



CATTLEMEN'S DAY 2020

BEEF CATTLE RESEARCH



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Effects of Prescribed Fire Timing on Stocker Cattle Performance, Native Plant Composition, Forage Biomass, and Root Carbohydrate Reserves in the Kansas Flint Hills: Year One of Six

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Abstract

Prescribed fire is required to maintain the native tallgrass prairie ecosystem. Typically, ranchers apply annual spring fire from mid-March through late April to suppress woody vegetation and to stimulate cattle performance. It has been recently documented that shifting prescribed fire from spring to late summer or early fall provides comprehensive control of the noxious weed sericea lespedeza (*Lespedeza cuneata*). In spite of those findings, Flint Hills ranchers have voiced reluctance to consider using late-summer or early-fall prescribed burning as a routine sericea lespedeza control measure on grazing lands because of concerns about unintended harm to beef cattle growth performance or a perceived protracted weakening of native warm-season grass populations. In year one of a six-year study, 18 pastures were grouped by watershed and assigned to one of three burn treatments: spring (April), mid-summer (August), or early fall (October). All fire treatments were applied before grazing began. Yearling heifers ($n = 360$) were grazed for 90 days beginning May 1. Plant composition, forage biomass, and root carbohydrate concentration in key native plants in the tallgrass prairie were evaluated during late June and early July. Heifers grazing spring-burned pastures had greater total body weight gain and greater average daily gain ($P = 0.02$) than heifers grazing summer- or fall-burned pastures. Pre-treatment forage biomass was not different ($P = 0.12$) between treatments. One year following fire application, forage biomass was greatest ($P \leq 0.01$) in the summer-burn treatment, intermediate in the spring-burn treatment, and least in the fall-burn treatment. Total grass and forb basal cover did not differ ($P \geq 0.13$) between treatments. Conversely, spring and summer fires were associated with greater ($P = 0.03$) native grass basal cover compared with fall fire. Furthermore, summer fire resulted in lesser ($P = 0.02$) basal cover of introduced grass species compared to the fall fire. Root starch and water-soluble carbohydrate levels in three key warm-season forage grasses and one key native legume did not differ ($P \geq 0.32$) among treatments. These preliminary findings were interpreted to indicate that prescribed fire timing influenced stocker cattle performance, plant composition, and forage biomass accumulation. In contrast, root carbohydrate reserves were not affected by season of fire. Beef producers are encouraged to compare potential revenue loss associated with the declines in yearling growth performance reported here with the cost of alternative methods of sericea lespedeza control.

Introduction

The tallgrass prairie once extended from Indiana in the east, Kansas in the west, Canada in the north, and Texas in the south. Settlement of the prairie resulted in the conversion of native grasslands into farmland. Of the 170 million acres of tallgrass prairie that once existed, less than 4% of those acres remains today. The Kansas Flint Hills make up the largest contiguous portion of the remaining tallgrass prairie; this area is used primarily for cattle production. One of the challenges facing Flint Hills ranchers is the rapid degradation of native pastures by the noxious weed, sericea lespedeza (*Lespedeza cuneata*). Sericea lespedeza was introduced to southeastern Kansas in the 1930s because of its perceived soil conservation properties. Since that time, the highly prolific plant has moved westward and invaded more than 960 square miles of grasslands in Kansas, most of which is located in the Flint Hills.

Traditionally, ranchers have applied annual spring-season prescribed fires to native tallgrass rangelands because of their ability to limit encroachment of trees and shrubs while subsequently boosting cattle performance. Unfortunately, this practice has resulted in numerous air-quality issues in downwind municipalities and has not limited the proliferation of sericea lespedeza. Recent research has indicated that shifting the timing of prescribed fire from spring to late summer or early fall provided comprehensive control of sericea lespedeza, and a significant motive for ranchers to evaluate alternative seasons for prescribed fire application. Although late-summer or early fall fires have been shown to successfully and affordably control sericea lespedeza, some ranchers remain hesitant to apply these techniques out of concerns over sacrificing cattle performance or negatively impacting native plant populations. 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, plant composition, and forage biomass annually over a six-year period. This manuscript reports the first complete year of our work. It is our hope that this project will generate the data necessary for ranchers to make well-informed management decisions about noxious weed control.

Experimental Procedures

Our study was conducted at the Kansas State University Beef Stocker Unit located northwest of Manhattan, KS. The Beef Stocker Unit is fenced into 18 pastures ranging from 30 to 75 acres in size. Pastures were grouped by watershed and each watershed assigned to one of three prescribed burning times ($n = 6$ pastures per treatment): early spring (April), mid-summer (August), or early fall (October). A permanent 328-foot transect was established in each pasture. Transects were marked with orange survey stakes and GPS coordinates were recorded. Botanical composition and basal cover were estimated utilizing the modified step-point method. Plant sampling began in June 2018 and burn treatments were applied prior to grazing in summer of 2019.

In year one of a six-year trial, yearling heifers ($n = 360$) were stocked at 250-lb live weight/acre and grazed from May 1 to August 1. Heifers were individually weighed on day 0 and randomly assigned to pastures. On day 90, cattle were individually weighed.

Pre-treatment standing forage biomass was measured using 2.7 square foot clipping frames placed at 32.8-foot intervals along each transect. Plant material was clipped to a height of 0.39 in and dried to a constant weight. A visual obstruction technique was used to estimate forage biomass before and after fire treatments were applied. These observations were collected at 3.28-foot intervals along each 328-foot transect. Root-carbohydrate flux was evaluated in three native warm season (C4) grasses (i.e., big bluestem, little bluestem, and Indian grass), and one leguminous, native forb (i.e., purple prairie clover). Individual roots and rhizomes were collected, washed, separated from parent plants, and dried. Root samples were analyzed for both total starch and total water-soluble carbohydrate concentrations.

Results and Discussion

Following fire-treatment applications (i.e., August of 2018, October of 2018, and April of 2019), total body weight gain during the summer of 2019 was slightly improved ($P = 0.02$; Table 1) in the spring-burn treatment compared to summer- and fall-burn treatments. Heifers that grazed spring-burned pastures gained 29 and 21 lb more body weight than heifers that grazed summer- and fall-burned pastures, respectively. No difference ($P = 0.37$; Table 1) in total body weight gain was observed between summer and fall treatments. In addition, the average daily gain was greater ($P = 0.02$; Table 1) for heifers that grazed the spring treatment compared to those that grazed summer and fall treatments.

Initial forage biomass did not differ ($P = 0.12$; Table 1) between treatments; however, after fire-treatment applications, standing forage biomass was greater ($P < 0.01$; Table 1) in the summer-burn treatment compared with the spring- and fall-burn treatments. Pastures burned in the summer produced 493 and 300 more pounds of dry biomass per acre compared with pastures burned in fall and spring, respectively. The elevated forage biomass observed in the summer treatment may have been due to the presence of standing dead plant material. When fire was applied in the summer treatment, regrowth occurred before the first frost and standing dead plant material was present at the beginning of the following grazing season. Forage biomass was measured using a visual obstruction technique, which included standing dead plant material in the biomass estimate. Consumption of this material may have contributed to the reduction in cattle growth performance observed in the summer fire treatment. Heifers grazing summer-burned pastures had an increased opportunity to consume standing dead plant material, which is known to have poor nutritive value relative to actively-growing plants.

Litter cover on the soil surface was greater ($P = 0.04$; Table 2) in the summer-burn treatment compared with the spring-burn treatment, whereas pastures burned in the fall were intermediate. Conversely, bare soil tended to be less ($P = 0.08$; Table 2) in the summer burn treatment compared to spring, and fall burned pastures were intermediate. Increased bare soil has been associated with increased soil temperature and earlier plant growth but can lead also to increased water runoff and soil moisture loss.

When basal vegetation cover was evaluated, no differences ($P = 0.42$; Table 2) were detected between treatments; however, differences in plant composition were apparent. Spring- and summer-burned pastures had a greater ($P = 0.03$; Table 3) native grass cover compared with fall-burned pastures. In addition, summer fire was associated with

less ($P = 0.05$; Table 3) introduced grass species cover than fall fire, whereas spring fire was intermediate. Cover attributable to warm- and cool-season grasses did not differ ($P \geq 0.12$) between fire treatments. Total forb cover, native forb cover, introduced forb cover, and perennial forb cover, likewise, did not differ ($P \geq 0.24$; Table 3) between treatments. Conversely, annual forb cover was greatest ($P = 0.04$; Table 3) in the fall fire treatment, least in the spring fire treatment and intermediate in the summer fire treatment.

Root starch and total water-soluble carbohydrate concentrations in big bluestem, little bluestem, Indian grass, and purple prairie clover did not differ ($P \geq 0.23$; Table 4, Table 5) between treatments. The lack of difference in root carbohydrate reserves between treatments was likely an indication that the timing of burning had little impact on growth potential of native plants.

Implications

The first year of data from our six-year study was interpreted to indicate that prescribed fire timing influenced stocker cattle performance and was associated with small changes in range-plant composition; however, fire timing did not affect root carbohydrate reserves of key native forage plants. Beef producers are encouraged to compare potential revenue shortfalls resulting from the declines in yearling growth performance reported here with the cost of chemical methods for sericea lespedeza control.

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

Item	Prescribed fire season			Standard error of the mean	P-value
	Spring	Summer	Fall		
Initial body weight, lb	619	625	622	13.1	0.92
Final body weight, lb	856	831	837	12.5	0.14
Total body weight gain, lb	236 ^a	207 ^b	215 ^b	9.5	0.02
Average daily gain, lb/day	2.6 ^a	2.3 ^b	2.4 ^b	0.11	0.02
Initial forage biomass (2018), lb dry matter/acre	1528	1754	1645	109.8	0.12
Final forage biomass (2019), lb dry matter/acre	852 ^b	1120 ^a	680 ^c	27.8	< 0.01

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

Table 2. Effects of prescribed fire timing on tallgrass prairie soil cover in the Kansas Flint Hills

Item, % of total area	Prescribed fire season			Standard error of the mean	P-value
	Spring	Summer	Fall		
Bare soil	58	47	49	4.8	0.08
Litter cover	23 ^b	36 ^a	32 ^{ab}	4.8	0.04
Total basal vegetation cover	19	17	19	1.6	0.42

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

Table 3. Effects of prescribed fire timing on basal 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	91	92	87	2.5	0.13
Native grass species	89 ^a	90 ^a	82 ^b	2.9	0.03
Introduced grass species	2.3 ^{ab}	1.6 ^b	5.0 ^a	1.41	0.05
Cool-season grass species	20.3	19.5	23.3	2.80	0.37
Warm-season grass species	70.8	72.2	64.1	4.09	0.12
Total forb cover	8.4	7.1	11.0	2.39	0.28
Native forb species	8.3	7.1	11.0	2.34	0.25
Introduced forb species	0.1	0	0	2.34	0.24
Annual forb species	0.3 ^b	0.7 ^{ab}	1.9 ^a	0.69	0.05
Perennial forb species	8.1	6.5	9.1	2.10	0.45

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

Table 4. Effects of prescribed fire timing on root starch reserves of key tallgrass prairie species during July

Item, % dry matter	Prescribed fire season			Standard error of the mean	P-value
	Spring	Summer	Fall		
Big bluestem	2.02	4.06	2.55	1.26	0.23
Little bluestem	1.96	2.11	1.59	0.86	0.83
Indian grass	4.55	2.94	2.33	1.86	0.46
Purple prairie clover	5.09	3.98	3.95	1.65	0.72

Table 5. Effects of prescribed fire timing on root water-soluble carbohydrate reserves of key tallgrass prairie species during July

Item, % dry matter	Prescribed fire season			Standard error of the mean	<i>P</i> -value
	Spring	Summer	Fall		
Big bluestem	3.89	5.27	4.35	1.20	0.48
Little bluestem	3.51	5.50	3.72	1.49	0.32
Indian grass	6.14	3.87	4.02	1.98	0.42
Purple prairie clover	5.07	3.63	5.84	1.67	0.40

Evaluating Stocker Steer Gains on Tallgrass Native Range with Two Burn Dates and Spices in Mineral

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Abstract

Two operational management strategies were evaluated in which two treatments were evaluated within each management strategy. The first operational management strategy evaluated was timing of burning native tallgrass pasture with burn dates in March or April. The second operational management strategy evaluated was free-choice mineral where steers received a complete balanced mineral with 25% of the magnesium, zinc, copper, and manganese coming from chelated organic sources or that same base mineral with the addition of spices. Eight pastures stocked with 281 head of stocker steers (initial weight 644 ± 63 lb) were used. Steers were assigned to one of four treatments, weighed individually, grazed for 87 days in a double stock system, and then individually weighed at the end of the study. There was no interaction between the two management practices for average daily gain, total gain, and out weights ($P > 0.17$). Average daily gain was increased by 0.35 lb/day ($P = 0.03$) with an April pasture burn instead of March. There was no difference in average daily gain based on mineral supplement ($P = 0.23$), even though numerically the cattle on spice mineral had a greater average daily gain. When evaluating final weights, cattle on April burned pastures tended ($P = 0.09$) to weigh 20 lb more than those grazing pastures burned in March. Calves on the spice mineral tended ($P = 0.10$) to weigh 19 lb more at the end of the study than steers on the control mineral. The two management practices were not additive, but taken individually implementing an April burn or offering the spice mineral could result in greater calf weight coming off pasture. Using 2019 prices, the spice mineral added \$2.71 per head to cost with an increase in \$26.65 in revenue.

Introduction

Cattle producers are considering alternative methods to reduce the use of synthetic products in cattle production, and to reduce the feeding of antibiotics, in response to growing preferences from consumers. Essential oils/spices have been offered as a potential method to control insects in cattle (Showler, 2017), alter rumen microbial population (Elcoso et al., 2019), and replace feed antibiotics in feedlot diets (Araujo et al., 2019), all of which may increase cattle gains. There have been varying responses to cattle gains based on type of essential oil within feedlot diets, with a greater majority reporting similar gains as control diets. In a grazing study, no improvements in gains were observed when either hand-feeding or offering as free-choice a cinnamon and garlic essential oil product (Beck et al., 2017). To our knowledge, there are limited data on cattle gains while grazing pastures, thus showing the importance of evaluating essential oils on stocker cattle gains is to be investigated.

Previous research from Kansas State University found that burning pasture in April results in about 20 lb more gain per grazing steer than burning a pasture in March

(summarized by Owensby, 2010). The state of Kansas has been under scrutiny because high smoke production in April creates smoky conditions that drift to large metropolitan areas. Extending the burning season can reduce smoke load. If March burning produces gains and plant population changes that are not too different from the results when burning in April, it would provide the opportunity to develop a smoke management plan. Therefore, the overall objective of this study was to evaluate management practices that may impact stocker steer gains on a 90-day double stocking grazing system in tallgrass native range. Specific objectives include evaluating (1) timing of burning, (2) addition of spices in a complete free-choice mineral, and (3) determination if the effects are additive.

Experimental Procedures

The study was conducted at the Bressner Research Range Unit in Yates Center, KS. The unit consists of eight pastures on 625 acres of tallgrass native prairie. Two management strategies were evaluated to determine effects on stocker steer gains in a 2×2 factorial arrangement. The two management strategies were timing of pasture burning and free-choice mineral supplementation, with two different treatments to evaluate within each management strategy. Pasture burning times were March or April. The March burn treatment occurred on March 19, 2019, while the April burn treatment occurred April 15, 2019. Mineral treatments evaluated were: (1) free-choice complete mineral (control treatment) and (2) the same base mineral with the addition of spices (spice treatment; Table 1). The spices included were powdered forms of oils from garlic and the product Solace (proprietary blend of spices; Wildcat Feeds LLC, Topeka, KS). Minerals were formulated for a 4 oz/head/day intake and offered fresh weekly at 125% of calculated optimal pasture intake.

Two hundred eighty-one steers (644 ± 63 lb) were weighed individually on April 26, 2019, and assigned to pasture randomly based on order through the chute (initial weights not different, $P > 0.24$). Cattle were weighed at the end of the study on July 23, 2019, for a total of 87 days of grazing. Twenty-four head were not included in final data set because at one point during the study period they were found in the incorrect treatment pasture or in the neighbor's pasture. Therefore, only cattle that were known to stay within their respective treatment the entire 87 days were used for analysis.

Results and Discussion

Average daily gain was not different when evaluating the four treatment combinations ($P = 0.17$; Figure 1). An average daily gain advantage of 0.33 lb/day was observed for steers grazing pastures burned in April and this resulted in an average of 20 lb more weight coming off grass (Table 2). This is consistent with other studies conducted at Kansas State University (summarized by Owensby, 2010). There was no difference ($P = 0.23$) in steer average daily gain based on type of mineral consumed, however, independent of pasture burning time, the calves on the spice mineral tended to average 19 lb more than those on the control mineral ($P = 0.10$; Table 3). Even though the calves started at the same weight, these heavier final weights show positive managerial options with burning pasture in April and offering the spice mineral. In contrast to what was observed in an Arkansas and Oklahoma study with Beck et al. (2017), the spices used in this study tended to increase weight of steers as compared to control.

Based on 2019 prices, the spice mineral was \$200 more per ton than the control mineral. This added a total of \$2.71 per head to the feeding cost of steers. The added 19 pounds of calf weight, with August 2019 prices (\$135/cwt), resulted in \$26.65 more sale value per calf than calves on the control mineral. This was close to a 10-fold return on investment of the spice mineral.

Implications

Burning pastures in April results in a greater calf gain than burning in March, while the addition of spices to a free-choice complete mineral shows promise as a cost-effective method to increase gains in stocker steers on tallgrass native range.

Acknowledgments

Wildcat Feeds LLC (Topeka, KS) donated mineral for the project. We also appreciate the Bressner Research committee for support of the project; Dale Lanham, agriculture agent in Southwind Extension District for leading the burning of pastures and overall management of Bressner Unit; and Juliette (Ellie) Toothaker, undergraduate intern; and Chris Petty, agriculture agent in Southwind District, for feeding the mineral weekly.

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Table 1. Analysis of supplemental free-choice minerals

Item (on dry matter basis)	Control mineral	Spice mineral ¹
Crude protein	4.81	4.79
Calcium	18	18
Phosphorus	3	3
Salt	23	23
Magnesium ²	3	3
Potassium	1	1
Iron	5,664	5,670
Copper ³	1,153	1,153
Zinc ³	3,470	3,470
Manganese ³	1,816	1,818
Selenium	22	22
Iodine	333	333
Cobalt	13	13
Vitamin A	141,667	141,667
Vitamin D	14,167	14,167
Vitamin E	172	172

¹Spice mineral was similar base as control mineral with addition of 3 lb/ton garlic oil and 6 lb/ton of Solace (Wildcat Feeds LLC, Topeka, KS) that replaced dried distillers grains and limestone in control mineral.

²Nuplex Mg/K (Nutech Biosciences Inc., Oneida, NY) composed 25% of the magnesium.

³Nuplex 3-chelate blend (Nutech Biosciences Inc.) composed 25% each of the copper, zinc, and manganese of the total trace mineral supply.

Table 2. Average steer production responses based on burning pasture in March or April

Item	March burn ¹	April burn ²	Standard error	<i>P</i> -value
			of means	
Steer initial weight, lb	650	639	6.3	0.26
Steer average daily gain, lb/day	2.75	3.08	0.07	0.03
Total gain of steer, lb	239	268	6.1	0.03
Steer final weight, lb	890	910	6.6	0.09

¹Four pastures were burned on March 19, 2019, with steers starting to graze April 26, 2019.

²Four pastures were burned on April 15, 2019, with steers starting to graze April 26, 2019.

Table 3. Average steer production responses based on type of mineral offered

Item	Control mineral ¹	Spice mineral ²	Standard error of means	P-value
Steer initial weight, lb	641	649	6.2	0.45
Steer average daily gain, lb/day	2.85	2.99	0.07	0.23
Total gain of steer, lb	248	260	6.2	0.23
Steer final weight, lb	890	909	6.6	0.10

¹Control mineral was a complete free-choice mineral formulated for a 4 oz/head/day intake (Wildcat Feeds LLC, Topeka, KS). Chelated mineral sources were included at 25% of the total mineral supply for magnesium (Nuplex Mg/K; Nutech Biosciences Inc., Oneida, NY), copper, zinc, and manganese (Nuplex 3-chelate blend; Nutech Biosciences).

²Spice mineral was a complete free-choice mineral formulated for a 4 ounce/head/day intake (Wildcat Feeds LLC, Topeka, KS) with the spices in powdered form of garlic oil (3 lb/ton) and Solace (proprietary blend of spices; 18 lb/ton; Wildcat Feeds LLC). Chelated mineral sources were included at 25% of the total mineral supply for magnesium (Nuplex Mg/K; Nutech Biosciences Inc.), copper, zinc, and manganese (Nuplex 3-chelate blend; Nutech Biosciences).

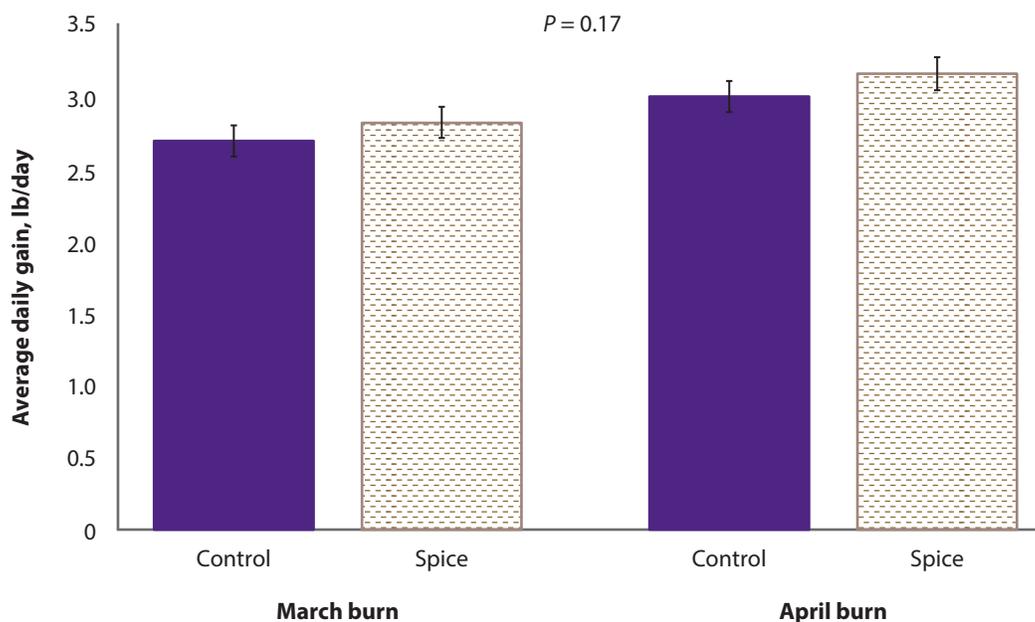


Figure 1. Average daily gain based on each burn time (March or April) and whether cattle were on control mineral or mineral with spices.

¹Control mineral (solid bars) was a complete free-choice mineral formulated for a 4 oz/head/day intake (Wildcat Feeds LLC, Topeka, KS). Chelated mineral sources were included at 25% of the total mineral supply for magnesium (Nuplex Mg/K; Nutech Biosciences Inc., Oneida, NY), copper, zinc, and manganese (Nuplex 3-chelate blend; Nutech Biosciences).

²Spice mineral (striped bars) was a complete free-choice mineral formulated for a 4 oz/head/day intake (Wildcat Feeds LLC, Topeka, KS) with the spices in powdered form of garlic oil (3 lb/ton) and Solace (proprietary blend of spices; 18 lb/ton; Wildcat Feeds LLC). Chelated mineral sources were included at 25% of the total mineral supply for magnesium (Nuplex Mg/K; Nutech Biosciences Inc.), copper, zinc, and manganese (Nuplex 3-chelate blend; Nutech Biosciences).

Effects of Limit Feeding Cold Stressed Growing Calves in the Morning Versus the Evening, as well as Bunk Line Sharing on Performance

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Abstract

Previous work has shown that shifting the time of feed delivery from morning to evening hours for cold stressed growing calves can result in greater feed efficiency. It is not known what the extent of the feed efficiency response is when limit feeding cold stressed growing calves later in the day. In order to determine the growing calf response to later feeding times, 360 crossbred steers (mean weight = 638 lb) of Texas, Oklahoma, and Idaho origin were blocked by weight and allocated to pens based on weight. Steers in four separate treatment groups were fed a total mixed ration once daily for 77 days, and a fifth treatment received half in the morning and half in the evening. The four treatment diets were formulated to provide 60 Mcal net energy for gain/100 lb. Cattle off-test weights were not different ($P > 0.05$) for calves fed in the evening. Overall, feed efficiency was not improved, nor was average daily gain greater for calves fed later in the day.

Introduction

Previous work at Kansas State University and North Dakota State University has shown that shifting the time of feed delivery from morning to evening hours for cold stressed growing calves can result in greater feed efficiency. The suspected mode of action behind this is shifting the heat of fermentation from daytime hours to nighttime hours, when ambient temperatures tend to be lower. It is hypothesized that this heat helps to maintain body temperature so the animal uses less of the energy from digestion to meet maintenance requirements. It is not known to what extent feed efficiency can be improved when limit feeding cold stressed growing calves later in the day. Further, producer interest has been expressed in bunk line sharing. This management practice provides that two groups of calves eat out of the same bunk, and are rotated daily to a holding pen to allow the other group to eat. This maximizes infrastructure, as limit fed cattle tend to consume their allocated feed within several hours of delivery.

Experimental Procedures

A total of 377 crossbred steers of Texas, Oklahoma, and Idaho origin, averaging 638 lb were allocated to pens based on weight. Animals were previously vaccinated for viral and clostridial diseases. Thirty-two pens with feed bunks were used (8 for each treatment) and 8 holding pens were utilized. Each group of steers consisted of nine head. Fourteen steers on the higher end of the weight spectrum and three on the lower end were removed from the research population. The remaining 360 steers were blocked by weight into four size groups and randomly assigned to groups, which were randomly

allocated to one of five treatments. The five treatments all received a diet formulated to provide 60 Mcal net energy for gain/100 lb of dry matter and all were limit fed with a target of 2.0% of their body weight in dry matter intake. The experiment consisted of one treatment fed in the morning (AM), one in the evening (PM), one fed half of their feed in the morning and half in the evening (50/50), and two additional treatments (Shuttle AM, Shuttle PM) that were fed in the same pen yet were rotated twice daily utilizing a holding pen. This scheme allowed for half of the calves to be fed in the morning and half to be fed in the evening, doubling the use of the pen and bunk line. Pen was the experimental unit. The steers were fed their respective diets once daily at approximately 0800 for morning fed calves and 1600 for evening fed calves for 77 days. Individual animal weights were taken on day -1 (allocation), day 0 (initial processing), day 64/65 (blood sampling), and day 77 (final weights). Plasma glucose was obtained individually on day 64 and 65 and frozen for later analysis. Pen weights were collected on days 0, 21, 28, 35, 56, 63, 70, and 77. Feed delivery was adjusted based on daily refusals while calves were adjusting to ration, and later bunks were checked daily to ensure total feed consumption. Bunk and individual ingredient samples were taken weekly.

Results and Discussion

Over the entire 77-day trial, average daily gain for calves fed in the evening and/or assigned to share a bunk line was not different ($P > 0.95$) compared to calves fed in the morning and not rotated daily (Table 2), although there was a difference at day 35 ($P > 0.01$). Dry matter intake did not tend to be different ($P > 0.77$) between treatments over the entire 77-day trial. Feed efficiency was not greater in calves fed in the evening nor shuffled between pens ($P > 0.98$), but a difference was seen at day 35 ($P > 0.03$). No numerical difference was observed in blood glucose levels.

Implications

When limit feeding cold stressed growing calves, no statistically significant differences were observed with the performance data of the calves over the entire 77-day trial. Significant effects on day 35 average daily gain and feed efficiency may potentially be explained by colder weather in January and February (Figure 1). There were no negative observations regarding cattle health or behavior with feeding calves at different times of the day, nor with utilizing one pen by two groups of calves at different times of the day. Further aspects of evening feeding and bunk line sharing should be considered by a producer, such as labor needs, equipment wear, and infrastructure requirements.

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. Experimental diet

Ingredient	Dry matter %
Corn	25.50
Supplement	7.50
Corn silage	27.00
Wet corn gluten feed (Sweet Bran ¹)	40.00
Total	100.00

Item	100% Dry matter basis
Dry matter, %	54.60
Protein, %	14.22
Calcium, %	0.70
Phosphorus, %	0.55
Salt, %	0.38
Potassium, %	0.94
Magnesium, %	0.26
Fat, %	3.10
Acid detergent fiber, %	11.37
Net energy for maintenance, Mcal/100 lb	92.11
Net energy for gain, Mcal/100 lb	60.71

¹Cargill Sweet Bran.

Table 2. Effects of feeding time on performance

Weight, lb							
	Day:	0		35		77	
			Standard error of the mean		Standard error of the mean		Standard error of the mean
AM		590	22.54	675	6.38	821	9.85
AM Shuttle		619	22.54	677	6.22	827	9.60
PM		616	22.54	701	6.22	827	9.60
PM Shuttle		650	22.54	696	6.37	831	9.84
50/50		628	24.09	699	6.66	822	10.28
Treatment <i>P</i> -value			0.47		0.01		0.95

Average daily gain, lb/day					
	Day:	0–35		0–77	
			Standard error of the mean	Standard error of the mean	
AM		1.57	0.18	2.60	0.13
AM Shuttle		1.61	0.18	2.69	0.12
PM		2.29	0.18	2.68	0.12
PM Shuttle		2.15	0.18	2.74	0.13
50/50		2.26	0.19	2.62	0.13
Treatment <i>P</i> -value			0.01		0.95

Dry matter intake, lb/day					
	Day:	0–35		0–77	
			Standard error of the mean	Standard error of the mean	
AM		11.80	0.31	13.62	0.40
AM Shuttle		12.22	0.30	14.21	0.39
PM		12.25	0.30	14.14	0.39
PM Shuttle		12.10	0.31	14.16	0.40
50/50		12.37	0.33	14.34	0.42
Treatment <i>P</i> -value			0.78		0.77

continued

Table 2. Effects of feeding time on performance

	Day: 0–35		0–77	
		Standard error of the mean		Standard error of the mean
Feed-to-gain ratio, lb				
AM	8.75	0.97	5.36	0.34
AM Shuttle	8.81	0.94	5.31	0.33
PM	5.52	0.94	5.51	0.33
PM Shuttle	5.90	0.97	5.22	0.33
50/50	5.67	1.01	5.50	0.35
Treatment <i>P</i> -value		0.03		0.96

	Day: 0–35		0–77	
		Standard error of the mean		Standard error of the mean
Gain-to-feed ratio, lb				
AM	0.13	0.02	0.19	0.01
AM Shuttle	0.13	0.02	0.19	0.01
PM	0.19	0.02	0.19	0.01
PM Shuttle	0.18	0.02	0.19	0.01
50/50	0.18	0.02	0.18	0.01
Treatment <i>P</i> -value		0.02		0.98

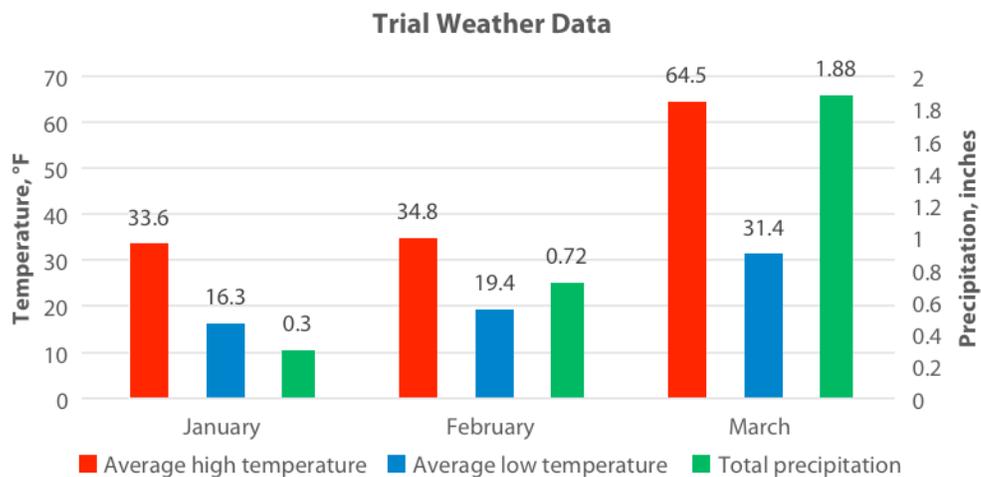


Figure 1. Trial weather data.

Sale Price of Holstein Feeder Steer Lots Relative to Other Breed Descriptions Sold Through Superior Livestock Video Sales from 2010 Through 2018

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

Abstract

The objective of this study was to determine the relative value of Holstein feeder steer lots compared to steer lots of other breed descriptions sold through video auctions while adjusting for all other factors that significantly influenced sale price. Data were analyzed from 14,075 lots of feeder steers sold through 211 livestock video auctions from 2010 through 2018. All lot characteristics that could be accurately quantified or categorized were used to develop a multiple regression model that evaluated effects of independent factors on sale price using a backwards selection procedure. A value of $P < 0.05$ was used to maintain a factor in the final model. A lot was categorized into one of four breed descriptions: 1) English and/or English crossed; 2) English-Continental crossed; 3) Brahman influenced; and 4) Holstein. The average weight and number of steers in lots analyzed were 800.8 ± 111.5 lb and 121.1 ± 110.3 head, respectively. During the nine years, English, English crossed lots sold for the greatest ($P < 0.05$) sale price (\$152.39/cwt). English-Continental crossed lots sold for the second greatest ($P < 0.05$) sale price (\$150.61/cwt). Brahman influenced sold for the third greatest ($P < 0.05$) sale price (\$148.75/cwt). Holstein lots sold for the lowest ($P < 0.05$) sale price (\$110.56/cwt). To determine potential change in relative value of Holstein feeder steers from 2010 to 2018, data were analyzed in three-year increments. In all three-year increments, Holstein feeder lots sold for the lowest ($P < 0.05$) sale price compared to the other breed descriptions of beef steer lots. The average discount of Holstein feeder lots relative to other breed descriptions was \$33.19/45.36 cwt in 2010–2012, \$42.96/cwt in 2013–2015, and was the greatest in 2016–2018 at an average discount of \$46.24/cwt, likely indicating lessening interest in the feedlot sector to feed Holstein steers to harvest.

Introduction

Dairy-type animals have a significant role in United States beef production. In 2018, fed dairy steers contributed 12.6% or 3.37 billion pounds to beef production (Boetel, 2019). Dairy carcasses often receive high quality grades, are uniform and consistent, and provide a year-around supply of beef (Andersen, 2019). The finishing process for dairy-type steers, however, has common challenges compared with beef steers. Challenges include poorer feed efficiency, a lower dressing percentage, gut health issues, as well as carcasses that are light-muscled and often too large (Andersen, 2019). For these reasons, dairy-type steers are often undesirable for feedlots and packers. The objective was to determine relative value of Holstein feeder steer lots compared to steer lots of other

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breed descriptions sold through video auctions while adjusting for all other factors that significantly influenced sale price.

Experimental Procedures

Information describing factors about lots sold through a livestock video auction service (Superior Livestock Auction, Fort Worth, TX) was obtained from the auction service in an electronic format. These data were collected for lots of feeder steers sold from 2010 through 2018.

The descriptive pieces of information that were available for each lot of feeder steers were auction year, area of the United States where lot originated, breed description of lot, health protocol administered to the lot, the amount of weight variation within the lot, frame score of the lot, flesh score of the lot, implant status, source and age verification, freight adjustment status, whether or not the steers had horns, lot size (both linear and quadratic effects), base weight of the lot (both linear and quadratic effects), the number of days between auction and forecasted delivery dates, and sale price of the lot (\$/cwt). A multiple-regression model was developed using a backwards selection procedure to quantify the effects of factors on the sale price of feeder steer lots. The model was adjusted for the random effect of auction date nested within auction year. The specific and current requirements of each of the video auction service's special health and management programs are available at www.SuperiorLivestock.com.

Results and Discussion

Data were analyzed from 14,075 lots of feeder steers sold via 211 video auctions through Superior Livestock Auction from 2010 through 2018. Average weight and number of steers in lots analyzed were 800.8 ± 111.5 lb and 121.1 ± 110.3 head, respectively (Table 1).

From 2010 through 2018, English, English crossed lots sold for the greatest ($P < 0.05$) sale price (\$152.39/cwt) (Table 2). English-Continental crossed lots sold for the second greatest ($P < 0.05$) sale price (\$150.61/cwt). Brahman influenced sold for the third greatest ($P < 0.05$) sale price (\$148.75/cwt). Holstein lots sold for the lowest ($P < 0.05$) sale price (\$110.56/cwt). To determine potential change in relative value of Holstein feeder steers from 2010 to 2018, data were analyzed in three-year increments. In all three-year increments, Holstein feeder lots sold for the lowest ($P < 0.05$) sale price compared to the other breed descriptions of beef steer lots. The average discount of Holstein feeder lots relative to other breed descriptions was \$33.19/cwt in 2010–2012, \$42.96/cwt in 2013–2015, and was the greatest in 2016–2018 at an average discount of \$46.24/cwt.

In each three-year increment, there was a greater relative price discount for Holstein steers than the previous increment. Evaluation of the average sale price was based on a percentage discount revealed in lower market prices. Lots of Holstein feeders were discounted a greater percentage than when market prices are higher. From 2010–2012, the average sale price for lots of feeder steers was \$123.21/cwt and lots of Holstein feeder steers were discounted 26.9% (Table 3). From 2013–2015, the average sale price was \$176.62/cwt and lots of Holstein feeder steers were discounted 24.3%. From

2016–2018, the average sale price was \$139.13/cwt with a 33.2% discount for lots of Holstein feeder steers.

As the supply for beef increases, buyers have the ability to be more selective with their purchases. In early 2017, a major packer announced their decision to no longer harvest Holstein steers. Industry decisions like this influence many segments of beef production, and likely is related to the relative price discounts of Holstein feeder steer lots compared with steer lots of other breed descriptions.

The discount for Holstein lots and the lessening interest in feeding dairy-type steers has resulted in many dairy producers utilizing beef semen in lower quality dairy cows and heifers. Domestic beef semen sales drastically increased by 59% from 2017 to 2018, primarily as a result of use in dairy cows and heifers (Geiger, 2019). Several major semen companies have created programs designed to identify bulls to breed to dairy cows and heifers.

Implications

The relative price discount for Holstein feeder steer lots compared with other breed descriptions appears to have increased during this time frame, and thus is likely indicating lessening interest in the feedlot sector to feed Holstein steers to harvest.

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Table 1. Non-adjusted means, medians, and ranges for factors describing the lots of single-gender steer feeder cattle sold through 211 Superior Livestock Auction's video sales from 2010 through 2018

Factor	Mean \pm standard deviation	Median	Range
Number of calves in the lot	121.1 \pm 110.3	70	17 to 1,680
Base weight of the lot, lb	800.8 \pm 111.5	825	220 to 1,280
Number of days from auction to forecasted delivery	30.8 \pm 38.2	15	0 to 287
Price per 100 lb, \$	145.80 \pm 33.77	141.00	68.00 to 333.00

Table 2. Sale price of Holstein feeder steer lots relative to other breed descriptions sold through 211 Superior Livestock Auction video sales from 2010 through 2018

Breed description	Number of lots	Least squares mean of sale price (\$/cwt)	Regression coefficient
2010–2018			
English, English crossed	3,829	152.39 ^a	41.83
English-Continental crossed	4,310	150.61 ^b	40.05
Brahman influenced	4,945	148.75 ^c	38.19
Holstein	991	110.56 ^d	0.00
2010–2012			
English, English crossed	1,252	128.10 ^a	34.47
English-Continental crossed	1,562	126.81 ^b	33.18
Brahman influenced	2,185	125.56 ^c	31.93
Holstein	282	93.63 ^d	0.00
2013–2015			
English, English crossed	1,171	182.43 ^a	44.82
English-Continental crossed	1,485	180.46 ^b	42.85
Brahman influenced	1,630	178.83 ^c	41.22
Holstein	373	137.61 ^d	0.00
2016–2018			
English, English crossed	1,465	145.62 ^a	47.84
English-Continental crossed	1,359	144.47 ^b	46.69
Brahman influenced	1,283	141.97 ^c	44.19
Holstein	360	97.78 ^d	0.00

Breed description affected the sale price ($P < 0.0001$).

^{a,b,c,d}Prices without a common superscript differ ($P < 0.05$) within years.

Table 3. Non-adjusted average sale price of Holstein feeder steer lots and the percentage discount for each three-year increment

Years	Non-adjusted average sale price (\$/cwt)	Average discount (\$/cwt)	Percentage discount
2010–2012	123.41	33.19	26.9
2013–2015	176.62	42.96	24.3
2016–2018	139.13	46.24	33.2

Factors Affecting the Sale Price of Bred Heifers and Bred Cows Sold Through Superior Livestock Video Auctions

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

Abstract

This study utilized data from Superior Livestock Video Auction with the objective of quantifying various management factors, physical descriptors, and lot characteristics that possess the potential to influence the sale price of bred females. Variation among several of these female traits indicates that numerous characteristics affect the sale price. Understanding the forces driving investment decisions may prove valuable to buyers and sellers within the beef industry.

Introduction

Literature regarding factors that influence the sale price of bred heifers and bred cows is typically limited to analyses within a defined region or breed composition. Descriptive information about bred females is often provided to buyers across numerous marketing venues. From physical descriptors, management factors, and lot characteristics, comprehending how traits have the potential to cause variation in sale price is imperative in allowing producers to make sound and informed purchasing decisions. Continued research and understanding of the value placed on bred female traits may prove advantageous to producers throughout various regions of the United States.

Experimental Procedures

Information describing factors about lots of bred heifers and bred cows 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 bred heifers offered for sale from 2010 through 2018 and all lots of bred cows offered for sale from 2011 through 2018. Two separate multiple regression models were developed using a backwards selection procedure to investigate various factors influencing sale price of both bred heifers and bred cows. Quantifiable factors within both models included sale year, weight (linear and quadratic), region of the United States where the lot originated, breed description, variation in weight within the lot, origin (home-raised or purchased), frame score, flesh score, and size of the lot (linear and quadratic).

Results and Discussion

Data were collected from 1,870 lots of bred heifers over a nine-year period (2010–2018) and 1,237 lots of bred cows over an eight-year period (2011–2018). Sale year was a significant factor influencing price within both models. Bred heifers sold for the greatest ($P < 0.05$) price in 2014, compared to all other years. In 2014 and 2015, bred cows sold for similar ($P > 0.05$) prices, but at prices greater ($P < 0.05$) than all other years. For both bred heifers and bred cows, those lots categorized as Red Angus sired sold for the greatest ($P < 0.05$) price, compared to all other breeds. Region of the United States affected bred heifer sale price, with the greatest ($P < 0.05$) price paid for bred heifers originating from the North Central region. Additional lot characteristics that significantly influenced price within both models included weight (linear), frame score, and flesh score. Non-significant factors for bred heifers were weight variation within

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the lot, lot size (linear and quadratic), and weight (quadratic). Non-significant factors for bred cows included lot size (quadratic), origin (home-raised or purchased), and region where the lot originated. A complete list of factors affecting the sale price of bred heifers and bred cows are shown in Table 1 and Table 2, respectively.

Implications

Continued research and understanding of the characteristics and factors that influence the sale price of breeding cattle across the United States may provide insight to cow-calf producers.

Acknowledgments

We would like to thank the Red Angus Association of America for their support in conducting this research.

Table 1. Factors affecting the sale price of bred heifers sold through Superior Livestock video auctions from 2010 through 2018

Factor	Number of lots	Least squares mean of sale price (\$/head)	Price difference (\$/head)	P-value
Auction year				<.0001
2010	44	1,086 ^a	-340	
2011	146	1,294 ^b	-132	
2012	228	1,394 ^c	-32	
2013	260	1,688 ^d	262	
2014	405	2,455 ^e	1,029	
2015	372	2,201 ^f	775	
2016	178	1,449 ^c	23	
2017	146	1,463 ^c	37	
2018	91	1,426 ^c	0	
Base weight of the lot	1,870		.90	<.0001

continued

Table 1. Factors affecting the sale price of bred heifers sold through Superior Livestock video auctions from 2010 through 2018

Factor	Number of lots	Least squares mean of sale price (\$/head)	Price difference (\$/head)	P-value
Region of the United States where the lot originated ^g				<.0001
West Coast	233	1,563 ^a	4	
Rocky Mountain/North Central	988	1,681 ^b	122	
South Central	591	1,622 ^c	63	
South East	58	1,559 ^{ac}	0	
Breed description of the lot				<.0001
English, English crosses	438	1,584 ^a	62	
English-Continental crosses	149	1,622 ^a	100	
Black Angus sired ^h	768	1,582 ^a	60	
Red Angus sired ⁱ	391	1,721 ^b	199	
Brahman influenced	124	1,522 ^a	0	
Origin				.0008
Home-raised	390	1,628 ^a	44	
Purchased	1,480	1,584 ^b	0	
Frame score of the lot				.0016
Medium	582	1,579 ^a	-42	
Medium-medium large	875	1,618 ^b	-3	
Medium large	413	1,621 ^b	0	
Flesh score of the lot				.0249
Light medium-medium	123	1,565 ^a	-74	
Medium	1,622	1,615 ^b	-24	
Medium-medium heavy	125	1,639 ^b	0	

^{a,b,c,d,e,f}Values within a factor without a common superscript differ ($P < 0.05$).

^gStates in the region of origin were: West Coast—California, Idaho, Nevada, Oregon, Utah, and Washington; Rocky Mountain/North Central—Colorado, Iowa, Illinois, Indiana, Michigan, Minnesota, Montana, North Dakota, Nebraska, South Dakota, Wisconsin, and Wyoming; South Central—Arizona, Kansas, Missouri, New Mexico, Oklahoma, and Texas; South East—Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, and Virginia.

^hLots in this group were sired by Black Angus bulls and out of dams with no Brahman influence.

ⁱLots in this group were sired by Red Angus bulls and out of dams with no Brahman influence.

Non-significant factors include variation in weight within the lot ($P = 0.75$), number of heifers in the lot ($P = 0.35$), number of heifers in the lot (quadratic)^j ($P = 0.63$), and base weight of the lot (quadratic)^k ($P = 0.07$).

^jIn order to prevent multicollinearity between the linear and quadratic lot size terms, the number of heifers in each lot was centered at zero by subtracting the mean lot size of all the lots (47.5 head) from the lot size of each lot.

^kIn order to prevent multicollinearity between the linear and quadratic base weight terms, the base weight of each lot was centered at zero by subtracting the mean base weight of all the lots (1,000.7 lb) from the base weight of each lot.

Table 2. Factors affecting the sale price of bred cows sold through Superior Livestock video auctions from 2011 through 2018

Factor	Number of lots	Least squares mean of sale price (\$/head)	Price difference (\$/head)	P-value
Auction year				<.0001
2011	232	1,295 ^a	-5	
2012	140	1,381 ^{ad}	81	
2013	132	1,590 ^b	290	
2014	159	2,392 ^c	1,092	
2015	197	2,402 ^c	1,102	
2016	184	1,604 ^b	304	
2017	120	1,420 ^d	120	
2018	73	1,300 ^{ad}	0	
Base weight of the lot	1,237		-.65	<.0001
Base weight of the lot (quadratic) ^e	1,237		-.0025	<.0001
Number of cows in the lot	1,237		-.82	.0312
Breed description of the lot				<.0001
English, English crosses	515	1,637 ^a	202	
English-Continental crosses	121	1,638 ^{ab}	203	
Black Angus sired ^f	362	1,719 ^b	284	
Red Angus sired ^g	168	1,935 ^c	500	
Brahman influenced	71	1,435 ^d	0	
Variation in weight within the lot				<.0001
Fairly even	109	1,747 ^a	149	
Uneven	1128	1,598 ^b	0	
Frame score of the lot				.0418
Medium	354	1,637 ^a	-55	
Medium-medium large	482	1,690 ^a	-2	
Medium large	401	1,692 ^a	0	

continued

Table 2. Factors affecting the sale price of bred cows sold through Superior Livestock video auctions from 2011 through 2018

Factor	Number of lots	Least squares mean of sale price (\$/head)	Price difference (\$/head)	P-value
Flesh score of the lot				<.0001
Light medium-medium	221	1,517 ^a	-279	
Medium	926	1,705 ^b	-91	
Medium-medium heavy	90	1,796 ^c	0	

^{a,b,c,d}Values within a factor without a common superscript differ ($P < 0.05$).

^eIn order to prevent multicollinearity between the linear and quadratic base weight terms, the base weight of each lot was centered at zero by subtracting the mean base weight of all the lots (1,182.8 lb) from the base weight of each lot.

^fLots in this group were sired by Black Angus bulls and out of dams with no Brahman influence.

^gLots in this group were sired by Red Angus bulls and out of dams with no Brahman influence.

Non-significant factors include number of cows in the lot (quadratic)^h ($P = 0.71$), origin ($P = 0.48$), and region of the United States where the lot originated ($P = 0.08$).

^hIn order to prevent multicollinearity between the linear and quadratic lot size terms, the number of cows in each lot was centered at zero by subtracting the mean lot size of all the lots (43.6 head) from the lot size of each lot.

Region of Origin in the United States Affects Price Premiums Associated with Value-Added Health Protocols of Beef Calf Lots Sold Through Summer Video Auctions from 2010 Through 2018

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

Abstract

The objective of this study was to identify the effects of value-added health protocols within a region on the sale price of beef calf lots sold through video auctions over a nine-year period. Differences in sale price of calves qualifying for various health programs suggest that the relative value perceived by buyers varies by region. Results may be indicative of the value associated with more intensively managed calves with increased potential transportation distance from origin to delivery.

Introduction

The benefits associated with the incorporation of value-added health protocols are thoroughly understood. The practice of preconditioning aims to reduce the risk of bovine respiratory disease, while increasing calf immunity and minimizing stress around weaning. The advantages associated with this increased level of management, and the value that accompanies the practice are well established. While price premiums are evident, it is imperative to consider that the value of a vaccination program may be dependent on the location in which a lot of calves originate.

While extensive research shows that preconditioning programs provide price premiums on a national basis, to our knowledge the effect of varying levels of management throughout different regions of the United States has not been investigated. Differences in local climate conditions, diverse management and marketing strategies, and variation in trucking distance are regional factors that can influence the health protocol calves may receive. These concerns suggest the potential for observed differences in the relative value associated with various preconditioning programs across numerous regions of the country.

Experimental Procedures

Information describing factors about lots marketed and sold through a livestock video auction service (Superior Livestock Auction, Fort Worth, TX) were obtained from the auction service in an electronic format. These data were collected for lots of beef calves offered for sale during summer sales from 2010 through 2018.

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Consigners to Superior Livestock Video Auction have the option to enroll their calves in different value-added health protocols. These programs are designed to align with various management practices, uniquely fitting operations with diverse facilities and marketing goals. A lot was categorized into one of five groups concerning health status: 1) VAC 34 or 34+; 2) VAC 45 or 45+; 3) Weaned: viral vaccinated; 4) Non-weaned: viral vaccinated; and 5) VAC 24. Calf lots originated from one of five U.S. regions: West Coast (California, Idaho, Nevada, Oregon, Utah, and Washington), Rocky Mountain/North Central (Colorado, Iowa, Illinois, Indiana, Michigan, Minnesota, Montana, North Dakota, Nebraska, South Dakota, Wisconsin, and Wyoming), South Central (Arizona, Kansas, Missouri, New Mexico, and Oklahoma), Southeast (Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, Tennessee, Texas, and Virginia), and Northeast (excluded due to few lots). For each region included within the study, a separate multiple regression model was developed using a backwards selection procedure to evaluate the effect of health program on the sale price of beef calves.

The specific and current requirements of each of the video auction's recognized vaccination protocols (VAC 34 and 34+, VAC 45 and 45+, and VAC 24) are available at www.SuperiorLivestock.com. Calves not qualifying for a defined health program were categorized into one of two groups: lots that were weaned and received at least one dose of a viral vaccination prior to shipment from the farm or ranch of origin (Weaned: viral vaccinated), and those lots that were non-weaned and received at least one dose of a viral vaccination (Non-weaned: viral vaccinated).

Results and Discussion

There were 43,242 total lots of beef calves fitting the study criteria. Within the analysis including all four regions, lots qualifying for VAC 45 or 45+ sold for the greatest price ($P < 0.05$) compared to all other health protocols. In the West Coast, lots qualifying for VAC 45 or 45+ and Weaned: viral vaccinated sold for similar ($P > 0.05$) prices, but at prices greater ($P < 0.05$) than calves administered all other health protocols within that region. Within the Southeast region, lots qualifying for VAC 45 or 45+ and Weaned: viral vaccinated sold for similar ($P > 0.05$) prices, and again at prices greater ($P < 0.05$) than calves in all other health programs. In both the North Central and South Central regions, lots meeting the requirements for VAC 45 or 45+ sold for the greatest ($P < 0.05$) price in their respective regions. Specific premiums for health protocols within respective regions can be seen in Table 1.

Differences in the sale price of calves eligible for numerous health programs indicates that the relative value of a calf health program recognized by buyers fluctuates between regions. As distance between origin of calves sold from the most concentrated area of cattle feeding in the northern plains became greater, price premiums concerning health protocols increased. This finding suggests evident advantages and premiums associated with vaccination programs for those areas located farther away from the plains, as calves transported farther may be at greater risk of health issues.

Implications

While there are clear price advantages associated with vaccination and weaning management strategies across all regions, information regarding premiums within specific areas may prove valuable to producers from these regions.

Table 1. Effect of value-added health protocols within region¹ on the sale price of beef calf lots sold through summer video auctions from 2010 through 2018

Value-added health protocol administered to the lot	Number of lots	Least squares mean of sale price (\$/100 lb)	Regression coefficient
All regions			
VAC 34 or VAC 34+	21,464	166.64 ^a	2.69
VAC 45 or 45+	11,149	171.04 ^b	7.09
Weaned: viral vaccinated ²	3,325	170.35 ^c	6.40
Non-weaned: viral vaccinated ²	1,465	163.68 ^d	-0.27
VAC 24	4,143	163.95 ^d	0.00
West Coast			
VAC 34 or VAC 34+	4,337	164.82 ^a	4.60
VAC 45 or VAC 45+	4,827	168.71 ^b	8.49
Weaned: viral vaccinated ²	1,263	168.80 ^b	8.58
Non-weaned: viral vaccinated ²	210	160.88 ^c	0.66
VAC 24	680	160.22 ^c	0.00
Rocky Mountain/North Central			
VAC 34 or VAC 34+	13,766	171.46 ^a	1.31
VAC 45 or VAC 45+	2,887	175.25 ^b	5.10
Weaned: viral vaccinated ²	571	171.81 ^a	1.66
Non-weaned: viral vaccinated ²	457	169.45 ^c	-0.70
VAC 24	1,058	170.15 ^c	0.00
South Central			
VAC 34 or VAC 34+	1,590	166.70 ^a	4.25
VAC 45 or VAC 45+	1,838	171.80 ^b	8.63
Weaned: viral vaccinated ²	638	167.49 ^a	5.04
Non-weaned: viral vaccinated ²	223	164.27 ^c	1.82
VAC 24	510	162.45 ^c	0.00

continued

Table 1. Effect of value-added health protocols within region¹ on the sale price of beef calf lots sold through summer video auctions from 2010 through 2018

Value-added health protocol administered to the lot	Number of lots	Least squares mean of sale price (\$/100 lb)	Regression coefficient
Southeast			
VAC 34 or VAC 34+	1,820	162.17 ^a	0.76
VAC 45 or VAC 45+	1,452	168.37 ^b	6.96
Weaned: viral vaccinated ²	860	169.28 ^b	7.87
Non-weaned: viral vaccinated ²	560	159.86 ^c	-1.55
VAC 24	1,812	161.41 ^a	0.00

The value-added health protocol affected sale price ($P < 0.0001$) in each region.

¹The United States was divided into five regions. These include: West Coast (California, Idaho, Nevada, Oregon, Utah, and Washington); Rocky Mountain/North Central (Colorado, Iowa, Illinois, Indiana, Michigan, Minnesota, Montana, North Dakota, Nebraska, South Dakota, Wisconsin, and Wyoming); South Central (Arizona, Kansas, Missouri, New Mexico, and Oklahoma); Southeast (Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, Tennessee, Texas, and Virginia); and Northeast (excluded due to few lots).

²Calves in this category were vaccinated against one or more of the following respiratory tract viruses at some time between birth and the date of delivery: IBR, BVD Type 1, BVD Type 2, PI₃, and BRSV.

^{a,b,c,d}Means without a common superscript differ ($P < 0.05$) in each region.

Syngenta Enogen Feed Corn Containing an Alpha Amylase Expression Trait Improves Digestibility in Growing Calf Diets

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Abstract

Previous research has shown that finishing cattle fed Enogen Feed corn are able to utilize more starch from the corn grain. It is not known if the same response will occur in growing cattle. In order to determine the growing calf response, seven ruminally cannulated Holstein steers were fed four diets consisting of two varieties of corn (Enogen vs. yellow) and two methods of corn processing (dry-rolled vs. whole-corn). The study consisted of four consecutive 15-day periods. There were 10 days for adaptation to diet changes, fecal samples were collected on days 11 through 14, and ruminal fluid was sampled on day 15. Overall, total tract ruminal organic matter and dry matter digestibility improved by 8% and 9%, respectively, when feeding Enogen Feed corn. Digestibility parameters reveal that feeding whole Enogen Feed corn results in equal or improved digestion as opposed to feeding dry-rolled corn from either corn source.

Introduction

Recent studies conducted to evaluate the alpha amylase enzyme expression trait in Enogen Feed corn (Syngenta) found improvements in feed efficiency of growing and finishing cattle when fed wet corn gluten feed or wet distillers grains. Metabolism work with finishing cattle has shown that cattle fed Enogen Feed corn are able to utilize more starch from the corn grain, thus providing more available energy for gain. The objectives of this study were to evaluate digestibility parameters of growing cattle when fed Enogen Feed corn.

Experimental Procedures

Seven ruminally cannulated Holstein steers (body weight = 437 ± 22 lb) were used in an incomplete 4×4 Latin rectangle design to determine diet digestibility and digestion characteristics. The study consisted of four consecutive 15-day periods. There were 10 days for adaptation to diet changes, fecal samples were collected on d 11 through d 14, and ruminal fluid was sampled on d 15. The four experimental diets were formulated to provide 51 Mcal net energy for gain/100 lb dry matter and included two varieties of corn, Enogen versus yellow; and two methods of corn processing, dry-rolled versus whole-corn. Animals were housed in individual outdoor pens with ad libitum access to water. Steers were fed their respective diets once daily at approximately 1000 hours to ensure ad libitum intakes. Total mixed ration samples were collected on days 10 through 14 and composited for each period for analysis. On days 4 through 14, 10 g chromium (III) oxide was top-dressed and hand mixed into each animal's ration as a marker to calculate digestibility. Refusals were collected on days 11 through 15 and composited for each animal for each period. Fecal samples were also collected

¹ Eileen D. Watson, Syngenta Crop Protection, LLC.

on days 11 through 14, taken from the rectum of the steers every 8 hours with the sampling time increasing by 2 hours each day so that every 2-hour interval after feeding was represented over 24 hours. On day 15 of each period, ruminal fluid samples were sampled at four different locations in the rumen at 0, 2, 4, 6, 8, 12, 18, and 24 hours after feeding. Following the 0 hour sampling, 3 g of cobalt-ethylenediamine tetraacetic acid (0.4 g cobalt) dissolved in 200 mL of deionized water, was dosed into the rumen to determine liquid passage rate.

Results and Discussion

There was no effect for corn processing other than a small tendency for pH to be lower for dry-rolled corn ($P < 0.15$). Liquid passage rate was higher for yellow corn-fed calves ($P < 0.01$), which explains the tendency for dry matter intake to be highest for yellow/dry-rolled corn ($P < 0.11$). Total tract ruminal organic matter and dry matter digestibility were higher for Enogen-fed calves ($P < 0.04$). Ruminal acetate concentration was lower for Enogen-fed calves ($P < 0.05$) and as a percent of total volatile fatty acids, valerate tended to increase for Enogen treatments ($P < 0.10$). A tendency was observed for total volatile fatty acids to be greatest for yellow/dry-rolled corn and Enogen/whole-corn ($P < 0.14$). There was also a tendency for ruminal acetate concentration to be least for Enogen/dry-rolled corn and greatest for yellow/dry-rolled corn ($P < 0.06$). A corn \times processing interaction revealed a tendency for Enogen/dry-rolled corn to have the highest percent isobutyrate ($P < 0.07$) and valerate ($P < 0.09$) and for yellow/dry-rolled corn to have the least. Overall, total tract ruminal organic matter and dry matter digestibility improved by 8% and 9%, respectively, when feeding Enogen Feed corn. Digestibility parameters reveal that feeding Enogen/whole-corn results in equal or improved digestion as opposed to feeding dry-rolled corn. For growing calves, processing Enogen corn might not be necessary to improve digestion.

Implications

When fed in an ad libitum fashion to growing steers, Enogen Feed corn improves total tract ruminal organic matter and dry matter digestibility by 8% and 9%, respectively. There were no negative observations regarding cattle health or behavior with the feeding of Enogen Feed corn. Based on the results of this study, dry matter and organic matter of Enogen Feed corn are digested to a greater extent, thereby improving feed efficiency in growing calves.

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Table 1. Experimental diets

Ingredient	Dry matter %
Corn (variety × processing) ¹	28.57
Supplement	6.43
Alfalfa hay	17.50
Prairie hay	17.50
Wet distillers grains	30.00
Total	100.00

Composition	100% Dry matter basis
Dry matter, %	60.30
Protein, %	16.08
Calcium, %	0.85
Phosphorus, %	0.41
Salt, %	0.32
Potassium, %	1.09
Magnesium, %	0.22
Fat, %	4.72
Acid detergent fiber, %	20.59
Net energy for maintenance, Mcal/100 lb	78.81
Net energy for gain, Mcal/100 lb	51.13

¹Corn type: Enogen Feed (Syngenta) corn versus yellow; and fed as either whole-corn or dry-rolled.

Table 2. Effects of Enogen Feed corn and processing on digestibility and ruminal characteristics

Item	Corn source				Standard error of the mean ²	P-value		
	Enogen ¹		Yellow			Process	Source	Process × source
	Dry-rolled	Whole	Dry-rolled	Whole				
Number of observations	6	7	7	7				
Dry matter intake, lb/day	17.09	17.95	18.10	16.93	0.43	0.80	0.99	0.11
Ruminal								
pH ³	5.84	5.87	5.81	5.93	0.06	0.15	0.82	0.37
Ammonia, mM ³	3.63	2.80	2.79	2.38	0.73	0.32	0.30	0.73
Total volatile fatty acids, mM ³	102.1	109.5	109.4	107.0	5.27	0.45	0.45	0.14
Acetate, mM ³	60.6	65.8	66.6	65.9	3.01	0.16	0.05	0.06
Propionate, mM ³	26.3	28.9	28.1	26.7	2.68	0.73	0.90	0.29
Butyrate, mM ³	10.9	10.4	10.6	10.2	0.72	0.28	0.52	0.86
Isobutyrate, mM ³	1.40	1.41	1.31	1.47	0.12	0.29	0.82	0.38
Valerate, mM ³	1.77	1.64	1.57	1.59	0.15	0.64	0.28	0.48
Isovalerate, mM ³	1.15	1.17	1.19	1.21	0.14	0.82	0.68	0.97
Liquid passage rate, %/hour ⁴	7.43	8.38	9.52	8.84	0.67	0.77	0.01	0.09
Digestibility, % (total tract)								
Dry matter	62.05	63.17	58.41	56.21	2.53	0.83	0.04	0.50
Organic matter	64.84	66.02	61.51	59.28	2.45	0.82	0.04	0.46
Neutral detergent fiber	51.52	53.51	51.14	46.96	4.18	0.79	0.41	0.46
Acid detergent fiber	50.01	54.52	48.49	42.05	5.20	0.85	0.17	0.28
Starch	86.43	90.43	84.66	85.14	2.90	0.37	0.16	0.47
Ruminal volatile fatty acids, % of total								
Acetate ⁵	60.8	60.3	62.0	61.4	1.33	0.68	0.34	0.95
Propionate ⁵	24.4	26.4	24.5	25.1	1.38	0.33	0.65	0.60
Butyrate ⁵	10.6	9.50	9.66	9.51	0.60	0.24	0.41	0.36
Isobutyrate ⁵	1.40	1.30	1.22	1.38	0.07	0.62	0.47	0.07
Valerate ⁵	1.69	1.44	1.42	1.45	0.09	0.18	0.10	0.09
Isovalerate ⁵	1.17	1.06	1.11	1.13	0.12	0.65	0.99	0.52

¹Enogen Feed corn, Syngenta.²Largest value among treatments reported.³Average of values collected at 0, 2, 4, 6, 8, 12, 18, and 24 hours after feeding.⁴Calculated values from samples collected at 2, 4, 6, 8, 12, and 18 hours after feeding.⁵Average of values collected at 0, 2, 4, 6, 8, 12, 18, and 24 hours after feeding expressed as a percentage of total volatile fatty acids.

Smartamine M Supplementation Reduces Inflammation but Does Not Affect Performance in Receiving Beef Heifers

M.S. Grant, H.F. Speer, W.R. Hollenbeck, R.N. Wahl, N.D. Luchini,¹ D.A. Blasi, and E.C. Titgemeyer

Abstract

Methionine supplementation can improve immune function in transition dairy cattle. To determine if supplemental methionine could improve health and performance in newly received growing cattle, a group of 384 crossbred heifers (489 ± 10.9 lb) of Tennessee origin were received in four truckloads (blocks) over nine days. The day following arrival (day 0), cattle were stratified within block by arrival weight to one of eight pens containing 12 heifers each. Cattle were limit-fed a by-product and corn-based ration at 2.2% of body weight, once daily for 45 days. Within blocks, pens were assigned to one of two treatments: 0 (control) or 10 grams/day Smartamine M as a source of ruminally protected methionine. Pen weights were measured weekly and used to adjust feed offered the following week. Individual heifer body weights and tail vein blood samples were collected on days 0, 14, and 45. Plasma haptoglobin was measured to assess inflammation. Incidences of morbidity and mortality were low. Between days 0 and 45, no differences were observed for average daily gain or gain-to-feed ratio. An interaction between treatment and linear effect of day was detected for plasma haptoglobin ($P = 0.05$); over time, haptoglobin increased more for control than for Smartamine M. Supplemental methionine may alleviate acute phase protein responses in stressed receiving cattle.

Introduction

Methionine supplementation has been shown to improve immune function and reduce inflammation in transition dairy cows. High-risk receiving cattle are also subjected to a wide variety of stressors, such as comingling, transportation, disease exposure, and low feed intake. Because methionine supplementation helps to mitigate stress-induced immune responses in dairy cows, it can likely provide similar benefits to receiving cattle as well. The objective of this trial was to evaluate the ability of supplemental methionine to improve health, inflammation status, and performance of receiving cattle.

Experimental Procedures

A group of 384 crossbred heifers (initial body weight 489 ± 10.9 lb) were purchased from auction markets in Tennessee and transported to the Kansas State University Beef Stocker Unit, Manhattan, KS, in four truckloads over nine days from October 4 to October 13, 2018. Heifers were blocked by load and stratified by individual arrival body weight within a block to pens containing 12 heifers each. Within block, pens were randomly assigned to one of two treatments creating 16 pens per treatment, for a total of 32 pens. Experimental diets (Table 1) were offered at 2.2% of body weight daily (dry matter basis) and contained either 0 (control) or 10 grams/day Smartamine M

¹ Adisseo USA Inc., Alpharetta, GA.

(Adisseo, Alpharetta, GA), a ruminally protected methionine product. The 10 grams/day Smartamine M provided 6 grams/day supplemental metabolizable methionine. Smartamine M was delivered in the diet as a mixture with dry-rolled corn.

On day 0, heifers were vaccinated for common viral and clostridial pathogens, treated for internal and external parasites, and received Draxxin (1.1 mg tulathromycin/lb body weight). On day 14, heifers were revaccinated for viral respiratory diseases. Individual body weights were measured at processing (day 0), revaccination (day 14), and the conclusion of the trial (day 45). Pen weights were measured weekly using a pen scale on days 14, 21, 28, 35, and 45. Weekly pen weights were used to calculate feed offered for the following week. Animals were fed once daily at 7:00 a.m. using a Roto-Mix feed wagon.

Heifers were observed twice daily for clinical signs of illness. Animals showing signs of morbidity were treated according to protocol of the K-State Beef Stocker Unit. Prior to feeding on days 0, 14, and 45 a tail vein blood sample was collected from each animal and plasma harvested. Plasma samples were analyzed for haptoglobin concentration as a biomarker of inflammation.

Results and Discussion

Performance data are presented in Table 2. Although there were some statistical differences between treatments for dry matter intake, this was a result of differences in dietary dry matter among treatments as analyzed from weekly feed samples collected on days 0–14, and dry matter intake did not differ practically between groups. No differences in body weight ($P \geq 0.65$), average daily gain ($P \geq 0.52$), or gain-to-feed ratio ($P \geq 0.28$) were observed at any time throughout the trial.

Very low incidences of morbidity and mortality were observed for this trial; data were not analyzed statistically (Table 3). A total of eight heifers were treated once (2.1%) for respiratory illness, five from the Smartamine M treatment (2.6%) and three from the control treatment (1.6%). Two previously treated animals died during the trial, one from each treatment, resulting in total and treatment mortality rates of 0.52%.

For plasma haptoglobin, an interaction between dietary treatment and linear effect of day was observed ($P = 0.05$) (Figure 1). Over the duration of the trial, haptoglobin levels for the Smartamine M treatment group remained relatively stable. Control cattle had numerically lower haptoglobin on day 0, which then linearly increased over the duration of the trial. It appears that supplemental methionine mitigated the increase in plasma haptoglobin over time in the Smartamine M cattle.

Implications

Our research determined that supplemental methionine mitigated acute phase protein response in supplemented cattle, suggesting a reduction in systemic inflammation.

Acknowledgments

The authors thank Adisseo USA Inc. for their financial support of this project.

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Table 1. Diet composition and Smartamine M inclusion in rations fed to receiving heifers

Item	Treatment	
	Control	Smartamine M
Ingredient, % of dry matter		
Corn, dry rolled	34.5	---
Corn, dry rolled, with Smartamine M ¹	---	34.5
Sweet Bran ²	40.0	40.0
Corn silage	10.0	10.0
Alfalfa hay	4.0	4.0
Prairie hay, chopped	4.0	4.0
Supplement ³	7.5	7.5
Smartamine M, grams/day	0	10

¹Dry-rolled corn and Smartamine M were combined and mixed for 60 seconds in a paddle mixer according to Smartamine M User Guide instructions. The mixture contained 99.5% dry-rolled corn and 0.5% Smartamine M.

²Cargill Animal Nutrition, Blair, NE.

³Supplement pellet formulated to contain (dry matter basis) 10.6% crude protein, 8.7% calcium, 0.62% phosphorus, 4.6% salt, 0.70% potassium, 0.20% magnesium, 5.1% fat, and 330 ppm monensin (Rumensin; Elanco, Greenfield, IN).

Table 2. Effect of Smartamine M on performance in receiving beef heifers

Item	Treatment		Standard error of the mean	<i>P</i> -value
	Control	Smartamine M		
Number of pens	16	16		
Number of heifers	191	191		
Body weight, lb				
Day 0	489	489	10.9	0.70
Day 14	534	533	6.4	0.87
Day 21	554	553	5.5	0.88
Day 28	570	571	5.4	0.66
Day 35	589	590	6.3	0.87
Day 45	612	614	6.7	0.65
Average daily gain, lb/day				
Days 0–14	3.17	3.18	0.37	0.95
Days 14–45	2.54	2.61	0.11	0.52
Days 0–45	2.74	2.79	0.14	0.55
Dry matter intake, lb/day				
Days 0–14	9.8	9.6	0.10	0.008
Days 14–45	12.4	12.4	0.11	0.54
Days 0–45	11.6	11.5	0.10	0.001
Gain-to-feed ratio, lb/lb				
Days 0–14	0.326	0.334	0.0412	0.70
Days 14–45	0.204	0.211	0.0075	0.45
Days 0–45	0.236	0.243	0.0141	0.28

Table 3. Effect of Smartamine M on morbidity and mortality

Item	Treatment	
	Control	Smartamine M
Morbidity, %		
Treated once	1.6	2.6
Treated twice	0.5	0.5
Chronic	0.0	0.5
Mortality, %	0.5	0.5

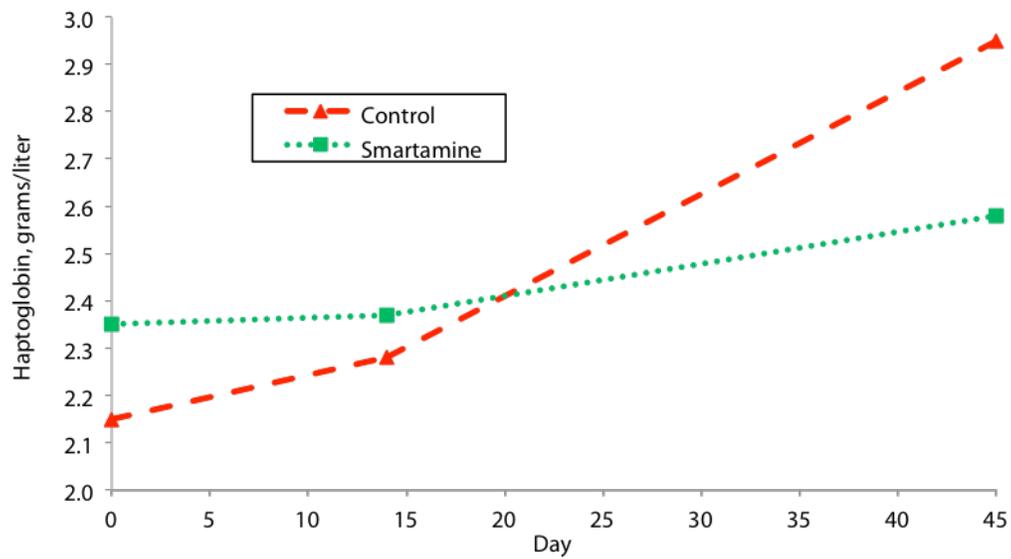


Figure 1. Effect of Smartamine M supplementation on plasma haptoglobin over time. Treatment \times linear day interaction, $P = 0.05$, standard error of the mean = 0.22.

Effects of Guanidinoacetic Acid on Lean Growth and Methionine Flux in Cattle

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Abstract

Creatine stores energy in muscles as high-energy phosphate bonds. Creatine is endogenously synthesized in the liver through the methylation of guanidinoacetic acid. We hypothesized that provision of guanidinoacetic acid, the precursor to creatine, would increase creatine supply to the body and improve animal production. Because increased synthesis of creatine will increase methyl group consumption, an adequate supply of methyl groups might improve the benefits of guanidinoacetic acid supplementation. This study was to determine whether guanidinoacetic acid supplementation could improve lean tissue deposition (growth) and whether an additional methyl group source (methionine) was required to optimize the response to guanidinoacetic acid. Ruminally-cannulated steers were housed in metabolism crates to allow complete collection of feces and urine for calculation of nitrogen retention. The experiment included six 10-day periods, and each animal received one of the 6 different treatments in each period. The 6 treatments were supplementation of 0, 7.5, or 15 g/day of guanidinoacetic acid each in the presence or absence of 6 g/day supplemental L-methionine. Supplementation of guanidinoacetic acid increased plasma creatine concentrations, demonstrating that the cattle converted guanidinoacetic acid to creatine. Responses to guanidinoacetic acid for lean tissue deposition were dependent on the methionine status of the steers. When methionine was supplemented to steers, there was an increase in nitrogen retention when 15 g/day of guanidinoacetic acid was provided. In contrast, supplemental guanidinoacetic acid did not improve nitrogen retention when no methionine was supplemented. The growth-enhancing effect of guanidinoacetic acid supplementation indicates a direct means of increasing beef production, although further research is required to confirm benefits.

Introduction

Creatine serves as an energy source for muscles by storing energy in high-energy phosphate bonds. Creatine is endogenously synthesized in the liver through the methylation of guanidinoacetic acid, the precursor to creatine that can be synthesized in the kidney. Both creatine and guanidinoacetic acid can also be absorbed from the diet. The requirement for creatine is considerable in growing animals, and its provision in the diet has the potential to increase performance. Production of guanidinoacetic acid is typically the rate-limiting step in the endogenous synthesis of creatine by the body; therefore, supplementation of creatine or creatine precursors such as guanidinoacetic acid can be beneficial to increase creatine in the body. Previous studies have shown increases in growth and yield of breast meat in chickens and muscle mass in humans when creatine was supplemented to the diet. In recent years, creatine use as a dietary supplement has been widespread among athletes to maximize exercise performance.

Methionine acts as a methyl donor and typically is the most limiting amino acid for beef and dairy cows. Although cattle might benefit from increased creatine synthesis, the increased synthesis of creatine will increase methyl group consumption, which might lead to methyl group deficiency in the animal. Therefore, an adequate supply of methyl groups might improve the benefits of guanidinoacetic acid supplementation on growth, because methionine also has an important function in protein synthesis. However, to our knowledge, there are little data available about creatine utilization by cattle and no data are available regarding the ability of guanidinoacetic acid to increase the lean growth rate of cattle. In a preliminary study with guanidinoacetic acid using growing Holstein heifers, we observed that large doses of guanidinoacetic acid could be provided to cattle without any signs of toxicity under conditions where methionine was not likely to be limiting. This research evaluated the effects of guanidinoacetic acid supplementation under conditions where methionine was limiting. The purpose of this study was to determine whether guanidinoacetic acid supplementation could improve lean tissue deposition (growth) in a model where cattle were purposefully maintained under conditions of a methionine deficiency.

Experimental Procedures

Seven ruminally-cannulated Holstein steers (355-lb initial body weight) were housed in metabolism crates to allow complete collection of feces and urine for calculation of nitrogen retention. Cattle had free access to water and were limit-fed twice daily. All steers received 6 lb of dry matter daily of a diet designed to provide deficient amounts of methionine. The diet contained 82% soybean hulls, 8.5% wheat straw, 4.2% molasses, and 5.1% of a vitamin/mineral premix. The methionine deficiency was reinforced by supplementing energy via volatile fatty acid infusions into the rumen (0.66 lb/day) and glucose infusions into the abomasum (0.73 lb/day). Both infusions increase energy supply without increasing methionine supply. Additionally, all steers received an abomasal infusion of all essential amino acids except methionine to ensure that amino acids other than methionine did not limit performance.

The experiment included six 10-day periods, with 4 days for initial adaptation and 6 days for sample collection, and each animal received one of the 6 different treatments in each period. The 6 treatments were supplementation of 0, 7.5, or 15 g/day of guanidinoacetic acid each in the presence or absence of 6 g/day supplemental L-methionine. Methionine was included in the treatment structure because it provides the methyl group used for the conversion of guanidinoacetic acid to creatine. Urine and feces samples were collected daily from days 5 through 10 of each period to measure nitrogen retention, and blood samples were collected from the jugular vein from each steer on days 6, 8, and 10 of each period for analyses of creatine. On day 10 of each period, jugular catheters were placed for infusion of labeled methionine to allow measurement of whole body methionine methyl flux.

Results and Discussion

Nitrogen retention, a measure of lean tissue growth, was significantly elevated by methionine supplementation (Figure 1; $P < 0.01$); this response to methionine was expected because methionine was deficient by design. Responses to guanidinoacetic acid for lean tissue deposition were dependent on the methionine status of the steers. When

methionine was supplemented to steers, there was an increase in nitrogen retention when 15 g/day of guanidinoacetic acid was provided. The lack of a nitrogen retention response to 7.5 g/day of guanidinoacetic acid might have been due to an offsetting decrease in endogenous production of guanidinoacetic acid, which was expected to be near 7.5 g/day. Therefore, at the supplementation level greater than endogenous production (i.e., 15 g/day), the increase in total guanidinoacetic acid/creatinine availability seemed to improve animal production. In contrast, supplemental guanidinoacetic acid did not improve nitrogen retention when no methionine was supplemented (Figure 1). When methionine was not supplemented (i.e., methionine was deficient), the lack of response to guanidinoacetic acid might have been due to the guanidinoacetic acid consuming methionine for the production of creatine. Under conditions of a poor methionine status, increases in creatine production may not be able to improve cattle growth. These observations provide a starting point for further research on the effects of guanidinoacetic acid supplementation on increasing lean tissue deposition in growing cattle.

By increasing the supply of guanidinoacetic acid, plasma creatine concentrations increased linearly (Figure 2; $P < 0.01$). The increases in plasma creatine in response to guanidinoacetic acid supplementation can be attributed to conversion of guanidinoacetic acid to creatine in cattle. Steers supplemented with methionine had lower concentrations of plasma creatine. This may be attributable to enhanced tissue growth in response to methionine, which could lead to an increased uptake of creatine into muscle.

The consumption of methyl groups from methionine (Figure 3) was increased by guanidinoacetic acid supplementation when no supplemental methionine was provided, suggesting that the guanidinoacetic acid increased use of methionine to provide methyl groups for creatine synthesis. However, the flux of methionine methyl groups was not affected by guanidinoacetic acid supplementation when supplemental methionine was provided. This may be because the steers receiving supplemental methionine had enough readily available methyl groups from the supplemental methionine to prevent creatine synthesis from being a major drain on the body's methyl group supplies.

Implications

Supplementation of guanidinoacetic acid (15 g/day) in the presence of supplemental methyl groups (as methionine) tended to increase nitrogen retention, demonstrating that tissue growth was stimulated by post-ruminal guanidinoacetic acid supplementation. The growth-enhancing effect of guanidinoacetic acid supplementation indicates a direct means of increasing beef production, although further research is required to confirm benefits.

Supplementation of guanidinoacetic acid elevated plasma creatine concentration, demonstrating that guanidinoacetic acid supplementation can be an effective way to increase creatine supply to cattle. Supplementation of methionine decreased plasma creatine concentration, perhaps indicating that the greater tissue growth in response to methionine supplementation resulted in increased muscle creatine uptake.

In the absence of supplemental methyl groups, supplementation of guanidinoacetic acid increased methionine methyl group flux, suggesting that guanidinoacetic acid might increase methionine methyl group utilization for creatine synthesis. In contrast, when methionine was supplemented, methionine methyl group flux was not affected by supplementation with guanidinoacetic acid.

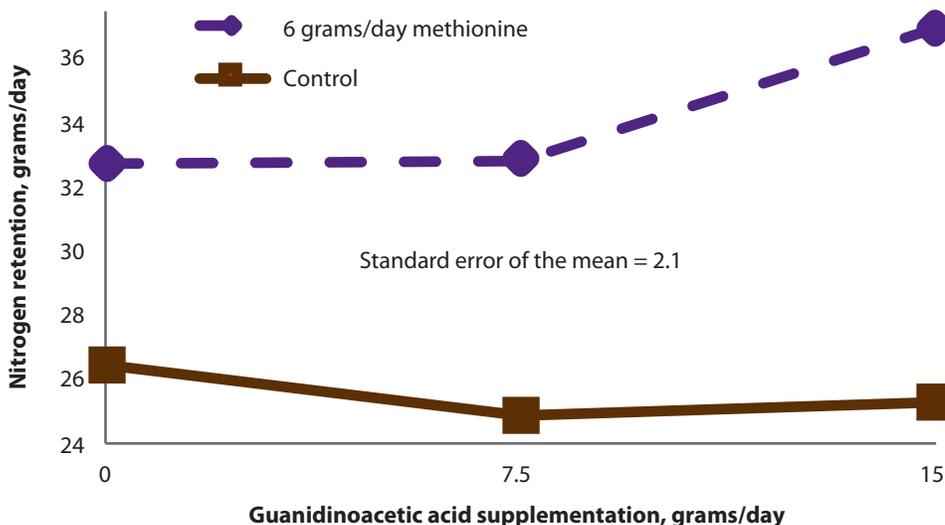


Figure 1. Effect of methionine and guanidinoacetic acid supplementation on nitrogen retention (effect of methionine, $P < 0.01$; interaction of guanidinoacetic acid \times methionine, $P = 0.10$).

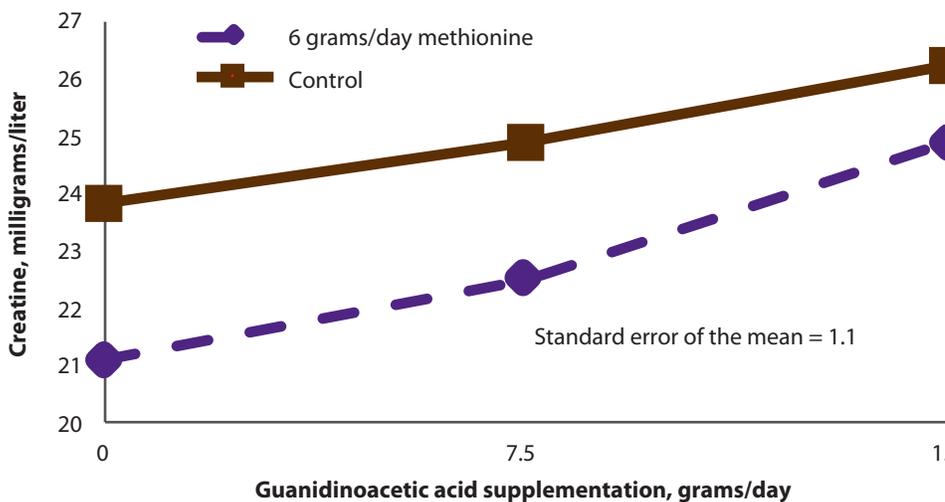


Figure 2. Effect of methionine and guanidinoacetic acid supplementation on plasma creatine concentrations (effect of methionine, $P < 0.01$; linear effect of guanidinoacetic acid, $P < 0.01$).

BEEF CATTLE NUTRITION

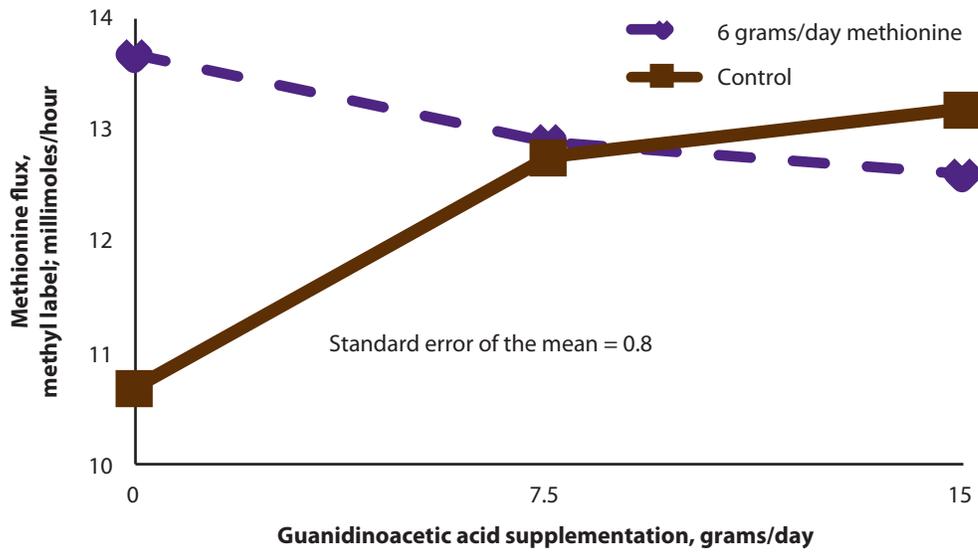


Figure 3. Effect of methionine and guanidinoacetic acid supplementation on methionine methyl flux (effect of methionine, $P = 0.17$; interaction of guanidinoacetic acid \times methionine, $P = 0.03$).

The Use of Bioelectrical Impedance to Assess Shelf-Life of Beef *Longissimus Lumborum* Steaks

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Abstract

The quality attributes of beef *longissimus lumborum* during 15 days of simulated retail display using bioelectrical impedance were assessed. Beef strip loins (n = 18) were obtained from three commercial processors with 3 postmortem ages (27, 34, or 37 days). Loins were fabricated into 12 1-in thick steaks, subdivided into six consecutively cut pairs, and randomly assigned to one of six display days: 0, 3, 6, 9, 12, and 15. Microbiological and bioelectrical impedance analysis, pH, objective color assessment, proximate composition, and lipid oxidation were measured. There was a postmortem age × display day interaction ($P < 0.05$) for surface bioelectrical impedance. Overall, steaks aged 27 days had higher ($P < 0.05$) surface bioelectrical impedance values than steaks aged 34 and 37 days. There was no postmortem age × display day interaction ($P > 0.05$) for internal bioelectrical impedance values; however, an effect on postmortem age and display day was found ($P < 0.05$). Steaks aged 27 days had 17% higher internal bioelectrical impedance values ($P < 0.05$) than steaks aged 37 days, but were similar ($P > 0.05$) to steaks aged 34 days. For all postmortem age times, display day 0 had the lowest ($P < 0.05$) internal bioelectrical impedance value. Furthermore, the covariance component was smaller in internal bioelectrical impedance than surface bioelectrical impedance. Internal bioelectrical impedance has potential for use to assess shelf-life of retail steaks and is more precise than surface bioelectrical impedance.

Introduction

In the U.S., meat discounted or discarded due to discoloration accounts for 15% of meat loss, leading to revenue losses up to \$1 billion for the industry (Smith et al., 2000). As little as 20% discoloration is sufficient for consumers to reject meat (Djenane et al., 2001). A study by Buzby et al. (2014) estimated that 1.3 million tons of meat is not being utilized at the retail level. The need for quantitative, objective, fast, non-destructive, non-invasive methods to predict freshness has risen in the past decade. Bioelectrical impedance analysis has been studied as a potential technology to assess quality attributes of fresh meat. It is well documented that fresh meat has higher bioelectrical impedance values due to decreased extracellular fluid, allowing the flow of electric current. Conversely, increased extracellular fluid leads to lower bioelectrical impedance values due to membrane damage, resulting in poor water holding capacity. Meat scientists have reported bioelectrical impedance as an effective technology to assess carcass composition, aging, and post-mortem changes in muscle cell membranes. At the carcass level, bioelectrical impedance has been shown to be highly correlated to fat and water content, salable yield, fat trim, and marbling scores. Slaughter plant location, types of breed, and sex had an impact on impedance measurements. The objective of this study

was to evaluate the efficacy of using surface and internal bioelectrical impedance to assess beef *longissimus lumborum* shelf-life during 15 days of simulated retail display.

Experimental Procedures

The experiment was designed as a split-plot with loin as the whole-plot and paired steaks as the sub-plot. Display day was treated as the sub-plot treatment. Postmortem age time and display day were treated as fixed effects. Beef strip loins ($n = 18$; Institutional Meat Purchase Specifications #180) with a postmortem age of 27, 34, or 37 days were obtained from three commercial processors. Loins were fabricated into 12 1-inch thick steaks ($n = 216$). Steaks were subdivided into 6 consecutively cut pairs and pairs were randomly assigned to one of six display days: 0, 3, 6, 9, 12, and 15.

For all pairs, one steak was allocated to microbiological analysis and pH and the paired steak for bioelectrical impedance analysis, objective color assessment, proximate composition, and lipid oxidation using the thiobarbituric acid reactive substances method. In addition, surface bioelectrical impedance and internal bioelectrical impedance assessment were compared. Steaks were packaged on Styrofoam trays with a moisture absorbent pad, overwrapped with polyvinyl chloride film, and displayed under fluorescent lighting at 32–40°F in coffin-style retail cases.

Results and Discussion

There was a postmortem age \times display day interaction ($P < 0.05$) for surface bioelectrical impedance (Figure 1). From day 0 to 12 of display, steaks aged 27 days had higher ($P < 0.05$) surface bioelectrical impedance values than steaks aged 34 and 37 days. On day 15 of display, steaks aged 34 days had 22% higher ($P < 0.05$) surface bioelectrical impedance values than steaks aged 37 days, but had similar ($P > 0.05$) values compared to steaks aged 27 days. There was no postmortem age \times display day interaction ($P < 0.05$) for internal bioelectrical impedance values; however, an effect on postmortem age and display day was found ($P < 0.05$). Steaks aged 27 days had 17% higher internal bioelectrical impedance values ($P < 0.05$) than at 37 days, but were similar ($P > 0.05$) to steaks aged 34 days (Figure 2). For all postmortem aging times, day 0 had the lowest ($P < 0.05$) internal bioelectrical impedance values among all display days (Figure 3). Day 3 had the next lowest internal bioelectrical impedance ($P < 0.05$) and was 8% higher than day 0. Day 6 internal bioelectrical impedance was 16% higher ($P < 0.05$) than day 3, but similar ($P > 0.05$) to day 9 and day 12. Internal bioelectrical impedance was similar ($P > 0.05$) for steaks displayed for 12 and 15 days.

Covariance component was smaller in internal bioelectrical impedance than surface bioelectrical impedance. There was no postmortem age \times display day interaction ($P > 0.05$) for a^* (redness) and b^* (blueness) values; however, there was an interaction for L^* (lightness) values. On display day 0, steaks aged 27 days were 6% lighter ($P < 0.05$) than steaks aged 34 or 37 days, but on display day 15 all samples were similar ($P > 0.05$) in lightness. Postmortem age had no effect ($P > 0.05$) on L^* ; however, an effect on a^* and b^* was found ($P < 0.05$). Steaks aged 27 days had higher ($P < 0.05$) a^* and b^* values by 12 and 7%, respectively, compared to other postmortem aging times. For aerobic plate count populations, there was a postmortem age \times display day interaction ($P < 0.05$). Steaks aged 27 days had the lowest ($P < 0.05$) aerobic plate count popu-

lation on display day 0 with 2.3 log colony forming units/g in comparison to steaks aged 34 and 37 days, which had 4.3 and 4.5 log colony forming units/g, respectively. On display day 15, aerobic plate count populations were similar ($P > 0.05$) among all post-mortem days (6.3 to 7.2 log colony forming units/g). No postmortem age \times display day or postmortem age effects ($P > 0.05$) were found for lipid oxidation; however, there was a display day effect ($P < 0.05$). On display day 0, thiobarbituric acid reactive substances values were similar ($P > 0.05$) on steaks, regardless of postmortem age with 0.15 mg malondialdehyde/kg. On display day 15, thiobarbituric acid reactive substances values on steaks aged 34 and 37 days were greater ($P < 0.05$) with 0.9 mg malondialdehyde/kg than steaks aged 27 days with 0.55 mg malondialdehyde/kg. There was no postmortem age \times display day interaction ($P > 0.05$) or postmortem age effect ($P > 0.05$) for moisture content. Display day ($P < 0.05$) had an effect on moisture content.

Moderate negative correlations occurred between surface bioelectrical impedance values and a^* , b^* , and moisture content with -0.48, -0.46, and -0.46, respectively; and -0.51, -0.48, and -0.43, respectively, for internal bioelectrical impedance. Conversely, moderate positive correlations were found between surface bioelectrical impedance values and aerobic plate counts and lipid oxidation with 0.34 and 0.53, respectively; and 0.29 and 0.51, respectively, for internal bioelectrical impedance.

Implications

Internal bioelectrical impedance has potential for use to assess shelf-life of retail steaks and was more precise than surface bioelectrical impedance; however, using the internal bioelectrical impedance method may translocate bacteria into the muscle. Protein degradation and water holding capacity should be evaluated to better understand bioelectrical impedance changes over time.

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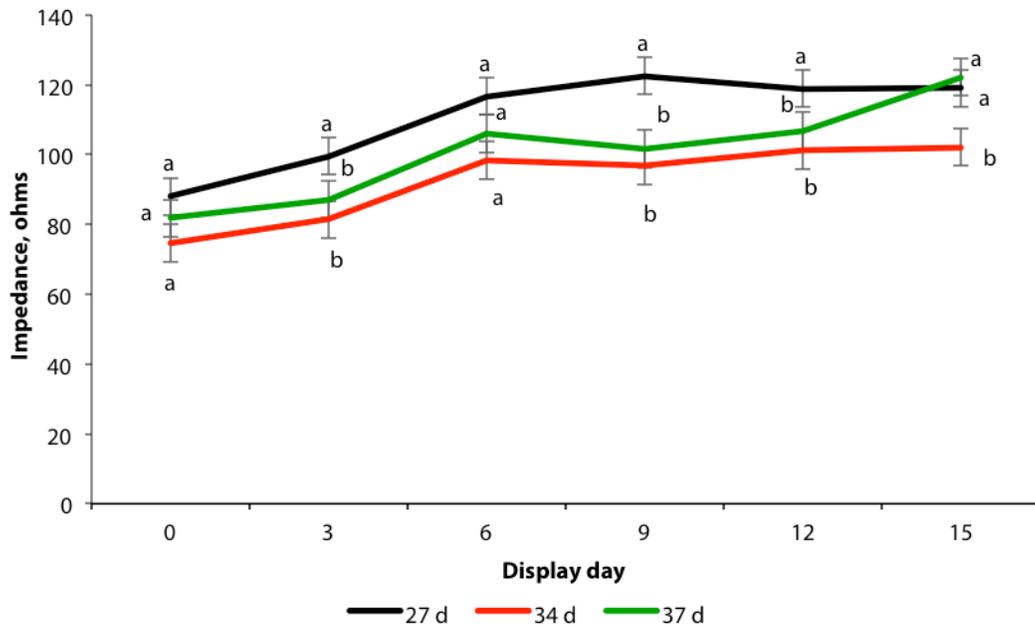


Figure 1. Surface bioelectrical impedance values of beef *longissimus lumborum* (strip loin) steaks aged 27, 34, or 37 days and displayed for 15 days under fluorescent lighting at 32–40°F. ^{ab}Means with different superscripts differ ($P < 0.05$).

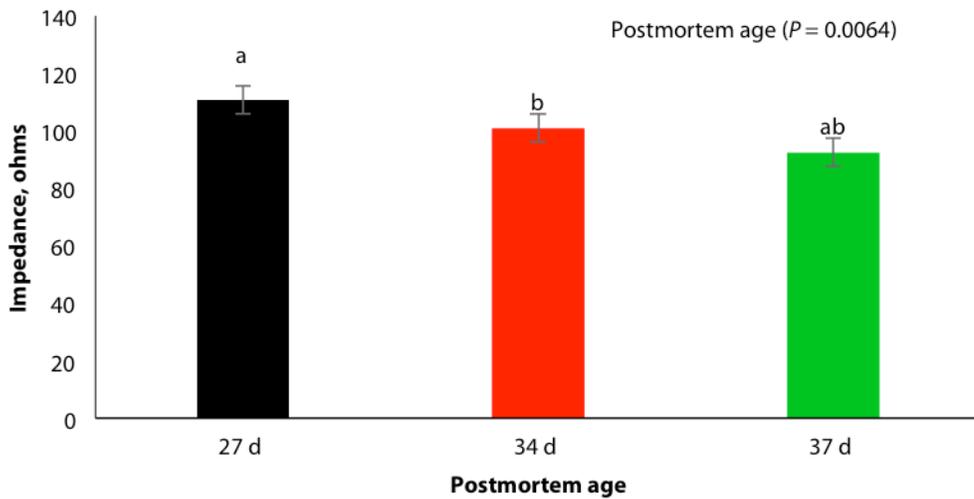


Figure 2. Internal bioelectrical impedance values of beef *longissimus lumborum* (strip loin) steaks aged for 27, 34, or 37 days. ^{ab}Means with different superscripts differ ($P < 0.05$).

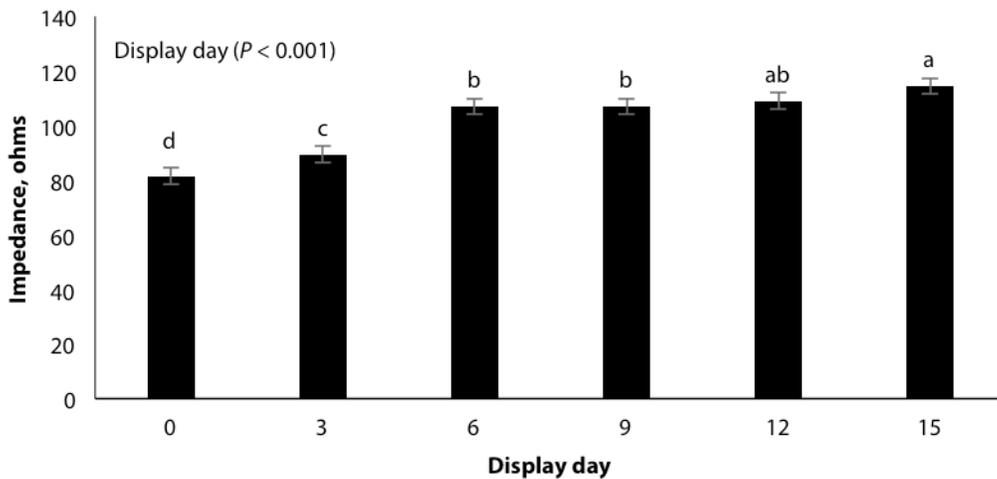


Figure 3. Internal bioelectrical impedance values of beef *longissimus lumborum* (strip loin) steaks displayed for 15 days under fluorescent lighting at 32–40°F.

^{ab}Means with different superscripts differ ($P < 0.05$).

Beef *Longissimus Lumborum* Steak pH Affects External Bioelectrical Impedance Assessment

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Abstract

Postmortem chemical changes in normal- and high-pH beef strip loins (n = 20; post-mortem age = 14 days) were assessed using external bioelectrical impedance during simulated retail display. Beef strip loins obtained from a commercial processor were sorted into normal- (n = 11) and high-pH (n = 9) treatments. Loins were fabricated into five 1-inch thick steaks and randomly assigned to one of five display days: 1, 3, 5, 7, and 9. External bioelectrical impedance, oxygen consumption, metmyoglobin reducing ability, protein degradation, water holding capacity, and pH were measured. There was a meat-pH × display day interaction for water holding capacity, pH, and oxygen consumption ($P < 0.05$). There was no meat-pH × display day interaction ($P < 0.05$) for external bioelectrical impedance or metmyoglobin reducing ability values; however, an effect on meat-pH and on display day was observed ($P < 0.05$). Intact and degraded desmin was 33% and 43% higher ($P < 0.05$), respectively, in normal-pH beef than high-pH beef. The meat-pH × display day interaction was marginally significant ($P = 0.0601$) for troponin-t 40 KDa. External bioelectrical impedance was moderately correlated with water holding capacity, oxygen consumption, and metmyoglobin reducing ability ($r = 0.35$; $P < 0.05$) and negatively correlated with pH ($r = -0.48$; $P < 0.05$) in high-pH beef. In normal-pH beef, external bioelectrical impedance was moderately correlated with water holding capacity, degraded troponin-t, and degraded portion ($r = 0.28$; $P < 0.05$) and negatively correlated with pH, intact and degraded desmin, and intact and degraded troponin-t ($r = -0.24$; $P < 0.05$). External bioelectrical impedance is a method that could be used to separate normal- and high-pH strip loins with potential for rapid, in-plant use to identify dark-cutting beef.

Introduction

Meat is a highly perishable commodity which naturally contains myoglobin, a protein responsible for the red color of fresh beef. Meat color is unstable, but is considered one of the major criteria for consumers when selecting meat purchases (Kropf, 1993). Bioelectrical impedance, a non-destructive analysis, was first documented for use by medical sciences in the early 1900s (Morse, 1925). Later, Swatland (1985) used electrical impedance to evaluate the relationship between the quality of pork carcasses and its electrical properties. Bioelectrical impedance analysis has been demonstrated to provide an accurate fat content determination in different pork and beef grinds; however, the smaller the grind size (1/8-inch plate), the more accurate bioelectrical impedance analysis was for predicting fat content (Marchello et al., 1999). In this study, external bioelectrical impedance analysis was used to assess postmortem chemical changes in normal- and high-pH beef *longissimus lumborum* steaks during simulated retail display.

Experimental Procedures

The experiment was designed as a split-plot with loin as the whole-plot and paired steaks as the sub-plot. Display day was treated as the sub-plot treatment. Meat-pH and display day were treated as fixed effects. Beef strip loins ($n = 20$; Institutional Meat Purchase Specifications #180) were obtained from a commercial processor (post-mortem age = 14 days). Loins were sorted into two treatments, normal-pH (5.61–5.64; $n = 11$) and high-pH (6.2–7.0; $n = 9$), fabricated into five 1-inch thick steaks ($n = 100$), and randomly assigned to one of five display days: 1, 3, 5, 7, and 9. Steaks were packaged on Styrofoam trays with a moisture absorbent pad, overwrapped with polyvinyl chloride film, and displayed under fluorescent lighting (32 W Del-Warm White 3000° K; Philips Lighting Co., Somerset, NJ) at 32–40°F in coffin-style retail cases (model DMF 8; Tyler Refrigeration Corp., Niles, MI) in the Kansas State University Color Laboratory. External bioelectrical impedance values, oxygen consumption, metmyoglobin reducing ability, protein degradation, water holding capacity, and pH were assessed on each storage day.

Results and Discussion

There was no meat-pH \times display day interaction ($P > 0.05$) for external bioelectrical impedance values; however, an effect on meat-pH and display day was found ($P < 0.05$). External bioelectrical impedance was 20% higher ($P < 0.05$; Figure 1) for high-pH meat than normal-pH meat. As seen in Figure 2, steaks on day 1 had lower external bioelectrical impedance values ($P < 0.05$) compared to days 5 and 7, but similar ($P > 0.05$) to days 3 and 9.

There was no meat-pH \times display day interaction ($P > 0.05$) for metmyoglobin reducing ability values; however, an effect on meat-pH and display day was found ($P < 0.05$). The metmyoglobin reducing the ability of high-pH meat was increased by 12% ($P < 0.05$) in comparison with normal-pH meat. Metmyoglobin reducing ability increased ($P < 0.05$) over the 9 days of retail display. There was no meat-pH \times display day interaction ($P > 0.05$) or display day effect for intact or degraded desmin, however, a meat-pH effect ($P < 0.05$) was found. Normal-pH meat had 33 and 43% higher ($P < 0.05$) amount of intact and degraded desmin, respectively, than high-pH meat. The meat-pH \times display day interaction was marginally significant for troponin-t 40 and 30 KDa ($P = 0.0601$). In addition, no meat-pH \times display day interaction ($P > 0.05$) was found for troponin-t 36, 34, and 30 KDa.

In high-pH beef, external bioelectrical impedance values were moderately correlated with water holding capacity, oxygen consumption, and metmyoglobin reducing ability ($r = 0.35$; $P < 0.05$; Table 1). Additionally, a negative correlation occurred between external bioelectrical impedance and pH ($r = -0.48$; $P < 0.05$). External bioelectrical impedance was moderately correlated with water holding capacity, degraded troponin-t (30 KDa), and degraded portion ($r = 0.28$; $P < 0.05$; Table 2) for normal-pH beef. External bioelectrical impedance values were negatively correlated with pH, intact and degraded desmin, and intact and degraded troponin-t (36 KDa) ($r = -0.24$; $P < 0.05$).

Implications

External bioelectrical impedance is a method that could be used to separate normal- and high-pH strip loins with potential for rapid, in-plant use to identify dark-cutting beef.

References

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Table 1. Correlation coefficients between electrical measurements¹ of high-pH beef *longissimus lumborum* steaks and water holding capacity, pH, oxygen consumption, metmyoglobin reducing ability, desmin, troponin-t, and degraded portion

	Water holding capacity	pH	Oxygen consumption	Metmyoglobin reducing ability	Desmin ² KDa		Troponin-T ³ KDa				Degraded portion ⁴
					55	38	30	34	36	40	
<i>R</i>	0.28	0.40*	-0.17	-0.05	0.06	0.07	-0.16	0.28	0.04	0.23	0.18
<i>X_c</i>	0.37*	0.47***	-0.28	-0.33*	0.19	0.20	-0.10	0.27	0.02	0.08	0.09
<i>Z</i>	0.35*	-0.48**	0.56***	0.48**	-0.17	-0.23	0.12	-0.08	0.04	0.12	0.14

* $P < 0.05$.

** $P < 0.01$.

*** $P < 0.001$.

¹ R = resistance; X_c = reactance; Z = impedance ($Z = X_c + R^2/X_c$).

²Intact desmin (55 KDa); degraded desmin (38 KDa).

³Intact troponin-t (40 KDa); degraded troponin-t (30, 34, and 36 KDa).

⁴Degraded portion = degraded desmin + degraded troponin-t.

Table 2. Correlation coefficients between electrical measurements¹ of normal-pH beef *longissimus lumborum* steaks and water holding capacity, pH, oxygen consumption, metmyoglobin reducing ability, desmin, troponin-t, and degraded portion

	Water holding capacity	pH	Oxygen consumption	Metmyoglobin reducing ability	Desmin ² KDa		Troponin-T ³ KDa				Degraded portion ⁴
					55	38	30	34	36	40	
<i>R</i>	0.26*	-0.06	-0.16	-0.05	0.01	0.06	0.33*	0.11	-0.20	0.14	0.01
<i>X_c</i>	0.21	0.55***	-0.29*	-0.27*	0.07	-0.27*	-0.18	0.01	0.15	0.47*	0.22
<i>Z</i>	0.28*	-0.37**	0.14	0.20	-0.24*	-0.31*	0.41**	-0.08	-0.30*	-0.43*	0.36**

**P* < 0.05.

***P* < 0.01.

****P* < 0.001.

¹*R* = resistance; *X_c* = reactance; *Z* = impedance ($Z = X_c + R^2/X_c$).

²Intact desmin (55 KDa); degraded desmin (38 KDa).

³Intact troponin-t (40 KDa); degraded troponin-t (30, 34, and 36 KDa).

⁴Degraded portion = degraded desmin + degraded troponin-t.

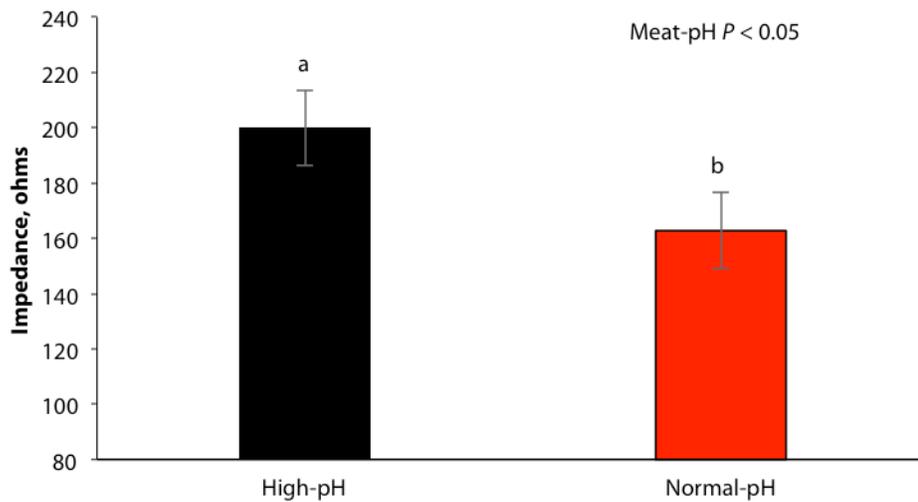


Figure 1. External bioelectrical impedance values of high-pH and normal-pH beef *longissimus lumborum* steaks.

^{ab}Means with different superscripts differ (*P* < 0.05).

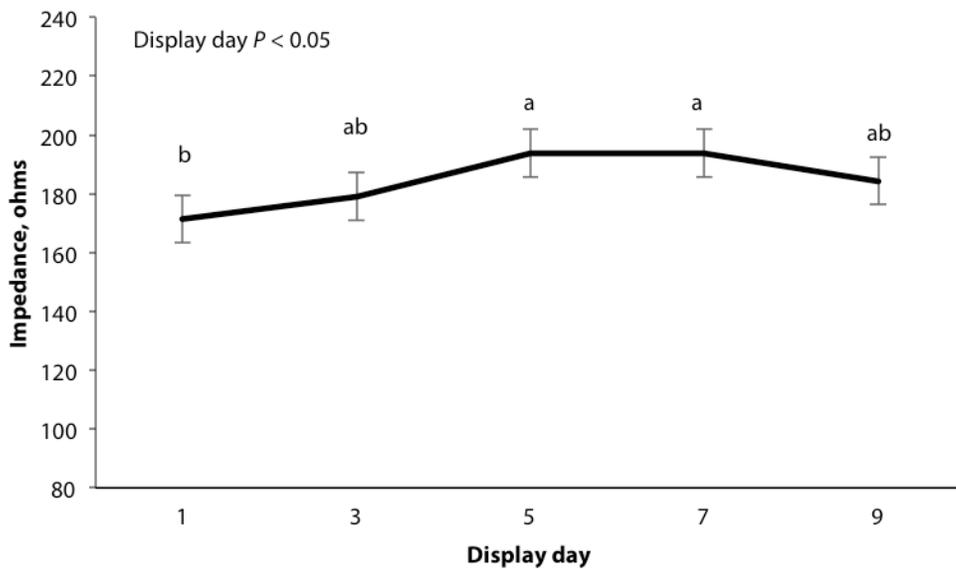


Figure 2. External bioelectrical impedance values of beef *longissimus lumborum* steaks displayed under fluorescent lights at 32–40°F for up to 9 days.

^{ab}Means with different superscripts differ ($P < 0.05$).

Sensory Evaluation from Asian Consumers of Six Different Beef Shank Cuts

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Abstract

The objective of this study was to evaluate factors affecting Asian consumers' purchasing decisions and eating preferences of six different beef shank cuts. Beef shanks were collected from a Midwestern meat processor, transported to the Kansas State University Meat Laboratory (Manhattan, KS), and fabricated into different shank cuts. Six shank cuts, three from the forequarter [*biceps brachii* (shank A); a combination of *deep digital flexor* and *flexor digitorum superficialis* (shank B); and *extensor carpi radialis* (shank C)], and three from the hindquarter [*flexor digitorum superficialis* (shank D); *deep digital flexor* (shank E), and a combination of *long digital extensor*, *medial digital extensor*, and *peroneus tertius* (shank F)] were collected from 12 U.S. Department of Agriculture Low Choice beef carcasses. Shanks from the left side of the carcasses were used for Asian consumer taste panels, while shanks from the right sides were used for visual evaluation. Shanks A, D, and F received high sensory scores, followed by shanks C and E, with shank B receiving the lowest score among all shank cuts ($P < 0.05$). For visual overall liking, shanks A and C received the highest scores, followed by shanks B, E, and F, and shank D received the lowest score ($P < 0.05$). Consumers indicated that there was no difference in flavor and surface color among shank cuts ($P > 0.05$). All shank cuts had similar Warner-Bratzler shear force values except for shank B, which had the highest value ($P < 0.01$). For objective color measurement, shank D had the highest lightness (L^*) value ($P < 0.01$), followed by shanks A, B, C, and E ($P > 0.05$), while shank F had the lowest L^* value ($P < 0.01$). There were no differences found in redness (a^*) and yellowness (b^*) among shank cuts.

Introduction

A significant percentage of beef shank meat produced in the U.S. is sold through domestic Asian markets or exported to Asian countries as whole-muscle cuts because stewed beef shank is a popular dish in many Asian cultures. However, to our knowledge, there is little published research available characterizing different beef shank cuts based on Asian consumers' preference and quality traits. Therefore, the objective of this study was to evaluate factors affecting Asian consumers' purchasing decisions as well as their eating preferences of six different beef shank cuts.

Experimental Procedures

The cross-section and whole-muscle cut of six different beef shank cuts, three from the forequarter [*biceps brachii* (shank A); a combination of *deep digital flexor* and *flexor digitorum superficialis* (shank B); and *extensor carpi radialis* (shank C)], and three from the hindquarter [*flexor digitorum superficialis* (shank D); *deep digital flexor* (shank E); and a combination of *long digital extensor*, *medial digital extensor*, and *peroneus tertius* (shank F)] collected from both sides of 12 USDA Low Choice beef carcasses ($n = 72$)

are shown in Figure 1. Shanks from the left side of the carcasses, used for consumer taste panels, were stewed in 208°F water for 90 minutes. Cooking loss and peak temperature of each sample were measured prior to serving. Consumers ($n = 91$) were fed six samples per person and evaluated samples for connective tissue texture, amount of connective tissue, juiciness, flavor, and overall texture based on Just-About-Right (JAR) line scales. In addition, consumers evaluated sensory overall liking on a continuous line scale and rated each sample as acceptable or unacceptable. Following sensory evaluation, consumers ($n = 84$) moved to the Kansas State University Color Laboratory to visually evaluate the size and surface color of samples obtained from the right side of the carcasses on Just-About-Right line scales. Consumers also evaluated visual overall liking of each sample on a continuous line scale and rated each sample as acceptable or unacceptable. Warner-Bratzler shear force determination and objective color measurement were conducted after the consumer panels. Following the American Meat Science Association Meat Cookery and Sensory Guidelines to determine Warner-Bratzler shear force (AMSA, 2015), six cores were removed from each sample parallel to the muscle fiber orientation and sheared perpendicular to the muscle fiber using an Instron (Model 5569, Instron Corp., Canton, MA). A MiniScan EZ color measurement spectrophotometer (Model 4500L, Hunter Associates Laboratory Inc., Reston, VA) was used to measure color on each sample cross-section following the CIE L^* (lightness), a^* (green to red), and b^* (blue to yellow) system described in Meat Color Measurement Guidelines (AMSA, 2012). Objective color measurements were obtained by averaging readings taken from three random locations on the sample cross-sections.

Results and Discussion

Shanks A, C, D, and F received similar scores ($P > 0.05$) close to Just About Right for connective tissue texture (Table 1). Connective tissue texture of shank E was harder than shanks A and D, and shank B was the hardest ($P < 0.01$). For connective tissue amount, shanks A, D, and E received ratings close to Just About Right ($P > 0.05$). Consumers rated shank B with having too much connective tissue and shanks C and F with having too little ($P < 0.01$) connective tissue. Shanks A, D, and F received similar ratings close to Just About Right for juiciness ($P > 0.05$), while shanks C and E were less juicy, and shank B was the least juicy shank ($P < 0.01$). All shanks rated similar for flavor ($P > 0.10$). For overall texture, shanks A, D, and F received similar ratings close to Just About Right ($P > 0.05$), and shanks C and E were tougher ($P < 0.01$). Shank B was the toughest for overall texture ($P < 0.01$). Shanks A, D, and F received the highest sensory overall liking scores, and shank B received the lowest overall liking score ($P < 0.01$). All shank cuts received high sensory acceptability scores ($> 85\%$) except for shank B (62%; $P < 0.01$).

Results from Table 2 indicated that shanks A and C both received scores that were close to Just About Right for shank size. Consumers rated shanks B, E, and F as too big in size, while shank D was too small ($P < 0.01$). Shanks B, C, E, and F had the heaviest raw weight ($P < 0.01$) and were similar in size ($P > 0.05$), followed by shank A, while shank D was the lightest shank ($P < 0.01$). All shanks were rated similar for surface color ($P > 0.10$). For visual overall liking, shank A received the highest score and shank D received the lowest score ($P < 0.05$) although it was similar to shanks B, E, and F ($P > 0.05$). Shanks A and C were most visually acceptable ($> 95\%$), while shanks B, D, E, and F were less acceptable than shanks A and C ($> 70\%$; $P < 0.01$).

Shanks A, C, D, E, and F had similar ($P > 0.01$) Warner-Bratzler shear force values, and shank B had the highest ($P < 0.01$) shear force value (Table 3). For objective color measurement, shank D had the highest L^* value ($P < 0.01$), followed by shanks A, B, C, and E ($P > 0.05$), with shank F having the lowest L^* value ($P < 0.01$). There were no differences ($P > 0.05$) found in a^* and b^* among different beef shank cuts. Shanks C and E had a greater percentage in cooking loss compared to shank A, and shanks B, D, and F had the least cooking loss percentage ($P < 0.01$).

Implications

Connective tissue texture and amount directly affected Asian consumers' eating preference for different beef shank cuts, while shank size was the main factor affecting their purchasing decision.

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Table 1. Consumer (n = 91) ratings of palatability traits, overall liking, and acceptability percentage on various beef shank cuts

Beef shank cuts	Connective tissue texture ¹	Connective tissue amount ¹	Juiciness ¹	Flavor ¹	Overall texture ²	Overall liking ³	Acceptability (%) ⁴
Fore shank							
A	52.10 ^a	47.43 ^c	49.87 ^a	42.23	50.98 ^{ab}	69.26 ^{ab}	94.95 ^{ab}
B	24.46 ^c	66.09 ^a	38.29 ^d	38.68	30.29 ^d	45.55 ^d	62.27 ^c
C	47.87 ^{ab}	39.31 ^d	43.47 ^{bcd}	34.57	43.44 ^c	58.91 ^c	88.72 ^b
Hind shank							
D	54.77 ^a	53.31 ^b	48.79 ^{ab}	39.86	53.03 ^a	73.10 ^a	96.99 ^a
E	44.11 ^b	47.11 ^c	41.18 ^{cd}	37.72	45.08 ^{bc}	62.33 ^{bc}	91.86 ^{ab}
F	48.45 ^{ab}	43.83 ^{cd}	47.34 ^{abc}	40.86	47.35 ^{abc}	67.83 ^{ab}	93.93 ^{ab}
SEM ⁵	2.60	2.35	2.31	2.67	2.35	3.10	3.19
<i>P</i> -value	<0.01	<0.01	<0.01	0.06	<0.01	<0.01	<0.01

^{a-d}Least squares means without a common superscript differ ($P < 0.05$).

¹Sensory evaluation scores: 0 = too hard/too little, too dry, too bland; 50 = just about right (ideal score); 100 = too soft/too much, too wet/too intense.

²Combination of myofibrillar and connective tissue texture. Sensory evaluation scores: 0 = too tough; 50 = just about right (ideal score); 100 = too tender.

³Sensory evaluation scores: 0 = dislike extremely; 50 = neither like nor dislike; 100 = like extremely.

⁴Acceptability (%) = percentage of people accept the muscle ÷ total number of observations.

⁵Standard error of the least squares mean.

Table 2. Consumer (n = 84) visual evaluation rating of size, color, overall liking, and acceptability percentage for various beef shank cuts

Beef shank cuts	Raw weight (g)	Size ¹	Color ¹	Overall liking ²	Acceptability (%) ³
Fore shank					
A	724.31 ^b	52.51 ^c	54.17	63.79 ^{ab}	95.37 ^a
B	881.18 ^a	67.50 ^a	59.26	58.68 ^{bc}	84.82 ^b
C	881.48 ^a	59.89 ^b	55.80	67.45 ^a	96.53 ^a
Hind shank					
D	435.17 ^c	32.11 ^d	55.69	52.99 ^c	74.11 ^b
E	936.06 ^a	68.49 ^a	53.32	59.05 ^{bc}	84.82 ^b
F	864.77 ^a	67.41 ^a	50.99	59.16 ^{bc}	84.82 ^b
SEM ⁴	35.43	2.00	2.51	3.06	3.58
<i>P</i> -value	<0.01	<0.01	0.21	0.02	<0.01

^{a-d}Least squares means without a common superscript differ ($P < 0.05$).

¹Visual evaluation scores: 0 = too small/too light; 50 = just about right (ideal score); 100 = too large/too dark.

²Visual evaluation scores: 0 = dislike extremely; 50 = neither like nor dislike; 100 = like extremely.

³Acceptability (%) = percentage of people accept the muscle ÷ total number of observations.

⁴Standard error of the least squares mean.

Table 3. Warner-Bratzler shear force values, L*, a*, and b* in color measurement, and cooking loss percentage for various beef shank cuts

Beef shank cuts	Warner-Bratzler shear force, kg	L* ¹	a* ²	b* ³	Cooking loss (%) ⁴
Fore shank					
A	3.30 ^b	45.50 ^b	24.41	16.06	30.95 ^b
B	8.85 ^a	45.86 ^b	24.53	16.48	28.96 ^c
C	3.31 ^b	45.59 ^b	25.26	16.22	33.05 ^a
Hind shank					
D	3.90 ^b	47.72 ^a	25.64	17.28	29.06 ^c
E	3.65 ^b	45.84 ^b	24.07	16.30	33.63 ^a
F	3.89 ^b	43.44 ^c	23.78	15.85	27.92 ^c
SEM ⁵	0.28	0.65	0.83	0.56	0.82
<i>P</i> -value	<0.01	<0.01	0.54	0.47	<0.01

^{a-c}Least squares means without a common superscript differ ($P < 0.05$).

¹L* = lightness (0 = black and 100 = white).

²a* = redness (-60 = green and 60 = red).

³b* = blueness (-60 = blue and 60 = yellow).

⁴Cooking loss (%): [(raw weight - cooked weight) ÷ raw weight] × 100.

⁵Standard error of the least squares mean.

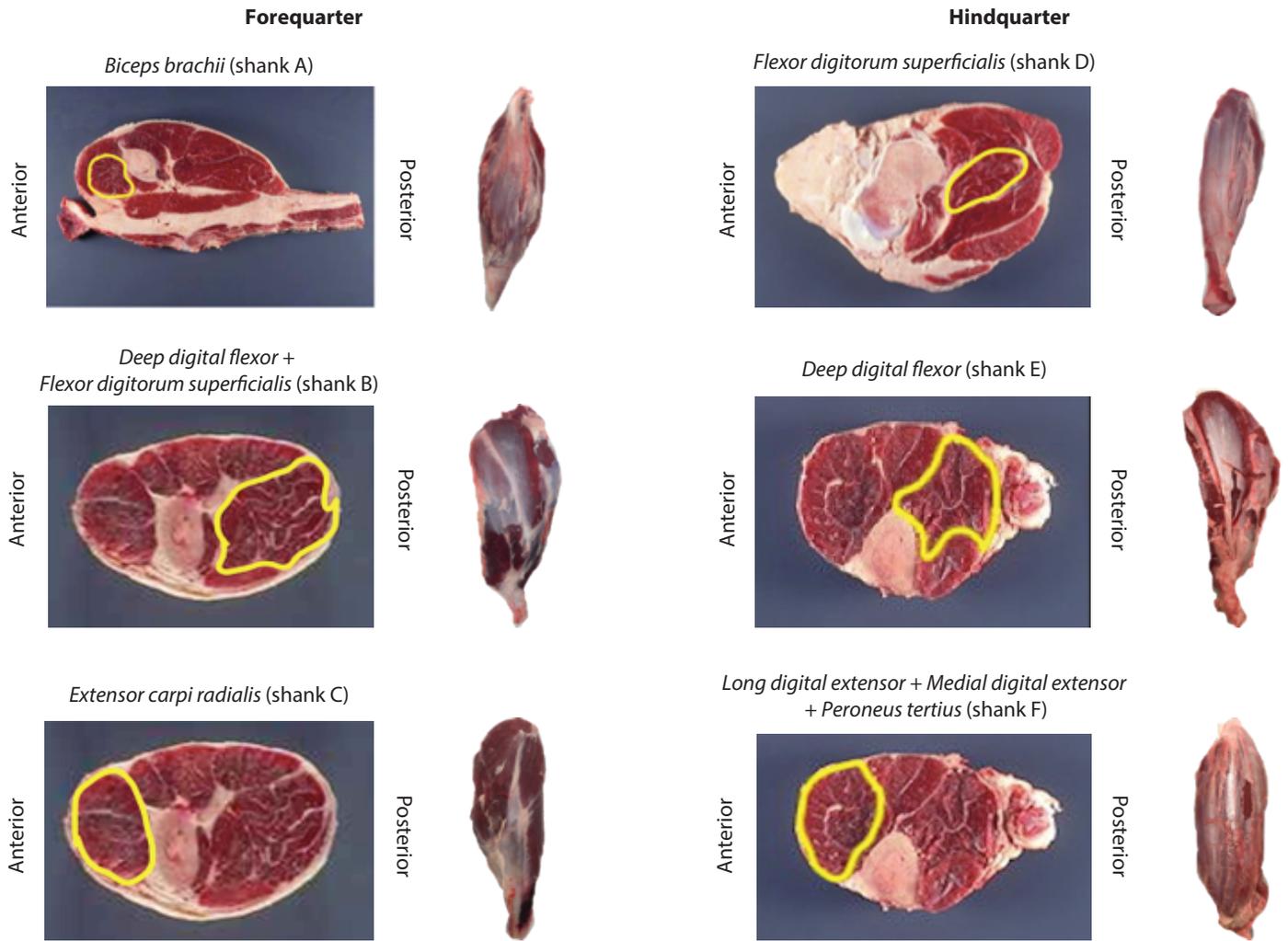


Figure 1. Cross-section of the anatomical location of 6 different beef shank cuts (left; courtesy of Bovine Myology), and the whole-muscle cut (right) corresponding to each shank cut utilized in this study.

Acknowledgments

Listed below are individuals, organizations, and firms that have contributed to the beef research program through financial support, product donations, or services. We appreciate your help!

ADM Animal Nutrition, Quincy, Illinois
Adisseo, Alpharetta, Georgia
Agri-Trails Coop, Tampa, Kansas
Alltech, Nicholasville, Kentucky
American Angus Association,
St. Joseph, Missouri
American Hereford Association,
Kansas City, Missouri
American Simmental Association,
Bozeman, Montana
Angus Foundation, St. Joseph, Missouri
Bayer Animal Health,
Shawnee Mission, Kansas
Lee Borck, Larned, Kansas
Cargill Corn Milling (Sweet Bran),
Blair, Nebraska
Cargill Meat Solutions, Wichita, Kansas
Cattlemen's Beef Board,
Centennial, Colorado
Certified Angus Beef, Wooster, Ohio
Elanco Animal Health,
Indianapolis, Indiana
Global Food Systems Initiative,
Manhattan, Kansas
H.J. Baker & Bro. Inc., Tuscola, Texas
Innovative Livestock Services, LLC,
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Iowa Limestone Company,
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Kansas Artificial Breeding Service Unit,
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Kansas Beef Council, Topeka, Kansas
Kansas Livestock Association,
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Kenny Knight, Lyons, Kansas
Lhoist North America, Fort Worth, Texas
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(LMIC), Manhattan, Kansas
Merck Animal Health,
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Merial Limited, Duluth, Georgia
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MS-Biotec, Wamego, Kansas
National Cattlemen's Beef Association,
Centennial, Colorado
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