CATTLEMEN'S DAY 2011

BEEF CATTLE RESEARCH

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CATTLEMEN'S DAY 2011

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Contents

Biological Variability and Chances of Error

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

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

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

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

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

Nutrient Restriction Does Not Affect Implant Efficacy

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Introduction

Anabolic implants in finishing beef cattle offer significant return on investment. Anabolic implants improve average daily gain feed efficiency in pasture and feedlot cattle. One way growth-promoting implants stimulate growth is through increasing production of insulin-like growth factor 1. This hormone causes muscle cells to increase their uptake of glucose and amino acids from the bloodstream.

Plasma urea nitrogen is a simple measure of the protein nutritional status of animals. If lean growth is stimulated, more feed protein is utilized and retained as body protein, reducing the amount of circulating plasma urea nitrogen. If an animal is stressed and is not growing, more of the feed protein is broken down, processed, and excreted as urea nitrogen.

Cattle usually are processed and implanted upon arrival at most feed yards. At that time, many calves are stressed by transport, changes in environment, and changes in feeding routine. These cattle have lower than normal feed intakes for up to 3 weeks after arrival at the feedlot and can subsequently become immunocompromised. Stress or infection can lead to weight loss and increased muscle protein breakdown.

The response of the body to implants is to stimulate nutrient uptake by tissues, which is normally measured as increased insulin-like growth factor 1 and decreased plasma urea nitrogen in healthy, non-stressed cattle. However, if nutrients are not in excess, it is not known what effect the external growth stimulation by implants may have on the body. Given the anabolic nature of implants, it is conceivable that implants may be counter-productive when the nutrient requirements of the animal are not met. The objective of our study was to evaluate the impact that anabolic implants have on animals that are in a restricted nutritional state.

Experimental Procedure

Sixteen 650-lb crossbred beef steers were used in this study. All cattle were weighed and processed at receiving. The steers were fed a common, pelleted, wheat middlings-based growing diet (15.3% crude protein; NEg 0.39 Mcal/lb) for the duration of the study. The study was designed as a 2 × 2 factorial arrangement of treatments. Four calves each were randomly assigned to: (1) implant (Revalor XS; Intervet/Schering-Plough, Inc., Millsboro, DE) + 2x maintenance intake, (2) implant (Revalor XS) + 1x maintenance intake, (3) no implant + 2x maintenance intake, or (4) no implant + 1x maintenance intake. Cattle were fed for 28 days. Blood samples were drawn on days 0, 14, and 28 for analysis of plasma urea nitrogen and insulin-like growth factor 1.

Results and Discussion

No diet x implant interactions arose in our analysis of calf body weights (P=0.23). Calves that were fed at 2x maintenance had greater (P<0.01) body weights at the end of the study than the calves fed at 1x maintenance. Diet also affected average daily gain (P<0.05; 3.63 vs. 0.09 lb/day for 2x maintenance vs. 1x maintenance, respectively). By design the restricted cattle were fed only to maintain their weight, which was accomplished. Implant status did not affect average daily gain (P=0.45).

Plasma urea nitrogen decreased (P=0.01) in the cattle fed only to maintain their weight compared to those fed at 2x maintenance (Figure 1), which is as expected because the restriction was designed to meet only maintenance protein and energy requirements. Therefore, we would not expect a great deal of circulating nitrogen. However, an interaction occurred between diet and implant status in plasma urea nitrogen (P=0.09) on day 28. Plasma urea nitrogen was greater (P<0.05) in full-fed, implanted calves than in restricted, non-implanted calves, with other treatments being intermediate and not different from either.

No interaction occurred between diet and implant status on day 28 in insulin-like growth factor 1 (P=0.33), and plasma insulin-like growth factor 1 levels in calves fed only to maintain body weight were lower (P<0.05) than in calves fed at 2x maintenance (Figure 2). This is as expected because previous research has demonstrated that when healthy calves are restricted in nutrient intake, insulin-like growth factor 1 decreases[1]. In contrast to previous research, however, plasma insulin-like growth factor 1 was not affected by implant status (P=0.41), which agrees with the lack of gain response to implants in the present study. Normally, implanted calves have elevated insulin-like growth factor 1 levels compared to non-implanted calves, accompanied by greater daily gain. The hypothesis was that the implants would have caused increased insulin-like growth factor 1 in nonrestricted-fed calves but not in the restricted-fed calves; however, this was not the case.

Implications

As expected, nutrient intake affected growth rate, plasma urea nitrogen, and insulin-like growth factor 1, but implant status did not substantially alter the effects of nutrient restriction on these measures. Additional work will assess whether other circulating factors could influence muscle growth in response to implants at different levels of nutrition.

[1] Reinhardt, C.D. 1991. Metabolic indices for growth: Endocrine profile of steers on various nutritional and growth promotional regimes. Texas A&M University, College Station, TX.

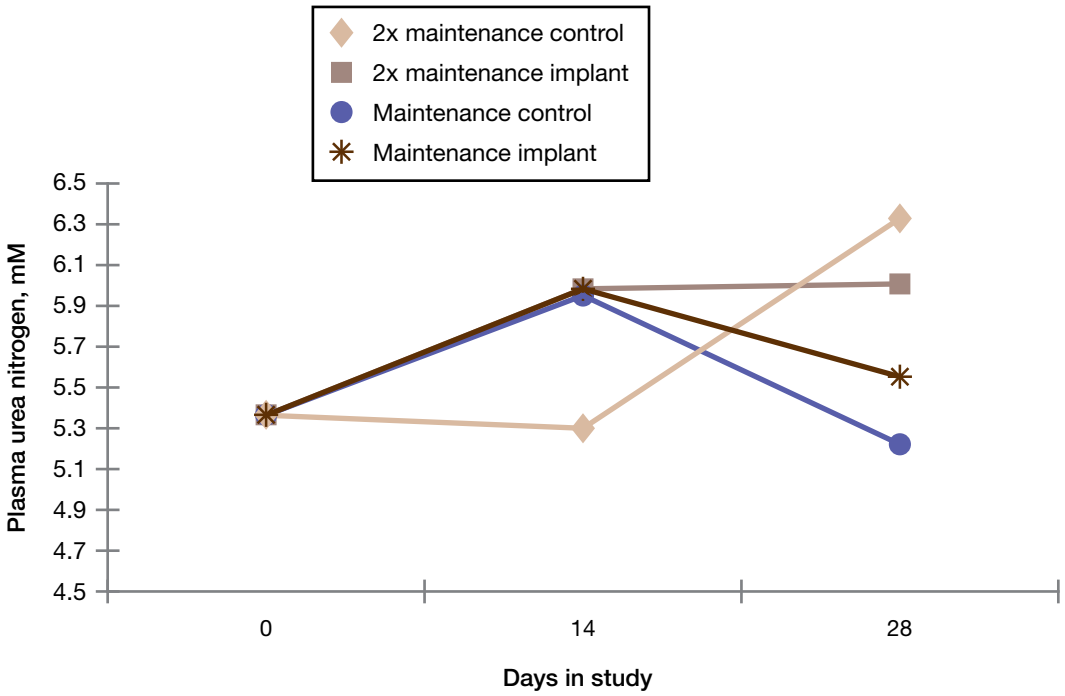

Figure 1. Plasma urea nitrogen affected by level of feed intake and implant status (diet P=0.01; implant P=0.54; diet × implant P=0.09).

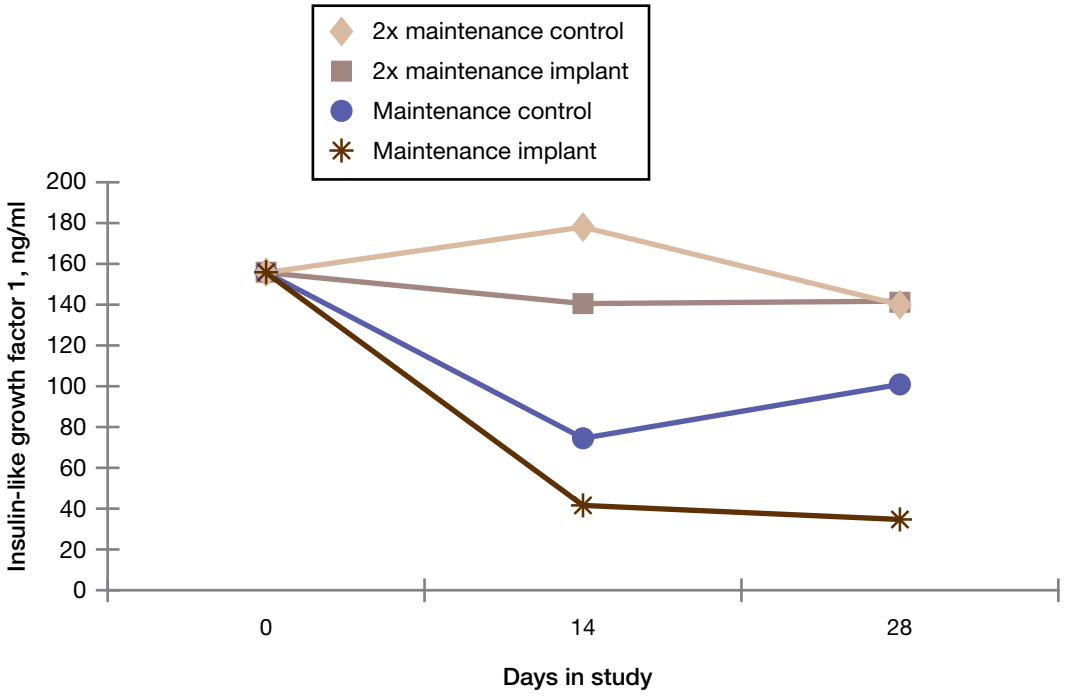

Figure 2. Plasma insulin-like growth factor 1 as affected by level of feed intake and implant status (diet P<0.01; implant P=0.41; diet × implant P=0.33).

Length of Weaning Period But Not Timing of Vaccination Affects Feedlot Finishing Performance and Carcass Characteristics of Fall-Weaned, Ranch-Direct Beef Calves

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Introduction

Bovine respiratory disease decreases profitability associated with cattle feeding. The cost of respiratory disease includes death loss, expenses associated with treatment, and reduced growth performance. Respiratory disease also decreases carcass weights, USDA quality grade, and ribeye area of feedlot cattle. Decreased carcass weights, fat thickness, and ribeye area have been associated with treatment of apparent respiratory disease when compared to animals not treated, whereas reduced incidence of the disease resulted in improved carcass merit. Preshipment weaning and vaccination has been found not only to prepare calves for improved performance in feedlots, but also to reduce incidence and severity of respiratory disease.

Previous KSU research reported that length of the preshipment weaning period influenced carcass characteristics and time on feed during finishing. Therefore, we hypothesized that vaccination strategy and the length of the preshipment weaning period would interact to influence calf performance during finishing as well as subsequent carcass characteristics. The objective of our experiment was to compare the effects of respiratory disease vaccination administered prior to weaning on the ranch of origin or after feedlot arrival for calves weaned 45, 15, or 0 days before feedlot arrival.

Experimental Procedures

Angus x Hereford calves (n = 437; average initial weight 458 $\pm$ 54 lb) were used for this experiment. Calves originated from the Kansas State University Commercial Cow-Calf Unit herds in Manhattan (n = 263) and Hays (n = 174). At the time of maternal separation, calves were 175 to 220 days of age. All calves were dehorned and castrated (if needed) prior to 60 days of age.

Approximately 60 days prior to maternal separation, calves were weighed, stratified by birth date, and randomly assigned to a preshipment weaning period treatment (i.e., 45, 15, or 0 days). Within each weaning period treatment, calves were randomly assigned to 1 of 2 vaccination treatments. One group was vaccinated 14 days prior to maternal separation and again at weaning. The second group was vaccinated on the day of arrival at the feedlot and again 14 days later. Initial and booster vaccinations against IBR, BVD, PI3, and BRSV were administered using a modified-live product (Bovi-Shield Gold FP, Pfizer Animal Health, Exton, PA).

Calves were treated for internal and external parasites using Dectomax (Pfizer Animal Health, Exton, PA) and vaccinated against clostridial diseases (Vision 7 with SPUR,

Intervet Inc., Millsboro, DE) at the time of maternal separation. Calves at both locations were immediately transported a short distance (<15 miles) to a central home-ranch weaning facility.

Calves were maintained in dirt pens (4 pens per treatment) and fed a common weaning diet during the preconditioning period. The byproduct-based diet was formulated to allow for weight gain of 2 lb/day at a dry matter intake of 2.5% of body weight.

All calves were individually weighed and transported 4 hours from their respective weaning facilities to an auction market in Hays, KS, on November 5, 2008. Calves from both origins were commingled and maintained on the premises for 12 hours to simulate pathogen exposure typically encountered by market-ready calves. On November 6, calves were shipped 5 miles to the feedlot at the Agricultural Research Center–Hays. Upon arrival at the feedlot, calves were weighed individually and assigned to a receiving pen based on weaning and vaccination treatments. The cattle were adapted to a sorghum grain/silage-based receiving diet and fed for a 60-day receiving period.

Calves were monitored for symptoms of respiratory disease at 7:00 a.m. and 2:00 p.m. daily during the experiment. Calves with clinical symptoms of disease (Table 1) were removed from home pens and evaluated. Animal caretakers weighed, measured rectal temperatures, and assigned clinical illness scores (Table 1) to these calves. Calves that presented a clinical illness score greater than 1 and a rectal temperature greater than 104° F were treated according to the schedule described in Table 2. Cattle were evaluated 72 hours post-treatment and re-treated based on observed clinical signs.

Following the receiving phase, calves were adapted to a common finishing diet over a 21-day period (Table 3). Steers remained in their respective receiving pens during finishing. After 165 days on feed, steers were scanned ultrasonically to determine subcutaneous fat thickness over the 12th rib. Steers were assigned to 1 of 3 harvest dates based on this scan to meet an average carcass endpoint of 0.45 inches of fat depth over the 12th rib. Calves were transported approximately 3 hours to a commercial abattoir on their respective harvest date. At the abattoir, lungs were examined for lesions and livers were examined for abscesses. After carcasses were chilled for 48 hours, carcass characteristics were measured by a trained evaluator unaware of treatments. Carcass measurements included 12th rib fat thickness; ribeye area at the 12th rib; kidney, pelvic, and heart fat; USDA maturity grade; USDA yield grade; USDA quality grade; and marbling score.

Results and Discussion

Average daily gain during finishing was greater ($P<0.01$) for calves weaned for 45 or 15 days before shipping compared to calves weaned for 0 days before shipping (Figure 1), whereas average daily gain was similar ($P=0.26$) between calves vaccinated for respiratory disease-causing organisms before shipping and those vaccinated for disease-causing organisms at feedlot arrival (Figure 2). Calves weaned 45 days before shipping required fewer ($P=0.02$) days on feed than calves weaned 15 or 0 days before shipping (Figure 3). Longer weaning periods were associated with improved average daily gain and translated into fewer days on feed. This finding is consistent with previous Kansas State University experiments. Consequently, calves weaned 45 days before shipping

had greater (P<0.01) harvest weights than calves weaned 15 or 0 days before shipping (Figure 4). Timing of respiratory disease vaccination did not affect feedlot growth performance in this experiment.

Hot carcass weight was greater (P<0.02) for calves weaned 45 and 15 days prior to shipping than for calves weaned 0 days before shipping (Table 4). This increase was attributed to greater feedlot performance. Marbling score, USDA yield grade, 12th rib fat thickness, ribeye area at the 12th rib, and kidney, pelvic, and heart fat were similar (P≥0.22) between weaning and vaccination treatments (Tables 4 and 5). Deposition of internal or external fat for our ranch-direct calves was not influenced by preshipment weaning length or timing of vaccination. Likewise, incidence of liver abscesses was similar (P<0.47) between weaning and vaccination treatments. Incidence of lung lesions was not affected (P>0.81) by weaning treatment; however, cattle vaccinated for respiratory disease after arrival in the feedlot tended (P<0.09) to have greater incidence of lung lesions than cattle vaccinated for respiratory disease before shipping. Deferring BRD vaccination until feedlot arrival may allow subclinical respiratory disease incidence to occur in such animals.

Implications

A preconditioning period was found to increase steer average daily gain and harvest weight. Therefore, this increase in growth decreased days on feed but had minimal effect on carcass traits. Carcass weight, carcass merit, and growth performance during finishing were similar between calves weaned for 45 days or 15 days before shipping. Preshipment respiratory disease vaccination did not improve growth performance or carcass merit of ranch-direct cattle relative to vaccination deferred until feedlot arrival. Length of preshipment weaning period had greater effects on performance and carcass merit than vaccination timing. Deferred respiratory disease vaccination potentially caused an increase in observed lung lesions upon slaughter.

Table 1. Scoring system used to classify the severity of clinical illness

Clinical illness score	Description	Clinical appearance
1	Normal	No abnormalities noted
2	Slightly ill	Mild depression, gaunt, +/- cough
3	Moderate illness	Severe depression, labored breathing, ocular/nasal discharge, +/- cough
4	Severe illness	Moribund, little response to human approach

Table 2. Treatment schedule used to treat calves diagnosed with bovine respiratory disease complex

Treatment	Drug	Dose	Route of injection
1st Pull	Baytril[1] (enrofloxacin)	5 mL/cwt	Subcutaneous
2nd Pull	Nuflor[2] (florfenicol)	6 mL/cwt	Subcutaneous
3rd Pull	Biomycin 200[3] (oxytetracycline)	5 mL/cwt	Subcutaneous

[1] Bayer Animal Health, Shawnee Mission, KS
[2] Intervet/Schering-Plough Animal Health, Summit, NJ
[3] Boehringer Ingelheim Vetmedica, Inc., St. Joseph, MO

Table 3. Average ingredient and nutritional composition of the finishing diet

Ingredient	%, dry matter basis
Ground sorghum grain	80.86
Sorghum silage	14.81
Soybean meal	3.23
Limestone	0.50
Rumensin 80[1]	0.30
Ammonium sulfate	0.11
Salt	0.10
Tylan[1]	0.09
Nutrient composition	
Crude protein, %	13.43
Calcium, %	0.32
Phosophorus, %	0.33
NEm, Mcal/lb	0.86
NEg, Mcal/lb	0.57

[1] Elanco Animal Health, Greenfield, IN

Table 4. Carcass characteristics of beef calves following ranch-of-origin weaning periods lasting 0, 15, or 45 days

	Length of weaning period, days				
Item	0	15	45	SEM	P-value
Hot carcass weight, lb	741[b]	763[c]	781[d]	9.884	0.02
Marbling score[a]	47.9	46.6	49.1	1.033	0.22
USDA yield grade	3.3	3.2	3.4	0.081	0.33
12th rib fat thickness, in.	0.54	0.54	0.54	0.018	0.20
Ribeye area, in.^{2}	12.3	12.4	12.5	0.177	0.74
Kidney, pelvic, and heart fat, %	2.66	2.56	2.64	0.081	0.56
Calves with ≥1 liver abscess, %	18.68	23.38	25.35	-	0.47
Calves with ≥1 lung lesion, %	34.38	32.14	29.73	-	0.81

[a] Marbling score: 30 = Slight^{00}, 40 = Small^{00}, 50 = Modest^{00}; ex. 55 = Modest^{50}.
[bcd] Treatment means within row that share common superscript are similar.

Table 5. Carcass characteristics of beef calves vaccinated against respiratory disease pathogens prior to shipping or at feedlot arrival

	Vaccination timing			
Item	Preshipment	Feedlot arrival	SEM	P-value
Hot carcass weight, lb	763	759	7.304	0.73
Marbling score[a]	47.4	48.4	0.763	0.36
USDA yield grade	3.3	3.3	0.060	0.59
12th rib fat thickness, in.	0.52	0.54	0.014	0.23
Longissimus area, in.^{2}	12.4	12.4	0.132	0.90
Kidney, pelvic, and heart fat, %	2.59	2.65	0.060	0.50
Calves with ≥1 liver abscess, %	24.79	19.67	-	0.63
Calves with ≥1 lung lesion, %	27.20	37.21	-	0.09

[a] Marbling score: 30 = Slight^{00}, 40 = Small^{00}, 50 = Modest^{00}; ex. 55 = Modest^{50}.

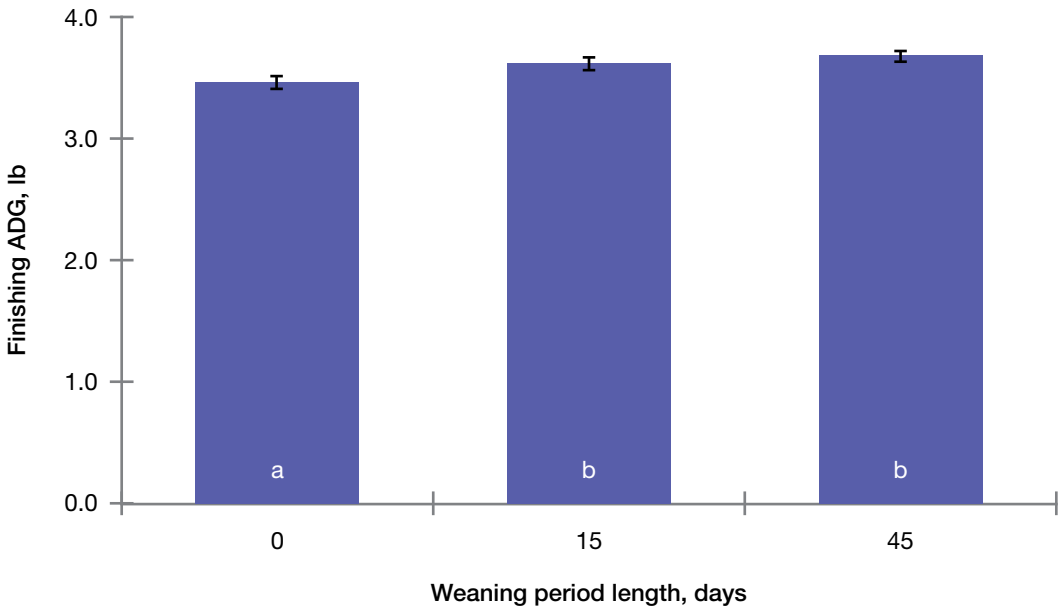

Figure 1. Effect of the length of ranch-of-origin weaning period on finishing average daily gain (ADG) of beef steers.

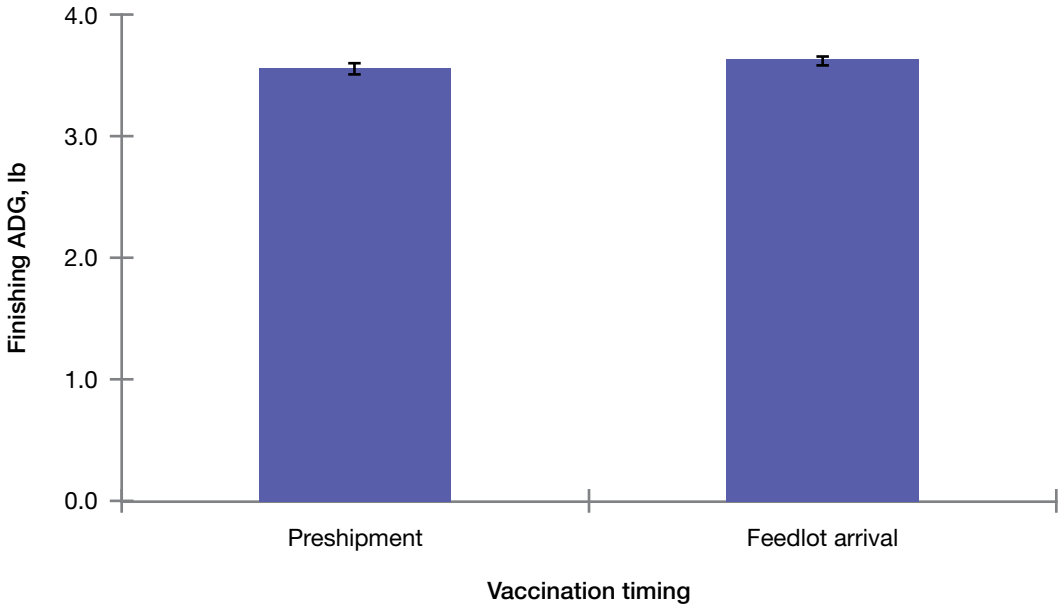

Figure 2. Effect of respiratory disease vaccination timing on finishing average daily gain (ADG) of beef steers.

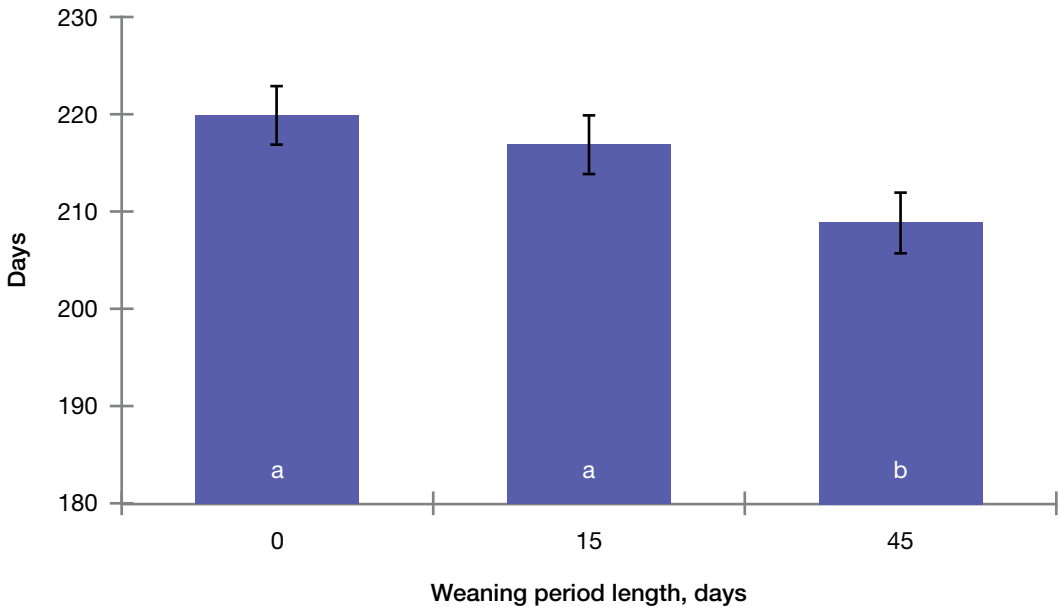

Figure 3. Effect of length of ranch-of-origin weaning period on days on feed until harvest.

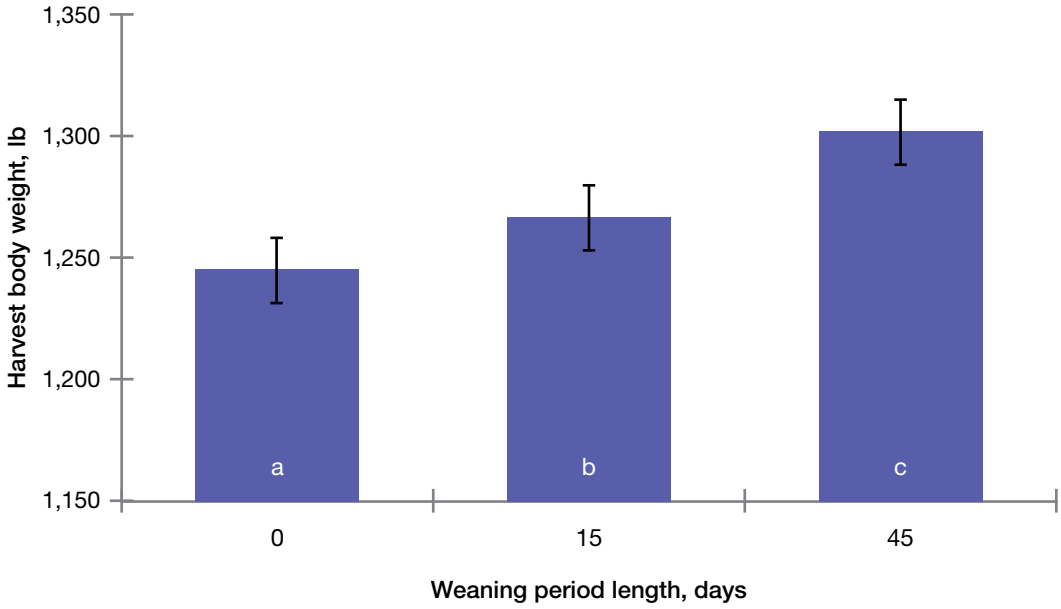

Figure 4. Effect of length of ranch-of-origin weaning period on harvest body weight of beef steers.

Relationship Between Ultrasonically Measured Beef Cow Carcass Traits and Lifetime Productivity

L.A. Pacheco, J.R. Jaeger, J. Minick-Bormann, and K.C. Olson

Introduction

Ultrasound is widely used in seed stock production, commercial operations, and in feed yards to predict carcass merit. It also has been used to assess the value of individuals as parents in the seed stock industry. Ultrasound has several advantages as a technique to evaluate body composition: it is relatively inexpensive; it produces results more rapidly compared to progeny testing programs; and data are less prone to selection bias than direct carcass data collection. Ultrasound measures of ribeye area and proportion of intramuscular fat are accurate predictors of their corresponding carcass traits in fed slaughter cattle. Thus, average heritability estimates of ultrasonically measured ribeye area and intramuscular fat are moderate to high. Moderate to high heritability allows seed stock breeders to select replacement animals with confidence based on ultrasound measurements.

A large body of research has evaluated the use of sire and ultrasound measures as predictors of progeny carcass measurements and growth. In contrast, little research has examined the use of ultrasonically measured compositional traits as a means of predicting cow productivity and subsequent progeny performance. The objective of our experiment was to examine the use of ultrasound measures of intramuscular fat and ribeye muscle depth as a means of predicting lifetime cow productivity and progeny performance. Specifically, we wished to determine whether ultrasound measurements of intramuscular fat and ribeye muscle depth obtained from yearling heifers were related to calf birth weight, calf weaning weight, cow pregnancy rate, and calving interval.

Experimental Procedures

Angus-cross heifers (n = 160) were retained from the KSU Agricultural Research Center–Hays herd or purchased from two sources with similar genetics and breeding seasons and managed as a contemporary group. Females were developed in a drylot and had free-choice access to a grower diet and clean water. At approximately 1 year of age, measurements of heifer intramuscular fat and ribeye muscle depth at the 12th to13th rib interface were obtained by an experienced technician. Ultrasound images were generated using an Aloka 500V (Aloka Co., Ltd, Wallingford, CT). Images were collected by a single technician with software from the Cattle Performance Enhancement Company (CPEC, Oakley, KS). Backfat thickness, intramuscular fat, and ribeye muscle depth were estimated using image analysis software integral to the CPEC product. Marbling scores were coded such that 4.0 = slight^{00} (low select) and 5.0 = small^{00} (low choice). Measurements of intramuscular fat and ribeye muscle depth from yearling heifers were categorized into low, medium, and high groups (<3.88%, 3.88 to 5.33%, and >5.33%, respectively, for intramuscular fat and <17.24 in., 17.24 to 20.48 in., and >20.48 in., respectively, for ribeye muscle depth).

Following breeding at approximately 14 months of age, heifers were managed in a spring-calving, native range-based production system with a 12-month calving interval for the duration of the 4-year study (2004 to 2007). Each year, females were mass-mated following estrous synchronization and exposed to Angus bulls 10 days later for the duration of a 45-day breeding season. Pregnancy rate to artificial insemination (AI) was determined 31 to 35 days after fixed-time AI with transrectal ultrasonography. Cows were examined for pregnancy in August each year via rectal palpation and non-pregnant females were removed from the herd. Calves were weighed at birth and weaning. Weaning weights were adjusted for age of calf, age of dam, and sex of calf.

Results and Discussion

Pregnancy rate was not related to cow intramuscular fat, ribeye muscle depth, or intramuscular-fat grouping ($P>0.05$); however, more cows became pregnant in the high and medium ribeye muscle depth grouping compared to the low ribeye muscle depth grouping ($P<0.04$; Table 1). Heavier muscling may be associated with greater fertility. In contrast, heavier muscling may have been secondary to a superior plane of nutrition between weaning and breeding. Calving interval was not related to cow intramuscular fat, ribeye muscle depth, intramuscular fat grouping, or ribeye muscle depth grouping ($P>0.05$).

Calf body weight at birth was not related to dam intramuscular fat, ribeye muscle depth, intramuscular fat grouping, or ribeye muscle depth grouping ($P>0.05$). Calf 205-day adjusted body weight was not related to dam ribeye muscle depth, intramuscular-fat grouping, or ribeye muscle depth grouping ($P>0.05$); however, calf 205-day adjusted calf body weight increased as dam intramuscular fat increased ($P<0.05$). These data suggest that heifer intramuscular fat was associated with greater progeny body weight at weaning. Based on these data, each 1% increase in intramuscular fat was associated with an 8.58-lb increase in calf body weight at weaning. Cow intramuscular fat was not related to pregnancy rate, calf birth weight, or calving interval. Moreover, cow ribeye muscle depth and intramuscular fat grouping were not related to pregnancy rate, calf birth weight, calf 205-day adjusted body weight, or calving interval.

Implications

Ultrasound measures of ribeye muscle characteristics in yearling heifers can predict some aspects of cow and calf performance. Further analyses appear to be warranted as more production records are obtained from these females.

Table 1. Relationship between ribeye muscle depth in heifers at 1 year of age and production measures collected from 2 to 5 years of age

	Ribeye muscle depth group*, mean ± SE		
Trait	Low (<17.24 in)	Medium (17.24 to 20.48 in)	High (>20.48 in)
Calf birth weight, lb	82 ± 2.2	79 ± 0.7	78 ± 1.5
Calf 205-day adjusted body weight, lb	512 ± 14.5	526 ± 9.7	535 ± 12.5
Calving interval, days	351 ± 5.1	344 ± 4.0	346 ± 4.9
Pregnancy rate, %	78.0[a]	91.0[b]	88.0[b]

* Ribeye muscle depth was measured at approximately 1 year of age with ultrasound; heifers were categorized into high, medium, or low ribeye muscle depth groups.

[ab] Within a row, means without a common superscript differ at P<0.05.

Table 2. Relationship between amount of intramuscular fat in the ribeye mucle in heifers at 1 year of age and production measures collected from 2 to 5 years of age

	Intramuscular fat group*, mean ± SE		
Trait	Low (<3.88%)	Medium (3.88 to 5.33%)	High (>5.33%)
Calf birth weight, lb	79 ± 1.5	81 ± 0.7	79 ± 1.5
Calf 205-day adjusted body weight, lb	519 ± 11.7	526 ± 10.0	537 ± 12.8
Calving interval, days	344 ± 4.7	346 ± 4.2	342 ± 4.7
Pregnancy rate, %	92.7	89.4	84.9

* Intramuscular fat in the ribeye muscle was measured at the 12th to 13th rib interface at approximately 1 year of age with ultrasound. Heifers were categorized into high, medium, or low intramuscular-fat groups.

Optimizing a New 5-day CIDR-CO-Synch Timed Artificial Insemination Program

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Introduction

The 7-day CO-Synch + CIDR protocol is a popular ovulation-synchronization program used by cow-calf producers to facilitate artificial insemination (AI). A progesterone-impregnated controlled internal drug release (CIDR) insert is placed intravaginally and an injection of gonadotropin-releasing hormone (GnRH) is given. After 7 days, prostaglandin $F_{2\alpha}$ ($PGF_{2\alpha}$) is administered and the CIDR insert is removed. Between 58 and 72 hours after insert removal, cows are inseminated after another injection of GnRH to induce ovulation. Timed AI pregnancy rates generally have ranged from 40 to 60% when suckled cows are treated with the 7-day CO-Synch + CIDR protocol.

Reducing the period of follicular dominance in a 5-day compared with a 7-day CIDR insert program resulted in a new follicular wave producing a younger dominant follicle. When a CIDR insert is placed at the beginning of the protocol and removed after 7 days at the same time $PGF_{2\alpha}$ is injected, the newly developed dominant follicle is approximately 5 days old. In contrast, when the CIDR insert is removed after 5 days, the newly developed dominant follicle is smaller in diameter and 2 days younger. Concentrations of progesterone decline when the corpus luteum regresses in response to $PGF_{2\alpha}$ and the exogenous source of progesterone in the CIDR insert is removed. The dominant follicles then mature in both scenarios and secrete sufficient estradiol to cause estrus. The younger and smaller follicle must develop longer in a low-progesterone proestrous environment that is more favorable to produce a more fertile egg. Actual comparisons of fertility of 5- vs. 7-day CIDR programs have generally shown improved fertility for the 5-day program when applied to suckled beef cattle.

The disadvantage of the 5-day program is the corpus luteum that develops in response to the GnRH injection given at CIDR insertion is less responsive to $PGF_{2\alpha}$ because it is younger and less mature. Therefore, to make a 5-day program successful, a second or larger dose of $PGF_{2\alpha}$ must be given. The objective of this study was to determine whether a single large or double dose of $PGF_{2\alpha}$ would be as effective as two doses given 8 hours apart. The control was a single dose of $PGF_{2\alpha}$ at CIDR insert removal.

Experimental Procedures

This study was part of a multi-location study in which more than 2,420 cows were treated in 13 different locations in 8 states. The study was conducted in lactating postpartum beef cows. Three locations of cows were treated in Kansas: (1) Purebred Angus, Hereford, and Simmental cows at the Kansas State University Purebred Beef Unit; (2) Angus x Hereford cows at the Kansas State University Commercial Cow-Calf Unit; and (3) Angus cows at the Kansas State University Agricultural Research Center–Hays. Cows were allotted randomly to treatments based on breed, age (primiparous vs.

multiparous), and days postpartum at the onset of the treatment scheme. In total, we treated 591 cows at our Kansas locations.

Treatments

On day -5, cows were assigned a body condition score (1 = thin; 9 = very fat), were administered 100 μg GnRH (Factrel; Pfizer Animal Health, New York, NY), and received an intravaginal progesterone-releasing CIDR insert (Pfizer Animal Health; Figure 1). On day 0, CIDR inserts were removed and cows received 1 of 3 treatments of $PGF_{2\alpha}$ at the time of CIDR insert removal: (1) two doses (2 x 5 mL) of Lutalyse (Pfizer Animal Health) 8 hours apart with the initial injection administered at CIDR insert removal (2 x 8 hours), (2) double dose (10 mL) of Lutalyse (Double dose), or (3) one dose (5 mL) of Lutalyse (Single dose). All cows were inseminated 72 hours after CIDR removal concurrent with another 100-μg injection of GnRH. Cleanup bulls were placed with cows no sooner than 12 days after timed AI or cows were observed for estrus and reinseminated (Purebred Beef Unit). The breeding season averaged 65 days in duration, but ranged from 45 to 96 days across locations.

Cyclicity

Blood samples were collected on day -15 and -5 (CIDR insertion) to determine concentrations of progesterone (Figure 1). At the Purebred Beef Unit, additional blood samples were collected on days 0 and 3 to determine if the corpus luteum regressed (luteolysis) in response to treatment.

Tail paint scoring

At CIDR insert removal all cows were marked with tail paint (Aerosol Tell Tail, FIL Agritech, Homer, NY). At timed AI, tail paint scores were assessed: 1 = tail paint was completely gone; 2 = tail paint was partially gone, obvious signs of mounting; 3 = tail paint was undisturbed, no signs of mounting.

Pregnancy diagnosis

Pregnancy rates were determined via transrectal ultrasonography (Aloka 500V, 5 MHz rectal transducer, Wallingford, CT) between 33 and 35 days after timed AI. Overall breeding season pregnancy rates and embryonic losses after the initial positive pregnancy diagnosis were determined between 35 and 45 days after the end of the breeding season via ultrasonography.

Results and Discussion

Only 42.8% of the cows enrolled in the study had previous elevated concentrations of progesterone on either day -15, day -5, or both, and were considered to be cycling by day -5 when the timed AI program was initiated. Pregnancy rates per AI were greater for cows that were cycling compared with noncycling cows (53.4% vs. 45.6%, respectively). Cycling cows (n = 249) were 1.5 times (95% confidence intervals = 1.17 to 2.3) more (P=0.02) likely to become pregnant after the timed AI than noncycling cows (n = 335). Cows 3 or more years old (n = 419) were 1.6 times (95% confidence intervals = 1.0 to 2.4) more (P=0.035) likely to conceive after timed AI than 2-year-old cows (n = 165).

Proportion of cows having luteolysis after treatment did not differ (Table 1). Tail paint score did not differ among treatments, indicating that cows likely came into estrus at similar intervals after treatment and before AI. Timed AI pregnancy rates were greater (P=0.02) for cows receiving the two doses of $PGF_{2\alpha}$ administered 8 hours apart compared with a single dose (Table 1). Timed AI pregnancy rates in cows receiving the double dose of $PGF_{2\alpha}$ was intermediate and did not differ from the other 2 treatments. Pregnancy loss after the timed AI and final breeding-season pregnancy rates did not differ among treatments (Table 1).

More cows 3 or more years of age were pregnant at the end of the breeding season (2-year-olds = 79.4% vs. 3+year-olds = 93.8%). Cows 3 or more years old (n = 419) were 3.9 times (95% confidence intervals = 2.2 to 6.7) more (P<0.001) likely to be pregnant at the end of the breeding season than 2-year-old cows (n = 165). In addition, cows having body condition scores of 6 or more tended (P=0.07) to have had greater end-of-breeding season pregnancy rates at 90.9% compared with 88.6% for cows having body condition scores of 5 or less.

Our Kansas results were similar to those in the full study. Timed AI pregnancy rates were 55% (n = 800), 51% (n = 806), and 48% (n = 800) for the cows receiving the 2 doses (8 hours apart) of $PGF_{2\alpha}$, the double dose, and the single dose, respectively. Timed AI pregnancy rates were greater for cows receiving the two doses of $PGF_{2\alpha}$ administered 8 hours apart compared with a single dose. Timed AI pregnancy rates in cows receiving the double dose of $PGF_{2\alpha}$ was intermediate and did not differ from the other 2 treatments.

Implications

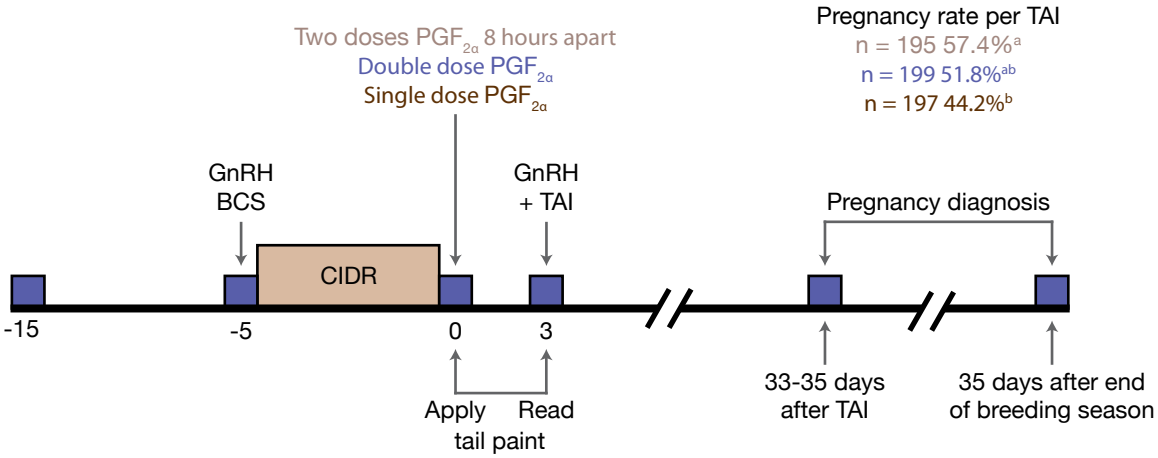
These results indicate that two doses of $PGF_{2\alpha}$ administered 8 hours apart are required to maximize timed AI pregnancy rates, but pregnancy rates were not different from those when the double dose of $PGF_{2\alpha}$ was given. The disadvantage of the 5- vs. 7-day CIDR-CO-Synch programs is the necessity of injecting the extra dose of $PGF_{2\alpha}$. Timed AI pregnancy rates may not justify the extra expense, but the 5-day program does offer a viable alternative to the 7-day program to produce timed AI pregnancy rates in excess of 50%.

Table 1. Responses to $PGF_{2\alpha}$ treatments in a 5-day CIDR-CO-Synch ovulation-synchronization program

Treatment	Luteolysis	Pregnancy rate	Pregnancy loss[1]	Final pregnancy rate
	Number/total (%)			
2 doses (8 hours apart)	49/51 (96.1[a])	112/195 (57.4[a])	4/112 (3.6[a])	176/193 (91.2[a])
Double dose	50/51 (98.0[a])	103/199 (51.8[ab])	5/104 (4.8[a])	175/198 (88.4[a])
Single dose	46/51 (92.0[a])	87/197 (44.2[b])	2/84 (2.4[a])	173/193 (89.6[a])

[ab] Means having different superscript letters within traits differ (P<0.05).

[1] Loss of the timed artificial insemination (AI) pregnancy after a positive pregnancy diagnosis was made between 33 and 35 days after AI.



GnRH = gonadotropin-releasing hormone (Factrel); $PGF_{2\alpha}$ = prostaglandin $PGF_{2\alpha}$ (Lutalyse); CIDR = intravaginal progesterone-releasing controlled drug release (EAZI-BREED CIDR); BCS = body condition score.

[abc] Means having a different superscript differ (P<0.05)

Figure 1. Five-day timed artificial insemination (TAI) program testing the appropriate mode of treatment of PGF2α to induce death of the corpus luteum before TAI.

Export Sales of U.S. Beef Semen Increased Faster than Domestic Semen Sales

S.K. Johnson and K.C. Dhuyvetter

Introduction

The use of artificial insemination (AI) in the dairy industry grew tremendously in the 1940s and has since become the industry norm. Adoption of AI in the beef industry has been much slower largely due to the more extensive nature of beef production systems. Improvements in protocols to synchronize estrus and ovulation now allow beef producers to achieve high pregnancy rates to AI with no heat detection and value-driven marketing programs have provided more incentive for use of high-accuracy genetics. The 2007 USDA National Animal Health Monitoring Surveillance survey reports the proportion of beef operations that use AI is only 7.6%. However, adoption of AI in herds of 200 head or greater was 19.8% compared to 5.6% and 8.4% for herd sizes of 1 to 49 and 50 to 99 head, respectively, indicating larger operations are more likely to adopt this technology.

Little information is available concerning changes in semen use over time in the beef industry and what this may reflect about the adoption of AI by beef producers. The purpose of this study was to examine trends in domestic, custom frozen, and export sales of semen over time and how these trends relate to beef feeder calf prices and cow inventories.

Experimental Procedures

Data from 1979 to 2009 on domestic, custom frozen, and export semen sales were obtained from the National Association of Animal Breeders website. We used USDA January 1 beef cow inventory records and 500- to 600-lb steer calf prices from Oklahoma City, OK, as reported by the Livestock Marketing Information Center. We estimated simple correlations between domestic semen sales, export semen sales, custom frozen semen, and calf prices. We utilized multiple regression models including calf prices and cow inventory values to describe domestic semen sales, custom frozen semen sales, and export semen sales.

Results and Discussion

Domestic semen use by breed (Figure 1) reflects the current dominance of the Angus breed in semen sales. Angus semen sales were consistently 37 to 42% of the total from 1979 until 1989, after which they steadily increased until reaching a plateau of about 75% of the market in 2005. The number of Angus registrations reported by the Purebred Livestock Council and the American Angus Association over the same time period was highly correlated (0.87) with domestic Angus semen sales. The proportion of Angus registrations recorded as AI-sired calves was 52.1% in FY 2009. During the time that sales of Angus semen have increased, sales of Hereford (polled and horned) and Continental (Charolais, Limousin, and Simmental) breeds have decreased both as a percentage of total sales and in absolute value.

Domestic beef semen sales are highly correlated to calf prices (Figure 2). Domestic beef semen sales and 500- to 600-lb October steer prices from Oklahoma City, OK, have a correlation coefficient of 0.70 from 1979 to 2009, which increases to 0.82 when evaluated between calf prices lagged one year and semen sales (e.g., 2009 semen sales vs. 2008 calf price). After accounting for average October steer calf price and January 1 beef cow inventory numbers, domestic semen sales have increased ($P<0.01$) since 1979 at the rate of 6,547 units per year (Table 1). The regression model of calf price, cow inventory number, and a year trend variable explains 80% of the variation in domestic sales of semen in the last 31 years (1979 to 2009).

Figure 3 shows the units of custom frozen, exported, and domestically sold semen. The correlation between calf price and units of custom frozen semen (0.67) is lower than for domestic semen sales (0.70). A model that accounts for year, October calf prices, and beef cow inventory numbers explains 93% of the variation in units of custom frozen semen (Table 1). Custom frozen semen sales have increased ($P<0.01$) since 1979 at the rate of 76,338 units per year. Custom collected semen often goes into storage and is never used, but the relative amount used or exported is unknown. Cow inventory and calf price are not significant factors in explaining semen export sales. Export sales of semen have increased at a rate of 38,536 units per year since 1979.

Implications

This analysis provides a perspective on industry use of genetics available via AI and adoption of AI as a technology in the beef industry. The market share of Angus semen for domestic use has increased significantly over the last 30 years whereas sale of semen from Continental breeds and Herefords have declined. Domestic use of semen is highly correlated with calf prices and has shown a modest upward trend since 1979. Historically, the domestic market has been considerably larger than the export market for semen sales; however, the sales growth rate of semen for export has been much greater than for domestic sales. The number of units of semen exported surpassed the number of units sold domestically for the first time in 2008 and again in 2009.

Table 1. Parameter estimates of units of semen sales and custom frozen semen models[a]

	Dependent variable		
Independent variables	Domestic sales[a]	Export sales[a]	Custom frozen[a]
Year	6,546.7	38,535.8	76,337.5
	(0.034)	(<0.001)	(<0.001)
Beef cow inventory, thousand head	46.88	32.79	220.40
	(<0.001)	(0.155)	(<0.001)
Calf price, $/cwt	9,002.2	211.4	10,635.2
	(<0.001)	(0.931)	(<0.001)
R^{2b}	0.80	0.80	0.93

[a] Values in parentheses are P-values indicating significance of variable's difference from zero.
[b] R^2 value indicates proportion of variation explained by all the variables in the model.

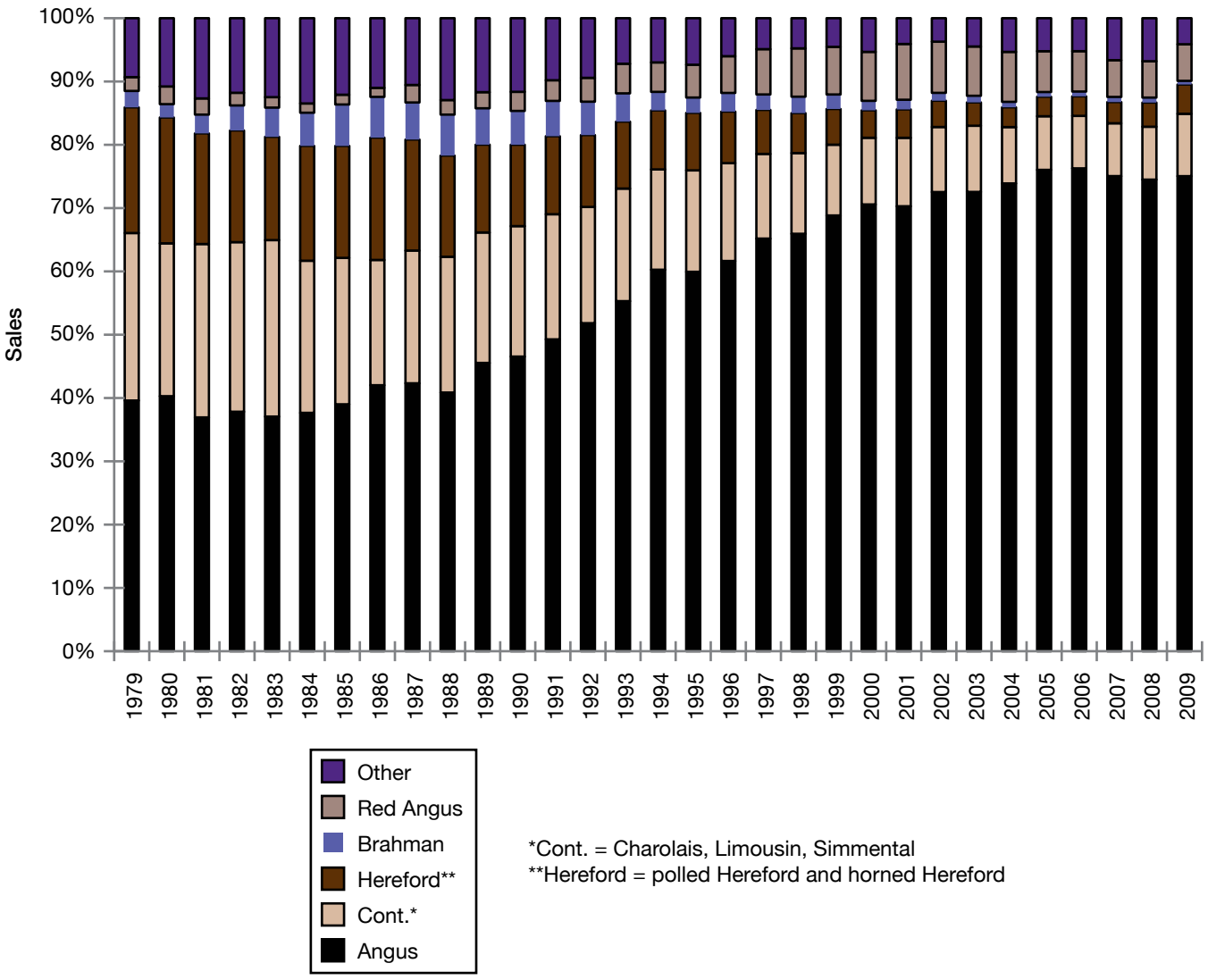


Figure 1. Proportion of domestic semen sales by breed.

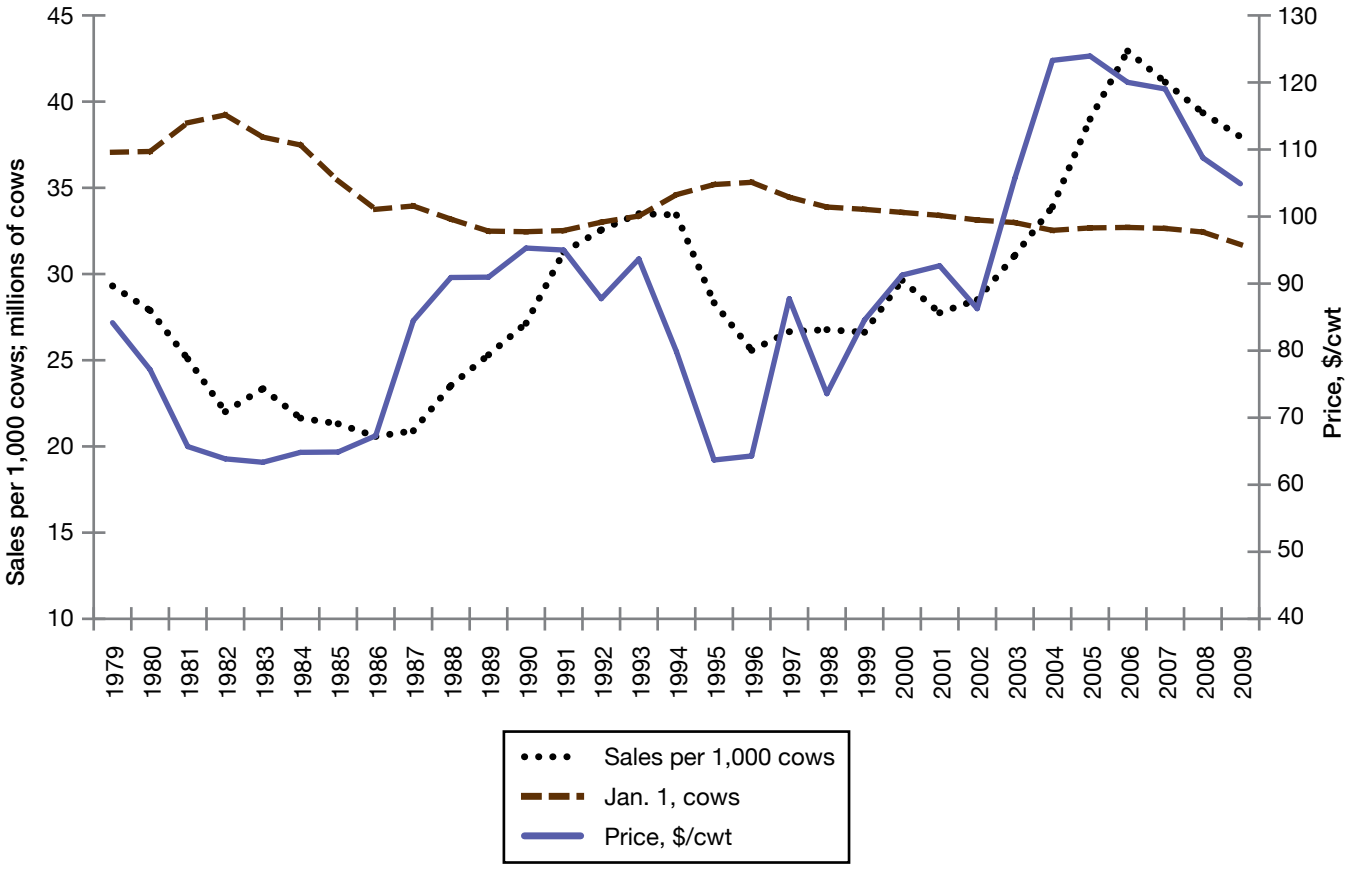


Figure 2. Domestic semen sales per 1,000 cows, January 1 beef cow inventory, and 500- to 600-lb calf price.

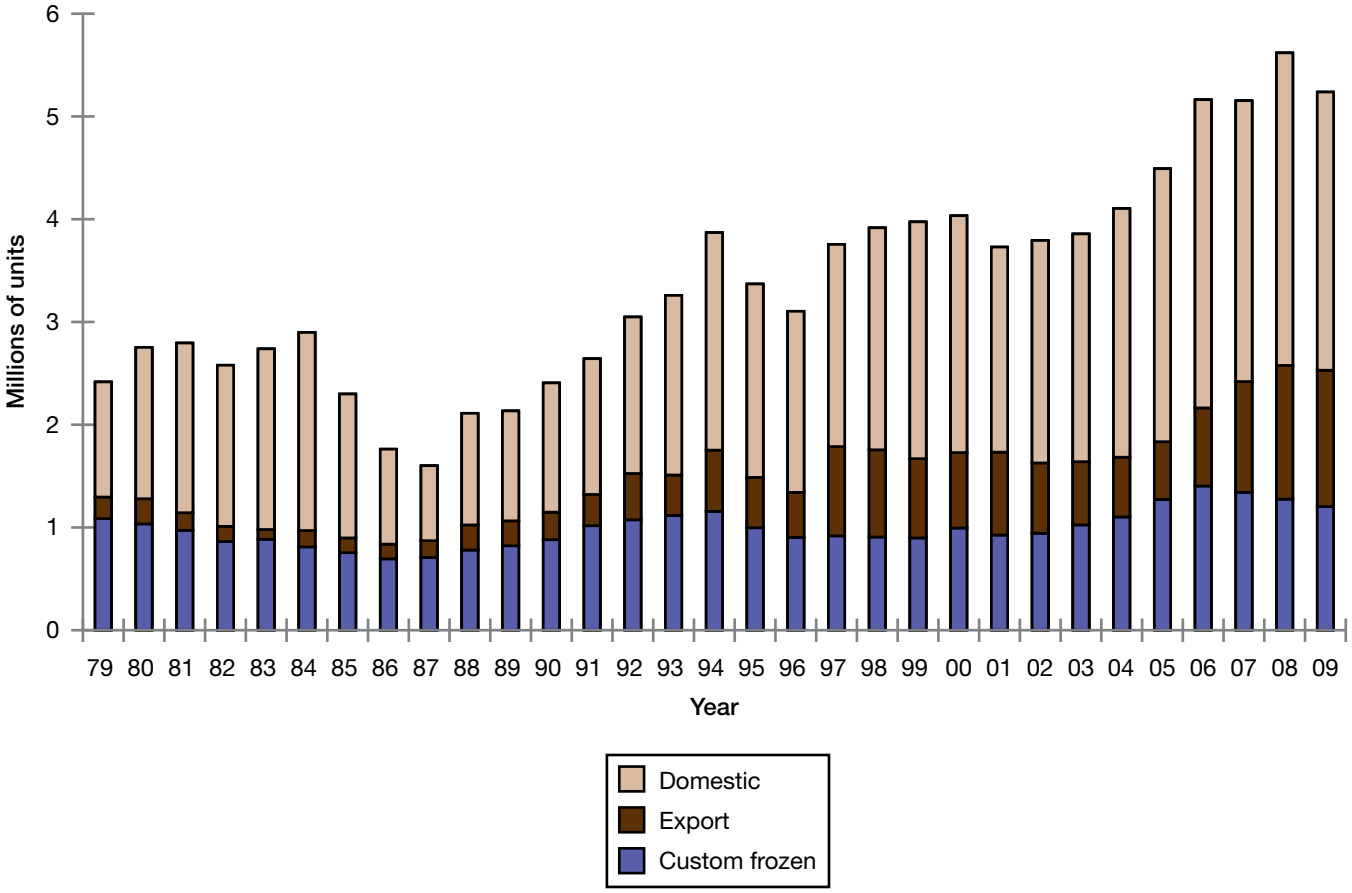


Figure 3. Units of semen custom frozen, exported, or sold domestically.

Grazing Wheat Did Not Reduce Beef Cow Pregnancy Rates

S.K. Johnson and K. Harmoney

Introduction

Beef producers can lower feed costs by extending the grazing period and reducing the need for harvested forages. Complementary forage systems extend the native range grazing season; wheat pasture is common in the southern portion of the High Plains. Anecdotal reports have been made concerning lowered fertility in beef cows bred on lush forage such as wheat pasture; however, ruling out other possible causes of low fertility is difficult.

In lactating dairy cows, fertility is lower during consumption of high-protein diets that result in high blood urea nitrogen content. Lower uterine pH that in turn affects embryo survival is thought to be the general mechanism responsible for lower fertility. Little information is available on the fertility of beef cows consuming high-protein diets. Therefore, the objective of this study was to compare pregnancy rates of spring-calving cows consuming either wheat pasture or native range before and during the early breeding season.

Experimental Procedures

This study was conducted at the Kansas State University Agricultural Research Center–Hays from 2001 to 2005. Primiparous and multiparous (all second parity) crossbred cows were assigned to one of two grazing systems by age, sire breed, and calving date. Cows remained in their respective treatment groups throughout the study. The number of cows used each season ranged from 93 to 105. Whenever possible, contemporaries of the original group of cows were used to replace open or dead cows to maintain group size. Grazing treatments were (1) grazing mixed-grass native rangeland from early spring until late fall in a season-long continuous grazing system (Native) or (2) grazing winter annual wheat in early spring followed by mixed-grass native rangeland until late fall in a seasonal complementary forage system (Wheat). Japanese brome and western wheatgrass (cool-season grasses) were available in small proportions to the Native group early in the spring in warm-season grass-dominated native rangeland pastures.

Cows in the Wheat group were placed on winter annual wheat pasture in late March or April each season (when growth had reached a height of 6 in.) in 6 replicates of 8 to 10 head. Wheat cows were allowed access to free choice sorghum-sudangrass hay the first two weeks of grazing wheat to slow passage rate. Average initial wheat grazing date and removal date was April 11 and June 11, respectively, and varied depending on the year. In 2001 and 2002, half of the Wheat group was moved from rangeland to graze sudangrass for 30 to 40 days in August and early September and then were placed back on the native rangeland.

Cows in the Native group were placed on native pasture in three replicates of 13 to 14 head on the same grazing initiation dates as the Wheat group. Weights and body conditions scores (1 = thin, 9 = very fat) of all cows were assessed at the initiation of wheat

grazing. Native cows were stocked at 10.0 acres per pair from April through October, whereas the Wheat group was stocked at 1.4 acres per pair from April through June and 4.2 acres per pair through October on native rangeland. The Wheat cows that grazed sudangrass during 2001 and 2002 also were stocked at 1.4 acres per pair while on sudangrass.

At the end of the grazing season, all cows were placed in wintering pasture lots and fed a diet of sorghum-sudangrass hay and oat hay supplemented with vitamin- and mineral-fortified 26% protein range cubes as needed until being placed back into wheat pasture or native rangeland the following spring. Calving occurred in the wintering lots prior to wheat and native rangeland grazing.

The breeding season began between May 15 and May 20 each year. Cows in the Wheat group grazed on wheat 21 to 50 days prior to breeding, depending on the year. The first day of the breeding season consisted of a fixed-time artificial insemination (AI) of all cows following a melengestrol acetate (MGA)-Select protocol (Pfizer Animal Health, New York, NY). The MGA-Select protocol consisted of 0.5 mg MGA in 4 lb of a 26% crude protein cube per head per day from day -36 to day -22. Cubes were fed by hand daily to all pasture groups. Cows received 100 μg gonadotropin-releasing hormone (GnRH) intramuscularly on day 10 and 25 mg prostaglandin F (PGF) on day -3. Cows were inseminated to a single Angus sire on day 0, 72 hours following PGF, concurrent with 100 μg GnRH.

A total of three cleanup bulls were used each breeding season and turned in with cows 10 days after fixed-timed AI. One cleanup bull was used for the Native group, whereas cows in the Wheat group were divided into two groups of 30 head, each with one cleanup bull. Cows on wheat at the time of breeding remained on wheat an average of 25 days following AI. Pregnancy was determined by transrectal ultrasonography 30 to 40 days after timed AI to determine pregnancy rate to AI and on days 76 to 141 to determine final pregnancy rate.

Results and Discussion

Pregnancy rate to AI of cows that grazed sudangrass in August and September was equal to cows that grazed only wheat the first two years of the study, so the data were pooled and values are presented together in Table 1 as a single Wheat group. Cows that grazed wheat before and during breeding had a similar pregnancy rate to fixed-time AI as cows that grazed native rangeland before and during breeding, 51.7% and 57.7%, respectively. Pregnancy rates averaged across grazing groups tended ($P<0.11$) to vary between years, mostly because of lower AI pregnancy rates the first year of the study when cows were all 2- and 3-year-olds (Table 1). A separate simple regression analysis showed that a one-unit increase in body condition score improved AI pregnancy rate by just over 10% (Figure 1). Cows were thinner (Table 2) and weighed less (Table 3) prior to breeding in 2001, which reflected the high nutrient demand of young lactating cows. Final pregnancy rate was not different between the two grazing groups, and over all years averaged 94.4 and 95.9% for the Wheat and Native groups, respectively (Table 1). Cow weight prior to breeding was higher for Native cows in years 2003, 2004, and 2005, but had no effect on either AI or final pregnancy rate. Average days postpartum at breeding was not different between groups (Table 4).

Implications

Cows grazing wheat pasture prior to and during the early breeding season had similar pregnancy rates as cows grazing native mixed-grass rangeland. Timing of peak protein content of wheat would have varied with the annual growing conditions and was not controlled in relationship to start of the breeding season. It is not known if the 3 weeks or more differential between the timing of AI and the timing of the initiation of wheat grazing influenced the potentially negative impacts of a high-protein diet.

Table 1. Pregnancy rate to fixed-time artificial insemination (AI) and final pregnancy rate (AI plus natural service) for cows grazing either wheat pasture or native mixed-grass rangeland for 21 to 50 days prior to day of AI

	AI pregnancy rate, %		Final pregnancy rate, %	
Year	Wheat	Native	Wheat	Native
2001	43.3	35.0	91.7	97.5
2002	50.8	66.7	91.5	93.3
2003	52.5	64.4	94.8	100.0
2004	63.3	60.0	95.0	91.1
2005	47.9	60.0	100.0	97.8
Average	51.7	57.7	94.4	95.9

Table 2. Pre-breeding body condition score for cows grazing either wheat pasture or native mixed-grass rangeland for 21 to 50 days prior to fixed-time artificial insemination

	Cow body condition score[1]	
Year	Wheat	Native
2001	4.6±0.1[a]	4.5±0.2[a]
2002	5.2±0.1[a]	5.2±0.1[a]
2003	5.9±0.1[b]	6.5±0.1[a]
2004	5.9±0.1[b]	7.0±0.1[a]
2005	6.1±0.1[b]	6.5±0.1[a]
Average	5.5[b]	5.9[a]

[1] 1 = thin, 9 = very fat.

[ab] Values within a row followed by the same letter are statistically similar (P>0.05).

Table 3. Pre-breeding body weight for cows grazing either wheat pasture or native mixed-grass rangeland for 21 to 50 days prior to fixed-time artificial insemination

	Cow weight, lb	
Year	Wheat	Native
2001	989±21[a]	1003±24[a]
2002	1198±17[a]	1148±21[a]
2003	1287±18[b]	1327±20[a]
2004	1353±16[b]	1436±20[a]
2005	1290±16[b]	1351±20[a]
Average	1224[a]	1253[a]

[ab] Values within a row followed by the same letter are statistically similar (P>0.05).

Table 4. Days postpartum at artificial insemination (AI) for cows grazing either wheat pasture or native mixed-grass rangeland for 21 to 50 days prior to fixed-time AI

	Days postpartum	
Year	Wheat	Native
2001	88±7	88±8
2002	68±2	69±4
2003	66±3	72±4
2004	73±4	77±6
2005	72±3	73±4
Average	73	76

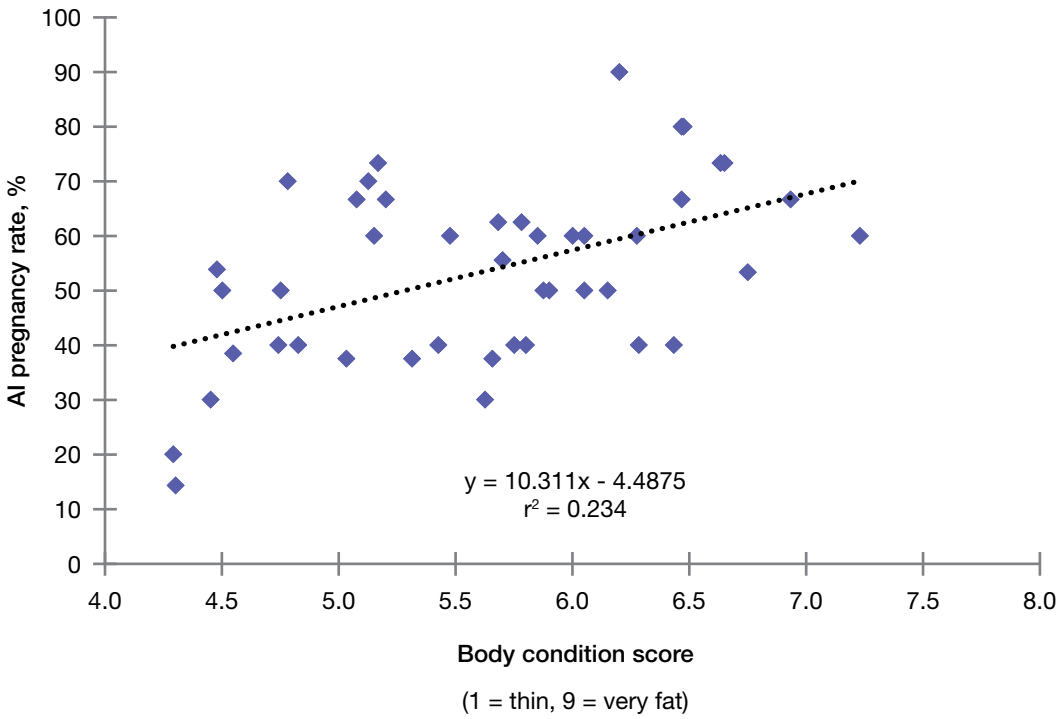


Figure 1. Relationship between cow body condition score and pregnancy rate to fixed-time artificial insemination (AI) for beef cows grazing wheat or native mixed-grass rangeland for 21 to 50 days prior to fixed-time AI.

Administration of Human Chorionic Gonadotropin at Embryo Transfer Induced Ovulation of a First-Wave Dominant Follicle and Increased Progesterone and Transfer Pregnancy Rates

L.D. Wallace, C.A. Breiner[1], R.A. Breiner, A.R. Spell[2], J.A. Carter[2], G.C. Lamb[3], and J.S. Stevenson

Introduction

Embryo transfer (ET) has become more widespread in recent years as a way to improve cattle genetics. According to the annual statistical survey of the American Embryo Transfer Association, more than 200,000 fresh and frozen bovine embryos were transferred in 2008. But despite advancements in reproductive technologies that have occurred since ET was commercialized in the 1970s, industrywide pregnancy rates are only 62.4 and 56.9% for fresh and frozen-thawed ET, respectively. Using ET helps avoid problems from failed fertilization; however, fertilization failure has been characterized as a relatively unimportant factor of pregnancy loss. Approximately 10% of pregnancy failures resulted from fertilization failure and another 10% from failed embryo development. Approximately 20 to 25% of the pregnancy loss in an ET program could be characterized as early embryonic loss.

Use of supplemental progesterone has been shown to reduce early embryonic loss and enhance growth of the early embryo. Post-artificial insemination (AI) supplementation with progesterone also increased pregnancy rates. In contrast to those studies, use of a controlled intravaginal drug release (CIDR) insert to supplement progesterone in ET recipients post-transfer was not effective in reducing early embryonic loss.

Use of human chorionic gonadotropin (hCG) to stimulate ovulation of ovarian follicles to form accessory corpora lutea (CL) has been reported to increase circulating progesterone concentrations and increase pregnancy rates when administered during the post-breeding early luteal phase. More recent studies have determined that administration of 1,000 IU hCG was sufficient to ovulate a follicle. We recently administered 1,000 IU hCG to beef cows 7 days post-AI and observed formation of accessory CL and an increase in progesterone concentrations 14 days post-AI. Further, hCG administration to ET recipients at the dosage of 1,500 IU on either day 5 or 6 post-estrus has produced results ranging from no improvement to greater pregnancy rates than controls.

The objectives of this study were to: (1) monitor recipients for formation and retention of accessory CL, (2) determine if the circulating progesterone concentrations of pregnant recipients that received hCG were greater than those in control recipients, and (3) determine if hCG would reduce early embryonic loss (i.e., between transfer and first

[1] Cross Country Genetics North, Westmoreland, KS.
[2] Advanced Reproductive Associates, Daphne, AL.
[3] University of Florida, Marianna, FL.

pregnancy diagnosis). We hypothesized that administration of hCG to recipients at ET would induce accessory CL, increase circulating progesterone concentrations, and reduce early embryonic loss.

Experimental Procedures

Mature beef cows at three locations (n = 719) received embryos approximately 7 days post-estrus if they had palpable CL. Fresh (n = 160) or frozen-thawed (n = 559) grade 1 or 2 embryos and transfers were made according to standard techniques as described by the International Embryo Transfer Society (IETS Manual, third edition, Champaign, IL). Embryo transfers were performed by 2 experienced veterinarians (Cross Country Genetics North, Inc., Westmoreland, KS) at Locations 1 and 2. Transfers at Location 3 were performed by a single experienced technician (Advanced Reproductive Associates, Daphne, AL). A single embryo was transferred to the uterine horn of the recipient ipsilateral to the CL. At the time of transfer, recipients alternately received either 1,000 IU hCG (1 mL, Chorulon; Intervet, Inc., Millsboro, DE) or 1 mL saline. Recipients were assigned a body condition score (BCS; 1 = thin and 9 = very fat). Pregnancy diagnoses were performed by transrectal ultrasonography (5.0 MHz linear-array transducer; Aloka 500 V; Corometrics Medical Systems, Inc., Wallingford, CT) at 35 and 65 days (mean) post-estrus.

Blood samples were collected from a coccygeal vessel at both pregnancy diagnoses in pregnant cows at Locations 1 and 2. Blood samples were refrigerated overnight and centrifuged the following morning. Blood serums were frozen at -4° F until the assay for progesterone was performed by radioimmunoassay.

Results and Discussion

Embryo transfer pregnancy rates did not differ among locations. Factors that significantly affected ET pregnancy rates at the first pregnancy diagnosis of 719 recipients are shown in Table 1. Treatment with hCG (P=0.026) at ET and transfer of fresh embryos (P=0.016) increased the likelihood of pregnancy at the first diagnosis. Further, recipients having BCS >5 at the time of transfer tended (P=0.074) to have greater pregnancy rates than recipients having BCS ≤5.

Positive additive effects of hCG treatment, BCS, and embryo type are illustrated in Figure 1. Within BCS class (≤5 vs. >5), recipients receiving fresh embryos always had greater transfer pregnancy rates, and hCG treatment produced greater transfer pregnancy rates in all embryo type-BCS classes except for cows of greater BCS receiving frozen embryos.

Serum progesterone concentrations in pregnant cows were greater (P<0.05) in hCG-treated recipients than recipients treated with saline at the time of the first (8.1 ± 0.9 vs. 6.1 ± 0.8 ng/mL) and second pregnancy diagnosis (8.7 ± 0.9 vs. 6.5 ± 0.7 ng/mL). Ovaries of pregnant recipients (n = 59) from Location 1 were monitored for the number of luteal structures at the time of both pregnancy diagnoses. All occurrences of accessory CL at the time of pregnancy diagnosis (20 of 29; 68.9%) on day 32 were detected in the hCG treatment. Nineteen multiple ovulating cows each had 1 accessory CL, and 1 cow formed 2 accessory CL. The proportion of recipients having 1 or more accessory CL was greater (P<0.001) after hCG treatment (68.9%) than after saline (0%).

In summary, administration of hCG to ET recipients at the time of transfer increased the incidence of accessory CL, increased serum progesterone concentrations, and increased transfer pregnancy rates. Assuming equal viability of embryos transferred to cows receiving hCG or saline, the increased transfer pregnancy rates were interpreted to indicate that increased progesterone resulting from hCG-induced ovulation reduced early embryonic losses after transfer of embryos to recipients. As expected, pregnancies were more likely in recipients that received fresh embryos than in cows that received frozen-thawed embryos. The tendency for cows in better body condition (BCS >5) to have greater transfer pregnancy rates reiterates the importance of properly managing the nutrition program for the recipient herd. Monitoring BCS could help predict the success of an ET. The positive effects of hCG treatment helped improve transfer rates resulting from transfer of fresh embryos and improved BCS of recipients.

Implications

Administering 1,000 IU hCG (1 mL Chorulon) to ET recipients at the time of ET increased transfer pregnancy rates.

Table 1. Factors affecting embryo transfer pregnancy rates

Item	n	Pregnancy rate, %	AOR (95% CI)[a]	P-value
Treatment				
Saline	358	53.9	Referent	
hCG	361	61.8	1.40 (1.04-1.89)	0.026
Embryo type				
Frozen	559	55.5	Referent	
Fresh	160	66.3	1.57 (1.08-2.27)	0.016
BCS				
≤5	454	55.3	Referent	
>5	265	62.3	1.33 (0.97-1.82)	0.074

[a] AOR = adjusted odds ratio; CI = confidence interval. An example of how to interpret an odds ratio: Treatment with hCG was 1.4 times more likely to increase transfer pregnancy rates than saline (referent).

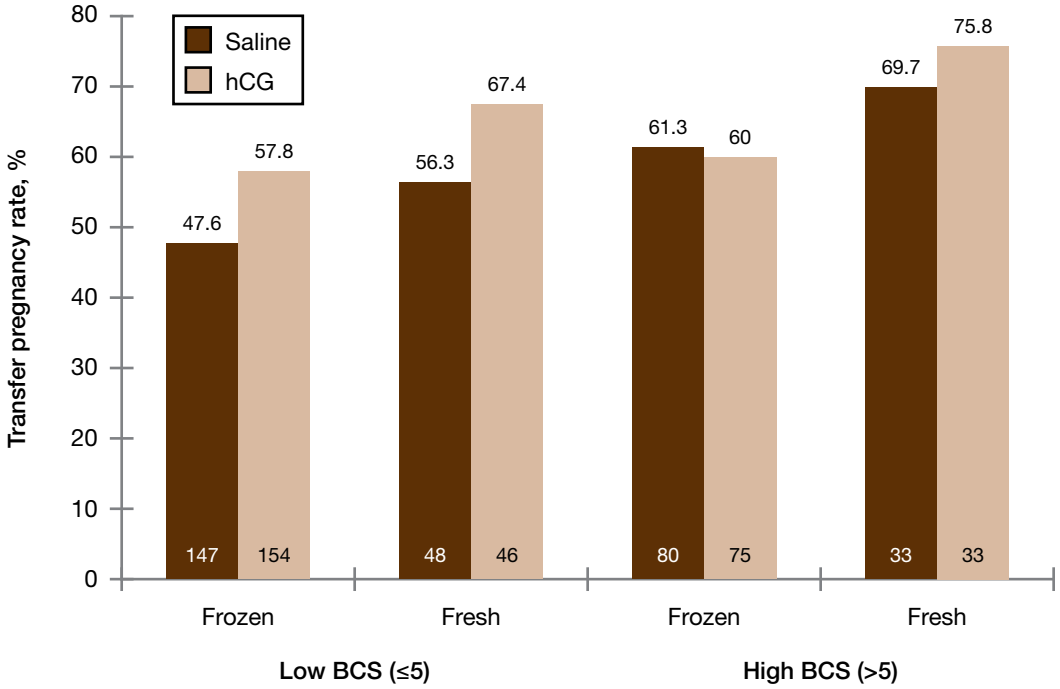


Figure 1. Additive effects of hCG treatment at embryo transfer, body condition score (BCS), and type of embryo transferred on transfer pregnancy rates in beef cow recipients. Numbers in bar boxes represent the number of recipients treated with either saline or 1,000 IU hCG at embryo transfer.

Is GnRH Necessary at CIDR Insertion Using a 7-Day CIDR Synchronization Protocol for Beef Heifers?

D.R. Eborn[1], E.E. Blair, and D.M. Grieger

Introduction

The EAZI-BREED CIDR is commonly used in estrous synchronization protocols for both beef heifers and cows. The label calls for insertion of a progesterone-impregnated controlled internal drug release (CIDR) for 7 consecutive days with an injection of prostaglandin $F_{2\alpha}$ given a day before CIDR removal. Animals should display estrus 1 to 3 days after CIDR removal. Modifications to this protocol include administration of gonadotropin-releasing hormone (GnRH) at the time of CIDR insertion and administration of the prostaglandin injection at the time of CIDR removal on day 7. Use of GnRH in conjunction with a CIDR may improve estrous synchronization in beef cows and fertility at fixed-time insemination but may not be necessary when synchronizing beef heifers. Our objective was to compare heat response and fertility in heifers with or without GnRH administration at the time of CIDR insertion. Our hypothesis was that heifer fertility would be similar between treatments.

Experimental Procedures

Yearling heifers from the Kansas State University Commercial Cow-Calf Unit in 2009 (n = 93) and Purebred Beef Teaching Unit in 2009 (n = 62) and 2010 (n = 85) were assigned to one of two treatments (Figure 1). Heifers in the Select Synch+CIDR treatment were administered a 2 cc injection of GnRH (Cystorelin; Merial Limited, Duluth, GA) at the time of CIDR insertion (EAZI-BREED CIDR, Pfizer Animal Health, New York, NY). Seven days later, a 5 cc injection of prostaglandin $F_{2\alpha}$ (Lutalyse; Pfizer Animal Health, New York, NY) was given and the CIDR was removed. The 7-day CIDR treatment was similar except no GnRH was administered at CIDR insertion. Heifers at the Purebred Beef Teaching Unit were observed twice daily for 5 days beginning at the time of CIDR removal and artificially inseminated approximately 12 hours after onset of estrus following the AM/PM rule. Heifers at the Cow-Calf Unit were given an injection of GnRH at a fixed-time insemination 54 hours after CIDR removal. Conception and pregnancy rates were determined by transrectal ultrasonography 30 to 35 days after insemination. Progesterone assays were performed from blood samples taken at CIDR insertion and a minimum of 1 hour after CIDR removal. Heifers with at least one sample containing progesterone concentration >1 ng/ml were considered to be cycling.

Results and Discussion

Most heifers (>91%) had reached puberty in each herd by time of either CIDR insertion or CIDR removal. Interval from CIDR removal to onset of estrus was similar between treatments with more than 85% displaying estrus from 48 to 72 hours after the prostaglandin $F_{2\alpha}$ injection. Synchronization rate (percent of heifers that displayed

[1] USDA ARS Meat Animal Research Center, Clay Center, NE

estrus) at the Purebred Beef Teaching Unit did not differ between treatments (89% vs. 87% for females in the 7-day CIDR and Select Synch+CIDR treatments, respectively) but tended to differ (P<0.06) between 2009 and 2010 (92% vs. 81%, respectively; Table 1). Because all heifers received Estrotect Heat Detector (Rockway, Inc., Spring Valley, WI) patches at time of CIDR removal and were placed in pens with penile-deviated bulls, the difference between years is unlikely due to errors in heat detection. The Select Synch+CIDR conception rate was 58% and did not differ from the 7-day CIDR conception rate of 59%. Pregnancy rates were similar between the Select Synch+CIDR and 7-day CIDR treatments (56% vs. 58%, respectively). Conception and pregnancy rates for the 11 heifers that had <1 ng/ml of progesterone at both CIDR insertion and removal (considered prepubertal) were 6/9 (66%) and 6/11 (54%), respectively. Pregnancy rates to a 54 hour fixed-time insemination for heifers at the Cow-Calf Unit were similar between the Select Synch+CIDR and 7-day CIDR treatments (56% vs. 53%, respectively).

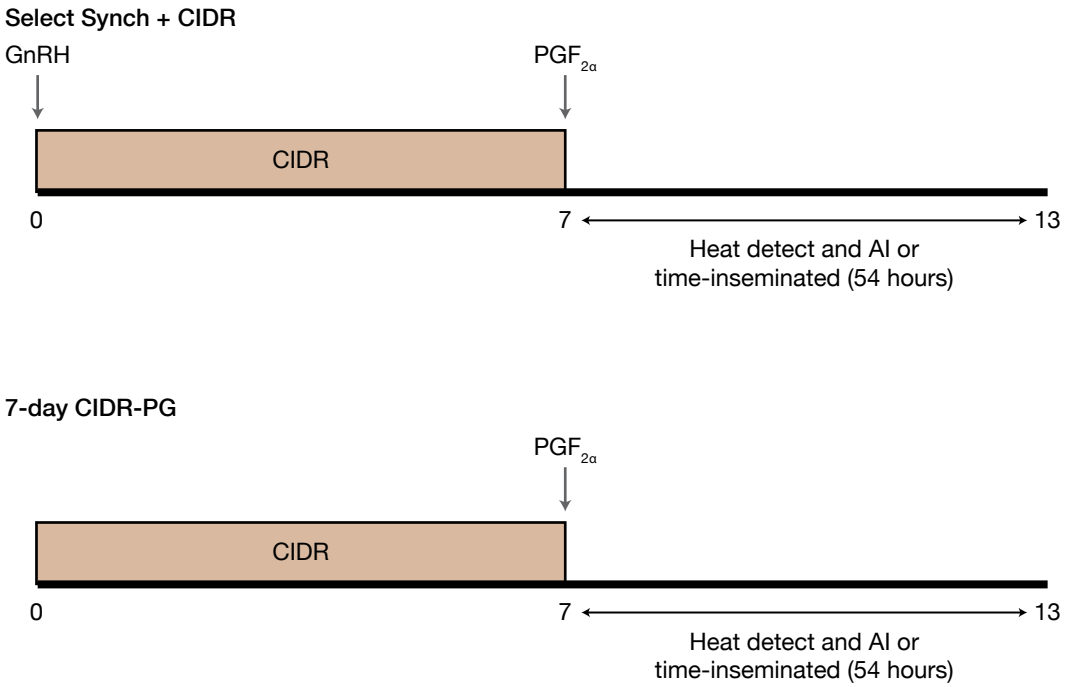
Implications

In cycling beef heifers, administering GnRH at the beginning of a 7-day CIDR protocol gained no advantage in fertility. Interestingly, 60% of prepubertal heifers (12/20) conceived to insemination on their first estrus induced by this protocol.

Table 1. Estrous detection, conception, and pregnancy rates for Select Synch+CIDR and 7-Day CIDR treatments by herds

	Select Synch+CIDR	7-day CIDR
Item	% (total n)	% (total n)
Synchronization rate		
PBU09	90.9 (33)	93.9 (33)
PBU10	82.9 (41)	80.0 (40)
Overall	87.5 (74)	88.7 (73)
Conception rate*		
PBU09	63.3 (30)	54.8 (31)
PBU10	52.9 (34)	62.5 (32)
Overall	58.2 (64)	58.7 (63)
Pregnancy rate**		
PBU09	60.6 (33)	53.1 (33)
PBU10	51.4 (41)	61.3 (40)
PBU overall	56.4 (74)	56.9 (73)
CCU09	56.0 (47)	52.7 (46)

* Number of heifers conceiving to artificial insemination/number of heifers inseminated.
** Number of heifers conceiving to artificial insemination/total number of heifers synchronized.



GnRH = gonadotropin-releasing hormone (Cystorelin); $PGF_{2\alpha}$ = prostaglandin $F_{2\alpha}$ (Lutalyse); CIDR = intravaginal progesterone-releasing controlled drug release (EAZI-BREED CIDR)

Figure 1. Experimental protocol: Heifers at the Kansas State University Purebred Beef Teaching Unit were inseminated after estrous detection. Heifers at the Kansas State University Cow-Calf Unit were time-inseminated at 54 hours after prostaglandin $F_{2\alpha}$ injection.

Reproduction of Heifers Sired by High or Low Residual Feed Intake Angus Bulls

Erika Blair, J.M. Bormann, D.W. Moser, and T.T. Marston

Introduction

Residual feed intake (RFI) has gained popularity as a selection tool for improving feed efficiency in beef cattle. RFI is the difference between what an animal consumes and what it is predicted to consume based on size and growth rate. Animals with low or negative RFI eat less than predicted and are more efficient. Although RFI is being used by the industry, research on the impact of selection for RFI on female fertility is lacking. The objective of this study is to evaluate the reproductive performance of heifers that have been selected for RFI.

Experimental Procedures

This study was conducted under guidelines established by the Kansas State University Institutional Animal Care and Use Committee. Angus-based commercial cows were bred to sires with high or low estimated breeding values for RFI as published by the Angus Society of Australia (Armidale, New South Wales, Australia) in two consecutive breeding seasons. Table 1 shows the sire estimated breeding value and the distribution of heifers by sire. Heifers born in 2006 were tested in two groups (Test 1 and Test 2) using Calan gates (Northwood, New Hampshire), and heifers born in 2007 were tested in one group (Test 3) using a GrowSafe system (Airdrie, Alberta, Canada). In all three tests, heifers were allowed a 14-day warm-up period to adjust to the equipment. Test 1 and 2 heifers were measured for feed intake for 42 days and for gain for 58 days. Test 3 heifers were measured for both feed intake and gain for 57 days. All heifers were allowed *ad libitum* consumption of a high roughage complete diet (approximately 2.63 Mcal ME/kg dry matter in for Test 1 and Test 2 and 1.9 Mcal ME/kg dry matter for Test 3). Heifers were synchronized and bred by artificial insemination (AI) one time then exposed to natural service sires. Diagnoses for pregnancy status were performed approximately 60 days after the breeding season. Heifers were determined to have conceived to first service (AI), to have conceived to natural service, or to be open at fall pregnancy check. RFI was calculated within each test group. Body weights were collected every 14 days and used to calculate mid-test body weight and average daily gain. Actual dry matter intake was regressed on mid-test metabolic body weight and average daily gain to calculate an expected dry matter intake for each heifer. The model for expected feed intake was:

$$y_i = b_0 + b_1 ADG_i + b_2 WT_i + e_i$$

where ADG_i is the average daily gain of animal i, WT_i is mid-test metabolic body weight of animal i, and e_i is the error. Expected dry matter intake was calculated within each contemporary (test) group separately. RFI was calculated by subtracting the expected intake from the actual intake. Calving day was defined as the relative day of calving season when the heifer calved. For example, within year, the first heifer that calved received a calving day of 1, heifer(s) that calved the next day received a calving day of 2, and so on.

Effects of sire RFI-estimated breed value group

Pregnancy and first service pregnancy were analyzed as categorical variables, with test group within year, heifer's sire RFI group (efficient versus inefficient), service sire within year, and breeding treatment (synchronization protocol) as fixed effects and heifer birth date as a covariate. The model for analysis of calving day and age at first calving included fixed effects of test group within year, heifer's sire RFI group, service sire within year and breeding treatment, and random effect of heifer's sire. Heifer birth date was included as a covariate in the analysis of calving day, but not age at first calving. If age at first calving is adjusted for birth date of the heifer, it becomes the same trait as calving day. The model for analysis of calf birth weight included year, calf sex, calf sire within year, and dam's sire RFI group as fixed effects; dam's sire as a random effect; and dam's birth date as a covariate.

Effects of phenotypic RFI

The model to determine whether pregnant and open heifers had different phenotypic RFI included fixed effects of test within year, breeding treatment, service sire within year and pregnancy, and the covariate of heifer birth date. The continuous variables calving day, age at first calving, and calf birth weight were regressed on phenotypic RFI. For calving day and age at first calving, fixed effects included test within year, breeding treatment, and service sire of the heifer with covariates of heifer birth date and phenotypic RFI. For calf birth weight, fixed effects included year, calf sex, and calf sire within year with covariates of heifer birth date and phenotypic RFI.

To further examine the relationship of phenotypic RFI and other traits, heifers were divided into high and low groups based on their phenotype for RFI. The model to determine the relationship between phenotypic RFI group and pregnancy, first service pregnancy, and calving day included the fixed effects test within year, breeding treatment, service sire within year, and phenotypic RFI group with heifer birth date as a covariate. The same model was used to determine the relationship between age at first calving and RFI except that heifer birth date was not included. The model for calf birth weight included year, calf sex, calf sire within year, and phenotypic RFI group with heifer birth date as a covariate.

Results and Discussion

Effects of sire RFI-estimated breeding value group

Overall pregnancy rates and first service conception rates are shown in Table 2. Least squares means for calving day, age at first calving, and calf birth weight by sire RFI group are shown in Table 3. Heifers sired by efficient RFI bulls tended ($P<0.10$) to calve earlier in the season than heifers sired by inefficient RFI bulls. No difference occurred between sire RFI groups in age at first calving or calf birth weight.

Effects of phenotypic RFI

No difference was present in phenotypic RFI between heifers that were pregnant or open after first service or at the end of the breeding season ($P>0.70$). However, when first service conception rates and overall pregnancy rates of heifers with high and low phenotypic RFIs were compared, low (feed-efficient) RFI heifers tended to have lower first service conception rates (Table 4). Overall pregnancy rates were similar between heifers with high and low phenotypic RFI groups.

No correlation exists between calving day and age at first calving and phenotypic RFI of heifers (P>0.40). Calving day and age at first calving were similar between heifers with high and low phenotypic RFIs (Table 5). Calf birth weight and phenotypic RFI of the heifers were inversely related (-0.79; P<0.09), indicating a tendency for feed-efficient heifers to have heavier calves at birth. Phenotypic correlations between heifer RFI and calving day, age at first calving, and calf birth weight were small and insignificant (Table 6).

Implications

The beef industry is emphasizing selection for RFI as a method to improve feed efficiency. However, very little information exists about potential effects of selection for RFI on other traits, particularly in the female. In our study, pregnancy rates did not differ, but a favorable relationship emerged between RFI and calving date for calves sired by efficient sires. In contrast, a previous Australian study showed an unfavorable relationship. As more animals are measured and selected for RFI, further research should examine relationships between RFI and female fertility traits.

Table 1. Sire residual feed intake group[1], residual feed intake estimated breeding value, and number of daughters

Sire	Sire group	Estimated breeding value, lb	Daughters
1	I	0.64	18
2	I	0.58	10
3	I	0.66	3
4	I	0.69	21
5	I	0.42	4
6	E	-1.19	8
7	E	-1.58	7
8	E	-0.90	7
9	E	-1.06	14

[1] I = inefficient, E = efficient.

Table 2. Overall conception rate and first service conception rate for heifers sired by efficient residual feed intake (RFI) estimated breeding value bulls (E) and inefficient RFI estimated breeding value bulls (I)

Sire group	n	Overall conception rate, %	First service conception rate, %
E	36	77.8	38.9
I	56	82.1	48.2
P-value		0.89	0.84

Table 3. Number of animals and least squares means for calving day and age at first calving of heifers and birth weight of their calves by efficient residual feed intake (RFI) estimated breeding value bulls and inefficient RFI estimated breeding value bulls

Sire group	Calving day, days[a]	Age at first calving, days	Calf birth weight, lb
Number	55	55	79.2
Efficient	12.88	733.36	74.14
Inefficient	20.53	751.66	76.604
P-value	0.0964	0.21	0.48

[a] Calving day was defined as the relative day of the calving season when the heifer calved. See Experimental Procedures.

Table 4. Overall conception rate and first service conception rate for heifers that had high or low phenotypic residual feed intake (RFI)

RFI group	n	Overall conception rate, %	First service conception rate, %
High	46	82.6	52.2
Low	46	78.3	37.0
P-value		0.68	0.06

Table 5. Number of animals and least squares means for calving day and age at first calving of heifers, and birth weight of their calves for heifers that had high or low phenotypic residual feed intake (RFI)

RFI	Calving day, days[a]	Age at first calving, days	Calf birth weight, lb
Number	55	55	79.2
High	18.26	738.93	73.41
Low	18.51	744.94	77.31
P-value	0.95	0.34	0.17

[a] Calving day was defined as the relative day of the calving season when the heifer calved. See Experimental Procedures.

Table 6. Phenotypic correlations between heifer residual feed intake (RFI) and calving day, age at first calving, and calf birth weight

	Correlation (P-value) with phenotypic RFI
Calving day, days[a]	0.04 (0.78)
Age at first calving, days	-0.11 (0.42)
Calf birth weight, lb	-0.19 (0.27)

[a] Calving day was defined as the relative day of the calving season when the heifer calved. See Experimental Procedures.

Zilpaterol-HCl Reduces Urinary Excretion of N-tau-methylhistidine by Finishing Steers[1]

D.W. Brake and E.C. Titgemeyer

Introduction

Zilpaterol-HCl is an orally active b-adrenergic agonist that repartitions nutrient use in cattle and has been approved for use during the final 20 to 40 days of the finishing period. Zilpaterol administration to finishing cattle increases average daily gain, feed efficiency, hot carcass weight, ribeye area, and dressing percentage; however, zilpaterol decreases meat tenderness, which is detectable by sensory panelists. Attenuation of zilpaterol's effect on tenderness would improve its benefits to cattle producers.

Decreases in tenderness of meat from cattle fed zilpaterol may be closely related to decreases in protein degradation in skeletal muscles. Urinary excretion of N-tau-methylhistidine (NMH) in cattle reflects skeletal muscle protein degradation *in vivo* and provides a convenient research measure of muscle protein degradation. We analyzed NMH excretion by cattle fed zilpaterol to estimate the breakdown rate of skeletal-muscle protein.

Materials and Methods

Twelve steers of British breeding were used in two sets of six and placed into two replicates of similarly designed trials conducted at different times. Steers were blocked in each set based on pretrial voluntary feed intake and treatments of zilpaterol were randomly assigned within each block. In each replicate, three steers were administered zilpaterol (60 mg/day) provided as Zilmax (Intervet Schering-Plough Animal Health, Millsboro, DE) throughout the trial, and three steers received no zilpaterol. Zilpaterol treatment was administered in a randomized block design.

Within each group of six steers, the three steers receiving the same zilpaterol treatment were used in concurrent 3 × 3 Latin squares and administered dietary protein treatments. Dietary protein treatments were three corn-based diets: control (10.2% crude protein), urea (13.3% crude protein), or dried distillers grains with solubles (DDGS; 14.9% crude protein). Treatments delivered DDGS (20% of dry matter) and urea (1% of dry matter) at inclusion rates similar to those used commonly in corn-based diets fed to finishing cattle. DDGS was selected as a supplemental protein source because of its relatively high content of undegradable intake protein. Urea was selected as a supplemental nitrogen source because it is completely ruminally degraded.

Steers were housed in metabolism crates to facilitate total collection of urine and feces. Steers were fed twice daily in equal amounts. Total urinary excretion of NMH and creatinine were analyzed to estimate skeletal-muscle protein degradation. Urinary creatinine excretion was used to estimate total skeletal muscle mass.

[1] This project was supported by National Research Initiative Competitive Grant no. 2007-35206-17848 from the USDA Cooperative State Research, Education, and Extension Service.

Results and Discussion

We measured urinary NMH excretion to estimate *in vivo* skeletal muscle protein degradation and urinary creatinine excretion as a measure of total skeletal muscle protein mass. Thus, the ratio of urinary NMH excretion to urinary creatinine excretion was directly related to the proportion of skeletal muscle protein that was degraded.

Total daily excretion of urinary NMH was not affected by zilpaterol ($P=0.70$; Table 1). Creatinine excretion was numerically increased by zilpaterol administration. These differences together led to an NMH:creatinine ratio that was less ($P<0.01$) for steers receiving zilpaterol than for those not receiving zilpaterol (Figure 1). Zilpaterol reduced skeletal-muscle protein degradation *in vivo* when expressed as a proportion of total skeletal-muscle protein mass.

In this trial, steers fed zilpaterol unexpectedly had greater ($P<0.01$) feed intakes than control steers. Generally, skeletal muscle protein turnover (both protein synthesis and protein degradation) is increased as feed intake increases; however, zilpaterol reduced skeletal muscle protein turnover in spite of greater feed intakes that should have increased skeletal muscle protein turnover.

We observed no effect of dietary protein or its interaction with zilpaterol ($P>0.5$) on urinary excretion of NMH or creatinine or on the ratio between the two. We interpreted this to suggest that dietary protein type had no effect on protein degradation or that our model was not sensitive enough to detect differences.

Implications

Zilpaterol administration to cattle receiving corn-based diets reduced skeletal-muscle protein degradation. This might explain, in part, reductions in meat tenderness for cattle fed zilpaterol.

Table 1. Effect of zilpaterol-HCl (Zilmax) on N-tau-methylhistidine and creatinine excretion in steers consuming corn-based diets supplemented with no protein (control), with dried distillers grains with solubles (DDGS), or with urea

	Zilpaterol			No zilpaterol				P-value		
Item	Control	DDGS	Urea	Control	DDGS	Urea	SEM	Zilpaterol	Diet	Interaction
Number of steers	4	5	4	6	5	5				
N-tau-methylhistidine, mmol/day	1.20	1.20	1.23	1.24	1.26	1.28	0.11	0.71	0.87	0.99
Creatinine, g/day	15.4	15.4	14.8	13.1	13.6	13.8	1.1	0.20	0.89	0.52
N-tau-methylhistidine:creatinine, mmol:g	75.9	77.5	81.4	94.4	92.9	92.5	5.4	<0.01	0.92	0.76

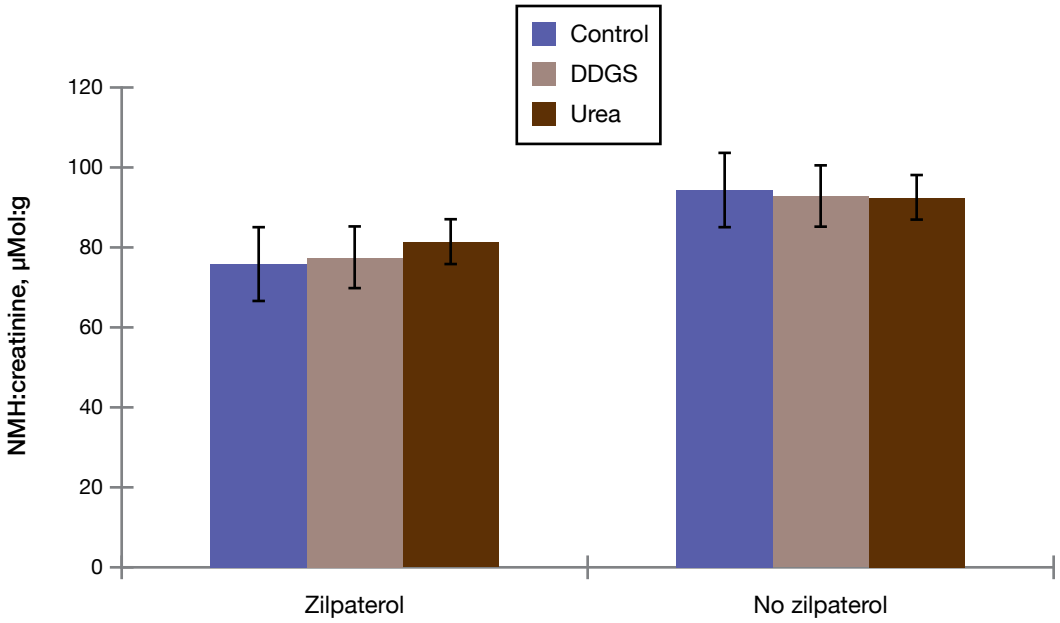


Figure1. Effect of zilpaterol on the ratio of urinary excretion of N-tau-methylhistidine (NMH) to creatinine in steers consuming corn-based diets supplemented with no protein (control), with dried distillers grains with solubles (DDGS), or with urea.

Dietary Sulfur Concentration Has No Effect On *In Vitro* Fermentative Activity of Ruminal Mixed Microorganisms

S. Uwituze, L. Hollis, and J. Drouillard

Introduction

We previously reported that elevated concentrations of dietary sulfur (0.65% sulfur, dry basis) in finishing diets containing dried distillers grains with solubles decreased dry matter intake and average daily gains of feedlot cattle. Furthermore, high dietary sulfur concentrations yielded lower ruminal concentrations of volatile fatty acids, but were associated with increased ruminal ammonia concentrations and improved total tract digestibility of the diet. The objective of this study was to investigate, in culture tubes, effects of added sulfur on *in vitro* dry matter disappearance, volatile fatty acid profiles, and ammonia concentrations from substrates containing different sulfur concentrations when fermented by mixed ruminal microorganisms from a steer fed a diet based on corn and alfalfa.

Experimental Procedures

A study was conducted in culture tubes to evaluate effects of adding sulfur from sodium sulfate at 0, 0.1, 0.2, 0.3, 0.4, 0.5, or 0.6% of substrate (dry basis) on fermentative activity of mixed ruminal microorganisms from a steer fed a diet based on corn and alfalfa. Substrates consisted of a 94:4.5:1.5 mixture of ground corn, soybean meal, and urea, or a 69.4:30.6 mixture of ground corn and distillers grains. Basal sulfur concentrations were 0.18% (dry basis) for the corn-soybean meal-urea mixture and 0.28% for the corn-distillers grains mixture. Both substrates contained 14.4% crude protein (dry basis). Sulfur concentrations were increased experimentally to allow evaluation of potential threshold concentrations at which dietary sulfur might depress microbial activity. Varying concentrations of sulfur were added to substrates prior to incubation in culture tubes containing a 2:1 mixture of artificial saliva and clarified ruminal fluid from a single donor.

The study was repeated daily for 3 days. Each day, three tubes per substrate and sulfur concentration were incubated for 24 hours at 102°F. The steer used as the source of ruminal fluid was fed a diet containing (dry basis) 49% ground corn, 40% alfalfa hay, 5% corn steep liquor, and 6% of a supplement that provided 300 mg/day of Rumensin and 90 mg/day of Tylan (Elanco Animal Health, Greenfield, IN). The diet contained 13.3% crude protein and 0.19% sulfur (dry basis). After 24 hours of fermentation, tubes were chilled in an ice bath and centrifuged, and the supernatant was used for analysis of volatile fatty acid profiles and ammonia concentrations. Pellets of residue were dried and used to determine *in vitro* dry matter disappearance.

Results and Discussion

No interactions occurred ($P>0.05$) between sulfur level and substrate type with respect to concentrations of ammonia (Figure 1), total volatile fatty acids (Figure 2), acetate, propionate, butyrate, isovalerate, isobutyrate, valerate, and lactate; acetate:propionate

ratio; or *in vitro* dry matter disappearance (Figure 3). These parameters also were unaffected by sulfur concentration (P>0.05). Microorganisms fed ground corn with distillers grains produced greater concentrations of valerate compared to microbes fed corn and soybean meal, but produced lower concentrations of ammonia (Figure 1), total volatile fatty acids, propionate, and butyrate and had lower *in vitro* dry matter disappearance than microorganisms fed a mixture of ground corn, soybean, and urea (P<0.05; Figure 3).

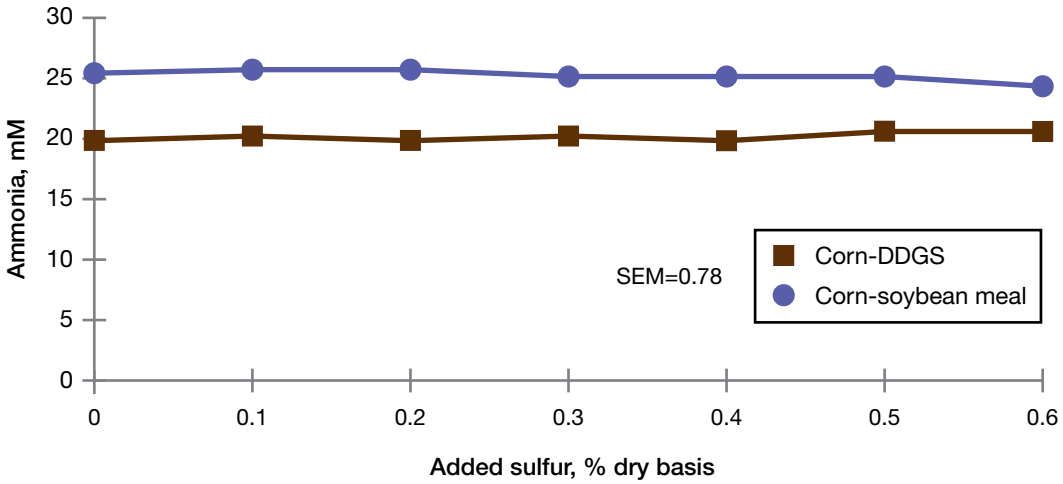
Lack of effect of dietary sulfur on ruminal fermentation parameters and *in vitro* dry matter disappearance has been previously reported with sulfur concentrations of 0.2, 0.4, and 0.8% of a steam-flaked corn-based substrate (dry basis). In our study, as well as in the previous work, dietary sulfur had no effect on ruminal fermentation parameters. Ruminal fluid in our study was from a steer fed a high-roughage diet, whereas previous work used fluid from animals fed a high-concentrate diet. Collectively, these studies suggest that microbial populations are unaffected by concentration of dietary sulfur.

The present study was designed to allow direct comparison between two substrates. Our intent was to identify threshold concentrations at which dietary sulfur depresses microbial activity under different situations, but we observed no effects of sulfur with either substrate. These results suggest that previously observed changes in cattle performance and *in vivo* diet digestibility associated with high sulfur intake are likely attributable to host factors such as feed intake. Elevated dietary sulfur depresses feed intake, which leads to poor growth performance.

Differences between substrate types may be attributable to differences in the content of fiber (neutral detergent fiber) and ruminally degradable protein. The ground corn-soybean meal-urea mixture provided more degradable protein but less fiber compared to the ground corn-distillers grains mixture. Hence, improved diet digestibility was observed in cultures incubated with ground corn-soybean meal-urea mixture compared to cultures incubated with the ground corn-distillers grains mixture.

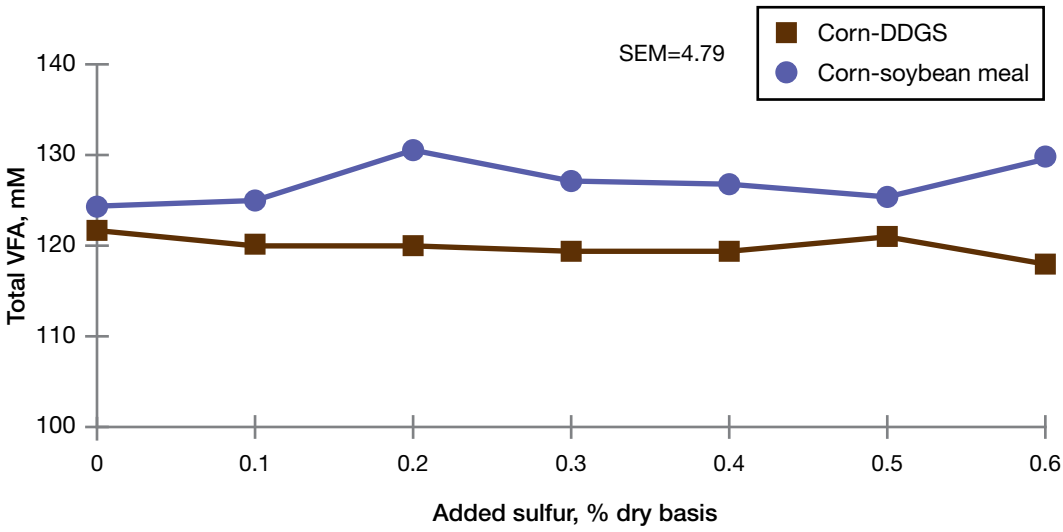
Implications

Substrates yielded marked differences in fermentative end products, but elevated sulfur did not alter fermentation of these substrates by mixed ruminal microorganisms in culture tubes. Previously observed deleterious effects of elevated dietary sulfur on cattle growth performance are unlikely to be the result of impact on gut microbes.



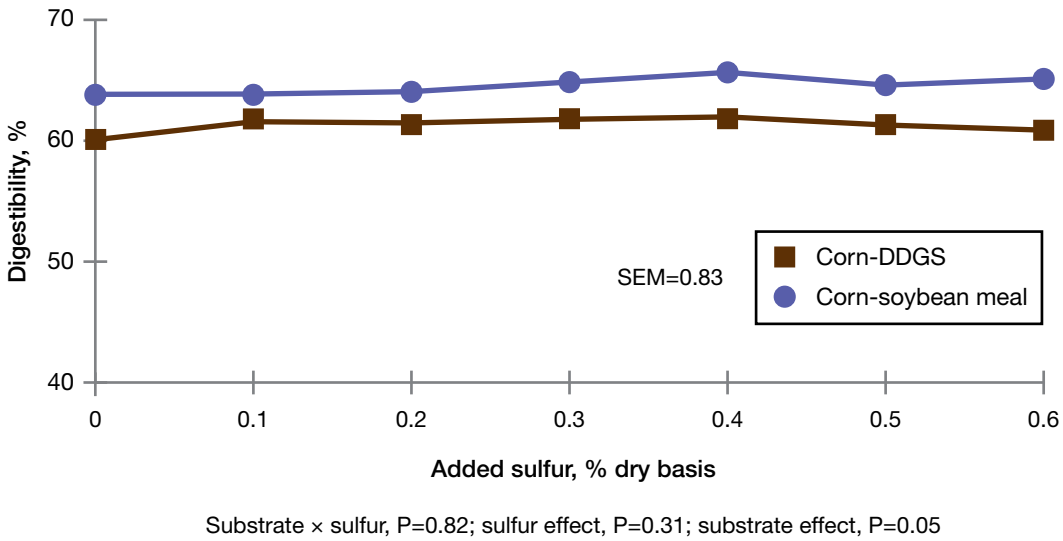
Substrate × sulfur, P=0.32; sulfur effect, P=0.95; substrate effect, P<0.01

Figure 1. *In vitro* ammonia concentration of substrates with or without distillers grains with solubles (DDGS) with increasing concentrations of sulfur.



Substrate × sulfur, P=0.11; sulfur effect, P=0.80; substrate effect, P=0.09

Figure 2. *In vitro* total volatile fatty acid (VFA) concentration of substrates with or without distillers grains with solubles (DDGS) with increasing concentrations of sulfur.



Substrate × sulfur, P=0.82; sulfur effect, P=0.31; substrate effect, P=0.05

Figure 3. *In vitro* dry matter disappearance of substrates with or without distillers grains with solubles (DDGS) with increasing concentrations of sulfur.

Forage Selection Preferences of Experienced Cows and Naïve Heifers Grazing Native Tallgrass Range During Winter

N.A. Aubel, K.C. Olson, J.R. Jaeger, D.A. Blasi, L.N. Edwards, G.J. Eckerle, L.A. Pacheco, and L.W. Murray

Introduction

Estimating the nutritive value of a grazing animal's diet is a significant challenge. Description of the botanical composition of a grazed diet is vital in that regard. Microhistological analysis of fecal material has been used for estimating the botanical composition of wild and domestic ungulate diets since first described by Baumgartner and Martin in 1939.

Little research has been conducted on the diet selection preferences of multiparous beef cows compared to primiparous beef cows. We hypothesized that foraging strategies change as cows age. To that end, our objective was to characterize differences in diet selection between experienced multiparous and naïve primiparous beef cows grazing dormant, native tallgrass pastures during winter.

Experimental Procedures

The study was conducted on 8 pastures (approximately 69 acres each) located at the Kansas State University Beef Stocker Unit. These native range pastures were dominated by big bluestem (*Andropogon geradii*) and little bluestem (*Schizachyrium scoparium*), which were grouped together for the purposes of microhistological analysis; sideoats grama (*Bouteloua curtipendula)*; blue grama (*Bouteloua gracillis*); switchgrass (*Panicum virgatum*); indiangrass (*Sorghastrum nutans*); leadplant (*Amorpha canescensi*); heath aster (*Symphyotrichum ericoides*); dotted gayfeather (*Liatris punctata*); and purple prairie clover (*Dalea purpurea*). Pastures were grazed from February 21 to March 1, 2009.

Treatments consisted of non-pregnant multiparous cows (n = 18; average initial body weight = 1299 ± 110 lb; average initial body condition score = 4.9 ± 0.5) that were 9 years of age and had grazed dormant, native tallgrass pastures during each winter of their lives and non-pregnant primparous cows (n = 20; average initial body weight = 664 ± 55 lb; average initial body condition score = 4.1 ± 0.4) that were 11 months of age and had never grazed dormant, native tallgrass pastures. Cows were grouped randomly into grazing cohorts by treatment (i.e., experienced cows or naïve heifers). Cows were allowed to adapt to their cohort groupings and to graze separate dormant, native tallgrass pastures for 9 days before the study began. The grazing cohorts were then assigned randomly to graze 4 of the 8 pastures in sequence during 4 consecutive, 48-hour periods; cohorts were never commingled before or during the study. No supplemental feed or mineral was offered to cows during the study.

In keeping with previous research comparing diets grazed by dissimilar classes of beef cattle, grazing cohorts were gathered into a corral at the end of each 48-hour collection period and fecal grab samples were collected from each animal for analysis. Samples

were prepared by soaking in 50% ethanol (volume/volume) solution overnight, then homogenized and washed with deionized water to remove contaminants. Samples were then dried and ground to pass a 1-mm screen for slide preparation.

For slide preparation, subsamples were soaked to soften them, rinsed with deionized water, homogenized, and rinsed again. The subsample was placed on a slide with 1 to 3 drops of Hertwig's solution and placed over a propane flame until dry; 1 to 2 drops more of Hoyer's solution was added to mount a cover slip. Slides were dried before viewing.

Slides were viewed on a compound microscope at 10× magnification. The microscope was equipped with a digital camera; each slide field was photographed for comparison with standard slides. Twenty fields per slide were selected randomly from the entire slide view and were used to measure the frequency with which plant fragments appeared. Plant fragment prevalence in slide fields was assumed to be equivalent to prevalence in fecal samples and in grazed diets on a dry matter basis. Plant fragments that were not among the 10 predominant range plants for which standards were prepared were classified as either an unknown grass or an unknown forb.

Results and Discussion

Relatively few plant species comprise the majority of diets selected by beef cows grazing the Kansas Flint Hills in winter. The prevalence of unidentifiable grasses and forbs in each grazing cohort observation within each period was ≤0.14% in our study; moreover, we observed no effects ($P \geq 0.32$) of parity or period on the amounts of unidentified grasses or forbs in beef cow diets (Table 1).

Primiparous cows selected more ($P=0.09$) forbs and fewer ($P=0.09$) grasses than multiparous cows (Table 2). The average difference between multiparous cows and heifers was modest (4.0%) but typical of previous reports comparing botanical composition of diets grazed by dissimilar classes of beef cattle. Greater consumption of forbs by primiparous cows compared with multiparous cows was unexpected. Previous research indicated that preference for broadleaf plants generally increases with grazing experience; however, these conclusions were based on research with forages of greater quality than those evaluated in our study.

Multiparous cows ate more ($P=0.07$) bluestem and less ($P=0.05$) dotted gayfeather than primiparous cows (Table 2). Grass consumption by the cows in our study was less and forb consumption greater than that reported for spring and summer grazing seasons in the northern United States; however, similar grass:forb ratios have been reported in cattle diets in the southern United States. Kansas researchers reported that forbs comprised only 2.5 to 6% of all range plants on Kansas tallgrass prairie. In contrast, forb consumption in our study ranged from a high of 39.6% in period 1 to a low of 27.1% in period 4 (Table 3). Consumption of total forbs, purple prairie clover, leadplant, and dotted gayfeather by both classes of cows declined ($P \leq 0.04$) over time, whereas consumption of total grasses, bluestem, and blue grama increased ($P \leq 0.02$) over time. The cattle in our study appeared to actively seek certain forb species during foraging. The decline in forb consumption over time may have indicated that forb availability diminished during the study.

Occasional differences in consumption of indiangrass, switchgrass, sideoats grama, and heath aster between primiparous and multiparous cows occurred; however, differences were inconsistent (parity × period effect; $P \leq 0.02$) over time and we consider these effects to be of little importance (Table 1).

Implications

Differences observed in diet selection patterns between multiparous and primiparous cows during a short-term winter grazing period could be indicative of differences in long-term foraging strategies.

Table 1. Effects of collection period on botanical composition of diets selected by multiparous or primiparous beef cows grazing the Kansas Flint Hills in winter

						P-value		
% of diet dry matter	Period 1	Period 2	Period 3	Period 4	SEM	Parity	Period	Parity × period
Grasses								
Multiparous	61.7	66.5	73.0	74.6	2.5	0.09	<0.01	0.55
Primiparous	59.0	64.6	64.8	71.4				
Bluestem								
Multiparous	27.2	15.2	19.6	17.8	1.5	0.07	<0.01	0.58
Primiparous	26.4	10.5	17.0	16.0				
Indiangrass								
Multiparous	19.4	34.2	37.2	40.9	1.7	0.24	<0.01	<0.01
Primiparous	16.4	44.7	36.2	41.8				
Switchgrass								
Multiparous	10.0	11.8	11.6	10.1	1.2	0.01	0.60	0.03
Primiparous	9.3	5.1	7.0	7.5				
Blue grama								
Multiparous	3.6	3.9	2.6	4.3	0.5	0.79	0.02	0.13
Primiparous	4.6	2.9	2.8	3.6				
Sideoats grama								
Multiparous	1.47	1.64	1.84	1.57	0.24	0.82	0.22	0.04
Primiparous	2.23	1.06	1.48	1.60				
Unknown grasses								
Multiparous	0.03	0.05	0.03	0.02	0.055	0.32	0.74	0.60
Primiparous	0.04	0.09	0.10	0.14				
Forbs								
Multiparous	38.3	33.5	27.0	25.4	2.5	0.09	<0.01	0.55
Primiparous	41.0	35.4	35.3	28.7				
Purple prairie clover								
Multiparous	14.2	13.7	11.7	10.0	1.1	0.15	<0.01	0.22
Primiparous	15.9	16.2	10.1	12.1				
Leadplant								
Multiparous	10.8	10.3	5.6	6.2	1.6	0.42	0.04	0.14
Primiparous	10.6	9.1	10.6	7.4				
Dotted gayfeather								
Multiparous	7.1	6.5	6.2	5.4	1.1	0.04	0.01	0.28
Primiparous	11.2	8.4	7.8	5.6				
Heath aster								
Multiparous	6.2	3.0	3.7	3.9	0.9	0.88	<0.01	<0.01
Primiparous	3.2	2.0	6.9	4.2				
Unknown forbs								
Multiparous	0.03	trace	0.01	0.01	0.014	0.58	0.60	0.38
Primiparous	trace	trace	trace	0.02				

Table 2. Effect of parity status on botanical composition of diets selected by beef cows grazing the Kansas Flint Hills in winter

% of diet dry matter	Primiparous	Multiparous	SEM	P-value
Grasses	64.9	69.0	1.4	0.09
Bluestem matter	17.5	20.0	0.8	0.07
Forbs	35.1	31.0	1.4	0.09
Dotted gayfeather	8.3	6.3	0.6	0.05

Table 3. Effect of collection period on botanical composition of diets selected by beef cows grazing the Kansas Flint Hills in winter

% of diet dry matter	Period 1	Period 2	Period 3	Period 4	SEM	P-value
Grasses	60.4	65.6	68.9	73.0	1.8	<0.01
Bluestem	26.8	12.9	18.3	16.9	1.0	<0.01
Blue grama	4.1	3.4	2.7	4.0	0.4	0.02
Forbs	39.6	34.5	31.1	27.1	1.8	<0.01
Purple prairie clover	15.1	14.9	10.9	11.0	0.8	<0.01
Leadplant	10.7	9.7	8.1	6.8	1.1	0.04
Dotted gayfeather	9.2	7.5	7.0	5.5	0.7	0.01

Supplementing Dried Distillers Grains with Solubles to Heavy Yearling Stocker Cattle Grazing Native Tallgrass Pastures During Late Summer and Fall Improves Animal Performance and Carcass Characteristics[1]

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Introduction

Grazing stocker cattle on low-quality forages is a common practice in Kansas; however, animal performance typically is modest. Due to the increasing availability of ethanol co-products, producers may be able to use dried distillers grains with solubles (DDGS) as a protein source to help increase body weight of stocker cattle grazing native tallgrass pastures during the late summer and fall. Therefore, the purpose of this research was to investigate the impact of feeding DDGS to heavy stocker cattle during late summer and fall and to document its effects on animal performance and subsequent carcass characteristics.

Experimental Procedures

The experimental design was a randomized complete block design with a 2 x 3 factorial treatment arrangement. Factors consisted of DDGS supplementation during grazing (0 or 1% of body weight with DDGS on a dry matter basis) and, subsequently, the number of days on a finishing diet (75, 100, or 125 days). Supplementation during the grazing period did not influence animal response to number of days on a finishing diet; therefore, main effects of DDGS supplementation and days on a finishing diet were reported.

Crossbred steers (n = 144; initial body weight = 808 ± 40 lb) were stratified by weight and randomly assigned to 1 of 12 pastures. Supplemented cattle were fed DDGS at 1% of their body weight (dry matter basis) once daily while grazing mature, dormant (2.62% crude protein) native pastures for 90 days. Grazing took place from mid-August to mid-November of 2009 at the Kansas State University Commercial Cow-Calf Unit. Animal performance measurements taken during the grazing portion of the experiment included average daily gain from 0 to 45 days, 45 to 90 days, and 0 to 90 days.

After the grazing portion of the experiment was completed, steers were placed in uncovered, concrete-surfaced feedlot pens at the Kansas State University Beef Cattle Research Center and fed a high-concentrate diet for 75, 100, or 125 days. Cattle were fed once daily and had access to fresh, clean water. Animal performance measurements taken during the finishing phase included average daily gain, dry matter intake, and feed efficiency.

[1] Funding for this project was provided by the Beef Checkoff.

After the finishing phase was completed, two paired groups of control- and DDGS-fed cattle were harvested at a commercial slaughter facility on three separate days. Hot carcass weights were measured immediately after harvest. Following a 24- to 48-hour chill, the percentage of kidney, pelvic, and heart fat; 12th rib fat thickness; ribeye area; and USDA marbling scores were determined. Yield grade was calculated based on the USDA yield grade equation. Dressing percentage was calculated as hot carcass weight divided by shrunk final body weight.

Results and Discussion

Live Animal Grazing Performance

The performance of heavy stocker cattle supplemented with DDGS during late summer and fall grazing is displayed in Table 1. Supplementing DDGS to steers grazing native pasture increased ($P<0.05$) average daily gain from 0 to 45 days, 45 to 90 days, and for the entire grazing period, resulting in a greater total weight gain after 90 days compared to control steers.

Live Animal Feedlot Performance

Feedlot performance of heavy stocker cattle supplemented with DDGS during grazing is shown in Table 2. Control cattle had greater ($P<0.01$) feedlot average daily gain than supplemented cattle. Dry matter intake ($P=0.91$) was similar between treatments over the entire finishing period. For this reason, efficiency of control cattle during the finishing period was greater ($P=0.02$) than that of cattle supplemented with DDGS.

Carcass Characteristics

The carcass characteristics of heavy stocker cattle supplemented with DDGS during grazing are shown in Table 3. Cattle supplemented with DDGS during grazing had heavier ($P<0.01$) hot carcass weights and larger ($P=0.02$) ribeye areas than unsupplemented cattle, but there were no differences in dressing percentage, USDA yield grade, fat thickness, marbling score, or kidney, pelvic, and heart fat percentage. We interpret these data to indicate that supplementing DDGS to heavy stocker cattle grazing native tallgrass pastures in late summer and fall can improve red meat yield without sacrificing quality grade.

Implications

Stocker operators can supplement DDGS while grazing late-season native tallgrass pastures to increase weight gain and improve carcass red meat yield without affecting quality or yield grade. Feedlot operators should be aware that supplemented stocker cattle will be slightly less efficient than non-supplemented stocker cattle during the finishing phase.

Table 1. Pasture performance of heavy stocker cattle supplemented with DDGS[1] during grazing

	Treatment		
Trait	Control	DDGS	SEM
Average daily gain, 0 to 45 days, lb	2.02[a]	3.39[b]	0.153
Average daily gain, 45 to 90 days, lb	-0.58[a]	1.44[b]	0.134
Average daily gain, 0 to 90 days, lb	0.76[a]	2.45[b]	0.116
Total gain, lb	68.5[a]	220.7[b]	10.47

[1] DDGS = Dried distillers grains with solubles supplemented at 1% of body weight on a dry matter basis.
[ab] Means within a row with different superscripts differ (P<0.05).

Table 2. Feedlot performance of heavy stocker cattle supplemented with DDGS[1] during grazing

	Treatment		
Trait	Control	DDGS	SEM
Average daily gain, lb	3.68[b]	3.20[a]	0.090
Average daily dry matter intake, lb	27.6	27.6	0.384
Feed:gain	7.50[a]	8.63[b]	0.34
Total gain, lb	367.0[b]	320.4[a]	9.2

[1] DDGS = Dried distillers grains with solubles supplemented at 1% of body weight on a dry matter basis.
[ab] Means within a row with different superscripts differ (P<0.05).

Table 3. Carcass characteristics of heavy stocker cattle supplemented with DDGS[1] during grazing

	Treatment		
Trait	Control	DDGS	SEM
Hot carcass weight, lb	729.3[a]	800.1[b]	7.2
Dressing percentage	61.1	61.7	0.3
USDA yield grade	2.1	2.2	0.08
12th rib fat thickness, in.	0.27	0.32	0.18
Longissimus muscle area, in.[2]	13.2[a]	14.0[b]	0.18
Marbling score[2]	387.6	399.6	9.1
Kidney, pelvic, and heart fat, %	1.86	1.96	0.03

[1] DDGS = Dried distillers grains with solubles supplemented at 1% of body weight (dry basis).
[2] Marbling score: small = 400 to 499; slight = 300 to 399.
[ab] Means within a row under a common main effect with different superscripts differ (P<0.05).

Sun-Curing and Harvest Maturity Impacts Concentration and Protein-Binding Capacity of Condensed Tannins in Sericea Lespedeza (*Lespedeza Cuneata*)

G.J. Eckerle, K.C. Olson, J.R. Jaeger, and L.A. Pacheco

Introduction

Sericea lespedeza (*Lespedeza cuneata*) is a noxious weed that infests approximately 600,000 acres of native tallgrass range in Kansas. Intake of sericea lespedeza by grazing livestock is poor, presumably as a result of the plant's tannins. Condensed tannins reduce protein digestion by ruminants and may also decrease plant palatability.

Prolific seed production, in combination with little or no grazing pressure, has contributed to the rapid spread of sericea lespedeza on Kansas rangelands. Increasing grazing pressure on sericea lespedeza may reduce seed production and slow its advance; however, development of appropriate research models to study sericea lespedeza intake by ruminants has been slow. Tannin concentration in sericea lespedeza changes dramatically during drying and storage. Therefore, avoidance of sericea lespedeza by grazing livestock is not generally observed when sericea lespedeza is fed to livestock in the form of sun-cured hay. Little is known about how harvest maturity and sun-curing influence the concentration of condensed tannins in sericea lespedeza or the degree of protein-binding by condensed tannins over the course of an entire growing season. Such information could lead to more effective research models for the study of sericea lespedeza intake by ruminant livestock. Therefore, the objective of our study was to examine changes in condensed-tannin concentrations and in protein-binding capacity of condensed tannins throughout the growing season in both sun-cured and fresh sericea lespedeza.

Experimental Procedures

Sample Collection and Preparation

Samples were collected throughout the summer of 2009 from a single 160-acre pasture in Greenwood County, Kansas. Plant-species composition was determined using a modified step point technique; sericea lespedeza comprised 19.3% of all plants encountered during the procedure.

Individual plants were collected at 1- to 4-week intervals from June 24 to October 11 (n = 200 plants per sampling date) that corresponded to single-stem, branch-stem, budding, flowering, and senescent stages of plant growth. At the time of collection, samples were either allowed to sun-cure in burlap bags or were flash-frozen. Flash-frozen samples were preserved by freeze drying and dried samples were ground with dry ice to prevent polymerization of tannins.

Extraction and Determination of Condensed Tannins

Tannins were extracted using a methanol extraction procedure. Samples were combined with 1.69 oz of 50% methanol (volume/volume). Samples were agitated for 20 minutes then centrifuged to remove solids. The supernatant was removed and used for further analysis. Condensed tannin concentrations were measured using a modified butanol-HCl reaction. Reaction mixtures were read at 550 nm on a spectrophotometer and absorbance was adjusted to concentration of condensed tannin using luecocyandin as a standard.

Determination of Protein-Precipitable Phenolics

Protein-precipitable phenolics were determined through a reaction between ferric chloride and tannin phenolics. This reaction produced a pink chromatophore that could be read spectrophotometrically. These samples were read on a spectrophotometer with prepared standards at 510 nm. Concentrations were determined using a standard curve after accounting for the amount of sodium dodecyl sulfate solution that was added.

Results and Discussion

Condensed Tannins

Allowing forage to sun-cure substantially decreased concentrations of detectable condensed tannins at all stages of sericea lespedeza maturity (main effect of treatment $P<0.001$). Concentrations of condensed tannins were different in both treatments at each stage of sericea maturity (main effect of harvest date $P<0.05$). Concentrations of condensed tannins were lowest in June and October and peaked in August (Figure 1). Peak concentrations corresponded to the flowering stage of the sericea lespedeza life cycle.

Protein-Precipitable Phenolics

Concentrations of protein-precipitable phenolics were decreased by sun curing sericea lespedeza (Figure 2). Protein-binding capacity differed at each stage of growth ($P<0.01$). The magnitude of the effect changed over time and was influenced by treatment (treatment x time interaction, $P<0.01$; Figure 2). The protein-binding capacity was least during June and October and again peaked in August. These quadratic responses of the fresh frozen sericea lespedeza suggest that condensed tannins in sericea lespedeza retained their ability to bind proteins late into the growing season.

Implications

Results from this study suggest that allowing sericea lespedeza to sun-cure after harvest can dramatically decrease the amount of extractable condensed tannins and the capability of condensed tannins to bind proteins. Moreover, condensed tannin concentration and protein-binding capability peaked near the flowering stage of sericea lespedeza. These data may explain why sharp avoidance of sericea lespedeza exhibited by grazing livestock is difficult to replicate in a laboratory setting when the plant is offered to livestock in the form of sun-cured hay. Understanding how drying and plant growth stage influence condensed tannin concentrations and protein-binding capacity of sericea lespedeza could lead to more effective research models for the study of sericea lespedeza intake by ruminant livestock.

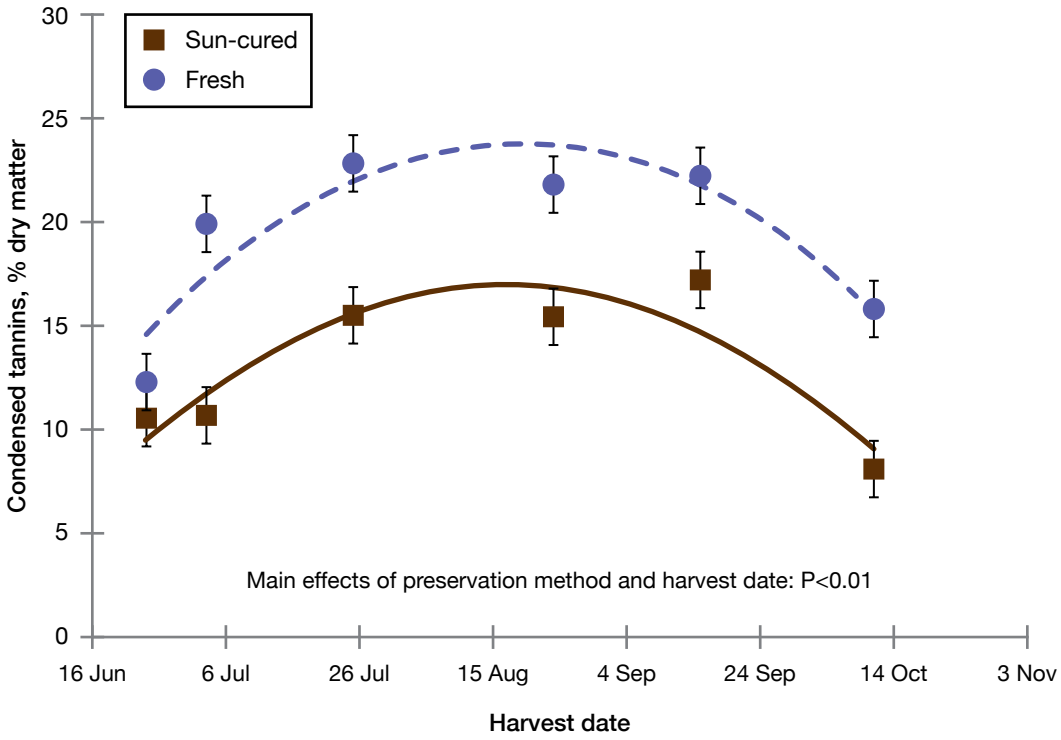

Figure 1. Effects of sun-curing and harvest date on concentration of condensed tannins in sericea lespedeza.

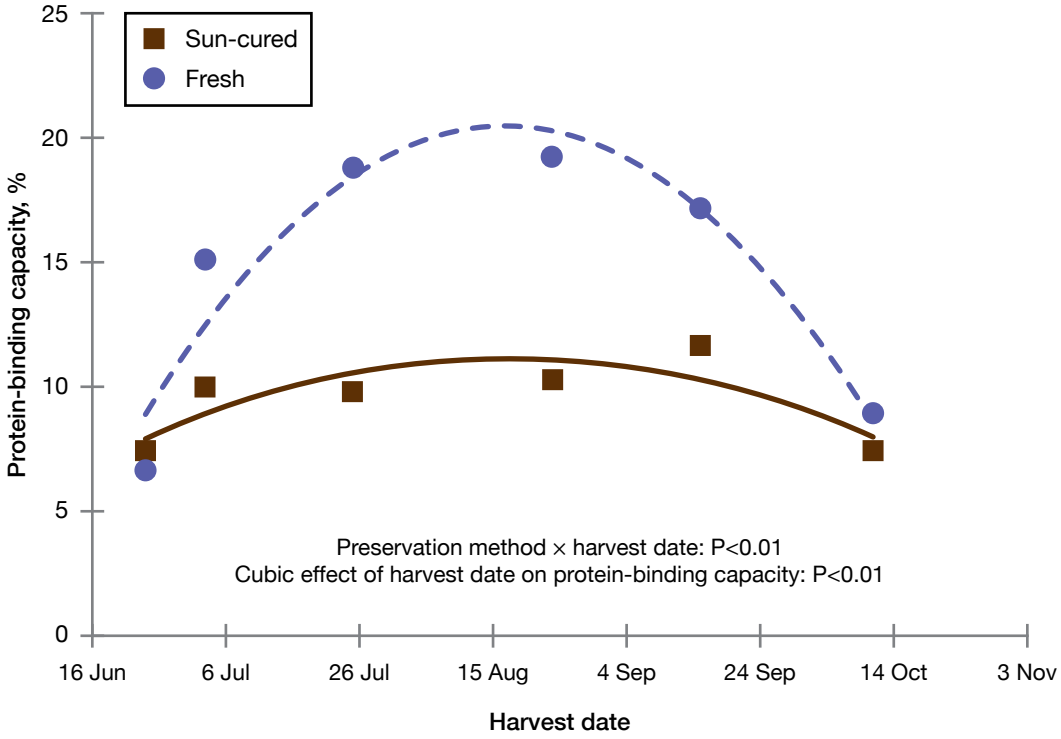

Figure 2. Effects of sun-curing and harvest date on the protein-binding capacity of condensed tannins in sericea lespedeza.

Voluntary Intake of Prairie Hay Contaminated with Sericea Lespedeza (*Lespedeza Cuneata*) by Beef Cows

G.J. Eckerle, K.C. Olson, J.R. Jaeger, and L.A. Pacheco

Introduction

Sericea lespedeza (*Lespedeza cuneata*) is a noxious weed that infests approximately 600,000 acres of native tallgrass range in the Kansas Flint Hills. Intake of sericea lespedeza by grazing beef cattle is poor due to the presence of condensed tannins in the plant. Condensed tannins reduce protein digestion by beef cattle and may decrease plant palatability because of their astringence.

Prolific seed production, in combination with little or no grazing pressure, has contributed to the rapid spread of sericea lespedeza in the Flint Hills. Increasing grazing pressure on sericea lespedeza may reduce seed production and slow its invasion; however, the difficulties associated with measurement of intake by grazing beef cattle have hampered development of workable research models. Detailed study of the appetite-suppressing effects of sericea lespedeza under controlled conditions is essential to develop appropriate strategies to increase grazing pressure on this plant. Such information could lead to a degree of biological control of this noxious weed using the most economically important grazer (i.e., beef cattle) in the Flint Hills.

Feeding sericea lespedeza as sun-cured hay to confined beef cattle would be a feasible way to study the intake-limiting properties of this plant. This approach has not been attempted to date because previous research indicated that allowing sericea lespedeza to sun-cure after harvest sharply decreased the amount of extractable condensed tannins in the plant and the capability of condensed tannins to bind proteins. Based on these reports, it was doubtful whether sun-cured sericea lespedeza hay would produce the aversion in confined beef cattle that is commonly observed in free-ranging beef cattle exposed to the fresh plant. Therefore, the objective of our study was to compare intake of tallgrass prairie hay by beef cows when hay was either uncontaminated or heavily contaminated by sericea lespedeza.

Experimental Procedures

Tallgrass prairie forage contaminated with sericea lespedeza was harvested from a single pasture in Greenwood County, KS. The forage was sun-cured, packaged in bales, and stored at the Kansas State University Commercial Cow-Calf Unit. Forage was harvested in late July, corresponding to the budding stage of sericea lespedeza. Concentrations of condensed tannins in the plant typically are greatest at this stage of growth. Plant-species composition on the study site was estimated using a modified step-point technique; sericea lespedeza comprised 19.3% of all plants encountered during the procedure. Aboveground biomass of sericea lespedeza averaged 893 lb/acre.

Uncontaminated tallgrass prairie forage was harvested in Pottawatamie County, KS, in late July. Species composition of contaminated and uncontaminated forages were simi-

lar in all respects except for the presence of sericea lespedeza in the contaminated forage. Bales of each forage type were sampled to determine crude protein and acid detergent fiber concentrations and paired based on similarity in those values. Average protein and acid detergent fiber concentrations in contaminated and uncontaminated hays are shown in Table 1. Purposeful selection for similarity in protein and fiber concentrations between forage types was intended to prevent confounding of differences in forage quality with effects on intake. Bales of contaminated and uncontaminated hays selected for the study were ground separately through a 4-in. screen.

Twenty-four mature beef cows (average initial weight = 1022 ± 153 lb; average initial body condition score = 4.2 ± 0.8) were used in the study. Cows were housed in a single pen and were fed individually using a Calan gate system (American Calan, Inc., Northwood, NH). Cows were stratified by body weight and body condition score and assigned randomly to be fed either contaminated (C) or uncontaminated (UC) hay.

Cows were trained to use the Calan gate feeding system over a period of approximately 30 days. During this time, all cows were fed UC free choice. When forage intake stabilized at approximately 2.5% of body weight, the trial was initiated. All cows were fed UC free choice for the first 5 days of the trial. At that point, cows assigned to C were abruptly switched to prairie hay contaminated with sericea lespedeza. All cows were offered hay free choice according to their respective treatments for the next 10 days. Hay was offered at 6 a.m. and 6 p.m. daily. Refusals were collected daily at 5:30 a.m. Daily voluntary hay intakes (dry basis) were determined by subtracting daily refusals from the total amount of hay offered. Intakes were expressed as a percentage of initial cow body weight.

Results and Discussion

Average daily voluntary dry matter intake (DMI) of C and UC are shown in Figure 1. Both groups of cows were fed UC during the first 5 days of the trial (i.e., days -5 to -1). No differences ($P \geq 0.38$) in DMI occurred during this period. C was substituted for UC on day 0, after which voluntary DMI immediately began to diverge (treatment x time interaction, $P < 0.01$). From day 0 to day 4, average voluntary DMI of C and UC were within 0.2 to 0.5% of body weight of one another. Thereafter, daily average voluntary DMI of cows assigned to C declined sharply such that by day 9 of the study, cows assigned to UC were eating 7 times more forage dry matter than those assigned to C.

The immediate decline in voluntary DMI that occurred during the first 5 days (day 0 to day 4) after the abrupt switch to C was interpreted to indicate that palatability of sericea lespedeza had a negative but relatively minor influence on consumption. Conversely, the precipitous drop in intake of C that followed (days 5 to 9) appeared to be driven by significant post-ingestive consequences of sericea lespedeza ingestion. This effect may have been associated with a ruminal buildup of tannin-protein complex, preceding a general decrease in the activity of ruminal cellulolytic microorganisms.

Implications

Results of this study suggest that tallgrass prairie hay heavily contaminated with sericea lespedeza may be a useful model for the study of the appetite-suppressing effects of that plant. Furthermore, the major source of appetite suppression by sericea lespedeza in

sun-cured form was attributed to the post-ingestive consequences of anti-nutritional factors, possibly condensed tannins, rather than anti-palatability factors. Whether these generalizations can be extrapolated to actively growing sericea lespedeza under grazing conditions is unknown.

Table 1. Concentration of acid detergent fiber (ADF) and crude protein in tallgrass prairie hay contaminated with sericea lespedeza and in uncontaminated tallgrass prairie hay (dry matter basis)

Item	% Crude protein	% ADF
Prairie hay contaminated with sericea lespedeza	5.5	41.0
Uncontaminated prairie hay	5.4	39.8

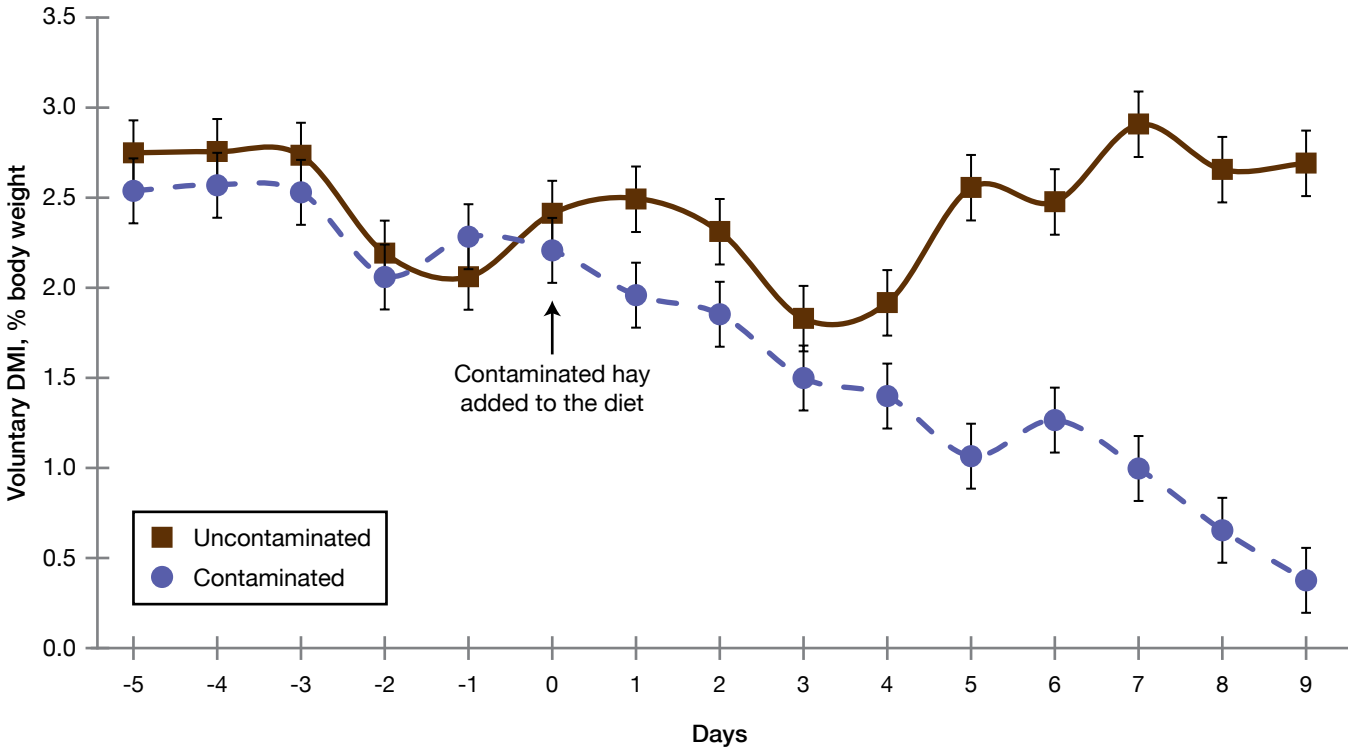

Figure 1. Effects of sericea lespedeza contamination on voluntary dry matter intake (DMI) of tallgrass prairie hay by beef cows.

Effects of Prepartum Ruminally Protected Choline Supplementation on Performance of Beef Cows and Calves

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Introduction

Prepartum supplementation of spring-calving beef cows is a vital part of cow-calf enterprises, often affecting subsequent reproductive success. Most research in the area of prepartum supplementation has focused on provision of either energy or protein; only modest attention has been given to the use of supplemental micronutrients. One such micronutrient is choline.

Choline is classified generally as a B vitamin and is an essential nutrient. Phosphatidylcholine and other choline-containing lipids maintain the structural integrity of cellular membranes and play a vital role in metabolism of dietary fat. Choline-containing phospholipids are also important precursors for intracellular-messenger molecules and cell-signaling molecules critical to the reproductive process.

Choline is commonly found in feedstuffs and forages but is highly degradable in the rumen. For choline supply to be increased effectively, it must be offered in a form that is resistant to ruminal digestion. This can be achieved by encapsulating choline in lipid. Therefore, the objective of our study was to evaluate the effect of prepartum ruminally protected choline supplementation on cow and calf performance.

Experimental Procedures

Angus-cross cows and heifers (n = 438; initial body weight = 1,173 lb) were blocked by age, body condition score, and expected calving date and randomly assigned to one of two supplement treatment groups: (1) a 40% crude protein mixture of corn and soybean meal with ruminally protected choline, or (2) 40% crude protein mixture corn and soybean meal with no ruminally protected choline (Table 1). Treatments were applied during the 60-day period immediately preceding the earliest predicted calving date. Cows were fed 5.2 lb per head per day of their respective supplement 6 times per week. The average daily feeding rate of choline for treated cows was 0.16 oz per cow per day.

Cows were evenly distributed by treatment, body condition score, and expected calving date into 4 native tallgrass prairie pastures with approximately 47 cows per pasture (23 or 24 per treatment group per pasture). Cattle were gathered from their pastures at 7:00 a.m., sorted into pens by treatment, fed their allotted amount of supplement, and allowed one hour to consume the supplement. Cows continued to receive supplements until calving. After that time, all cows were moved to a separate pasture and fed the control supplement.

Ultrasound measurements of ribeye muscle characteristic were collected at the beginning and end of the supplementation period. Backfat thickness, ribeye muscle depth, and intramuscular fat measurements were taken along the spine between the 12th and 13th rib interface using an Aloka 500V (Aloka Co., Ltd., Wallingford, CT). Cow body weights and body condition scores were measured at calving, 15 days prior to estrous synchronization, at estrous synchronization, at artificial insemination (AI) pregnancy check, at weaning, and at final pregnancy check. Calf body weights also were measured at these times.

Ovulation was synchronized using the Co-synch + CIDR protocol and cows were subsequently mass mated via timed AI. Cows were exposed to bulls 10 days after AI for the remainder of a 60-day breeding season. Conception to AI was determined via ultrasound 30 days after AI and final pregnancy rate was determined via rectal palpation 60 days after end of the breeding season.

Results and Discussion

Cow body weights, body condition scores, backfat thicknesses, and intramuscular fat percentages were similar ($P \geq 0.25$) between treatments at the onset of supplementation and at final pregnancy diagnosis. Cows fed ruminally protected choline tended to lose 0.03 inches more ($P=0.10$) ribeye muscle depth between the onset of the trial and the conclusion of the supplementation period. Conception to AI and final pregnancy rates were not affected ($P \geq 0.19$) by treatment (Table 2). Early season average daily gain, overall average daily gain, and adjusted 205-day body weight of calves was similar ($P \geq 0.39$) between treatments. Calves born to dams fed ruminally protected choline had slightly greater ($P=0.05$) average daily gain during the latter part of the grazing season than calves born to dams fed the control supplement (Table 3).

Implications

Under the conditions of our study, prepartum supplementation with ruminally protected choline had only minor effects on performance of beef cows and calves.

Table 1. Nutrient analysis of ruminally protected choline (RPC) or control (CON) supplements fed to beef cows during the prepartum period (dry matter basis)

Item	RPC	CON
Corn, %	50	50
Soybean meal, %	50	50
Dry matter, %	89.22	88.59
Crude protein, %	40.66	37.12
Calcium, %	0.3	0.22
Phosphorus, %	0.57	0.54
Neutral detergent fiber, %	10.26	9.91
Acid detergent fiber, %	4.27	4.45
Starch, %	12.35	15.78

Table 2. Performance response of beef cows fed ruminally protected choline (RPC) or control (CON) supplements during the 60-day prepartum period

Item	RPC	CON	SE	P-value
Cow body weight change 01/22 to 10/05, lb	16.5	10.2	4.05	0.80
Cow BCS[a] change 01/22 to 10/05, BCS units	0.44	0.53	0.038	0.25
Change in ribeye muscle characteristics				
12th rib backfat, in.	-0.01	-0.002	0.05	0.88
Ribeye muscle depth, in.	-0.04	-0.01	0.45	0.10
Intramuscular fat, %	-0.01	-0.02	0.03	0.39
Timed-AI pregnancy, %	45.8	44.7	-	0.83
Overall pregnancy, %	87.5	91.6	-	0.19

[a] Body condition score, 1 to 9 scale (1 = thin, 9 = very fat)

Table 3. Performance response of calves born to beef cows fed ruminally protected choline (RPC) or control (CON) supplements during the 60-day prepartum period

Item	RPC	CON	SE	P-value
Early average daily gain (ADG; birth to 08/01), lb	2.4	2.4	0.02	0.09
Late ADG (08/02 to 10/05), lb	2.3	2.2	0.02	0.05
Overall ADG (birth to 10/05), lb	2.3	2.3	0.01	0.64
Adjusted 205-day body weight, lb	576.4	571.1	3.5	0.51

Marination Technique Influences Whole Muscle Beef Jerky Salt Content and Flavor Intensity

G.R. Skaar and E.A.E. Boyle

Introduction

Beef jerky is a popular meat snack that is simple to recognize and define. The USDA Food Standards and Labeling Policy Book (FSLPB) allows labeling use of the title "jerky" to a product that has been dried to a moisture-to-protein ratio (MPR) of 0.75:1.0 or less, and states the species or kind (such as beef, pork, or venison) in the name. As long as the product is dried to the required MPR and the species of origin is noted, all additional ingredients used, spice applications, and processing procedures are open for interpretation and application. The USDA FSLPB goes on to state that the product may be cured or uncured, dried, and may be smoked or unsmoked as well as air dried or oven dried.

With such a short list of requested, jerky has a great deal of optimization potential for small- and large-scale production. Marination of sliced meat is one stage in the jerky-making process that is open to variation. Our study compared two common beef jerky marination techniques: 1) traditional marination via extended soaking in a tub, and 2) short-time vacuum tumbling. Additionally, a liquid smoke-based anti-mold spray provided by Kerry Ingredients & Flavors (Monterey, TN) was applied after drying to evaluate the final product for taste differences.

Experimental Procedures

Jerky Production

Beef inside rounds were obtained from the Kansas State University Meat Laboratory. Three rounds were used, one on each of three days, resulting in three replicated jerky production batches. On the initial day of production a round was trimmed practically free of fat and heavy connective tissue, weighed as an intact muscle, and then sliced into 0.25- to 0.125-in.-thick pieces. The round slices were weighed and separated into two equal weight portions; half were designated for a traditional, long-time soaking marination and half for short-time vacuum tumbling. Those slices designated for tumbling were re-packaged in a vacuum bag and stored in a cooler to be tumble-marinated the following day. The slices for traditional long-time soaking marination were placed in a large tub with 42.7% marinade (Table 1), according to meat weight. Alternating layers of sliced beef and marinade were added until all designated beef and marinade were utilized. A single piece of plastic wrap was placed over the marinating beef to serve as a temporary seal to prevent drying of those pieces on the top layer. Beef slices soaked for 24 hours in cooler storage.

The following day, soaked pieces were removed from the tub and weighed to find the amount of marinade picked up by the meat. This ratio (% pickup) was used to determine the amount of marinade to be added during vacuum tumbling. The remaining half of the sliced round was then placed in a vacuum tumbler (Model VTS-42, Biro Manufacturing, Marblehead, OH) with the correlating amount of marinade from above. Twenty-in. mercury (Hg) vacuum was applied and the beef slices were tumble-

marinated for 20 minutes. After tumbling, both marination treatments were randomly placed on a single smoke truck to be cooked and dried. The product was cooked for 90 minutes at 140°F and dried for 2.5 hours at 145°F. Upon completion, a final dried weight for the product was recorded and each marination group was split in half by weight. Lastly, a liquid smoke-based anti-mold spray (Kerry Ingredients & Flavors, Monterey, TN) was applied to one half from each marination technique. Final production treatments were as follows: (1) soaked, not sprayed (S); (2) soaked, sprayed (SS); (3) tumbled, not sprayed (T); and (4) tumbled, sprayed (TS). Product was allowed to cool to at least 40°F for packaging and then stored for subsequent analysis.

Jerky Evaluation

Color was evaluated with readings taken with a HunterLab MSEZ-4500L spectrophotometer (Hunter Associates Laboratories, Reston, VA). Individual jerky pieces were placed on top of another jerky piece prior to taking each set of readings. Values were recorded for L* (lightness), a* (redness), and b* (yellowness).

Water activity readings were taken with an AquaLab 4 Water Activity Meter (Decagon Devices, Pullman, WA). Readings were taken in duplicate for each treatment on the day of production.

Warner-Bratzler shear force values were evaluated using an Instron Universal Testing Machine (Instron Worldwide, Norwood, MA). Six 1.2-in.-wide strips were cut and sheared from each treatment/production day, taking care to avoid areas where the product may have folded over and dried together or areas where the product appeared uncharacteristically thin. A flat blade was used to cut each strip six times with readings taken to assess total force required to shear each strip.

Salt (NaCl) content was analyzed with Quantab chloride strips (Hach Company, Loveland, CO). Samples were frozen with liquid nitrogen, pulverized in a blender, and mixed with boiling water. After cooling to room temperature, samples were filtered and evaluated with an individual test strip, according to the manufacturer's printed instructions, for Quantab number and correlating NaCl concentration.

Moisture and protein composition were evaluated by the Kansas State University Analytical Laboratory for use in determining the MPR.

A sensory panel composed of faculty and students from the Kansas State University Department of Animal Sciences and Industry was assembled and trained over three orientation sessions on the assessments to be taken for the beef jerky samples. Panelists were asked to score jerky samples on a scale of 1 to 8 for initial bite (1 = extremely soft, 8 = extremely firm), chewiness (1 = no chews, 8 = 19 to 21 chews), moisture (1 = extremely dry, 8 = extremely moist), saltiness (1 = not at all salty, 8 = extremely salty), flavor intensity (1 = extremely bland, 8 = extremely intense), smoke flavor (1 = none, 8 = abundant), and off-flavor intensity (1 = abundant, 8 = none). Jerky from each of the four treatments made on each of the three production days resulted in 12 total "products," each of which were evaluated by the panel twice. Six panel sessions were held with each of the four treatments represented in all panels. The production day used for each panel was randomly selected from each treatment independently.

Results and Discussion

During production, marinade pickup percentage was approximately 3% higher for soaked product compared with tumbled product. Soaked product was placed in a marinade amount equal to 42.7% of the meat weight, whereas tumbled product was placed in a marinade amount equal to the percentage pickup of the soaked product for that production day, equaling 23.5%, 20.8%, and 24.3% for productions 1, 2, and 3, respectively. Ideally, the final pickup percentages of each treatment would have been equal. Notably, vacuum tumbling does not result in 100% marinade pickup and more marinade should be added than is intended to be absorbed by the product when utilizing this form of production.

The required MPR for jerky products is 0.75:1or less. Although final MPR for all treatments were lower than 0.75:1, the final MPR ($P>0.05$) was similar for all treatments, regardless of whether jerky had been produced by soaking or tumbling (Table 2). Therefore, any quality differences due to over- or under-drying a single product were avoided. The compared techniques of soaking marination and vacuum tumbling showed minimal differences for composition of the final product (Table 2). Although a lower ($P<0.05$) water activity was noted for S compared with all other treatments, this difference is not at a level that would affect final product quality. Color values for lightness, redness, and yellowness were similar ($P>0.05$) for all treatments (data not shown). Of greater interest is the approximately 2% higher salt content ($P<0.05$) for soaked product compared with tumbled treatments. This difference could be due to the similar increase in marinade pickup for the soaked product. The salt level of some marinade ingredients, such as soy sauce, is unable to be accounted for; therefore, we cannot say with any certainty that marination technique is responsible for the resulting salt difference.

The increased salt level of product soaked for 24 hours was also identified in the sensory panel evaluation (Table 3), with the saltiness of both soaked treatments scoring higher than tumbled treatments ($P<0.01$). Additionally, soaked treatments were evaluated as having a more intense flavor ($P<0.05$) than tumbled treatments. A higher salt content potentially intensifies beef jerky flavor. We hypothesized that an additional smoke flavor might present itself as a result of the liquid smoke-based anti-mold spray application; however, the sensory panel did not find any differences ($P>0.05$) in smoke flavor or off-flavor among all treatments, suggesting that the application of this specific spray would not alter the flavor profile of beef jerky.

Implications

Using vacuum tumbling as a form of marination saves time compared with soaking beef slices for 24 hours and could alter final product attributes, but if an equal level of marinade pickup is expected compared with soaking then additional marinade above the desired absorption level needs to be included in the tumbler.

Table 1. Beef jerky marinade ingredients

Soy sauce
Worcestershire sauce
Water
Purasil P Optiform 4
Seasoned salt
Monosodium glutamate
Seasonings

Table 2. Composition of beef jerky marinated by 24-hour soaking or 20-minute vacuum tumbling, with and without a liquid smoke-based anti-mold spray

Treatment*	Water activity	Salt, %	Moisture, %	Protein, %	MPR†
S	0.542[a]	7.27[a]	16.7[a]	55.9[a]	0.30[a]
SS	0.591[b]	6.58[a]	17.3[a]	56.0[a]	0.31[a]
T	0.594[b]	5.01[b]	17.8[a]	59.9[b]	0.30[a]
TS	0.619[b]	4.66[b]	18.0[a]	58.1[b]	0.31[a]

[a] Means within a column followed by different superscripts differ (P<0.05).
* Treatments: S – 24-hour soak marinated, SS – 24-hour soak marinated, anti-mold spray, T – 20-minute vacuum tumble marinated, TS – 20-minute vacuum tumble marinated, anti-mold spray.
† MPR: moisture-to-protein ratio.

Table 3. Trained panel sensory evaluation† of beef jerky marinated by 24-hour soaking or 20-minute vacuum tumbling, with and without a liquid smoke-based anti-mold spray

Treatment*	Initial bite	Chewiness	Moisture	Saltiness	Flavor intensity	Smoke flavor	Off-flavor intensity
S	7.0[a]	7.0[a]	2.3[a]	6.0[a]	6.4[a]	3.4[a]	7.5[a]
SS	6.9[a]	6.9[a]	2.6[a]	6.1[a]	6.4[a]	3.4[a]	7.6[a]
T	6.9[a]	6.7[a]	2.4[a]	5.5[b]	5.9[b]	3.3[a]	7.8[a]
TS	6.8[a]	6.6[a]	2.6[a]	5.4[b]	5.9[b]	3.3[a]	7.7[a]

[ab] Means within a column followed by different superscripts differ (P<0.05).
* Treatments: S – 24-hour soak marinated, SS – 24-hour soak marinated, anti-mold spray, T – 20-minute vacuum tumble marinated, TS – 20-minute vacuum tumble marinated, anti-mold spray.
† A scale of 1 to 8 is used for all descriptors. A score of 8 for all traits would describe jerky as extremely firm, chewy, moist, and salty with an intense flavor, abundant smoke flavor, and no off-flavor.

Increasing Days on Feed for Heavy Short-Fed Yearling Stocker Cattle Improves Carcass Characteristics

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Introduction

With increasing feed costs, producers may be able to utilize forage resources to help cattle gain weight before entering a high-concentrate finishing phase. In theory, heavy stocker cattle need less time on feed before slaughter compared to lighter weight cattle; however, research determining the impact of a short feeding system on product quality is limited. Therefore, the purpose of this research was to investigate the impact of a shortened, high-concentrate feeding period on carcass characteristics and meat quality traits of heavy yearling stocker cattle.

Experimental Procedures

The experimental design was a randomized complete block design with a 2 × 3 factorial treatment arrangement. Factors consisted of dried distillers grains with solubles (DDGS) supplementation during grazing (0 or 1% of body weight with DDGS on a dry matter basis) and days (75, 100, or 125 days) on finishing diet. No interactions occurred between grazing supplementation and days on feed, so only the days on feed portion of the experiment will be presented in this report.

Crossbred steers from the grazing portion of the experiment (n = 144; 955.4 ± 78.5 lb body weight) were randomly assigned to one of three treatments consisting of 75, 100, or 125 days on feed with four pens per treatment for a total of 12 experimental units. Cattle were housed at the Kansas State University Beef Research Unit in uncovered, concrete feedlot pens. Cattle were fed a high-concentrate diet once daily based on the previous day's intake and had access to fresh, clean water. Animal performance measurements taken during the finishing phase included average daily gain, dry matter intake, and gain-to-feed ratio.

Cattle were harvested in 3 groups at a commercial slaughter facility and represented the 75, 100, and 125 days on feed treatments. Hot carcass weight was recorded immediately following harvest, and after a 24- to 48-hour chill the percentages of kidney, pelvic, and heart fat, 12th rib fat thickness, ribeye area, and marbling score were collected. Yield grade was calculated based on the USDA yield grade equation. Dressing percentage was calculated as hot carcass weight divided by shrunk final body weight.

For each harvest group, 24 rib and plate sections were collected and fabricated for carcass composition prediction. Instrumental fat color measurements including L* (lightness), a* (redness), and b* (yellowness) values were taken over the rib and plate sections. Ribeye steaks were cut and allowed to bloom and instrumental lean color

including L*, a*, and b* values were recorded from the longissimus muscle. Steaks were then vacuum packaged, allowed to age for 14 days, and then frozen and stored for further evaluation. Steaks were thawed for instrumental tenderness for approximately 12 hours at 32 to 36°F and cooked to 104°F, turned, and cooked to a final internal temperature of 160°F. Steaks used for instrumental tenderness were chilled overnight at 32 to 35°F before 8 round cores were cut from each steak and sheared once perpendicular to the muscle fibers. Steaks used for sensory evaluation were cooked following the same procedures as instrumental tenderness. Cooked steaks were cut into 1-in. × 0.5-in. × 0.5-in. samples. A 6-person trained sensory panel evaluated steaks on an 8-point scale. Each panelist received two cubes from each sample in random order. Each session included a warmed sample and samples from all treatments, making 7 longissimus steaks total per session.

Results and Discussion

Live Animal Feedlot Performance

Feedlot performance of heavy stocker cattle fed for 75, 100, or 125 days is displayed in Table 1. Increasing days on feed from 75 to 100 and 125 days increased total weight gain but did not alter ($P>0.05$) average daily gain, average daily dry matter intake, or gain-to-feed ratio. These data indicate that efficiency was not different for cattle on feed for 75, 100, or 125 days.

Carcass Characteristics

Carcass characteristics of heavy stocker cattle fed for 75, 100, or 125 days are listed in Table 2. Increasing days on feed from 75 to 125 days increased ($P<0.05$) hot carcass weight, 12th rib fat thickness, ribeye area, and marbling score. Increasing days on feed did not affect dressing percentage, yield grade, or percentage kidney, pelvic, and heart fat. An increase ($P<0.05$) in marbling score was observed by increasing days on feed from 75 to 100 days.

Carcass Composition

Carcass composition data from heavy stocker cattle fed for 75, 100, or 125 days are also listed in Table 2. Increasing days on feed decreased ($P<0.05$) carcass protein and carcass moisture percentages while increasing ($P<0.05$) the carcass fat percentage. Increasing carcass fat percentage is expected as animals on a high-concentrate diet consume excess calories that are stored as fat.

Instrumental Color Measurements

Instrumental lean and fat color data from heavy stocker cattle fed for 75, 100, or 125 days are exhibited in Table 3. Increasing days on feed from 75 to 125 days did not affect lean color. However, increasing days on feed from 75 to 100 days affected all of the color parameters for the external fat covering. Increasing days on feed from 75 to 100 days increased ($P=0.05$) L* values, indicating the sample was getting whiter in color; decreased ($P<0.05$) a* values, indicating the color was becoming less red; and decreased ($P<0.05$) b* values, indicating that the color was becoming less yellow. Therefore, a higher prevalence of yellow fat was found on cattle fed for 75 days compared to those fed for 100 or 125 days.

Sensory Analysis and Instrumental Tenderness

Sensory traits and tenderness values of ribeye steaks fabricated from heavy stocker cattle fed for 75, 100, and 125 days is shown in Table 4. No differences were detected in most sensory traits or instrumental tenderness as a result of increasing days on feed; however, increasing days on feed from 100 to 125 led to more off-flavors in samples from cattle fed 125 days compared to 100 days.

Implications

Producers can place heavy yearling stocker cattle on high-concentrate diets for a minimum of 75 days with minimal changes to performance, efficiency, and sensory traits, but heavy yearling stocker cattle should be fed for a minimum of 100 days to optimize marbling score and white external fat color.

Table 1. Feedlot performance of heavy stocker cattle fed for 75, 100, or 125 days

	Days on feed			
Trait	75	100	125	SEM
Average daily gain, lb	3.42	3.52	3.37	0.110
Average daily dry matter intake, lb	27.67	27.30	27.82	0.471
Gain:feed ratio	0.125	0.128	0.120	0.005
Total gain, lb	257.7[a]	354.4[b]	419.1[c]	11.23

[abc] Means within a row with different superscripts differ (P<0.05).

Table 2. Carcass characteristics and composition of heavy stocker cattle fed for 75, 100, or 125 days

	Days on feed			
Trait	75	100	125	SEM
Hot carcass weight, lb	704.7[a]	758.6[b]	820.9[c]	8.85
Dressing percentage	60.5	61.7	62.0	0.004
Yield grade	2.1	2.1	2.4	0.100
Fat thickness, in.	0.27[a]	0.27[a]	0.35[b]	0.022
Ribeye area, in.[2]	13.05[a]	13.71[ab]	14.13[b]	0.217
Marbling score[1]	363.6[a]	407.1[b]	409.5[b]	11.12
Kidney, pelvic, and heart fat, %	2.08	2.07	2.36	0.100
Carcass composition				
Protein, %	17.0[b]	16.5[ab]	16.0[a]	0.261
Fat, %	24.2[a]	25.0[a]	28.9[b]	0.554
Moisture, %	57.8[b]	56.9[b]	54.0[a]	0.393

[1] Marbling score: small = 400 to 499; slight = 300 to 399.
[abc] Means within a row with different superscripts differ (P<0.05).

Table 3. Exterior fat and longissimus muscle L*1, a*2, and b*3 values for heavy stocker cattle fed for 75, 100, or 125 days

	Days on feed			
Trait	75	100	125	SEM
Longissimus muscle lean L*	42.9	42.2	42.8	0.298
Longissimus muscle lean a*	28.0	28.6	28.3	0.267
Longissimus muscle lean b*	19.6	20.1	20.0	0.341
Exterior fat L*	78.0[a]	80.8[b]	79.7[b]	0.344
Exterior fat a*	10.4[a]	6.43[b]	8.53[c]	0.421
Exterior fat b*	17.1[b]	14.3[a]	14.6[a]	0.356

[1] L* brightness (0 = black, 100 = white).
[2] a* redness/greenness (positive values = red, negative values = green).
[3] b* yellowness/blueness (positive values = yellow, negative values = blue).
[abc] Means within a row with different superscripts differ (P<0.05).

Table 4. Sensory traits and instrumental tenderness scores of ribeye steaks from heavy stocker cattle fed for 75, 100, or 125 days

	Days on feed			
Trait	75	100	125	SEM
Myofibrillar tenderness[1]	6.3	6.2	6.0	0.09
Juiciness[2]	5.6	5.6	5.6	0.05
Beef flavor intensity[3]	5.6	5.6	5.6	0.03
Connective tissue amount[4]	6.8	6.8	6.7	0.07
Overall tenderness[5]	6.3	6.3	6.1	0.09
Off flavor intensity[6]	7.5[ab]	7.7[b]	7.4[a]	0.05
Warner-Bratzler shear force, lb	7.3	7.8	8.1	0.246

[1] Extremely tender = 8, extremely tough = 1.
[2] Extremely juicy = 8, extremely dry = 1.
[3] Extremely intense = 8, extremely bland = 1.
[4] None = 8, abundant = 1.
[5] Extremely tender = 8, extremely tough = 1.
[6] None = 8, abundant = 1.
[ab] Means within a row with different superscripts differ (P<0.05).

Tenderness and Intramuscular Lipid of Most Major Muscles from *Bos Indicus* Cattle are Less than *Bos Taurus* Cattle

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Introduction

In semitropical climates in the United States, *Bos indicus* breeds of cattle, primarily the Brahman breed, are utilized in crossbreeding programs with *Bos taurus* cattle to improve productivity by increasing disease and insect resistance, heat tolerance, heterosis, and additive genetic variation. About 25% of the U.S. beef population contains some *Bos indicus* breeding. Numerous published reports show that tenderness of ribeye and strip loin steaks and marbling are significantly reduced in *Bos indicus* straightbred or crossbred cattle compared to most *Bos taurus* breeds. One very large study reported that heritability of tenderness and marbling is around 0.4, making it a positive trait to try to improve through selection. Only one published report has compared tenderness differences between *Bos indicus* and *Bos taurus* cattle for more than the ribeye and strip loin (longissimus muscle) and that study showed that other muscles were less tender for *Bos indicus* cattle. The objectives of our study were: (1) to compare carcass traits between Hereford x Angus crossbred cattle with those containing at least 50% Brahman and Sahiwal inheritance, and (2) to validate Warner-Bratzler shear force of steaks and roasts and proximate composition of 10 different muscles from these cattle.

Experimental Procedures

Twenty *Bos taurus* (Hereford x Angus) and 20 *Bos indicus* (Brahman or Sahiwal sires mated to Hereford and Angus cows), from Phase 5 of Cycle III of the Germ Plasm Evaluation Project conducted at the Roman L. Hruska U.S. Meat Animal Research Center (Clay Center, NE) were used. Calves were weaned at approximately 200 days of age, preconditioned 30 days, and then fed a corn and corn silage diet until harvest after 169 days on feed. Carcasses were electrically stimulated and chilled for 24 hours postmortem, ribbed at the 12th rib, and evaluated for carcass traits by USDA graders. Right sides were fabricated to obtain the following muscles: *supraspinatus* (SS), *infraspinatus* (IF), and *triceps brachii* (TB) from the chuck; *deep pectoral* (DP) from the brisket; *longissimus lumborum* (LL), *psoas major* (PM), and *gluteus medius* (GM) from the loin; and *biceps femoris* (BF), *semitendinosus* (ST), and *semimembranosus* (SM) from the round. One steak was cut from each muscle, trimmed of visible connective tissue and external fat, and used for fat, moisture, and protein analysis. Remaining portions of the muscles were vacuum packaged, aged at 2°F until 10 days postmortem, then blast frozen at -40°F for 8 hours. One 1-in. steak and one roast were cut from each frozen muscle using a power band saw. The size for roasts was dependent on the muscle size. The SS, TB, DP, GM, and BF were cut into 2-in.-thick roasts; the other muscles were cut into 3-in.-thick roasts.

Steaks and roasts were thawed at room temperature, held overnight in a cooler, cooked in a 325°F Blodgett oven to an internal temperature of 150°F, and cooled for 2 hours at room temperature. Then 0.5-in.-diameter cores were removed and sheared using a

Warner-Bratzler shear machine. Data were analyzed statistically using SAS GLM procedures with a probability level of $P<0.05$ for mean separations.

Results and Discussion

Carcass traits are shown in Table 1. *Bos taurus* carcasses were heavier, had more fat cover, and had larger ribeye areas than the *Bos indicus* carcasses ($P\leq0.05$). In addition, *Bos taurus* carcasses had higher marbling scores ($P=0.08$). Yield grade tended to be higher for *Bos taurus* but it was not statistically significant. Intramuscular fat percentage was higher ($P<0.05$) in all *Bos taurus* muscles compared to *Bos indicus* muscles (Table 2). The IF muscle had the highest fat percentage; SM had the least intramuscular fat. Differences in intramuscular fat percentages between breeds were noticeably greater for the LM and BF muscles than for the other muscles.

The percent cooking loss for each muscle was pooled for the breed types and is shown in Table 3. For all muscles except TB, roasts took less time per oz to reach the final end point temperature than steaks (data not shown). Cooking losses were less ($P<0.05$) for TB, LL, and SM steaks than for roasts, and greater ($P<0.05$) for PM and GM roasts than steaks. Cooking loss in steaks and roasts was similar for SS, IF, DP, and BF muscles. The relative surface area exposed to heat was greater for steaks, resulting in more intense evaporation that required more time per oz of raw weight to reach the final internal temperature.

Figures 1 through 9 show Warner-Bratzler shear force values for the 10 muscles. In the forequarter, no breed or cut size main effect differences occurred in Warner-Bratzler shear force for SS muscles (Figure 1) but a breed × cut size interaction ($P<0.001$) arose where roasts from *Bos taurus* had higher ($P<0.05$) Warner-Bratzler shear force values than steaks, whereas no differences occurred among steaks and roasts for *Bos indicus*. No breed differences were found for IF (Figure 2), but roasts for both breed types were more tender than steaks. For the TB muscle, both steaks and roasts from *Bos taurus* were more tender ($P<0.05$) than those from *Bos indicus* (Figure 3). Figure 4 shows that steak tenderness of DP was not different between breeds, but *Bos indicus* roasts were less tender ($P<0.05$) than roasts from *Bos taurus*. Surprisingly, the DP was more tender when cooked as steaks than as roasts ($P<0.05$).

Figure 5 shows that *Bos indicus* LL roasts and steaks had higher ($P<0.05$) Warner-Bratzler shear force values than *Bos taurus* and steaks for both breeds had greater ($P<0.05$) Warner-Bratzler shear force values than roasts. For the GM muscle, *Bos taurus* was more tender ($P<0.05$) than *Bos indicus* when cooked as steaks and roasts (Figure 6). The BF muscle from *Bos indicus* was less tender ($P<0.05$) than *Bos taurus* when cooked as steaks but not when cooked as roasts (Figure 7). When ST muscles were cooked as steaks, no breed differences were observed, but *Bos indicus* ST roasts were less tender ($P<0.05$) than *Bos taurus* roasts (Figure 8). In addition, ST roasts had lower Warner-Bratzler shear force values than steaks. For SM steaks and roasts, *Bos indicus* muscles were tougher ($P<0.01$) than *Bos taurus* muscles (Figure 9). In addition, SM muscles were less tender ($P<0.05$) when cooked as roasts than when cooked as steaks.

Implications

When handled to have a similar age, background, management, and days on feed, *Bos taurus* carcasses were expected to be heavier, have more fat cover, have larger ribeye areas, higher marbling scores, and greater intramuscular fat percentages for all 10 muscles than *Bos indicus* carcasses. Furthermore, muscles cooked as roasts were expected to cook faster per unit weight than steaks. From the forequarter, tenderness of the SP and IF muscles were not expected to differ due to breed or cut size. However, *Bos indicus* TB muscles were expected to be less tender than those from *Bos taurus*. *Bos taurus* LL, GM, and SM muscles cooked as steaks were expected to be more tender than those from *Bos indicus*, and *Bos taurus* LL, GM, ST and SM muscles cooked as roasts were expected to be more tender than those from *Bos indicus*. Overall, 7 of the 10 muscles evaluated were more tender from *Bos taurus* when cooked as steaks, roasts, or both cut sizes.

Table 1. Carcass traits for *Bos indicus* and *Bos taurus* heifers

	Mean		P-value
Traits	*Bos indicus*	*Bos taurus*	Breed
Hot carcass weight, lb	512.79	572.32	0.05
Maturity[a]	53	55	0.47
Marbling[b]	386	434	0.08
Fat Thickness, in.	0.35	0.47	0.01
Adjusted fat, in.	0.31	0.43	0.02
Ribye area, in.^{2}	10.12	11.11	0.05
Kidney, pelvic, and heart fat, %	2.5	2.8	0.13
Yield grade	2.57	2.86	0.2

[a] All carcasses were A maturity; number refers to percentage within A maturity.
[b] 386 = Slight[86], 434 = Small[34]

Table 2. Mean percentages of intramuscular fat by muscle and breed

	Intramuscular fat, %	
Muscle	*Bos indicus*	*Bos taurus*
Supraspinatus	2.13[g]	2.82[g]
Infraspinatus	6.17[a]	7.80[a]
Triceps brachii	3.25[f]	3.48[f]
Deep pectoral	3.22[ef]	4.13[ef]
Longissimus lumborum	3.79[cd]	5.75[cd]
Psoas major	5.33[b]	6.46[b]
Gluteus medius	3.94[de]	4.55[de]
Biceps femoris	3.61[cd]	5.67[cd]
Semitendinosus	4.49[c]	5.76[c]
Semimembranosus	1.33[h]	1.68[h]

[abcdefgh] Means within a column lacking a common superscript letter differ (P<0.05). Fat percentages in all muscles were higher for the *Bos taurus* cattle (P=0.001).

Table 3. Least squares means for cooking loss, %

	Roast	Steak
Supraspinatus	31.59[a]	30.55[a]
Infraspinatus	28.99[a]	28.57[a]
Triceps brachii	28.04[a]	25.42[b]
Deep pectoral	25.64[a]	24.62[a]
Longissimus lumborum	28.83[a]	23.56[b]
Psoas major	28.64[a]	30.03[b]
Gluteus medius	27.69[a]	29.89[b]
Biceps femoris	28.47[a]	28.06[a]
Semitendinosus	N/A	N/A
Semimembranosus	34.80[a]	29.49[b]

[ab] Means comparing cooking losses within each muscle lacking common superscript differ (P<0.05).

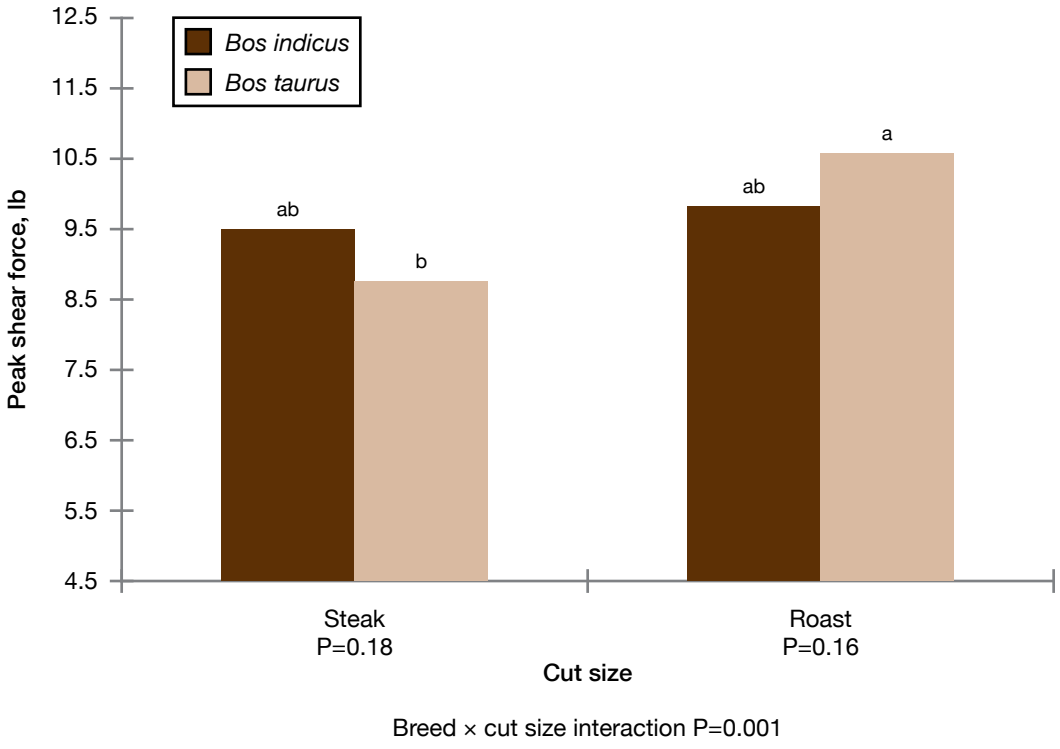

Figure 1. Peak force by breed and cut size in *Supraspinatus* muscles.

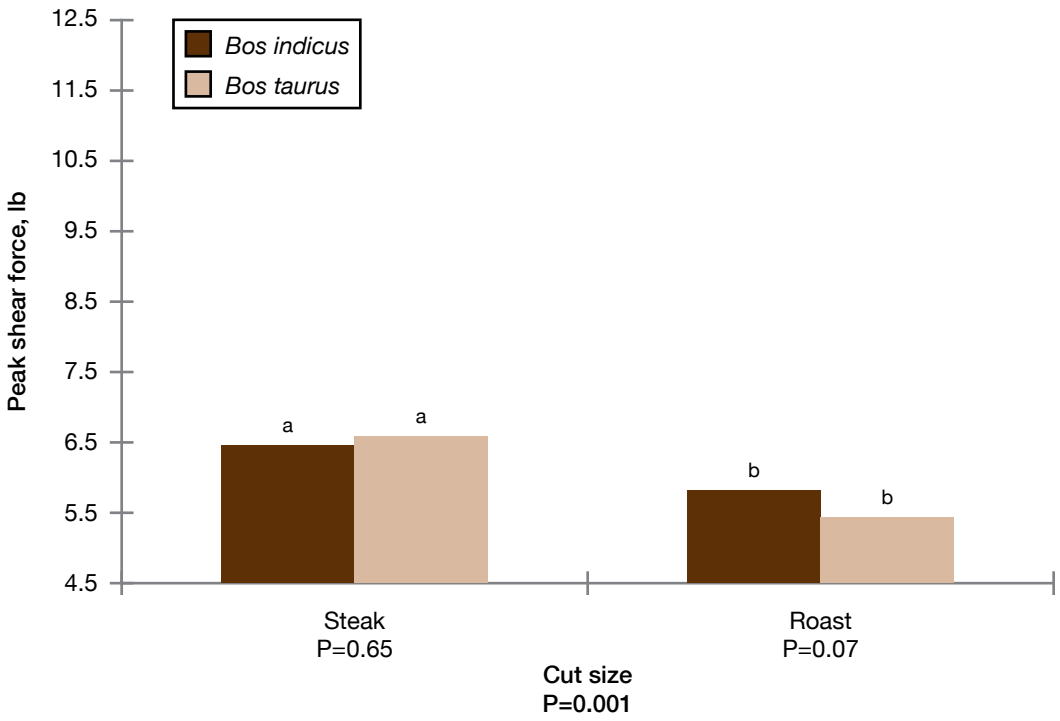

Figure 2. Peak force by breed and cut size in *Infraspinatus* muscles.

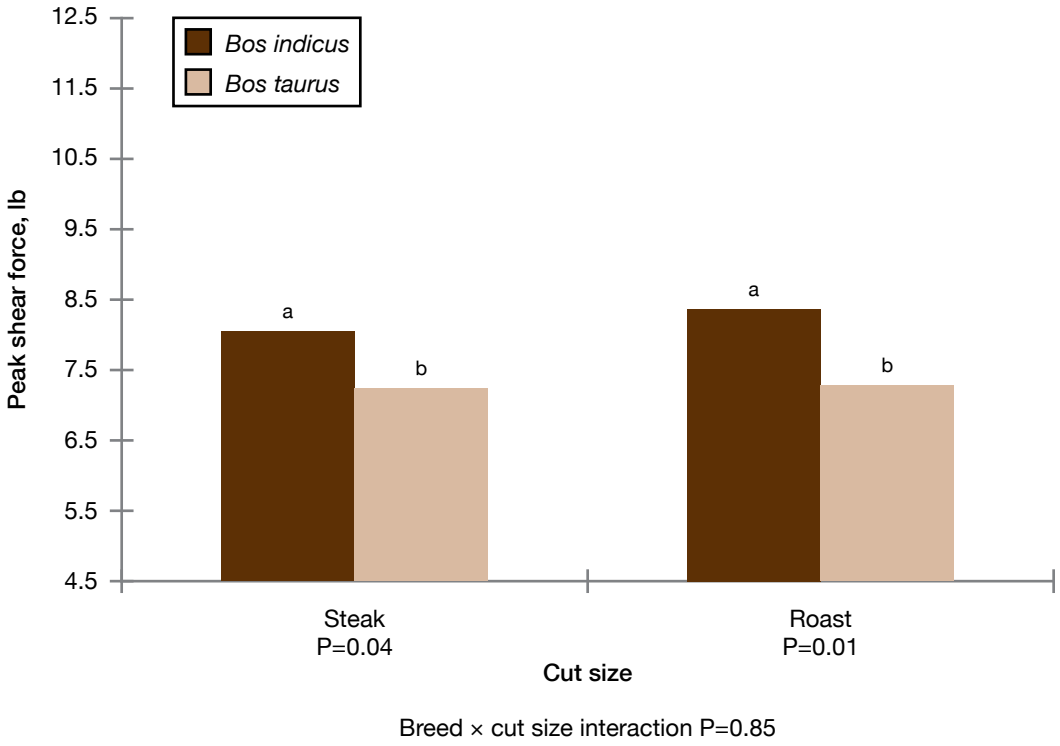

Figure 3. Peak force by breed and cut size in *Triceps brachii* muscles.

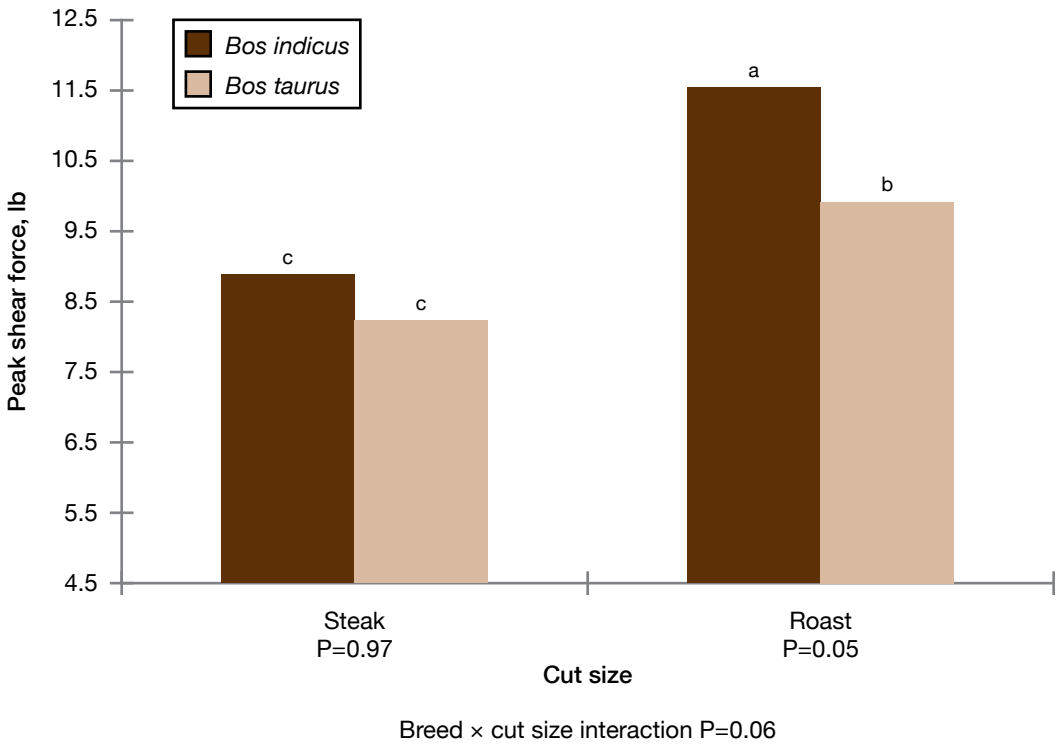

Figure 4. Peak force by breed and cut size in *Deep pectoral* muscles.

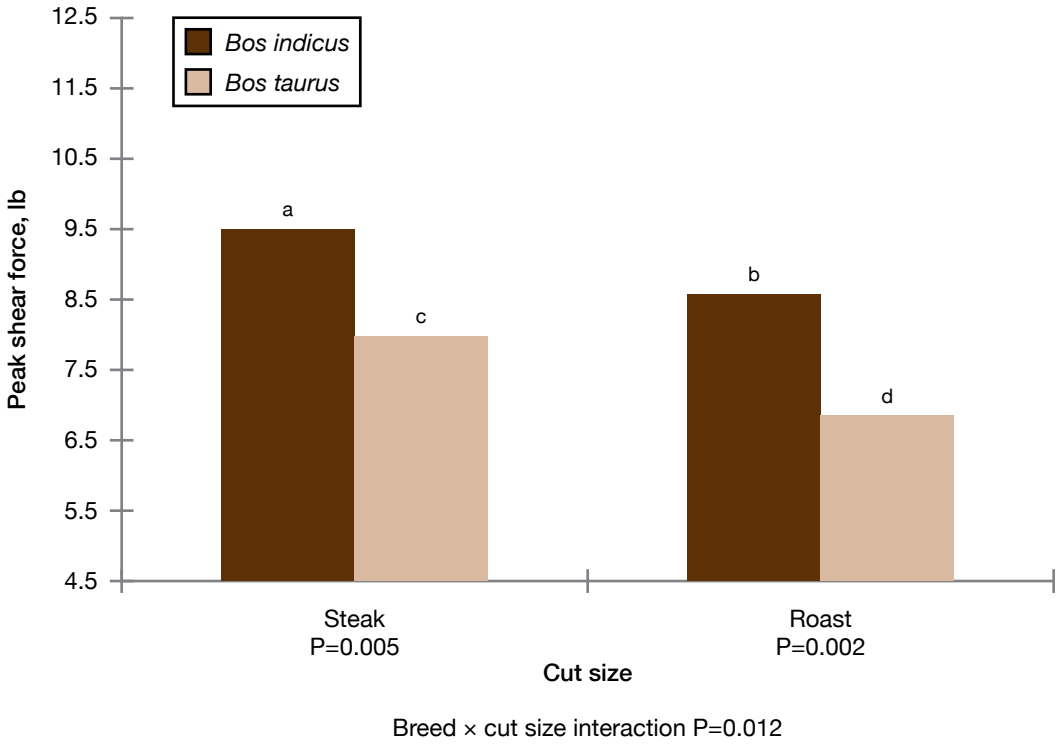

Figure 5. Peak force by breed and cut size in *Longissimus lumborum* muscles.

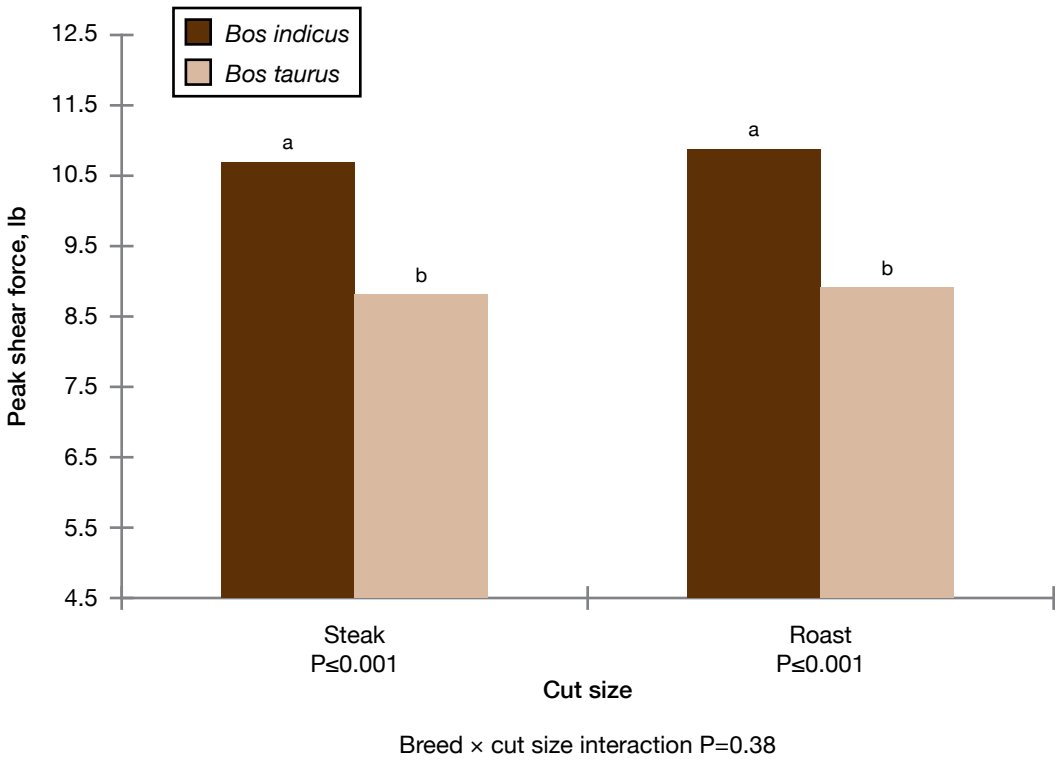

Figure 6. Peak force by breed and cut size in *Gluteus medius* muscles.

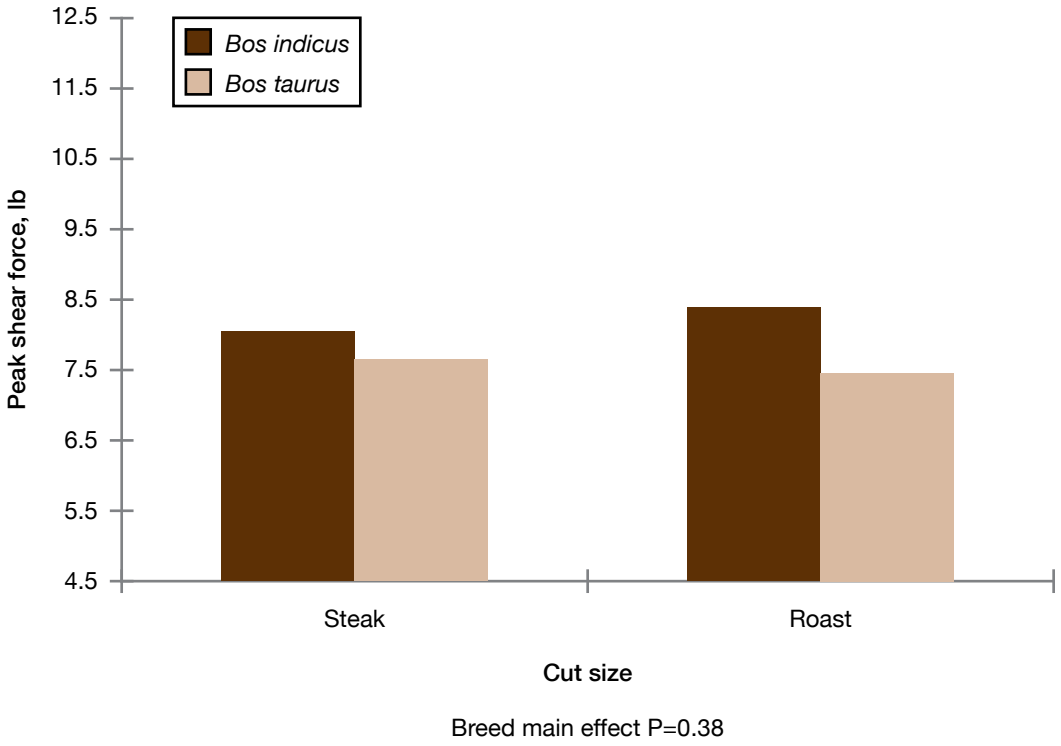

Figure 7. Peak force by breed and cut size in *Psoas major* muscles.

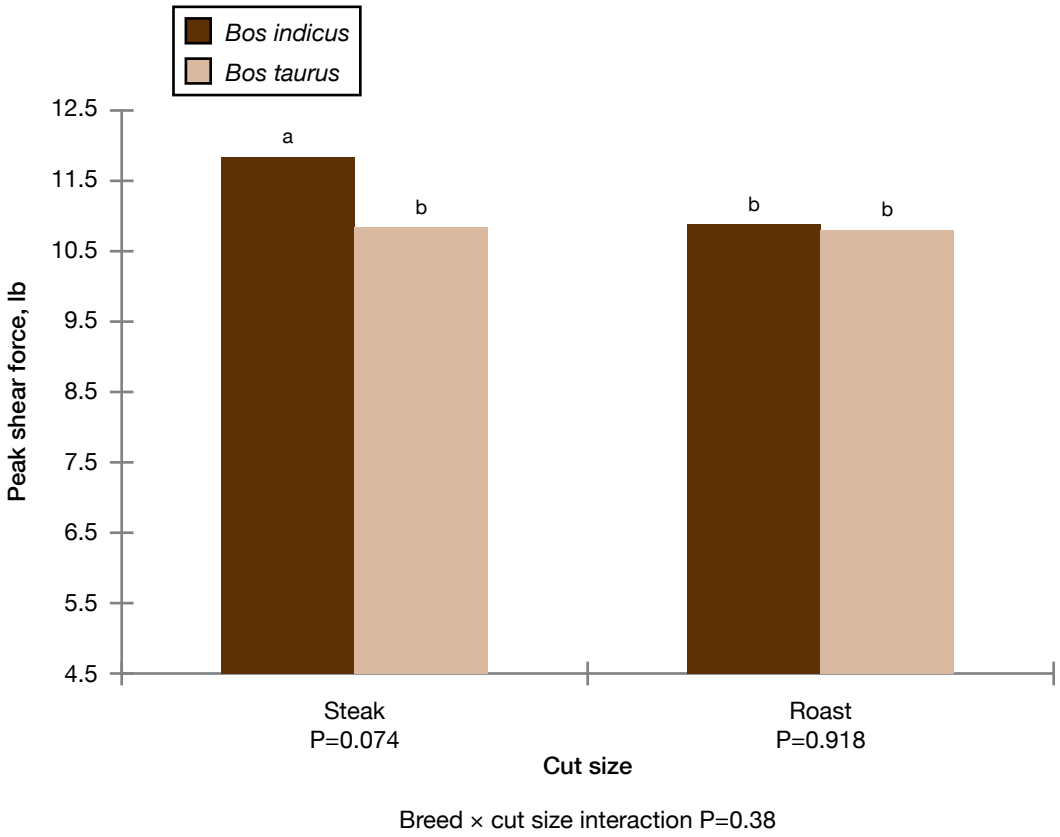

Figure 8. Peak force by breed and cut size in *Biceps femoris* muscles.

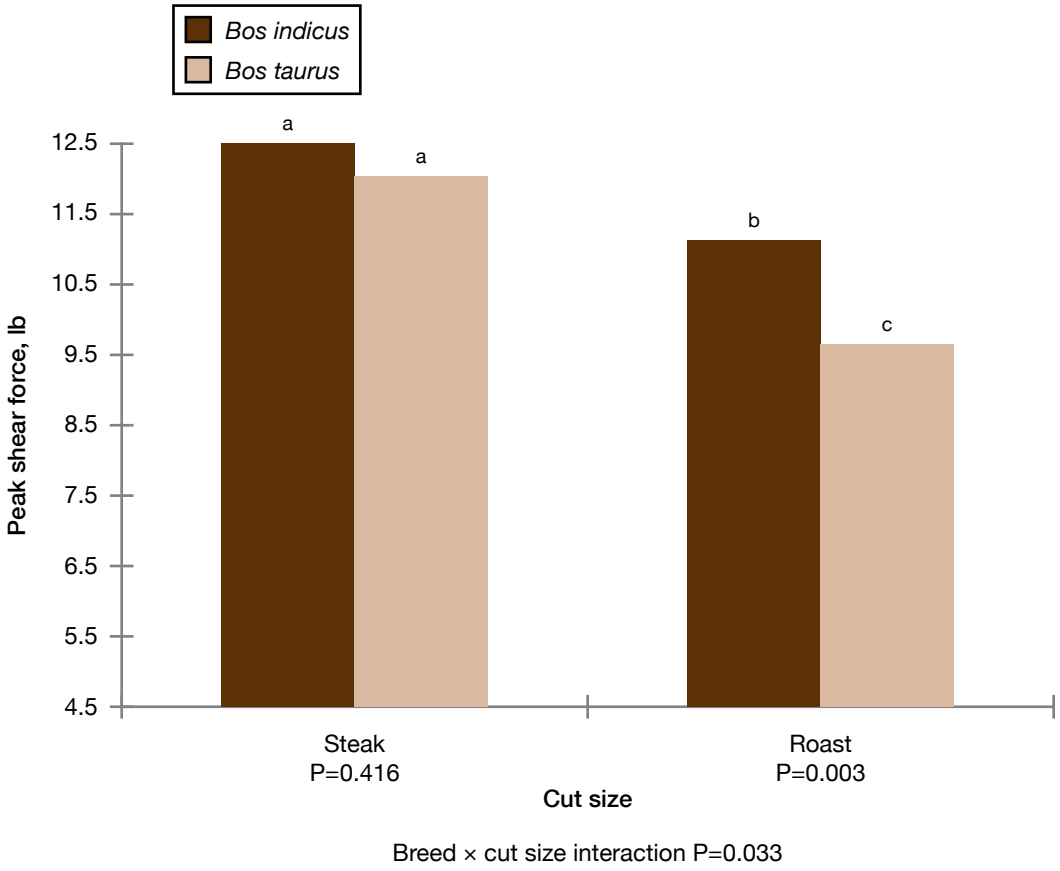

Figure 9. Peak force by breed and cut size in *Semitendinosus* muscles.

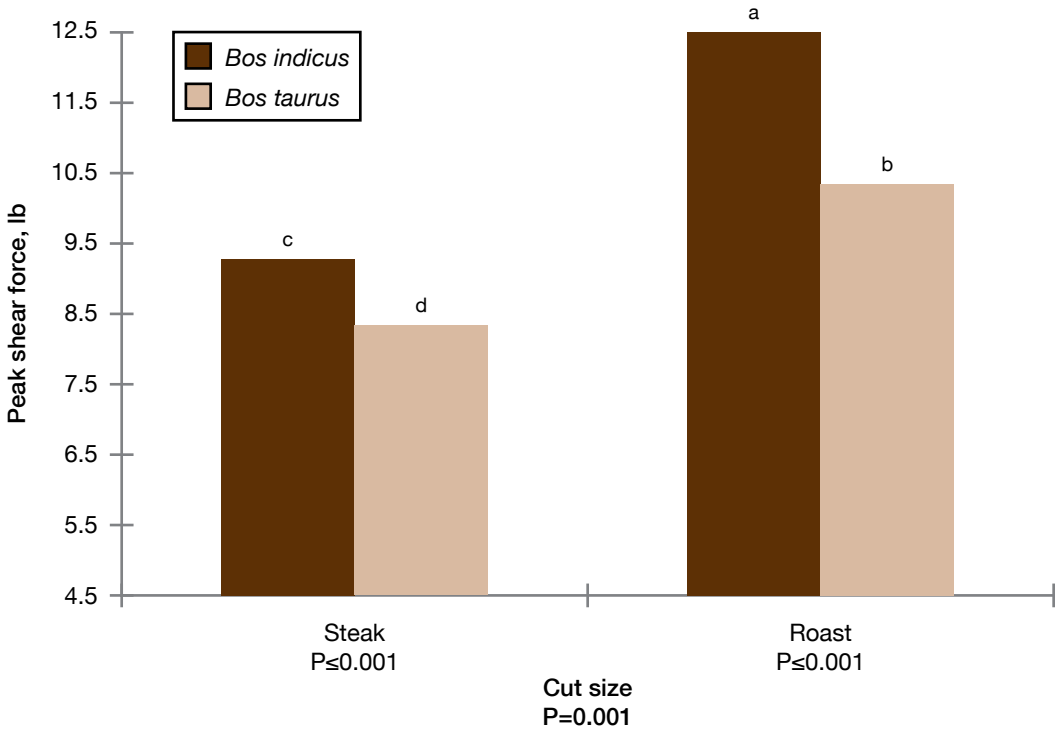

Figure 10. Peak force by breed and cut size in *Semimembranosus* muscles.

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