bladhii*) pose a threat to the preservation of native prairies across the central and southern Great Plains. Recent research indicates that late summer prescribed fire may reduce the presence of old-world bluestems while maintaining or improving native plant populations. Eighteen one-acre plots were established in a section of private land that was heavily infested with Caucasian bluestem (*Bothriochloa bladhii*) and assigned to one of three treatments: no burn (i.e., control); single burn (i.e., burned only once in 2019); and biennial burn (i.e., burned in 2019 and 2021). Soil cover, botanical composition, and forage biomass were measured annually on each plot. The first fire treatment was applied on August 14, 2019; a second is planned for 2021. Within treatment, basal vegetation cover decreased ($P < 0.01$) from 2019 to 2020 on the biennial-burn treatment only; however, litter cover decreased ($P < 0.01$) and bare soil increased ($P < 0.01$) from 2019 to 2020 on burned plots compared to non-burned plots. Total grass cover and native grass cover were not affected ($P \geq 0.16$) by treatment; however, Caucasian bluestem decreased ($P = 0.04$) in burned plots compared with non-burned plots. No changes to total forb cover ($P = 0.13$) were observed in any treatments between 2019 and 2020; however, both grass and forb species richness increased ($P < 0.01$) in burned plots compared with non-burned plots. Within treatment, forage biomass was unchanged ($P \geq 0.11$) from 2019 to 2020. These data were interpreted to suggest that application of late-summer prescribed fire may be effective for control of Caucasian bluestem.

Introduction

The spread of introduced old-world bluestem species (*Bothriochloa ischaemum* and *Bothriochloa bladhii*) across the southern Great Plains represents a major concern to livestock producers and conservationists. Initially introduced as a source of forage and for soil conservation, old-world bluestems spread quickly in native rangelands, resulting in reduced forage quality, degraded wildlife habitat, and decreased botanical diversity. While prescribed fire has been applied to Kansas rangelands to control many undesirable plant species, old-world bluestems are unaffected by the conventional spring burns.

Recent research suggested that prescribed burning late in the summer may result in significant control of yellow bluestem (*Bothriochloa ischaemum*). With similar morphology and phenology, Caucasian bluestem (*Bothriochloa bladhii*) may respond similarly to late summer fire. Therefore, the objective of our experiment was to document the effects of late-summer prescribed fire on soil cover, botanical composition, plant-species richness, and forage production in mixed-grass prairie with established Caucasian bluestem stands over a four-year period.

Experimental Procedures

This experiment was conducted on a private ranch in Ellsworth County, KS. The experimental site was native mixed-grass prairie which contained established stands of Caucasian bluestem. Eighteen plots of one square acre each were established, and then assigned randomly to one of three treatments (n = 6 plots/treatment): no burn, single year burn (i.e., in 2019 only), or biennial burn (i.e., in 2019 and again in 2021). Permanent 164-ft transects were established in each plot. Pre-fire soil cover, botanical composition, and forage biomass were measured in July 2019. The first fire treatment was applied on August 14, 2019; post-fire effects were assessed in July 2020.

Ground cover and botanical composition were evaluated along each transect using a modified step-point method. Forage biomass was estimated by clipping the vegetation inside three randomly placed 0.82-ft^2 clipping frames per plot. Litter was removed from the frame and the remaining plant matter was clipped to a height of 0.39 in. Clipped material was dried in a forced-air oven (131°F; 96 hours) and weighed to estimate forage biomass.

Results were analyzed using a mixed statistical model that contained treatment, year, and treatment × year as fixed effects and pasture within treatment as a random effect. When protected by a significant *F*-test ($P < 0.05$), least-squares means of treatment × year effects were separated using the method of least significant difference.

Results and Discussion

Within treatment, forage biomass was not influenced ($P \geq 0.11$) by prescribed fire (Table 1). One year following fire application, litter cover was less in burned plots compared with non-burned plots, whereas bare soil was greater ($P < 0.01$) in burned plots compared with non-burned plots. Basal vegetation cover did not change ($P > 0.35$) in non-burned controls and plots assigned to a single burn; however, basal vegetation cover decreased ($P < 0.01$) in plots assigned to the biennial burn treatment. These data are likely reflective of the late season in which plots were burned. Fire applied during summer clears litter accumulation and the short growing season between August and the first frost prevents dominant warm-season grasses from building up significant amounts of litter before the next growing season begins.

Evaluation of plant composition pre-fire indicated no differences ($P = 0.55$) between treatments in total grass cover. Total grass cover did not change between years or treatments, ($P = 0.16$); however, burned plots were associated with lesser ($P < 0.01$) total warm-season grass cover (Table 2). This trend can likely be attributed to the reduction ($P = 0.04$) in Caucasian bluestem in fire-treated plots (Table 2). From 2019 to 2020, basal cover of Caucasian bluestem declined by approximately 38% in burned plots; whereas it was unchanged in non-burned plots. No changes ($P \geq 0.51$) in response to fire were detected in native-grass cover or warm-season (C4) tall-grass cover. Native grasses may be more tolerant of late-summer fire than Caucasian bluestem. While overall composition of introduced grasses did not change ($P = 0.31$) in response to fire, cool-season (C3) grass cover generally increased ($P < 0.01$) in fire-treated plots compared with non-burned plots (Table 2).

No treatment differences ($P \geq 0.10$) were detected in total forb cover or cover of native, introduced, perennial, nectar-producing, or leguminous forbs (Table 3). Small increases ($P = 0.03$) in annual forb cover were observed in burned plots, but not in non-burned plots. Likewise, grass- and forb-species richness in burned plots increased ($P < 0.01$) 20 to 40% in response to prescribed fire, whereas they were unchanged in non-burned plots (Table 4). Litter accumulation within stands of Caucasian bluestem may prevent light and water penetration to the soil. Removal of this litter with prescribed fire may have allowed greater numbers of native grass and forb species an opportunity for growth.

Implications

These data were interpreted to suggest that late-summer prescribed fire has the potential to allow low-cost, low-impact control of Caucasian bluestem in mixed-grass native rangeland. In addition, prescribed fire during late summer was also associated with improvements in plant-species richness and no change to basal cover of native grasses and forbs. We will continue to monitor these trends over the next two years.

Table 1. Effects of late-summer prescribed fire on mixed-grass prairie soil cover and forage biomass in the Kansas Smoky Hills

	Year 1			Year 2				
Item	No burn	Single burn	Biennial burn	No burn	Single burn	Biennial burn	Standard error of the mean	*P*-value
Bare soil, %	8.7^{b}	10.3^{b}	8.0^{b}	5.7^{b}	62.3^{a}	69.3^{a}	5.74	<0.01
Litter cover, %	80.0^{a}	73.3^{a}	71.3^{a}	81.0^{a}	24.7^{b}	21.7^{b}	5.85	<0.01
Basal vegetation cover, %	11.3^{bc}	16.3^{ab}	20.7^{a}	13.3^{b}	13.0^{bc}	9.0^{c}	2.00	<0.01
Forage biomass, lb dry matter/acre	2336^{ab}	1817^{bc}	2162^{b}	2823^{a}	1639^{c}	1893^{bc}	276.3	<0.01

^{abc}Within rows, means with unlike superscripts differ ($P \leq 0.05$).

Table 2. Effects of late-summer burning on mixed-grass prairie graminoid composition in the Kansas Smoky Hills

	Year 1			Year 2			Standard error of the mean	*P*-value
Item, % of total	No burn	Single burn	Biennial burn	No burn	Single burn	Biennial burn		
Total grass	92.0	90.3	90.0	89.0	82.0	81.0	2.71	0.16
Native	42.3	39.0	48.7	39.0	36.7	42.0	6.85	0.85
Introduced	49.7	51.3	41.3	50.0	45.3	39.0	7.50	0.61
Total C4 grasses	63.0[a]	66.3[a]	65.0[a]	63.7[a]	46.0[b]	47.7[b]	5.87	<0.01
C4 tall grasses	17.7	17.3	19.3	16.0	12.7	20.3	4.80	0.51
C4 mid-grasses	13.7[ab]	10.0[b]	18.0[a]	17.7[ab]	9.0[b]	10.3	4.03	0.02
Caucasian bluestem	31.7[a]	38.3[a]	27.3[ab]	30.0[a]	23.7[bc]	17.0[c]	9.55	0.04
Total C3 grasses	29.0[ab]	24.0[b]	25.0[ab]	25.3[ab]	36.0[a]	33.3[ab]	5.49	<0.01

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

Table 3. Effects of late-summer prescribed fire on mixed-grass prairie forb composition in the Kansas Smoky Hills

	Year 1			Year 2			Standard error of the mean	*P*-value
Item, % of total	No burn	Single burn	Biennial burn	No burn	Single burn	Biennial burn		
Total forbs	7.7	9.3	9.7	10.4	17.8	18.9	2.71	0.13
Native	7.6	9.1	9.7	10.3	16.3	17.2	2.56	0.21
Introduced	0.1	0.2	0.1	0.1	1.4	1.7	0.58	0.12
Perennial	7.4	9.0	9.5	10.3	15.7	16.7	2.53	0.30
Annual	0.3[b]	0.3[b]	0.2[b]	0.1[b]	2.1[a]	2.1[a]	0.62	0.03
Nectar-producing	3.5	4.6	4.7	5.0	9.1	10.3	1.58	0.10
Legumes	0.5	0.5	0.8	0.8	0.8	1.0	0.35	0.89

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

Table 4. Effects of late-summer prescribed fire on mixed-grass prairie grass and forb richness in the Kansas Smoky Hills

	Year 1			Year 2			Standard error of the mean	*P*-value
Item	No burn	Single burn	Biennial burn	No burn	Single burn	Biennial burn		
Grass species richness, number	7.8[b]	7.5[b]	7.7[b]	7.3[b]	9.3[a]	9.5[a]	0.65	<0.01
Forb species richness, number	13.3[a]	10.8[bc]	12.0[ab]	9.7[c]	15.2[a]	15.0[a]	1.89	<0.01

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

Yearling Cattle Grazing Pastures Burned During Summer Perform Similarly to Cattle Grazing Pastures Burned in Early Spring: Year 2 of 6

Z.M. Duncan, A.J. Tajchman, M.P. Ramirez, J. Lemmon, W.R. Hollenbeck, D.A. Blasi, and KC Olson

Abstract

The Kansas Flint Hills represent a major segment of the stocker cattle industry in the United States. Before each grazing season, ranchers typically apply annual spring-season prescribed fire to improve stocker cattle body weight gains. At this time, no direct comparisons of stocker cattle performance are available for yearling cattle grazing native rangelands burned later in the year (i.e., August-October). In the second year of a six-year study, 18 pastures were grouped by watershed and assigned to one of three prescribed-fire treatments: early spring (April 7 ± 2.1 days), summer (August 21 ± 5.7 days), or early fall (October 2 ± 9.9 days). All fire treatments were applied prior to grazing. Yearling cattle were grazed from May to August at a targeted stocking density of 250 lb of live weight per acre. Initial body weight did not differ ($P = 0.82$) between prescribed fire treatments; however, total body weight gains and average daily gains were greater ($P = 0.01$) for calves that grazed spring- and summer-burned pastures compared with those that grazed fall-burned pastures. In addition, calves in the spring and summer prescribed-fire treatments had greater ($P = 0.04$) final body weights compared to those in the fall prescribed-fire treatment. We interpreted these data to suggest that summer prescribed fire could be used to manage sericea lespedeza (*Lespedeza cuneata*) populations without negatively affecting stocker cattle performance.

Introduction

The value of prescribed fire to improve yearling cattle performance has been well-documented in the Kansas Flint Hills. Traditionally, ranchers apply annual spring-season prescribed fire to native rangelands to improve stocker cattle performance, increase warm season grass production, and reduce woody vegetation. Although spring-season prescribed fire has been established as the standard for many Flint Hills ranchers, it does not reduce the proliferation of sericea lespedeza (*Lespedeza cuneata*). Recent research has demonstrated that sericea lespedeza populations are reduced when the timing of prescribed fire is shifted from spring to late summer or early fall. While late summer (i.e., August-September) or early fall prescribed fire (i.e., August-October) can affordably manage sericea lespedeza infestations, ranchers have concerns that cattle growth performance will be negatively affected. At this time, no direct comparisons of stocker cattle performance are available for these prescribed fire regimes. The objective of our experiment was to document the effects of prescribed-fire timing on stocker cattle performance over a six-year period.

Experimental Procedures

Our experiment was conducted at the Kansas State University Beef Stocker Unit. The Beef Stocker Unit is located northwest of Manhattan, KS, and is comprised of approximately 1,100 acres of native tallgrass prairie. Eighteen pastures were grouped by watershed and each watershed was assigned to one of three prescribed-fire treatments (n = 6 pastures per treatment): spring (April 7 ± 2.1 days), summer (August 21 ± 5.7 days), or fall (October 2 ± 9.9 days). All prescribed fire treatments were applied prior to grazing.

Pastures were stocked with yearling cattle at a targeted stocking density of 250 lb of live weight per acre from May to August, subsequent to prescribed fire. Upon arrival, cattle were individually weighed, given an individual visual identification tag, and assigned randomly to pasture and treatment. On the day grazing began, each calf was weighed to determine initial body weight and then allocated to the respective pastures. At the completion of the grazing season, calves were gathered and individual body weights were measured to determine total body weight gains and average daily gains. Gain data from 2019 and 2020 were analyzed using a mixed model, considering the effects of year, pasture, and treatment. The year × treatment interaction was not significant; therefore, the main effects of treatment were reported.

Results and Discussion

Total body weight gains did not differ ($P = 0.43$; Table 1) between the spring and summer burn treatments; however, calves that grazed the fall-burn treatment had less ($P = 0.01$; Table 1) total body weight gain compared to calves that grazed the spring- or summer-burn treatments. Calves that grazed spring- and summer-burned pastures gained 26 and 20 lb more body weight, respectively, than calves that grazed fall-burned pastures. Similarly, no differences ($P = 0.47$; Table 1) in average daily gain were observed between spring and summer prescribed-fire treatments. Conversely, average daily gain was greater ($P = 0.01$; Table 1) for calves that grazed the spring and summer fire treatments compared with calves that grazed the fall-fire treatment. As a result, final body weight was greater ($P = 0.04$; Table 1) for calves that grazed the spring- and summer-burn treatments compared with calves that grazed the fall burn treatment. The first two years of data from our six-year experiment were interpreted to indicate that prescribed fire timing influenced stocker cattle performance. In year one, we estimated that calves could afford to gain about 80 lb less if summer or fall prescribed fire was used to manage sericea lespedeza populations, as opposed to spring-season fire followed by herbicide application. This estimate was based on a value of gain at $0.65 per lb (CattleFax 04-12-2019 vs. 08-09-2019), prescribed fire cost of $2.25 for three acres required to support a calf, and herbicide application cost of $54. In year two, the value of gain increased to $1.15 per lb (CattleFax 04-17-2020 vs. 08-14-2020) while the cost of prescribed fire and herbicide application remained roughly the same. The increase in the value of gain resulted in a breakeven performance difference of 45 lb per calf. Beef producers are encouraged to compare these revenue changes with the costs of chemical methods for sericea lespedeza control.

Implications

We interpreted our data to suggest that beef producers could utilize summer-season prescribed fire to manage sericea lespedeza populations without sacrificing yearling growth performance. We will continue to evaluate these trends and modify our conclusions over the next five years.

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

	Prescribed fire season			Standard error of the mean	
Item	**Spring**	**Summer**	**Fall**		***P*-value**
Initial body weight, lb	680	684	677	11.3	0.82
Final body weight, lb	930[a]	927[a]	900[b]	11.1	0.04
Total body weight gain, lb	249[a]	243[a]	223[b]	7.5	0.01
Average daily gain, lb/day	2.8[a]	2.7[a]	2.5[b]	0.08	0.01

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

Effects of Prescribed Fire Timing on Native Plant Composition, Forage Biomass Accumulation, and Root Carbohydrate Reserves in the Kansas Flint Hills: Year 2 of 6

Z.M. Duncan, A.J. Tajchman, M.P. Ramirez, J. Lemmon, W.R. Hollenbeck, D.A. Blasi, and KC Olson

Abstract

Sericea lespedeza (*Lespedea cuneata*) is a highly-invasive forb that has degraded more than 960 square miles of Kansas rangeland. Recent research has demonstrated that mid-summer or early-fall prescribed fire can achieve comprehensive control of sericea lespedeza; however, ranchers have voiced concerns that fire later in the year (i.e., August-October) may negatively impact native warm-season plant populations. In year two of a six-year study, 18 pastures were grouped by watershed and assigned to one of three burn treatments: early spring (April 7 ± 2.1 days), mid-summer (August 21 ± 5.7 days), or early fall (October 2 ± 9.9 days). All fire treatments were applied prior to grazing by yearling stocker calves. Soil cover, botanical composition, forage biomass, and root carbohydrate reserves were evaluated over a three-year period. Total grass and forb basal cover did not differ ($P = 0.15$) between treatments. In addition, no differences ($P = 0.23$) were observed in total cool-season grass cover or warm-season grass cover between fire regimes; however, native-grass species were greatest ($P = 0.05$) in the summer fire treatment, intermediate in the spring fire treatment, and least in the fall fire treatment. Forage biomass, root starch, and total water-soluble carbohydrate levels in three key warm-season forage grasses and one key native legume did not differ ($P = 0.27$) between treatments. We interpreted these data to suggest that prescribed fire timing caused small changes in range-plant composition but did not reduce forage biomass or root carbohydrate reserves of key native plant species.

Introduction

The Kansas Flint Hills represent the largest intact remnant of the original tallgrass prairie on earth. Traditionally, ranchers apply annual spring-season prescribed fire to these native rangelands to improve stocker cattle growth performance, increase warm-season grass production, and limit the encroachment of woody and invasive plant species. On average, 2.1 million acres throughout the Flint Hills are burned annually from mid-March to early May. Burning during this time of year presents certain challenges including low relative humidity, strong unpredictable winds, and elevated fuel loads. When combined, these factors increase the potential for uncontrolled fire. Another concern associated with spring prescribed fire is smoke management. Each spring, smoke produced from burning the Flint Hills travels to downwind municipalities, reduces air quality, and can negatively affect human health.

In addition, sericea lespedeza (*Lespedea cuneata*) likely proliferates with annual spring prescribed fire. Sericea lespedeza was introduced to Kansas in the 1930s and has since invaded more than 960 square miles of Kansas grasslands. Recent research demonstrated that shifting the timing of prescribed fire from spring to mid or late summer provided comprehensive control of sericea lespedeza. Although control of sericea lespedeza can be achieved through late-summer burning (i.e., August-September), ranchers have voiced concerns that native warm-season grass populations or forage biomass may be affected negatively. The objective of our experiment was to document the effects of prescribed-fire timing on plant composition, forage biomass accumulation, and root carbohydrate concentrations of key tallgrass plant species over a six-year period.

Experimental Procedures

Our experiment was conducted at the Kansas State University Beef Stocker Unit. The Beef Stocker Unit is comprised of approximately 1,100 acres of native tallgrass prairie and is fenced into 18 pastures. Pastures were grouped by watershed and each watershed was assigned to one of three prescribed-fire treatments (n = 6 pastures per treatment): spring (April 7 ± 2.1 days), summer (August 21 ± 5.7 days), or fall (October 2 ± 9.9 days). A single, permanent 328-ft transect was established in each pasture. Pre-treatment botanical composition, basal cover, standing forage biomass, and root carbohydrate concentrations were determined in June 2018 and re-evaluated after fire application in 2019 and 2020. Prescribed fire treatments were applied prior to grazing in 2019 and 2020.

Botanical composition and soil cover were evaluated along each permanent 328-ft transect using a modified step-point method. Standing forage biomass was determined by clipping the vegetation within ten 0.82-ft^2 frames randomly placed at 33-ft intervals along each transect. Plant material was clipped at a height of 0.39-in above the soil and dried in a forced-air oven (122°F; 96 hours). Root-carbohydrate concentrations of three native C4 grasses (i.e., big bluestem, little bluestem, and Indiangrass), and one leguminous, native forb (i.e., purple prairie clover) were also evaluated. Individual roots and rhizomes were collected from each pasture, washed with tap water, dried in a forced-air oven (122°F; 96 hours), and analyzed for both total starch and total water-soluble carbohydrate concentrations.

Results and Discussion

Following the second full cycle of prescribed fire application, bare soil cover was greater ($P \leq 0.01$; Table 1) in the spring burn treatment compared with the summer and fall burn treatments. Conversely, litter cover on the soil surface was greater ($P \leq 0.01$; Table 1) in pastures burned in the summer or fall compared with pastures burned in the spring. These trends can likely be attributed to the length of time since prescribed fire application. Soil cover was evaluated annually between late June and early July. As the time since fire application increased, bare soil cover was reduced while litter cover on the soil surface increased. In contrast, basal vegetation cover did not differ ($P = 0.22$; Table 1) between prescribed fire treatments.

When botanical composition was evaluated, no differences ($P = 0.15$; Table 2) in total grass cover, cool-season grass cover, or warm-season grass cover were detected; however, differences within warm-season grass growth forms were apparent. Warm-season perennial tallgrass cover tended to be greater (*P* = 0.07; Table 2) in pastures burned in the summer or fall compared with those pastures burned in the spring. Warm-season perennial mid-grass cover was greater (*P* = 0.05; Table 2) in the spring-burn treatment compared with the fall-burn treatment, whereas summer-burned pastures were intermediate. Spring-season prescribed fire increased (*P* = 0.01; Table 2) warm-season perennial short grass cover compared with summer or fall prescribed fire. In addition, native grass species cover was greatest (*P* = 0.05; Table 2) in the summer-fire treatment, least in the fall-fire treatment, and intermediate in the spring-fire treatment. No differences (*P* = 0.17; Table 2) were observed between treatments when total forb cover and native forb cover were evaluated; however, nectar-producing forb cover was greater (*P* = 0.02; Table 2) in fall-burned pastures compared to spring- and summer-burned pastures. Similarly, annual forb cover was greater (*P* = 0.03; Table 2) in the fall treatment compared to the spring treatment, whereas the summer treatment was intermediate. Shrub cover was minimal (i.e., ≤ 1.5%) and not different (*P* = 0.08) between treatments.

No differences (*P* = 0.91; Table 1) in forage biomass were observed between prescribed-fire treatments. Furthermore, root starch and total water-soluble carbohydrate concentrations in big bluestem, little bluestem, Indiangrass, and purple prairie clover did not differ (*P* = 0.27; Table 3, Table 4) between the spring-, summer-, or fall-fire treatments. The lack of differences in forage biomass accumulation and root-carbohydrate concentrations were interpreted to suggest that prescribed fire timing may not affect the growth potential of key native tallgrass species.

Implications

We interpreted our data to suggest that prescribed fire timing is associated with small changes in range-plant composition; however, fire timing did not affect forage biomass accumulation or root carbohydrate reserves of key native tallgrass species. We will continue to evaluate these trends and modify our conclusions over the next five years.

Table 1. Effects of prescribed fire timing on tallgrass prairie soil cover and forage biomass in the Kansas Flint Hills

	Prescribed fire season			Standard error	
Item	Spring	Summer	Fall	of the mean	*P*-value
Bare soil, % of total area	62[a]	49[b]	48[b]	3.7	< 0.01
Litter cover, % of total area	21[b]	36[a]	35[a]	4.8	< 0.01
Total basal vegetation cover, % of total area	17	15	17	1.6	0.22
Forage biomass, lb dry matter/acre	1796	1870	1897	252.1	0.91

[a,b]Within rows, means with unlike superscripts differ (*P* ≤ 0.05).

Table 2. Effects of prescribed fire timing on basal cover (% of total basal plant cover) of grasses and forbs on tallgrass prairie in the Kansas Flint Hills

Item, % of total basal plant cover	Prescribed fire season			Standard error of the mean	*P*-value
	Spring	Summer	Fall		
Total grass cover	90	90	85	2.8	0.15
Native grass species	85[ab]	87[a]	79[b]	3.2	0.05
Cool-season grass species	20.7	21.2	23.7	2.93	0.61
Warm-season grass species	68.9	69.1	61.4	4.90	0.23
C4 perennial tallgrasses	31.9	38.9	34.6	2.87	0.07
C4 perennial mid-grasses	33.0[a]	29.0[ab]	25.4[b]	2.84	0.05
C4 perennial short grasses	3.7[a]	1.2[b]	1.3[b]	0.83	0.01
Total forb cover	9.9	8.4	13.4	2.74	0.21
Native forb species	9.7	8.3	13.4	2.62	0.17
Annual forb species	0.3[b]	1.0[ab]	1.7[a]	0.49	0.03
Nectar-producing forbs	1.8[b]	1.9[b]	3.8[a]	0.68	0.02
Total shrub cover	0.5	1.2	1.5	0.98	0.08

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

Table 3. Effects of prescribed fire timing on root starch concentrations in key tallgrass species during summer

Item, % dry matter	Prescribed fire season			Standard error of the mean	*P*-value
	Spring	Summer	Fall		
Big bluestem	2.57	3.22	2.00	0.92	0.43
Little bluestem	1.53	1.57	1.28	0.57	0.86
Indiangrass	3.19	2.09	1.81	1.22	0.49
Purple prairie clover	4.92	3.39	3.59	1.23	0.41

Table 4. Effects of prescribed fire timing on root water-soluble carbohydrate concentrations in key tallgrass species during summer

Item, % dry matter	Prescribed fire season			Standard error of the mean	*P*-value
	Spring	Summer	Fall		
Big bluestem	3.31	4.57	4.02	0.78	0.27
Little bluestem	3.15	4.44	3.34	0.98	0.37
Indiangrass	5.11	3.47	3.95	1.29	0.42
Purple prairie clover	4.55	3.36	5.24	1.08	0.24

Managing the Intake of Mineral Supplements that Contain Feed Additives for Beef Calves Grazing Flint Hills Native Grass Pasture is Important

R.L. Allison, Z.M. Duncan, C.E. Schneider, W.R. Hollenbeck, K.J. Suhr, B.J. Dedrickson,[1] and D.A. Blasi

Abstract
Managing the consumption of feed additives through a self-fed mineral is an important consideration for ensuring that improved cattle performance and pasture productivity can occur. In 2020, a 91-day grazing study was conducted at the Kansas State University Beef Stocker Unit to compare the performance of 314 crossbred steers provided with a self-fed mineral supplement containing either Bambermycin, Monensin, or fed the control. The initial consumption of Bambermycin and Monensin was substantially less than the intended daily intake of 4 oz per head. To attain the desired mineral intake level, dry molasses was added to all three supplements in increasing amounts as the grazing season progressed. Unfortunately, the Bambermycin treatment was consumed quickly, sometimes in one day, with no additional provision of mineral containing the additive for the remainder of the week. Even with the addition of dried molasses to the Monensin treatment, consumption was still significantly lower than the Bambermycin and control treatments. There were no statistical differences in performance between the three groups.

Introduction
For stocker cattle grazing in native Flint Hills pasture, optimizing growth rate is important in determining overall profitability. The use of feed additives as a part of a mineral supplementation program is a management practice that can be effectively used to help promote overall productivity during a grazing season. However, provision of mineral on pasture also requires a dedicated effort to manage for the intended level of consumption. The objective of this study was to manage the consumption of a mineral supplement containing two different types of feed additives that can improve the growth rate of stocker calves grazing native grass pastures in the Flint Hills region of Kansas.

Experimental Procedures
A 91-day grazing study was conducted at the Kansas State University Beef Stocker Unit, Manhattan, KS, starting in May 2020 utilizing 314 Brahman influenced crossbred steers (739.57 ± 10.54 lb) from Gorman, TX. Steers were randomized and allocated across 18 pastures at a targeted stocking density of 250 lb/acre. Pastures were randomly assigned to three treatment groups with six replications (paddocks) per group. Identical supplement feeders (Bullmaster; Mann Enterprises, Inc., Waterville, KS) were used in each pasture. The treatments assessed consisted of standard free-choice

[1] Huvepharma, Peachtree, GA.

mineral: 1) control; 2) Bambermycin to be included in the supplement at 32 lb/ton on a dry matter basis to provide 20 mg/head/day, when consumed in 4 oz of supplement; and 3) Monensin to be included in the supplement at 26.67 lb/ton on a dry matter basis to provide 150 mg/head/day when consumed in 4 oz of supplement (see Table 1). Additionally, these treatments were randomly allocated with prescribed fire burn treatments (spring, summer, and fall). A common basal mineral supplement was used for all treatment groups throughout the study. In addition to the mineral supplement, cattle were provided free-choice salt blocks ad libitum.

After receiving the cattle, a 60 net energy for gain diet (mcal/lb) containing Amprolium 1.25% Medicated Pellets (Huvepharma, Peachtree, GA), was fed for 5 days in a limit-fed fashion. Upon initiation of the study initial weights were recorded, and steers were randomly assigned to treatment. During this process, calves were given an individual numbered tag, dewormed with Prohibit (levamisole hydrochloride) Soluble Drench Powder Anthelmintic (Huvepharma, St. Joseph, MO), implanted with Ralgro (Merck, Madison, NJ), and injected with RespiVax5 plus Pulmogard (Huvepharma, St. Joseph, MO), or vaccinated against Infectious Bovine Rhinotracheitis, Bovine Viral Diarrhea, and Bovine Respiratory Syncytial Virus, *Pasteurella multocida*, and *Manheimia hemolytica*. Cattle also received an injection of Agri-Mectin (ivermectin) (Huvepharma, St. Joseph, MO), and then were sorted according to assigned pastures.

Cattle were weighed individually on day 0 and day 91. Group pasture pen scale weights were taken and recorded on day 0, 45, and 91. On a weekly basis, mineral feeders were weighed to determine consumption. The data collected were used to calculate the previous week's intake of mineral. Mineral in the feeder of each paddock was checked daily for manure, water, or other foreign matter that could interfere with normal supplement consumption. To help cattle find the mineral, all rubber flap covers on all mineral feeders were opened at the beginning of the study. When inclement weather was forecasted, the flaps were closed and reopened as the threat passed. As consumption increased, flaps were closed permanently to minimize exposure to the environment. The initial targeted intake of mineral was 4 oz/head daily for all treatments.

A variety of management strategies were used to drive mineral intake to attain the targeted daily consumption. Because the calculated daily consumption of Monensin was significantly lower during the initial stages of the study, it was deemed necessary to add dried molasses to all treatments. Therefore, beginning week five, 1 lb of dried molasses was added and hand mixed per 50 lb of mineral for all 3 treatments. Because consumption was not increased, the amount of dried molasses was increased to 2 lb per every 50 lb of mineral for all treatments on week six. This concentration remained constant throughout the remainder of the trial for the control and Bambermycin treatments. Despite this increase, low levels of consumption for the Monensin treatment still persisted. On week nine, the level of dried molasses was increased to 3 lb per 50 lb of mineral for the remainder of the trial.

With the addition of dried molasses, the consumption of the control and Bambermycin treatments was vastly improved to the extent that the consumption of their calculated allotted levels was achieved within a 1- to 4-day timeframe over a one-week period. To slow the consumption of these two treatments, mineral feeders were checked daily and moved a distance from the water if mineral was being consumed too quickly. Free-choice salt blocks were also provided to slow the consumption of the control and Bambermycin treatments.

Results and Discussion

Manager attention to detail of the daily intake of mineral supplements is critical as feed additives need to be consumed regularly over several days to attain optimum performance. Figure 1 depicts the actual weekly intake of the mineral treatments over the 91-day grazing season. Daily intake for control and Bambermycin was at or above the target consumption for the first five weeks. During the initial stages of the trial, the consumption of the Monensin treatment was significantly lower than the other two treatments ($P < 0.05$). By week seven, Monensin consumption was improved but the dosage was below the intended optimum level required to demonstrate a response over control. Over the 91-day trial, there were no significant differences in average daily gain ($P = 0.72$) between the mineral treatments. The results in Table 3 show the forage quality at four time points of the experimental pastures during this study.

Implications

Continuous monitoring of mineral consumption in relation to its intended intake target is an important management practice that is often overlooked when using mineral supplements as a vehicle for delivery of feed additives. Strategic placement of mineral supplements in a pasture, use of salt blocks, and addition of flavor enhancers such as dried molasses to continuously adjust desired consumption may be used as needed based on intended intake levels.

Brand names appearing in this publication are for product identification purposes only. No endorsement is intended, nor is criticism implied of similar products not mentioned. Persons using such products assume responsibility for their use in accordance with current label directions of the manufacturer.

Table 1. Nutrient composition of free-choice mineral supplements[a,b]

	Treatment	
Item	**Monensin**	**Bambermycin**
Calcium, minimum %	20.50	20.50
Calcium, maximum %	21.50	21.50
Phosphorus, total minimum %	4.00	4.00
Salt, minimum %	12.50	12.50
Salt, maximum %	13.50	13.50
Magnesium, minimum %	0.50	0.50
Manganese, minimum ppm	435.00	435.00
Zinc, minimum ppm	476.00	474.00
Copper, minimum ppm	24.00	24.00
Cobalt, minimum ppm	28.00	28.00
Iodine, minimum ppm	150.00	150.00
Selenium, minimum ppm	25.00	25.00
Vitamin A, minimum KIU/lb	30.00	30.00
Vitamin D, minimum KIU/lb	10.00	10.00
Vitamin E, minimum IU/lb	10.00	10.00
Active ingredient		
Bambermycin, g/ton		160.00
Monensin, g/ton	1200.00	

[a] Supplements were manufactured by Key Feeds, Fourth and Pomeroy Associates, Inc., Clay Center, KS.
[b] Control mineral was formulated identically but with no Bambermycin or Monensin included.

Table 2. Performance data for cattle supplemented with mineral containing Bambermycin or Monensin while grazing Flint Hills pasture

Item	Control	Bambermycin	Monensin	Standard error	*P*-value
Pastures, number	6	6	6		
Animals on trial, number	110	99	105		
Grazing days, number	91	91	91		
Initial weight, lb	717	709	716	10.54	0.8389
Final weight, lb	914	897	908	13.43	0.68
Grazing average daily gain, lb/day, day 0–45	2.24	2.34	2.07	0.127	0.3363
Grazing average daily gain, lb/day, day 45–91	2.16	1.86	2.21	0.108	0.0967
Grazing average daily gain, lb/day, day 0–91	2.2	2.10	2.14	0.087	0.722
Average mineral consumption	3.97[a]	4.06[a]	2.95[b]	0.183	0.0003

[a,b] $P < 0.01$.

Table 3. Forage quality of Flint Hills pasture by date of sampling

	Sample date											
	5/13/2020			6/1/2020			6/22/2020			7/13/2020		
Season of burning	Spring	Fall	Summer	Spring	Fall	Summer	Spring	Fall	Summer	Spring	Fall	Summer
Dry matter, %	28.27	34.31	58.89	30.00	34.89	38.16	38.83	42.01	45.08	44.66	48.88	49.26
Crude protein, %	15.48	11.05	7.06	10.51	8.65	7.63	7.67	6.83	7.24	6.26	6.45	6.19
Acid detergent fiber, %	37.04	41.22	46.36	37.46	41.11	42.95	39.59	44.41	43.50	40.73	43.88	44.03
Neutral detergent fiber, %	49.10	50.89	58.21	52.16	52.51	58.04	58.96	57.29	56.48	60.84	58.88	62.25
Net energy gain, Mcal/lb	0.37	0.34	0.29	0.35	0.28	0.29	0.35	0.29	0.28	0.32	0.25	0.28
Net energy maintenance, Mcal/lb	0.69	0.67	0.62	0.68	0.61	0.62	0.68	0.62	0.61	0.64	0.58	0.60
Total digestible nutrients, %	59.79	60.64	57.14	61.39	56.20	57.14	61.63	56.86	56.48	59.04	54.03	55.78
Calcium, %	0.82	0.86	0.64	0.75	0.90	0.69	0.74	0.87	0.85	0.69	0.77	0.73
Phosphorus, %	0.28	0.24	0.23	0.26	0.23	0.23	0.21	0.22	0.22	0.19	0.20	0.20
Potassium, %	2.20	1.78	1.68	2.08	1.80	1.74	1.62	1.67	1.50	1.38	1.48	1.34
Magnesium, %	0.22	0.14	0.06	0.17	0.15	0.08	0.15	0.19	0.11	0.15	0.16	0.43

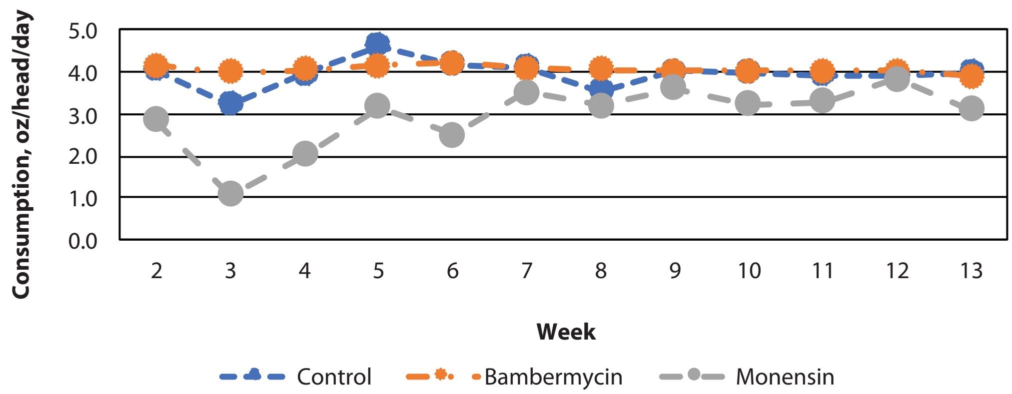


Figure 1. Mineral consumption.

Effect of Trucking Distance on Sale Price of Beef Calf and Feeder Cattle Lots Sold Through Video Auctions from 2010 Through 2018

E.D. McCabe, M.E. King, K.E. Fike, M.J. Smith, G.M. Rogers,[1] *and K.G. Odde*

Abstract
The objective was to determine the effect of trucking distance on the sale price of beef calf and feeder cattle lots sold through Superior Livestock Video Auctions from 2010 through 2018. Data analyzed were collected from 211 livestock video auctions. There were 42,043 beef calf lots and 19,680 feeder cattle lots used in these analyses. Six states (Colorado, Iowa, Kansas, Nebraska, Oklahoma, and Texas) of delivery comprised 70% of calf lots and 83% of feeder cattle lots and were used in these analyses. All lot characteristics that could be accurately quantified or categorized were used to develop multiple regression models that evaluated effects of independent factors using backwards selection. A value of $P < 0.05$ was used to maintain a factor in the final models. Based upon reported state of origin and state of delivery, lots were categorized into one of the following trucking distance categories: 1) within-state, 2) short-haul, 3) medium-haul, and 4) long-haul. Average weight and number of calves in lots analyzed was 571.4 ± 84.7 lb and 100.6 ± 74.3 head, respectively. Average weight and number of feeder cattle in lots analyzed was 790.1 ± 75.6 lb and 110.6 ± 104.1 head, respectively. Beef calf lots hauled within-state sold for more ($169.24/cwt; $P < 0.0001$) than other trucking distance categories. The long-haul calf lots sold for the lowest ($P < 0.0001$) price ($166.70/cwt). Within-state and short-haul feeder cattle lots sold for the greatest ($P < 0.0001$) prices ($149.96 and $149.81/cwt, respectively). Long-haul feeder cattle lots sold for the lowest ($P < 0.0001$) price ($148.43/cwt).

Introduction
Beef cattle production occurs throughout the United States. The vast majority of cattle feeding, however, is concentrated in the plains closer to feed resources. This means beef calves must eventually travel from throughout the United States towards the plains for finishing. There are costs and risks associated with the transportation of beef calves and feeder cattle. Some of the risks associated with transportation impact overall health, including injury and stress. Previously, we evaluated the effect of state origin on sale price for lots of beef calves. These results indicated lots originating from states that were closer to where cattle are finished sold for higher sale prices. Thus, the objective was to determine the effect of trucking distance on sale price of beef calf and feeder cattle lots sold through Superior Livestock Video Auctions from 2010 through 2018.

[1] Grassy Ridge Consulting, Aledo, TX.

Experimental Procedures

Information describing factors about lots of beef calves and feeder cattle 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 and feeder cattle sold from 2010 through 2018. The unit of study was a lot of beef calves or a lot of feeder cattle.

Data available for each lot included:

- Auction year
- Gender of the lot
- Lot size (linear and quadratic)
- Base weight (linear and quadratic)
- Mixed gender lot
- Breed description
- Health protocol administration
- Region of United States lot originated from
- Number of days between auction and forecasted delivery dates
- Weight variation
- Presence of horns
- Implant status
- Frame score
- Flesh score
- Whether the lot qualified for one or more of these programs: Bovine Viral Diarrhea Persistently Infected free, Source and Age verified, Beef Quality Assurance, Superior Progressive Genetics, Non-Hormone Treated Cattle program, or Certified Natural program
- Sale price of lot ($/cwt)

The top six states in number of lots delivered to the state were included in these analyses. The top six delivery states were Colorado, Iowa, Kansas, Nebraska, Oklahoma, and Texas. Lots were categorized into one of four trucking distance categories: 1) within-state, 2) short-haul, 3) medium-haul, and 4) long-haul. Lots categorized as within-state originated and were delivered within the same state. Lots categorized as short-haul were approximately one state away from the delivery state. Lots were determined as short-haul based on their originating state and delivered to one of the top six delivery states: Colorado (origins were: Kansas, Nebraska, Oklahoma, New Mexico, Utah, and Wyoming); Iowa (origins were: Illinois, Kansas, Minnesota, Missouri, Nebraska, South Dakota, and Wisconsin); Kansas (origins were: Colorado, Missouri, Nebraska, and Oklahoma); Nebraska (origins were: Colorado, Iowa, Kansas, Missouri, South Dakota, and Wyoming); Oklahoma (origins were: Arkansas, Colorado, Kansas, Louisiana, Missouri, New Mexico, and Texas); Texas (origins were: Arkansas, Louisiana, New Mexico, and Oklahoma). Lots categorized as medium-haul were approximately two states away from the delivery state. Lots were determined as medium-haul based on their originating state and delivered to one of the top six delivery states: Colorado (origins were: Iowa, Missouri, South Dakota, and Texas); Iowa (origins were: Indiana, Missouri, North Dakota, and Oklahoma); Kansas (origins were: Arkansas, Iowa, New Mexico, and South Dakota); Nebraska (origins were: Arkansas, Illinois, Minnesota, Montana, North Dakota, Oklahoma, and Wisconsin); Oklahoma (origins were: Arizona, Illinois, Iowa, Kentucky, Mississippi, Nebraska, and Tennessee); Texas (origins were: Colorado, Kansas, Mississippi, and Missouri). Lots were determined as long-haul based on their originating state and delivered to one of the top six delivery states. This category included all other states not previously listed as originating states for each of the top six delivery states.

Separate multiple-regression models, one for beef calf lots and one for feeder cattle lots, were developed using a backwards selection procedure to quantify effects of independent factors on the sale price of beef calves. Each model was adjusted for the random effect of auction date nested within auction year. The multiple regression models included the 22 variables provided by the video auction service in addition to the trucking distance category. The variable of interest in this study was trucking distance.

Results and Discussion

Data analyzed were collected from 211 livestock video auctions from 2010 through 2018. Six states (Colorado, Iowa, Kansas, Nebraska, Oklahoma, and Texas) of delivery comprised 70% of calf lots and 83% of feeder cattle lots and were used in these analyses. There were 42,043 beef calf lots and 19,680 feeder cattle lots used in these analyses. Average weight and number of calves in lots analyzed was 571.4 ± 84.7 lb and 100.6 ± 74.3 head, respectively. Average weight and number of feeder cattle in lots analyzed was 790.1 ± 75.6 lb and 110.6 ± 104.1 head, respectively.

For beef calf lots the presence of horns, implant status, and bovine viral diarrhea persistently infected tested did not affect sale price while the other 20 variables did affect sale price and remained in the model. Regarding trucking distance, beef calf lots hauled within-state sold for more ($169.24/cwt; $P < 0.05$) than other trucking distance categories (Figure 1). The short-haul calf lots sold for the second greatest ($P < 0.05$) sale price ($168.77/cwt). The medium-haul calf lots sold for the third greatest ($P < 0.05$) sale price ($167.58/cwt). The long-haul calf lots sold for the lowest ($P < 0.05$) price ($166.70/cwt). Transportation of calves in general causes live weight loss. In addition, the commingling of calves, potential for fluctuations in weather conditions, and additional animal handling add stressors associated with increased risk for developing health issues. It appears hauling distance may be related to perceived risk for the buyer in that they are willing to pay more for calves hauled shorter distances perhaps due to less detrimental effects on performance and less cost associated with transport.

For feeder cattle lots, presence of horns did not affect sale price while the other 22 variables did affect sale price and remained in the model. Regarding trucking distance, within-state and short-haul feeder cattle lots sold for the greatest ($P < 0.05$) prices ($149.96 and $149.81/cwt, respectively; Figure 2). The medium-haul feeder cattle lots sold for the second greatest ($P < 0.05$) sale price ($149.25/cwt). The long-haul feeder cattle lots sold for the lowest ($P < 0.05$) price, $148.43/cwt. Similar to beef calf lots, buyers were generally willing to pay more/cwt for feeder cattle hauled shorter distances. Interestingly, the price difference between each trucking distance category within feeder cattle lots was less than for beef calf lots, likely because feeder cattle are typically lower-risk animals incurring less potentially detrimental effects in performance and cost associated with trucking distance.

Implications

These results indicate there is a price advantage for lots expected to be hauled shorter distances, likely because of cost and risk associated with transportation.

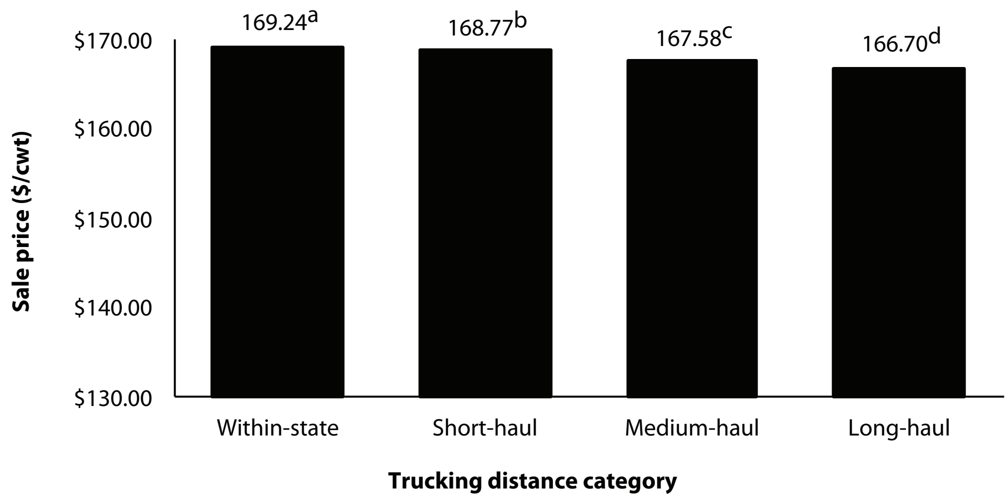


Figure 1. The effect of trucking distance on sale price of beef calf lots sold through 211 Superior Livestock Auction video sales from 2010 through 2018.
[a,b,c,d] $P < 0.05$.

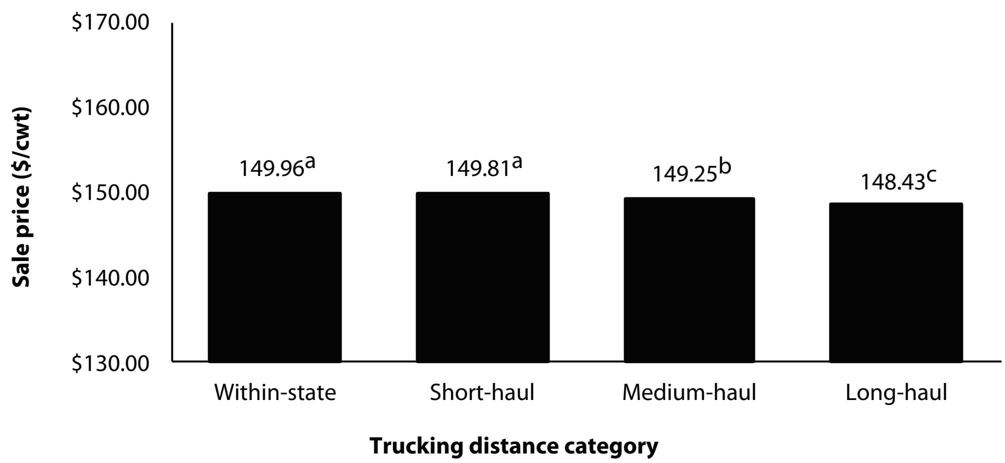


Figure 2. The effect of trucking distance on sale price of feeder cattle lots sold through 211 Superior Livestock Auction video sales from 2010 through 2018.
[a,b,c] $P < 0.05$.

Trends in the Percentage of Doses of Modified Live, Killed, and Combination Respiratory Viral Vaccines Administered to Beef Calves Offered for Sale in Summer Video Auctions From 2000 Through 2018

M.J. Smith, K.E. Fike, M.E. King, E.D. McCabe, G.M. Rogers,[1] and K.G. Odde

Abstract
Data from the Superior Livestock Video Auction services were used to identify trends in the percentage of doses of modified live, killed, and combination respiratory viral vaccines administered to lots of beef calves over a nineteen-year period (2000–2018). There was an increase ($P < 0.05$) in the number of modified live viral vaccine doses given to beef calf lots from 2000 through 2018. The number of doses of both killed and combination respiratory viral vaccines administered to beef calves declined ($P < 0.05$).

Introduction
There has been strong debate regarding the perceived protection, efficacy, and safety of modified live vaccine usage in nursing calves over the past several years; however, progressive cattle producers have long recognized the benefits of modified live vaccine usage in nursing calves. In 1990, a severe strain of Bovine Viral Diarrhea type 2 entered the United States by way of Canada. As a result, many producers found that calves that had been vaccinated with a killed viral vaccine were much more susceptible to infection when compared to those calves vaccinated with a modified live viral vaccine (Nordstrom, 2013).

Throughout the 1990s and into the early 2000s, animal health companies began pursuing approval for a label for modified live use in suckling calves nursing pregnant cows (Nordstrom, 2013). This research led to the addition of safety claims across numerous modified live vaccine labels, further supporting the idea of safety in the use of modified live viral vaccines in nursing calves. The objective of this study was to quantify trends in the percentage of doses of types of respiratory viral vaccines administered to beef calves offered for sale in summer video auctions from 2000 through 2018.

Experimental Procedures
Information describing factors about lots of beef calves marketed and sold nationwide through a livestock video auction service (Superior Livestock Video Auction, Fort Worth, TX) were obtained from the auction service in an electronic format. These data were collected for all lots of beef calves offered for sale from 2000 through 2018. Named 4- or 5-way respiratory viral vaccines, number of treatments, and number of head per lot listed within the lot description were utilized to calculate the type of respiratory viral

[1] Grassy Ridge Consulting, Aledo, TX.

vaccine and the number of doses administered to beef calves. Named 4- or 5-way respiratory viral vaccines were classified into three groups based on the type of antigens they contained: all modified live antigens, all killed antigens, and a combination of modified live and killed antigens. The Cochran-Armitage Trend test was used to quantify potential trends in the usage of each respiratory viral vaccine type with a $P < 0.05$ considered significant.

Results and Discussion

There were 59,762 lots of single-gender beef calves (7,167,352 total calves) offered for sale in 145 summer video auctions through Superior Livestock Auction from 2000 through 2018. Over the nineteen-year period, 11,787,935 total doses of respiratory viral vaccine were administered to beef calves included within these data.

When examining the overall trend in total respiratory viral vaccine usage across all three types (Figure 1), a pattern of major growth was witnessed, showing an increase in respiratory viral vaccine usage from 2000 (292,377 doses) through 2018 (746,323 doses). There was an increase ($P < 0.05$) in the percentage of doses of modified live viral vaccine given to beef calf lots from 2000 (41.7%, 121,976 doses) through 2018 (90.3%, 673,862 doses) (Figure 2). The number of doses of both killed and combination viral vaccines administered to lots of beef calves declined ($P < 0.05$) (Figure 3 and Figure 4, respectively). In 2000, 31.2% (91,176 doses) and 27.1% (79,225 doses) of the total respiratory viral vaccines given to beef calf lots were killed or combination viral vaccines, respectively (Figure 5). By 2018, only 4.2% (31,325 doses) of respiratory viral vaccines were killed, and only 5.5% (41,136 doses) of respiratory viral vaccines were combination.

Implications

This dramatic shift indicates an industry trend towards increasing modified live viral vaccine utilization compared with declining usage of killed and combination respiratory viral vaccines. This trend may be a result of modified live viral vaccine approval for use in suckling calves nursing pregnant cows.

References

Nordstrom, S. 2013. Risk and reward: Modified-live vaccines in pregnant cows. Progressive Dairy. https://www.progressivedairy.com/topics/herd-health/risk-and-reward-modified-live-vaccines-in-pregnant-cows.

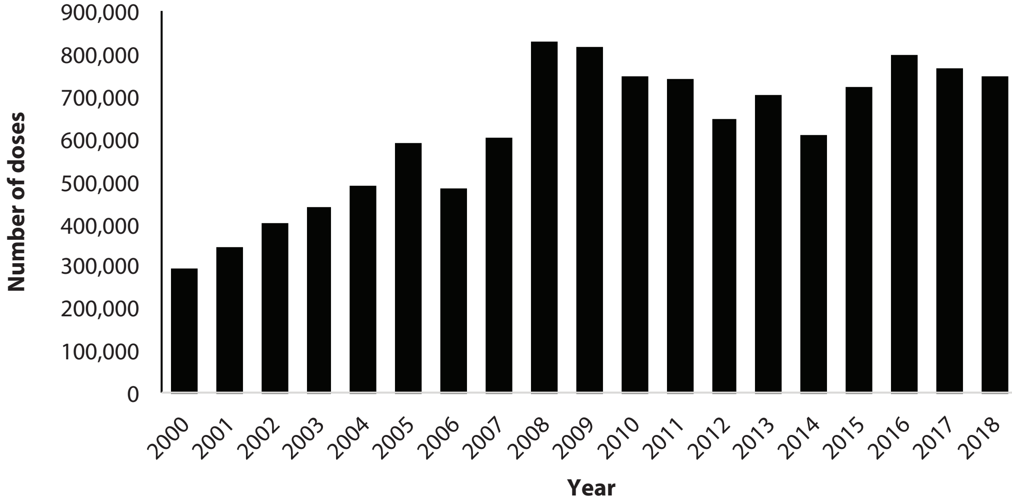


Figure 1. Trend in total respiratory viral vaccine usage in doses from 2000 through 2018.

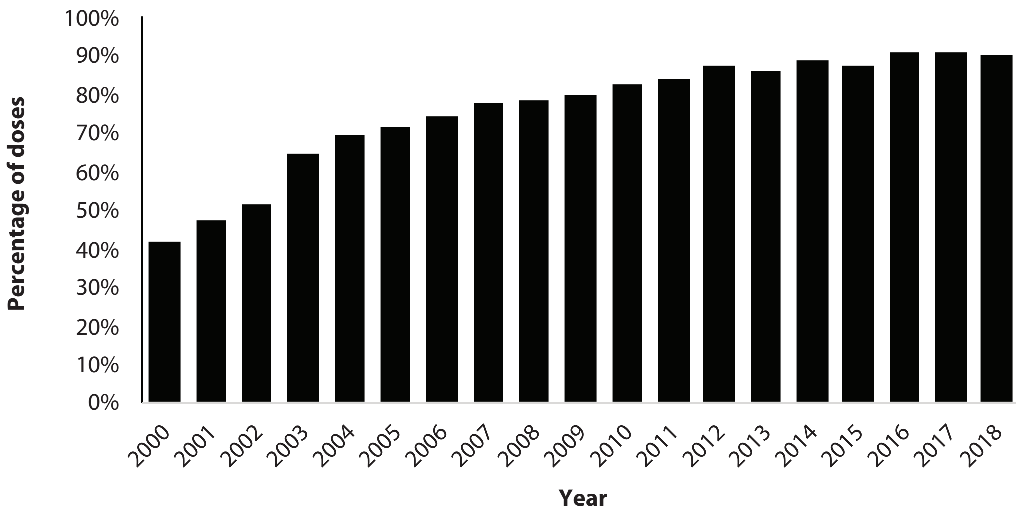


Figure 2. Trend in the percentage of doses of modified live respiratory viral vaccines.
*There was an increase ($P < 0.05$) in the use of 4- or 5-way respiratory viral vaccines that contained all modified live antigens from 2000 through 2018.

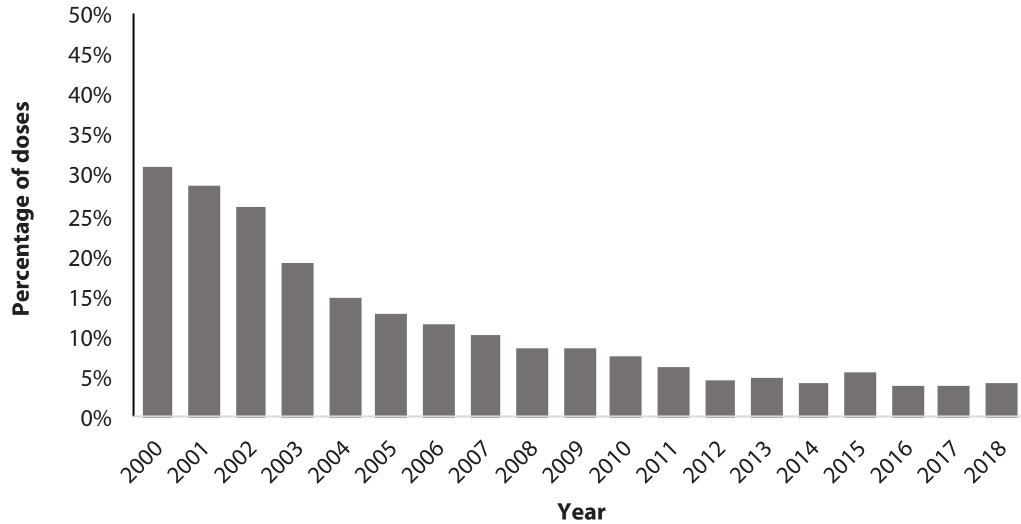


Figure 3. Trend in the percentage of doses of killed respiratory viral vaccines.
*There was a decrease ($P < 0.05$) in the use of 4- or 5-way respiratory viral vaccines that contained all killed antigens from 2000 through 2018.

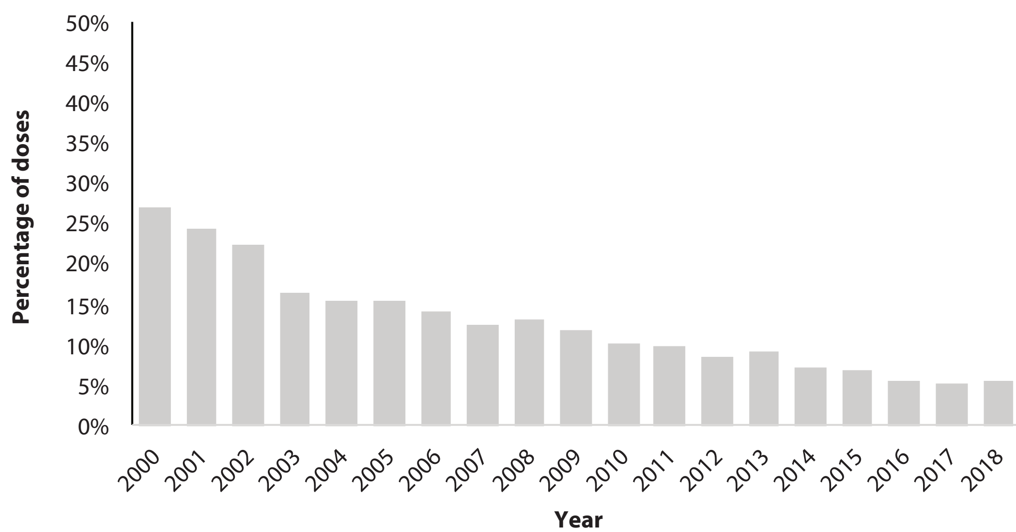


Figure 4. Trend in the percentage of doses of combination respiratory viral vaccines.
*There was a decrease ($P < 0.05$) in the use of 4- or 5-way respiratory viral vaccines that contained a combination of modified live and killed antigens from 2000 through 2018.

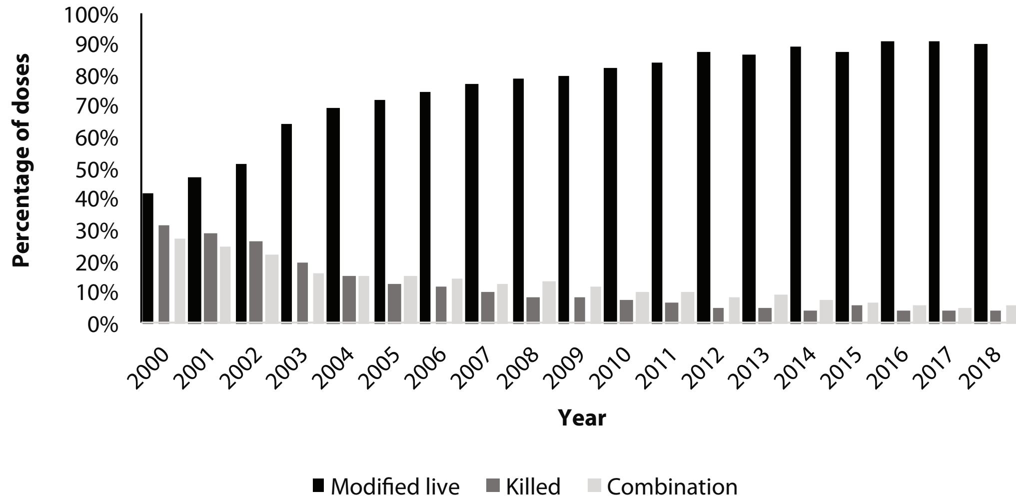


Figure 5. Trends in the percentage of doses of modified live, killed, and combination respiratory viral vaccines.

Carcass Trait Trends for Steers and Heifers Finished Through the Tri-County Steer Carcass Futurity Cooperative from 2002 Through 2018

E.D. McCabe, M.E. King, K.E. Fike, M. Groves,[1] and K.G. Odde

Abstract

The objective was to evaluate trends in carcass characteristics for steers and heifers finished through the Tri-County Steer Carcass Futurity Cooperative (Lewis, IA). Data analyzed included 74,207 steers and 33,529 heifers harvested from 2002 through 2018. Carcass trait trends evaluated for steers and heifers included calculated yield grade score, fat thickness, hot carcass weight, kidney, pelvic, heart fat percentage, marbling score, and ribeye area. Calculated yield grade score increased slightly from 2002 through 2018 for steers and heifers. Fat thickness increased 0.08 in for steers and 0.07 in for heifers, both peaking in 2017. Hot carcass weight increased slightly. Kidney, pelvic, and heart fat percentage did not change for steers and heifers. Marbling score increased from 422 to 456 for steers and 449 to 493 for heifers. Ribeye area slightly increased. Corresponding with increases in fat thickness and minimal to no improvement in ribeye area, yield grade scores increased over the past 17 years. Genetic selection pressure on marbling within the beef industry is evident from these data.

Introduction

The Tri-County Steer Carcass Futurity Cooperative is a consortium of custom feedyards in southwest Iowa whose primary objective is to provide feedlot performance, average daily gain, and carcass data for use in management and marketing decisions for producers participating in the program. From 2002 through 2018, an average of 6,638 head of cattle were finished annually. This dataset allowed the opportunity to evaluate long-term trends in beef carcass traits to include calculated yield grade score, fat thickness, hot carcass weight, kidney, pelvic, heart fat percentage, marbling score, and ribeye area.

Experimental Procedures

Information describing factors about steers and heifers finished through the Tri-County Steer Carcass Futurity Cooperative (Lewis, IA) was obtained in an electronic format. These data were collected for steers and heifers from 2002 through 2018. Detailed requirements for the program are available at www.tcscf.com.

Carcass characteristics were collected at the harvest facility. Steers and heifers were harvested in Denison, IA from 2002 through 2014, then in Dakota City, NE, from 2015 through 2018. Data began to be collected from instrument grading starting in 2015.

[1] Tri-County Steer Carcass Futurity Cooperative, Lewis, IA.

To depict potential changes in mean carcass trait variables over the 17-year period, data were plotted and linear regression trend lines fit within Microsoft Excel.

Results and Discussion

Data analyzed included 74,207 steers and 33,529 heifers finished at the Tri-County Steer Carcass Futurity Cooperative and harvested from 2002 through 2018. Steers and heifers were harvested at live weights of 1,235.0 ± 119.8 lb and 1,124.2 ± 106.7 lb, respectively.

Calculated yield grade increased from 2002 through 2018 for both steers and heifers (Figure 1). Fat thickness increased 0.08 in for steers and 0.07 in for heifers, both peaking in 2017 at 0.55 and 0.59 in, respectively (Figure 2). Hot carcass weights ranged from 727 to 780 lb for steers and increased over the 17-year period (Figure 3). Hot carcass weights for heifers ranged from 671 to 711 lb and increased slightly from 2002 through 2018 (Figure 3). Kidney, pelvic, and heart fat percentage did not change over time for steers or heifers (Figure 4). Marbling score increased from 422 to 456 for steers and 449 to 493 for heifers (Figure 5). Ribeye area appeared to increase slightly for steer carcasses while decreasing slightly for heifers (Figure 6).

The cattle represented in these data were harvested at lighter weights than the industry average. Focus on Feedlots compiles data from nine feedlots in Kansas (Kansas State University, 2018). Data from Focus on Feedlots showed an increasing trend in live weight for both steers and heifers from 2002 through 2018. Steers had a mean live weight of 1,344 lb and heifers 1,215 lb. The U.S. Department of Agriculture Economic Research Service (2020) historical data also showed an increasing trend during this time in mean live weight for cattle ranging from 1,235 lb to 1,366 lb with a mean of 1,299 lb.

Hot carcass weights in the present study were lighter than other industry averages. The U.S. Department of Agriculture Economic Research Service (2020) also reported an increase in hot carcass weight from 2002 through 2018. The USDA reported a range of 746 lb to 829 lb with a mean hot carcass weight of 788 lb. The National Beef Quality Audit from 2011 and 2016 provides insight into industry changes between these periods of time (Moore et al., 2011; Boykin et al., 2017). In 2011, the mean hot carcass weight was 819 lb (Moore et al., 2011). In 2016, Boykin et al. (2017) reported a mean hot carcass weight of 868 lb. This was a 49-lb increase in hot carcass weight in a five-year period. The hot carcass weights in the present study had an average of 732 lb in 2011 and 738 lb in 2016, an increase of six pounds.

While fat thickness increased, calculated yield grade increased from 2002 through 2018 as well. This observation aligns with noted changes in these variables from the 2011 and 2016 National Beef Quality Audits (Boykin et al., 2017). Ribeye area likewise increased for steers but actually decreased slightly for heifers over time. It appears the expected increase in ribeye area required for corresponding increases in hot carcass weights did not occur to the proportion expected and with simultaneous increases in fat thickness, yield grade scores rose over time.

Marbling scores in these data increased over time with mean scores falling within the Choice quality grade. The National Beef Quality Audit, in both 2011 and 2016, reported mean marbling scores (Moore et al., 2011; Boykin et al., 2016). In 2011, the mean marbling score was 449 (Moore et al., 2011) and 475 in 2016 (Boykin et al., 2016). In the present study, the mean marbling score in 2011 was 451 and 487 in 2016. Marbling scores in these data were numerically slightly greater but all mean scores fell within the Choice quality grade.

Implications

Corresponding with increases in fat thickness and minimal to no improvement in ribeye area, yield grade scores increased over the past 17 years. Genetic selection pressure on marbling within the beef industry is evident from these data. Lighter hot carcass weights than industry average in these data correspond with lighter mean live weights at time of harvest.

References

Boykin, C. A., L. C. Eastwood, M. K. Harris, D. S. Hale, C. R. Kerth, D. B. Griffin, A. N. Arnold, J. D. Hasty, K. E. Belk, D. R. Woerner, R. J. Delmore Jr., J. N. Martin, D. L. VanOverbeke, G. G. Mafi, M. M. Pfeiffer, T. E. Lawrence, T. J. McEvers, T. B. Schmidt, R. J. Maddock, D. D. Johnson, C. C. Carr, J. M. Scheffler, T. D. Pringle, A. M. Stelzleni, J. Gottlieb, and J. W. Savell. 2017. National Beef Quality Audit – 2016: Survey of carcass characteristics through instrument grading assessments. J. Anim. Sci. 95:3003-3011. doi:10.2527/jas2017.1544.

Kansas State University. 2018. Focus on feedlots. Accessed May 02, 2020. https://www.asi.k-state.edu/about/newsletters/focus-on-feedlots/.

Moore, M. C., G. D. Gray, D. S. Hale, C. R. Kerth, D. B. Griffin, J. W. Savell, C. R. Raines, K. E. Belk, D. R. Woerner, J. D. Tatum, J. L. Igo, D. L. VanOverbeke, G. G. Mafi, T. E. Lawrence, R. J. Delmore Jr., L. M. Christensen, S. D. Shackelford, D. A. King, T. L. Wheeler, L. R. Meadows, and M. E. O'Connor. 2012. National Beef Quality Audit – 2011: In-plant survey of targeted carcass characteristics related to quality, quantity, value, and marketing of fed steers and heifers. J. Anim. Sci. 90:5143–5151. doi:10.2527/jas.2012-5550.

U.S. Department of Agriculture, Economic Research Service (USDA ERS). 2020. Livestock and Meat Domestic Data. Accessed September 13, 2020. https://www.ers.usda.gov/data-products/livestock-meat-domestic-data/.

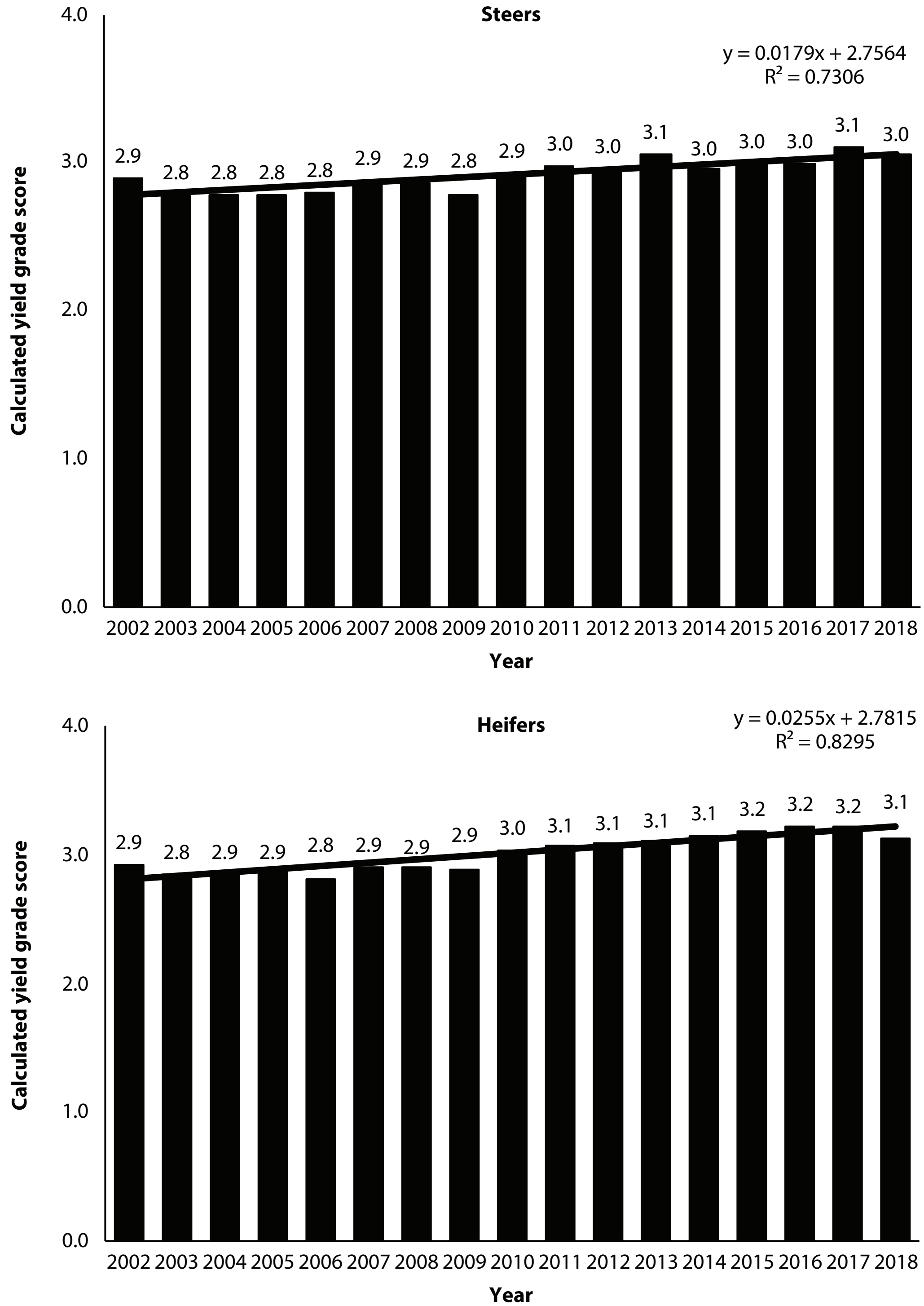


Figure 1. Trend of mean calculated yield grade score for steers and heifers finished through Tri-County Steer Carcass Futurity Cooperative from 2002 through 2018.

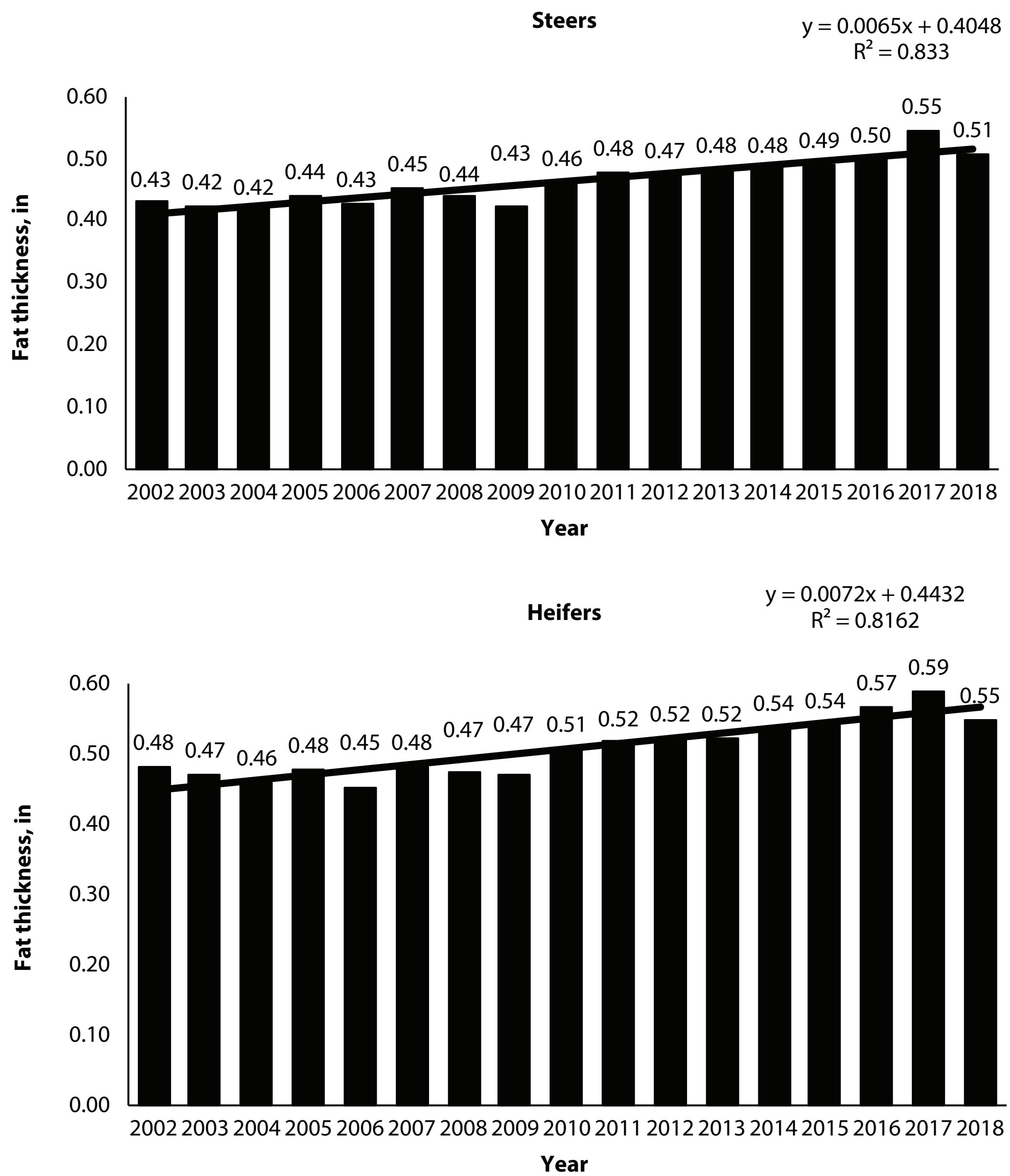


Figure 2. Trend of mean fat thickness for steers and heifers finished through Tri-County Steer Carcass Futurity Cooperative from 2002 through 2018.

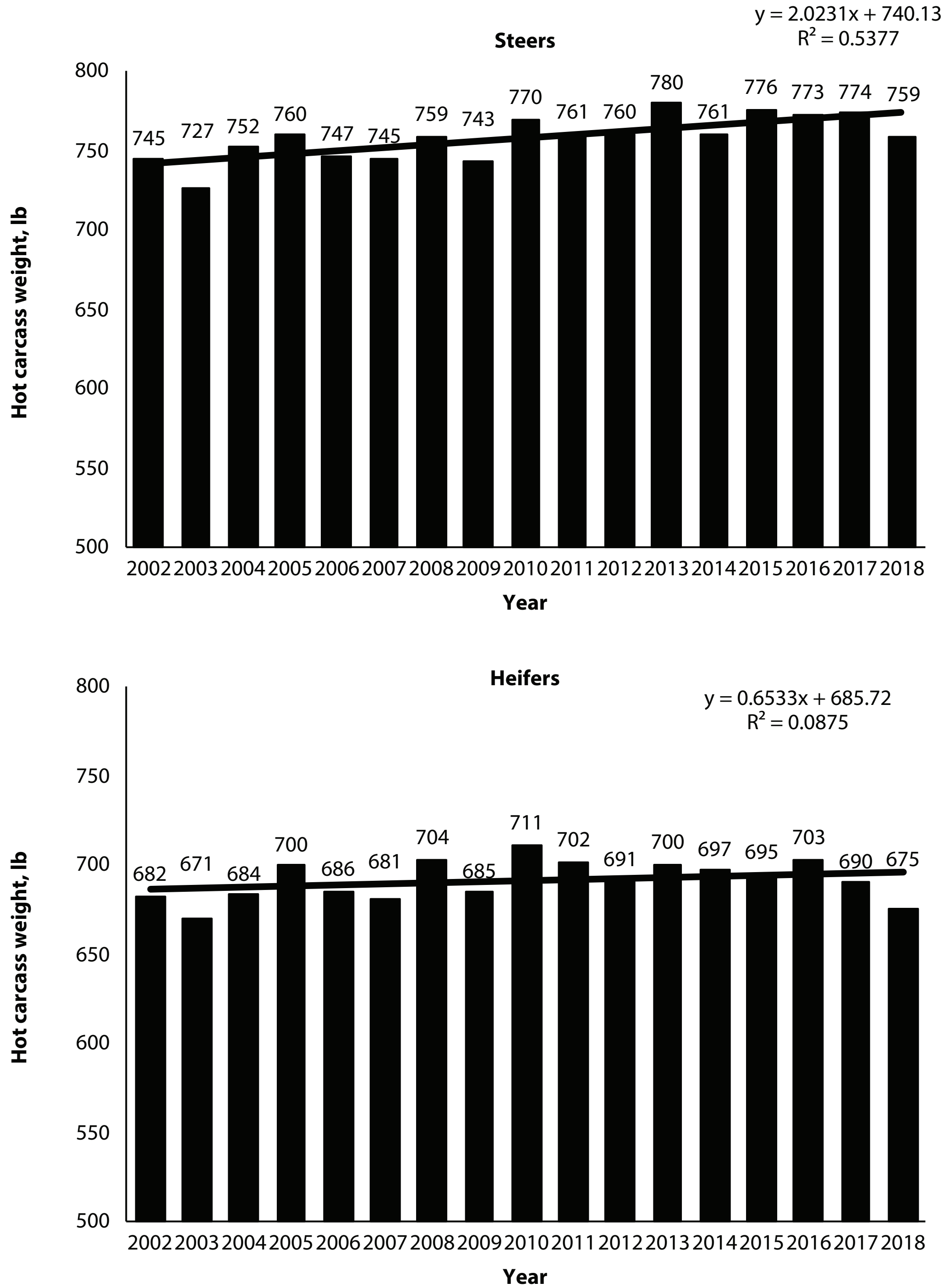
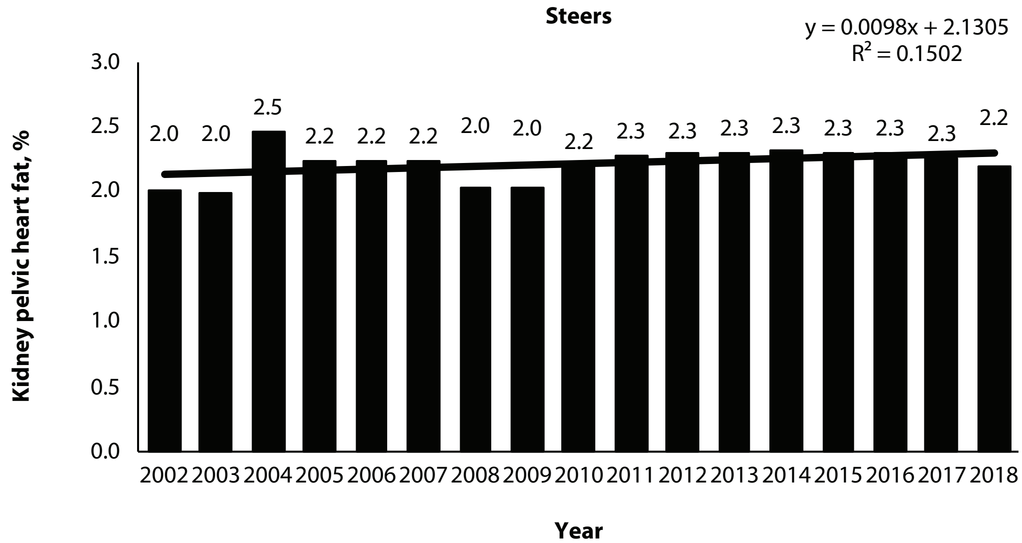


Figure 3. Trend of mean hot carcass weight for steers and heifers finished through Tri-County Steer Carcass Futurity Cooperative from 2002 through 2018.



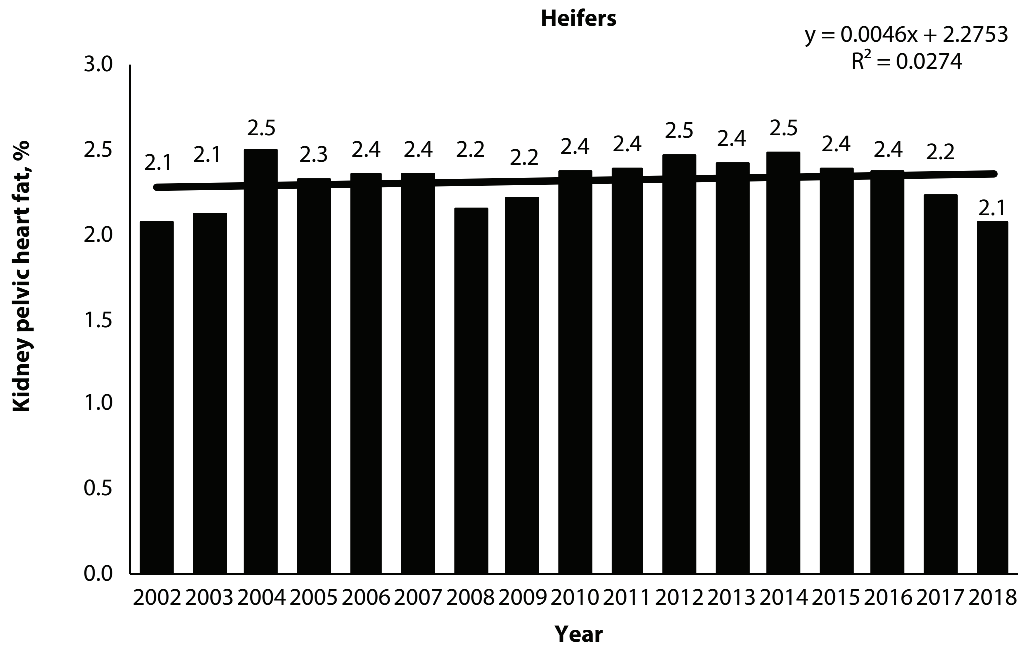


Figure 4. Trend of mean kidney, pelvic, and heart fat for steers and heifers finished through Tri-County Steer Carcass Futurity Cooperative from 2002 through 2018.

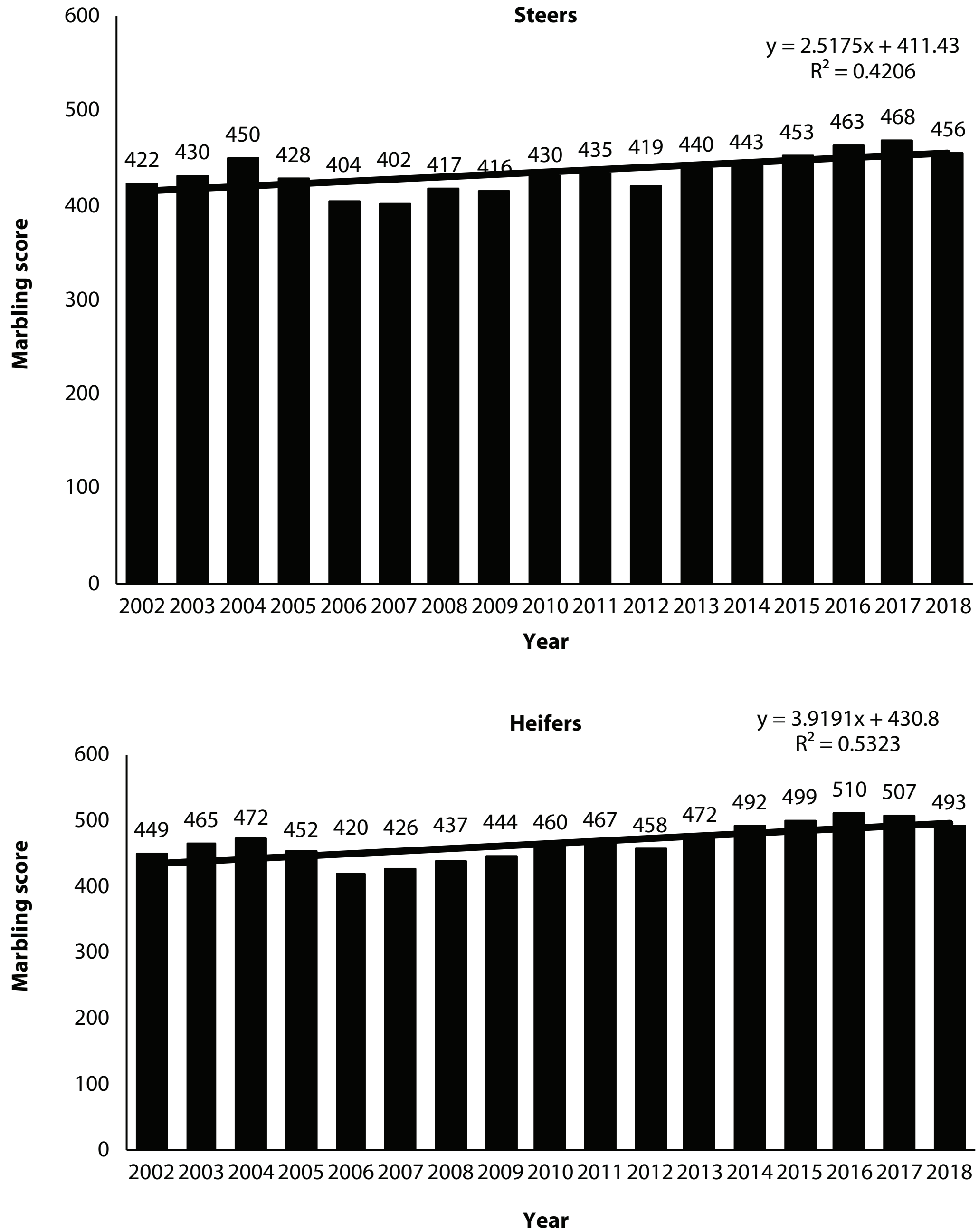
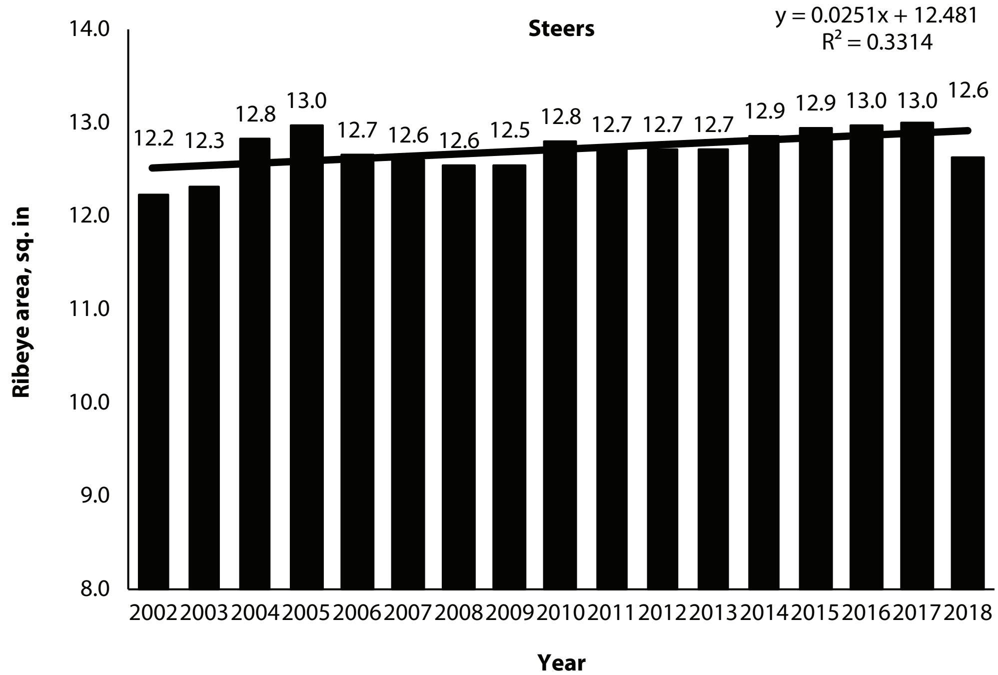


Figure 5. Trend of mean marbling score[1] for steers and heifers finished through Tri-County Steer Carcass Futurity Cooperative from 2002 through 2018

[1]100 = Practically devoid^{00}; 300 = Slight^{00}; 400 = Small^{00}; 500 = Modest^{00}; 700 = Slightly Abundant^{00}; 900 = Abundant^{00}.



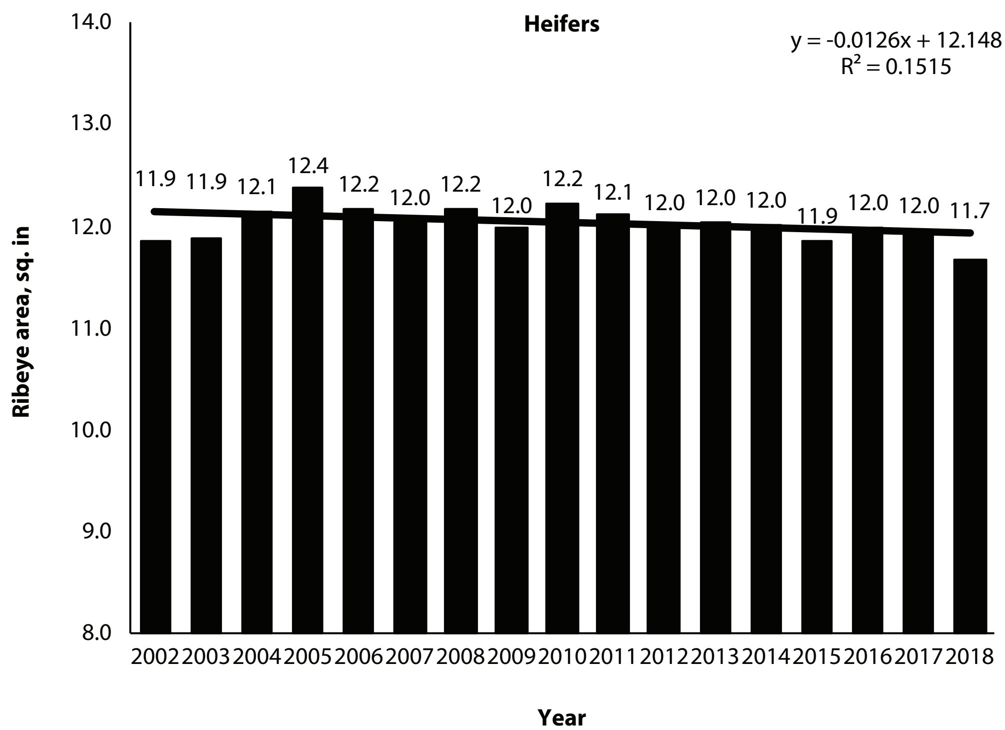


Figure 6. Trend of mean ribeye area for steers and heifers finished through Tri-County Steer Carcass Futurity Cooperative from 2002 through 2018.

Relationships Among Terminal Traits and Sale Prices of Red Angus Bulls Sold at Auction From 2017 Through 2019

M.J. Smith, K.E. Fike, M.E. King, E.D. McCabe, G.M. Rogers,[1] and K.G. Odde

Abstract
The objective of this study was to evaluate the influence of terminal traits in the form of selection indices and expected progeny differences on the sale price of Red Angus bulls sold at auction from 2017 through 2019 across the United States. Various factors were discovered to be of significance through statistical models. Through the construction of descriptive figures, sale price was found to be positively associated with several terminal traits. However, relatively low R^2 values across both models indicated that only a small amount of price variation was accounted for with these factors. Other factors likely affecting sale price were breeder reputation and visual aspects of bull quality.

Introduction
The selection of a beef bull is an important choice, as a herd sire provides more than 80% of genetic merit and change to a herd (Ishmael, 2017). In an industry with rapid change in producer priorities and preferences, the utilization of various management strategies and selection tools has been crucial in ensuring a continued level of economic productivity (Hersom et al., 2011). Numerous categories of information are provided to potential buyers through various auction channels. Information includes values concerning expected progeny differences, selection indices, and phenotypic data and characteristics. Different information provided to buyers during the time of sale may have the potential to alter the price a buyer may be willing to offer for the bull depending on the goals and priorities of the specific producer (Dhuyvetter et al., 1996).

Experimental Procedures
Information describing various factors about Red Angus bulls marketed and sold nationwide through auctions were obtained from the Red Angus Association of America (Commerce City, CO) in an electronic format. These data were available for Red Angus bulls offered for sale in auctions during the spring and fall of 2017 and 2018, and the spring of 2019 sale seasons. Quantifiable factors came in the form of two selection indices and fourteen expected progeny differences, encompassing a variety of maternal and terminal traits.

Two separate multiple regression models were developed using backward selection procedures to examine the effect of genetic factors in the form of selection indices and expected progeny differences on the sale price of Red Angus bulls. Terminal traits included with the selection index model came in the form of the GridMaster Index. Terminal traits in the form of expected progeny differences included birth weight expected progeny difference, weaning weight expected progeny difference, yearling

[1] Grassy Ridge Consulting, Aledo, TX.

weight expected progeny difference, yield grade expected progeny difference, marbling score expected progeny difference, carcass weight expected progeny difference, ribeye area expected progeny difference, and 12th rib fat thickness expected progeny difference. Relationships between sale price and these genetic parameters were further examined by evaluating the trends in selection indices and expected progeny differences across sale price categories. Red Angus bulls were categorized into eight groups by respective sale price. The unadjusted, average values of these selection indices and expected progeny differences were then calculated across price categories to investigate the trend of these various genetic factors relative to sale price.

Results and Discussion

Data were collected for 21,362 Red Angus bulls offered for sale in auctions from 2017 through 2019. Within the selection index model, GridMaster Index ($P < 0.05$) was found to be a significant factor positively influencing bull sale price. Regression coefficients from the model indicate that a single unit increase in GridMaster Index increased auction price by $331.00 (Table 1).

Correlations among expected progeny differences were examined to minimize the occurrence of multicollinearity. The following parameters were excluded from the regression model due to high correlations across traits: weaning weight expected progeny difference, yearling weight expected progeny difference, and yield grade expected progeny difference. Within the expected progeny difference model, various terminal traits significantly influenced bull sale price. Those factors were: birth weight expected progeny difference ($P < 0.05$), marbling score expected progeny difference ($P < 0.05$), carcass weight expected progeny difference ($P < 0.05$), ribeye area expected progeny difference ($P < 0.05$), and 12th rib fat thickness expected progeny difference ($P < 0.05$) (Table 2). Positive relationships with sale price were discovered for the variables of marbling score expected progeny difference, carcass weight expected progeny difference, ribeye area expected progeny difference, and 12th rib fat thickness expected progeny difference, while birth weight expected progeny difference was found to be inversely associated with bull sale price. While selection indices and expected progeny differences were found to be significant through statistical models, relatively low R^2 values were found across both models (Table 1 and Table 2), indicating a small amount of variation in auction price was explained by the associated genetic parameters. This may suggest that producers are relying on other factors not captured within the data when making purchasing decisions.

When summarizing descriptive data for terminal traits across bull sale price groups, positive trends were discovered for GridMaster Index (Figure 1), weaning weight expected progeny difference (Figure 2), yearling weight expected progeny difference (Figure 3), marbling score expected progeny difference (Figure 4), carcass weight expected progeny difference (Figure 5), ribeye area expected progeny difference (Figure 6), and 12th rib fat thickness expected progeny difference (Figure 7). An inverse relationship was discovered between sale price and birth weight expected progeny difference (Figure 8). A relatively flat trend was observed for yield grade expected progeny difference (Figure 9).

Implications

Relatively low R^2 values suggest that bull buyers are utilizing other informational components not captured within these data when making purchasing decisions. Knowledge of physical attributes, marketing strategies, and breeder reputation is likely influencing buyers, and may explain additional variation in the sale price of Red Angus bulls. Continued research on terminal traits influencing the sale price of beef bulls across the United States may prove advantageous to producers.

References

Dhuyvetter, K. C., T. Schroeder, D. Simms, R. Bolze Jr., and J. Geske. 1996. Determinants of purebred beef bull price differentials. J. Agr. Resource Econ. 21(2):396-410.

Hersom, M., T. Thrift and J. Yelich. 2011. The impact of production technologies used in the beef cattle industry. IFAS Extension, University of Florida. AN272. Accessed 09 June 2019. https://edis.ifas.ufl.edu/pdffiles/AN/AN27200.pdf.

Ishmael, W. 2017. What's a bull really worth? Beef Magazine. Accessed 01 May 2020. https://www.beefmagazine.com/seedstock/what-s-bull-really-worth.

Table 1. Terminal traits in the form of selection indices affecting the sale price of Red Angus bulls sold at auction from 2017 through 2019

Factor	Estimate	Standard error	T-value of factor	*P*-value
Intercept	-12,800.00	521.30	-24.55	<0.0001
GridMaster index	331.00	10.53	31.44	<0.0001
Number of observations	21,362			
R^2	0.05			
Adjusted R^2	0.05			

Table 2. Terminal traits in the form of expected progeny differences affecting the sale price of Red Angus bulls sold at auction from 2017 through 2019

Factor expected progeny difference	Estimate	Standard error	T-value of factor	*P*-value of factor
Birth weight	-276.40	18.32	-15.09	<0.0001
Marbling score	567.15	114.16	4.97	<0.0001
Carcass weight	69.47	2.78	24.96	<0.0001
Ribeye area	1,125.72	115.62	9.74	<0.0001
12th Rib fat thickness	3,114.31	1,016.32	3.06	<0.01
Number of observations	21,362			
R^2	0.07			
Adjusted R^2	0.07			

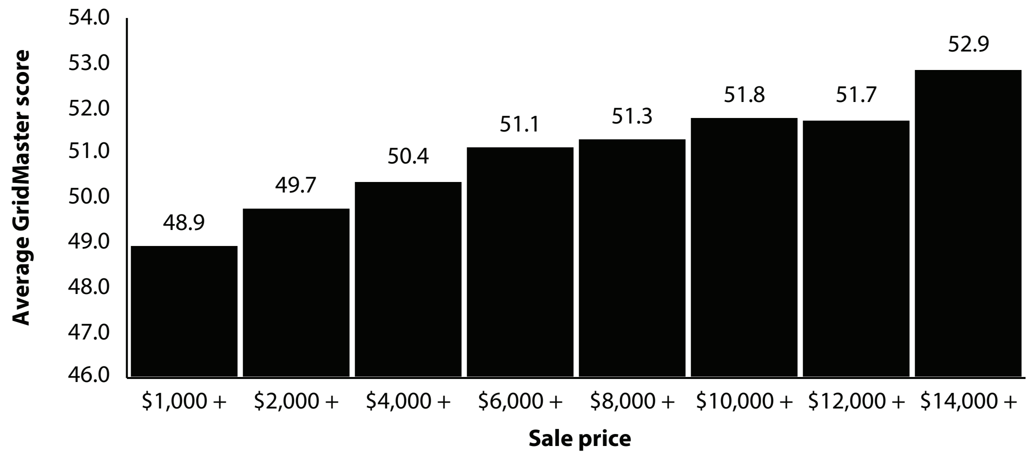


Figure 1. GridMaster score by sale price category.

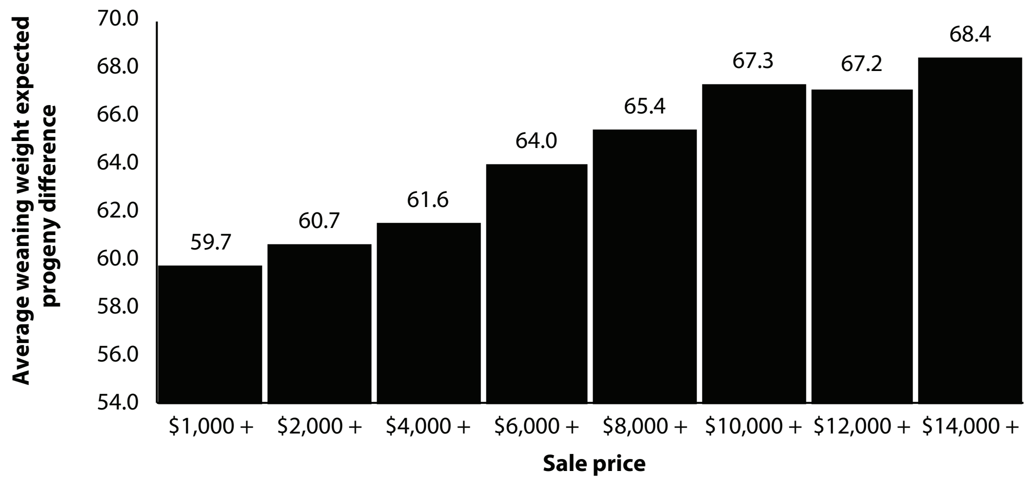


Figure 2. Weaning weight expected progeny difference by sale price category.

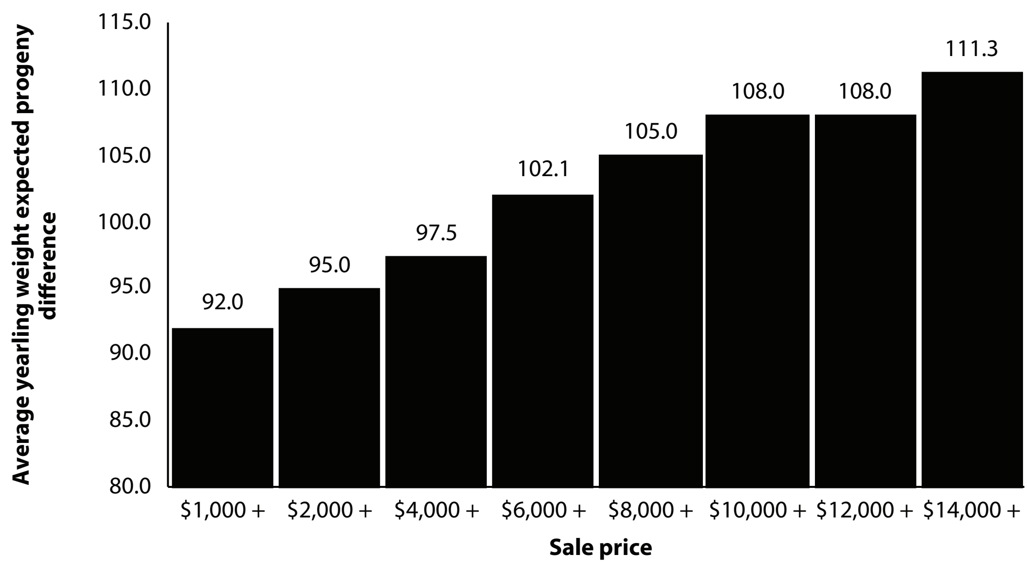


Figure 3. Yearling weight expected progeny difference by sale price category.

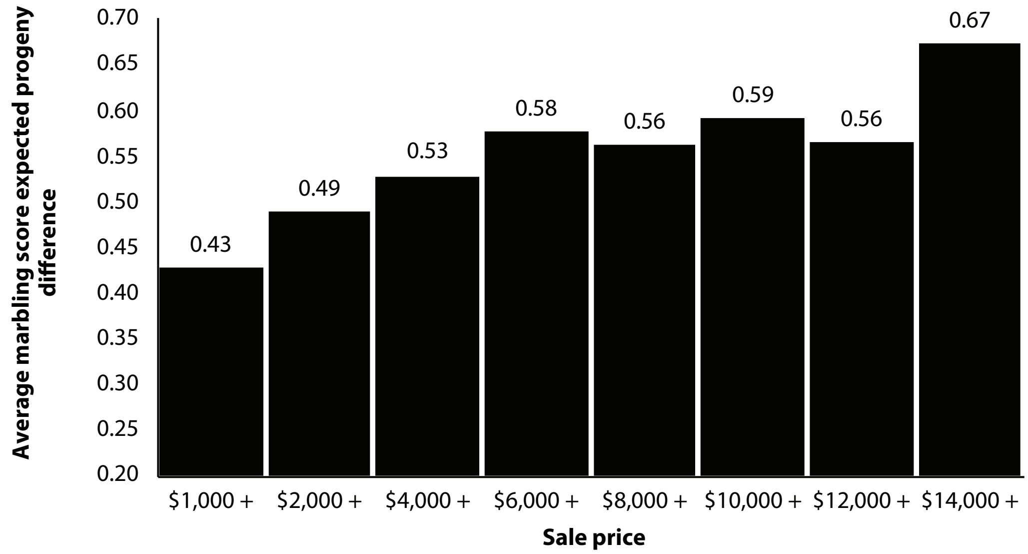


Figure 4. Marbling score expected progeny difference by sale price category.

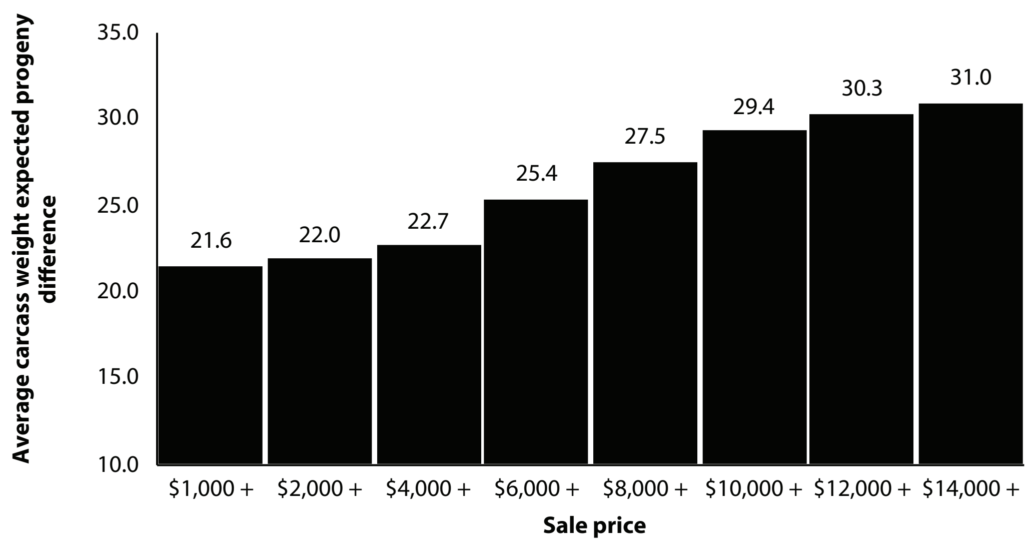


Figure 5. Carcass weight expected progeny difference by sale price category.

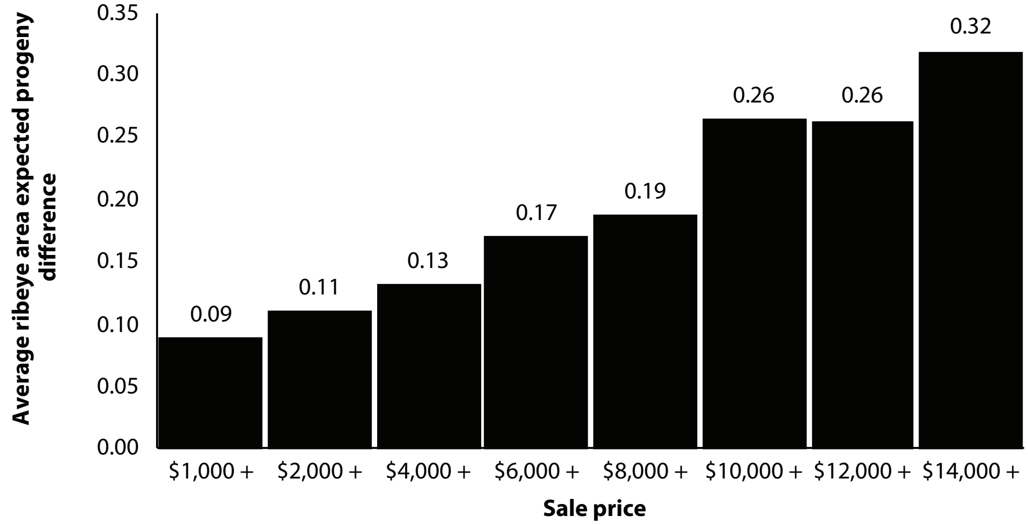


Figure 6. Ribeye area expected progeny difference by sale price category.

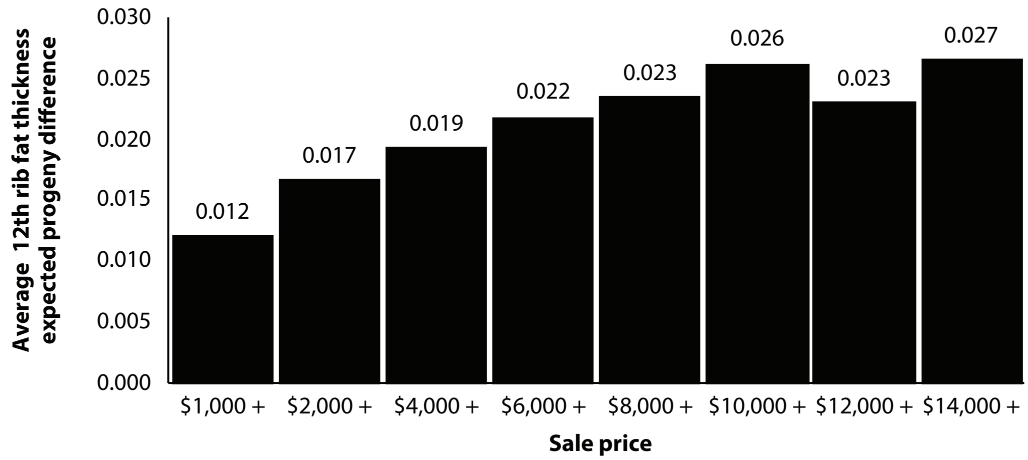


Figure 7. 12th Rib fat thickness expected progeny difference by sale price category.

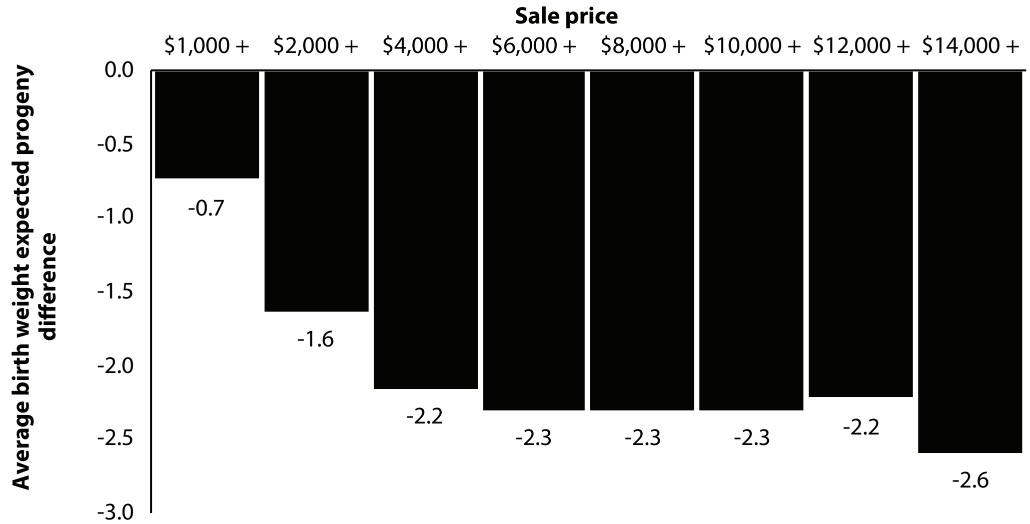


Figure 8. Birth weight expected progeny difference by sale price category.

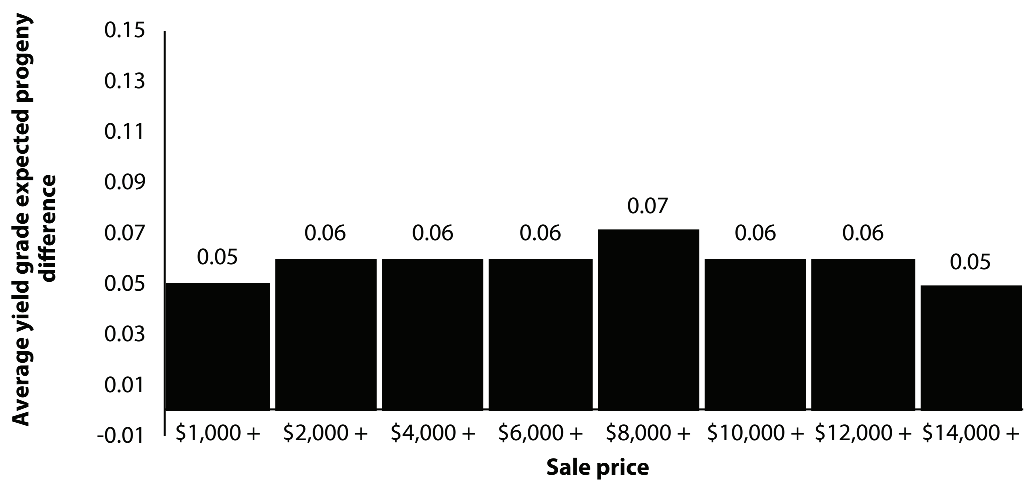


Figure 9. Yield grade expected progeny difference by sale price category.

Relationships Among Maternal Traits and Sale Prices of Red Angus Bulls Sold at Auction From 2017 Through 2019

M.J. Smith, K.E. Fike, M.E. King, E.D. McCabe, G.M. Rogers,[1] and K.G. Odde

Abstract

The objective of this study was to evaluate the influence of maternal traits in the form of selection indices and expected progeny differences on the sale price of Red Angus bulls sold at auction from 2017 through 2019 across the United States. Various factors were discovered to be of significance through statistical models. Through the construction of descriptive figures, sale price was found to be positively associated with several maternal traits. However, relatively low R^2 values indicate that only a small amount of the price variation was accounted for, suggesting buyers are using additional information that we are not able to fully characterize.

Introduction

The selection of a beef bull is an important choice, as a herd sire provides more than 80% of genetic merit and change to a herd (Ishmael, 2017). In an industry with rapid change in producer priorities and preferences, the utilization of various management strategies and selection tools has been crucial in ensuring a continued level of economic productivity (Hersom et al., 2011). Numerous categories of information are provided to potential buyers through various auction channels. Information ranges from values concerning expected progeny differences, selection indices, and phenotypic data and characteristics. Different information provided to buyers during the time of sale may have the potential to alter the price a buyer may be willing to offer for the bull, depending on the goals and priorities of the specific producer (Dhuyvetter et al., 1996).

Experimental Procedures

Information describing various factors about Red Angus bulls marketed and sold nationwide through auctions were obtained from the Red Angus Association of America (Commerce City, CO) in an electronic format. These data were available for all Red Angus bulls offered for sale in auctions during the spring and fall of 2017 and 2018, and the spring of 2019 sale seasons. Quantifiable factors came in the form of two selection indices and fourteen expected progeny differences, encompassing a variety of maternal and terminal traits.

Two separate multiple regression models were developed using backward selection procedures to examine the effect of genetic factors in the form of selection indices and expected progeny differences on the sale price of Red Angus bulls. Maternal traits included with the selection index model came in the form of the HerdBuilder Index. Maternal expected progeny difference traits included calving ease direct expected progeny difference, milk expected progeny difference, maintenance energy expected

[1] Grassy Ridge Consulting, Aledo, TX.

progeny difference, heifer pregnancy expected progeny difference, calving ease maternal expected progeny difference, and stayability expected progeny difference. Relationships between sale price and these maternal genetic parameters were further examined by evaluating trends in selection indices and expected progeny differences across sale price categories. Red Angus bulls were categorized into eight groups by respective sale price. The unadjusted, average values of these selection indices and expected progeny differences were calculated across price categories to investigate the trend of these various genetic factors relative to sale price.

Results and Discussion

Data were collected for 21,362 Red Angus bulls offered for sale in auctions from 2017 through 2019. Within the selection index model, the HerdBuilder Index ($P < 0.05$) was found to be a significant factor positively influencing bull sale price. Regression coefficients from the model indicate that a single unit increase in HerdBuilder Index increased auction price by $5.08 (Table 1).

Within the expected progeny difference model, various maternal traits significantly influenced bull sale price. Those factors were: calving ease direct expected progeny difference (P < 0.05), maintenance energy expected progeny difference ($P < 0.05$), heifer pregnancy expected progeny difference ($P < 0.05$), calving ease maternal expected progeny difference ($P < 0.05$), and stayability expected progeny difference ($P < 0.05$) (Table 2). Milk expected progeny difference ($P > 0.05$) did not affect the sale price of Red Angus bulls and was excluded from the final model. Positive relationships with sale price were discovered for the variables of calving ease direct expected progeny difference, heifer pregnancy expected progeny difference, and stayability expected progeny difference, while maintenance energy expected progeny difference and calving ease maternal expected progeny difference were found to be inversely associated with bull sale price. While selection indices and expected progeny differences were found to be significant through statistical models, relatively low R^2 values were found across both models (Table 1 and Table 2), indicating a small amount of variation in auction price was explained by the associated genetic parameters. This suggests that producers are using other factors not captured within the data, such as physical attributes, management and marketing factors, and breeder reputation when making selection decisions.

When summarizing descriptive data for maternal traits across bull sale price groups, positive trends were discovered for the HerdBuilder Index (Figure 1), calving ease direct expected progeny difference (Figure 2), heifer pregnancy expected progeny difference (Figure 3), and stayability expected progeny difference (Figure 4). Relatively flat trends were observed for milk expected progeny difference (Figure 5), maintenance energy expected progeny difference (Figure 6), and calving ease maternal expected progeny difference (Figure 7).

Implications

Relatively low R^2 values suggest that bull buyers are utilizing other informational components not captured within the data when making investment decisions. Knowledge of physical attributes, marketing strategies, and breeder reputation are likely influencing buyers, and may explain additional variation in the sale price of Red Angus bulls.

Continued research on maternal traits influencing the sale price of beef bulls across the United States may prove advantageous to producers.

References

Dhuyvetter, K.C., T. Schroeder, D. Simms, R. Bolze Jr., and J. Geske. 1996. Determinants of purebred beef bull price differentials. J. Agr. Resource Econ. 21(2):396-410.

Hersom, M., T. Thrift and J. Yelich. 2011. The impact of production technologies used in the beef cattle industry. IFAS Extension, University of Florida. AN272. Accessed 09 June 2019. https://edis.ifas.ufl.edu/pdffiles/AN/AN27200.pdf.

Ishmael, W. 2017. What's a bull really worth? Beef Magazine. Accessed 01 May 2020. https://www.beefmagazine.com/seedstock/what-s-bull-really-worth.

Table 1. Maternal traits in the form of selection indices affecting the sale price of Red Angus bulls sold at auction from 2017 through 2019

Factor	Estimate	Standard error	T-value of factor	*P*-value of factor
Intercept	-12,800.00	521.30	-24.55	<0.0001
HerdBuilder Index	5.08	0.60	8.61	<0.0001
Number of observations	21,362			
R^2	0.05			
Adjusted R^2	0.05			

Table 2. Maternal traits in the form of expected progeny differences affecting the sale price of Red Angus bulls sold at auction from 2017 through 2019

Factor expected progeny difference	Estimate	Standard error	T-value of factor	*P*-value of factor
Intercept	627.10	164.24	3.82	<0.01
Calving ease direct	57.09	9.91	5.76	<0.0001
Maintenance energy	-62.53	7.19	-8.70	<0.0001
Heifer pregnancy	51.62	9.82	5.26	<0.0001
Calving ease maternal	-22.79	11.58	-1.97	<0.05
Stayability	20.66	8.75	2.36	0.02
Number of observations	21,362			
R^2	0.07			
Adjusted R^2	0.07			

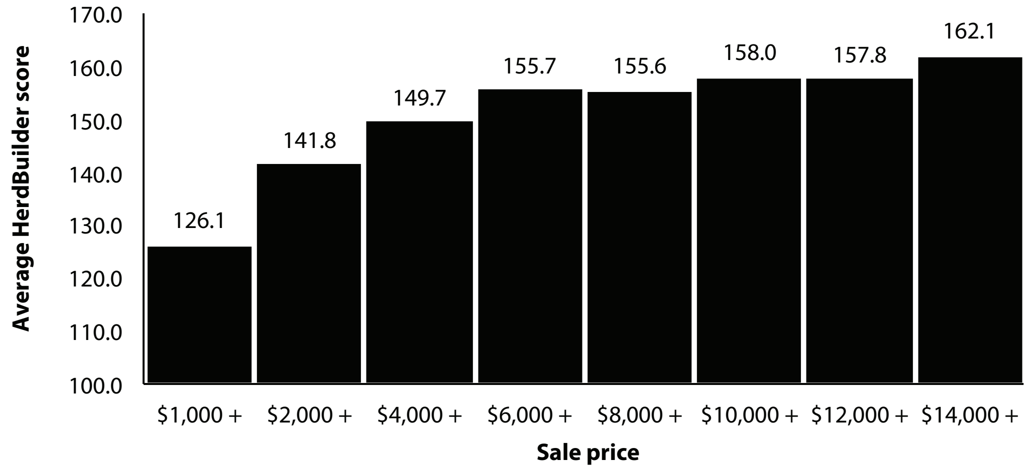


Figure 1. HerdBuilder score by sale price category.

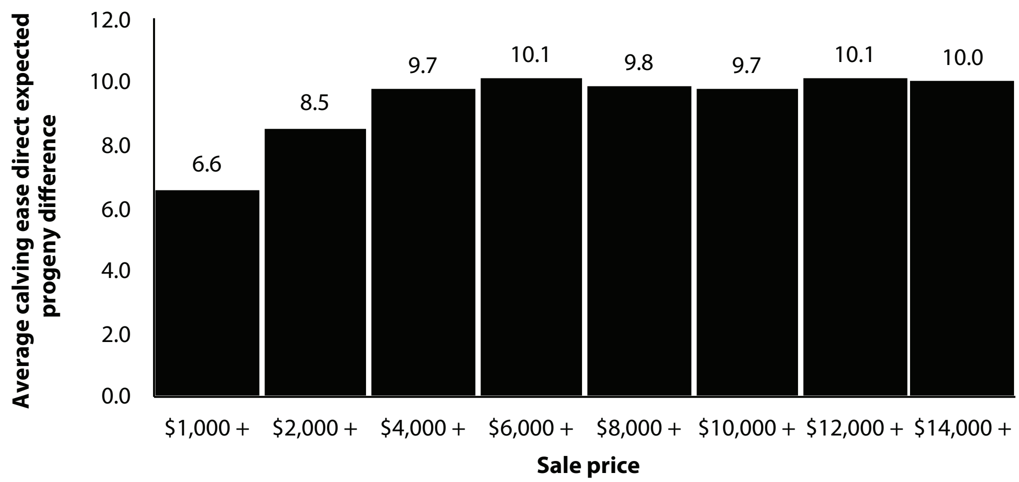


Figure 2. Calving ease direct expected progeny difference by sale price category.

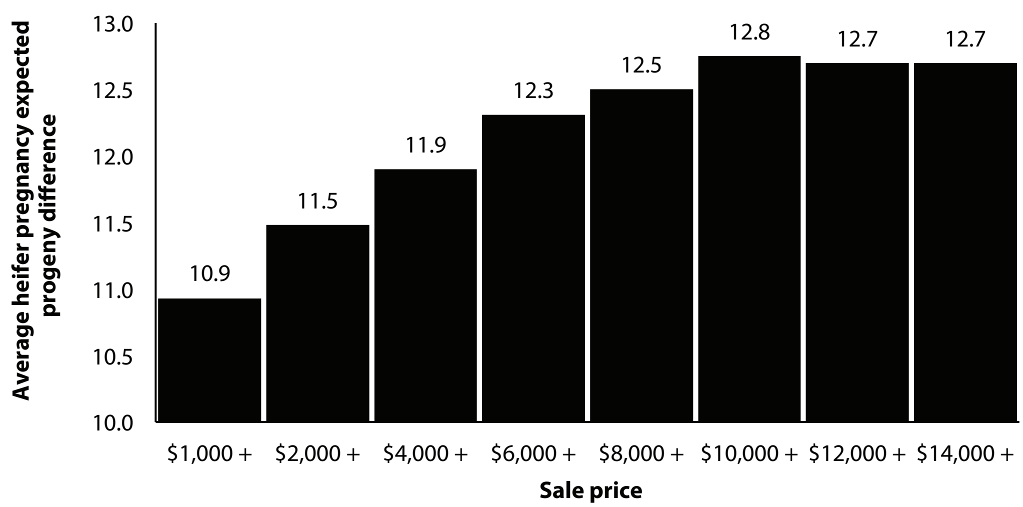


Figure 3. Heifer pregnancy expected progeny difference by sale price category.

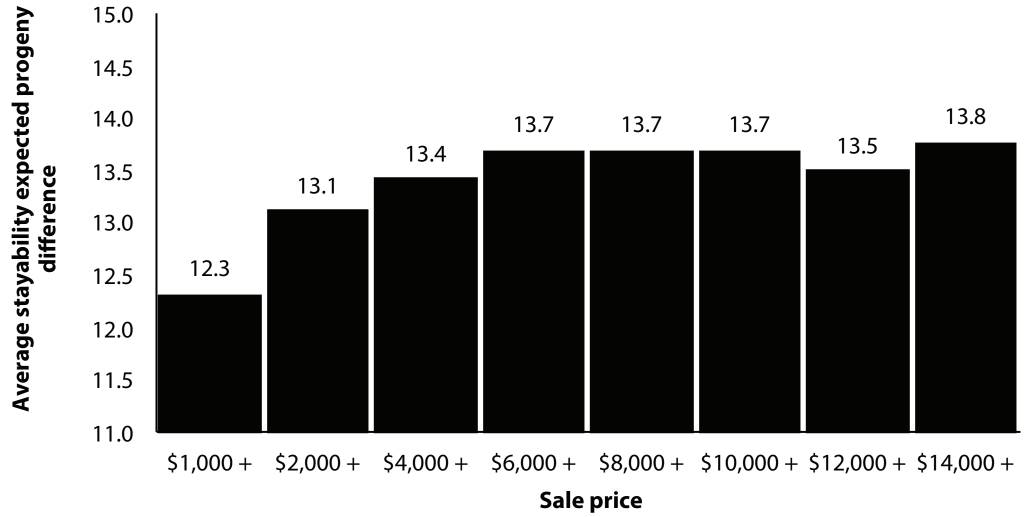


Figure 4. Stayability expected progeny difference by sale price category.

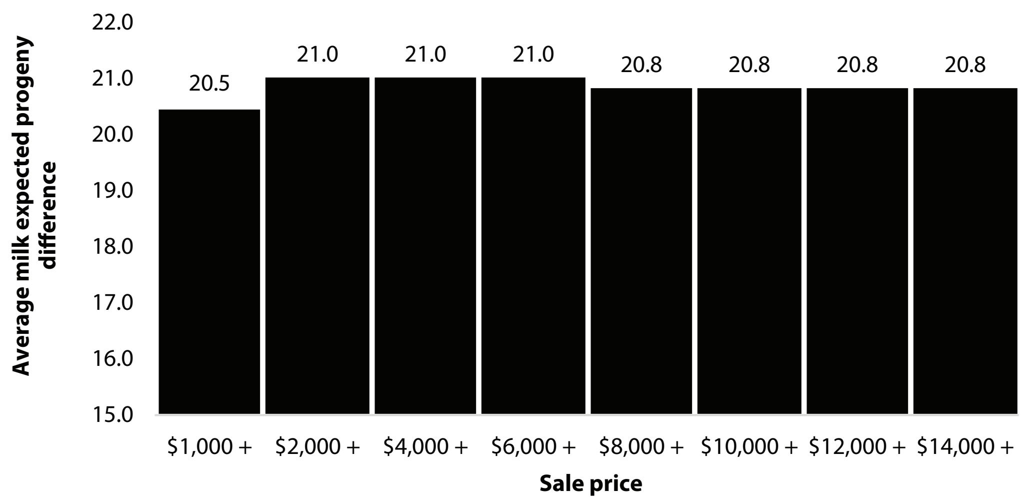


Figure 5. Milk expected progeny difference by sale price category.

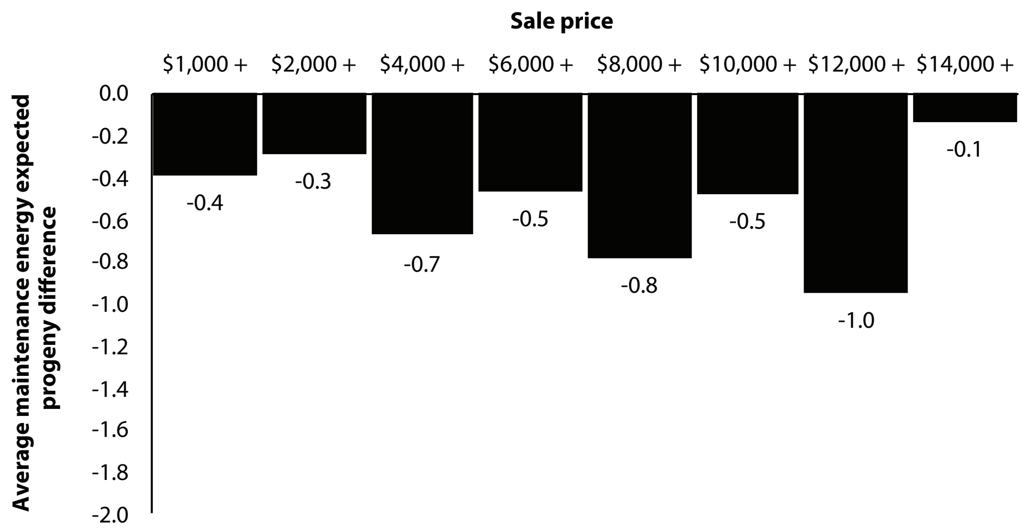


Figure 6. Maintenance energy expected progeny difference by sale price category.

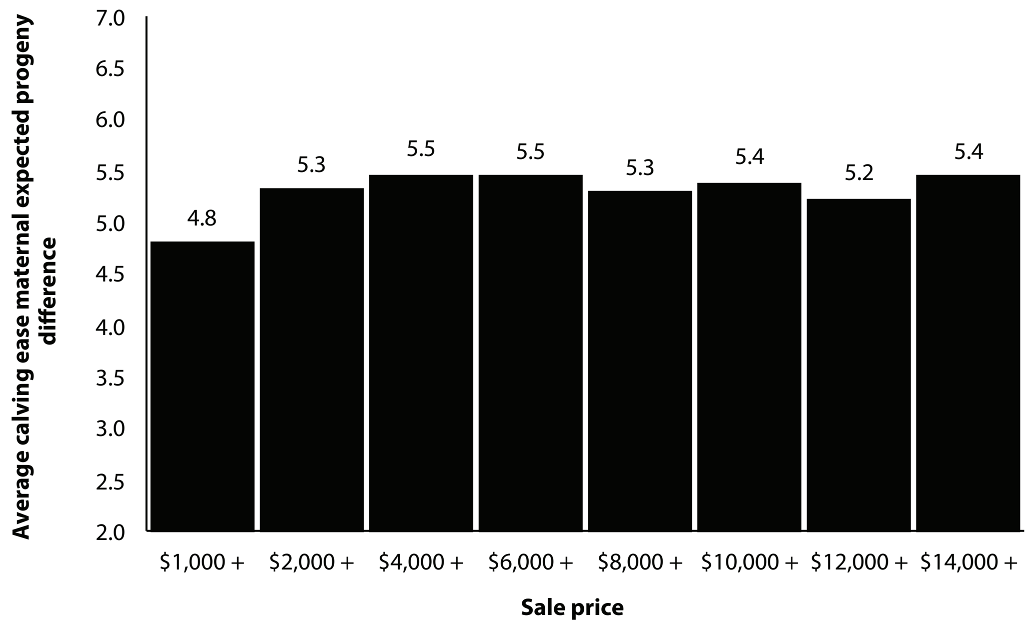


Figure 7. Calving ease maternal expected progeny difference by sale price category.

Limit-Fed, High-Energy Diets Can Achieve Improved Feed Conversion Rates Without Compromising Rate of Gain When Compared to Conventional High Roughage Diets

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Abstract
Recent research suggests that limit feeding a high-energy diet to growing cattle improves performance, with no increased incidence of morbidity and mortality. The objective of this study was to compare the performance impacts of limit feeding a high-energy diet to a traditional high roughage diet fed ad libitum. Crossbred heifer calves (n = 418) were used in an 84-day growing and receiving study at the Kansas State University Beef Stocker Unit with two treatment diets, including a high-energy, limit-fed treatment consisting primarily of dry-rolled corn and Sweet Bran (Cargill Animal Nutrition, Blair, NE), and a high roughage, ad libitum treatment. Pen performance statistics were measured throughout the study. Compared to the high roughage, ad libitum treatment, the high-energy, limit-fed cattle gained 14.7% more ($P < 0.01$) with 25.5% less dry matter consumption ($P < 0.01$). According to ultrasound scanning data, high-energy, limit-fed cattle showed a greater extent of muscle depth over the ribs and more marbling in the ribeye ($P < 0.02$).

Introduction
Previous research conducted at the Kansas State Beef Stocker Unit has demonstrated the possible benefits of limit feeding high-energy diets based on dry-rolled corn and corn co-products for newly received growing cattle. This study was conducted to further explore subsequent feedlot performance and carcass merit implications. During the receiving and growing phase of production, roughage-based diets are commonplace in the industry. However, in times of drought, or when forage prices are high, producers often seek alternative, yet readily available feedstuffs such as corn, distiller's grains, or wet corn gluten feed. Coupled with limit feeding, the use of high-energy feeds is a powerful means to achieve comparable, or even improved performance in young growing cattle prior to feedlot entry.

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Experimental Procedures

A total of 418 weaned, crossbred heifers (body weight = 615 ± 53 lb) were purchased at auction markets in Texas and New Mexico, assembled at two different farms approximately 90 miles southwest of Amarillo, TX, then shipped 570 miles to the Kansas State University Beef Stocker Unit, Manhattan, KS, on May 28, 2019. The heifers were used in a completely randomized block design, 84-day receiving and growing study to evaluate the impact of a high-energy, limit-fed diet containing dry-rolled corn and Sweet Bran (Cargill Animal Nutrition, Blair, NE) to a high roughage diet fed ad libitum on animal performance. Cattle were randomized by arrival weight and assigned to pens, each containing 13 or 14 heifers. Additionally, each pen was randomly assigned to one of two treatments in a "treatment pair" (one high-energy, limit-fed pen, and one high roughage, ad libitum pen). There was a total of 32 pens. The high roughage and high-energy diets were formulated to provide either 45 or 60 Mcal of net energy for gain/100 lb of dry matter, respectively. Feed intakes of the high-energy, limit-fed groups were initially set at 85% of the feed intakes of the high roughage, ad libitum groups. However, this percentage was reduced when it became apparent that 85% of the high roughage, ad libitum intakes resulting in ad libitum intakes for the high-energy, limit-fed treatment. Both diets were formulated to contain 40% Sweet Bran on a dry matter basis (Table 1).

At the time of arrival, all calves were evaluated for disease and lameness. Each animal was individually weighed, given a visual identification ear tag, and was vaccinated for typical respiratory diseases. Cattle were fed once daily, and each pen was weighed once per week. A 24-hour shrunk weight was measured at the end of the study to calculate pen performance statistics. Pen was the experimental unit. On day 84, ultrasound was performed on all cattle to determine muscling and fat differences by a technician from the Cattle Performance Enhancement Company, and preliminary carcass data were obtained.

Results and Discussion

Performance and growth results are provided in Table 2 for each treatment group. Ultrasound data are shown in Table 3. Overall, the high-energy, limit-fed cattle out-gained the high roughage, ad libitum cattle ($P < 0.01$). Inherently, dry matter intakes were considerably lower for the high-energy, limit-fed cattle; their efficiency was also markedly better, with gain-to-feed and feed-to-gain ratios better than the high roughage, ad libitum treatment ($P < 0.01$). Body weight was not different between treatments ($P = 0.22$) on day 84. Initially, the high-energy, limit-fed feed intake was set at 85% of the feed intakes of the high roughage, ad libitum treatment. However, the high roughage, ad libitum cattle consumed more dry matter than expected. Consequently, over subsequent weeks, each high-energy, limit-fed pen's intake was decreased to maintain limit-fed conditions according to each adjacent high roughage, ad libitum contemporary pen. Although 85% may work for some groups of cattle, this percentage is highly variable and depends on several factors such as breed type, age, weight, weather conditions, and eating experience. In practical producer settings, it would be more economical and convenient to base limit-fed cattle intakes on a fixed percentage of body weight to achieve a targeted rate of gain. In ultrasound scans, high-energy, limit-fed cattle showed greater muscle depth ($P < 0.01$) and marbling in the ribeye ($P = 0.02$).

Furthermore, this treatment group also deposited more backfat ($P < 0.01$). These outcomes may allow for shorter times on feed to achieve desired carcass indices.

Implications

Limit feeding a high-energy diet, as compared to feeding a traditional high roughage diet ad libitum in growing cattle can result in comparable, or even improved, feed conversion without negatively affecting rate of gain. Moreover, limit feeding the higher energy diet also increases muscling depth and fat deposition.

Acknowledgments

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Table 1. Composition of experimental diets fed in the backgrounding phase

	Diet[1]	
Item	**High roughage, ad libitum**	**High-energy, limit-fed**
Ingredient, % dry matter inclusion		
Alfalfa	22.50	6.50
Dry rolled corn	8.57	38.82
Prairie hay	22.50	6.50
Sweet Bran[2]	40.00	40.00
Supplement	6.43	8.18

1 Diets were formulated to contain 45 or 60 Mcal net energy for gain/100 lb dry matter, respectively.
2 Cargill Animal Nutrition, Blair, NE.

Table 2. Performance data collected from heifers in an 84-day backgrounding study

Item	Diet[1] High roughage, ad libitum	Diet[1] High-energy, limit-fed	Standard error of the least square means	*P*-value
Number of pens	16	16		
Number of animals	205	204		
Body weight, lb				
Day 0	618	615	13.5	0.89
Day 42	753	748	14.2	0.81
Day 84	811	837	14.6	0.22
Average daily gain, lb/day				
Day 0–84	2.30	2.64	0.04	< 0.01
Dry matter intake, lb/day				
Day 0–84	23.26	17.32	0.4	< 0.01
Feed to gain, lb/lb				
Day 0–84	10.15	6.55	0.2	< 0.01
Gain to feed, lb/lb				
Day 0–84	0.100	0.153	0.002	< 0.01

[1] Diets were formulated to contain 45 or 60 Mcal net energy for gain/100 lb dry matter, respectively, and were fed to each pen once/day. Weekly pen weights were measured, and feed intakes were adjusted accordingly.

Table 3. Ultrasound scanning data from heifers in the backgrounding phase and predicted carcass traits

Item	Diet[1] High roughage, ad libitum	Diet[1] High-energy, limit-fed	Standard error of the least square means[2]	*P*-value
Carcass quality traits in back-grounding phase[3]				
Backfat, in	0.20[a]	0.22[b]	0.01	< 0.01
Muscle depth, in[4]	2.11[a]	2.25[b]	0.02	< 0.01
Marbling score[5]	4.78[a]	4.92[b]	0.04	0.02
Predicted carcass quality traits upon slaughter[6]				
Days on feed	139.0[a]	126.0[b]	3.6	0.02
Pay weight, lb	1246.0	1229.7	8.1	0.16
Hot carcass weight, lb	787.1	775.1	5.8	0.15
Backfat, in	0.57	0.58	0.01	0.19
Marbling score	6.93	6.92	0.06	0.93
Probability of final yield grade[7]				
Yield grade 2, %	29.6	27.5	0.01	0.16
Yield grade 3, %	62.3	63.7	0.01	0.21
Yield grade 4, %	6.6[a]	7.5[b]	0.01	0.03

[ab] Least square means with different superscripts are different ($P < 0.05$).
[1] Diets were formulated to contain 45 or 60 Mcal net energy for gain/100 lb of dry matter, respectively, and were fed to each pen once/day in the 84-day backgrounding phase.
[2] Standard error (largest) of the least square means.
[3] Carcass quality traits observed by ultrasound scanning on day 84.
[4] Measured by the Cattle Performance Enhancement Company software program from the bottom backfat line to the rib bones.
[5] A number between 4.00–4.99 indicates "select" marbling, and 5.00–5.99 indicates "low choice" marbling.
[6] Predicted carcass quality traits for cattle upon slaughter, based on day 84 ultrasound scan data and prediction equations from the Cattle Performance Enhancement Company.
[7] Probability (from 0–100%) that the final yield grade of a carcass will be 2, 3, or 4 upon slaughter, based on U.S. Department of Agriculture standards.

Subsequent Carcass Merit of Feedlot Cattle May Be Improved by Limit Feeding a High-Energy Diet During the Backgrounding Phase

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Abstract
Limit feeding cattle a high-energy diet can be an effective strategy in the backgrounding phase to program more efficient gains in young growing cattle. Research is needed to better understand the extent to which limit feeding cattle in the backgrounding phase affects cattle performance in the feedlot and carcass merit. To determine these impacts, 409 crossbred heifers previously backgrounded at the Kansas State University Beef Stocker Unit were tracked through the feedlot phase and carcass data were obtained at the abattoir. Original backgrounding treatment integrity was maintained throughout the finishing phase. Each backgrounding treatment group was split into a light-heavy sort and fed separately, with approximately 102 or 103 head per group. The heavy-sort, high-energy, limit-fed cattle had more backfat, compared to cattle previously fed a high roughage diet ad libitum ($P < 0.01$). In addition, it appears the light-sort, high-energy, limit-fed cattle deposited a greater amount of muscling in the ribeye compared to the light-sort, high roughage, ad libitum cattle ($P < 0.01$). The effects of limit feeding the high-energy diet on liver abscesses were not apparent.

Introduction
In a typical feedlot setting, cattle are fed ad libitum in order to maximize energy intake. This has also been the case for many backgrounding operations, where primarily roughages are used. Recent work conducted at the Kansas State University Beef Stocker Unit demonstrated that limit feeding a high-energy diet based on corn in the backgrounding phase does not negatively impact rate of gain; efficiency of energy intake is improved in growing cattle when compared to those fed a high roughage diet ad libitum. However, what is not known is the extent of limit-feeding's impact on subsequent cattle performance in the feedlot, and ultimately, how carcass merit is affected. Another question raised is whether this strategy causes a greater incidence of liver abscesses. Research is also needed to identify how economically important carcass traits may be affected by the limit feeding strategy prior to finishing.

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Experimental Procedures

A total of 418 weaned, crossbred heifers (body weight = 615 ± 53 lb) were purchased at auction markets in Texas and New Mexico, assembled at two different farms approximately 90 miles southwest of Amarillo, TX, then shipped 570 miles to the Kansas State University Beef Stocker Unit, Manhattan, KS, on May 28, 2019. The heifers were used in an 84-day receiving and growing study to evaluate the impact of limit-fed diets containing dry-rolled corn and Sweet Bran (Cargill Animal Nutrition, Blair, NE) compared to high roughage diets fed ad libitum on animal performance. Upon completion of the backgrounding phase, each treatment group was split into a light and heavy sort. All cattle were shipped 188 miles to Pratt Feeders in Pratt, KS, on August 26–27, 2019, for the finishing phase, and original treatment integrity was maintained throughout. Cattle were fed according to Pratt Feeders' standard protocols. Heavy-sort cattle were sent to National Beef (Dodge City, KS) for processing on January 14, 2020, and light-sort cattle were sent on February 4, 2020. Carcass data were obtained, including liver scores, by a team of researchers from West Texas A&M University.

Results and Discussion

Carcass results and liver scores for each feed group are shown in Table 1. The heavy-sort, high-energy, limit-fed cattle had the greatest backfat thickness ($P < 0.01$). Moreover, they scored nearly one-half of a yield grade higher compared to the other feed groups. The light-sort, high roughage, ad libitum cattle had almost 1 in^2 less ribeye area compared to the other feed groups ($P < 0.01$). In terms of quality grade, the light-sort, high roughage, ad libitum cattle had the most prime carcasses ($P < 0.05$). Regarding the livers, the light-sort, high-energy, limit-fed cattle had the least amount of edible liver tissue ($P < 0.01$), whereas the heavy-sort, high-energy, limit-fed group had the most edible liver tissue ($P < 0.01$). Both the light and heavy-sort, high-energy, limit-fed cattle trended toward greater incidence of major abscesses, or the A+ score, according to Elanco's liver scoring system ($P < 0.11$). Despite this, effects of limit feeding a high-energy diet during the backgrounding phase on the promotion of liver abscesses were not apparent.

Implications

Cattle previously receiving a high-energy, limit-fed diet in the backgrounding phase appeared to have greater backfat deposition and higher overall yield grade scores, along with greater muscle deposition, particularly in the light-sort cattle. The effects of limit feeding the high-energy diet on liver abscesses were not apparent.

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Table 1. Carcass traits, quality grades, and liver scores collected from crossbred heifers fed in separate feeding groups during the finishing phase

	Backgrounding diet				Standard error of the least square means[2]	*P*-value
	High roughage, ad libitum		High-energy, limit-fed			
	Feedlot sort[1]					
Item	Light	Heavy	Light	Heavy		
Carcass traits[3]						
Live weight, lb	1252.4	1307.5	1270.3	1302.1	19.6	0.17
Hot carcass						
Weight, lb	809.3[b]	851.5[a]	826.4[ab]	855.1[a]	12.7	0.05
Backfat, in	0.64[b]	0.66[b]	0.66[b]	0.75[a]	0.02	< 0.01
Yield grade[4]	2.54[b]	2.45[b]	2.43[b]	2.84[a]	0.09	< 0.01
Ribeye area, in^2	14.0[b]	14.8[a]	15.0[a]	14.7[a]	0.19	< 0.01
Quality grade[5]						
Select, %	7.8	3.1	9.4	2.1	9.4	0.13
Choice, %	76.5[b]	91.8[a]	85.4[ab]	92.8[a]	4.2	0.01
Prime, %	14.7[a]	5.2[b]	5.2[b]	5.2[b]	3.5	0.05
Liver score[6]						
No abscesses, %	83.3	88.7	80.2	92.8	4.1	0.09
A-, %	5.9	5.2	6.3	5.2	2.5	0.98
A, %	1.0	0.0	1.0	1.0	1.0	1.00
A+, %	9.8	6.2	11.5	10.3	3.3	0.11

[abc] Means in the same row with different superscript are significantly different ($P < 0.05$).
[1] A light-heavy sort for each original backgrounding treatment was created before shipping to Pratt Feeders. These four groups were fed separately at the feed yard according to their standard feeding protocols for finishing cattle.
[2] Standard error (largest) of the least square means.
[3] Carcass traits collected upon slaughter at National Beef (Dodge City, KS).
[4] U.S. Department of Agriculture yield grade score.
[5] The percent of cattle that graded either U.S. Department of Agriculture Select, Choice, or Prime.
[6] Livers were scored according to Elanco's liver check system (O, A-, A, A+). Scores of O indicated a normal, healthy liver with no abscesses. Scores of A- indicated one or two small abscesses. Scores of A had up to four abscesses under 1-in in diameter. Livers with a score of A+ had one or more large, inflamed abscesses.

Differences in Rumination and Animal Activity Can Be Quantified by Utilizing New Technologies

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Abstract

The objective of this research was to evaluate the Allflex eSense Flex ear tag (Allflex Livestock Intelligence, Madison, WI), which measures rumination and activity between two different diets fed to growing calves. One diet was high-energy, limit-fed, while the other was high roughage, fed ad libitum. For this study, 418 crossbred heifers of Texas and New Mexico origin were utilized in an 84-day backgrounding study at the Kansas State University Beef Stocker Unit. Coupled with the software data system called Heat-Time Pro+, it was determined that high-energy, limit-fed cattle ruminated less than the high roughage, ad libitum cattle ($P < 0.01$). Using GoPro cameras, footage was also collected to determine activity and enthusiasm differences between diets during feeding time, but the data were inconclusive.

Introduction

Industry-advancing technologies have given cattle producers new opportunities and ways to monitor the performance and health of their animals. The dairy industry, for example, has seen rapid innovation in cow-health monitoring and heat detection for reproduction in recent years. Beef cattle researchers are developing and evaluating similar applications for health or production in the cow-calf sector, stocker-backgrounder phase, and feedlot stage. The Allflex eSense ear tag (Allflex Livestock Intelligence, Madison, WI) provides perspective into the animal that otherwise would largely be unnoticed. Moreover, it measures rumination and general activity through motions of the ear and the animal's body that have been correlated back to a specific behavior (rumination or activity). As it relates to backgrounders and feedlot operators, health monitoring to proactively avoid nutritional or other disruptions to growth is critical. The aim of this study was to observe ruminal and activity differences in high-energy, limit-fed cattle compared to high roughage, ad libitum cattle.

Experimental Procedures

A total of 418 weaned, crossbred heifers (body weight = 615 ± 53 lb) were purchased at auction markets in Texas and New Mexico, assembled at two different farms approximately 90 miles southwest of Amarillo, TX, then shipped 570 miles to the Kansas State University Beef Stocker Unit, Manhattan, KS, on May 28, 2019. The heifers were used in a completely randomized block design, 84-day receiving and growing study. The study evaluated the impact of high-energy, limit-fed diets containing dry-rolled corn and Sweet Bran (Cargill Animal Nutrition, Blair, NE) compared to high roughage

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diets fed ad libitum on both animal rumination and activity, as well as enthusiasm to approach the bunk upon arrival of the feed wagon. Cattle were randomized by arrival weight and assigned to pens, each containing 13 or 14 heifers. Additionally, each pen was randomly assigned to one of two treatments in a "treatment pair." Each treatment pair consisted of one high-energy, limit-fed pen, and one high roughage, ad libitum pen. There was a total of 32 pens. The high roughage, ad libitum diet and the high-energy, limit-fed diet each were formulated to provide 45 or 60 Mcal of net energy for gain/100 lb of dry matter, respectively. Each heifer was tagged with an Allflex eSense Flex Ear Tag to monitor and measure rumination and general activity. In addition, during the first ten days of the study, GoPro cameras were mounted on the feed wagon and tractor to capture footage of the cattle during the feeding process.

Results and Discussion

The high-energy, limit-fed heifers ruminated 45 minutes less per day, compared to the high roughage, ad libitum heifers ($P < 0.01$), as shown in Figure 1. This may be due to less dry matter consumption and lower roughage content of the high-energy, limit-fed diet. However, activity was not affected by diet ($P = 0.70$), which is shown in Figure 2. Based on observation of the GoPro videos collected, it could not be determined if the high-energy, limit-fed cattle were more enthusiastic at feeding time compared to the high roughage, ad libitum cattle.

Implications

Limit feeding practices decreased total time spent ruminating per day by 45 minutes compared to cattle fed a high roughage diet ad libitum. However, it was not conclusive from our data whether one group was generally more active than the other.

Acknowledgments

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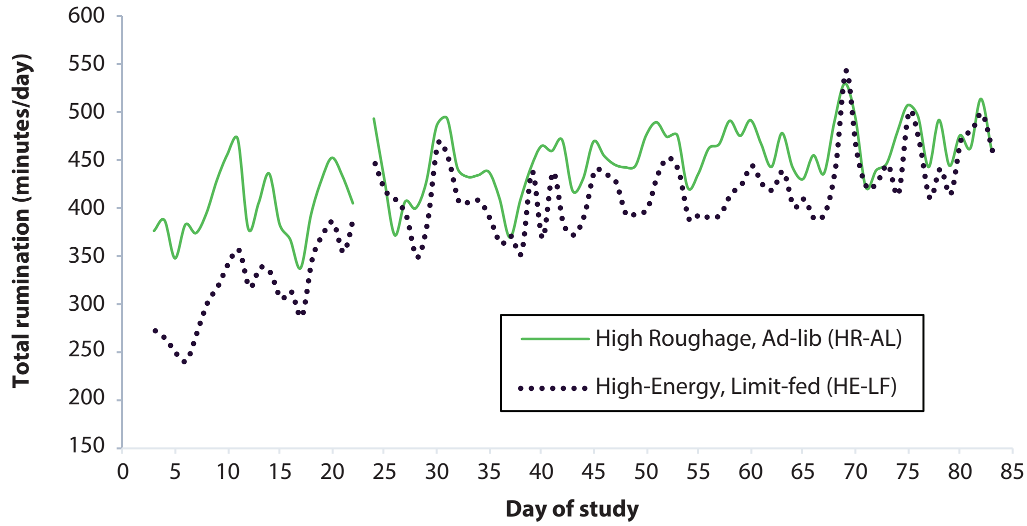

Figure 1. Total daily rumination, measured in minutes per day, for both high-energy, limit-fed and high roughage, ad libitum heifers.

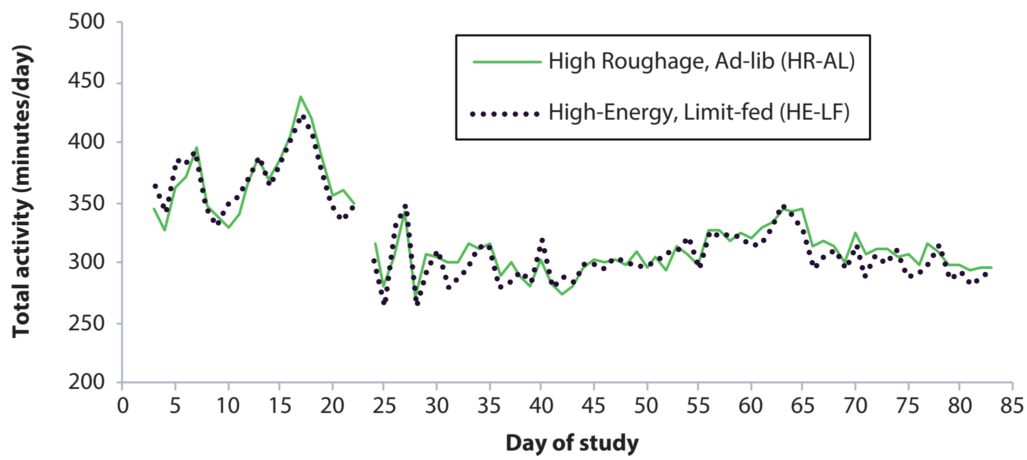

Figure 2. Total daily activity, measured in minutes per day, for both high-energy, limit-fed and high roughage, ad libitum heifers.

The Effect of Method of Collection and Number of Sequential Ejaculates on Semen Characteristics of Beef Bulls

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Abstract

As more genomic information becomes available for young beef bulls, age at time of semen collection has decreased. Factors affecting collection characteristics include collection method, electro-ejaculate or artificial vagina, and the number of ejaculates collected. The objective of this study was to determine the effect of managerial factors on collection characteristics. From 2008 to 2018, 11,642 individual ejaculates were analyzed by a single technician at the Kansas Artificial Breeding Service Unit. Bulls not receptive to the artificial vagina after 3 or 4 attempts were subject to electro-ejaculation. Collection characteristics were evaluated using multiple regression models; fixed effects included collection method and sequence of ejaculates collected/day and were evaluated for their impact on collection characteristics. Progressive motility before freezing was greater ($P < 0.0001$) for bulls collected with electro-ejaculate compared to artificial vagina. Ejaculate volume for electro-ejaculate collections was greater ($P < 0.0001$) than those collected with artificial vagina. The percent of spermatozoa with secondary abnormalities was greater ($P < 0.05$) for bulls collected with electro-ejaculate compared to artificial vagina. Concentration of spermatozoa/mL was less ($P < 0.0001$) for bulls collected with an electro-ejaculate (514×10^6) compared to artificial vagina (617×10^6). Total number of straws frozen/ejaculate were less ($P < 0.001$) for bulls collected with electro-ejaculate (94) compared to artificial vagina (108). Bulls that were collected more than once/day produced a greater percentage of secondary spermatozoa abnormalities ($P < 0.001$). As ejaculate number/day increased, the concentration of spermatozoa decreased (713, 580, 535, and 434×10^6/mL, respectively; $P < 0.0001$), and the number of straws frozen/ejaculate decreased (123, 107, 93, and 82, respectively; $P < 0.0001$). In conclusion, artificial vagina collections resulted in a higher number of straws frozen. The method of collection could cause a significant impact when collecting young high-demand bulls.

Introduction

As age of bulls admitted to collection facilities decreases, many management challenges arise. These young bulls are often identified as genetically superior prior to puberty. This creates an issue for producers and bull studs to manage young bulls in such a way that semen collection can begin as soon as possible, without compromising quality. The average age of bulls at the time of collection has decreased from 4.5 years to 1.5 years of age at most major bull studs (Hartstine, 2018). Artificial vagina is the preferred method of collection for ejaculates, however; inexperienced bulls are often more hesitant to mount and serve an artificial vagina. When bull studs are unable to collect bulls with an artificial vagina, they must use an electro-ejaculator. Electro-ejaculators are believed to have similar effectiveness as artificial vaginas, but this has not been recently investigated.

To our knowledge, literature also lacks information on the total sequential ejaculates that can be collected/day by either method before impairing semen quality.

Experimental Procedures

Data were provided from Kansas Artificial Breeding Services Unit and were collected from January 2008 to December 2018. A total of 11,642 ejaculates from 906 bulls were provided for analysis. Bulls were collected twice weekly on Mondays and Thursdays, with the preferred collection method, artificial vagina. Bulls at this facility not receptive to the mount steers or the artificial vagina after 3 or 4 attempts, were subject to electro-ejaculation to ensure ejaculates were collected.

Once an ejaculate was collected, a single technician at Kansas Artificial Breeding Services Unit was responsible for all pre-freeze and post-thaw semen analysis. Ejaculates were required to meet quality standards which included a pre-freeze progressive motility of greater than 50% and post-thaw progressive motility of greater than 30% at initial evaluation and two-hour evaluation. The ejaculates could not contain greater than 30% abnormal spermatozoa post-thaw to pass quality standards. All ejaculates that passed initial assessment were extended and frozen in half cubic centimeter straws. The descriptive information provided for each ejaculate was volume, concentration of spermatozoa/mL, progressive motility prior to freezing, progressive motility initially post-thaw, two-hour post-thaw progressive motility, primary and secondary sperm abnormalities, and straws frozen. Collection characteristics were evaluated using multiple regression models in Statistical Analysis System (SAS v. 9.4 (SAS Inst. Inc., Cary, NC)); fixed effects included collection method and sequence of ejaculates collected/day and were evaluated for their impact on collection characteristics.

Results and Discussion

The age of bulls ranged from 10 months to 13 years, with a median age of 25 months. Average motility prior to freezing was 40%, the average volume was 4.6 mL, and the average units of straws frozen were 121. The average percentage of primary spermatozoa abnormalities was 40%, while the average for secondary spermatozoa abnormalities was 16%.

Table 1 displays the least square means for the effect of the collection method. Progressive motility before freezing was greater ($P < 0.0001$) for bulls collected with electro-ejaculate (44%) compared to artificial vagina (43%). Ejaculate volume for electro-ejaculate (4.8 mL) collections was greater ($P < 0.0001$) than those collected with artificial vagina (4.8 mL). Percent of spermatozoa with secondary abnormalities was greater ($P < 0.05$) for bulls collected with electro-ejaculate (16%) compared to artificial vagina (15%). Concentration of spermatozoa/mL was less ($P < 0.0001$) for bulls collected with an electro-ejaculate (514×10^6) compared to artificial vagina (617×10^6). Bulls that were collected with electro-ejaculate had a greater volume yet a lower concentration, resulting in a lower total number of straws of frozen/ejaculate ($P < 0.001$). The method of collection did not have a significant impact on primary spermatozoa abnormalities, initial post-thaw motility, or two-hour post-thaw motility.

Bulls that were collected more than once/day had a decreasing percentage of secondary spermatozoa abnormalities, as ejaculate frequency increased (17, 16, 14, and 15%, respectively; $P < 0.001$). As ejaculate number/day increased, the concentration of spermatozoa decreased (713, 580, 535, and 434 × 10^6/mL, respectively; $P < 0.0001$; Figure 1). The number of straws frozen/ejaculate also decreased as ejaculate number/day increased (123, 107, 93, and 82, respectively; $P < 0.0001$; Figure 2). Conversely, initial post-thaw motility increased as ejaculate frequency increased (36, 39, 40, and 40%, respectively; $P < 0.0001$).

In conclusion, artificial vagina collections resulted in a higher number of straws frozen. Understanding the impacts of collection method on production could help producers better understand the difficulties of the collection process. While artificial vagina is the preferred collection method, bulls can still be collected with electro-ejaculate; this will result in fewer frozen straws of semen. Producers and bull studs should choose the collection method that best fits each bull and is most economically beneficial. Collecting more than one ejaculate/day will help increase straws frozen over time, and potentially have the greatest economic impact for producers. It should be noted that semen quality does decrease with increased ejaculates/day, and the optimum ejaculate/day may be individually dependent.

Implications

Producers and collection facilities should work together to balance the collection method and number of ejaculates collected/day to maximize production while maintaining semen quality.

Acknowledgments

We would like to thank Kansas Artificial Breeding Services Unit's employees and customers for providing their data and insight to make this project possible.

References

Harstine, B.R., 2018. Invited Review: Focusing on bull management and puberty attainment in the genomic era. *The Professional Animal Scientist*, *34*(6), pp. 523-532.

Table 1. Effects of method of collection, artificial vagina or electro-ejaculate, on collection characteristics in beef bulls*

		Collection method			
	Number of ejaculates	Least square means of artificial vagina	Least square means of electro-ejaculate	Standard error of the mean	*P*-value
Progressive motility prior to freezing, %[1]	11,642	43	44	0.32	< 0.0001
Volume, mL[2]	11,520	4.0	4.8	0.06	< 0.0001
Concentration, $\times 10^6$/mL[3]	11,315	617	514	10.35	< 0.0001
Secondary abnormalities, %[4]	3,699	14.7	16.3	0.56	< 0.01
Straws frozen/ejaculate[5]	2409	108	94	4.13	< 0.001

*From 2008 to 2018, individual ejaculates were analyzed by a single technician at the Kansas Artificial Breeding Service Unit, Manhattan, KS. Bulls that were not receptive to the artificial vagina after 3 or 4 attempts, were subject to electro-ejaculation.

[1]Percent progressive motility prior to freezing was determined at time of collection. Based on the regression model other significant factors included: breed, sequential ejaculate number, age, Julian date of collection, and temperature humidity index 75 days before collection.

[2]Volume of semen collected/ejaculate. Based on the regression model other significant factors included: breed, sequential ejaculate number, age, and temperature humidity index 75 days before collection.

[3]Concentration of spermatozoa/mL in each ejaculate. Based on the regression model other significant factors included: sequential ejaculate number, age, and temperature humidity index 75 days before collection.

[4]Percentage of secondary abnormalities/ejaculate. Based on the regression model other significant factors included: sequential ejaculate number, age, and temperature humidity index 75 days before collection.

[5]Units of 0.5 cm^3 straws frozen/ejaculate. Based on the regression model other significant factors included: breed, sequential ejaculate number, age, and temperature humidity index 75 days before collection.

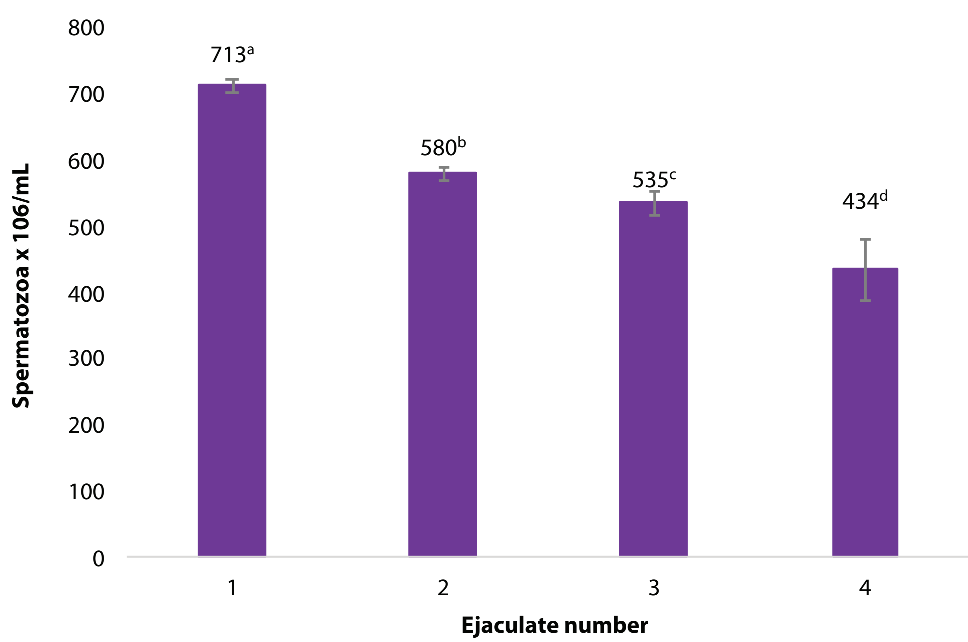

Figure 1. Effect of sequential ejaculates on the concentration of spermatozoa in beef bulls.
[a,b,c,d]Values within a factor without a common superscript differ ($P < 0.05$).

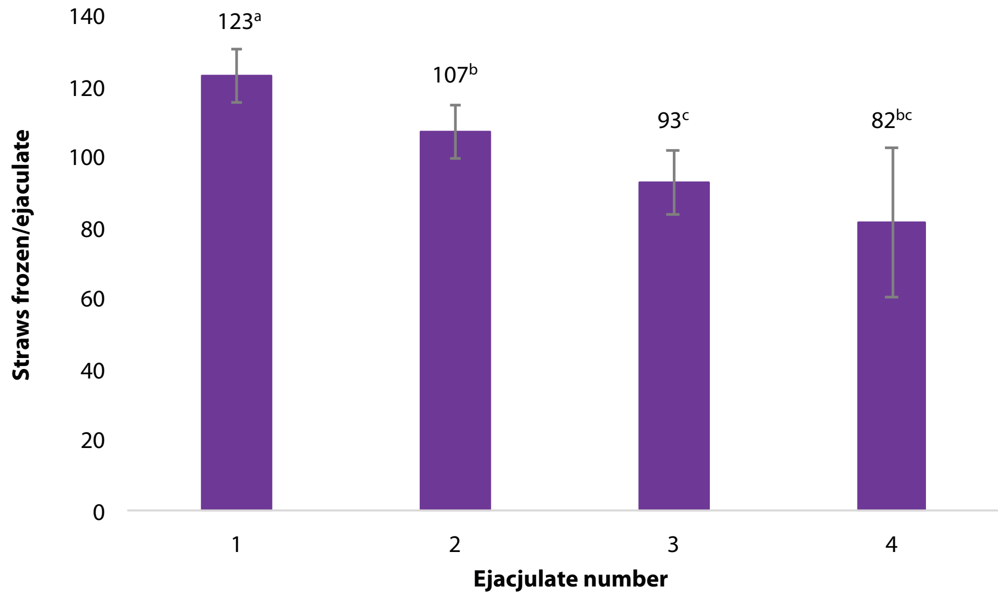

Figure 2. Effect of sequential ejaculate collection on number of straws frozen/ejaculate in beef bulls.

[a,b,c,d]Values within a factor without a common superscript differ ($P < 0.05$).

Effects of Guanidinoacetic Acid, Creatine, and Choline on Protein Deposition and Creatine Status in Growing Cattle

M.S. Grant, M.D. Miesner, and E.C. Titgemeyer

Abstract

Creatine is a molecule that stores energy in muscle tissue and is produced in the liver when guanidinoacetic acid is methylated. Guanidinoacetic acid supplementation can improve creatine supply in growing cattle and possibly improve performance when the methyl group (i.e., methionine) supply is adequate. Creatine synthesis increases methyl group consumption, so providing methyl group sources other than methionine, such as choline, may also allow for benefits to guanidinoacetic acid supplementation. Our objective was to evaluate the effects of guanidinoacetic acid and creatine supplementation in the presence or absence of supplemental choline on protein deposition (lean tissue growth) in growing steers. Six ruminally cannulated Holstein steers were housed in metabolism crates to allow for total collection of urine and feces to measure nitrogen retention. The experiment consisted of six 10-day periods, with each animal receiving one of the six treatments in each period. The six treatments included a saline control; 15 g/day guanidinoacetic acid (which consumes methyl groups); or 16.8 g/day creatine (which spares methyl groups), each in the presence or absence of 5 g/day supplemental choline. Relative to control, protein deposition increased when guanidinoacetic acid was provided, but creatine did not affect protein deposition. Supplemental guanidinoacetic acid and creatine both increased plasma creatine concentrations compared to control, with guanidinoacetic acid leading to a larger increase than creatine. This demonstrates that guanidinoacetic acid was effectively methylated in the body to form creatine. Choline supplementation did not affect protein deposition but increased plasma creatine concentrations, suggesting that choline provision may have spared methyl groups that were then diverted to methylate guanidinoacetic acid to form creatine. Consistent with previous work in our lab (Ardalan et al., 2020), guanidinoacetic acid has potential to improve protein deposition in growing cattle. Additionally, choline may have potential to improve body creatine status.

Introduction

Creatine serves to store energy in muscle tissues. Creatine can be acquired through the diet or synthesized in the liver when guanidinoacetic acid accepts a methyl group from methionine to form creatine. Because creatine is only found in feedstuffs of animal protein origin, livestock consuming vegetarian diets (i.e., ruminants) rely exclusively on creatine produced in the body to support their requirement. Growing animals require more creatine than do mature animals, so it is possible that the production of creatine in the body may not be great enough to support optimal performance. Research in swine and poultry has demonstrated that supplemental guanidinoacetic acid, as the precursor to creatine, can improve creatine supply and overall performance. Recent work in our lab has demonstrated that guanidinoacetic acid supplemented to growing cattle increases body creatine supply and may improve lean muscle growth when methionine (i.e., methyl group) supply is adequate.

Choline is an essential nutrient that is present in some feedstuffs and can be produced in the liver. Because choline is rapidly degraded in the rumen, ruminants rely almost solely on choline produced in the body. Choline is synthesized when phosphatidylethanolamine accepts three methyl groups from methionine, producing phosphatidylcholine; choline can then be cleaved from phosphatidylcholine for use in the body. Once synthesized, choline can serve as a methyl donor in the body when converted to betaine. Supplemental choline has been shown to improve performance in finishing cattle and transition dairy cows.

Supplementation of guanidinoacetic acid or creatine in conjunction with methyl sources other than methionine (i.e., choline) has not been evaluated. Our objective was to evaluate the effects of guanidinoacetic acid, creatine, and choline on protein deposition and creatine status in growing cattle consuming a corn-based diet.

Experimental Procedures

Six ruminally-cannulated Holstein steers (321 lb initial body weight) were housed in metabolism crates in an environmentally controlled room to allow for total collection of urine and feces to measure nitrogen retention. Steers were limit-fed a corn-based diet twice daily and had free access to water. The diet contained 75.6% dry-rolled corn, 12.7% alfalfa hay, 6.2% soybean meal, 4.2% cane molasses, and 1.4% vitamin and mineral supplement. Cattle were fed 7.7 lb of dry matter per steer daily of the diet.

The experiment included six 10-day periods, allowing 6 days for treatment adaptation and 4 days for sample collection. Each animal received one of the six different treatments during each period. The six treatments were supplementation of 3 methyl group modulators: a saline solution (control); 15 g/day guanidinoacetic acid (which consumes methyl groups to synthesize creatine); or 16.8 g/day creatine (which spares methyl groups that would be used for its synthesis), each in the presence or absence of 5 g/day supplemental choline. Choline supplementation may improve methyl groups status in the body, either by conversion to betaine, which can then resynthesize methionine, or by sparing methyl groups that would otherwise be used for its synthesis. Urine and fecal samples were collected from days 6 through 9 of each period to measure nitrogen retention, and blood samples were collected from the jugular vein of each steer on day 10 to assess plasma creatine concentration.

Results and Discussion

Nitrogen retention, a measure of protein deposition, tended to be affected by methyl group modulator (Figure 1; $P = 0.10$). Retained nitrogen increased when guanidinoacetic acid was supplemented ($P = 0.04$) but was not affected by creatine supplementation. Supplemental choline did not affect nitrogen retention ($P = 0.65$). Previous work in our lab has demonstrated a tendency for guanidinoacetic acid to improve protein deposition in growing steers when methionine supply was adequate, but not when methionine was deficient. The positive response in protein deposition with supplemental guanidinoacetic acid may suggest that creatine supply in the body was improved, which in turn increased animal performance. It is not clear why creatine supplementation did not similarly improve nitrogen retention, but we hypothesize that creatine may not have been completely absorbed in the small intestine. The lack of a nitrogen retention response to choline supplementation suggests that choline was unable to spare methionine to a degree that would improve animal performance.

Plasma creatine concentration was used as a measure of body creatine status. Supplemental guanidinoacetic acid and creatine both increased plasma creatine concentrations relative to control ($P < 0.0001$; Figure 2), with guanidinoacetic acid leading to a greater increase ($P = 0.01$). Previous work in our lab has also demonstrated increases in plasma creatine when guanidinoacetic acid was supplemented, which can be attributed to the conversion of guanidinoacetic acid to creatine in the body. The greater increase in plasma creatine for guanidinoacetic acid-supplemented steers relative to creatine may support our earlier hypothesis that creatine was not completely absorbed in the small intestine. Choline supplementation also increased plasma creatine concentrations ($P = 0.04$), suggesting greater body creatine synthesis. This may suggest that direct choline provision may limit the body's need to consume methyl groups for its synthesis, which could make more methyl groups available for creatine synthesis.

Implications

Supplementation of guanidinoacetic acid improved nitrogen retention, demonstrating that there is potential for its provision to improve lean tissue growth. Additionally, guanidinoacetic acid, creatine, and choline supplementation all improve body creatine status, which may have value to growing cattle with high creatine requirements.

Acknowledgments

The authors thank Balchem Corporation for their financial support of this project.

References

Ardalan, M., M. D. Miesner, C. D. Reinhardt, D. U. Thomson, C. K. Armendariz, and E. C. Titgemeyer. 2020. Effects of guanidinoacetic acid on lean growth and methionine flux in cattle. Kansas Agricultural Experiment Station Research Reports: Vol. 6: Iss. 2. https://doi.org/10.4148/2378-5977.7892

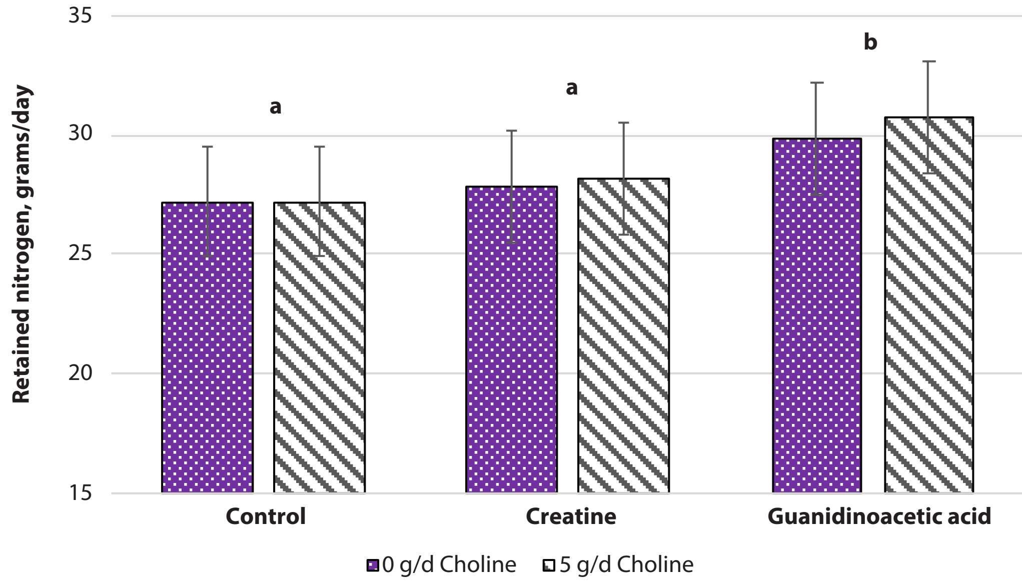

Figure 1. Effects of guanidinoacetic acid, creatine, and choline supplementation on nitrogen retention in growing steers (no interactions between treatments; no effect of choline; main effect of creatine was not different from control; main effect of guanidinoacetic acid was different from control; means not bearing a common letter [a,b] differ at $P \leq 0.05$).

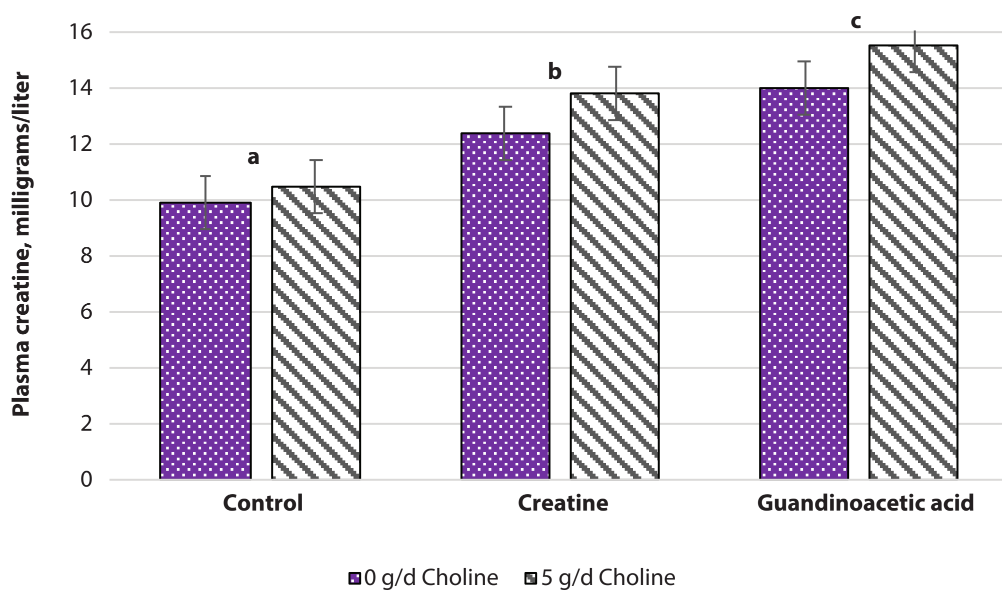

Figure 2. Effects of guanidinoacetic acid, creatine, and choline on plasma creatine concentrations in growing steers (no interactions between treatments; main effect of choline, $P = 0.04$; main effect of creatine was different from control; main effect of guanidinoacetic acid was different from control; means not bearing a common letter [a-c] differ at $P \leq 0.05$).

Effects of Choline on Neutrophil Function and Inflammation in Growing Cattle with Modulated Methyl Group Status

M.S. Grant, H.D. Aufdemberge, B.J. Bradford,[1] L.K. Mamedova,[1] and E.C. Titgemeyer

Abstract
Methyl donors such as methionine and choline can improve health and immune function in transition dairy cows. Our objective was to evaluate the effects of modulated methyl group status on immune cell function, inflammation, and antioxidant capacity in growing cattle. Six ruminally cannulated Holstein steers were housed in metabolism crates in a temperature-controlled room. The experiment consisted of six 10-day periods, with each animal receiving one of the six treatments in each period. The six treatments included a saline control; 15 g/day guanidinoacetic acid (which consumes methyl groups); or 16.8 g/day creatine (which spares methyl groups), each in the presence or absence of 5 g/day supplemental choline. Blood was collected on day 10 of each period to assess neutrophil oxidative burst and phagocytosis, haptoglobin concentration, and plasma antioxidant potential. Choline supplementation tended to decrease plasma haptoglobin concentration but did not affect antioxidant potential. Supplemental guanidinoacetic acid and creatine did not affect haptoglobin concentrations, but creatine did reduce plasma antioxidant capacity relative to guanidinoacetic acid and control. Choline tended to reduce neutrophil phagocytosis in the presence of lipopolysaccharide but did not affect neutrophil phagocytosis without lipopolysaccharide or oxidative burst in the presence or absence of lipopolysaccharide. No effects of guanidinoacetic acid or creatine on neutrophil phagocytosis or oxidative burst in the presence or absence of lipopolysaccharide were observed.

Introduction
Choline is an essential nutrient that is present in some feedstuffs and is produced in the liver. Ruminants rely almost solely on choline synthesized in the body because it is extensively degraded in the rumen. Choline is produced in the liver when phosphatidylethanolamine is methylated three times by methionine to produce phosphatidylcholine. Once synthesized, choline can be cleaved from phosphatidylcholine to be used in the body. Choline serves as a methyl donor when converted to betaine and participates in numerous other bodily processes. Supplemental choline has been shown to improve health and immune function in transition dairy cows.

Creatine is a molecule that stores energy in muscle tissues. It is produced when guanidinoacetic acid accepts a methyl group from methionine. Because the conversion of guanidinoacetic acid to creatine consumes methyl groups (i.e., methionine) in the body, supplemental guanidinoacetic acid may cause a methyl group deficiency if methionine supply is not adequate. Recent work in our lab (Ardalan et al., 2020) has demonstrated that guanidinoacetic acid supplemented to growing cattle increases body creatine supply and may improve lean muscle growth when methionine supply is adequate.

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Additionally, guanidinoacetic acid supplementation can be used in a research model to evaluate the effects of an induced methyl deficiency in the body. To our knowledge, the effects of guanidinoacetic acid or creatine supplementation on health and immune function in cattle has not been investigated. Our objective was to evaluate the effects of choline in combination with guanidinoacetic acid or creatine on immune cell function, inflammation, and antioxidant status in growing cattle consuming a corn-based diet.

Experimental Procedures

Six ruminally-cannulated Holstein steers (321 lb initial body weight) were housed in metabolism crates in an environmentally controlled room to allow for abomasal treatment infusion. Steers were limit-fed a corn-based diet twice daily and had free access to water. The diet contained 75.6% dry-rolled corn, 12.7% alfalfa hay, 6.2% soybean meal, 4.2% cane molasses, and 1.4% vitamin and mineral supplement. Cattle were fed 7.7 lb of dry matter per steer daily of the diet.

The experiment included six 10-day periods. Each animal received one of the six different treatments during each period. The six treatments were supplementation of three methyl group modulators: a saline solution (control); 15 g/day guanidinoacetic acid (which consumes methyl groups to synthesize creatine); or 16.8 g/day creatine (which spares methyl groups that would be used for its synthesis), each in the presence or absence of 5 g/day supplemental choline. Choline supplementation may improve methyl groups status in the body, either by conversion to betaine, which can then resynthesize methionine, or by sparing methyl groups that would be used for its synthesis. On day 10 of each period, blood was collected from the jugular vein. Plasma was isolated to measure haptoglobin concentration as a biomarker of inflammation and plasma antioxidant capacity. Additional blood was collected for neutrophil isolation and assessment of neutrophil function. Once isolated, neutrophils were treated with or without lipopolysaccharide (which simulates an inflammatory response in treated cells) and underwent analyses to measure oxidative burst and phagocytosis.

Results and Discussion

Plasma haptoglobin concentration tended to be reduced by choline supplementation ($P = 0.07$; Figure 1) but was not affected by guanidinoacetic acid or creatine. Decreased haptoglobin concentration is associated with a reduction in systemic inflammation, suggesting that supplemental choline may have reduced inflammation in our cattle. We hypothesized that guanidinoacetic acid supplementation would potentially increase inflammation as a result of increased methyl demand in the body, but the data do not support this hypothesis.

Plasma antioxidant potential was not affected by choline supplementation ($P = 0.50$; Figure 2). There was an effect of methyl group modulator on plasma antioxidant potential ($P = 0.008$) as the creatine-supplemented steers had lower antioxidant potential than control or guanidinoacetic acid-supplemented steers ($P \leq 0.01$). This suggests that creatine-supplemented steers may have had increased oxidative stress in the body.

Choline supplementation tended to reduce neutrophil phagocytosis in the presence of lipopolysaccharide ($P = 0.09$; Figure 3). Neutrophil phagocytosis without lipopolysaccharide and neutrophil oxidative burst with or without lipopolysaccharide were not affected by choline. The tendency for choline to reduce neutrophil phagocytosis in the presence of lipopolysaccharide may suggest that choline in some way modulated the immune response, although the precise mode of action is not known. No effects of methyl group modulator on neutrophil phagocytosis or oxidative burst in the presence or absence of lipopolysaccharide were observed. This suggests that short-term modulation of methyl group status did not alter immune cell functionality. Additionally, a lack of interaction between choline and methyl group modulator suggests that any action of choline likely occurred independently of methyl status.

Implications

Supplemental choline may reduce systemic inflammation and alter neutrophil function in growing cattle. Additionally, it appears that short-term modulation of methyl group status with guanidinoacetic acid or creatine does not alter inflammation or immune cell functionality.

Acknowledgments

The authors thank Balchem Corporation for their financial support of this project.

References

Ardalan, M., M. D. Miesner, C. D. Reinhardt, D. U. Thomson, C. K. Armendariz, and E. C. Titgemeyer. 2020. Effects of guanidinoacetic acid on lean growth and methionine flux in cattle. Kansas Agricultural Experiment Station Research Reports: Vol. 6: Iss. 2. https://doi.org/10.4148/2378-5977.7892.

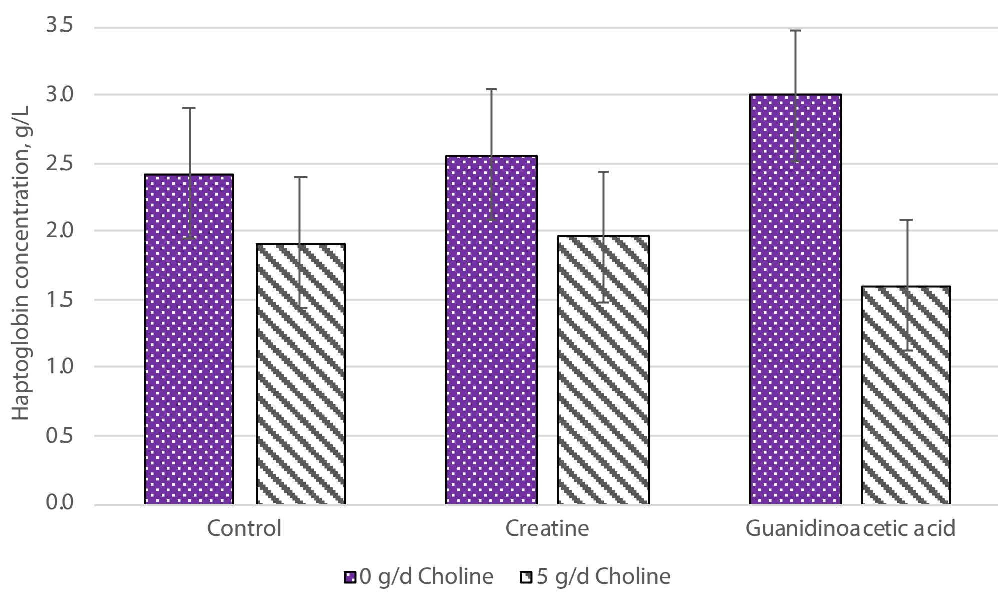

Figure 1. Effects of choline, creatine, and guanidinoacetic acid on plasma haptoglobin concentration (no interactions between treatments; effect of choline, $P = 0.07$; main effect of creatine was not different from control; main effect of guanidinoacetic acid was not different from control).

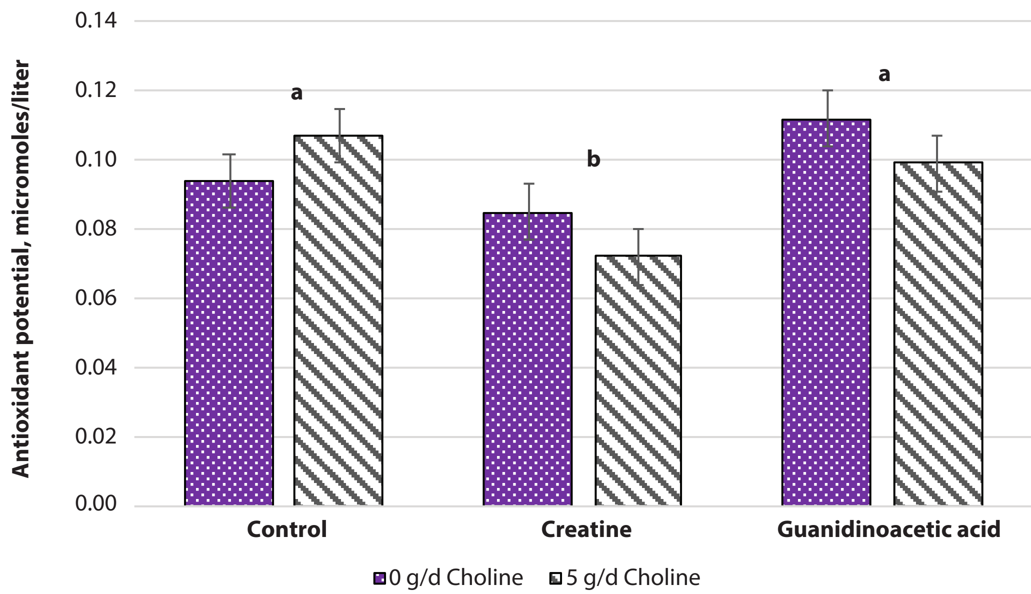

Figure 2. Effects of choline, guanidinoacetic acid, and creatine supplementation on plasma antioxidant potential (no interactions between treatments; no effect of choline; main effect of creatine was different from control, $P = 0.01$; main effect of guanidinoacetic acid was not different from control; means not bearing a common letter [a,b] differ at $P \leq 0.05$).

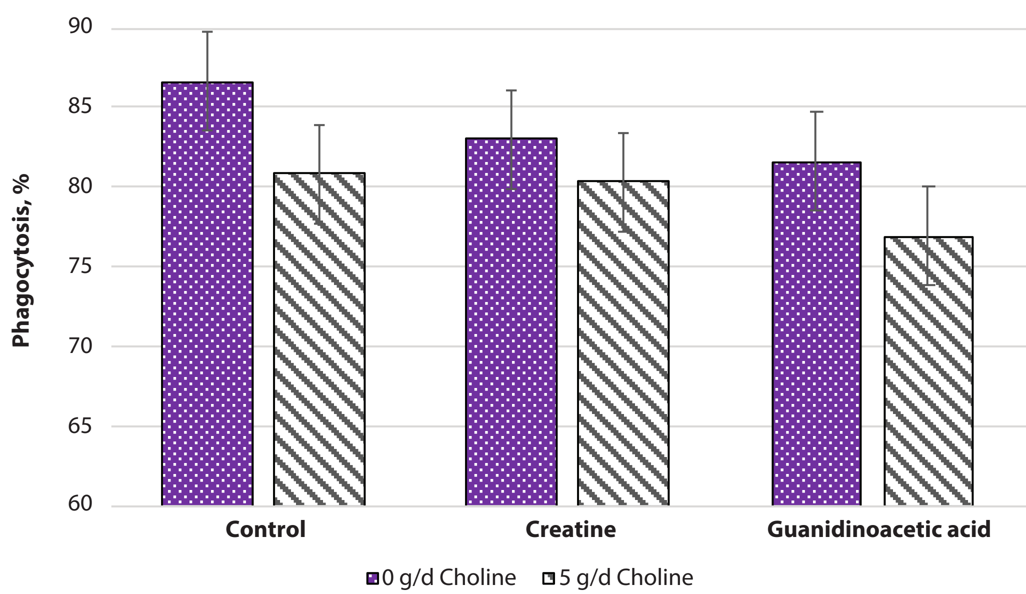

Figure 3. Effects of choline, guanidinoacetic acid, and creatine on neutrophil phagocytosis in the presence of a lipopolysaccharide challenge (no interactions between treatments; effect of choline, $P = 0.09$; main effect of creatine was not different from control; main effect of guanidinoacetic acid was not different from control).

Investigating the Contribution of Mature Collagen Crosslinks to Cooked Meat Toughness Using a Stewed Beef Shank Model

W. Wu, A.A. Welter, C.K.Y. Chun, T.G. O'Quinn, G. Magnin-Bissel, and M.D. Chao

Abstract

The objective of this study was to investigate mature collagen crosslink densities and their relationship to connective tissue texture using a stewed beef shank model. Six shank cuts, three from forequarter [biceps brachii (shank A); deep digital flexor from foreshank (shank B); extensor carpi radialis (shank C)], and three from hindquarter [flexor digitorum superficialis (shank D); deep digital flexor from hindshank (shank E); a combination of long digital extensor, medial digital extensor, and peroneus tertius (shank F)] were collected from eight U.S. Department of Agriculture Low Choice beef carcasses. Shanks from the left side of the carcasses were designated for the cooked treatment, and shanks from the right side were designated as the raw treatment. Connective tissue texture, Warner-Bratzler shear force, and collagen content and characteristics were measured for the six different beef shank cuts. Shank B had the toughest connective tissue texture, greatest Warner-Bratzler shear force value, most cooked collagen content, greatest insoluble collagen percentage as well as greatest raw and cooked pyridinoline densities among all the beef shank cuts ($P < 0.05$). Correlation analysis showed that cooked collagen content, insoluble collagen percentage as well as raw pyridinoline densities had positive correlations with connective tissue texture (r = 0.550, 0.498, and 0.560 respectively; $P < 0.01$) and Warner-Bratzler shear force (r = 0.615, 0.392, and 0.730, respectively; $P < 0.05$). Raw pyridinoline density may be a good indicator for cooked beef connective tissue texture and ultimately, tenderness in beef cuts with a high concentration of connective tissue prepared with moist heat cookery.

Introduction

It is well established that connective tissue provides the "background toughness" in meat, and past research has demonstrated this background toughness is the result of heat insoluble collagen content in meat after cooking. However, the characteristics of heat insoluble collagen are not well studied. Therefore, the objective of this study was to investigate mature collagen crosslink densities and their relationship to cooked beef tenderness and connective tissue texture using a stewed beef shank model.

Experimental Procedures

The cross-section and whole-muscle cut of six different beef shank cuts, three from the forequarter [biceps brachii (shank A); deep digital flexor from foreshank (shank B); extensor carpi radialis (shank C)] and three from the hindquarter [flexor digitorum superficialis (shank D), deep digital flexor from hindshank (shank E), a combination of long digital extensor, medial digital extensor, and peroneus tertius (shank F)] that were collected from eight USDA Low Choice beef carcasses (n = 48) are shown in Figure 1. Shanks from the left side of the carcasses were designated for the cooked treatment, then were stewed in water for 90 minutes at 199°F, and shanks from the right side were designated as the raw treatment. Asian consumers (n = 61) evaluated the connective tissue texture from cooked shanks based on Just About Right line scales. Since connective tissue texture is an important component of many Asian cuisines, only Asian consumers were selected for the consumer panel of this study due to their ability to distinguish small differences in connective tissue texture. In addition, Warner-Bratzler shear force value was obtained. Mature collagen crosslinks densities (pyridinoline and deoxypyridinoline) and collagen content were measured for raw and cooked beef shanks. The collagen contents were adjusted to dry matter basis based on moisture content of the raw and cooked shanks to account for moisture loss during the cooking process, and the relative percentages of soluble and insoluble collagen content were calculated. Finally, a correlation analysis was performed to understand the relationship between each collagen characteristic and cooked beef shank tenderness.

Results and Discussion

Collagen content results are displayed in Table 1. There was a significant muscle × cooking treatment interaction for collagen content ($P < 0.01$). In general, shanks D and F had higher amount of raw collagen content compared to A and E ($P < 0.01$). Shank B had higher amount of raw collagen than shank C ($P < 0.01$), but it was not different from the other four beef shank cuts ($P > 0.05$). Shank C contained the least amount of raw collagen among all the beef shank cuts ($P < 0.01$). On the other hand, all the beef shank cuts had similar cooked collagen content except for shank B ($P < 0.01$), which had the greatest cooked collagen content. In addition, collagen content declined after cooking for all the beef shank cuts ($P < 0.01$).

Results for soluble and insoluble collagen percentages, connective tissue texture evaluated by Asian consumers, and Warner-Bratzler shear force are shown in Table 2. Shanks A, D, E, and F all had greater soluble and least insoluble collagen percentage compared to shank B ($P < 0.01$), while shank C was in between and not different from shanks A, B, E, and F ($P > 0.05$) for insoluble collagen. Among all the beef shank cuts evaluated in this study, Asian consumers rated shank B with the toughest connective tissue texture, followed by shank E, with shanks A and D having the softest connective tissue texture among all ($P < 0.01$). Shanks C and F had softer connective tissue texture than shank B, but were not different from shanks A, D, and E ($P > 0.05$). Finally, shank B was significantly tougher than the rest of shank cuts when measured by Warner-Bratzler shear force ($P < 0.01$), and all other beef shank cuts had much lower but similar Warner-Bratzler shear force values ($P > 0.10$).

Raw and cooked pyridinoline and deoxypyridinoline density of the six different beef shank cuts are shown in Table 3. There was a significant muscle × cooking treatment interaction for pyridinoline density. Cooking only decreased pyridinoline density for shank B ($P < 0.05$), and pyridinoline density for the rest of the beef shank cuts was not affected by cooking ($P > 0.10$). For deoxypyridinoline density, Shank C was one of the beef shank cuts that had greater deoxypyridinoline density for raw and cooked samples ($P < 0.01$). Again, there was a cooking effect in which cooking decreased deoxypyridinoline density for shanks B, C, and D ($P < 0.01$), but not for the other cuts ($P > 0.10$).

Correlation coefficients of raw and cooked collagen content, soluble and insoluble collagen percentage, and different collagen crosslinks density with connective tissue texture and Warner-Bratzler shear force of six different beef shanks are presented in Table 4. As expected, cooked collagen content, insoluble collagen percentage as well as raw pyridinoline densities had positive correlations with connective tissue texture ($P < 0.01$) and Warner-Bratzler shear force ($P < 0.05$). There was still a noted positive correlation between cooked pyridinoline density with connective tissue texture ($P < 0.05$) and Warner-Bratzler shear force ($P < 0.10$), but the relationship was not nearly as strong as for raw pyridinoline density.

Implications

Pyridinoline is a heat stable collagen crosslink, and raw pyridinoline density is a good indicator for heat insoluble collagen content, cooked beef connective tissue texture and ultimately, tenderness in beef cuts with a high concentration of connective tissue prepared with moist heat cookery.

Table 1. Least square means of raw and cooked collagen content of the six different beef shank cuts (n = 48)

	Collagen content, % dry matter basis[1]			
Beef shank	**Raw**	**Cooked**	**Standard error of the least squares means**	***P*-value**
Foreshank			4.21	< 0.01
A	5.74^{Ab}	3.08^{Bb}		
B	6.54^{Aab}	4.71^{Ba}		
C	4.22^{Ac}	2.70^{Bb}		
Hindshank				
D	7.58^{Aa}	3.23^{Bb}		
E	5.71^{Ab}	3.12^{Bb}		
F	7.58^{Aa}	3.55^{Bb}		

[abc]Least squares means in a column without a common superscript differ ($P < 0.05$).
[AB]Least squares means in a row without a common superscript differ ($P < 0.05$).
[1]Raw and cooked collagen content were adjusted to dry matter basis to account for moisture loss during the cooking process.

Table 2. Least squares means of percent soluble and insoluble collagen, connective tissue texture evaluated by Asian consumers,[3] and Warner-Bratzler shear force of six different beef shanks (n = 48)

Beef shank	Soluble collagen, %[1]	Insoluble collagen, %[1]	Connective tissue texture[2]	Warner-Bratzler shear force, lb
Foreshank				
A	45.58^{ab}	54.42^{bc}	47.90^{c}	7.27^{b}
B	27.70^{c}	72.30^{a}	75.54^{a}	19.51^{a}
C	35.95^{bc}	64.05^{ab}	52.13^{bc}	7.30^{b}
Hindshank				
D	57.16^{a}	42.84^{c}	45.23^{c}	8.60^{b}
E	43.31^{ab}	56.69^{bc}	55.89^{b}	8.05^{b}
F	51.94^{ab}	48.06^{bc}	51.55^{bc}	8.58^{b}
Standard error of the least squares means	5.38	5.38	2.60	0.62
P-value	0.01	0.01	< 0.01	< 0.01

^{abc}Least squares means in a column without a common superscript differ ($P < 0.05$).
[1]Soluble collagen % = (raw collagen content – cooked collagen content) / raw collagen content.
Insoluble collagen % = cooked collagen content / raw collagen content – all in dry matter basis.
[2]Connective tissue texture scores: 0 = too soft; 50 = just about right (ideal score); 100 = too hard.
[3]Asian consumers were selected for the consumer panel of this study due to their ability to distinguish small differences in connective tissue texture.

Table 3. Least square means of raw and cooked pyridinoline and deoxypyridinoline densities of six different beef shanks (n = 48)

Beef shank	Pyridinoline density, mol/mol collagen		Standard error of the least square means	*P*-value	Deoxypyridinoline density, mol/mol collagen		Standard error of the least square means	*P*-value
	Raw	Cooked			Raw	Cooked		
Foreshank			0.04	< 0.05			0.001	< 0.01
A	0.14^{Ac}	0.23^{Ab}			0.008^{Ac}	0.012^{Aa}		
B	0.54^{Aa}	0.42^{Ba}			0.016^{Aa}	0.008^{Bb}		
C	0.19^{Ac}	0.14^{Ac}			0.019^{Aa}	0.013^{Ba}		
Hindshank								
D	0.34^{Ab}	0.28^{Ab}			0.014^{Ab}	0.007^{Bb}		
E	0.19^{Ac}	0.31^{Ab}			0.010^{Ac}	0.010^{Aa}		
F	0.13^{Ac}	0.12^{Ac}			0.010^{Ac}	0.007^{Ab}		

^{abc}Least squares means in a column without a common superscript differ ($P < 0.05$).
^{AB}Least squares means in a row without a common superscript differ ($P < 0.05$).

Table 4. Correlation coefficient (r) of raw and cooked collagen content, soluble and insoluble collagen % and raw and cooked mature collagen crosslink densities with connective tissue texture and Warner-Bratzler shear force of six beef shanks

Collagen components	Connective tissue texture	Warner-Bratzler shear force
Raw collagen content in dry matter basis[1]	-0.005	0.211
Cooked collagen content in dry matter basis[1]	0.550***	0.615***
Soluble collagen %	-0.498***	-0.392**
Insoluble collagen %	0.498***	0.392**
Raw pyridinoline density	0.560***	0.730***
Cooked pyridinoline density	0.375**	0.324*
Raw deoxypyridinoline density	0.257	0.321*
Cooked deoxypyridinoline density	-0.150	-0.220

[1]Raw and cooked collagen content were adjusted to dry matter basis to account for moisture loss during the cooking process.
* $P < 0.10$.
** $P < 0.05$.
*** $P < 0.01$.

A Preliminary Investigation of the Contribution of Different Tenderness Factors to Beef Loin, Tri-tip, and Heel Tenderness

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Abstract
The objective of this study was to identify the relative contribution of tenderness factors for three beef muscles with similar tenderness ratings. Longissimus lumborum (loin), tensor fascia latae (tri-tip), and gastrocnemius (heel) were collected from 10 U.S. Department of Agriculture choice beef carcasses, fabricated into steaks and assigned to a 5 or 21 day aging period (n = 60). Tri-tip had the longest sarcomere, followed by heel and loin (3.01, 2.59, and 1.71 μm, respectively; $P < 0.01$). Heel had the greatest relative troponin-T degradation percentage, followed by tri-tip and loin (68.10, 53.42, and 35.01%, respectively; $P < 0.01$). As expected, heel had the greatest collagen content, followed by tri-tip and loin (0.61, 0.40, and 0.28%, respectively; $P < 0.01$). Out of the three cuts, heel had the highest overall collagen crosslink density (0.20 mol/mol collagen; $P < 0.05$), while loin and tri-tip did not differ (0.13 and 0.15 mol/mol collagen, respectively; $P > 0.05$). Heel had lower lipid content than the others (2.68%; $P < 0.01$), while tri-tip and loin did not differ in lipid content (8.24 vs. 6.99 %; $P > 0.05$). Loin was ranked by the trained panel to have the highest overall tenderness, while tri-tip and heel did not differ in overall tenderness ($P > 0.05$). A multivariate regression analysis was conducted to quantify the relative contribution of each of the tenderness factors to overall tenderness evaluated by trained panelists. The equations indicated that each beef cut had a unique profile of tenderness contributors. Loin tenderness was driven by lipid content ($P < 0.05$); tri-tip tenderness was driven by collagen content ($P < 0.05$). Heel tenderness was driven by proteolysis ($P < 0.01$). Only collagen content may be casually used as an overall tenderness predictor for all three cuts.

Introduction
Beef tenderness is a complex palatability trait with many tenderness-contributing components. The overall perception of beef tenderness is dependent on all the tenderness-contributing components as well as the interaction among these components. Evaluating one or two tenderness components does not provide the whole picture of these interactions. One beef cut may excel in one or two of these tenderness components, but still fail to be perceived as tender due to failing one single tenderness component. Therefore, the objective of this study is to understand the relative contribution of each tenderness component to beef muscles.

Experimental Procedures

Boneless beef strip loin (Institutional Meat Purchasing Specifications #180), heel (Institutional Meat Purchasing Specifications #171F), and tri-tip (Institutional Meat Purchasing Specifications #185C) were collected from 10 U.S. Department of Agriculture Choice beef carcasses from a commercial beef processing facility in the Midwest and transported back to Kansas State University's Meat Laboratory, Manhattan, KS. Steaks were fabricated from the anterior to the posterior end of each strip loin and dorsal to the ventral end of each tri-tip and heel after 2 and 21 days of aging. Steaks from each aging period from each subprimal were assigned to one of three assays: 1) trained sensory analysis; 2) objective tenderness evaluation (Warner-Bratzler shear force); or 3) physiochemical analysis (sarcomere length, proteolysis, intramuscular fat content, collagen crosslink densities and content). Sensory panelists were trained according to the American Meat Science Association sensory guidelines (AMSA, 2015). Steaks were cooked to medium doneness (160°F). Sensory panelists evaluated myofibril tenderness, connective tissue amount, lipid flavor intensity, and overall tenderness of the steak samples. Objective tenderness was evaluated using Warner-Bratzler shear force. Procedures were conducted according to sensory guidelines (AMSA, 2015). Steaks were also cooked to medium doneness. Grilled steaks were cooled at 39°F overnight, and then cored. Six cores were measured for each sample. Sarcomeres were imaged with a confocal microscope using a 100 × 1.4/f objective. Thirty sarcomeres were measured for each sample. Myofibrillar proteins were isolated and the degree of proteolysis was measured by troponin-T degradation using gel electrophoresis and western blotting. Intact and degraded forms of troponin-T were found at 35 and 28 kDa, respectively. Percent troponin-T degraded was measured by band intensities of degraded bands divided by band intensities of all bands in a specific lane. Fat content was measured by extracting lipid from samples via chloroform, methanol, and water. The chloroform layer was evaporated leaving lipid content. Percent lipid was calculated by dividing the lipid weight over the sample weight. Collagen content was determined by measuring hydroxyproline concentration. Hydroxyproline concentrations of the samples were determined using a spectrophotometer. A conversion factor of 7.14 for hydroxyproline to collagen ratio was used to determine collagen content of each sample. Mature collagen crosslinks pyridinoline and deoxypyridnoline were measured by an ultra-high-pressure liquid chromatography unit. Finally, a correlation analysis was conducted to quantify the relative contribution of each of the tenderness factors to overall tenderness evaluated by trained panelists.

Results and Discussion

Biochemical composition and objective tenderness of the three beef cuts are displayed in Table 1. Tri-tip had the longest sarcomere, followed by heel and loin (3.01, 2.59, and 1.71 μm, respectively; $P < 0.01$). It was interesting to note that heel increased in sarcomere length from 5 to 21 days of postmortem storage (2.49 vs. 2.70 μm; $P < 0.05$). Heel had the greatest relative troponin-T degradation percentage, followed by tri-tip and loin (68.10, 53.42, and 35.01%, respectively; $P < 0.01$). As expected, heel had the greatest collagen content, followed by tri-tip and loin (0.61, 0.40, and 0.28%, respectively; $P < 0.01$). It is also worth noting that collagen content decreased for all cuts from 5 to 21 days of postmortem storage (0.46 vs. 0.39%; $P < 0.05$). Out of the three cuts, heel had the highest total mature collagen crosslink density (0.20 mol/mol collagen;

$P < 0.05$), while loin and tri-tip did not differ (0.13 and 0.15 mol/mol collagen, respectively; $P > 0.05$). It is important to note there was also an aging effect for collagen crosslinks. As collagen content decreased with aging, total mature crosslinks maintained their concentration, resulting in an increase in mature collagen crosslink density from 5 to 21 days of postmortem storage (0.14 vs. 0.20; $P < 0.01$). Heel had lower lipid content than the others (2.68%; $P < 0.01$), while tri-tip and loin did not differ in lipid content (8.24 vs. 6.99%; $P > 0.05$). As expected, loin had the lowest Warner-Bratzler shear force value followed by tri-tip and heel (5.53, 7.96, and 9.66 lb, respectively; $P < 0.01$).

Trained panel analysis of the three beef cuts are displayed in Table 2. Loin was ranked by the trained panel to have the highest overall tenderness, while tri-tip and heel did not differ in overall tenderness ($P > 0.05$). Biochemical measurements showed tri-tip to have all the attributes of a tender cut, yet panelists rated it similar to heel in overall tenderness. This leads us to speculate about the results of our mature crosslink data. More research is required to characterize collagen and collagen crosslinks to provide a better understanding of meat tenderness. Table 3 shows that each beef cut had a unique profile of tenderness contributors. Loin tenderness was driven by lipid content ($P < 0.05$); tri-tip tenderness was driven by collagen content ($P < 0.05$). Heel tenderness was driven by proteolysis ($P < 0.01$). Only collagen content may be casually used as an overall tenderness predictor for all three cuts.

Implications

Each muscle showed a unique tenderness factor profile. Loin is inherently tender, and tri-tip has the attributes for a tender cut as shown by our biochemical analysis, yet panelists rated tri-tip to have similar overall tenderness as heel, an inherently tough muscle. Collagen characteristics are the least studied tenderness factors, but may play the greatest role in meat tenderness regardless of cut.

References

American Meat Science Association. 2015. Research guidelines for cookery, sensory evaluation, and instrumental tenderness measurements of meat. 2 ed. American Meat Science Association, Champaign, IL.

Table 1. Physiochemical analysis and Warner-Bratzler shear force of three retail beef cuts aged for 5 or 21 days

Items	Age	Treatment			Standard error of the means	*P*-value
		[1]Loin	[2]Tri-tip	[3]Heel		
Troponin-T, % degraded					3.44	< .01
	5	29.99[Aa]	38.83[Aa]	60.36[Ab]		
	21	40.04[Bb]	68.00[Ba]	75.84[Ba]		
Sarcomere length, µm					0.08	< .05
	5	1.79[Ac]	3.07[Aa]	2.49[Ab]		
	21	1.63[Ac]	2.96[Aa]	2.70[Bb]		
Lipid content, %		6.99[a]	8.24[a]	2.68[b]	0.56	< .01
Collagen, %		0.28[c]	0.40[b]	0.61[a]	0.39	< .01
Warner-Bratzler shear force, lb		5.53[c]	7.96[b]	9.66[a]	0.12	< .01
Pyridinoline + deoxypyridinoline/collagen, mol/mol		0.14[b]	0.16[b]	0.21[a]	0.02	= .01
Pyridinoline/collagen, mol/mol		0.13[b]	0.15[b]	0.20[a]	0.01	< .01
Deoxypyridinoline/collagen, mol/mol					0.002	< .01
	5	0.018[aA]	0.016[aA]	0.007[bA]		
	21	0.002[bB]	0.014[aA]	0.008[abA]		

[a-c]Within a row, means without a common superscript differ at $P < 0.05$.
[A-B] Within a column, means without a common superscript differ at $P < 0.05$.
[1] Loin = Longissimus lumborum.
[2] Tri-tip = Tensor facia latae.
[3] Heel = Gastrocnemius.

Table 2. Trained panel ratings[1] of three retail beef cuts aged for 5 or 21 days

Items	Treatment			Standard error of the means	*P*-value
	Loin	Tri-tip	Heel		
Myofibril tenderness	75.82[a]	63.00[b]	63.48[b]	1.91	<.01
Connective tissue	6.08[b]	14.15[a]	18.22[a]	1.57	<.01
Lipid flavor	23.21[b]	28.07[a]	21.88[b]	0.784	<.01
Overall tenderness	73.95[a]	59.04[b]	57.44[b]	2.36	<.01

[a-b] Within a row, means without a common superscript differ at $P < 0.05$.
[1] Sensory scores: 0 = extremely tough/none/bland; 50 = neither tough nor tender; 100 = extremely tender/abundant/intense.

Table 3. Correlation coefficient (r) of overall tenderness with different tenderness components of three retail beef cuts

	Correlation coefficient (r) to overall tenderness			
Tenderness components	**All cuts**	**Loin**	**Tri-tip**	**Heel**
Collagen content	-0.423***	0.352	-0.456**	-0.143
Pyridinoline density	-0.094	0.317	0.089	0.050
Deoxypyridinoline density	-0.114	-0.267	0.056	-0.126
Lipid content	0.104	-0.534**	-0.069	-0.012
Degraded troponin-T%	-0.237	-0.102	0.145	0.730***
Sarcomere length	-0.452***	0.276	0.099	0.387*

* $P < 0.10$.
** $P < 0.05$.
*** $P < 0.01$.

Consumer Sensory Evaluation of Plant-Based Ground Beef Alternatives in Comparison to Ground Beef of Various Fat Percentages

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Abstract

The objective of this study was to determine if current plant-based protein ground beef alternatives offer similar palatability characteristics to ground beef patties of varying fat percentages. Fifteen different production lots (n = 15/fat level) of 3-lb ground beef chubs of three different fat levels (10%, 20%, and 30%) were collected from retail markets in the Manhattan, KS area. Additionally, alternative products including a soy protein-based foodservice ground beef alternative, a pea protein-based retail ground beef alternative, and a traditional soy protein-based ground beef alternative, (n = 15 production lots/product) currently available through commercial channels were collected from retail markets and a commercial foodservice chain. All ground beef and alternative treatments were formed into 0.25-lb patties and frozen at -40°F until consumer sensory analysis. All three ground beef samples rated higher ($P < 0.05$) than the three alternative samples for appearance, overall flavor, beef flavor, and overall liking. Retail alternative rated lowest ($P < 0.05$) for appearance, overall flavor, texture, and overall liking. Of the alternative samples, the foodservice alternative rated highest ($P < 0.05$) for juiciness, beef flavor, and texture liking, and the traditional alternative rated lowest ($P < 0.05$) for juiciness. However, foodservice alternative samples rated higher ($P < 0.05$) for tenderness than the 20% fat ground beef samples. Moreover, of the alternative samples, foodservice alternative and traditional alternative samples rated similar ($P > 0.05$) for appearance, tenderness, overall flavor liking, and overall liking. Among the ground beef samples, no differences ($P > 0.05$) were found for appearance, juiciness, overall flavor liking, beef flavor liking, or overall liking. For the percentage of samples rated acceptable for each palatability trait, all three ground beef treatments had a higher ($P < 0.05$) percentage of samples rated acceptable for appearance, overall flavor liking, beef flavor liking, texture, and overall liking than the three alternatives. Retail alternative had the lowest ($P < 0.05$) percentage of samples rated acceptable for appearance, overall flavor, texture, and overall liking. Traditional alternative had the lowest ($P < 0.05$) percentage of samples rated acceptable for juiciness. Among the alternative samples, the foodservice alternative had the highest ($P < 0.05$) percentage of samples rated acceptable for juiciness and beef flavor liking. Furthermore, among the alternative treatments, foodservice alternative and traditional alternative had a similar ($P > 0.05$) percentage of samples rated acceptable for appearance, overall flavor liking, texture liking, and overall liking.

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Introduction

Plant-based ground beef alternatives have seen increased demand in recent years (Aubrey, 2017). As time has progressed, vegetable-based patties have changed to more closely mimic the texture, taste, and juiciness of ground beef (Lopez, 2020). Multiple plant-based ground beef alternative companies have made claims stating they would like to replace animals in the food system. Their products are said to be almost identical to ground beef. However, little research has been conducted to assess the differences between ground beef and ground beef alternatives.

Experimental Procedures

Fifteen different production lots (n = 15/fat level) of 3-lb ground beef chubs of three different fat levels (10%, 20%, and 30%) were collected from retail markets in the Manhattan, KS, area. Additionally, ground beef alternative products including a soy and potato protein-based foodservice ground beef alternative, a pea protein-based retail ground beef alternative, and a traditional soy protein-based ground beef alternative, (n = 15 production lots/product) currently available through commercial channels were collected from retail markets and a commercial foodservice chain. All ground beef and alternative treatments were formed into 0.25-lb patties and frozen at -40°F until consumer sensory analysis. Patties were thawed 12–24 hours prior to cooking and were cooked to 160°F on a clamshell-style grill, cut into six equally sized wedges, and served within five minutes of cooking to consumers. Consumers (n = 120) were fed six samples (1 wedge/sample) in a random order and evaluated sample appearance, juiciness, tenderness, overall flavor liking, beef flavor liking, texture liking, and overall liking on continuous 100 point line scales verbally anchored at the ends and midpoints. Additionally, consumers rated each trait as either acceptable or unacceptable. All data were analyzed as a completely randomized design with treatment as a fixed effect.

Results and Discussion

As shown in Table 1, all three ground beef samples rated higher ($P < 0.05$) than the three alternative samples for appearance, overall flavor, beef flavor, and overall liking. Retail alternative rated lowest ($P < 0.05$) for appearance, overall flavor, texture, and overall liking. Of the alternative samples, foodservice alternative rated highest ($P < 0.05$) for juiciness, beef flavor, and texture liking, and traditional alternative rated lowest ($P < 0.05$) for juiciness. However, foodservice alternative rated higher ($P < 0.05$) for tenderness than the 20% fat ground beef samples. Moreover, of the alternative samples, foodservice alternative and traditional alternative rated similar ($P > 0.05$) for appearance, tenderness, overall flavor liking, and overall liking. Among the ground beef samples, no differences ($P > 0.05$) were found for appearance, juiciness, overall flavor liking, beef flavor liking, or overall liking. For the percentage of samples rated acceptable for each palatability trait (Table 2), all three ground beef treatments had a higher ($P < 0.05$) percentage of samples rated acceptable for appearance, overall flavor liking, beef flavor liking, texture, and overall liking than the three alternatives. Retail alternative had the lowest ($P < 0.05$) percentage of samples rated acceptable for appearance, overall flavor, texture, and overall liking. Traditional alternative had the lowest ($P < 0.05$) percentage of samples rated acceptable for juiciness. Among the alternative samples, foodservice alternative had the highest ($P < 0.05$) percentage of samples rated acceptable for juiciness and beef flavor liking. Furthermore, among the alternative treatments, foodservice alternative and traditional alternative had a similar ($P > 0.05$) percentage of samples rated acceptable for appearance, overall flavor liking, texture liking, and overall liking.

Implications

These results indicate that ground beef samples had higher palatability ratings than alternative samples for most palatability traits evaluated. Moreover, a higher percentage of samples were rated as acceptable for ground beef than for alternatives. This clearly indicates that the eating experience provided by the alternatives is different than that provided by traditional ground beef. Thus, consumers who purchase alternatives should not expect the same eating quality as they would receive with ground beef.

Acknowledgements

Funding for this project was provided by the Kansas Beef Council.

References

Aubrey, A. 2017. Saving the Planet, One Burger At a Time: This Juicy Patty is Meat-Free. NPR. https://www.npr.org/sections/thesalt/2017/02/11/514544431/saving-the-planet-one-burger-at-a-time-this-juicy-patty-is-meat-free. Accessed June 28, 2020.

Lopez-Alt, J. K. 2020. How Do They Make Plant-Based Meat Behave Like Beef? The New York Times. https://www.nytimes.com/2020/03/03/dining/plant-based-meat-science.html. Accessed June 23, 2020.

Table 1. Least squares means for consumer (n = 120) ratings[1] of the palatability traits of ground beef and plant-based ground beef alternative patties

Treatment	Appearance liking	Juiciness	Tenderness	Overall flavor liking	Beef flavor liking	Texture liking	Overall liking	Price factor[2]
Ground beef 90% lean/10% fat	56.9[a]	65.8[a]	64.5[a]	57.2[a]	65.9[a]	62.5[a]	58.5[a]	51.7[a]
Ground beef 80% lean/20% fat	59.4[a]	63.8[a]	57.3[bc]	58.6[a]	64.3[a]	59.8[b]	56.5[a]	50.6[a]
Ground beef 70% lean/30% fat	63.2[a]	68.3[a]	63.5[ab]	59.0[a]	67.5[a]	64.3[a]	59.6[a]	56.2[a]
Retail ground beef alternative	26.7[c]	47.0[b]	56.4[c]	27.5[c]	28.7[c]	28.0[d]	23.8[c]	17.9[c]
Foodservice ground beef alternative	46.9[b]	68.0[a]	64.9[a]	44.6[b]	37.0[b]	46.6[b]	41.2[b]	34.1[b]
Traditional ground beef alternative	41.0[b]	32.7[c]	62.3[abc]	40.0[b]	27.2[c]	37.7[c]	34.7[b]	26.2[bc]
Standard error mean (largest) of the least square means	2.93	3.01	2.52	2.87	2.59	2.57	2.95	3.03
P-value	< 0.01	< 0.01	0.04	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01

[abcd]Least squares means in the same column without a common superscript differ ($P < 0.05$).
[1]Sensory scores: 0 = extremely dislike/extremely dry/extremely tough/extremely dislike; 50 = neither like nor dislike/neither dry nor juicy/neither tough nor tender, neither like nor dislike; 100 = like extremely/extremely juicy/extremely tender/like extremely.
[2]If price were not a factor, how likely would you be to purchase each treatment (1 = not likely, 100 = extremely likely).

Table 2. Least squares means for percentage of samples rated acceptable by consumers (n = 120) of ground beef and plant-based ground beef alternative patties

Treatment	Appearance liking	Juiciness	Tenderness	Overall flavor liking	Beef flavor liking	Texture liking	Overall liking
Ground beef 90% lean/10% fat	83.9[a]	88.2[a]	92.8[a]	77.5[a]	83.6[a]	89.0[a]	77.5[a]
Ground beef 80% lean/20% fat	83.9[a]	84.9[a]	82.1[bc]	70.8[a]	77.0[a]	81.7[a]	73.3[a]
Ground beef 70% lean/30% fat	90.4[a]	84.1[a]	84.6[ab]	78.3[a]	84.5[a]	86.6[a]	79.2[a]
Retail ground beef alternative	28.7[c]	61.3[b]	71.3[c]	30.8[c]	28.9[c]	34.4[c]	22.5[c]
Foodservice ground beef alternative	67.9[b]	88.2[a]	84.6[ab]	51.7[b]	41.5[b]	63.1[b]	51.7[b]
Traditional ground beef alternative	59.4[c]	38.8[c]	81.3[bc]	50.8[c]	28.9[c]	50.9[b]	45.8[b]
Standard error mean (largest) of the least square means	5.01	5.18	4.49	4.56	4.38	5.42	4.56
P-value	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01

[abc]Least squares means in the same column without a common superscript differ ($P < 0.05$).

Comparison of the Physical Attributes of Plant-Based Ground Beef Alternatives to Ground Beef

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Abstract
The objective of this study was to evaluate the physical attributes of three different plant-based, ground beef alternatives in comparison to ground beef of three different fat percentages. Ground beef of three different fat percentages (10%, 20%, and 30%), a retail pea protein-based ground beef alternative, and a traditional soy flour-based ground beef alternative were obtained from retail stores in the Manhattan, KS, area over several weeks (n = 15 lots/treatment). Additional samples from 15 lots of a food-service soy protein-based ground beef alternative were obtained from a commercial foodservice chain. Ground beef, retail ground beef alternative, and foodservice ground beef alternative were fabricated into 0.25 lb patties and assigned to one of four assays: color analysis, texture profile analysis, shear force, and pressed juice percentage. When evaluating raw color, traditional ground beef alternative had the highest ($P < 0.05$) a* value and was redder when compared to all other treatments, with retail ground beef alternative having the lowest ($P < 0.05$) a* value. For texture attributes, retail ground beef alternative and foodservice ground beef alternative had lower ($P < 0.05$) values for cohesiveness, gumminess, hardness, and chewiness, as well as higher values for springiness, than all other treatments evaluated. For shear force, the three ground beef alternatives were more tender ($P < 0.05$) than all three ground beef treatments, with foodservice ground beef alternative and retail ground beef alternative being more tender ($P < 0.05$) than all treatments. The three ground beef treatments had greater ($P < 0.05$) pressed juice percentage values than all ground beef alternatives, indicating the ground beef was juicier than any of the ground beef alternatives evaluated. For physical attributes, the ground beef alternatives evaluated differed from ground beef. Retail ground beef alternative and foodservice ground beef alternative had the greatest differences, with the traditional ground beef alternative being the most similar to 20% and 30% fat ground beef for some traits.

Introduction
Plant-based ground beef alternatives have seen increased demand in recent years (Aubrey, 2017). As time has progressed, vegetable-based patties have evolved to more closely mimic the texture, taste, and juiciness of ground beef (Lopez-Alt, 2020). Little research has evaluated the differences between ground beef and ground beef alternatives. Therefore, our objective was to evaluate the physical attributes of three different plant-based, ground beef alternatives in comparison to ground beef of three different fat percentages.

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Experimental Procedures

Ground beef of three different fat percentages (10%, 20%, and 30%), a retail pea protein-based ground beef alternative, and a traditional soy flour-based ground beef alternative were obtained from retail stores in the Manhattan, KS, area over several weeks in order to obtain different production lots for each product (n = 15 lots/treatment). Additional samples from 15 production lots of a foodservice soy protein-based ground beef alternative were obtained from a commercial foodservice chain. Ground beef, retail ground beef alternative, and foodservice ground beef alternative were fabricated into 0.25 lb patties using a manual patty former and randomly assigned to one of four assays: color analysis, texture profile analysis, shear force, and pressed juice percentage. Patties used for texture profile analysis and shear force were cooked to 160°F on a clamshell-style grill with three 1-in cores taken from each patty for texture profile analysis and two 1-in wide strips taken from each patty for shear force. Patties were evaluated for L* (lightness), a* (redness), and b*(yellowness) using a handheld spectrophotometer both in the raw, precooked state as well as after cooking for both external and internal color. Pressed juice percentage measured the percentage of weight lost from 0.06-in^3 cooked samples that were compressed for 30 seconds at 17.6 lb of force. During cooking for texture profile analysis, shear force, and pressed juice percentage, patty weights, diameters, and thicknesses were measured for determination of size change through cooking. All data were analyzed as a completely randomized design.

Results and Discussion

Color results are listed in Table 1. When evaluating raw color, traditional ground beef alternatives had the highest ($P < 0.05$) a* value and were redder when compared to all other treatments, with retail ground beef alternative having the lowest ($P < 0.05$) a* value. Traditional ground beef alternative and retail ground beef alternative had the highest ($P < 0.05$) a* value, while foodservice ground beef alternative, and 30% and 10% fat ground beef had the lowest ($P < 0.05$) a* value for cooked surface color. Additionally, 30% and 20% fat ground beef had higher ($P < 0.05$) L* values for internal cooked color than all other treatments, with all ground beef alternative patties having the lowest ($P < 0.05$) L* values. For texture attributes (Table 2), retail ground beef alternative and foodservice ground beef alternative had lower ($P < 0.05$) values for cohesiveness, gumminess, hardness, and chewiness, as well as higher values for springiness, than all other treatments evaluated. Few differences were found between traditional ground beef alternative and 20% and 30% fat ground beef for texture, with traditional ground beef alternative only found softer and less chewy ($P < 0.05$) than both ground beef treatments. For shear force, the three ground beef alternatives were more tender ($P < 0.05$) than all three ground beef treatments, with foodservice ground beef alternative and retail ground beef alternative being more tender ($P < 0.05$) than all treatments. The three ground beef treatments had greater ($P < 0.05$) pressed juice percentage values than all ground beef alternatives, indicating the ground beef was juicier than any of the ground beef alternatives evaluated. Finally, during cooking, the three ground beef treatments had a greater ($P < 0.05$) cook loss percentage and decrease in patty diameter and thickness than the three ground beef alternatives, with foodservice ground beef alternative and retail ground beef alternatives increasing in thickness during cooking (Table 3).

Implications

This provides evidence that although ground beef alternative products attempt to mimic ground beef, they provide very different color, texture, tenderness, and cooking characteristics than traditional ground beef.

Acknowledgments

Funding for this project was provided by the Kansas Beef Council.

References

Aubrey, A. 2017. Saving the Planet, One Burger At a Time: This Juicy Patty is Meat-Free. NPR. https://www.npr.org/sections/thesalt/2017/02/11/514544431/saving-the-planet-one-burger-at-a-time-this-juicy-patty-is-meat-free. Accessed June 28, 2020.

Lopez-Alt, J. K. 2020. How Do They Make Plant-Based Meat Behave Like Beef? The New York Times. https://www.nytimes.com/2020/03/03/dining/plant-based-meat- science.html. Accessed June 23, 2020.

Table 1. Raw, cooked surface and cooked internal color values for ground beef and plant-based ground beef alternative patties

	Raw color			Cooked surface color			Cooked internal color		
Treatment	**L***	**a***	**b***	**L***	**a***	**b***	**L***	**a***	**b***
Ground beef 90% lean/10% fat	53.6[a]	22.4[bc]	22.6[d]	37.3[bc]	08.4[c]	17.1[e]	51.7[b]	11.3[ab]	19.3[bc]
Ground beef 80% lean/20% fat	53.4[a]	24.0[b]	25.5[c]	38.9[ab]	9.1[b]	19.7[bc]	56.1[a]	9.2[c]	18.7[c]
Ground beef 70% lean/30% fat	29.4[d]	21.3[c]	46.7[a]	40.4[a]	8.2[c]	18.0[de]	57.2[a]	7.6[d]	17.5[d]
Retail ground beef alternative	52.4[a]	11.6[e]	14.0[f]	36.0[c]	12.7[a]	18.7[cd]	42.3[c]	11.6[a]	16.6[e]
Food service ground beef alternative	49.4[b]	17.8[d]	20.6[e]	37.3[bc]	8.1[c]	20.8[b]	41.5[c]	12.7[a]	19.9[b]
Traditional ground beef alternative	42.7[c]	31.4[a]	29.7[b]	34.0[d]	12.6[a]	24.4[a]	42.7[c]	10.0[bc]	28.0[a]
Standard error mean (largest) of the least square means	0.72	0.60	0.62	0.66	0.24	0.47	0.54	0.53	0.25
P-value	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01

[abcdef] Least square means without a common superscript differ ($P < 0.05$).
L* = lightness (0 = black and 100 = white).
a* = redness (-60 = green and 60 = red).
b* = blueness (-60 = blue and 60 = yellow).

Table 2. Texture profile analysis,[1] Warner/Bratzler shear force, and pressed juice percentage results for ground beef and plant-based ground beef alternative patties

Treatment	Hardness	Cohesiveness	Springiness	Gumminess	Chewiness	Warner Bratzler shear force (lb)	Pressed juice percentage[2]
Ground beef 90% lean/10% fat	17.2[b]	31.4[b]	65.6[a]	5.4[b]	3.5[b]	7.5[a]	12.7[b]
Ground beef 80% lean/20% fat	21.9[a]	34.5[a]	68.6[a]	7.7[a]	5.2[a]	7.7[a]	14.7[a]
Ground beef 70% lean/30% fat	14.5[c]	31.4[b]	55.3[b]	4.6[b]	2.6[c]	6.8[a]	15.5[a]
Retail ground beef alternative	3.6[e]	21.5[c]	39.8[c]	0.8[c]	0.3[d]	4.0[c]	8.7[d]
Food service ground beef alternative	8.0[d]	19.8[c]	42.8[c]	1.6[c]	0.7[d]	4.4[c]	11.4[c]
Traditional ground beef alternative	17.1[b]	31.5[b]	65.3[a]	5.4[b]	3.6[b]	5.5[b]	3.0[e]
Standard error mean (largest) of the least squares means	0.8	0.7	1.2	0.4	0.2	0.2	0.4
P-value	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01

[1]Texture profile methods as followed from Wilfong, A.K., K.V. McKillip, J.M. Gonzalez, T.A. Houser, J.A. Unruh, E.A.E. Boyle, and T.G. O'Quinn. 2016. Determination of the effect of brand and product identification on consumer palatability ratings of ground beef patties. J. Anim. Sci. 94:4943-4958. doi:10.2527/jas.2016-0894.
[2]Percent juice pressed from sample.
[abc]Least squares means in the same column lacking a common superscript differ ($P < 0.05$).

Table 3. Patty shrink and cook loss of ground beef and ground beef alternative patties

	Patty shrink and cook loss[1]		
Treatment	Diameter shrink[2]	Thickness shrink[2]	Cook loss[2]
Ground beef 90% lean/10% fat	11.2[b]	12.2[a]	17.6[b]
Ground beef 80% lean/20% fat	16.2[a]	5.8[ab]	25.9[a]
Ground beef 70% lean/30% fat	15.5[a]	3.2[b]	27.5[a]
Retail ground beef alternative	1.0[c]	-10.3[c]	12.9[c]
Food service ground beef alternative	-1.5[d]	-15.3[c]	8.5[d]
Traditional ground beef alternative	0.4[c]	3.1[b]	1.3[e]
Standard error mean (largest) of the least square means	0.64	2.55	0.65
P-value	< 0.01	< 0.01	< 0.01

[abcde]Least squares means without a common superscript differ ($P < 0.05$).
[1]Negative values indicate patty expansion for both diameter and/or thickness.
[2]Values expressed as % shrink ((raw patty measurement - cooked patty measurement)/raw patty measurement) × 100.

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