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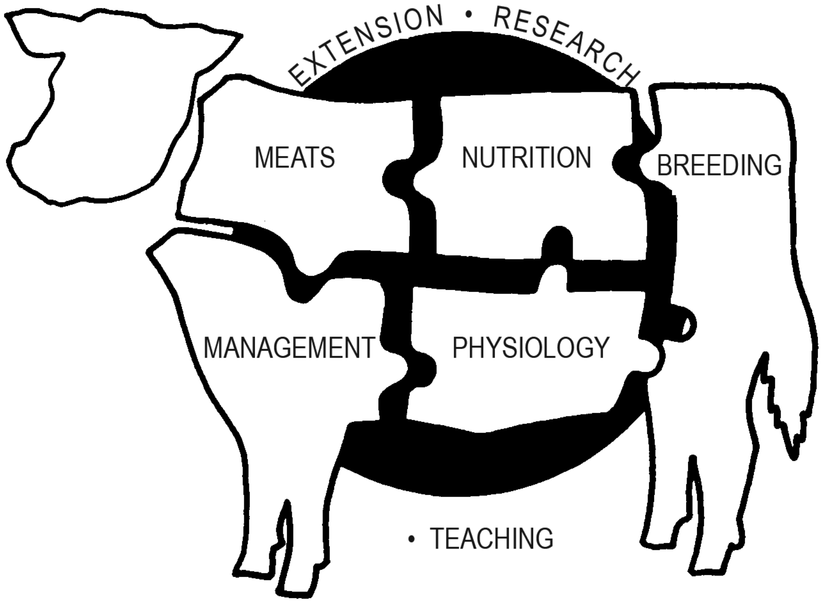

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2015 Beef Cattle Report

IANR

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Impact of Heifer Development System on Subsequent Gain and Reproduction

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Summary

Replacement heifers from 2 different calving herds (March and May) were fed ad libitum hay and 4 lb of supplement/day, or were allowed to graze meadow and received 1 lb of supplement/day from mid-January to mid-April prior to both breeding seasons. Heifers from both calving herds that received hay had a greater average daily gain during the treatment period compared with meadow grazing heifers. However, heifers grazing meadow experienced compensatory gain during their respective breeding season, resulting in similar body weights at pregnancy diagnosis for March-calving heifers. The proportion of heifers that attained puberty before breeding and became pregnant was similar between the treatment groups in both herds.

Introduction

Retaining replacement heifers can be a major expense to the cow-calf enterprise. The majority of this expense can be attributed to feed. Considering high feed costs, recent efforts have been made to devise more economical methods of developing heifers. It has been reported that heifers grown in a reduced input development system have comparable reproductive performance to heifers developed in higher input systems. Martin et al., (*2008 Nebraska Beef Cattle Report*, pp. 5-7) reported no significant difference in puberty attainment for heifers fed to 51% vs. 57% mature BW. However, a lesser percentage of heifers had reached puberty prior to the breeding season when developed on corn residue compared to winter range or drylot (*2008 Nebraska Beef Cattle Report*, pp. 8-10). The objective of this study was to determine the effect of reduced overwinter supplementation on ADG and reproductive performance in beef heifers in 2 breeding seasons.

Procedure

Replacement heifers from two calving seasons, March and May, were utilized in this study. Over a 2-year period, 100 March-born, crossbred (5/8 Red Angus, 3/8 Continental) heifers; and over a 3-year period, 196 May-born, crossbred (5/8 Red Angus, 3/8 Continental) heifers were utilized. Heifers were stratified by BW and randomly assigned to 1 of 2 post-weaning treatments (2 pastures·treatment^{-1}·year^{-1}) applied from mid-January to mid-April. Heifers in the HAY treatment were offered *ad libitum* meadow hay and 4 lb/day supplement (29% CP, DM basis). Heifers receiving MDW treatment were allowed to graze meadow and offered 1 lb/day supplement. Prior to and following treatment, all heifers were managed as a single herd until the respective breeding seasons. Immediately prior to each breeding season, 2 blood samples were drawn 10 days apart via caudal venipuncture for progesterone analysis to determine pubertal status. Five days after being placed with bulls (1:20 bull to heifer ratio), heifers were synchronized with a single $PGF_{2\alpha}$ injection and allowed a 45 day natural service breeding season beginning May 23 for March-calving heifers and July 10 for May-calving heifers. Pregnancy diagnosis was determined by ultrasound 40 days after bulls were removed.

Statistical Analyses

Data were analyzed using the GLIMMIX procedure of SAS (SAS Institute, Inc., Cary, N.C.), evaluating year, treatment, and year × treatment. The proportions of pubertal and pregnant heifers were analyzed using an odds ratio. Least squared means and SE of the proportion of pubertal and pregnant heifers by treatment were obtained using the ILINK function.

Economic Analyses

A cost analysis of treatment was generated to compare the winter feeding cost of HAY and MDW treatments. Hay prices were extremely variable during this study, ranging from $50 to $230 per ton, with an average hay cost of $120/ton assumed. The cost of grazing meadow was one-half the cost of winter grazing for a mature cow, based upon average BW over the treatment period. Basic management and yardage was estimated at $0.20/day. A partial budget analysis was conducted using the procedure by Feuz (*Journal of the American Society of Farm Managers and Rural Appraisers*, 1992, 56(1): 61-66). The budget analysis was evaluated for season (March and May) and treatment (HAY and MDW). Summer grazing cost was based on $1.00/head/day, basic management was $0.20/head/day, with an additional fixed expense of $15.00 for the year calculated in. Heifer value at the beginning of the study (Jan. 15) and at pregnancy diagnosis (Sept. 10 and Oct. 30, March and May herds) was calculated from the Nebraska average price reported by the USDA Agricultural Marketing Service (2014) for each corresponding date and respective average heifer BW. Total breeding cost included a single PGF_2 injection at $2.80/heifer and bull expense of $37.20/heifer. Total heifer cost was calculated by adding the purchase price, treatment cost, summer grazing and management cost, breeding cost, and 6% interest on the heifer purchase price. The net cost of one pregnant heifer was calculated as the difference between total heifer cost and cull value, divided by pregnancy rate.

Results

Gain and Reproductive Performance

March-born heifer BW gain and reproductive data are presented in Table 1. A significant ($P = 0.04$) year × treatment interaction is noted for ADG during the Jan. 12 to April 22 treatment period, with HAY heifers having similar ($P = 0.99$) treatment

(Continued on next page)

Table 1. Effect of overwinter treatment on developing March-born heifer ADG, BW, and reproductive performance.

	Development Year				Treatment			
Item	2012	2013	SEM	*P*-value	HAY[1]	MDW[2]	SEM	*P*-value
n	50	50			50	50		
ADG								
Treatment ADG,[3] lb/day	1.36	1.44	0.04	0.10	1.77	1.03	0.04	<.01
Spring ADG,[4] lb/day	1.87	0.93	0.10	<.01	0.95	1.85	0.09	<.01
Summer ADG,[5] lb/day	0.58	1.37	0.04	<.01	0.94	1.02	0.04	0.36
Body Weight								
Weaning BW, lb	424	411	7	0.17	415	421	6	0.63
Post-treatment BW, lb	644	639	7	0.64	676	607	7	<.01
Prebreeding BW,[6] lb	702	665	8	<.01	704	662	8	<.01
Percent Mature BW,[7] %	58	54	7	<.01	58	54	7	<.01
Pregnancy Diagnosis BW, lb	768	816	8	<.01	809	775	10	0.25
Pubertal,[8] %	66	30	7	<.01	43	52	8	0.40
Pregnancy Rate, %	92	82	6	0.14	89	87	5	0.72

[1]HAY = heifers received *ad libitum* hay and 4 lb/day supplement from Jan. 15 to April 15.
[2]MDW = heifers grazed meadow and received 1 lb/day supplement from Jan. 15 to April 15.
[3]Treatment ADG from Jan. 16 to April 22 (96 days), includes the treatment period.
[4]Spring ADG from April 22 to May 22 (30 days).
[5]Summer ADG from May 22 to Sept. 10 (111 days).
[6]Prebreeding BW determined May 22.
[7]Percent of mature BW at breeding based on mature cow size of 1,218 lb.
[8]Considered pubertal if blood serum progesterone concentration >1 ng/mL.

Table 2. Effect of overwinter treatment on developing May born heifer ADG, BW, and reproductive performance.

	Development Year					Treatment			
Item	2011	2012	2013	SEM	*P*-value	HAY[1]	MDW[2]	SEM	*P*-value
n	65	65	66			97	99		
ADG									
Treatment ADG,[3] lb/day	1.20[a,b]	1.27[a]	0.88[b]	0.17	<.01	1.46	0.77	0.08	<.01
Spring ADG,[4] lb/day	1.80[a]	1.93[a]	2.42[b]	0.06	<.01	1.93	2.23	0.04	<.01
Summer ADG,[5] lb/day	1.28[a]	0.68[b]	0.83[c]	0.03	<.01	0.87	0.99	0.03	<.01
Body Weight									
Weaning BW, lb	409[a]	434[b]	434[b]	7	<.01	425	426	5	0.91
Post-treatment BW, lb	558[a]	581[a]	523[b]	7	<.01	597	512	6	<.01
Prebreeding BW,[6] lb	673	695	673	11	0.11	713	647	7	<.01
Percent Mature BW,[7] %	54	56	55	1	0.59	59	52	1	<.01
Pregnancy Diagnosis BW, lb	806[a]	765[b]	773[b]	9	<.01	807	755	7	<.01
Pubertal,[8] %	69[a]	78[a]	37[b]	8	<.01	70	54	6	0.03
Pregnancy Rate, %	58	71	62	6	0.29	66	61	5	0.44

[1]HAY = heifers received *ad libitum* hay and 4 lb/day supplement from Jan. 15 to April 15.
[2]MDW = heifers grazed meadow and received 1 lb/day supplement from Jan. 15 to April 15.
[3]Treatment ADG from Jan. 5 to May 10 (125 days), includes the treatment period.
[4]Spring ADG from May 10 to July 9 (60 days).
[5]Summer ADG from July 9 to Sept 10 (63 days).
[6]Prebreeding BW determined Sept 10.
[7]Percent of mature BW at breeding based on mature cow size of 1,218 lb.
[8]Considered pubertal if blood serum progesterone concentration >1 ng/mL.
[a,b,c]Means in a row with different superscripts are different (P < 0.01).

period ADG between development years 2012 and 2013 (1.78 vs. 1.76 ± 0.07 lb/day, respectively), whereas MDW heifers ADG tended to differ ($P = 0.05$) between development years (2012 vs. 2013, 0.93 vs. 1.13 ± 0.07 lb/day). Heifers born in March on HAY had greater ($P < 0.01$) ADG during the treatment period than MDW heifers (1.77 vs. 1.03 ± 0.04 lb/day, respectively). However, following treatment, from April 22 to May 22, MDW heifers experienced a compensatory gain resulting in significantly ($P < 0.01$) greater ADG compared to HAY heifers (1.85 vs. 0.95 ± 0.09 lb/day, respectively). During the time period from May 22 to Sept. 10, ADG was similar ($P = 0.36$) between HAY and MDW heifers (0.94 vs. 1.02 ± 0.04 lb/day, respectively). Significant year effects ($P < 0.01$) are noted on spring and summer ADG between heifers developed in 2012 and 2013, most likely due to the severe drought experienced in 2012. Post-treatment BW was significantly ($P < 0.01$) greater for HAY vs. MDW heifers (676 vs. 607 ± 7 lb, respectively), which carried over to prebreeding BW (HAY vs. MDW; 704 vs. 662 ± 8 lb, respectively). At breeding, HAY heifers had reached a greater ($P < 0.01$) percent mature BW (58 vs. 54 ± 7%, for HAY and MDW, respectively). At pregnancy diagnosis, BW was similar ($P = 0.25$) between HAY and MDW heifers (809 vs. 775 ± 10 lb, respectively). The proportion of heifers attaining puberty prior to the breeding season was similar ($P = 0.40$) between HAY and MDW heifers (43 vs. 52 ± 8%, respectively). Pregnancy rate was also similar for HAY (89 ± 5%) and MDW (87 ± 5%, $P = 0.72$) heifers.

Table 3. Cost analysis of heifer development overwinter nutritional treatments.

Item	HAY[1]	MDW[2]
Hay,[3] $/head/day	0.66	—
Meadow pasture, $/head/day	—	0.50
Supplement,[4] $/head/day	0.77	0.19
Yardage, $/head/day	0.20	0.20
Total, $/head/day	1.63	0.89
Treatment total,[5] $/head	146.70	80.10

[1]HAY = heifers received *ad libitum* hay and 4 lb/day supplement from Jan. 15 to April 15.
[2]MDW = heifers grazed meadow and received 1 lb/day supplement from Jan. 15 to April 15.
[3]Hay cost assumed as $120/ton (11 lb/day).
[4]Supplement containing 29% CP, DM priced at $385/ton, comprised of processed grain byproducts, plant protein products, roughage products, calcium carbonate, molasses products, urea, vitamin A supplement, copper sulfate, zinc oxide, magnesium sulfate, and monensin.
[5]Treatment total for 90 day period.

Table 4. Partial budget analysis of heifer development calving season and overwinter nutritional treatments.

	March-calving		May-calving	
Item	HAY[1]	MDW[2]	HAY[1]	MDW[2]
Opportunity Cost of Heifer, Jan. 15, $	775.52	777.06	700.52	707.20
Feed Cost:				
Winter Treatment Period,[1,2] $	146.70	80.10	146.70	80.10
Summer grazing,[3] $	148.00	148.00	198.00	198.00
Breeding Expense,[4] $	40.00	40.00	40.00	40.00
Fixed Expenses, $	25.00	25.00	25.00	25.00
Management Expense,[5] $	29.60	29.60	39.60	39.60
Interest @ 6.0%, $	46.53	46.62	42.03	42.43
Total cost, $	1,211.35	1,146.38	1,191.85	1,132.33
Less: Value of cull heifers,[6] $	147.21	163.51	386.38	418.12
Net Cost, $	1,064.14	982.87	805.47	714.21
Net cost per pregnant heifer, $	1,195.66	1,129.74	1,220.41	1,170.84

[1]HAY = heifers received *ad libitum* hay and 4 lb/day supplement from Jan. 15 to April 15.
[2]MDW = heifers grazed meadow and received 1 lb/day supplement from Jan. 15 to April 15.
[3]Summer grazing calculated at $1.00/head/day.
[4]Breeding expense includes cost of bull use and a single injection of $PGF_{2\alpha}$.
[5]Management expense calculated at $0.20/head/day.
[6]Heifer cull value calculated from prices the week of pregnancy diagnosis.

Table 2 presents the BW and reproductive results for May-born heifers. Similar to the March-born heifers, May-born heifers on HAY treatment had greater ($P < 0.01$) ADG during the treatment period, from Jan. 5 to May 10, compared with MDW heifers (1.46 vs. 0.77 ± 0.08 lb/day, respectively). However, heifers grazing meadow experienced greater ($P < 0.01$) ADG following treatment, from May 10 to July 9 (HAY vs. MDW; 1.93 vs. 2.23 ± 0.04 lb/day). Furthermore, MDW heifers continued to have greater ($P < 0.01$) ADG, from July 9 to Sept. 10, compared with HAY heifers (0.87 vs. 0.99 ± 0.03 lb/day, respectively). Post-treatment BW was greater ($P < 0.01$) for heifers on HAY treatment compared with heifers on MDW treatment (597 vs. 512 ± 6 lb, respectively). This increased BW for HAY heifers continued to prebreeding (HAY vs. MDW, 713 vs. 647 ± 7 lb; $P < 0.01$) and pregnancy diagnosis (HAY vs. MDW; 807 vs. 755 ± 7 lb; $P < 0.01$). Significant effects of development year is noted for all ADG time periods and BW (except prebreeding BW) as a result of the extreme variability in forage quality between the relatively normal year, 2011; the severe drought year, 2012; and the unique post-drought recovery year, 2013. Heifers on HAY treatment were 59 ± 1% of their mature BW, while MDW were 52 ± 1% of mature BW at breeding ($P < 0.01$). The proportion of heifers attaining puberty prior to the breeding season was greater ($P = 0.03$) for HAY vs. MDW heifers (70 vs. 54 ± 6%, respectively). Pregnancy rate was similar ($P = 0.44$) between treatments (66 vs. 61 ± 5% for HAY and MDW heifers, respectively). These lower pregnancy rates are attributed to the decreasing forage quality and availability on Sandhills range during the breeding season (July and August) for a May-calving herd. Currently, breeding season supplementation strategies for the May-calving herd are being investigated to determine effect on pregnancy rates.

Economic Analysis

The treatment cost analyses is presented in *Table 3*. The overwinter daily cost for HAY heifers was $1.63/head/day compared to MDW heifers at $0.89/head/day, resulting in a $0.74/day savings. Over the 3 month treatment period, this equates to a significant difference ($P < .01$) in cost; $146.70 total cost for HAY heifers compared with $80.10 for MDW heifers, resulting in $66.60/heifer savings by grazing meadow with 1 lb of supplement compared with *ad libitum* hay and 4 lb of supplement.

The partial budget analyses (*Table 4*) reveals the cost per pregnant heifer is $65.92 greater for March-born heifers on HAY compared with MDW treatment. May-born heifers on HAY had $49.57/pregnant heifer greater cost than their contemporaries on MDW treatment.

Heifers on the HAY treatment had greater ADG during the winter feeding period resulting in greater prebreeding BW for HAY heifers compared with MDW heifers resulting in HAY heifers reaching a greater percentage of their mature BW at breeding. There was no difference in pubertal status or pregnancy rate between HAY and MDW heifers, indicating a lower input winter management system is viable to maintain heifer pubertal status and pregnancy rates in 2 breeding seasons. A $66.60/heifer savings from January to April in the MDW treatment indicates an economic advantage to the grazed meadow heifer development system.

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Genetic Parameter Estimates for Calving Difficulty and Birth Weight in a Multibreed Population

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Matthew L. Spangler[1]

Summary

Eighteen breeds were utilized to estimate genetic parameters for birth weight and calving difficulty on first-parity females. Birth weight and calving difficulty were moderately heritable allowing for genetic selection to decrease calving difficulty. Genetic correlation estimates were positive between direct effects for birth weight and calving difficulty. This work will serve as the foundation for estimating across-breed EPD for calving difficulty in the U.S.

Introduction

Calving difficulty (CD), also known as dystocia, is a significant cost to beef production and is more prevalent in first-calf heifers. Dystocia increases the likelihood of calf and dam mortality, increases the postpartum interval, and increases labor and veterinarian costs (*Journal of Animal Science,* 2001, 79:45-51). Calving ease (CE) EPD predicts the ability of calves to be born unassisted and typically includes birth weight (BWT) as an indicator trait.

Different breeds present the opportunity for the exploitation of heterosis and complementarity to match genetic potential with markets, feed resources, and climates. However, in the current U.S. beef industry, it is generally not possible to directly compare the EPD of animals across breeds without the aid of adjustment factors. Across-breed adjustment factors have been estimated by Kuehn and Thallman (*Proceedings, Beef Improvement Federation, Annual Research Symposium and Annual Meeting,* 2014, pp. 134-154) for birth weight and several growth and carcass traits. Unfortunately, across-breed adjustment factors do not exist for CE.

Consequently, the objectives of this study were to estimate genetic parameters for calving ease and birth weight in a multibreed population as a first step towards the development of across-breed adjustment factors for CE.

Table 1. Breeds of sires utilized in each Gerplasm Evaluation Program cycle.

Cycle	Breeds used in cycle
I	Angus, Hereford, South Devon, Limousin, Simmental, and Charolais
II	Angus, Hereford, Gelbvieh, Maine-Anjou, Chianina, and Santa Gertrudis
III	Angus, Hereford, Tarentaise, and Brahman
IV	Angus, Hereford, Shorthorn, Salers, and Charolais
V	Angus, Hereford, and Brahman
VI	Angus and Herford
VII	Angus, Hereford, Red Angus, Simmental, Charolais, Limousin, and Gelbvieh
VIII	Angus, Hereford, Brangus, and Beefmaster

Procedure

Animals

Pedigree and performance data used in this study originated from the Germplasm Evaluation (GPE) program at the U.S. Meat Animal Research Center (USMARC) in Clay Center, Neb. The breeds utilized in each GPE cycle are listed in Table 1. These breeds were used as A.I. sires and mated to Angus, Hereford, and MARC III females (¼ Angus, ¼ Hereford, ¼ Pinzgauer, ¼ Red Poll). Data from continuous evaluation of 18 breeds in GPE were also included.

Data

Data were recorded for calving difficulty (CD; the inverse of calving ease) and BWT on 5,795 calves born to first-parity females. Animals were removed from the data set if they were born with an abnormal presentation (e.g., breach), presented with cryptorchidism, born to a founder female (known breed with unknown parents), or a twin. Only animals born after 1970 (spring born) or after 2007 (fall born) were retained for analysis. After edits there were a total of 4,580 records. Cows were monitored closely for calving difficulty and were assigned a calving difficulty score as outlined in Table 2. Birth weights were recorded within the first 24 hours of calving.

Table 2. Description of calving difficulty scores.[1]

Score	Difficulty Level
1	No assistance given
2	Little difficulty, assisted by hand
3	Little difficulty, assisted by calf jack
4	Slight difficulty, assisted by calf jack
5	Moderate difficulty, assisted by calf jack
6	Major difficulty, assisted by calf jack
7	Caesarean birth
8	Malpresentation

[1]Records with scores of 8 were removed from the analysis.

Statistical Analysis

A bivariate linear-linear animal model was fitted with breed effects represented as genetic groups. All industry artificial insemination (AI) sires were assigned a genetic group according to their breed of origin. Dams mated to AI sires and natural service sires mated to F_1 females were also assigned to different genetic groups (i.e., Hereford dams were assigned to different genetic groups than Hereford AI sires). Herefords from selection lines were also assigned their own genetic groups. Most dams were Angus, Hereford, and MARC III (¼ Angus, ¼ Hereford, ¼ Pinzgauer, ¼ Red Poll) composite lines through Cycle VIII.

Table 3. Estimates of direct and maternal heritability and genetic correlations (SE) for birth weight (BWT) and calving difficulty (CD).[1]

Trait [2]	Trait			
	BWT_d	CD_d	BWT_m	CD_m
BWT_d	0.35 (0.09)			
CD_d	0.63 (0.10)	0.29 (0.09)		
BWT_m	-0.16 (0.29)	0.41 (0.39)	0.15 (0.07)	
CD_m	0.18 (0.36)	0.17 (0.42)	-0.44 (0.51)	0.14 (0.07)

[1]Heritabilities (SE) are on the diagonal and genetic correlations (SE) are on the off diagonal.
[2]Birth weight direct (BWT_d), calving difficulty direct (CD_d), birth weight maternal (BWT_m), and calving difficulty maternal (CD_m)

Systematic effects fitted in the model included sex, breed (fitted as genetic group), contemporary group (concatenation of year and season of birth and location of birth at USMARC), and covariates for direct and maternal heterosis. Random effects included animal, maternal effect, and a residual. The covariates for heterosis direct and maternal were estimated as the regression on expected breed heterozygosity fraction. For heterosis calculation, AI sires and commercial cows of the same breed were considered the same, Red Angus was assumed the same as Angus, and composite breeds were considered according to their nominal breed composition.

Variance components and fixed effects were estimated using ASReml version 3.0 (*ASReml User Guide Release 3.0,* 2009). Breed differences were adjusted to current (2012) breed breeding value levels by accounting for the weighted (using average relationship to phenotyped progeny) average EPD of AI sires that had descendants, with records, deviated from the mean EPD of their breed for calves born in 2012. Calving difficulty scores were scaled by a factor of 10 for analysis to reduce numerical problems.

Results

Genetic Parameters

Estimates of direct and maternal heritability for BWT and CD and their correlations are presented in Table 3. Even though there is a high positive correlation between BWT and CD direct, birth weight only explains 40% of the genetic variation in calving difficulty.

Challenges in Across-Breed EPD for CE Breed Effects

An underlying issue relative to the development of across-breed EPD for CE direct and maternal is correctly accommodating the differences in models used by various beef breed associations in the estimation of EPD for these traits. All breeds use a multi-trait model fitting BWT, but some use a linear-linear model while others use a threshold-linear model. Additionally, some breeds combine categories, thus shrinking the number of potential scores on a linear scale. For breeds that treat CE as a threshold character, the point at which CE is centered on the underlying scale differs. Also, the mean incidence of difficulty (e.g., 50%, 80%, etc.) at which the back-transformed EPD is calculated from the underlying EPD can be different.

Implementation of existing across-breed EPD has been through a table of additive adjustment factors. Due to many of the issues above, this approach becomes problematic for CE. An updated delivery model (perhaps web-based) would be required to effectively implement across-breed EPD for CE. It would also allow substantial improvements to the system for other traits.

Although BWT is a good indicator of CE, it does not explain all of the variation in CE. Consequently, producers should place selection pressure on CE (direct) and not BWT to decrease dystocia. Selection for both EPD simultaneously would essentially place undue additional selection for BWT. Although the genetic correlation between CD direct and maternal was slightly positive in the current study, it is associated with a large standard error. Caution should be used so that continued selection for CE direct does not lead to maternal CE issues.

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Estimation of British- and Continental-Specific Heterosis Effects for Birth, Weaning, and Yearling Weight in Cattle

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Summary

Heterosis, assumed proportional to expected breed heterozygosity, was calculated for 6,834 individuals with birth, weaning, and yearling weight records from Cycle VII of the U.S. Meat Animal Research Center Germplasm Evaluation Program. Heterosis was further estimated by proportions of British x British (BxB), British x Continental (BxC), and Continental x Continental (CxC) crosses. Estimates of BxB, BxC, and CxC heterosis were significant for weaning and yearling weight. This study illustrated that differences among biological types exist and provide an opportunity to utilize specific breeds and exploit heterosis in a crossbreeding system to achieve production goals.

Introduction

The benefits of crossbreeding and the effects of heterosis on growth traits have been well documented. The cumulative effects of heterosis on individual and maternal traits obtained from breed crosses have been shown to be economically important (*Journal of Animal Science*, 1960, 51:1224; *Journal of Animal Science*, 1980, 51:1197). Heterosis achieved through crossbreeding can increase weaning weight per cow exposed by 20% (*Journal of Animal Science*, 1991 69:947-960). Crossing breeds that are more divergent generates increased levels of heterosis as compared to crossing breeds that are more closely related. An example of this is that cumulative effects of heterosis contributing to calf weaning weight per cow exposed may be more than twice as great for crosses of *Bos indicus* breeds with *Bos taurus* breeds than among *Bos taurus* breeds (*Texas Agriculture Experiment Station Tech*., 1964; *Journal of Animal Science*, 1975, 40:826).

However, hypothesized differences in breed-specific and biological type (British vs Continental) heterosis estimates using data where various breed crosses are true contemporaries does not exist. Specific estimates of heterosis for various crosses of breeds could be useful when selecting breeds for a crossbreeding system and developing composite populations for various production environments. Differences in estimates of heterosis based on breed composition could be useful in multibreed evaluations since heterosis and breed differences are used in models for genetic predictions. The objective of this study was to calculate direct and maternal breed and heterosis effects by breed type for birth, weaning, and yearling weight.

Procedures

Animals with birth, weaning, and yearling weight records from Cycle VII and advanced generations of the U.S. Meat Animal Research Center (USMARC) Germplasm Evaluation (GPE) program were used in this study. Purebred Angus (AN), Hereford (HH), Simmental (SM), Limousin (LM), Charolais (CH), Gelbvieh (GV), and Red Angus (AR) sires were mated by artificial insemination (AI) to composite MARC III- [1/4 AN, 1/4 HH, 1/4 Pinzgauer (PZ), 1/4 Red Poll (RP)], AN- and HH-base cows to produce progeny designated as F_1, born in 1999, 2000, and 2001. The 1999- and 2000-born male calves were castrated and fed for slaughter. Female F_1 and the 2001-born F_1 males were kept for breeding and mated in multiple-sire pastures to produce 2-, 3-, and 4-breed cross progeny designated F_1^2. The F_1^2 calves were born from 2003 to 2007 from 3-year-old and older dams. Advanced GPE records were included in the data from individuals that were of varying proportion of the seven breeds used in cycle VII. Male calves were castrated within 24 hours after birth. Calves were weaned in September at approximately 165 days of age. After weaning, steers were managed and fed for slaughter, and heifers were developed for breeding starting the following May.

Outliers were identified and removed if the record was three standard deviations away from the mean after correcting for systematic effects of breed (fitted as genetic groups), sex, age of dam, and year of birth. After outliers were removed, there were 6,804 birth weight records, 6,451 weaning weight records, and 6,293 yearling weight records. Contemporary groups were formed based on year and season of birth, location of birth, and age of dam.

Breed fractions were assigned for each individual based on pedigree information. Expected breed heterozygosity for each individual was calculated as one minus the proportion of the same breed from the sire and dam. Proportions of heterozygosity were then assigned as either British (AN, AR, HH, RP) or Continental (CH, GV, LM, SM, or PZ) to form the fixed linear covariates of British x British (BxB), Continental x Continental (CxC) or British x Continental (BxC). Angus and Red Angus were considered a single breed in developing the covariates above. The breed proportions for the MARC III composites, which are 3/4 British and 1/4 Continental, were partitioned based on expected breed contribution to all three biological type classifications (BxB, CxC, and BxC).

All traits were analyzed using ASReml (*ASReml User Guide Release 3.0*, 2009). Fixed effects included sex; breed (fitted as genetic groups),

Table 1. Number of observations (N) and mean (SD) (lb) for birth, weaning, and yearling weight.

Trait	N	Mean (SD), lb
Birth weight	6,804	88.6 (13.0)
Weaning weight	6,451	540.1 (77.8)
Yearling weight	6,293	940.3 (146.4)

Table 2. Variance component and parameter estimates (SE) for birth weight (BWT), weaning weight (WT205D), and yearling weight (WT365D).

Parameter[1]	BWT[2]	WT205D	WT365D
Variance Component[3]			
V_p	122.5 (2.2)	2864.4 (61.0)	7321.2 (153.4)
V_a	51.9 (5.8)	625.8 (101.9)	2819.8 (395.1)
$Cov_{a,m}$	2.3 (3.0)	-184.7 (88.7)	-393.8 (233.4)
V_m	5.6 (3.5)	475.3 (140.9)	377.4 (263.9)
V_{pe}	2.3 (2.5)	682.4 (99.1)	771.9 (185.8)
V_e	57.6 (3.7)	1264.1 (68.9)	3745.8 (252.6)
Heritabilities			
h^2_a	0.42 (0.04)	0.22 (0.03)	0.39 (0.05)
h^2_m	0.05 (0.03)	0.17 (0.05)	0.05 (0.04)
c^2	0.04 (0.02)	0.24 (0.03)	0.11 (0.03)

[1] V_p = phenotypic variance, V_a = direct genetic variance, $Cov_{a,m}$ = direct by maternal covariance, V_m = maternal genetic variance, V_{pe} = permanent environmental variance, V_e = residual variance, h^2_a = direct heritability, h^2_m = maternal heritability, c^2 = proportion of phenotypic variance due to permanent environmental effects.
[2] BWT=birth weight, WT205D= weaning weight, WT365D= yearling weight.
[3] units = lb^2.

Table 3. Estimates of breed-specific heterosis (SE) and differences among heterosis (SE) of breed groups (British x British, British x Continental and Continental x Continental) for birth, weaning, and yearling weight.

Covariate[1]	BWT, lb[2]	WT205D, lb	WT365D, lb
BxB	1.02 (0.82)	14.17 (3.98)	38.78 (6.74)
BxC	1.65 (0.70)	19.06 (3.39)	30.61 (5.81)
CxC	1.61 (1.19)	12.95 (5.66)	20.11 (9.57)
Contrast[1]			
BxB - CxC	-0.55 (1.34)	1.25 (6.57)	18.74 (11.02)
BxC - CxC	0.04 (1.10)	6.13 (5.31)	10.58 (9.04)
BxC - BxB	0.57 (0.84)	4.89 (3.97)	-8.16 (6.83)

[1] B = British, C = Continental.
[2] BWT = birth weight, WT205D = weaning weight, WT365D = yearling weight.

covariates of expected breed heterozygosity from British x British, Continental x Continental, and British x Continental from the cross; contemporary group (birth year and season, birth location and age of dam), and maternal heterosis. Random effects included direct and maternal additive genetic effects, maternal permanent environmental effect, and a residual. Contrasts among heterosis of breed groups were obtained after adding overall direct heterosis as a fixed effect to the model described above.

Results

Means and SD for growth traits are reported in Table 1. Variance components and parameter estimates are presented in Table 2. The direct heritability estimates (SE) of birth, weaning, and yearling weight were 0.42 (0.04), 0.22 (0.03), and 0.39 (0.05), respectively. Maternal heritability estimates were 0.05 (0.03), 0.17 (0.05), and 0.05 (0.04) for birth, weaning, and yearling weight, respectively. Sex had a significant effect on all traits ($P < 0.001$). As expected, heifers were lighter at birth, weaning, and yearling ages and steers were intermediate to bulls and heifers at weaning and yearling ages.

The heterosis estimates for British x British and Continental x Continental proportions were not significantly different from zero for birth weight. The British x Continental proportions were significant for birth weight. The British x British, British x Continental, and Continental x Continental heterosis covariates were significant for weaning and yearling weight. Heterosis estimates were lower than expected based on previous heterosis studies (*Journal of Animal Science*, 1991, 69:3202) (Table 3).

Contrasts among the estimates of British x British, British x Continental, and Continental x Continental are presented in Table 3. Heterosis due to British x British and Continental x Continental differed by 18.74 (11.02) lb of yearling weight ($P < 0.01$). The same contrast for birth and weaning weight were not different from zero. British x Continental and British x British heterosis differed by -8.16 (6.83) lb of yearling weight ($P < 0.01$). However, British x Continental and British x British heterosis differed by 4.89 (3.97) lb of weaning weight ($P < 0.05$).

Differences between breeds and biological type exist and provide an opportunity to utilize specific breeds and exploit heterosis in a crossbreeding system to achieve production goals in various environments. Growth traits provide a valuable starting point in estimating breed-specific heterosis because of the availability of the data and the traits are moderately heritable. Further investigation of specific heterosis by breeds will provide useful estimates for the comparison and estimation of breeding values for various crosses.

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Using Sugar Beet Pulp to Replace Wheat Straw when Limit Feeding Late Gestation Beef Cows

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Summary

Sugar beet pulp was evaluated as a partial replacement for wheat straw in an energy dense, limit fed ration for gestating multiparous beef cows. Body weight and body condition were similar between cows fed a diet of wet distillers grains:beet pulp:wheat straw in either a 20:20:60 or a 20:45:35 ratio (DM basis). Cows on both diets gained 0.5 of a condition score over an average of 76 days. These data suggest sugar beet pulp can effectively reduce wheat straw to 35% diet DM in a byproduct/crop residue diet limit fed to gestating beef cows.

Introduction

As grass becomes less available and, subsequently, more expensive, cattle producers are searching for ways to maintain cows with alternative, cheaper resources. Late gestation cows have been successfully maintained on limit fed diets (less than 2% BW, DM basis) consisting of wet distillers grains and wheat straw or cornstalks. However, in western Nebraska, ethanol byproducts are not as readily available as in eastern Nebraska. Sugar beet pulp, included at 20% DM in limit fed rations, reduced the dependence on wet distillers grains while maintaining cow performance (*2012 Nebraska Beef Cattle Report,* pp. 13-14). Wheat straw is available in limited quantities in western Nebraska because very little wheat is irrigated and dryland wheat straw is typically left in the field as cover. Therefore, the objective of this experiment was to determine if late gestation beef cows could be maintained on a limit fed diet where beet pulp replaced a portion of the wheat straw.

Table 1. Diet and nutrient composition of rations containing sugar beet pulp.[1]

	Diet, % DM		Ingredient	Ingredient
	20 PULP	45 PULP	TDN, % DM	CP, % DM
Wet distillers grains	20	20	108	27.9
Sugar beet pulp	20	45	80	9
Wheat straw	60	35	45	3.5
TDN	64.6	73.3	—	—
CP	9.8	11.2	—	—
DM	49.6	37.1	—	—
DM lb fed/cow/day	18.6	15.3	—	—
TDN lb fed/cow/day	12.0	11.2		

[1]Supplements contained limestone, trace minerals, vitamins, and formulated to provide 200 mg/cow daily monensin sodium.

Procedure

An experiment was conducted over two years using late gestation multiparous beef cows (n = 40; BW = 1199 ± 27 lb in year 1; n = 38; BW = 1315 ± 36 lb in year 2) to determine the effects of partially replacing wheat straw with sugar beet pulp in a limit fed diet. Cows were stratified by BW and body condition score (BCS) and allotted to pens (4 or 5 cows/pen) in a completely randomized design. Pens were randomly assigned to one of two treatments. Treatments were diets containing 20% wet distillers grains, 20% beet pulp, and 60% wheat straw (PULP 20) or 20% wet distillers grains, 45% beet pulp, and 35% wheat straw (PULP 45) on a DM basis (Table 1). Limestone was added (0.3 lb/day/cow) to both diets to ensure the Ca:P ratio was at least 1.2:1. In order to supply the cows with 11 Mcal/day of energy, based on the requirements for late gestation cows, 18.6 lb PULP 20 and 15.3 lb of PULP 45 were fed once daily/cow (DM basis). The experiment was terminated approximately six weeks before calving. Five days prior to obtaining final BW, cows were limit fed a common diet to minimize gut fill differences. Initial and ending BW, BW change, BCS, BCS change were determined. Both experiments were statistically analyzed using the mixed procedures of SAS (SAS Institute, Inc., Cary, N.C.) with year as a random effect.

Results

Initial and ending BW, BCS, BW change, and BCS change were not different for the two treatments (Table 2; $P > 0.84$). These results agree with previous studies where ethanol byproducts and crop residues resulted in similar performance to hay when diets were formulated to contain the same energy density (*2012 Nebraska Beef Cattle Report,* pp. 13-14). Even though the diets were formulated to maintain BCS using the 1996 NRC, cows on both 20 PULP and 45 PULP gained approximately half a BCS over the average 76-day trials (Table 2). It is likely the energy requirements for confined cows are less than those for cow on range. It is also possible the passage rate is slower increasing digestibility for limit fed diets compared with *ad libitum* diets and, therefore, more energy is available to the animal. These results indicate ethanol and sugar byproducts can be combined with crop residue to maintain late gestation beef cows in limit fed, high energy diets. Additionally, sugar beet pulp can replace a portion of the crop residue, reducing the cost of the ration (Table 3) and improving

Table 2. Body weight and condition score of cows fed diets containing sugar beet pulp (year 1 and 2).

	20 PULP[1]	45 PULP	SE	*P*-value
Initial BW	1261	1255	61.5	0.85
Initial BCS[2]	5.5	5.5	0.38	1.00
Final BW	1390	1388	81.4	0.94
Final BCS	6.1	6.1	0.48	0.87
Weight change	128	132	21.2	0.72
BCS change	0.54	0.57	0.12	0.84

[1]20 PULP = diet containing 20% beet pulp, 45 PULP = diet containing 45% beet pulp.
[2]BCS on a scale of 1 to 9.

Table 3. Estimated costs of limit fed diets containing sugar beet pulp and *ad libitum* grass hay diets for gestating beef cows.

Commodity	DM ratio	Total lb Fed (DM basis)	Total lb Fed (as is basis)	Diet Cost ($/day, as is)[2]
WDGS:Pulp:straw[1]	20:20:60	18.6	38.7	1.25
WDGS:Pulp:straw	20:45:35	15.3	43.4	1.08
Hay	100	20.2	23.2	1.74

[1]WDGS = wet distillers grains
[2]As is basis prices for WDGS delivered $100/ton, wheat straw $80/ton ground and delivered, meadow hay $150 ground and delivered. Producers need to adjust prices to their location and current markets.

the handling characteristics of the diet. Although not a treatment in the trial, hay is included for comparison in Table 3. Good quality meadow hay would be lower in energy than the experimental diets and would need to be fed *ad libitum* to meet the cow's energy needs. When calculating the cost of the ration, producers need to factor in transportation, processing, and handling costs, as well as shrink for wet byproducts.

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Supplementing Cow-Calf Pairs Grazing Smooth Bromegrass

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Summary

A three-year study evaluated supplementing ethanol co-products mixed with low-quality forage to cow-calf pairs grazing smooth bromegrass as a method to replace grazed forage intake. Supplementing a 30:70 modified distillers grains plus solubles:cornstalks mixture reduced estimated grazed forage intake by approximately 40%. Doubling the stocking rate and supplementing did not impact cow or calf performance. A summer supplementation program designed to reduce grazed forage intake is a viable strategy for increasing stocking rate if forage for grazing is limited.

Introduction

As grass for summer grazing becomes more limited, investigating alternative management strategies to increase stocking rate is warranted. A practical approach to increasing stocking rate is to replace a portion of the grazed forage consumption of cattle on pasture with supplementation of low-quality crop residues mixed with co-products. Grazed forage intake may be limited due to the fiber and bulk from residues, and adding co-products to such forages improves residue palatability. Historically, co-products and residues are economical sources of energy, which favor their use as a supplement. Therefore, the objectives of this experiment were to evaluate the effect of supplementing modified distillers grains plus solubles (MDGS) mixed with low-quality forage to cow-calf pairs grazing smooth bromegrass on: 1) grazed forage intake and 2) cow and calf performance.

Procedure

Multiparous, nonpregnant, crossbred (Simmental × Angus), lactating beef cows (n = 48) with spring-born calves at side were utilized in a three-year experiment conducted on smooth bromegrass pastures at the University of Nebraska–Lincoln Agricultural Research and Development Center (ARDC) located near Mead, Neb. In a randomized complete design, cow-calf pairs (n = 16/year; 4/pasture) were stratified by total pair BW and assigned randomly within strata to one of two treatments with two replications (pasture) per treatment per year (total n = 12). Treatments consisted of pastures stocked at: 1) the recommended stocking rate of 3.82 AUM/ac without supplementation (CON), or 2) double the recommended stocking rate (7.63 AUM/ac) with supplementation (SUPP). Pairs continuously grazed smooth bromegrass pastures from early-May until mid-September annually (130 days). Data are reported as pooled across all years for 2011, 2012, and 2013.

The supplement fed in all years was a 30:70 MDGS:ground cornstalks (DM) mixture designed to replace approximately 50% of the grazed forage DM intake, thereby allowing for the twofold increase in stocking rate by the SUPP pairs. Ground cornstalks (1-inch grind) were used to provide rumen fill while MDGS was added at a minimal level necessary to encourage consumption of the low-quality forage. Based on data with confined cow-calf pairs fed average quality (IVDMD = 53%) forage, predicted total forage DMI was calculated as 2.58% of average pair BW throughout the grazing period (*The Professional Animal Scientist*, 28:664-669). Therefore, total estimated DMI was calculated retrospectively based on average pair BW for each treatment. It was anticipated grazed forage intake would be greatest early in the grazing season. As a result, pairs were supplemented at 0.6% of BW (DM) at trial initiation with increasing levels throughout the season on a weekly basis to account for 1) declining grazed forage quality and quantity and 2) increasing consumption by the calf. The supplement was mixed fresh daily and water was added to reduce the DM content to 30% to enhance palatability. To encourage pairs to begin consuming the supplement, a 50:50 MDGS:cornstalks mixture was initially fed with cornstalks increasing and MDGS decreasing by 2 percentage unit increments daily until the 30:70 ratio was obtained.

Two-day consecutive cow and calf BW measurements were recorded to determine cow BW change and calf gain throughout the grazing period. Prior to collecting weights, pairs grazed a common pasture for a minimum of five days prior to initiation and upon completion of the trial to minimize variation in gastrointestinal tract fill. All pairs were group fed once daily in metal feed bunks with at least 3 feet of bunk space per pair. Bunks were evaluated and feed refusals (if present) were removed and sampled daily. Refusals were sampled for DM determination using a 60°C forced air oven for 48 hours, and DMI was subsequently calculated on a pasture basis.

Data were analyzed as a randomized complete design with pasture serving as the experimental unit. All analyses included the fixed supplementation treatment effect with year considered a random effect. Since the

Table 1. Performance of cow-calf pairs grazing smooth bromegrass pastures by treatment.

	Treatment			
Item	CON[1]	SUPP[2]	SEM	*P*-value
Pastures (n)	6	6		
Cow				
Age, year	8.6	9.0	0.7	0.69
Initial BW, lb	1241	1235	25	0.73
Ending BW, lb	1296	1316	41	0.46
ADG, lb	0.42	0.62	0.13	0.19
Calf				
Age, day	47	50	3.3	0.48
Initial BW, lb	177	194	12	0.18
Ending BW, lb	470	502	41	0.08
ADG, lb	2.27	2.37	0.17	0.31
Grazed forage intake[3], lb DM/pair	41.0	26.3		
Supplement intake[3], lb DM/pair	—	15.7		
Total DMI[3], lb/pair	41.0	42.0		

[1]Pairs grazed at recommended stocking rate (3.82 AUM/ac) without supplementation.
[2]Pairs grazed at double the recommended stocking rate (7.63 AUM/ac) and received 50% of estimated daily intake of 30:70 MDGS:cornstalks mixture, DM.
[3]Predicted values.

proportion of steer and heifer calves was not equal between treatments, calf sex was initially included as a covariate in the model statement, but was ultimately removed as it was not significant for all variables tested. Significance was declared at $P \leq 0.05$.

Results

Cattle performance and supplement intake data are presented in Table 1. By design, initial cow BW was not different between treatments. Although not statistically significant, both ending cow BW and gain were numerically greater for SUPP than CON cows. Cows receiving supplement had 0.20 lb/day greater ADG than CON cows. Initial calf BW and gain were not significantly different. However, a numerical improvement in ADG resulted in a tendency for greater ending BW for SUPP calves. The small numerical increase in performance by SUPP pairs is logical, given the supplement would contain slightly more energy than the grass it is replacing. While no attempt was made to measure the amount of supplement consumed by the calves, they were observed at the bunk with their dams and appeared to be eating supplement daily.

Across all three years, average total pair BW was 1,592 and 1,624 lb for CON and SUPP pairs, respectively. Based on these weights, total estimated DMI was calculated to be 41 and 42 lb per pair daily for CON and SUPP, respectively. For SUPP pairs, supplement DMI averaged 15.7 lb daily throughout the season, and by difference grazed forage intake was 26.3 lb per day. This suggests the supplement reduced estimated grazed forage intake by 37%, or 1.0 lb of supplement replaced 0.94 lb of grazed forage. Similar research conducted in the Nebraska Sandhills (*2010 Nebraska Beef Cattle Report*, pp. 21-23) with cow-calf pairs demonstrated grazed forage replacement values of approximately 40 to 50% when a 30:70 wet distillers grains plus solubles:wheat straw (DM) supplement was fed. However, grazed forage intake was not reduced when yearling steers were supplemented only dried distillers grains plus solubles (*2008 Nebraska Beef Cattle Report,* pp. 28-30). This indicates using fibrous low-quality forages in the supplement is essential to reducing DMI and achieving significant forage replacement rates. The pastures in the current study received the same treatments for four consecutive years, and little difference between treatments was observed visually in condition or residual forage at the end of the grazing season each year. Additional N and P from the supplement that is returned to the soil via urine and feces are also beneficial for pasture productivity.

Supplementing cow-calf pairs grazing smooth bromegrass pastures with a mixture of MDGS and corn residue reduced estimated grazed forage intake without impacting animal performance. This may be a feasible management practice to increase stocking rate when pasture is limited by drought or demand. This technique may be more appropriate in Eastern Nebraska than on upland Sandhills range because there are likely fewer risks associated with potentially overgrazing smooth brome pasture. Likewise, distillers grains and crop residues are more abundant and may be more economically supplemented in Eastern Nebraska. This area of the state is also where greater competition for grazing acres may exist.

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Effects of Calf Age at Weaning on Cow and Calf Performance and Feed Utilization in an Intensive Production System

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Summary

The effects of calf weaning age on cow and calf performance, reproduction, and feed utilization were investigated in a two-year study. Early weaning increased cow BW in January. Pregnancy rates were not impacted by calf age at weaning. Dry matter intake (DMI) was similar between normal-weaned cow-calf pairs and early-weaned cows and calves. Feed requirements and utilization were comparable between early- and normal-weaned pairs when fed high energy diets, implying weaning decisions should be made on the basis of management rather than feed efficiency.

Introduction

When conditions dictate the necessity of feeding cows in a drylot setting, limit feeding high-energy diets can reduce feed costs without negatively impacting performance (*2009 Nebraska Beef Cattle Report*, pp. 11-12). Early weaning calves reduces cow maintenance requirements 30-40%, spares available forage, and may have positive effects on reproduction (*Journal of Animal Science*, 68:1438-1446). Previous studies have demonstrated that early-weaned calves are efficient at converting feed to gain (*Journal of Animal Science*, 77:323-329), and that early weaning reduces the total feed energy required by a cow-calf pair (*Journal of Animal Science*, 64:15-22). Given these data, if cow-calf pairs are managed in an intensive (semi- or total-confinement) system, then early weaning may be logical. The objectives of this research were to evaluate the impact of early weaning on: 1) cow-calf performance and reproduction and 2) the feed utilization of developing a weaned calf to 205 days of age.

Procedure

Multiparous (4.6 ± 1 year), crossbred (Red Angus × Red Poll × Tarentaise × South Devon × Devon), lactating beef cows (n = 156) with summer-born calves at side were utilized in a two-year experiment conducted at both the University of Nebraska–Lincoln Agricultural Research and Development Center (ARDC) feedlot located near Mead, Neb., and the Panhandle Research and Extension Center (PHREC) feedlot at Scottsbluff, Neb. The trial was a randomized complete block design with a 2 × 2 factorial arrangement of treatments. Each year, cows were blocked by pre-breeding BW (Heavy, Medium, and Light), stratified by calf age, and assigned randomly within strata to one of four treatments with three replications (pens) per treatment per year (total n = 24 pens). Treatment factors included 1) calf age at weaning: early weaned (EW) at 91 ± 18 days of age or normal weaned (NW) at 203 ± 16 days of age, and 2) research location: eastern (ARDC) or western (PHREC) Nebraska. Cows remaining in the herd for two consecutive years were assigned to the same treatments each year.

Prior to the beginning of the experiment each year, cows within locations were managed as a common group while calving in June and July in earthen feedlot pens without access to shade. Post-calving, cows

Table 1. Ingredient and nutrient composition of diets fed to all cows and calves from October to January by location and year.[1]

	Year 1		Year 2	
Ingredient, %	ARDC	PHREC	ARDC	PHREC
Corn silage	—	—	40.0	40.0
MDGS	56.5	—	36.5	—
WDGS	—	58.0	—	38.0
Cornstalks	40.0	—	20.0	—
Wheat straw	—	40.0	—	20.0
Supplement[2]	3.5	2.0	3.5	2.0
Calculated Composition				
CP, %	19.0	18.8	16.1	15.3
TDN, %	80.0	80.0	78.0	78.4
Ca, %	0.75	0.77	0.58	0.81
P, %	0.50	0.49	0.44	0.41

[1]All values presented on a DM basis.
[2]Supplements contained limestone, trace minerals, vitamins and formulated to provide 200 mg/cow daily monensin sodium.

Table 2. Daily DMI by weaning treatment and year.

	Year 1		Year 2	
Item	EW[1]	NW[2]	EW[1]	NW[2]
Cow	15.0	—	15.5	—
Calf	8.5	—	9.3	—
Cow-calf pair	—	22.8	—	24.9
Total	23.5	22.8	24.8	24.9

[1]EW = early weaned at 91 days of age.
[2]NW = normal weaned at 203 days of age.

Table 3. Performance of cows by location and weaning treatment.

	ARDC		PHREC			*P*-value		
Item	EW[4]	NW[5]	EW[4]	NW[5]	SEM	Weaning[1]	Location[2]	W × L[3]
Cow BW, lb								
October	1201	1180	1227	1212	114	0.26	0.08	0.85
January	1206	1166	1302	1232	104	0.02	<0.01	0.51
Cow BW change, lb	5	-14	74	20	23	<0.01	<0.01	0.15
Cow BCS[6]								
October	5.5	5.5	5.2	5.2	0.3	1.00	<0.01	0.59
January	5.4	5.3	5.6	5.6	0.4	0.60	0.03	0.60
Cow BCS change[6]	-0.1	-0.2	0.4	0.4	0.2	0.38	<0.01	0.38
Pregnancy, %	89.9	85.4	92.5	95.2	6	0.88	0.25	0.50

[1]Fixed effect of calf age at weaning.
[2]Fixed effect of location.
[3]Calf age at weaning × location interaction.
[4]EW = early weaned at 91 days of age.
[5]NW = normal weaned at 203 days of age.
[6]BCS on a 1 (emaciated) to 9 (obese) scale.

Table 4. Performance of calves by location and weaning treatment.

	ARDC		PHREC			*P*-value		
Item	EW[4]	NW[5]	EW[4]	NW[5]	SEM	Weaning[1]	Location[2]	W × L[3]
Calf BW[6], lb								
October	280	277	288	267	8	0.13	0.92	0.22
January	475[b,c]	510[a]	499[a,b]	461[c]	11	0.90	0.19	<0.01
Calf ADG, lb	1.73[b,c]	2.06[a]	1.86[b]	1.70[c]	0.18	0.09	0.02	<0.01

[1]Fixed effect of calf age at weaning.
[2]Fixed effect of location.
[3]Calf age at weaning × location interaction.
[4]EW = early weaned at 91 days of age.
[5]NW = normal weaned at 203 days of age.
[6]Actual weights.
[a-c]Within a row, least squares means without common superscripts differ at $P \leq 0.05$.

were limit-fed high energy distillers grains-based diets to meet nutrient requirements for lactation. Upon trial initiation (approximately Oct. 5), EW calves were weaned at 91 days of age and fed separately from their dams within each location. Normal-weaned calves remained with their dams and were weaned approximately Jan. 28 at 203 days of age. Two-day consecutive cow BW measurements were recorded to determine weight change from October to January. Body condition score was assessed visually by the same experienced technician at the same time weights were taken. Two-day consecutive calf BW measurements were collected to evaluate gain from October through January. Prior to collecting weights, all pairs were limit-fed for five days prior to initiation and upon completion of the trial to minimize variation in gastrointestinal tract fill.

From October through January, EW cows within each location were limit-fed 15.0 (year 1) or 15.5 (year 2) lb DM/cow daily a diet designed to meet maintenance energy requirements for a nonlactating cow (Table 1). Concurrently, EW calves within each location were offered *ad libitum* access to the same diet as the cows. Normal-weaned cow-calf pairs were limit-fed the equivalent amount of DM by adding the DMI of the EW cows and calves. Intake was not partitioned between the NW cow and calf. Consequently, the total DMI between either the EW cows and calves or the NW pairs was intended to be equal and increased due to growth and diet consumption by the calf. All cattle were pen-fed once daily in concrete fence line feed bunks with the following bunk space allotments: 2 feet per EW cow, 1 foot per EW calf, and 3 feet per NW cow-calf pair.

Cows were exposed to fertile Simmental × Angus bulls at a bull:cow ratio of 1:10 for 60 days beginning Sept. 26, and breeding occurred in the pens. Pregnancy was diagnosed via ultrasound 60 days after bull removal.

Data were analyzed as a randomized complete block design with pen as the experimental unit. Model fixed effects included calf age at weaning, location, and the weaning × location interaction. Since the proportion of steer and heifer calves was unequal among treatments, calf sex was initially included as a covariate for all variables tested and was subsequently removed if not significant. Block and year were included in all analyses as random effects, and significance was declared at $P \leq 0.05$.

Results

Early-weaned calves across locations had a daily DMI of 8.5 lb (year 1) and 9.3 lb (year 2) from October through January (Table 2). This amount was adjusted weekly and added to the 15.0 lb (year 1) or 15.5 lb (year 2) DM fed to the EW cows to derive the total amount fed to the NW pairs. Therefore, the EW cows and calves consumed 23.5 and 24.8 lb total DM/day in year 1 and 2, respectively. The NW pairs consumed 22.8 and 24.9 lb DM/day, for year 1 and 2, respectively. As a result, on average approximately 18.5 lb (year 1) and 19.5 lb (year 2) of TDN was supplied to both EW and NW treatments.

Cow performance and reproduction variables are presented in Table 3. The weaning age by location interaction for cow BW in January was not significant. Cows at PHREC had significantly greater BW than ARDC cows, and EW cows had greater BW in January than cows that nursed their calves. Likewise, there was no significant weaning age by location interaction for cow BW change, and EW cows gained more BW than

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NW. Additionally, cows at PHREC outgained those at ARDC ($P \leq 0.05$). Despite these changes in cow BW, there was no significant interaction or weaning age effect for January BCS or BCS change. Interestingly, regardless of weaning date, PHREC cows gained 0.4 BCS units while ARDC cows lost about 0.2 BCS units between October and January. The weaning age by location interaction was not significant for cow pregnancy rate nor were there significant effects of location or weaning.

Calf BW and gain data are presented in Table 4. By design, BW was similar among treatments in October. There were significant weaning age by location interactions for both ADG and ending January BW. At PHREC, EW calves gained significantly more and had greater January BW than NW, whereas at ARDC, calves nursing their dams had improved gain and ending BW over those early-weaned.

The positive response in cow BW and BW change from early weaning is logical as calf removal diverts intake energy from lactation towards body tissue storage (i.e., BCS). Why BCS did not respond to early weaning is interesting, but in general these changes in BW and BCS are numerically small and may have limited biological significance. Greater improvement in BW and BCS from early weaning would likely be seen in thin (BCS < 5.0) or young (2 to 3-year-old) cows. The pregnancy rates also suggest mature cows in adequate BCS prior to the onset of the breeding season may have limited reproductive response to early weaning. It is not clear why significant location effects were observed, but this may be related to inherent variance that can be present when genetically identical cowherds are managed similarly. Differences in weather conditions between locations throughout the trial may have contributed to the location effects. Although we assume equal energy values (43% TDN, DM) for cornstalks and wheat straw, potential differences in digestibility between these forages may also exist.

As both DMI and cow-calf performance were relatively similar between EW and NW pairs, feed utilization was comparable. When feed utilization is expressed as lb of calf gain per lb of TDN intake by the pair, EW and NW pairs on average had values of 0.094 and 0.099, respectively. Early weaning appears to have marginal effect on cow performance and reproduction when pairs are limit-fed high energy diets, provided BCS is acceptable (≥ 5.0) prior to the beginning of the breeding season, as in the current study. Early-weaned calves fed wet, high-energy diets with distillers grains have comparable ADG to those not weaned. Our data suggest that early weaning does not reduce the feed energy requirements necessary to support the pair. Therefore, decisions on early-weaning should be made on a management and forage availability basis as opposed to feed efficiency.

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An Economic Analysis of Conventional and Alternative Cow-Calf Production Systems

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Summary

Profitability through weaning was predicted for conventional and alternative cow-calf production systems using various input price scenarios. At base input price levels, conventional systems were more economical than alternative systems. As pasture price increased, alternative systems became cost effective. Feeding cows year-round in a confinement setting appeared the least economical; however, an alternative system combining summer drylot feeding with cornstalk grazing is projected to be economically competitive given an increasing abundance of corn residue.

Introduction

In recent years, numerous factors related to grain prices and interest rates have strengthened land values and stimulated the conversion of pastureland to cropland. When these changes in land use are combined with drought, the availability of grass for pasture and hay production for maintaining the beef cow-calf enterprise becomes challenged. However, crop residue from increased grain production represents the only forage resource for beef cattle that is increasing in Nebraska and the Midwest. There is also excess feeding capacity within the cattle industry. Therefore, alternative production systems involving partial or total intensive management (confinement) of cows using crop residues as forage resources may be economically viable alternatives to conventional cow-calf systems. The objectives were to model profitability through the weaning phase of production of seven (four conventional and three alternative) different cow-calf production systems under current and projected forage and feed price scenarios.

Procedure

The seven cow-calf systems analyzed were selected to represent various production environments across Nebraska. The first three systems represent conventional Nebraska Sandhills production using data from March (GSL-MA), June (GSL-JU), and August (GSL-AU) calving cowherds collected over four years at the University of Nebraska–Lincoln Gudmundsen Sandhills Laboratory (*Professional Animal Scientist,* 28:249-259). Cows in the GSL-MA herd grazed native range from May through October followed by cornstalks until the end of February. During the last 45 days of the cornstalk grazing period, cows were fed 1.0 lb/cow daily (DM) a distillers-grains-based supplement. From March 1 through April, GSL-MA cows were fed grass hay in a drylot. Calves were weaned in late-October. Cows in the GSL-JU herd grazed native range from April through October followed by cornstalks until the end of March. Cows were also supplemented (1.0 lb/cow/day, DM) from Aug. 1 until April 1. Cows in the GSL-AU herd also grazed native range from April through October and then cornstalks until the end of March. However, August calving cows were supplemented from Oct. 1 through May 30 (1.0 lb/cow/day, DM). In both the GSL-JU and GSL-AU systems, cows were not fed hay during the year unless snow cover prevented grazing, and calves remained with their dams while grazing cornstalks (April weaning).

The fourth system represents conventional southeast Nebraska production using data from a spring (March and April) calving cowherd in three years at the University of Nebraska–Lincoln Dalbey-Halleck (DH) Research Unit (*Journal of Animal Science*, 83:694-704). Cows in this system grazed cool- and warm-season pastures from April 1 through October followed by cornstalks until February, and were fed grass hay during calving. Weaning occurred in mid-October. The first alternative system evaluated (DH-SUPP) is similar to this, with the exception that cow-calf pairs are double stocked during summer grazing and half of the grazed forage is replaced by distillers grains and crop residue fed as a supplement (*2015 Nebraska Beef Cattle Report,* pp. 14-15).

The final two alternative production systems are total intensive management (INT) in which cows are confined to a drylot year-round, and an intensive management system with fall/winter cornstalk grazing (INTSG). The INT system (*2015 Nebraska Beef Cattle Report,* pp. 16-18) represents two years of data from a summer (June and July) calving cowherd fed distillers grains and crop-residue-based diets with calves weaned in February. The INTSG system is a proposed production system that will be researched in coming years, and is a combination of the INT and GSL-JU and GSL-AU systems. Cows will be maintained in confinement from April through October, and then will graze cornstalks until approximately the end of March. Therefore, calving will be in summer and weaning will occur when pairs return from cornstalk grazing. The logic for summer calving in the INT and INTSG systems was improved pen conditions during June and July, and calves would be marketed in the spring at historically higher prices. To meet protein requirements while on cornstalks, INTSG pairs would be fed 3.0 lb daily (DM) a distiller-grains-

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based supplement. Weaning weights in the INTSG system are projected to be approximately 100 lb greater than INT calves given they will be approximately 60 days older at weaning.

A spreadsheet for calculating total annual cow costs was developed by incorporating production data reported from all seven cow-calf systems (Table 1). Total annual cow costs were divided by actual calf weaning BW for each system to calculate a breakeven calf sale price or unit cost of production (UCOP, $/lb) through weaning. Unit cost of production was then adjusted to a common 95% weaning percentage (calves weaned per pregnant cow). Thus, we assume equal reproductive and weaning rates across all systems. Unit costs of production, including both steer and heifer calves, were first calculated using base input prices (Table 2) and then under various pricing scenarios.

Additional assumptions regarding analysis were: 1) Costs associated with cow ownership and management was similar across all systems at $250/cow/year. Of that cost, $50 is attributed towards breeding, with the remaining portion charged to cover expenses for replacement females, interest, depreciation, marketing, insurance, and taxes; 2) All calves produced in each system were marketed at weaning and no replacement heifers were retained. Marketing weights were based on actual weaning weights (not adjusted to 205 days of age) since three systems were designed to leave calves on the cow longer than 205 days; 3) Mature bred cows were purchased into the system annually as replacements as opposed to purchasing or retaining replacement heifers. Labor/yardage was equal between dry cows or cow-calf pairs and assessed at $0.10/cow/day for cows in conventional systems; $0.20/cow/day if supplemented on pasture or cornstalks and $0.45/cow/day for cows in intensive management. Feeds were priced on a 100% DM basis and included $5/ton for delivery and $15/ton for grinding of baled crop residue.

Table 1. Annual production inputs and calf weaning weights by cow-calf system.

	GSL MA[1]	GSL JU[1]	GSL AU[1]	DH[2]	DH SUPP[3]	INT[4]	INTSG[5]
Summer grass, day	180	215	215	200	100	—	—
Grazed cornstalks[6], day	120	195	180	105	105	—	188
Hay, lb DM	1645	—	—	1500	1500	—	—
Harvested residue, lb DM	—	—	—	—	2600	2738	1674
Distillers grains, lb DM	45	240	240	—	1100	4106	2961
WW, lb	521	557	504	500	502	486	580

[1]Gudmundsen Sandhills Laboratory March, June and August calving systems.
[2]Dalbey-Halleck system.
[3]Dalbey-Halleck system with half of summer grazing replaced with supplement.
[4]Intensive management system (year-round drylot confinement).
[5]Intensive management system with fall/winter cornstalk grazing.
[6]Includes days assigned to calves.

Table 2. Base prices for economic analysis.

Grass, $/pair/day	1.33
Cornstalk grazing, $/cow/day	0.60
Distillers grains[1], $/lb DM	0.11
Hay[2], $/lb DM	0.08
Baled residue[3], $/lb DM	0.05
Mineral/salt, $/cow/year	10.00
Labor/yardage, $/head/day	0.10
Cow ownership and management, $/cow/year	250.00

[1]115% of $4.50/bu corn plus delivery.
[2]$130/ton hay at 90% DM plus delivery.
[3]$67/ton residue at 90% DM plus delivery and grinding.

Table 3. Unit cost of production (calf breakeven sale price; $/lb) at several input price scenarios by cow-calf system.

	GSL MA	GSL JU	GSL AU	DH	DH SUPP	INT	INTSG
Base prices	1.50	1.42	1.55	1.55	1.80	2.19	1.65
Grass[1], $50	1.62	1.56	1.70	1.70	1.88	2.19	1.65
Grass[2], $72	1.89	1.85	2.03	2.00	2.03	2.19	1.65
Distillers[3], 100	1.50	1.41	1.54	1.55	1.77	2.07	1.58
Distillers[4], 85	1.49	1.40	1.53	1.55	1.74	1.94	1.50
Stalks[5], 0.35	1.44	1.33	1.45	1.50	1.75	2.19	1.57

[1]Grass at $50/pair/month.
[2]Grass at $72/pair/month.
[3]Distillers grains at 100% of $4.50/bu corn.
[4]Distillers grains at 85% of $4.50/bu corn.
[5]Grazed cornstalks at $0.35/cow/day.

Results

In the conventional systems (GSL-MA, GSL-JU, GSL-AU, DH), UCOP ranged from $1.42 to $1.55/lb of calf at weaning under base prices (Table 3). The June calving Sandhills system had the lowest UCOP largely because calves are older and heavier at weaning, no hay was fed, and cows grazed cornstalks for about five months. The GSL-AU and DH systems had the highest UCOP ($1.55/lb of calf at weaning), and the Sandhills March calving system was intermediate. However, the differences among these systems are small and given our assumptions may not be different. At the assumed base prices, UCOP for all conventional systems is less than all alternative systems. The year-round INT system had clearly the highest UCOP of all systems at $2.19/lb of calf at weaning. Although the current projected price of feeder cattle is high, this system appears to be the least economical. The proposed INTSG system appears to be more competitive with traditional systems mostly because cornstalk grazing is a more economical feed resource.

Our base pasture price of $1.33/pair/day represents a statewide reported average by the University of Nebraska–Lincoln Department of Agricultural Economics. As the price of pasture increases relative to other feed costs, UCOP for all conventional systems increase. Interestingly, UCOP for the alternative DH-SUPP system also increases, but to a lesser extent than the conventional systems because half of the grazed forage is replaced with a distillers and crop residue supplement. When the price of pasture is over $2.40/pair/day, alternative DH-SUPP and INTSG systems that rely less on summer grass appear to be economically viable.

The price of distillers grains, and any other feedstuff used as a protein and energy source, is a critical factor in the cost of alternative systems. Distillers grains and other commodities tend to follow corn price. As the price of distillers grains decreases from 115 to 100 or 85% of $4.50/bu corn, UCOP for conventional systems utilizing less distillers grains remain relatively unchanged while UCOP for alternative systems decrease more rapidly. This demonstrates that the potential profitability for alternative systems appears to be strongly related to the price of distillers grains. Cornstalk grazing represents an economical resource, and given the abundance of residue in Nebraska, it should remain cost effective. However, several factors including winter weather and the proximity of cattle to cornfields can influence this. While the beef cattle industry is challenged by diminishing traditional forage resources, there is an increasing supply of corn residue for use in alternative systems. Feeding cows in an intensive management or confinement system year-round does not appear to be competitive with conventional systems. A proposed alternative system of summer drylot with fall/winter cornstalk grazing appears to be economical when grass prices are elevated and cornstalk grazing is available.

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Effect of Post-Weaning Management and Age at Weaning on Calf Growing and Finishing Performance

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Summary

The impact of post-weaning management system and calf age at weaning on growing and finishing performance was evaluated. During the growing phase, cattle in the fast-track system had improved intake, gain, and feed conversion. Although initial finishing weight was similar between systems, slow-track cattle had greater intake, gain, final body weight, and carcass weight. While the impact of age at weaning was negligible, the improvement in finishing performance for slow-track cattle demonstrates the value of different management systems.

Introduction

Early weaning is a sound management practice if forage is limited or cow BCS is decreased. Prior research has indicated early-weaned calves are not only efficient in converting feed to gain, but overall ADG through finishing was also increased by early weaning *(Journal of Animal Science,* 77:323-329). Calves from later-calving (late-spring or summer) cowherds weaned the following spring are well suited to either graze summer pasture or be placed on feed, and the age at which calves are weaned may interact with how cattle are managed post-weaning. Thus, the objectives of this experiment were to evaluate the impact of calf age at weaning and post-weaning management system on cattle growing and finishing performance and carcass characteristics.

Procedure

This experiment was conducted at the University of Nebraska–Lincoln Agricultural Research and Development Center (ARDC) feedlot near Mead, Neb., utilizing summer-born crossbred (Red Angus × Red Poll × Tarentaise × South Devon × Devon) steer and heifer calves (n = 75, BW = 528 ± 80 lb). Cattle originated from cowherds maintained in an intensive management (drylot) system year-round located at ARDC and the Panhandle Research and Extension Center (PHREC), Scottsbluff, Neb. (*2014 Nebraska Beef Cattle Report,* pp. 27-28). Data are reported only for progeny weaned during year 1 of that experiment. Approximately one half of the calves were weaned from their dams in late-September the previous year at 87 ± 19 days of age and fed a distillers-grains and crop-residue-based diet. The remaining half were weaned in late-January at 205 ± 18 days of age. Following January weaning, all cattle were received at ARDC in mid-February. During initial processing, all cattle were vaccinated with Bovi-Shield Gold 5® (Zoetis), treated for internal and external parasites with Dectomax® (Zoetis), and implanted with Ralgro® (Merck Animal Health). The trial was a randomized complete design with a 2 × 2 factorial arrangement of treatments. Cattle were stratified by initial BW and assigned randomly within strata to one of four treatments with two replications (pens, based on location of origin) per treatment. Treatment factors included: 1) calf age at weaning, early weaned (EW) at 87 ± 19 days of age or normal weaned (NW) at 205 ± 18 days of age; and 2) post-weaning management system, fast-track (FT) or slow-track (ST). In the FT system, cattle were adapted to a feedlot finishing diet following a growing period in which cattle were fed for a high (≥ 3.0 lb) ADG. The ST system consisted of a growing period where cattle were fed for a moderate (1.5 lb) ADG, followed by summer grazing smooth bromegrass pastures, and then feedlot finishing in the fall.

Upon arrival and assignment to treatments, cattle in both systems entered a 78-day growing period from March to late-May. All cattle were fed a common diet (Table 1), but the amount fed daily differed between treatments as the intent was to produce different gains during the growing period. Cattle in the FT system were offered *ad libitum* access to the growing diet, while ST cattle were limit-fed approximately 2.0% of BW (DM). Heifers were spayed by a licensed veterinarian during the growing phase. At the end of the growing period, ST cattle were implanted with Revalor®-G (Merck Animal Health), received Ivomec® (Merial Animal Health), and were transported to smooth bromegrass pastures for summer grazing. Concurrently, FT cattle were poured with Ivomec (Merial Animal Health), implanted with either Revalor®-XS (steers, Merck Animal Health) or Revalor®-IH (heifers, Merck Animal Health), and began adaptation to a finishing diet (Table 1).

Table 1. Ingredient composition of diets fed to all cattle.[1]

Ingredient, %	Growing Diet
Corn silage	66.0
MDGS[2]	30.0
Supplement[3]	4.0
Ingredient, %	**Finishing Diet**
MDGS[2]	40.0
High-moisture corn	20.5
Dry-rolled corn	20.5
Corn silage	15.0
Supplement[4]	4.0

[1]All values presented on a DM basis.
[2]Modified distillers grains plus solubles.
[3]Formulated for 200 mg/animal daily of Rumensin®.
[4]Formulated for 450 mg/animal daily for Rumensin and 90 mg/animal daily for Tylan®.

Table 2. Growing performance of cattle by management system and weaning age.

Item	FT		ST		SEM	*P*-value		
	EW[4]	NW[5]	EW[4]	NW[5]		System[1]	Weaning[2]	S × W[3]
Initial BW, lb	517	538	519	540	16	0.90	0.27	0.97
Ending BW, lb	780	815	637	650	22	<0.01	0.35	0.65
ADG, lb	3.38	3.56	1.52	1.40	0.10	<0.01	0.79	0.24
DMI, lb/day	16.7	17.4	9.7	9.7	0.04	<0.01	<0.01	<0.01
F:G[6]	4.95	4.90	6.39	6.92	—	0.01	0.55	0.42
Off Grass BW, lb	—	—	769	792	—	—	—	—
Grass ADG, lb	—	—	0.95	1.02	—	—	—	—

[1]Fixed effect of post-weaning management system.
[2]Fixed effect of calf age at weaning.
[3]Management system × calf age at weaning interaction.
[4]EW = early weaned.
[5]NW = normal weaned.
[6]Analyzed as G:F, reported as F:G.

Table 3. Finishing performance of cattle by management system and weaning age.

Item	FT		ST		SEM	*P*-value		
	EW[4]	NW[5]	EW[4]	NW[5]		System[1]	Weaning[2]	S × W[3]
Live Performance								
DOF	172	172	165	165				
Initial BW, lb	780	815	769	792	21	0.49	0.27	0.81
Final BW, lb	1311	1294	1415	1460	22	0.01	0.47	0.19
ADG, lb	3.00	3.11	3.79	3.94	0.19	0.02	0.53	0.93
DMI, lb	20.7	20.9	26.4	25.5	0.8	<0.01	0.72	0.53
F:G[6]	6.90	6.71	6.94	6.45	—	0.59	0.11	0.37
Carcass Characteristics								
HCW, lb	826	816	892	920	14	0.01	0.47	0.19
LM area, in^2	13.5	13.5	13.9	14.2	0.3	0.11	0.69	0.60
12^{th} rib fat, in	0.56	0.65	0.57	0.56	0.04	0.27	0.32	0.23
Calculated YG	3.18	3.54	3.29	3.30	0.20	0.74	0.37	0.38
Marbling[7]	442	400	508	464	21	0.08	0.15	0.96

[1]Fixed effect of post-weaning management system.
[2]Fixed effect of calf age at weaning.
[3]Management system × calf age at weaning interaction.
[4]EW = early weaned.
[5]NW = normal weaned.
[6]Analyzed as G:F, reported as F:G.
[7]Marbling score: 400 = Small, 500 = Modest, etc.

Fast-track cattle began the finishing phase (including adaptation diets) May 24 and were harvested Nov. 13 (172 days on feed), and heifers were re-implanted (Revalor-H, Merck Animal Health) approximately 80 days prior to projected harvest. Cattle in the ST system grazed smooth bromegrass pastures until mid-October, then received the same implant and health regimen as the FT, and began the finishing period Oct. 18. Slow-track heifers were re-implanted approximately 80 days prior to projected harvest and all cattle in the ST system were harvested April 2 the following year (165 days on feed). Cattle in both systems had *ad libitum* access to a common finishing diet that included Optaflexx® (Elanco Animal Health) at 22.2 g/ton DM or 300 mg/head daily for the last 28 days prior to harvest. Weights were collected over a minimum of two consecutive days at both initiation and upon completion of the growing phase to determine gain during that period. Ending BW from the growing period was used as initial BW for the finishing period for FT cattle. Weights (two days consecutive) at the end of summer grazing were used as initial finishing BW for ST cattle. Prior to collecting all weights, cattle were limit-fed (2.0% of BW, DM basis) a diet of 50% alfalfa hay and 50% wet corn gluten feed for five days to minimize variation in gastrointestinal tract fill.

All cattle were harvested at a commercial abattoir (Greater Omaha Packing Co., Omaha, Neb.) once determined finished by visual appraisal. On the day of harvest, hot carcass weight (HCW) and liver abscess scores were recorded. After a 48-hour chill, 12^{th} rib fat thickness, USDA marbling score, and LM area were collected. Yield grade was subsequently calculated using the following equation: $2.5 + (2.5 \times 12^{th} \text{ rib fat}) - (0.32 \times \text{LM area}) + (0.2 \times 2.5 \text{ [KPH]}) + (0.0038 \times \text{HCW})$. Performance on a carcass adjusted basis was calculated using a common dressing percentage (63%) to determine final live BW, ADG, and F:G.

Data were analyzed as a randomized complete design with pen serving as the experimental unit. Model fixed effects included post-weaning management system, age at weaning, and the system × weaning interaction. Since the proportion of steers and heifers was unequal among treatments, sex was initially included as a covariate in the model statement for all variables tested and was subsequently removed if not significant. Location of origin was included in all analyses as a random effect, and significance was declared at $P \leq 0.05$.

Results

Cattle performance data during the growing and summer grazing periods are presented in Table 2. Although the system × weaning age interaction was significant for DMI, no other significant interactions were observed nor were there significant effects of weaning age. As intended, the significantly greater daily DMI by FT cattle resulted in increased gains and ending BW as compared to ST cattle. Likewise, F:G was improved 26% for cattle in the FT as opposed to the ST management system. Slow-track cattle gained approximately 1.0 lb daily during summer grazing, which is lower than previously reported gains for nonsupplemented steers grazing similar pastures (*2013 Nebraska Beef Cattle Report*, pp. 31-32). Given that cattle

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grazed pastures until mid-October, declining forage quality likely limited weight gain.

Finishing performance and carcass variables are presented in Table 3. No significant system × weaning age interactions were observed, nor were there significant effects of calf age at weaning. Although FT cattle gained more during the growing phase, initial finishing BW was similar among treatments due to gain during the summer by ST cattle. Dry matter intake was greater for ST cattle which resulted in increased gain and carcass adjusted final BW compared with FT cattle. However, feed conversion was similar among treatments. The increased final live BW corresponded to greater HCW for ST cattle. *Longissimus* muscle area, 12th rib fat thickness, and calculated YG were not impacted. Interestingly, cattle in the ST system also tended to have greater marbling scores, but additional numbers are needed to determine if this effect is biologically real or merely due to random variation.

In general, ADG during the growing phase was better than anticipated for cattle in both systems, but logical, given the quality of the diet. After having relatively low gains during the summer, ST cattle appeared to compensate when placed on the finishing diet. The FT cattle in the current study were not true calf-feds since they were grown prior to being fed the finishing diet. Conversely, ST cattle are similar to short-yearlings in terms of age at the onset of finishing. However, the difference in finishing performance between the two systems is typical for yearlings and calf-feds, with yearlings usually having greater intakes, gains, and final BW but less efficient. Increased DMI by the ST cattle may be due to age and greater rumen capacity from summer grazing. Additionally, the extended growing period may have allowed cattle in the ST system to increase skeletal growth (frame size), which could possibly explain the increased live and carcass weights even though initial BW at the start of finishing was similar. These preliminary data indicate early weaning has minimal impact on subsequent growing and finishing performance when EW calves are fed distillers grains and crop-residue-based diets. Post-weaning management may have greater influence on economically relevant traits such as final BW and HCW.

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Dried Distillers Grains Supplementation of Calves Grazing Irrigated Corn Residue

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Summary

Steer calves grazing irrigated corn residue received supplementation of dried distillers grains plus solubles (DGS) at 0.3, 0.5, 0.7, 0.9, or 1.1% of body weight. Steers were individually supplemented daily through Calan gates. Daily gain improved linearly (0.77 lb/head/day to 2.21 lb/head/day) with increasing supplementation (1.5 lb/day to 7 lb/day). Supplementing DGS to calves grazing corn residue increased gain during the winter period.

Introduction

There is significant potential for grazing corn residues in Nebraska due to the acres of corn planted annually. Grazing residues increases the length of the grazing season, allowing producers to feed less harvested feeds, thereby reducing annual feed costs. However, residues are lower in CP and energy than what is required to meet the needs of growing calves gaining more than 1 lb per day. Providing protein supplementation in the form of rumen undegradable protein (RUP) allows producers to increase winter gain of growing calves on corn residue. A feed that acts as an excellent source of RUP and energy in forage-based diets is distillers grains plus solubles (DGS). A quadratic effect has previously been demonstrated for calves grazing irrigated corn residue and receiving dried DGS at increasing levels, with optimal supplementation being at 1.1% of body weight (*2014 Nebraska Beef Catle Report,* pp. 48-49).

The objective of this trial was to compare different levels of supplementation of dried DGS for calves grazing an irrigated corn residue field.

Procedure

Sixty crossbred steers (519 ± 11 lb) were backgrounded on corn residue from Nov. 6, 2013, to Jan. 31, 2014, at the University of Nebraska–Lincoln Agricultural Research and Development Center near Mead, Neb. Treatments were arranged in a completely randomized design. Steers were assigned randomly to treatment to evaluate the effects of gain for calves grazing corn residue and receiving dried DGS supplementation. Dried DGS was fed at an inclusion level of 0.3, 0.5, 0.7, 0.9, or 1.1% of BW (5, 8.5, 11.5, 16, or 20 lb). Steers were gathered at 1,600 and offered supplementation individually through Calan gates. Steers were turned out at 0700 to graze residue for the remainder of the day. All calves were implanted with Ralgro® on day one of the trial and received monensin at 200 mg/steer and limestone at 60 g/steer daily as part of supplementation.

Six ruminally canulated steers were utilized for diet sampling. Diet samples were collected three times throughout the trial by evacuating the rumen of solid and liquid particulate matter. Once steers had a chance to graze for thirty minutes they were brought back in and the grazed forage was collected from the rumen, sealed in a labeled bag, and stored on ice for later analysis of *in vitro* organic matter disappearance (IVOMD). The original rumen contents prior to diet sampling were replaced in the rumen of the respective steer prior to turning them out with the herd. Total grazed contents were frozen and subsequently freeze dried. Samples were ground through a 1 mm screen prior to analysis. Diet IVOMD was determined by incubating each sample for 48 hours in a solution of MacDougall's buffer and rumen fluid. Samples were then filtered, dried, and ashed to obtain DM and OM amounts for the IVOMD calculation.

For grazing cattle, stocking rates are traditionally based on available forage and not the quality of the forage. Stocking rate was calculated based on yield of the field at harvest and previous research quantifying the amount of residue consumed per acre. The yield (bu/ac), estimated forage availability (8 lb/bu), grazing efficiency factor (85% for irrigated), and number of acres were multiplied together to estimate the total available forage for each field. Total available forage was then divided by estimated DMI of all steers allotted to graze each respective field in order to get days of available grazing. Using this calculation, the 32 acre irrigated field would allow 66 steers to graze for 84 days based on a yield of 260 bu of grain/ac. Due to the limited number of Calan gates, only 60 steers could be supplemented in the barn. The six ruminally canulated steers utilized for diet sampling were able to graze irrigated corn residue and received daily supplementation of dried DGS at 0.7% BW in a feed bunk outside the barn.

Results

Average daily gain increased linearly ($P = 0.03$) with increasing level of dried DGS supplementation for calves grazing irrigated corn residue. Calves supplemented at 0.3, 0.5, 0.7, 0.9, and 1.1% of BW gained an average of 0.77, 1.44, 1.71, 1.95, and 2.21 lb/day ($P < 0.01$). No feed refusals were observed for steers supplemented

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at any level. The gain response to increasing levels of DGS supplementation is shown in Figure 1. The linear effect suggests that optimal gain per lb of supplementation may not have been reached. Previous research (*2006 Nebraska Beef Cattle Report*, pp. 36-37) evaluating supplementation level of DGS used higher supplementation amounts than 1.1% of BW and found a quadratic response with increasing supplementation level. The highest level for this trial was set at 1.1% BW based on the previous year's trial which showed 1.1% BW as the optimal level while minimizing feed refusals (*2014 Nebraska Beef Cattle Report,* pp. 48-49). The current study may not have observed a quadratic response due to the maximum level of supplementation set in order to achieve maximum gain per lb of supplement.

No differences in IVOMD were present for diet samples collected and analyzed by sampling period ($P = 0.52$). Figure 2 shows the changes in IVOMD over time. The IVOMD calculation shows the quality of the diet samples throughout the sampling period for the irrigated field to remain relatively constant. Grazing corn residue is unique in that all of the available forage is accessible to the animal on the first day of grazing. Animal selectivity occurs with the steer consuming the grain, husk, leaf, cob, and then stalk. Residue parts are selected for in order of highest to lowest nutrient quality, supporting the decline in IVOMD over the grazing period. The lack of decline in diet quality suggests we had an appropriate stocking rate to maintain forage quality throughout the grazing season.

This experiment suggests gain is greater for calves receiving a higher supplementation level as a percentage of BW. The optimal supplementation level does not appear to have been met and may be higher than 1.1% BW since steers were given sufficient time to consume supplement.

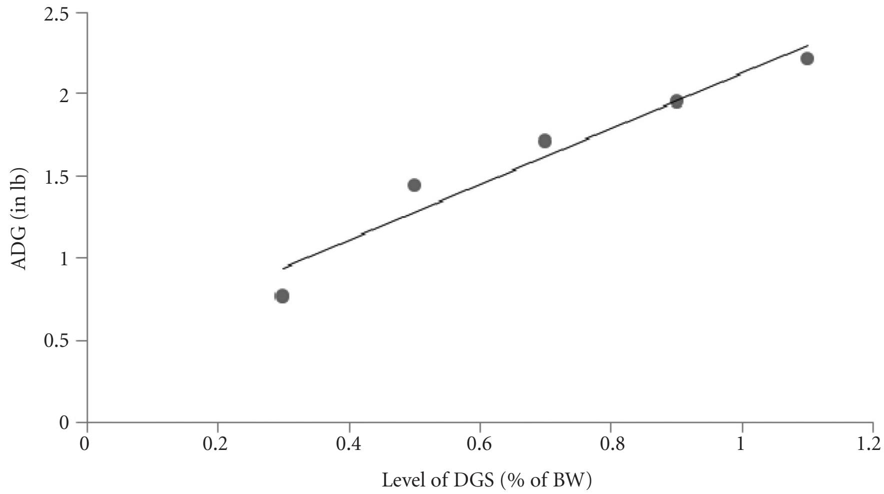

Figure 1. Effect of gain on level of dried distillers grains.

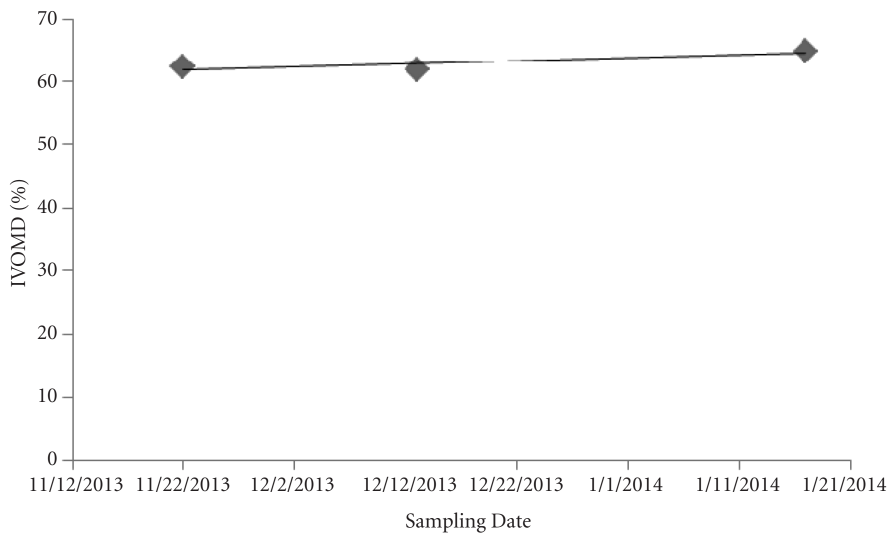

Figure 2. ***In vitro* organic matter disappearance of diet samples over time.**

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Comparison of Commercial Lick Tubs to Distillers Grains Supplementation for Calves Grazing Corn Residue

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Summary

Steer calves grazing irrigated corn residue were supplemented dried distillers grains plus solubles (DGS) or allowed continuous access to a commercial lick tub. Dried DGS was fed at 2.94 lb/steer/day and the lick tubs were consumed at 2.04 lb/steer/day (DM basis). Gain was greater for cattle supplemented with dried DGS (1.36 lb/day) compared to those with access to lick tubs (0.83 lb/day). Supplement efficiency varied between calves receiving dried DGS (46%) and those with continuous access to the lick tub (43%) when expressed on a DM basis. Values for dried DGS supplementation (48%) were not different for supplement efficiency on an OM basis when compared to cattle on the lick tub treatment (50%). Economic analysis shows that as the price of DGS increases, the difference in profit between supplementation strategies is reduced.

Introduction

Corn residue is an abundant forage source that is low in energy and crude protein to meet the needs of calves. Providing protein supplementation to calves grazing corn residue optimizes gain of the calves and improves intake of low-quality forages. Various methods of supplementation exist although dried distillers grains plus solubles (DGS) are among the most common. Dried DGS have a high protein (30% CP) and energy content (95% TDN; *2011 Nebraska Beef Cattle Report*, pp. 20-21). Other forms of supplementation are available as lick tubs and may result in similar performance while improving convenience for producers. The commercial lick tubs (Sweet Pro, Walhalla, N.D.) utilized for this trial are made during the proprietary fermentation process. A pressing technique is used to give the product its characteristic hardness which assists in controlling intake. However, performance relative to a common supplementation strategy is unknown. The objective of this trial was to compare the use of commercial lick tubs to daily byproduct supplementation of dried DGS for calves grazing corn residue.

Procedure

One hundred twenty five crossbred steers (529 ± 5.82) were backgrounded on irrigated corn residue for a 70 day grazing period at the University of Nebraska–Lincoln Agricultural Research and Development Center near Mead, Neb. The trial was replicated over two consecutive years. Each year, an irrigated corn residue field was divided into eight paddocks, with four replications receiving dried distillers grains plus solubles (DGS) and four having continuous access to lick tubs. The dried DGS treatment received supplementation in a bunk at 2.94 lb/steer daily on a DM basis. Lick tubs were replaced in each paddock when less than 10% remained and the plastic tray was removed once the supplement was consumed. Each lick tub was weighed prior to placement in the field and upon removal was corrected for DM to determine the amount of supplement consumed.

Cattle were limit-fed at 2% of BW for five days prior to the initiation of the trial. The diet consisted of 50% Sweet Bran, 25% alfalfa, and 25% grass hay. Three day weights were taken on day -1, 0, and 1 in order to reduce variation due to gut fill. Cattle were assigned to each paddock based on day -1 and day 0 weights. Paddock was then assigned randomly to treatment. At the conclusion of the trial, steers were limit-fed the same diet at 2% of BW and three-day weights were collected. Steers were implanted with Ralgro® on day 1 of the trial, prior to being turned out to graze.

Stocking rate was calculated based on yield of the field at harvest and previous research quantifying the amount of residue consumed per acre. The yield (bu/ac), estimated forage availability (8 lb/bu available due to trampling, weathering and leaving adequate ground cover), grazing efficiency factor (85% for irrigated), and number of acres were multiplied together to estimate the total available forage for each field. Total available forage was then divided by estimated DMI (10 lb/steer daily) of all steers allotted to graze each respective paddock in order to calculate days of available grazing. Using this calculation, the 60 acre irrigated field would allow 125 steers to graze for 70 days based on a yield of 250 bu of grain/acre. The field was then divided into eight paddocks to allow four replications of each treatment.

Samples of supplementation types were collected and dried in a forced air oven at 60ºC for 48 hours and were then dried in an ash oven for 4 hours at 600ºC to determine the mineral content.

Forage intake was not estimated during this trial. In order to compare the change in gain to the amount of supplement intake, supplement efficiency was estimated. This allows for the difference between supplement types to be accounted for. Supplement efficiency was calculated by dividing gain by supplement intake.

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Economic Analysis

Economic analysis was applied to performance values and days of grazing from year 1 and year 2.

Initial purchase price was calculated as a five-year average from the first week of November in 2009, 2010, 2011, 2012, and 2013 for 500-540 lb large-framed, number 1 steers. Feeder cattle weighted average sale data were collected from the archives at USDA Agricultural Marketing Service (AMS) at the Huss-Platte Valley location. The price of distillers grains was calculated at three different corn prices ($4/bu, $5.50/bu, and $7/bu) and priced at 120% the value of corn. The lick tub was priced at $80 per tub and was not adjusted with the price of corn. Selling price was calculated as a five-year average of the last week of January in 2010, 2011, 2012, 2013, and 2014 for large-framed, number 1 steers from the archives at USDA AMS. Ending weights varied by treatment and year.

Irrigated corn residue was charged at $15 per acre and approximately half an acre was allotted per steer for the grazing period. Yardage was set at $0.30/steer when feed was delivered daily and $0.15/steer on days when feed was not delivered. Dried DGS was supplemented daily while the lick tub was replaced every four days.

Net return was calculated as total revenue (selling price of the calf) minus total costs (initial price of the calf, total price of supplement, price of grazing residue, and transportation costs). Cost of gain was calculated as total costs divided by the gain of the calf. Total feed costs were calculated as the price of supplement plus the price of grazing residue.

Data were analyzed using PROC GLIMMIX with year as a random effect and treatment included in the model statement.

Table 1. Comparison of dried distillers grains and lick tub supplementation for calves grazing corn residue on a dry matter basis.

	Dried DGS	Lick Tub	S.E.	F-test
Initial BW, lb	529	529	5.8	0.62
Final BW, lb	608	578	9.2	<0.01
ADG, lb/day	1.36	0.83	0.06	<0.01
Supp. Intake, %BW	0.52	0.36	0.03	<0.01
Supp. Intake, lb/head/day	2.94	2.02	0.21	<0.01
Supp. Efficiency, %	46	43	0.15	<0.01

Table 2. Comparison of dried distillers grains and lick tub supplementation for calves grazing corn residue on a dry matter and organic matter basis.

	Dried DGS	Lick tub	S.E.	F-test
Initial BW, lb	529	529	5.82	0.6
Final BW, lb	608	578	9.2	<0.01
ADG, lb/day	1.36	0.83	0.06	<0.01
DM				
Supplemental Intake, %BW	0.52	0.36	0.03	<0.01
Supplemental Intake, lb/head/day	2.94	2.02	0.21	<0.01
Supplemental Efficiency, %	46	43	0.15	<0.01
OM				
Supplemental Intake, %BW	0.5	0.3	0.01	<0.01
Supplemental Intake, lb/head/day	2.82	1.68	0.08	<0.01
Supplemental Efficiency, %	48	50	0.03	0.64

Results

Average daily gain of steers supplemented with dried DGS was greater (1.36 lb) than those with access to lick tubs (0.83 lb; $P < 0.01$, Table 1). On a DM basis, steers receiving dried DGS consumed 2.94 lb DM per day compared to 2.02 lb DM for steers offered lick tubs ($P < 0.01$). As a percentage of BW on a DM basis, steers on the lick tub treatment consumed less supplement (0.36%) than those receiving DGS (0.52%; $P < 0.01$). Supplement efficiency on a DM basis for the DGS treatment was 46% compared to 43% for the cattle on the lick tub treatment ($P < 0.01$).

The OM content of the lick tubs was 76%. Analysis on an OM basis shows similar results for gain (Table 2). Calves consumed 2.82 lb/steer daily on the DGS treatment compared with 1.68 lb/steer daily for the lick tub ($P < 0.01$). As a percentage of BW, calves consumed 0.50% for the DGS and 0.30% for the lick tub ($P < 0.01$). Supplement efficiency was not different on an OM basis for the dried DGS (48%) and lick tub treatments (50%; $P = 0.64$). The lick tubs were designed to provide mineral supplementation. Differences seen when values are expressed on a DM or OM basis are expected due to the high mineral content of the tub. The high mineral content of the tub appears to dilute the energy available from OM.

Economic Analysis

In scenario 1, corn was priced at $4.00 per bushel and a difference exists between treatments for price of supplementation with the price of dried DGS at $28.40/steer compared to $55.89/steer for the lick tub ($P < 0.01$; Table 3). There are differences in net return when comparing dried DGS to the lick tubs at $103.54 and $44.63, respectively ($P < 0.01$). The cost of gain was greater for the

Table 3. Economics of feeding distillers grains at 120% the value of corn when compared to a commercial lick tub.

Item	$4.00 Corn				$5.50 Corn				$7.00 Corn			
	Dried Dgs	Lick Tub	S.E.	F-Test	Dried Dgs	Lick Tub	S.E.	F-Test	Dried Dgs	Lick Tub	S.E.	F-Test
$/Steer												
steer cost	792.74	793.68	3.57	0.4	792.74	793.68	3.57	0.4	792.74	793.68	3.57	0.4
supplement cost	28.40	55.89	5.14	<0.01	29.52	55.89	5.33	<0.01	33.54	55.89	5.12	<0.01
yardage cost	20.25	12.66	7.59	<0.01	20.25	12.66	7.59	<0.01	20.25	12.66	7.59	<0.01
grazing cost	7.11	7.22	0.18	0.7	7.11	7.22	0.18	0.7	7.11	7.22	0.18	0.7
total feed cost	25.95	63.10	7.12	<0.01	36.63	63.10	5.43	<0.01	40.66	63.10	5.22	<0.01
total steer cost	852.37	862.89	9.43	0.2	853.49	862.89	6.48	0.3	857.52	862.89	7.14	0.5
revenue	955.91	907.52	34.91	<0.01	955.91	907.52	34.91	<0.01	955.91	907.52	34.91	<0.01
net return	103.54	44.63	26.73	<0.01	102.42	44.63	29.26	<0.01	98.40	44.63	28.96	<0.01
$/lb												
cost of gain	0.75	1.47	0.14	<0.01	0.77	1.47	0.16	<0.01	0.82	1.47	0.16	<0.01

lick tub treatment at $1.47 compared with $0.75 for dried DGS ($P < 0.01$). Total feed costs were higher for calves on the lick tub treatment at $63.10 in comparison to those supplemented with dried DGS at $25.95 ($P < 0.01$).

In scenario 2, the price of corn was set at $5.50 per bushel (Table 3). A difference exists between treatments for price of supplementation with dried DGS costing $29.52 compared with the lick tub at $55.89 ($P < 0.01$). Differences were found for net return, with the dried DGS treatment at $102.42 and the lick tub at $44.63, respectively ($P < 0.01$). The cost of gain was higher for the lick tub treatment at $1.47 compared with dried DGS at $0.77 ($P < 0.01$). Total feed cost was lower for those supplemented with dried DGS at $36.63 compared with $63.10 for the lick tub treatment.

In the third scenario, corn was priced at $7.00 per bushel (Table 3). Differences were found in price when supplementing dried DGS ($33.54) compared to the lick tubs ($55.89; $P < 0.01$). Differences were found in net return with dried DGS treatment at $98.40 and the lick tub at $44.63, respectively ($P < 0.01$). The cost of gain was higher for the lick tub treatment at $1.47 compared with $0.82 for the dried DGS treatment ($P < 0.01$). Differences were present for total feed costs, with dried DGS at $40.66 and the lick tub at $63.10, respectively ($P < 0.01$).

In all scenarios, it appears to be more profitable to supplement with dried DGS when compared with the lick tubs. Calves receiving DGS had greater gain and lower supplementation costs, resulting in greater net return and lower cost of gain. Economic differences were smaller when the price of corn was higher assuming the price of the lick tub does not change.

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Efficacy of Bovatec 2.2 Mineral Blocks for Cattle Grazing Crested Wheatgrass Pastures

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Matt K. Luebbe[1]

Summary

A grazing study was conducted to determine if providing Bovatec® in a trace mineralized salt block would improve cattle performance over cattle provided a trace mineralized salt block without an ionophore while maintaining block consumption below 2 oz/head/day. Average daily block intake was 1.40 and 1.25 oz/day for the Bovatec and control cattle, respectively. Lasalocid consumption was 193 mg/head/day. Although cattle consuming the Bovatec block gained 5% more than the control cattle, this was not significant (1.75 vs 1.67 lb/day, respectively). Supplying an ionophore through a self-feeding block may not improve gain compared to supplying mineral alone in a self-feeding block.

Introduction

Beef cattle producers grazing cattle on improved or native pastures often are looking for inexpensive ways to increase gains and forage utilization efficiency. Ionophores have been shown to improve gains and efficiency in beef cattle. However, delivering them to grazing cattle can be challenging and expensive. If a grain or byproduct is chosen as a carrier, the supplement has to be routinely delivered to the cattle. Cattle producers with integrated operations are also farming during the growing season and may not have time to supplement cattle daily. In addition to the cost of the carrier, producers incur costs associated with time, labor, and equipment. Therefore, the objective of this study was to determine if a trace mineralized salt block supplying lasalocid could improve cattle performance while limiting consumption under 2 ounces/head/day.

Procedure

Ninety crossbred steers (728 lb ± 4 lb) were blocked by BW and randomly allotted in an incomplete block design and assigned to pastures, which were assigned to treatments, to determine ADG and supplement consumption of the Bovatec 2.2 block. Nine pastures were used in the study (10 head/pasture), five assigned randomly to the Bovatec 2.2 block (TRT) and four assigned to the control block (CON). A trace mineralized salt block was used for the control supplement (Table 1). The CON block did not contain protein or an ionophore. Cattle were limit-fed a common diet for five days prior to trial initiation and weighed two consecutive days prior to grazing the crested wheatgrass pastures starting May 24, 2012. Prior to trial initiation, cattle were vaccinated for respiratory viruses and clostridial perfinges, dewormed, and given a growth implant. Cattle were rotated through the pastures every two weeks to eliminate any pasture effect on treatment response. Cattle were removed from the pastures on Aug. 2, 2012, after only 69 days of grazing due to extreme drought. Cattle were then limit fed for five days, and weighed two consecutive days, Aug. 6 and 7.

The mineral blocks were weighed and placed in each pasture at the beginning of the experiment. The blocks were weighed for consumption approximately every three days. Blocks were replaced before cattle were without supplement. Data were analyzed using the MIXED procedure of SAS (SAS Institute, Inc., Cary, N.C.) with pasture as the experimental unit. The model included treatment.

Results

Initial BW and final BW were not different for the cattle consuming TRT or CON blocks ($P \geq 0.45$; Table 2). Steers consuming TRT gained 1.75 lb/day and CON steers gained 1.67 lb/day. Although ADG was 5% greater for TRT compared with CON, it was not statistically significant ($P > 0.34$). Previous research in these same pastures indicated that when cattle were fed ionophores mixed in a daily supplement, they gained more than cattle fed supplement without ionophores (*1996 Nebraska Beef Cattle Report,* pp. 69-70.) However, in another study, when ionophores were supplied in a mineral block ADG was not different from the control (*1991 Nebraska Beef Cattle Report,* pp. 29-30).

An increase in supplement disappearance for both treatments occurred during the fifth week of the grazing study. There was a rain event during this time, and some loss could have occurred due to rain. However, visual observations indicated that the blocks were largely unaffected by the

Table 1. Trace mineral content of Bovatec 2.2 and control mineral blocks.

	Bovatec 2.2 Block	Control Trace Mineral Block
Lasalocid sodium, g/lb	2.2	—
Salt (NaCl), %	87.5-92.0	95.5-98.5
Zn, ppm	3500	3500
Fe, ppm	3400	2000
Mn, ppm	2000	1800
Cu, ppm	330	280
Co, ppm	50	60
I, ppm	70	100

Table 2. Cattle performance and block intake for cattle consuming TRT or CON.[1]

	TRT	CON	SEM[2]	*P*-value
Initial BW, lb	727	729	3.95	0.45
Final BW, lb	854	850	8.82	0.60
ADG, lb/day	1.75	1.67	0.10	0.34
Block intake oz/head/day	1.40	1.25	0.13	0.42

[1]TRT = Bovatec 2.2 (2.2 g/lb of lasalocid), CON= trace mineral block without ionophore.
[2]SEM = Standard error of the mean.

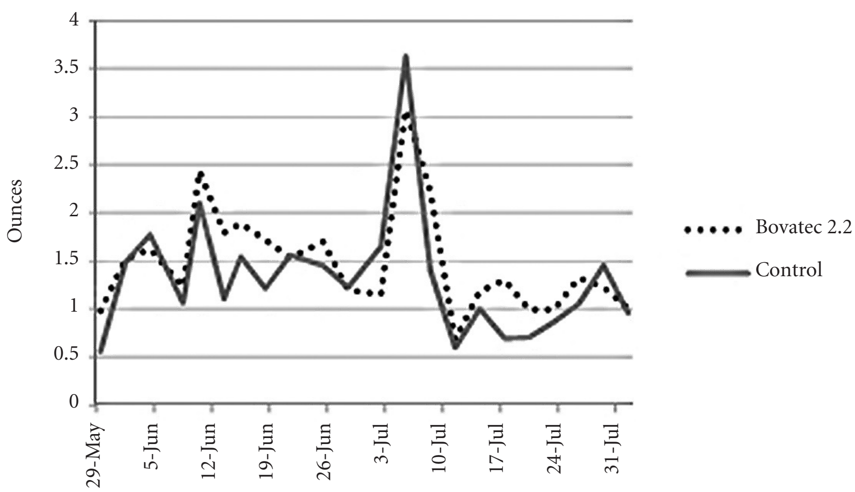

Figure 1. Block consumption per head per day, approximately every three days.

event. Just prior to the rain event, the temperature was over 100°F for three days in a row with one day reaching 106°F. It is more likely the spike is true consumption due to cattle standing around the water tanks, more so than a loss from rain. The fact that intake decreased to the lowest intake later that week for both treatments supports this (Figure 1).

Cattle consumed 1.40 and 1.25 oz./head/day of the TRT and CON blocks, respectively (Table 2; $P = 0.43$). The consumption of lasalocid in the TRT blocks was 193 mg/head/day. Consumption of both blocks was well under the 2 oz/head/day maximum intake targeted for the study. Previous authors (*1991 Nebraska Beef Cattle Report,* pp. 29-30) also indicated a lack of gain response when the ionophore was contained in a mineral block. These authors suggested the lack of treatment response was due to low consumption of the ionophore. When feeding the ionophore in a daily supplement (*1996 Nebraska Beef Cattle Report,* pp. 69-70) the intake of lasalocid was 200 mg/head/day and gains were greater than the control. Yet, in the present study the average daily intake of lasalocid was 193 mg/head/day. It is possible that each steer did not consume the mineral block every day. Intake was highly variable across days (Figure 1) with intake well above the targeted 2 oz on some days and well below that on others. Consuming more than 200 mg/head/day on some days did not result in a significant gain response overall. Possibly the lack of significant gain response above the control was due to inconsistent intake of the ionophore. Providing an ionophore through a self-feeding mineral block resulted in less than the targeted 2 ounces/head/day intake of supplement, and did not improve gain compared to the control mineral block, which did not include an ionophore.

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Effect of Distillers Grains Plus Solubles and Monensin Supplementation on Grazing Steers

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Summary

Yearling steers rotationally grazing smooth bromegrass were individually supplemented monensin at 0 or 200 mg with modified distillers grains plus solubles (MDGS) at .05, 0.4, 0.6, and 0.8% BW. Cannulated steers continuously grazing smooth bromegrass were assigned randomly to one of two treatments: 0.4% BW MDGS supplementation with 0 or 200 mg monensin. Monensin did not affect ADG of steers supplemented MDGS ≥ 0.4% BW. Steers supplemented with monensin had a decrease in estimated average forage intake from 16.16 lb to 14.75 lb/OM daily.

Introduction

Efficient beef production becomes more and more imperative as the national cattle herd remains at historical lows, the threat of forage shortages continues, and the global demand for protein continues to rise. The supplementation of distiller grains plus solubles (DGS), a byproduct of the dry milling industry, has significantly improved producers' ability to increase grazing efficiency by economically providing ruminally undegradable protein (RUP). The supplementation of DGS lowers forage DMI and increases ADG of cattle on grass (*2010 Nebraska Beef Cattle Report,* pp. 34-35). Supplementing MDGS to steers on grass increases profitability when cattle ownership is retained through the feeding period (*2014 Nebraska Beef Cattle Report,* pp. 46-47). Monensin, a feed additive, also has been shown to increase ADG when supplemented to grazing cattle. Therefore, the objective of this study was to determine how monensin and MDGS supplementation affected ADG and forage intake of steers grazing smooth bromegrass.

Procedure

Experimental Design and Animal Performance

Crossbred yearling steers (n = 60, BW = 736 ± 71 lb) were utilized in a 2 x 4 factorial design. The first factor was supplementation of 0 or 200 mg monensin. The second factor was increasing levels of MDGS (dry matter) at .05, 0.4, 0.6, and 0.8% of BW. Daily, each steer was individually supplemented MDGS with 0 or 200 mg of monensin in an individual feeding barn. Steers were allowed three hours to consume supplement, and that not consumed was weighed. The remainder of the day cattle grazed smooth bromegrass pasture. Cattle were managed in an intensive rotational grazing system from April 27, 2012, through July 20, 2012. The dry summer conditions forced the cattle to be relocated to an extra pasture from July 20 to Aug. 24. Total grazing days were 119.

Prior to the trial and following the last day of grazing, steers were limit-fed a common diet at 2% BW for five days to minimize gut fill variation. The steers were then weighed three consecutive days to determine initial and ending body weight. Animal ADG and actual MDGS intakes were calculated.

Performance and actual MDGS intake were analyzed using the SAS MIXED procedure (SAS Institute, Inc., Cary, N.C.). Steer was the experimental unit and MDGS intake was the covariate to determine linear and quadratic trends.

Experimental Design and Forage Intake

Ruminally cannulated steers (n = 6; BW = 868 lb) were assigned randomly in a switchback designed experiment to one of two treatments: 0.4% BW MDGS supplementation with 0 or 200 mg monensin. The steers continuously grazed a smooth bromegrass monoculture pasture from May 3, 2013, to Sept. 13, 2013. Daily, steers were individually supplemented 3 lb MDGS DM at 0700 hours. This was accomplished in the pasture using a custom pen structure with one alley and six individual pens. While the steers were consuming the MDGS supplement, a bolus with 10 g titanium dioxide (TiO_2) with 0 or 200 mg of monensin was inserted through the cannula. The bolus method was used to ensure that all monensin and TiO_2 were dosed.

The switchback designed experiment consisted of six, 21-day periods. Immediately following the end of each period, steers were administered the opposite treatment of what they were receiving in the previous period. On day one of each period, dosing of TiO_2 and monensin began.

Forage Intake Sampling and Analysis

Diet samples were taken at the end of each period by the same six cannulated steers that were on trial. Organic matter (OM), crude protein (CP), neutral detergent fiber (NDF), and *in vitro* organic matter digestibility (IVOMD) were determined. Neutral detergent fiber digestibility (NDFD) by *in situ* technique was also determined to observe monensin's effects on fiber digestibility.

Fecal output was estimated using TiO_2 as an external marker. Fecal samples were collected at 0700 hours for five consecutive days. Fecal TiO_2 concentration was determined and was then used to calculate the estimated fecal output per day.

Once total fecal output was estimated, feces from the MDGS were subtracted. Using the period appropriate forage IVOMD, forage organic matter intake (FOMI) was calculated by the following equation: fecal output / 1-IVOMD = FOMI. Forage organic

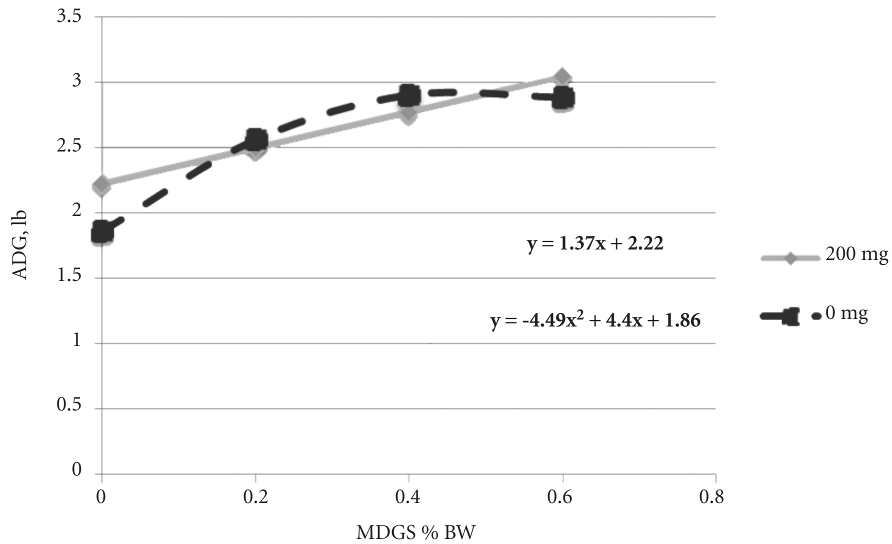

Figure 1. Interaction of monensin and MDGS supplementation on ADG of grazing steers.

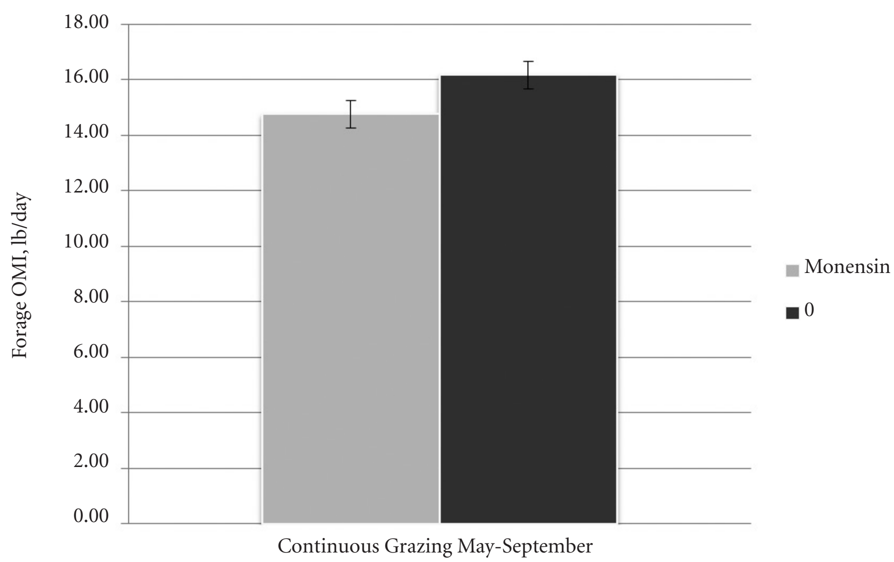

Figure 2. The effect of monensin (200 mg/day) on forage organic matter intake.

matter intake and diet sample components were analyzed using the MIXED procedure of SAS. Model effects included period, steer, and treatment. Probabilities of linear and quadratic trends were determined using orthogonal polynomial contrasts.

Results

Steers supplemented MDGS with 0 mg monensin had a quadratic increase ($P < 0.01$; Figure 1) in ADG as MDGS intake increased. The equation of the quadratic regression line was $y = -4.49 (\pm 1.50) x^2 + 4.4 (\pm 0.96) x + 1.86 (\pm 0.13)$ where y = ADG and x = level of MDGS. Steers supplemented MDGS with 200 mg monensin increased in ADG linearly ($P < 0.01$; Figure 1) as MDGS increased. The equation of the linear regression was $y = 1.37 (\pm 0.26) x + 2.22 (\pm 0.09)$ where y = ADG and x = level of MDGS. The intercept of the 0 mg monensin equation of 1.86 compared to the 200 mg monensin equation of 2.22 illustrates the interaction tendency ($P = 0.12$) between monensin and MDGS intake. When feeding MDGS at 0.05% BW, monensin increased ($P = 0.04$, Figure 1) ADG by 0.33 lb/day. The gain increase observed at 0.05% BW MDGS due to monensin reveals the advantage monensin provides through the protein sparing effect. However, performance was not affected by monensin as MDGS supplementation intake increased (Figure 1). Monensin did not effect ADG when supplemented with MDGS ≥ 0.4% BW ($P = 0.53$). Speculatively, there is no improvement in gain from monensin when fed with MDGS because the benefits of monensin are small relative to the response from RUP and energy of MDGS.

When steers were supplemented monensin with MDGS at 0.4% BW, estimated FOMI decreased 9% ($P = 0.10$, Figure 2). Cattle consumed 14.8 lb forage organic matter daily when supplemented monensin and 16.2 lb forage organic matter when monensin was not supplemented (Figure 2). Total consumption decreased from 2.12% BW to 1.99% BW when cattle were given 200 mg monensin. As has been shown in the literature previously, *in situ* fiber digestion was unaffected by monensin ($P = 0.73$).

Implications

The common belief is cattle on finishing diets and cattle on forage diets respond differently to monensin. The response to monensin in a finishing diet is a decrease in DMI without decreasing ADG, while cattle on forage diets respond with no change in DMI but increase in ADG. However, when monensin is supplemented along with DGS in a forage diet, the animal may respond similarly to an animal on a finishing diet. When cattle grazed smooth bromegrass, the addition of monensin to MDGS supplementation did not increase ADG. Instead, when monensin was supplemented with MDGS, forage intake decreased 9%. Supplementing monensin and MDGS may be an effective way to decrease forage intake and increase stocking rate and grazing efficiency.

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Comparison of Wet or Dry Distillers Grains Plus Solubles to Corn as an Energy Source in Forage-Based Diets

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Summary

Four experiments were conducted comparing wet or dry distillers grains plus solubles to each other or to corn as an energy source in forage-based diets. Diets included dry distillers grains plus solubles, wet distillers grains plus solubles or dry-rolled corn, with sorghum silage, grass hay and supplement. Data were pooled to generate ADG at differing inclusions allowing energy value of wet distillers grains plus solubles to be calculated relative to dry-rolled corn. The energy value of distillers grains plus solubles fed at 15% of diet DM was 137% and fed at 30% of the diet DM was 136% relative to dry-rolled corn. Wet and dry distillers grains plus solubles had equal energy values.

Introduction

Previous research showed the benefit of utilizing distillers byproducts in finishing diets in place of corn. However, the energy value of distillers byproducts in high-forage diets is not as well defined because they have been used primarily as protein sources. A study compared dry-rolled corn (DRC) and dried distillers grains plus solubles (DDGS) at two supplementation levels in a forage based diet and determined the energy value relative to DRC to be 118-130% that of corn (*2003 Nebraska Beef Cattle Report,* pp. 8-10). A meta-analysis based on prediction equations developed from 20 feedlot cattle finishing experiments suggests greater energy value for wet distillers grains plus solubles (WDGS; 130 to 143% between 20-40% inclusion diet DM) than DDGS (112% for any inclusion diet DM; *2010 Nebraska Beef Cattle Report,* p. 61). Few direct comparisons between wet and dry DGS in forage diets have been made.

The objective was to compare DRC, DDGS and WDGS as energy sources in forage based diets and determine the energy value of WDGS relative to DRC.

Procedure

Four growing experiments were used in this analysis (*2008 Nebraska Beef Cattle Report*, pp. 29-31; *2009 Nebraska Beef Cattle Report*, pp. 28-29; *2010 Nebraska Beef Cattle Report*, pp. 43-45; *2011 Nebraska Beef Cattle Report*, pp. 20-21). Data from two of the experiments were combined to determine the relative feeding values of WDGS and DDGS. In all experiments, protein was adequate in all diets so that gain and feed efficiency responses are due to energy and not due to protein.

Pooled Analysis

Data from the three experiments containing both DRC and WDGS were pooled in order to predict the energy value of WDGS relative to DRC. Using regression analysis, estimates were made for the amount of DRC in the diet to provide equal ADG to 15 and 30% WDGS. The regression analysis was used to estimate ADG at different concentrations. This analysis was needed in order to use the same net energy (NE) adjuster values for both the DRC and WDGS diets. Block et al., (*2001 Nebraska Beef Cattle Report,* pp. 117-119) reported that NE adjuster values changed with rate of ADG, declining as ADG increased. To facilitate the comparison of energy values of DRC and WDGS, it was necessary to do the evaluation at equal ADG.

Dry-rolled corn and WDGS replaced both grass hay and sorghum silage as the inclusion increased. The change in concentration of DRC or WDGS determined the calculated change in both hay and sorghum silage. This allowed the calculation of amounts of hay and silage in each of the three diets. Because DDGS was not included in two experiments, there were insufficient observations for DDGS and, therefore, no DDGS data were included in the pooled data.

Pooled data were analyzed using the GLIMIX procedure of SAS (SAS Institute, Inc., Cary, N.C.). Model effects included trial, type of energy source (DRC or WDGS), block within trial and inclusion within energy source (15 or 30% WDGS and 27.74 or 54.71% DRC). Inclusion of energy source was treated as a covariate. Regression analysis produced the following equations used to predict ADG at differing levels: DRC ($y = 0.02$ (± **0.02**) $x + 1.59$ (± 0.12)); WDGS ($y = 0.04$ (± **0.02**) $x + 1.61$ (± 0.12)).

Results

Pooled Analysis

The unadjusted average cattle performance values from the three trials are shown in Table 1. The predicted DRC inclusions at 15 and 30% WDGS were 27.74 and 54.71%, respectively (Figure 1), to achieve equal gains. Predictions for the DRC inclusions were done by regressing DGS or DRC inclusion against ADG. Using the observed ADG at 15% inclusion WDGS, we used regression to determine DRC inclusion at the same ADG. The inclusion of DRC diet equivalent to 15% WDGS was evaluated with the NRC model. Net energy adjuster of 103.2 was needed to predict the observed gain. Based on Loy et al., (*2003 Nebraska Beef Cattle Report*, pp. 8-10), the DRC was given an energy value of 83% TDN. The same NE adjuster

Table 1. Energy value of wet distillers grains (WDGS) compared to corn.[1]

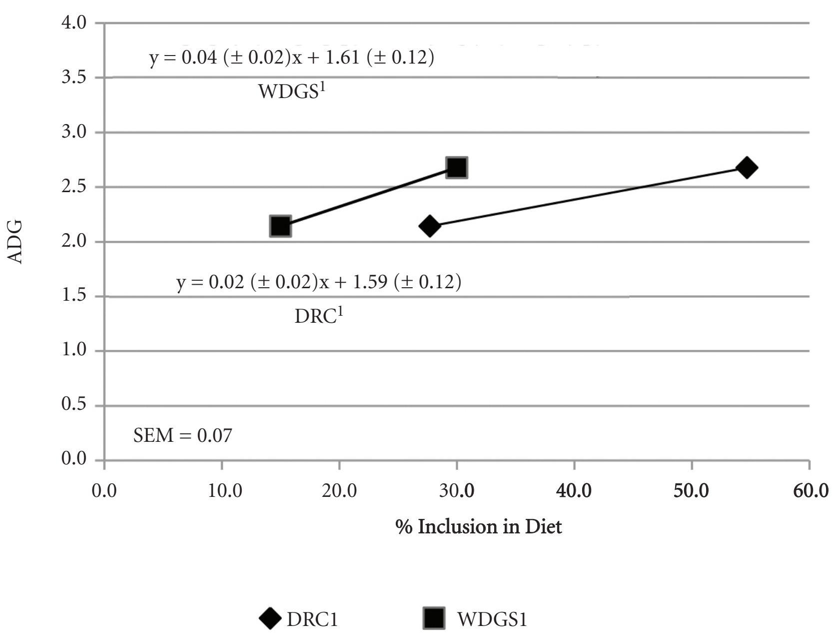
	Corn	WDGS
% of diet	35.9	23.3
DMI, lb/day	16.5	16.4
ADG, lb/day	2.37	2.48
Feed/gain	6.99	6.67

[1]Average of three trials (1 to 2 levels/trial).

Table 2. Value of dry versus wet distillers grains.

	DDGS[1]	WDGS[1]	SEM
DMI, lb/day			
Trial 1[2]	16.9	15.4	.61
Trial 4[3]	16.2	15.8	.44
ADG, lb/day			
Trial 1	2.48	2.37	.15
Trial 4	2.13	2.11	.07
Feed: Gain			
Trial 1	6.80	6.49	.27
Trial 4	7.58	7.41	.35

[1]DDGS = dry distillers grains plus solubles.
WDGS = wet distillers grains plus solubles.
[2]Average of 3 levels (24.7% diet dm).
[3]Average of 2 levels (22.5% diet dm).



[1]DRC — 22-57% inclusion dry-rolled corn; WDGS — 15-30% inclusion wet distillers grains plus solubles.

Figure 1. Regression analysis of pooled data for growing steers evaluating the energy value of WDGS relative to DRC.

was used with the 15% WDGS diet. The energy value of the WDGS was changed until the ADG for that diet (2.1 lb/day) was achieved. That energy value was 113.5% TDN which is 137% (113.5/83) the value of DRC.

The same process was used to estimate the TDN content of the DGS when fed at 30% of diet dry matter. In this case, the DRC diet contained 54.71% DRC and a NE adjuster of 96.8 was needed to predict the ADG of 2.7 lb/day. The energy value of the WDGS was 112.7% TDN which is 136% the value of DRC.

Wet Versus Dry DGS

Without a direct comparison in all four experiments, we cannot conclude that WDGS has more energy in forage diets than DDGS. However, data from Experiment 1 and Experiment 4 (Table 2) show there is no difference in energy value between WDGS and DDGS. There were no statistical differences in growth performance between DDGS and WDGS.

Implications

These experiments reiterate that distillers grains (dry or wet) have a high energy value relative to supplemented corn in forage-based diets. The moisture content of DGS does not affect the energy value relative to DRC in a forage-based diet, however inclusion of DGS responds quadratically after reaching 35% of the diet DM. The energy density of fat, undegradable protein, and corn fiber are the possible reasons contributing to greater energy value compared to corn as a supplement.

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Effects of Processing Treated Corn Stover and Distillers Grains on Performance of Growing Cattle

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Dirk B. Burken
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Summary

A study evaluated the effects of replacing a diet consisting of 60% corn stover, 18% solubles, and 18% distillers grains with a complete pelleted feed containing calcium oxide (CaO) treated corn stover and distillers grains on growing cattle performance. The pelleted feed was either pair-fed to the control treatment or fed ad libitum. There were no differences in ending BW, ADG, or F:G between the control and pair-fed treatment. Feeding the pellet ad libitum *resulted in greater DMI and ADG; however, the cattle had greater F:G. The pellet has 98% the feeding value of the control treatment.*

Introduction

Until recently there have been high corn prices, which have caused farmers to convert marginal cropland from forage production to crop production. This has resulted in an increase in forage prices and a decrease in the amount of forage available for cattle to graze. The increase in crop production has also caused an increase in corn residue available to be utilized as a feed source. Pellet Technology, USA (Gretna, Neb.) has utilized the abundant corn residue and developed a complete pelleted feed consisting of a CaO treated corn stover and distillers grains to replace traditional growing diets. A previous study (*2014 Nebraska Beef Cattle Report*, pp. 62-63) evaluated the impacts of replacing a growing diet with a complete pelleted feed containing CaO treated corn stover. They found that feeding a complete pelleted feed resulted in increased ending BW, ADG, and DMI; however, the pellet negatively impacted feed conversion compared to the un-pelleted treated corn stover. Therefore, the objective of this study was to evaluate the effects of replacing a traditional growing diet with a complete pelleted feed consisting of CaO treated corn stover, dry distillers grains (DDG), and supplement on growing cattle performance.

Procedure

A 92-day growing study was conducted utilizing 360 yearling crossbred steers (initial BW = 690 ± 47 lb). All steers were limit-fed a common diet consisting of 50% roughage and 50% byproduct at 2% of BW for five days prior to trial initiation to minimize gut fill. Following five days of limit feeding, steers were weighed two consecutive days. Initial BW was calculated by averaging the two-day weights. Cattle were implanted with Ralgro® during initial processing. Steers were separated into four weight blocks based on the first-day weights, stratified by BW within block, and assigned randomly to pens. There were a total of 20 steers per pen. Pens were assigned randomly to one of three treatments. There were six pens per treatment. The first weight block had one replication, the second weight block had two replications, the third weight block had two replications, and the fourth weight block had one replication. Pen was the experimental unit.

The three treatments (Table 1) were set up in a generalized randomized block design. One of the three treatments consisted of an un-pelleted control (CON) diet containing 60% corn stover, 18% solubles, 18% modified distillers grains plus solubles (MDGS), and 4% supplement. Supplement contained limestone, supplemental minerals, and vitamins A-D-E to meet NRC requirements. Rumensin was added in the supplement to supply 200 mg/head/day. The control was formulated with the same ingredients as the completed pelleted feed; however, the corn stover was not treated and MDGS was used instead of DDG. The remaining two treatments initially consisted of a 100% complete pelleted feed containing CaO treated corn stover, DDG, solubles, and supplement (provided by Pellet Technology, USA; Gretna, Neb.) either pair-fed (Pel-PF) with the control or fed *ad libitum (*Pel-AL). However, bloat was an issue in the Pel-AL treatment (11 incidences of bloat within the first 28 days); therefore, 15% corn silage (DM basis) was added to all dietary treatments 28 days into the study. Ending BW was collected similar to initial BW, steers were limit-fed a diet consisting of 50% roughage and 50% byproduct at 2% of BW for five days. Following the limit feeding period, steers were weighed for two consecutive days. Ending BW was then calculated by averaging the two day weights. Feeding value of the pellet was calculated by the following calculation: ((Pel-PF feed efficiency − CON feed efficiency) / CON feed efficiency) x 100 + 100.

Performance data (BW, DMI, ADG, F:G) were analyzed using the MIXED procedure of SAS (SAS Institute, Inc., Cary, N.C.) with pen as the experimental unit. One steer died due to bloat and was removed from the data set. The model included treatment and block. Incidence of bloat was analyzed using the GLIMMIX procedure of SAS.

Results

There were no significant ($P > 0.50$) differences in ending BW, DMI, or ADG between the Pel-PF treatment and the CON (Table 2). Steers being fed the Pel-AL treatment had greater DMI and ADG compared with the CON and Pel-PF treatments ($P < 0.01$). However, cattle consuming the Pel-AL treatment had lower feed efficiencies ($P = 0.05$) than the CON

Table 1. Diet (DM basis) fed to growing steers to evaluate the effects of replacing a traditional growing diet with a CaO treated stover and DDG pelleted complete feed.

Ingredient	CON	Pel-AL[1]	Pel-PF[2]
MDGS	14.5	—	—
Solubles	14.5	—	—
Untreated corn stover	52	—	—
Pellet[3]	—	85	85
Corn silage	15	15	15
Supplement[4]	—	—	—
Fine ground corn	2.408	—	—
Limestone	1.116	—	—
Salt	0.300	—	—
Tallow	0.100	—	—
Supplemental minerals[5]	0.050	—	—
Vitamin A-D-E[6]	0.015	—	—
Rumensin-90[7]	0.011	—	—

[1]Pellet fed *ad libitum.*
[2] Pellet pair-fed with the control diet.
[3]Pellet contained treated corn stover, DDG, solubles, and supplement. Supplement was formulated to contain 3.524% fine ground corn, 0.300% salt, 0.100% tallow, 0.050% beef trace mineral, 0.015% vitamin A-D-E, and 0.011% Rumensin-90.
[4]Supplement supplied at 4% of dietary DM.
[5]Premix contained 10% Mg, 6% Zn, 4.5% Fe, 2% Mn, 0.5% Cu, 0.3% I, and 0.05% Co.
[6]Premix contained 1,500 IU of vitamin A, 3,000 IU of vitamin D, and 3.7 IU of vitamin E•g-1.
[7]Formulated to supply 200 mg/head/day.

Table 2. Effects of feeding a treated corn stover and distillers pelleted complete feed on growing cattle performance.

	Control	Pel-PF	Pel-AL	SEM	F-Test
Initial BW, lb	696	695	695	0.6	0.73
Ending BW, lb	956[a]	951[a]	1024[b]	4.3	< 0.01
DMI, lb/day	19.91[a]	19.95[a]	26.80[b]	0.45	< 0.01
ADG, lb/day	2.83[a]	2.79[a]	3.58[b]	0.05	< 0.01
Feed:Gain[1]	6.99[a]	7.14[a]	7.46[b]	—	0.05

[a,b]Means with differing superscripts are different.
[1]Statistics calculated on Gain:Feed.

and Pel-PF treatment. The CON and Pel-PF treatments feed efficiencies were not different. When comparing the Pel-PF treatment to the CON, the pellet had 98% the feeding value of the CON diet.

There was a difference in the number of bloats observed between the three treatments, with 9.2% of the steers on the Pel-AL treatment experiencing a bloat incident. However, 0% of the steers on the CON or Pel-PF treatment experienced bloat. The bloat issue was attributed to the small particle size of the pellet since no bloating was observed after the addition of 15% corn silage to the diet on day 28.

In conclusion, feeding the pelleted feed resulted in similar performance to the control when it was pair-fed. The Pel-AL treatment had greater DMI and ADG, but it had greater F:G. Feeding the pellet as a complete feed could be an option for growing diets if the bloat issue is resolved. We hypothesize that bloating may be reduced with a modification to the particle size of the forage in the pellet.

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Digestibility of Calcium Oxide Treated Corn Residue with De-Oiled Distillers Grains

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Summary

A digestion study was conducted to evaluate diets containing calcium oxide treated corn residue in combination with de-oiled distillers grains in forage based growing diets. Chemical treatment did not affect digestibility of DM, OM, or NDF. However, concentration of distillers grains did improve DM and OM digestibility. The use of chemically treated residue in combination with distillers grains in growing diets may not impact diet digestibility.

Introduction

Previously completed trials (*2014 Nebraska Beef Cattle Report*, pp. 62-63, 67-68) indicated that calcium oxide (CaO) treated corn residue in growing diets increased DMI and ADG when compared to untreated corn residue. However, only a minimal F:G response was observed with CaO treatment. Both of these studies implied that the expense of chemical treatment might increase the cost per unit of energy of the corn residue when compared to untreated corn residue. Therefore, the objective of this trial was to compare digestibility of treated and untreated crop residues in diets containing de-oiled distillers grains diets.

Procedure

This experiment utilized 12 ruminally fistulated steers, of which six were yearlings and six were calves. Treatments were set up in a 2 x 2 factorial with factors including chemical treatment (treated or untreated) and de-oiled MDGS inclusion (20 or 40% of diet DM). Steers were assigned randomly and acclimated to each diet for four, 21-day periods, with a 14-day adaptation period and a seven-day collection period. Chemical treatment consisted of water, CaO (Standard Quicklime, Mississippi Lime Co., Kansas City, Mo.), and ground residue. Calcium oxide was added at 5% of residue DM, and the mixture was hydrated to a final targeted DM of 50%. The mixture was weighed and mixed in Roto-Mix feed trucks, dispensed into concrete bunkers, and subsequently covered with plastic. The treatment process was completed at least seven days prior to being fed, and was repeated throughout the duration of the study. Untreated residue was only ground and fed without chemical or water addition. All residue used for this study was ground through a 1-inch screen. De-oiled MDGS were fed at either 20 or 40% of the diet DM (Table 1), with residue inclusion at 76 or 56%. All diets contained a 4% dry meal supplement formulated to provide similar dietary Ca (1.19% DM basis) in untreated diets as treated residue diets did not contain limestone. Steers were fed 200 mg/steer of monensin daily. Diets were mixed twice each week and stored in a cooler (32°F) until used to ensure fresh feed throughout the experiment.

All steers were ruminally dosed with 7.5 g of TiO_2 twice daily at 0800 and 1600 hours. Fecal grab samples were collected at 0800, 1200, and 1600 hours from day 15 to day 21. All fecal samples collected in a day were composited on a wet basis into a daily composite, then freeze-dried. From daily composites, a steer within period fecal composite sample was made and analyzed for NDF, OM, and Ti percentage. Ruminal pH was recorded every minute using pH probes (Dascor, Inc., Escondido, Calif.) from day 15 to 21. Analysis of feeds offered and feed refusals were completed for DM, OM, and NDF

Table 1. Ingredient composition of diets fed to yearlings and calves.

	20 MDGS[1]		40 MDGS[1]	
	Untreated	Treated	Untreated	Treated
MDGS	20	20	40	40
Treated residue[2,3]	—	76	—	56
Untreated residue[3]	76	—	56	—
Supplement[1]	4	4	4	4
Fine ground corn	1.6794	1.8734	3.4124	1.8734
Limestone	1.1940	—	1.1110	—
Salt	0.3000	0.3000	0.3000	0.3000
Tallow	0.1000	0.1000	0.1000	0.1000
Urea	1.6500	1.6500	—	—
Rumensin®[4]	0.0116	0.0116	0.0116	0.0116
Trace mineral	0.0500	0.0500	0.0500	0.0500
Vitamin A-D-E	0.0150	0.0150	0.01500	0.0150
Nutrient composition, %				
CP	67.77	61.40	59.59	54.92
NDF	10.49	10.53	16.29	16.31
Ca	0.38	2.49	0.30	1.85
P	0.27	0.28	0.45	0.46

[1]MDGS = modified distillers grains plus solubles.
[2]Chemical treatment consisted of hydration with water to 50% DM and addition of 5% CaO (DM).
[3]All residue originated from the same source.
[4]Formulated to provide 200 mg/steer daily monensin.

Table 2. Effects of CaO treatment and MDGS on digestibility and lab analysis of forage NDF.

	20		40			*P*-values		
	Trt	Unt	Trt	Unt	SE	Dist[1]	Trt[2]	DxT[3]
DM								
Intake, lb	12.7	12.7	17.9	17.3	1.4	<0.01	0.79	0.82
Digestibility, %	45.6	49.8	58.7	60.6	0.1	0.02	0.46	0.79
OM								
Intake, lb	11.1	11.5	15.9	15.8	1.3	<0.01	0.92	0.81
Digestibility, %	52.7	55.6	61.6	64.0	0.1	0.05	0.49	0.96
NDF								
Intake, lb	7.3	8.7	9.2	10.2	0.9	0.05	0.11	0.77
Digestibility, %	48.1	54.9	54.3	56.6	0.1	0.48	0.37	0.67

[1]Fixed effect of 20 vs. 40% MDGS.
[2]Fixed effect of treated vs. untreated corn residue.
[3]Interaction of distillers inclusion x CaO treatment.

Table 3. Ruminal pH of steers fed 20 or 40% MDGS with CaO treated or untreated corn residue.

	20 MDGS[1]		40 MDGS[1]			*P*-values		
Item	Trt[2]	Unt	Trt[2]	Unt	SEM	Dist[3]	Trt[4]	TxD[5]
Maximum pH	6.94^{b}	7.47^{a}	7.04^{ab}	6.97^{ab}	0.30	0.56	0.10	<0.01
Average pH	6.65^{b}	7.13^{a}	6.80^{ab}	6.70^{b}	0.20	0.56	0.01	<0.01
Minimum pH	6.45^{b}	6.80^{a}	6.54^{ab}	6.38^{b}	0.13	0.26	0.33	<0.01

[1]MDGS = modified distillers grains plus solubles
[2]Chemical treatment consisted of hydration with water to 50% DM and addition of 5% CaO (DM).
[3]Fixed effect of MDGS level.
[4]Fixed effect of chemical treatment.
[5]Interaction of chemical treatment x MDGS level.

percentage. Dry matter was determined using a forced air oven set at 60°C for 48 hours. Digestibility data were analyzed using the MIXED procedure of SAS (SAS Institute, Inc., Cary, N.C.) with steer and period as fixed effects. Ruminal pH was analyzed as a repeated measure using the GLIMMIX procedure with day as the repeated measure. Main effects of chemical treatment, MDGS inclusion, and age of steer were tested as well as the interactions. Factors were deemed significant at $P < 0.10$.

Results

There were no chemical treatment x distillers level interactions ($P > 0.15$) observed for intakes or digestibilites. Chemical treatment did not impact ($P > 0.37$) DM, OM, or NDF digestibilities (Table 2), which was unexpected when compared to previous data (*2011 Nebraska Beef Cattle Report,* pp. 35-36). Additionally, a tendency for decreased ($P = 0.11$) NDF intake was observed for treated diets (8.26 vs. 9.49 lb/day). This suggests that treatment with CaO partly solubilized NDF and, therefore, decreased NDF intake. Lab analysis of forage indicated that CaO solubilized NDF by approximately 10 percentage units relative to the untreated residue (NDF content of 76.0 and 66.6 for untreated and treated residues, respectively). Presumably treatment with CaO partially solubilized NDF, thereby decreasing NDF intake.

Overall, greater DM and OM digestibilities were noted with 40 MDGS inclusion ($P \leq 0.05$) compared with 20 MDGS. Increased distillers inclusion also improved DM, OM, and NDF intakes ($P \leq 0.05$). Interactions were noted for maximum, average, and minimum ruminal pH ($P < 0.01$; Table 3) as untreated residue had greater maximum and average pH within 20 MDGS ($P \leq 0.10$) and treated residue had greater pH values within 40 MDGS. Minimum pH data tended to change in the same manner. Results suggest that increased de-oiled MDGS inclusion will increase dietary DM and OM digestibility as well as DM, OM, and NDF intake levels. However, residue treatment with CaO did not affect dietary digestibility. Treated residue inclusion in growing diets may not improve diet digestibility over untreated residues.

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Digestibility of De-Oiled Modified Distillers Grains Plus Solubles in Forage-Based Diets

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Summary

Over half of Nebraska's ethanol plants are removing oil from distillers grains via centrifugation of the thin stillage constituent. Removing oil by this method does not impact intake or total tract digestibility in beef cattle growing diets. However, increasing the concentration of de-oiled distillers grains in the diet significantly improved intake and digestibility. Thus, concentration of distillers grain in the diet has a greater impact on total tract digestibility than the fat content in forage-based diets.

Introduction

Forage-based diets are frequently fed to growing cattle in Nebraska. Adding distillers grains plus solubles to the diet is an excellent source of protein and energy for growing cattle. Historically, distillers grains have contained approximately 12-13% fat. Corrigan et al., (*2007 Nebraska Beef Cattle Report,* pp. 17-18) found that feeding high levels of fat, a concern when distillers grains are added at high concentrations in the diet, hinders rumen fiber digestion. Optimal fat concentration to maximize ADG and feed efficiency in high quality forage-based diet was between 3.6-4.5% for this study.

Over half of Nebraska's ethanol plants remove oil from the thin stillage stream (condensed distillers solubles) via centrifugation and add it back to distillers grains to produce de-oiled distillers grains plus solubles. The impact of de-oiled distillers grains plus solubles on forage digestion in growing cattle is poorly understood. To address this concern, Jolly-Breithaupt et al., (*2013 Nebraska Beef Cattle Report,* pp. 25-26) fed de-oiled (6.3% fat) and normal (20.1% fat) condensed distillers solubles (CDS) at 20 or 40% concentrations replacing a 80:20 blend of brome hay and sorghum silage (DM basis) to growing cattle. Diets containing de-oiled CDS fed at 20 or 40% were 2.39% and 5.15% fat, respectively. Diets containing normal CDS at 20 or 40% concentrations were 3.23% and 8.83% fat, respectively. Both diets containing 40% CDS were above the fat threshold value that Corrigan et al., (*2007 Nebraska Beef Cattle Report,* pp. 17-18) deemed optimal for growing cattle performance. As a result, there tended to be an interaction between CDS concentration and CDS type for F:G. Cattle fed normal CDS were 13.4% more efficient than cattle consuming de-oiled CDS diets at 20% but not at 40%. At 40% concentrations of CDS in the diet, fat appeared to be a hindrance to fiber digestion in the rumen. Thus, the objective of this study was to determine if feeding de-oiled modified distillers grains plus solubles (MDGS) impacts nutrient (i.e., fiber) digestion in a forage-based diet similar to feeding de-oiled CDS.

Procedure

An 84-day digestion study utilized 12 (six yearling and six calf-fed) ruminally cannulated steers in a Latin square experimental design. Steers were assigned to one of six treatment diets, four of which pertain to this trial. Treatments were organized in a 2 × 2 factorial arrangement (Table 1). Concentration of MDGS (20 vs. 40%) and type of MDGS (de-oiled vs. normal fat content) were the factors examined. Both de-oiled and normal fat MDGS were purchased prior to the start of the study from *Green Plains Renewable Energy* (Central City, Neb.) and stored at the Agricultural Research and Development Center (ARDC) near Mead, Neb., until needed in silo bags. The remainder of all diets consisted of 1" grind corn residue and 4% of a formulated supplement. The 20% distillers grains diets contained urea to meet the ruminally degradable protein (RDP) requirements. In addition, metabolizable protein requirements of the animals were met with distillers grains and predicted bacterial protein. Steers were housed in individual slatted floor pens and fed once daily at *ad libitium* intake.

This study was comprised of four, 21-day periods. Cattle were acclimated to treatment diets through days 1-15 and dosed with titanium dioxide (TiO_2) on days 8-20. Fecal and diet samples as well as orts were collected on days 15-21. Titanium dioxide was used as a marker for digestibility measurements, and was administered via rumen bolus twice daily (at 0800 and 1200 hours) at 7.5 g per dosage. Fecal grab samples were collected from the yearling steers at 0800, 1200, and 1600 hours each day of the collection period. Total fecal collection via fecal collection bags was conducted on the steer calves in addition to TiO_2 as a marker. Fecal samples were composited on a wet-basis by day, freeze-dried, and then composited dry by period for each steer. The TiO_2 method of digestibility quantification

Table 1. Dietary treatments for ruminally fistulated steers.

Item	20[2]		40[2]	
	DO[3]	NO[3]	DO[3]	NO[3]
De-oiled MDGS[1]	20.0	—	40.0	—
Normal MDGS[1]	—	20.0	—	40.0
Corn residue	75.0	75.0	55.0	55.0
Supplement	5.0	5.0	5.0	5.0
Nutrient Composition				
Fat, %	2.19	3.15	3.43	5.35
NDF, %	68.1	68.3	59.4	59.8
CP, %	12.1	11.6	17.9	16.7

[1]MDGS = modified distillers grains plus solubles.
[2]20 and 40 = % concentration of MDGS in the diet.
[3]DO = de-oiled MDGS, NO = normal MDG.

Table 2. Nutrient composition of feed ingredients.

Ingredient	DO[1] MDGS[2]	NO[3] MDGS[2]	Corn Residue
Fat, %	7.2	12.0	1.0
CP, %	35.5	32.6	6.7
OM, %	95.2	94.5	94.8
Sulfur, %	0.63	0.57	0.10
NDF, %	37.5	37.5	80.8

[1]DO = de-oiled.
[2]MDGS = modified distillers grains plus solubles.
[3]NO = normal.

Table 3. Effects of dietary treatments on intake, fecal output, and total tract digestibility of DM, organic matter, and NDF.

Distillers Level	20[1]		40[1]			*P*-values		
Distillers Type	DO[2]	NO[2]	DO[2]	NO[2]	SEM	NO vs. DO[3]	20 vs. 40[4]	DO x Level[5]
DM								
Intake, lb	12.9	14.5	16.8	18.3	1.2	0.15	<0.01	0.90
Fecal output, lb	6.5	6.8	6.7	6.7	0.6	0.80	0.92	0.73
Digestibility, %	50.0	53.2	60.3	61.2	2.55	0.45	0.01	0.68
OM								
Intake, lb	11.7	13.2	15.3	16.6	1.1	0.15	0.01	0.91
Fecal output, lb	5.2	5.4	5.5	5.5	0.5	0.86	0.69	0.72
Digestibility, %	55.6	58.4	63.9	64.7	2.33	0.46	0.02	0.70
NDF								
Intake, lb	8.83	9.96	9.97	11.30	1.09	0.08	0.10	0.93
Fecal output, lb	3.88	4.26	4.22	4.50	0.58	0.72	0.61	0.98
Digestibility, %	55.02	58.10	57.78	58.67	3.18	0.52	0.59	0.72

[1]20 and 40 = % concentration of MDGS in the diet.
[2]DO = de-oiled, NO = normal.
[3]*P*-value for comparison of normal vs. de-oiled modified distillers grains plus solubles (MDGS).
[4]*P*-value for comparison of 20 vs. 40% MDGS.
[5]*P*-value for interaction of MDGS type with MDGS concentration.

Table 4. Main effects of dietary treatments on average, minimum, and maximum ruminal pH value of steers.

	Concentration			Type			
	20[1]	40[1]	*P*-value	De-oiled[2]	Normal[2]	*P*-value	SEM
Average pH	6.83	6.78	0.85	6.91	6.70	0.51	0.24
Minimum pH	6.57	6.35	0.22	6.44	6.47	0.88	0.14
Maximum pH	7.14	7.29	0.78	7.32	7.12	0.71	0.73

[1]20 and 40 = % concentration of MDGS in the diet.
[2]De-oiled and normal modified distillers grains plus solubles.

was compared to values obtained from total fecal collection digestibility measurements in order to compare methods. Both methods produced comparable values, and thus TiO_2 digestibility values are presented in this report. Fecal and ingredient samples were analyzed for DM, OM, NDF, and fat contents. Orts were dried for accurate calculation of DMI. Wireless pH probes (Dascor, Inc., Escondido, Calif.) collected pH measurements continuously the last 7 days of the period.

Ruminal pH data were analyzed as a crossover design using the GLIMMIX procedure of SAS (SAS Institute, Inc., Cary, N.C.) and the compound symmetry covariance structure was used with day as a repeated measure. The MIXED procedure was used to analyze intake, fecal output, and digestibility.

Results

MDGS Type

Nutrient composition of feed ingredients is presented in Table 2. No interactions between concentration of MDGS and MDGS type were detected for this study, thus main effects are presented (Table 3). Steers consuming normal fat MDGS diets tended to consume more DM, OM, and NDF per day than did steers consuming de-oiled MDGS diets ($P = 0.15$, $P = 0.15$, and $P = 0.08$, respectively). When comparing digestibility (Table 3) and rumen pH values (Table 4) between calves consuming de-oiled versus those consuming normal fat MDGS, no significance between MDGS types existed ($P > 0.45$ and $P = 0.51$, respectively). Therefore, these data suggest that oil removal from distillers grains plus solubles does not improve digestibility in forage-based diets similar to those fed in this study, which is contrary to previous work with solubles alone.

Concentration of MDGS

As previous research supports, increasing the concentration of distillers grains from 20 to 40% in the diet significantly increased DM intake, OM intake, and tended to increase NDF intake ($P < 0.01$, $P = 0.01$, and $P = 0.10$, respectively, Table 3). DM digestibility and OM digestibility were greater in steers consuming 40% MDGS ($P = 0.01$ and $P = 0.02$, respectively) compared to 20% MDGS, which is logical given that MDGS replaced corn residue. Average ruminal pH was not different between cattle consuming either 20 or 40% MDGS ($P = 0.85$, Table 4).

This study suggests that growing cattle tend to consume more when fed normal MDGS diets compared to when fed de-oiled MDGS diets. This is contrary to what would be expected as typically cattle consuming forage-based diets of a lower fat content have greater DMI than those being fed a forage-based diet of a higher fat content. Fat hinders fiber digestion in the rumen, thus typically decreasing intake. The digestibility of normal MDGS diets was not statistically different from the digestibility exhibited by cattle consuming de-oiled MDGS diets. The fat concentration of 5.35% in the normal MDGS diet did not depress fiber digestion in this study. When MDGS concentration was increased in the diet, cattle performed similarly to what has been seen previously because as concentration of MDGS increasingly replaced corn residue in the diet, digestibility of the diet improved.

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Evaluation of the Impact of an Alternative Corn Residue Harvest Method on Performance and Methane Emissions from Growing Cattle

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Summary

A growing study was conducted to evaluate the impact of alternative corn residue harvesting methods and inclusion of Rumensin® on performance and methane to carbon dioxide ratio (CH_4:CO_2) of steers. Use of the alternative harvesting method resulted in greater ADG and improved F:G ratio than traditionally harvested cornstalks. Rumensin increased ADG and improved DMI; however, it did not have an impact on F:G ratio. Altering the composition of baled corn residue did affect CH_4:CO_2, while inclusion of Rumensin, whether included in the diet on a constant or rotational basis, had no impact.

Introduction

There is a significant potential for the utilization of corn residues as feed. The increase in corn production in recent years has resulted in an increased availability of residue for cattle producers. With increased residue, there have been advancements in harvesting methods allowing producers to alter the composition of plant parts available in the bale. New harvest methods now allow the producer to decrease the amount of the stalk in the bale compared to conventional baling. Studies have shown the digestibility of corn plant parts differ, with the husk being the most digestible and the stalk being the least digestible (*2012 Nebraska Beef Cattle Report,* pp. 11-12). The benefit of being able to alter the composition of plant parts in the bale is to improve the quality of harvested corn residue. Our objective was to determine if one of the new harvest methods results in an improvement in the performance of growing steers and to determine the effect that these differing feeds have on methane to carbon dioxide ratio.

Procedure

An 89-day growing study was conducted utilizing 60 crossbred steers (initial BW= 683 ± 61 lb) that were individually fed with the Calan gate system. Steers were limit-fed a diet of 50% alfalfa and 50% Sweet Bran® at 2% of BW for five days prior to the start of the trial to reduce variation in gut fill. Three consecutive weights were collected, utilizing the average as initial BW. Steers were blocked into 10 blocks according to initial BW, assigned randomly to one of six treatments within block; with 10 steers per treatment. Steers were implanted with Ralgro® on day 1 of the trial. Six forage-based treatment diets consisted of one of four forages: sorghum silage, corn stalks, husklage, and ensiled husklage (Table 1). Two additional ensiled husklage diets were included, one with no Rumensin for the duration of the study, and one which included Rumensin (200mg/head/day) on a rotational basis in three-week intervals. All the diets included SoyPass® and Sweet Bran. SoyPass was included in the diets to meet or exceed metabolizable protein requirements. The Sweet Bran was included to improve the palatability of the dry residues and to supply rumen degradable protein.

The husklage was produced with the use of a John Deere 569 round baler that was modified with the Hillco single pass round bale system (SPRB). This modification to the baler allows the baler to connect to the combine, where it collects the residue as it passes through the combine. This allows the producer to harvest both corn and residue in one pass through the field. The husklage had an average DM of 60%. The residue collected was 27% leaf, 17% husk, 42% cob, and 14% upper stem. Ensiled husklage was produced by adding water to the husklage to a DM content of 35% and bagging in an agricultural bag for a minimum of 30 days prior to initiation of the experiment.

Feed refusals were collected and weighed weekly, then dried in 140°F

Table 1. Composition of growing diets (DM basis).

Ingredient, % of DM	Sorghum Silage	Cornstalks	Husklage	Ensiled Husklage +	Ensiled Husklage -
Sorghum silage	62.0	—	—	—	—
Cornstalks	—	62.0	—	—	—
Husklage	—	—	62.0	—	—
Ensiled husklage	—	—	—	62.0	62.0
Sweet Bran	30.0	30.0	30.0	30.0	30.0
SoyPass	3.0	3.0	3.0	3.0	3.0
Fine-ground corn	3.31	3.44	3.44	3.44	3.45
Limestone	1.18	1.05	1.05	1.05	1.05
Tallow	0.13	0.13	0.13	0.13	0.13
Salt	0.3	0.3	0.3	0.3	0.3
Trace mineral	0.05	0.05	0.05	0.05	0.05
Vitamin A-D-E	0.02	0.02	0.02	0.02	0.02
Rumensin[1]	0.01	0.01	0.01	0.01	—

[1]Diets containing Rumensin were formulated to provide 200 mg/steer daily.

Table 2. Effects of forage with or without the inclusion of Rumensin on growing cattle performance and $CH_4:CO_2$.

Item	Sorghum Silage	Cornstalks	Husklage	Ensiled Husklage	Ensiled Husklage	Ensiled Husklage	SE	*P*-value
Rumensin[1]	+	+	+	+	-	+/-		
Initial BW, lb	682	680	682	691	682	680	5	0.53
Ending BW, lb	973[a]	837[d]	878[c]	916[b]	879[c]	874[c]	11	< 0.01
ADG, lb	3.27[a]	1.76[d]	2.20[c]	2.52[b]	2.21[c]	2.17[c]	0.11	< 0.01
DMI, lb	21.06[a]	13.87[d]	14.01[cd]	16.97[b]	14.98[cd]	15.54[bc]	0.67	< 0.01
F:G, lb/lb[2]	6.41[a]	7.84[c]	6.37[a]	6.73[ab]	6.73[ab]	7.15[b]	—	< 0.01
$CH_4:CO_2$[3]	0.092[a]	0.078[c]	0.084[b]	0.088[ab]	0.090[a]	0.088[ab]	0.002	< 0.01

[1]Rumensin + = diet contained Rumensin at 200mg/hea/day; Rumensin - = diet did not contain Rumensin; Rumensin +/- = Rumensin was rotated in and out of the diet every three weeks.
[2]$CH_4:CO_2$ = methane to carbon dioxide ratio; average of six time points during feeding period.
[3] Analyzed as gain to feed.
[a-d]Means within a row without a common superscript are different, ($P < 0.05$).

forced air oven for 48 hours to calculate an accurate DMI for individual steers. At the conclusion of the study, steers were again limit-fed for five days, the same diet as prior to the start of the trial. Weights were collected for three consecutive days and averaged to determine an accurate ending BW.

An *in vitro* procedure was performed twice in order to obtain an *in vitro* organic matter digestibility (IVOMD) on the husklage and ensiled husklage. Samples were dried in a 140°F oven for 48 hours, then ground through a 1-mm screen. An assay for *in vitro* OM (IVOMD) digestibility was then performed on the samples. Test tubes contained 0.5 grams of sample and 50mL of an inoculum. The inoculum for the procedure was a combination of rumen fluid from two donor steers that were fed a 70:30 forage: concentrate diet (DM-basis). Rumen fluid was filtered through four layers of cheesecloth to eliminate excess feed particles. The filtered rumen fluid was then put into separatory funnels and placed into a water bath in order to further separate small feed particles. McDougall's buffer was mixed into the rumen fluid at a 1:1 ratio, along with the inclusion of 1 gram of urea/L of buffer.

Once the test tubes were filled, they were placed in a water bath at 102°F for 48 hours to allow fermentation. To end the fermentation, each test tube received 6 mL of 20% HCL and 2mL of 5% pepsin solution. Tubes were then returned to the water bath for an additional 24 hours. At the end of the 24 hours the tubes were removed from the water bath and the residue was filtered through a non-ash filter. Filters were ashed at 600°C for a minimum of six hours.

To facilitate the collection of respired air by the cattle to be analyzed for methane and carbon dioxide, the individual Calan gate bunks were partially enclosed and outfitted with a small air pump that was used to gradually fill a gas collection bag. Gas collection was conducted at the time of feeding and gas sample bags were filled with air at a constant rate over approximately 10 minutes, once per week. Gas samples were collected only while steers were in their bunks. The collected gas consisted of a mixture of respired gasses and ambient air and was analyzed within 24 hours for concentration of methane and carbon dioxide in ppm using a gas chromatograph. Methane data are expressed as a ratio of methane to carbon dioxide ($CH_4:CO_2$) where CO_2 can be used as an internal marker since its production is relatively constant across cattle of similar size, type, and production level. Gas samples were collected from each steer approximately once per week throughout the feeding period.

Data were analyzed in the Mixed Procedures of SAS (SAS Institute, Inc., Cary, N.C.), with individual steer serving as the experimental unit. The model included treatment and weight block. The $CH_4:CO_2$ was analyzed as a repeated measure with six weekly measurements per steer.

Results

Effect of Forage Type

To evaluate the effects of forage type, comparisons were made only within diets which contained Rumensin for the entire feeding period. Steers fed sorghum silage had the greatest DMI and ADG compared to forage types ($P < 0.01$; Table 2). These steers consequently had the heaviest ending BW ($P < 0.01$), as they were consuming higher quality forage and at greater amounts. Steers consuming husklage had greater ADG, DMI, and an improved F:G ratio ($P < 0.01$) compared to the steers that were fed cornstalks. The cornstalks resulted in the lowest DMI, ADG, and greatest F:G ratio ($P < 0.01$). The John Deere SPRB appears to have been successful in improving the quality of residue that was baled, probably because the stalk was not collected in the bale. However, steers consuming husklage and ensiled husklage refused 5-8% of their daily feed offering vs. 2% for the cornstalks. Visual observation indicated they refused primarily the cob. Ensiling the husklage increased DMI and ADG ($P < 0.05$) but did not change F:G ratio ($P = 0.13$) compared to husklage that was not ensiled. The fact that feed conversion was not improved was supported by the *in vitro* digestibility analysis. The IVOMD of the husklage averaged 41.57% with the ensiled husklage averaging 36.74%. The $CH_4:CO_2$ results closely resemble the performance data. Steers fed

(Continued on next page)

stalks had the lowest DMI of the least digestible diet; therefore, had the lowest CH_4:CO_2 ($P < 0.01$; Table 2). Conversely, steers fed sorghum silage had greater CH_4:CO_2, reflective of their higher intakes of a more digestible diet, since methane production is largely driven by amount of fiber fermentation. Methane to carbon dioxide ratios was similar for cattle fed husklage or ensiled husklage ($P = 0.25$) and intermediate between the higher quality sorghum silage and the lower quality, unaltered cornstalks.

Effect of Rumensin Inclusion

Three ensiled husklage diets were utilized to evaluate the effect of inclusion of Rumensin for the entire 89 days (Rum +) compared with no Rumensin at any point during the study (Rum -), or an on/off rotation of Rumensin inclusion at three-week intervals (Rum +/-). Cattle receiving Rum+ had the greatest ADG ($P < 0.01$), while there was no difference between Rum - and Rum +/- ($P = 0.77$). Cattle fed Rum - had the lowest DMI, while those on Rum + had the greatest, and DMI of those steers on Rum +/- was intermediate ($P < 0.01$). No effect of Rumensin inclusion on F:G was observed ($P \geq 0.12$). Similarly, Rumensin had no impact on CH_4:CO_2 ($P > 0.36$). This lack of methane production response is not surprising considering the basal diets were identical and the effects of Rumensin on methane have been shown to be short lived in previous work. Our hypothesis that by rotating Rumensin inclusion, we could overcome any possible adaptation by the rumen microbes was not supported in this study.

These data suggest that by changing the harvest method of the corn residue, the quality could be improved compared to conventional cornstalks. This study also reinforces the conclusions from previous work (*2014 Nebraska Beef Cattle Report,* pp. 29-31), which demonstrated that in growing diets, forage quality is a main determinant of methane production.

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Effect of Diet on the Rumen Microbial Community Composition of Growing Cattle and the Role It Plays in Methane Emissions

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Summary

To understand the relationship between microbial community and methane, the microbial community of the rumen was examined by esophageally tubing cattle on a common diet and on 10 treatment diets. Microbial community analysis via 16S taq sequencing displayed structuring of microbial communities (Bacteria and Archaea) by diet. This study demonstrates that diet influences microbial community composition within the rumen, and the potential capacity to develop dietary intervention strategies for methane mitigation and animal performance.

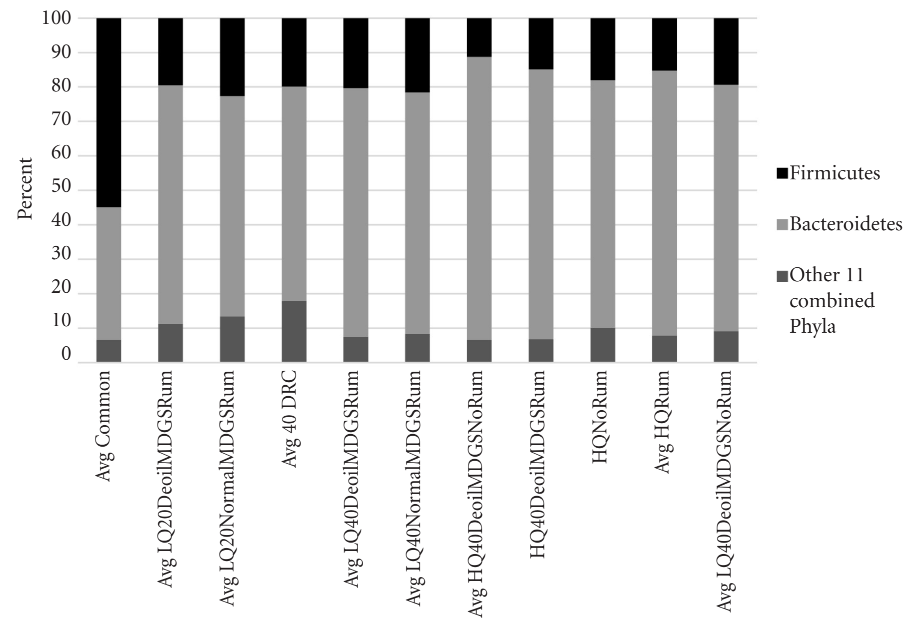
Introduction

Methane is a potent greenhouse gas that traps heat 21 times more than carbon dioxide. The livestock industry is a contributor to the anthropogenic methane produced. Rumen microbes are responsible for the breakdown of plant material and conversion of those products into usable energy for the animal through fermentation. As a result of this process, byproducts are formed such as volatile fatty acids and methane; methane carbon is not a usable energy by cattle and leads to reduced animal performance and efficiency. At the heart of methane production are microbes, and these microbes are known to change based on substrate availability in the diet. As diet can change microbial communities, dietary intervention can be used to reduce greenhouse gas emissions from cattle by controlling microbial populations. Dietary intervention strategies for mitigation of methane are being explored (*2014 Nebraska Beef Cattle Report,* pp. 29-31). Understanding the relationship between diet, methane, and microbial community will help identify microbial species associated with methane to develop new intervention strategies. The purpose of this study was to identify the role diet plays on the rumen microbiota, and how this will affect methane emissions in growing cattle.

Procedure

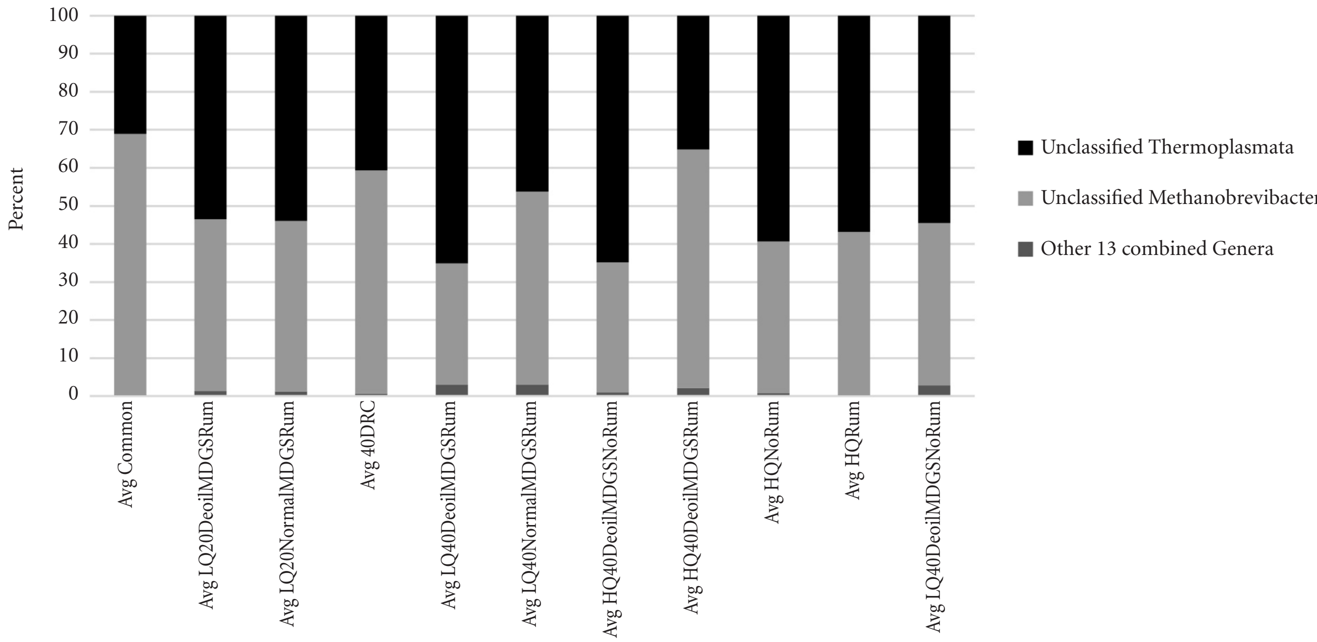
An 84-day growing study was performed starting in January 2013 to identify interactions between diet, methane, and microbial community. Rumen samples were collected by esophageal tubing 120 steers on a common diet containing alfalfa and Sweet Bran® at a 50/50 ratio. The cattle were then switched to one of 10 treatment diets containing high and low quality forage, with and without Rumensin®, with 20 or 40% MDGS supplementation (*2014 Nebraska Beef*

(Continued on next page)



Diet Abbreviation	Diet
Avg Common	50/50 Alfalfa Hay and Sweet Bran
Avg LQ20DeoilMDGSRum	Low Quality Forage 20% Deoiled MDGS plus Rumensin
Avg LQ20NormalMDGSRum	Low Quality Forage 20% Normal MDGS plus Rumensin
Avg 40 DRC	Low Quality Forage 40% DRC
Avg LQ40DeoilMDGSRum	Low Quality Forage 40% Deoiled MDGS plus Rumensin
Avg LQ40NormalMDGSRum	Low Quality Forage 40% Normal MDGS plus Rumensin
Avg HQ40DeoilMDGSNoRum	High Quality Forage 40% Deoiled MDGS no Rumensin
Avg HQ40DeoilMDGSRum	High Quality Forage 40% Deoiled MDGS plus Rumensin
Avg HQNoRum	High Quality Forage 20% MDGS no Rumensin
Avg HQRum	High Quality Forage 20% MDGS plus Rumensin
Avg LQ40DeoilMDGSNoRum	Low Quality Forage 40% Deoiled MDGS no Rumensin

Figure 1. Bacterial taxonomic distribution at the phylum level on common diet and 10 treatment diets.



Diet Abbreviation	Diet
Avg Common	50/50 Alfalfa Hay and Sweet Bran
Avg LQ20DeoilMDGSRum	Low Quality Forage 20% Deoiled MDGS plus Rumensin
Avg LQ20NormalMDGSRum	Low Quality Forage 20% Normal MDGS plus Rumensin
Avg 40 DRC	Low Quality Forage 40% DRC
Avg LQ40DeoilMDGSRum	Low Quality Forage 40% Deoiled MDGS plus Rumensin
Avg LQ40NormalMDGSRum	Low Quality Forage 40% Normal MDGS plus Rumensin
Avg HQ40DeoilMDGSNoRum	High Quality Forage 40% Deoiled MDGS no Rumensin
Avg HQ40DeoilMDGSRum	High Quality Forage 40% Deoiled MDGS plus Rumensin
Avg HQNoRum	High Quality Forage 20% MDGS no Rumensin
Avg HQRum	High Quality Forage 20% MDGS plus Rumensin
Avg LQ40DeoilMDGSNoRum	Low Quality Forage 40% Deoiled MDGS no Rumensin

Figure 2. Archaeal taxonomic distribution at the genus level on common diet and 10 treatment diets.

Cattle Report, pp. 29-31). The animals were tubed every 21days to evaluate volatile fatty acids and microbial community structure. The samples collected were placed in liquid nitrogen to freeze the contents instantly and inhibit continued microbial growth. DNA was extracted from all rumen samples and purified utilizing the MoBio PowerMag® Soil DNA Isolation Kit (Carlsbad, Calif.). The V3 region of the 16S rRNA genes from the rumen bacterial and V6 region of the 16S rRNA genes from archaea communities were amplified using the polymerase chain reaction (PCR) technique. The resulting amplicons were sequenced using the Ion Torrent Personal Genome Machine® (PGM™). The resulting sequence reads were analyzed using published bioinformatics pipelines UPARSE (*drive5.com/uparse/*, Edgar, 2013) and QIIME (*qiime.org/*). Statistical analysis was performed using the phantom package within MATLAB®.

Results

Taxonomic distribution at the phylum level shows that Bacteroidetes and Firmicutes dominate the bacterial populations in the rumen (Figure 1). The genus level of distribution for archaea is presented in Figure 2 and shows that the archaea population in the rumen is predominated by methanogens. Unclassified Thermoplasmata and Methanobrevibacter are the major Archaeal genera present in the rumen. The bacterial community composition in Figure 3 shows that microbial community composition changes significantly ($P < 0.05$) based on forage quality (high and low). The archaeal microbial communities are displayed in Figure 4, where changes in methane producing archaea are seen in low and high quality forages when MDGS is supplemented at 20%. Archaeal community differs from the common diet but were not different between high and low quality forage at 40% supplementation.

The common diet was utilized as a baseline for comparison to the treatment diets. Therefore, when animals

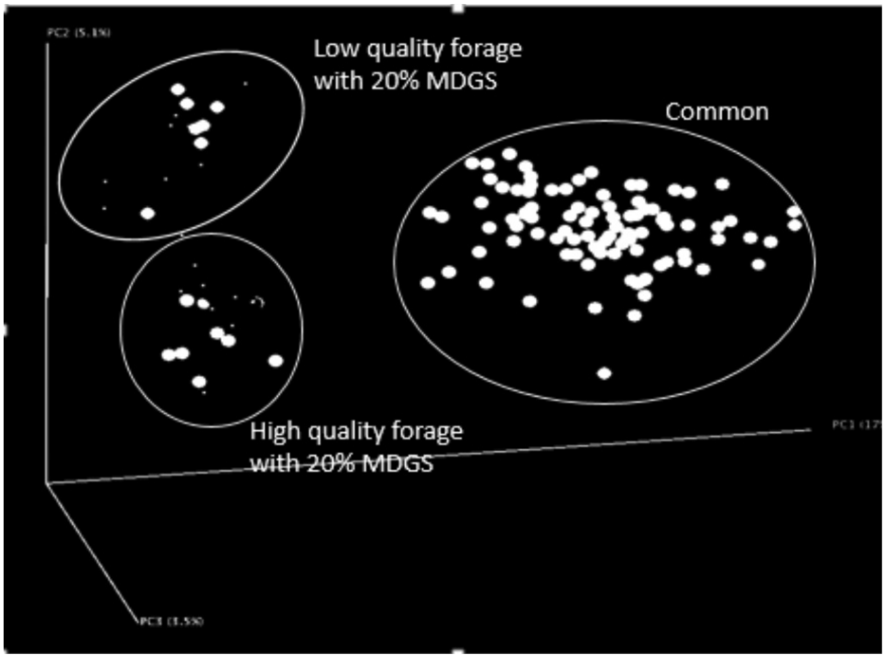


Figure 3. Bacterial community composition — high and low quality forage with 20% MDGS supplementation.

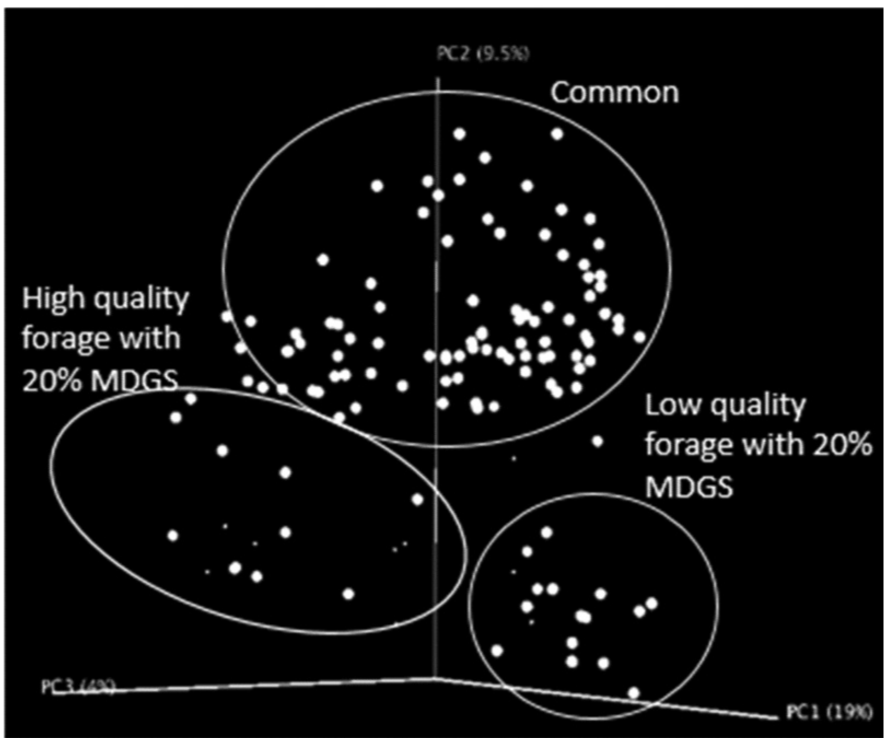


Figure 4. Archaeal community composition — high and low quality forage with 20% MDGS supplementation.

are shifted from the common diet to treatment diets, microbial communities change showing that diet influences rumen microbial community composition.

Methane is produced by a group of microbes known as methanogens which are found in the domain Archaea. Little is known about this group of organisms. However, to develop management based mitigation strategies, continued research in this area is crucial. Identifying the functions and the roles methanogens play towards digestion and hydrogen recycling within the rumen, may lead to methods that decrease methane emissions and improve cattle performance.

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Stocking Rate Effects on Forage Nutrient Composition in Early Summer Pastures

Jared V. Judy
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L. Aaron Stalker
Karla H. Jenkins
Terry J. Klopfenstein[1]

Summary

Nebraska Sandhills upland range pastures were used to measure the effects of stocking rate on forage nutrient content in early summer pastures. Stocked pastures had lower CP, in vitro *organic matter digestibility, forage availability, and higher NDF compared with ungrazed pastures. Clipped samples of current year growth had greater CP and* in vitro *organic matter digestibility than diet samples. Observed results indicate early season grazing decreases diet nutrient content and forage availability compared with ungrazed pastures, suggesting that cattle were consuming both current and previous year growth.*

Introduction

Upland range in the Nebraska Sandhills is an excellent resource for grazing cattle. Native upland range is dominated by warm-season grass species. Forage quality increases during the spring, reaching a peak during June, then steadily declines in quality throughout the remainder of the growing season (*1997 Nebraska Beef Cattle Report,* pp. 3-5). Research has shown changes in forage nutrient composition throughout the year but effects of stocking rate on Sandhills upland range were not addressed well. Therefore, the objectives of this research were to determine the effects of stocking rate on diet nutrient quality in early summer pasture, determine if new growth or previous year growth is being consumed, and determine forage production in the Nebraska Sandhills.

Procedure

Twelve, five-acre upland range paddocks at the Gudmundsen Sandhills Laboratory near Whitman, Neb., were used. Paddocks were stocked at 0 (control), 0.22 (light), and 0.33 (heavy) animal unit months per acre resulting in four replications per treatment. A stocking rate of 0.60 AUM/ac is commonly allotted for the entire year, so early in the growing season, before the majority of the growth has occurred, a stocking rate of 0.33 AUM/ac was considered heavy. Each stocked paddock was continuously grazed and all paddocks were sampled weekly during the three week trial in 2013 with the introduction of cattle on May 18 and the removal of cattle on June 8. Ten, 0.25 m^2 quadrats per paddock were clipped at ground level on each sampling date and separated into previous year growth and current year growth. Three esophageally fistulated cows were used to sample each pasture on each date to determine forage quality. Prior to each diet sample collection, cows were withheld from feed, but not water, for 12 hours, then transported to pastures where diets were to be collected. Cows were fitted with solid bottom bags after removal of the esophageal plug and introduced to the pasture, then allowed to graze for about 20 minutes.

Samples were separated into a liquid and fibrous portion for lab analysis. Immediately after separation, diet samples were frozen and stored at -20°C, then lyophilized. Clipped samples were dried in a forced air oven at 60°C for 48 hours. Both diet and clipped samples were ground to pass a 1-mm screen in a Wiley mill. Samples were analyzed for nitrogen, NDF content using the Van Soest et al., (1991) method, and *in vitro* dry matter disappearance using the Tilley and Terry method with the modification of adding 1 g of urea to the buffer then adjusted to *in vivo* values (IVOMD). Results were analyzed using repeated measures in PROC GLIMMIX procedure of SAS (SAS Institute, Inc., Cary, N.C.) with paddock being the experimental unit.

Table 1. Nutrient content of diet samples collected from esophageally fistulated cows comparing collection dates by stocking rate.

	Date					*P*-value		
Item	5/18/2013	5/25/2013	6/1/2013	6/8/2013	SEM[1]	Linear	Quadratic	Cubic
IVOMD								
Control[2]	70.3[c]	76.1[b]	79.8[a]	78.8[a]	1.27	0.02	< 0.01	0.38
Light[3]	73.2[a]	65.1[b]	67.4[c]	66.2[bc]	1.27	0.02	< 0.01	< 0.01
Heavy[4]	71.2[a]	63.2[b]	62.5[b]	63.2[b]	1.27	0.02	< 0.01	0.27
CP								
Control[2]	16.2[b]	20.5[a]	20.5[a]	18.9[a]	1.19	< 0.01	< 0.01	0.50
Light[3]	17.1[a]	10.5[b]	11.1[b]	11.6[b]	1.19	< 0.01	< 0.01	0.01
Heavy[4]	15.7[a]	8.9[c]	8.8[c]	10.8[b]	1.19	< 0.01	< 0.01	0.01
NDF								
Control[2]	54.4[a]	57.9[a]	45.0[b]	42.7[b]	3.44	< 0.01	0.35	0.06
Light[3]	61.2[b]	78.1[a]	74.5[a]	73.2[a]	3.44	< 0.01	< 0.01	0.01
Heavy[4]	68.8[b]	78.3[a]	69.9[b]	76.7[a]	3.44	0.08	0.48	< 0.01

[1]Standard error of the least squares mean.
[2]Non-stocked paddock (0 AUM/ac).
[3]Light stocking rate paddock (0.22 AUM/ac).
[4]Heavy stocking rate paddock (0.33 AUM/ac).
[a-c]Means within rows lacking common superscript differ ($P < 0.05$).

Table 2. Nutrient content of clipped sample current year growth comparing collection dates by treatment.

Item	Date				SEM[1]	P-value		
	5/18/2013	5/25/2013	6/1/2013	6/8/2013		Linear	Quadratic	Cubic
IVOMD								
Control[2]	71.5[b]	77.3[a]	73.2[b]	76.6[ab]	2.74	0.03	0.30	0.03
Light[3]	69.3[b]	74.5[a]	75.3[a]	76.6[a]	2.74	0.03	0.30	0.03
Heavy[4]	72.2	72.8	73.2	74.8	2.74	0.03	0.30	0.03
CP								
Control[2]	19.2[a]	17.6[a]	16.7[a]	14.0[b]	1.49	< 0.01	0.90	0.86
Light[3]	19.5[ac]	18.8[a]	16.4[b]	16.4[bc]	1.49	< 0.01	0.90	0.86
Heavy[4]	19.7[a]	17.7[ab]	17.0[b]	15.6[b]	1.49	< 0.01	0.90	0.86
NDF								
Control[2]	76.1	71.7	73.4	66.4	4.50	0.43	0.20	0.74
Light[3]	81.1	86.1	84.2	80.3	4.50	0.43	0.20	0.74
Heavy[4]	78.5	81.6	80.7	81.3	4.50	0.43	0.20	0.74

[1]Standard error of the least squares mean.
[2]Non-stocked paddock (0 AUM/ac).
[3]Light stocking rate paddock (0.22 AUM/ac).
[4]Heavy stocking rate paddock (0.33 AUM/ac).
[a-c]Means within rows lacking common superscript differ ($P < 0.05$).

Table 3. Nutrient content of diet samples from esophageally fistulated cows comparing stocking rate on each date.

Item	Control[1]	Light[2]	Heavy[3]	SEM[4]	P-value
IVOMD					
5/18/2013	70.3	73.2	71.2	1.88	0.12
5/25/2013	76.1[a]	65.1[b]	63.2[b]	1.88	< 0.01
6/1/2013	79.8[a]	67.4[b]	62.5[c]	1.88	< 0.01
6/8/2013	78.8[a]	66.2[b]	63.2[b]	1.88	< 0.01
CP					
5/18/2013	16.2	17.1	15.7	2.08	0.50
5/25/2013	20.5[a]	10.5[b]	8.9[b]	2.08	< 0.01
6/1/2013	20.5[a]	11.1[b]	8.8[b]	2.08	< 0.01
6/8/2013	18.9[a]	11.6[b]	10.8[b]	2.08	< 0.01
NDF					
5/18/2013	54.4[a]	61.2[ab]	68.8[b]	4.24	< 0.01
5/25/2013	57.9[b]	78.1[a]	78.3[a]	4.24	< 0.01
6/1/2013	45.0[b]	74.5[a]	69.9[a]	4.24	< 0.01
6/8/2013	42.7[b]	73.2[a]	76.7[a]	4.24	< 0.01

[1]Non-stocked paddock (0 AUM/ac).
[2]Light stocking rate paddock (0.22 AUM/ac).
[3]Heavy stocking rate paddock (0.33 AUM/ac).
[4]Standard error of the least squares mean.
[a-c]Means within rows lacking common superscript differ ($P < 0.05$).

Results

Diet samples had significant treatment x date interactions ($P < 0.01$; Table 1) for CP, NDF, and IVOMD. A quadratic effect was observed ($P < 0.01$) for diet IVOMD for control and heavy treatments with a cubic effect ($P < 0.01$) for the light stocking rate. Diet CP increased quadratically ($P < 0.01$) for the control treatment and showed a cubic effect ($P < 0.01$) for light and heavy treatments. Dietary NDF decreased linearly ($P < 0.01$) for control treatment and showed a cubic effect ($P < 0.01$) for light and heavy treatments. However, there were no treatment x date interactions ($P > 0.05$) in clipped samples. Clipped samples CP content decreased linearly ($P < 0.05$; Table 2) across all dates for each treatment and a cubic effect was shown for IVOMD ($P < 0.05$) of current year growth across all dates for all treatments. Diet samples collected in control stocking rate paddocks had greater IVOMD ($P < 0.05$) compared with those collected in light and heavy stocking rate paddocks on collection dates 2, 3, and 4 (Table 3). Diet samples collected in light stocking rate paddocks had greater IVOMD ($P < 0.05$) than heavy stocking rate on June 1. Diet samples collected in control stocking rate paddocks had greater CP ($P < 0.05$) than light and heavy stocking rates on dates 2, 3, and 4. Light and heavy stocking rates showed no difference in CP ($P > 0.05$) for each sampling date. Diet samples collected from control stocking rate paddocks had lower NDF ($P < 0.05$) than light and heavy stocking rates on dates 2, 3, and 4. These data suggest that stocking rate has a significant effect on the quality of the diet, helping to explain the treatment x date interaction in diet quality that was observed. When cattle were introduced into the paddock, they were able to select a diet greater in quality. As the grazing season progressed, cattle in the stocked paddocks consumed a diet lower in quality than the control paddocks, indicating that previous year growth was being consumed. Control stocking rate paddocks did reach a peak in diet quality in early June and then decreased in diet quality, likely due to plant maturation, which is in agreement with previous work (*1997 Nebraska Beef Cattle Report,* pp. 3-5).

For the clipped samples, no differences occurred for previous year growth for CP, NDF, and IVOMD among treatments ($P > 0.05$) with overall means of 5.2%, 82.0%, and 50.8%, respectively. Current year growth did not differ among treatments for CP, NDF, and IVOMD ($P > 0.05$) with overall means of 17.4%, 71.7, and 68.7%, respectively. However, CP ($P < 0.01$) and IVOMD ($P < 0.02$) content of current year growth increased linearly as stocking rate increased. Current growth was greater in CP and IVOMD ($P < 0.01$; Table 4) than diet sample and previous year growth on all dates.

(Continued on next page)

Neutral detergent fiber was greater ($P < 0.01$) in clipped samples versus diet samples. These results occur because cattle are selective and there are differences between collection methods. Current year growth increased linearly for all treatments ($P < 0.01$; Table 5). Control paddocks had greater current year forage availability versus stocked pastures ($P < 0.01$; Table 6) for all but the first sampling date. Stocking rate affects forage quality and, therefore, diet quality in early summer as well as forage availability.

The NRC model was used in a hypothetical example to compare performance of cows consuming either the control pasture or heavily stocked pasture. A 1,200 lb March calving cow producing 25 lb of milk at peak lactation, consuming an estimated 2.4% of her body weight was used in the analysis. Diet quality from control pastures exceeded both energy and protein requirements of the animal. However, heavily grazed pastures had much lower diet quality, which resulted in both a negative energy and protein balance by the end of the second week in the pasture. By the final sampling date which occurred after three weeks of grazing, the quality of the diet increased for the heavy stocked pasture which resulted in the animals maintaining body condition. Cattle grazing upland range early in the growing season initially consume diets high in quality but as pastures are grazed, diet quality decreases. Hence, producers trying to graze upland range early in the growing season need to understand the effects of grazing on diet quality and manage accordingly by rotating through pastures more frequently or delaying the start of grazing.

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Table 4. Nutrient content of esophageal diet sample versus live and dead clipped samples.

Item	Diet[1]	Live[2]	Dead[3]	SEM[4]	*P*-value
IVOMD					
5/18/2013	70.4[a]	71.0[a]	50.3[b]	1.07	< 0.01
5/25/2013	66.5[b]	74.8[a]	53.2[c]	1.99	< 0.01
6/1/2013	69.1[b]	73.9[a]	49.7[c]	2.17	< 0.01
6/8/2013	68.4[b]	76.0[a]	49.6[c]	2.38	< 0.01
CP					
5/18/2013	16.1[b]	21.0[a]	6.9[c]	1.12	< 0.01
5/25/2013	13.5[b]	18.4[a]	5.4[c]	1.54	< 0.01
6/1/2013	13.6[b]	16.8[a]	5.5[c]	1.48	< 0.01
6/8/2013	13.8[b]	15.7[a]	5.2[c]	1.64	< 0.01
NDF					
5/18/2013	59.4[b]	78.6[a]	82.9[a]	3.18	< 0.01
5/25/2013	77.4	79.8	78.7	3.06	0.62
6/1/2013	63.2[b]	79.4[a]	83.3[a]	4.81	< 0.01
6/8/2013	64.6[c]	76.0[b]	83.0[a]	6.02	< 0.01

[1]Mean diet collection for all treatments using esophageally fistulated cows.
[2]Mean clipped sample for all treatments current year forage growth.
[3]Mean clipped sample for all treatments for previous year forage growth.
[4]Standard error of the least squares mean.
[a-c]Means within rows lacking common superscript differ ($P < 0.05$).

Table 5. Nebraska Sandhills upland range forage availability comparing collection date by treatment.

	Date					*P*-value		
Item	5/18/2013	5/25/2013	6/1/2013	6/8/2013	SEM[1]	Linear	Quadratic	Cubic
Current year forage availability, lb/ac								
Control[2]	46.4[d]	84.5[c]	149.3[b]	202.1[a]	14.18	< 0.01	0.94	0.05
Light[3]	28.6[b]	24.4[b]	49.7[a]	52.3[a]	14.18	< 0.01	0.94	0.05
Heavy[4]	39.3	42.6	58.3	42.4	14.18	< 0.01	0.94	0.05
Previous year forage availability, lb/ac								
Control[2]	1087.1[a]	599.8[b]	533.5[b]	440.9[b]	191.80	< 0.01	0.03	0.01
Light[3]	809.5[a]	236.9[b]	547.1[a]	181.5[b]	191.80	< 0.01	0.03	0.01
Heavy[4]	907.8[a]	556.7[b]	440.9[bc]	303.6[c]	191.80	< 0.01	0.03	0.01

[1]Standard error of the least squares mean.
[2]Non-stocked paddock (0 AUM/ac).
[3]Light stocking rate paddock (0.22 AUM/ac).
[4]Heavy stocking rate paddock (0.33 AUM/ac).
[a-c]Means within rows lacking common superscript differ ($P < 0.05$) .

Table 6. Nebraska Sandhills upland range forage availability comparing treatment by date.

Date	Control[2]	Light[3]	Heavy[4]	SEM[1]	*P*-value
Current year forage availability, lb/ac					
5/18/2013	46.4	28.6	39.3	19.23	0.24
5/25/2013	84.5[a]	24.4[b]	42.6[b]	19.23	< 0.01
6/1/2013	149.3[a]	49.7[b]	58.3[b]	19.23	< 0.01
6/8/2013	202.1[a]	52.3[b]	42.4[b]	19.23	< 0.01
Previous year forage availability, lb/ac					
5/18/2013	1087.1	809.5	907.8	224.21	0.23
5/25/2013	599.8[a]	236.9[b]	556.7[a]	224.21	< 0.01
6/1/2013	533.5	547.1	440.9	224.21	0.23
6/8/2013	440.9	181.5	303.6	224.21	0.23

[1] Standard error of the least squares mean
[2] Non-stocked paddock (0 AUM/ac)
[3] Light stocking rate paddock (0.22 AUM/ac)
[4] Heavy stocking rate paddock (0.33 AUM/ac)
[a-c]Means within rows lacking common superscript differ ($P < 0.05$)

Effects of Grazing on Nebraska Sandhills Meadow Forage Nutrient Content

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L. Aaron Stalker
Karla H. Jenkins
Terry J. Klopfenstein[1]

Summary

Nebraska Sandhills subirrigated meadow pastures were used to measure the effects of grazing on forage nutrient content in summer pastures. Non-grazed pastures had greater diet CP content than grazed pastures early in the grazing season. By late July, grazed vs. non-grazed pastures did not differ in diet CP content. Non-grazed pastures had greater in vitro organic matter disappearance compared with grazed pastures from late July through September; however, early summer pastures were not affected. Observed results indicate the greatest differences in nutrient content between grazed and non-grazed meadow pastures occur early and late in the grazing season when the majority of cool-season grass species growth occurs.

Introduction

Nebraska Sandhills subirrigated meadows are an excellent resource for grazing cattle. Most are dominated by cool-season grass species which have greatest growth during early spring. However, as temperatures increase by mid-summer, forage quality decreases due to increased maturation of the plant (*1997 Nebraska Beef Cattle Report,* pp. 3-5). Previous research has shown changes in forage nutrient composition throughout the year, but how grazing affects the nutrient composition of Sandhills subirrigated meadows has not been documented. Therefore, the objective of this research was to determine the difference in forage quality between grazed pastures vs. non-grazed pastures in Nebraska Sandhills subirrigated meadows.

Procedure

A total of twenty-six subirrigated meadow pastures (262 ac ± 114 ac) in the Nebraska Sandhills were used. The meadow was divided into multiple pastures to allow rotational grazing. Of the 26 sampled pastures, two adjacent pastures were sampled on one of 13 dates throughout the 2013 grazing season: June 17, June 26, July 2, July 11, July 15, July 18, July 22, July 26, July 31, Aug. 7, Aug. 12, Aug. 22, Sept. 6, or Sept. 27. Of the two adjacent pastures sampled each date, one pasture was not previously grazed during the season (non-grazed), while the other pasture had been grazed the previous four days. On each sampling date the non-grazed pasture was sampled prior to introduction of cattle to the pasture and the grazed pasture was sampled after the allotted grazing had occurred. Grazing pressure ranged from 2.0 to 18.9 animal units per ton of available forage (Table 1). Three esophageally fistulated cows were used to sample each pasture on each date to determine forage quality. Prior to each diet sample collection, cows were withheld from feed, but not water, for 12 hours, then transported to pastures where diets were to be collected. Cows were fitted with solid bottom bags after removal of the esophageal plug, and introduced to the pasture, then allowed to graze for about 20 minutes.

Samples were separated into a liquid and fibrous portion for lab analysis. Immediately after separation, diet samples were frozen and stored at -20°C. Fibrous samples were lyophilized, ground to pass a 1-mm screen in a Wiley mill. Samples were analyzed for CP, NDF content using the Van Soest et al., (1991) method, and IVOMD using the Tilley and Terry method with the modification of adding 1 g of urea to the buffer and ashing the residue to calculate organic matter, then adjusted to *in vivo* values. Results were analyzed using the PROC MIXED procedure of SAS (SAS Institute, Inc., Cary, N.C.) with experimental unit being cow.

Results

Greater CP was observed in non-grazed pastures on June 17, July 2, July 11, July 18, July 26, and Sept. 27 than grazed pastures ($P < 0.10$, Table 1). This suggests less difference in protein content during August and early September between grazed and non-grazed pastures. Non-grazed pastures had greater IVOMD on July 15, July 31, Aug. 7, Aug. 22, and Sept. 27 than grazed pastures ($P < 0.10$). Non-grazed pastures tended to be greater in IVOMD on June 17 ($P = 0.12$) and Aug. 12 ($P = 0.11$) than grazed pastures. Non-grazed pastures had lower NDF on July 2 ($P < 0.10$) than grazed pastures and tended to be lower on June 17 ($P = 0.15$), July 11 ($P = 0.13$), and July 22 ($P = 0.11$). No other statistical differences were observed on all other sampling dates for NDF. These data suggest grazing, and most specifically grazing pressure, have the most impact on diet quality both early and late in the grazing season when the majority of new growth occurs. In the previous year of this study, similar results were observed in that diet quality was most affected by grazing early in the growing season; however, samples were not taken as late in the season (*2014 Nebraska Beef Cattle Report,* pp. 50-51).

Early in the growing season when cattle are first introduced into a pasture, they consume the highest quality forage available. When the

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Table 1. CP, NDF, and IVOMD values of masticate samples from Sandhills meadow between non-grazed and grazed pastures.

	CP			NDF			IVOMD			
Date[2]	Non-grazed	Grazed	SEM[1]	Non-grazed	Grazed	SEM[1]	Non-grazed	Grazed	SEM[1]	Grazing Pressure[3]
17-Jun	14.8[a]	10.5[b]	0.93	55.1[a]	63.7[a]	2.63	68.9[a]	65.4[a]	0.94	2.0
26-Jun	10.2[a]	9.9[a]	0.38	67.5[a]	68.6[a]	2.23	69.2[a]	66.3[a]	1.98	7.1
2-Jul	16.2[a]	8.0[b]	1.12	51.9[b]	66.4[a]	3.04	60.0[a]	64.1[a]	2.93	18.9
11-Jul	10.9[a]	8.9[b]	0.59	65.9[a]	76.3[a]	2.90	62.1[a]	62.2[a]	3.03	4.5
15-Jul	9.6[a]	7.8[a]	0.60	68.4[a]	73.6[a]	1.68	68.3[a]	60.9[b]	1.30	2.2
18-Jul	8.8[a]	7.7[b]	0.39	69.9[a]	71.6[a]	2.98	66.3[a]	67.0[a]	1.78	3.9
22-Jul	6.7[a]	6.5[a]	0.29	68.9[b]	75.3[a]	2.04	64.8[a]	65.7[a]	1.49	3.6
26-Jul	8.3[a]	6.5[b]	0.34	67.4[a]	67.4[a]	1.72	66.8[a]	64.6[a]	1.85	2.6
31-Jul	8.3[a]	6.4[a]	0.63	66.5[a]	75.3[a]	3.03	63.7[a]	55.7[b]	1.70	3.0
7-Aug	8.0[a]	9.1[a]	0.63	68.9[a]	66.4[a]	3.05	65.2[a]	56.4[b]	1.74	6.4
12-Aug	7.9[a]	8.3[a]	0.41	64.1[a]	67.2[a]	3.22	62.8[a]	55.2[a]	1.90	3.9
6-Sep	8.2[a]	9.7[a]	0.60	60.5[a]	64.7[a]	3.07	52.3[b]	61.8[a]	2.22	6.1
27-Sep	9.0[a]	6.7[b]	0.45	63.3[a]	67.0[a]	3.16	61.2[a]	52.3[b]	1.62	7.9

[a,b]Different subscript between ungrazed and grazed signifies a significant difference within nutrient analysis with a P-value < 0.10.
[1]Standard error of the least squares mean.
[2]Date pasture was sampled using esophageally fistulated cattle.
[3]Grazing pressure expressed as animal units per ton of available forage.

highest quality forage is consumed, cattle consume lower quality forage, which creates a change in diet quality over time independent of change in nutrient content of the forage. The lower quality forage could result from consuming more stem or consuming growth from the previous year. With greater grazing pressure, the new growth may become less available more rapidly, expediting the consumption of old growth. This would account for the decline in CP that was observed earlier in the growing season. As the growing season progresses, ample forage becomes available and grazing pressure may not have as great an impact on diet quality, so averaging the values of the pastures before grazing and after grazing may be practical. For example, on July 22 there was less than 1 percentage unit difference between the grazed and the ungrazed pastures TDN averaging about 65%, which is relatively high and would meet the energy requirements of a 1,200 lb cow. However, the average of the CP is about 6.6% which would result in a supply of DIP of about 4.6% which is below the required amount of 8.45% DIP. Later in the growing season, as regrowth of the cool-season grass species occurs and higher quality diet may become more available, grazing pressure may once again impact the duration that the new growth is available, and cattle are once again forced to eat older growth.

It is likely stocking rate plays a role in differences in nutrient content between grazed and ungrazed pastures (*2015 Nebraska Beef Cattle Report,* pp. 48-50). In this study, cattle were rotated to new pastures relatively quickly, resulting in light stocking rates and lower grazing pressures. If the same study were to be conducted under normal or heavy stocking rate conditions, larger differences in nutrient content of grazed compared with ungrazed pastures would be expected. By mid-summer with low protein values, supplementation may be needed, especially in a May calving system.

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Effect of Corn Residue Removal on Subsequent Crop Yields

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Summary

Two studies were conducted to evaluate the effects of corn residue harvest on subsequent crop yields. In a long-term study (16 years), cattle grazing corn residue in the spring (February to the middle of April) or the fall (November through January) slightly improved subsequent soybean yields and had no effect on corn yields in an irrigated field maintained in an annual corn-soybean rotation at Mead, Neb. In a five-year study, fall grazing (December through January) or baling of corn residue had no effect on subsequent corn grain yields in a field maintained in continuous corn production at Brule, Neb. These data suggest that the grazing of corn residue in the fall or spring at or below UNL recommended stocking rates will have slightly positive or no impacts on subsequent soybean or corn yields.

Introduction

Grazing cornstalks offers producers an inexpensive feed source and helps minimize purchased feed costs during the winter. Although corn crop residue grazing can reduce feed costs, some crop producers are concerned that it will have an adverse effect on subsequent crop yields, especially if cattle are grazed during the spring when the ground is thawed and muddy. These studies were designed to evaluate impacts of harvesting corn residue through grazing or baling on subsequent crop yields.

Procedure

Experiment 1

This study was designed to evaluate the long-term impacts of grazing corn residue in the fall or spring on soybean and corn yields when an annual corn-soybean rotation was used. A 90 acre irrigated crop field located at the Agriculture Research and Development Center located near Mead, Neb., was used. The soil in this field was Tomek (0-2% slope) silty clay loam, Yutan (2-5% slope) silty clay loam, and Filmore (0% slope) silty loam and contained 2-2.5% soil organic matter. Half of the field (east or west) was planted to corn and the other half was planted to soybeans each year, and crops were alternated yearly so that corn was grown in the portion of the field that grew soybeans the previous year and soybeans were grown in the portion of the field that grew corn the previous year. An irrigation access road that ran east to west in the middle of the field served as the separation between the two replications of each crop. Each quarter had three grazing treatments that were maintained on the same ground since 1997: 1) fall/winter grazed (November through January), 2) spring grazed (February to the middle of April), and 3) ungrazed.

Corn residue was the only residue that was grazed, thus the immediate impact of corn residue grazing on grain yield would be reflected in the soybean yields, whereas long-term effects would be measured in both grain crops. The fall/winter grazing is the time that most cattle graze crop residues in Nebraska. The field is typically frozen, and the mud and compaction associated with cattle grazing should, therefore, be minimized. The spring grazing treatment was designed to look at the effects of allowing cattle to remain on crop fields, after the fields thaw, until spring planting. Stocker cattle (500 to 700 lb BW) supplemented with distillers grains were used to apply grazing treatments and were stocked at 1.2 head/ac in the fall/winter (1.8 to 2.5 AUM/ac) grazing treatment and 1.2 head/ac in the spring grazing (0.9 to 1.3 AUM/ac) treatment up until 2000 (five years). At this point calves were stocked at 3 head/ac in the spring grazing treatment (2.3 to 3.1 AUM/ac).

The stocking rates utilized were consistent with UNL grazing recommendations, which result in removal of half the husks and leaves produced (8 lb of leaf and husk per bushel of corn grain produced). The corn yields ranged from a low of 186 bu/ac in 2004 to a high of 253 bu/ac in 2009, with a median over the 16 years of 203 bu/ac. Recommended stocking rates would have ranged from 2.1 to 2.9 AUM/ac with a median of 2.3 AUM/ac. The area harvested for determination of yield ranged from 0.40 to 0.65 acres per treatment per replicate and was measured on the same strips of land each year. Grain was harvested using a combine, and corn was weighed using a weigh wagon and soybeans were weighed in a 550 bu grain cart with load cells. Each year, samples were collected at harvest to determine DM, and yields were adjusted to 13% moisture for soybeans and 15.5% moisture for corn grain.

For the fall/winter grazing areas, no-till planting was utilized throughout the 16 years. However, yield data in the fall grazed area are only available from the harvest of 2004 through the 2013 harvest (10 years). Within the spring grazed and ungrazed treatment, three tillage treatments: no-till, ridge-till, or spring disk till, were imposed during the corn rotation with no-tillage being used following the soybean crop. These tillage treatments were maintained on the same

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strip of land until the spring of 2007, at which time only the no-till treatments were continued. Therefore, the comparison of spring grazing vs. no grazing under no-till management is available for 16 years, the split plot comparison of spring grazing vs. no grazing under three tillage strategies (no-till, ridge till, or spring till) is available for nine years, and the comparison of the effects of spring, fall/winter and no grazing under no-till management is available for 10 years.

Data were analyzed using the GLIMMIX procedure of SAS (SAS Institute, Inc., Cary, N.C.). Corn and soybean yields were analyzed separately. Each strip of land within field was considered the experimental unit. For all of the analyses, year was considered a random effect using an autoregressive (AR1) covariance structure to account for correlation among measures within each strip measured over repeated years. For the nine years of data in which different tillage methods were used, the analyses included the fixed effects of tillage and grazing and their interaction. In addition, the possible spatial correlation of the strips was accounted for with an autoregressive (AR1) covariance structure. For the 16 years of data in which spring grazing was conducted on land that was managed under no-till, the analyses included the fixed effect of grazing. For the 10 years of data in which both spring and fall grazing is available under no-till management, the analyses included the fixed effect of grazing season (spring grazed, fall grazed, or not grazed).

Experiment 2

This study was designed to evaluate the effects of corn residue harvest with fall grazing at two stocking rates or baling on subsequent corn grain yield in a continuous corn system. A center pivot (130 acres) irrigated corn field (consisting of loam, silt loam, and sandy loam soil, with the majority of the soil being classified as a fine-loamy, mixed, superactive, mesic Aridic Argiustoll) at the West Central Water Resources Field Laboratory near Brule, Neb., was divided into four treatments starting in 2008, grazed at 1 AUM/ac, grazed at 2 AUM/ac, baled, or ungrazed. Corn yields ranged from a low of 128 bu/ac in 2009 to a high of 162 bu/ac in 2011, with a median of 155 bu/ac. At these levels of production, UNL grazing recommendations would have been to stock at 1.5 to 1.8 AUM/ac with the median being 1.8 AUM/ac.

The field was divided into eight 16.25 acre paddocks and had two replications per treatment. Paddocks were assigned randomly initially and the same treatments were applied to these paddocks throughout the study (six-year period). The field was maintained in a continuous corn rotation and no-till management was used.

Beef cows (900 to 1,250 lb BW) were used to apply grazing treatments (0.5 cows/ac for the light and 1.1 cows/ac for the heavy) and were supplemented with 1 lb per cow of a 32% crude protein cube daily. Grazing occurred from December to February. Rows were planted east to west across the field such that they crossed all four treatments. Corn grain yield over five years of harvest (2009-2013) was measured using the yield monitor on the combine and adjusted to 15.5% moisture.

Yield data were analyzed using repeated measures in the MIXED procedure of SAS. Paddock was considered the experimental unit and the effect of year was considered random.

Table 1. Effect of grazing corn residue in the spring over a 16-year period (1997-2013) on corn and soybean yields[1] from a field managed in an annual corn-soybean rotation at Mead, Neb.

	Ungrazed	Spring grazed	SEM[1]	*P*-value[2]
Corn, bu/ac	214	214	2.6	0.96
Soybean, bu/ac	57.8[b]	59.3[a]	0.54	0.03

[1]Yields are based on 13% moisture for soybeans and 15.5% moisture for corn grain.
[2]Means with differing superscripts in a row are different ($P < 0.05$).

Results

Experiment 1

No interaction ($P \geq 0.55$) between tillage and spring grazing was observed for either soybean or corn yield over a nine-year period (1997-2006), suggesting that spring grazing had the same effect regardless of whether no-till, ridge till, or spring till was used. Across all tillage treatments, spring grazing of corn residue increased ($P < 0.01$) soybean yields (58.5 vs. 57.0 bu/ac for spring grazed and ungrazed, respectively) and had no effect ($P = 0.58$) on corn yields (210 vs. 210 bu/ac for spring grazed and ungrazed, respectively). Similarly, over the 16-year period (1997-2013) spring grazing of strips managed under no-till increased soybean yields and had no effect on corn yields (Table 1). Over a 10-year period (2003-2013), fall grazing improved soybean yields over both spring grazing and no grazing (Table 2), whereas spring grazing tended ($P = 0.07$) to increase soybean yields when compared to no grazing. No effects of grazing in either season were observed on corn yields.

Experiment 2

Removal of residue did not affect corn grain yields over the five-year period (2009-2013) in the continuous corn rotation (Table 3). However, it is interesting to note that corn grain yields in the grazing treatments were numerically increased by 4-7 bu/ac than the ungrazed treatment.

In summary, in the long-term study (16 years) at Mead, Neb., grazing

Table 2. Effect of grazing corn residue in the fall/winter or spring on corn and soybean yields[1] over a 10-year period (2003-2013) from a field managed in an annual corn-soybean rotation at Mead, Neb.

	Ungrazed	Spring grazed	Fall grazed	SEM	*P*-value[2]
Corn, bu/ac	207	209	211	3.9	0.55
Soybean, bu/ac	62.1[b]	63.5[b]	65.5[a]	0.54	< 0.01

[1]Yields are based on 13% moisture for soybeans and 15.5% moisture for corn grain.
[2]Means with differing superscripts in a row are different ($P < 0.05$).

Table 3. Effect of corn residue removal on corn grain yield[1] over a five-year period (2009-2013) from a field used for continuous corn production at Brule, Neb.

	Ungrazed	Fall grazing 1 AUM/ac	Fall grazing 2 AUM/ac	Baled	SEM	*P*-value
Corn, bu/ac	148	152	155	147	6.7	0.16

[1]Yields are based on 15.5% moisture.

corn residue in fall or spring resulted in an improvement in subsequent year soybean yields and had no effect on corn yields when an annual corn-soybean rotation was used. In the medium term (five years) study at Brule, Neb., in a continuous corn rotation, fall grazing or baling of corn residue had no effect on corn yields.

Many crop producers have concerns that cattle trampling will adversely affect soil physical properties and subsequent crop productivity. Soil physical properties influence the ability of a plant to acquire water, nutrients, and oxygen. Although some studies have shown that presence of cattle on cropland in winter/early spring can compact soils, effects of grazing are usually short-lived due to amelioration through natural processes such as wetting/drying or freezing/thawing cycles and the biological action of roots or soil biota that create pores and break down compacted layers. In the current studies, grazing did not cause negative impacts on crop yield, suggesting that any compaction caused by cattle did not negatively impact crop growth, even when fields were managed under no-till.

With high corn yield an excessive amount of residue can be produced and can have negative impacts on the subsequent crop by impeding seed placement and insulating the soil such that it remains excessively cold and wet in the spring, causing poor germination and slow emergence. Grazing of corn residue can be used to manage residue levels without tillage and its resulting loss of soil structure and soil organic matter (resulting from oxidation by soil bacteria when exposed to air).

Implications

These data suggest that the grazing of corn residue at UNL recommended stocking rates in the fall or in the spring will have slightly positive or no impacts on subsequent soybean or corn yields. Thus, grazing of corn residue can be an economical source of winter roughage for cattle producers as well as provide an extra source of income for corn producers. Further, grazing offers an alternative to tillage to manage residue levels on fields.

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Effect of Corn Plant Maturity on Yield and Nutrient Quality of Corn Plants

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Summary

Two corn plots (short season, 102-day, and normal season, 111-day corn) were serially harvested to evaluate nutrient, digestibility, and yield change over the duration from half-milk line through black layer. Digestibility of the corn plant decreased as corn plant maturity and NDF content increased. The lower leaf in the normal season plot decreased in digestibility, but did not change in the short season plot. Little change was observed in the digestibility of the internodes across time. The NDF content of the upper plant increased in both plots. The internodes increased in NDF content across time in both plots. The results of this study suggest there is a delicate balance between plant maturity, nutrient content, and yield.

Introduction

The use of corn silage may be economical in times of high priced roughages and corn. Previous research (*2013 Nebraska Beef Cattle Report,* pp. 74-75) reported that including corn silage in a finishing diet with distillers grains is economical and has more incentive in times of higher priced corn. With high land prices and production costs, corn silage production must be optimized for both yield and nutritive value. Previous research (*2013 Nebraska Beef Cattle Report,* pp. 42-43) investigated the effect of hybrid, growing season length, plant density, and harvest timing on whole corn plant DM yield and nutritive value. The results of their study suggested nutritive value and whole corn plant yield was effected by hybrid selection, planting density, and harvest timing. The time of harvest had the greatest impact on both yield and quality characteristics. Overall, the study showed that corn grain yield and corn plant DM yield increased over time, yet had little effect on nutritive quality. The objective of this experiment was to investigate the best time of harvest for optimal percent grain and the impacts of internode quality or cut height on corn silage.

Procedures

One normal season (NS) DEKALB variety DKC 61-16RIB (111 day) was planted on May 1, 2013, and one short season (SS) DEKALB variety DKC 52-61 VT3 (102 day) was planted on June 12, 2013, both at a seed rate of 33,000 plants/ac at ARDC near Mead, Neb. These plots were both under the same pivot irrigation system in the same section of the field. Both plots were sampled seven (NS) or six (SS) times, from Aug. 22 to Sept. 17 (NS) and Sept. 12 through Oct. 1 (SS), to reflect the time from half milk line through grain harvest. Corn plants were cut at the second crown root in the field. Each sample date consisted of 8 sample sets with 10 plants in each set. Stalk height remaining in the field was measured, then averaged, resulting in approximately 2 inches of stalk left in the field. Samples were weighed and separated into: cob/grain, lower leaf, internodes one, two, and three, and upper plant. Internodes were measured for height. For the NS plot, 2 inches represents the whole plant (minus the grain) down to 2 inches from the ground, this includes all internodes and lower leaf. Six inches represents everything except the grain above 6 inches from the ground, including second and third internodes. Twelve inches represents everything 12 inches above ground including third internode. Nineteen inches represents the upper plant minus the grain. The SS plot follows similarly, except at 2, 4, 9, and 14 inches. Samples were cut, divided, and analyzed by part to determine the difference in nutritive value as cutting height is adjusted. The upper plant was then ground using a wood chipper. A sub-sample of internodes, lower leaf, upper plant, and all cob/grain samples were dried in a 140°F forced-air oven. Another sub-sample of internodes, lower leaf and upper plant was taken for freeze drying and ground through a 2-mm screen for laboratory analysis.

Concentration of NDF and *in situ* NDF digestibility (NDFd) were analyzed for internodes one, two, and three, lower leaf, and upper plant (28 hour incubation). For each sampling date, internodes and upper plant samples were composited to make four samples instead of eight (1,2; 3,4; 5,6; 7,8). Lower leaf samples were composited by date. This was done to reduce sample numbers. A value for plant residue digestible NDF was calculated using DM percentage, NDF, and NDFd for internodes one, two, and three, lower leaf, and upper plant samples.

Yield and nutritive value data were analyzed using the MIXED procedure of SAS (SAS Institute, Inc., Cary, N.C.). The experimental unit was classified as steer (a composite of 20 corn plants) for digestibility work and plant composite (10 plants) for yield analysis. Harvest timing and plant part were fixed effects.

Results

Approximate black layer for the NS plot was Sept. 9, 2013, and Sept. 29, 2013, for the SS plot. The SS plot reached maturity late due to being

Table 1. Effect of maturity on yield characteristics of normal season corn.

Item	Days from Black Layer[1]							SEM	*P*-value[2]		*P*-value[4]	
	-18	-13	-10	-6	-3	3	8		Lin.	Quad.	Sample Day	Cutting Height
Silage yield[3] (~2 in)	11.07	11.41	11.59	11.43	13.88	12.99	13.89	0.38	0.96	1.00	<.01	<.01
Silage yield (~6 in)	10.82	11.16	11.31	11.21	13.73	12.78	13.49	0.38	0.96	1.00	<.01	<.01
Silage yield (~12 in)	10.42	10.72	10.92	10.87	12.56	12.37	12.94	0.38	0.96	1.00	<.01	<.01
Silage yield (~19 in)	9.98	10.24	10.48	10.50	12.20	11.94	12.42	0.38	0.96	1.00	<.01	<.01
Grain % (~2 in)	38.8	42.1	46.1	46.1	44.9	50.2	47.8	0.01	0.89	<.01	<.01	<.01
Grain % (~6 in)	39.7	43.0	48.3	47.0	46.2	51.0	49.2	0.01	0.89	<.01	<.01	<.01
Grain % (~12 in)	41.3	44.8	49.0	48.5	49.1	52.7	51.3	0.01	0.89	<.01	<.01	<.01
Grain % (~19 in)	43.1	46.9	51.0	50.1	52.3	54.6	53.4	0.01	0.89	<.01	<.01	<.01
% DM (~2 in)	32.6	31.5	34.5	33.0	37.4	38.2	39.5	0.01	0.93	0.09	<.01	<.01
% DM (~6 in)	33.1	32.0	35.2	33.7	37.8	38.9	40.1	0.01	0.93	0.09	<.01	<.01
% DM (~12 in)	33.6	32.8	36.1	34.8	38.0	40.2	41.0	0.01	0.93	0.09	<.01	<.01
% DM (~19 in)	34.6	33.8	37.2	36.0	38.3	41.6	42.2	0.01	0.93	0.09	<.01	<.01

[1]Days from black layer: -18 = Aug. 22, 2013; -13 = Aug. 27, 2013; -10 = Aug. 30, 2013; -6 = Sept. 3, 2013; -3 = Sept. 6, 2013; 3 = Sept. 12, 2013; 8 = Sept. 17, 2013. Black layer approximately Sept. 9, 2013.
[2]Lin. = *P*-value for the linear interaction response to plant maturity Quad. = *P*-value for the quadratic interaction response to plant maturity.
[3]Silage yield in DM tons/ac.
[4]Sample day = *P*-value for effect on day of sampling cutting height = *P*-value for effect on plant cutting height.

Table 2. Effect of maturity on yield characteristics of short season corn.

Item	Days from Black Layer[1]						SEM	*P*-value[2]		*P*-value[4]	
	-17	-12	-9	-5	-2	4		Lin.	Quad.	Sample Day	Cutting Height
Silage yield[3] (~2 in)	11.00	10.10	10.52	9.89	10.91	10.39	0.53	1.00	0.51	0.58	0.35
Silage yield (~4 in)	10.87	9.98	10.39	9.79	10.78	10.29	0.53	1.00	0.51	0.58	0.35
Silage yield (~9 in)	10.64	9.80	10.21	9.63	10.59	10.10	0.53	1.00	0.51	0.58	0.35
Silage yield (~14 in)	10.40	9.62	10.03	9.46	10.39	9.90	0.53	1.00	0.51	0.58	0.35
Grain % (~2 in)	47.0	50.3	51.0	52.2	52.8	52.8	0.01	1.00	<.01	<.01	<.01
Grain % (~4 in)	47.6	50.9	51.6	52.7	53.5	53.3	0.01	1.00	<.01	<.01	<.01
Grain % (~9 in)	48.6	51.8	52.5	53.6	54.5	54.3	0.01	1.00	<.01	<.01	<.01
Grain % (~14 in)	49.7	52.8	53.5	54.6	55.5	55.4	0.01	1.00	<.01	<.01	<.01
% DM (~2 in)	29.7	30.2	33.1	37.5	40.1	45.4	0.01	0.89	<.01	<.01	<.01
% DM (~4 in)	30.1	30.6	33.7	38.0	40.8	46.0	0.01	0.89	<.01	<.01	<.01
% DM (~9 in)	30.8	31.3	34.5	38.8	41.7	47.1	0.01	0.89	<.01	<.01	<.01
% DM (~14 in)	31.5	32.1	35.2	39.5	42.7	48.1	0.01	0.89	<.01	<.01	<.01

[1]Days from black layer: -17 = Sept. 12, 2013; -12 = Sept. 17, 2013; -9 = Sept. 20, 2013; -5 = Sept. 23, 2013; -2 = Sept. 27, 2013; 4 = Oct. 1, 2013. Black layer approximately Sept. 29, 2013.
[2]Lin. = *P*-value for the linear interaction response to plant maturity Quad. = *P*-value for the quadratic interaction response to plant maturity.
[3]Silage yield in DM tons/ac.
[4]Sample day = *P*-value for effect on day of sampling cutting height = *P*-value for effect on plant cutting height.

planted 43 days later than the NS plot. Silage yield was calculated in tons produced per acre. Percent grain was calculated as the percentage of the dry plant being composed of grain. As the corn plant matures, a linear increase ($P < 0.01$) in silage yield was observed in the NS plot, but interestingly no change ($P = 1.00$) was observed in the SS plot. As expected, percent grain increased with increasing plant maturity. Percent grain increased quadratically for both the NS and SS plot ($P < .01$; Tables 1 and 2). An interaction was observed between cutting height and plant maturity in both plots for percent grain. With increasing maturity, lower plant parts contributed less to the percent grain. Percent grain peaked at approximately black layer, then tended to decrease slightly. Also expected, an increase in percent DM was observed as the corn plant matured. A quadratic interaction was observed between cutting height and maturity for percent DM in the SS plot, but no interaction was observed in the NS plot. The NS plot did however increase in DM linearly as the plant matured during the time of sampling (Tables 1 and 2). As cutting height was increased, there was an increase in percent grain and a decrease in percent DM at later maturity but at the expense of less silage yield.

Overall digestibility of the corn plant decreased, as expected, with an increase in corn plant maturity for both the NS and SS plots (Table 3). The NS plot decreased linearly with a cutting height by day interaction, but the SS plot showed no interaction ($P < .01$, $P = .17$). Interestingly, there was also a day by day interaction for the NS plot as well, but not the SS plot ($P < .01$, $P = .07$). The higher digestibility of the lower leaf brings the overall digestibility of the plant up slightly at the lowest cutting height.

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Table 3. Effect of maturity on plant NDF digestibility.[3]

Item	Days from Black Layer[1]								*P*-value[2]		*P*-value[4]		
Normal Season	-18	-13	-10	-6	-3	3	8	SEM	Lin.	Quad.	Day*Day	Sample Day	Cutting Height
~2 in	50.61	49.27	46.11	44.32	41.06	41.87	42.40	0.01	0.51	0.98	<.01	<.01	<.01
~6 in	51.48	50.31	46.96	44.80	41.75	42.41	42.95	0.01	0.51	0.98	<.01	<.01	<.01
~12 in	53.44	52.50	48.48	45.85	43.37	43.67	43.96	0.01	0.51	0.98	<.01	<.01	<.01
~19 in	55.85	55.12	50.91	47.32	44.97	44.46	46.04	0.01	0.51	0.98	<.01	<.01	<.01
Short Season	-17	-12	-9	-5	-2	4	—						
~2 in	38.38	37.76	38.71	35.97	35.18	35.11	0.02		0.99	1.00	0.66	<.01	<.01
~4 in	38.97	38.19	39.05	36.06	35.24	35.33	0.02		0.99	1.00	0.66	<.01	<.01
~9 in	40.19	39.21	39.86	36.58	35.90	36.06	0.02		0.99	1.00	0.66	<.01	<.01
~14 in	41.28	40.37	42.36	37.36	37.14	37.59	0.02		0.99	1.00	0.66	<.01	<.01

[1]Days from black layer: -18 = Aug. 22, 2013; -13 = Aug. 27, 2013; -10 = Aug. 30, 2013; -6 = Sept. 3, 2013; -3 = Sept.r 6, 2013; 3 = Sept. 12, 2013; 8 = Sept. 17, 2013. Black layer approximately Sept. 9, 2013. Short: -17 = Sept. 12, 2013; -12 = Sept. 17, 2013; -9 = Sept. 20, 2013; -5 = Sept. 23, 2013; -2 = Sept. 27, 2013; 4 = Oct. 1, 2013. Black layer approximately Sept. 29, 2013.
[2]Lin. = *P*-value for the linear response to plant maturity Quad. = *P*-value for the quadratic response to plant maturity
[3]Digestibility as percent of plant
[4]Sample day = *P*-value for effect on day of sampling cutting height = *P*-value for effect on plant cutting height

The upper plant had the next highest digestibility (14 inches and up). Digestibility then decreased as lower parts of the plant were added in. This means that as cutting height decreased, digestibility of the silage is decreased overall, but with an increase in silage yield.

The results from this study suggest there is a delicate balance between obtaining the greatest silage yield and the best nutrient quality of the silage. By decreasing cutting height, overall volume of the silage produced will increase, but not have a positive impact on quality. These data also suggest that there is little change in the digestibility of the lower internodes (3-12 inches cutting height), though this digestibility is low to begin with. When faced with the challenge of needing more silage, but not wanting to sacrifice quality, it may be possible to extend harvest time in some cases to meet this need. More research is needed to determine how harvesting at later maturity will affect the stability, fermentation, and nutritional value of the silage.

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Evaluation of Changes in Nutritional Quality of Corn Residue Over Time

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Summary

Irrigated corn residue was sampled across time in order to determine changes in quality and proportion of corn residue as the plant dried and was exposed to effects of weathering. Corn plants from two hybrids were planted on two different planting dates and harvested at periodic intervals from August 2012 to December 2012. Proportions of stem, blade/sheath, husk/shank, and cob made up smaller components of total plant DM as it matured, with the largest relative reduction occurring in the blade/sheath or stem. Hybrid impacted TDN values primarily because the 119 day hybrid was less mature at the early sampling dates.

Introduction

Residues of corn (*Zea mays*) have successfully been utilized as an economical roughage and energy source for ruminants. After grain harvest, the majority of what remains in the field is the forage portion of the plant. Residue proportions are estimated to be 40% stem, 45% husk/blade, 11% cob, and 4% grain for an irrigated field. Quality of the residue is largely dependent on plant part. This is supported by previous research showing husk being higher in quality compared with the blade, stem, and cob (2012 *Nebraska Beef Cattle Report,* pp. 11-12). Grain, the highest quality part of the corn plant, is typically found in minimal amounts in a residue field. Unlike grain, the forage is subject to decreasing quality as the plant matures, with the change in quality largely dependent on the effects of weathering. The objective of this trial was to determine the nutritional quality of corn residue over time.

Procedure

Two experiments were conducted in 2012 at the University of Nebraska–Lincoln Agriculture Research and Development Center near Mead, Neb. Standing corn plants were sampled from an irrigated demonstration corn plot and harvested at periodic intervals from August 2012 to December 2012. Experiment (Exp.) 1 was planted May 27 and Exp. 2 was planted April 27. Both experiments contained two hybrids, a 102 day (DKC52-59) and 119 day (DKC69-40) maturity of DeKalb brand corn. Corn plants in Exp. 1 were harvested at two week intervals August through October and then four week intervals through December while Exp. 2 was harvested at four week intervals from October through December. Corn was not harvested for grain; instead, the plant remained standing in the field for the duration of the collection period. Hybrids within each experiment were divided into quadrats and a sample from each quadrat was collected at sampling time for a total of four replications. Replications consisted of five plants in a row that were representative of the field. Plants were separated into stem, blade/sheath, husk/shank, cob, and grain. Data on black layer were not collected from the field. Instead, black layer was calculated with an equation using planting date, hybrid, and weather pattern data to estimate maturity relative to the time of sampling.

Plant parts for each sampling date were analyzed for DM and neutral detergent fiber (NDF) digestibility. Samples collected prior to November 1 were freeze-dried, and those collected afterwards were dried in a forced air oven at 60°C for 48 hours. Samples were ground through a 2 mm screen in a Wiley mill and placed in labelled, airtight bags. Dacron bags with a 50 μm pore size were used for *in situ* to determine NDF digestibility. Two steers were used for *in situ* work with a 28 hour incubation period. Duplicate 1.25 g samples were weighed into Dacron bags and 40 Dacron bags were placed in a mesh bag. Eight mesh bags were placed in each steer during each incubation period. After incubation, bags were rinsed and washed in NDF solution. Bags were dried in a forced air oven at 100°C for 12 hours and then weighed back for DM.

True digestibility of stem, blade/sheath, husk/shank, and cob were calculated in order to determine how much is fermented by the microbial community during retention time in the rumen. Solubles were considered 100% digestible and were calculated by subtracting the percentage of NDF from 100%. Therefore, true digestibility is the sum of the solubles and digestible NDF.

Results were analyzed using the MIXED procedure of SAS (SAS Institute, Inc., Cary, N.C.). The experimental unit consisted of the five competitive plants within each replication. Repeated measures was used to determine how plant parts changed over time in regards to NDF content, NDF digestibility and true digestibility. Hybrid was included in the model as a treatment.

Results

Experiment 1

No effect of hybrid was found so results were combined. There was a quadratic change in the proportion of

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residue DM over time for stem, blade/sheath, and husk/shank, with few changes in DM proportion occurring once grain was estimated to reach 15.5% moisture ($P < 0.01$; Table 1). A quadratic increase in NDF content occurred over time for blade/sheath, husk/shank and cob ($P < 0.01$; Table 2). An increase in the amount of NDF is correlated with a decrease in solubles of the plant part. The amount of NDF has been shown to increase with plant maturity. Stem had a linear decrease in NDF content ($P = 0.01$). This implies that the stem increased in solubles over time. This is unlikely and is not supported by previous research since solubles are metabolized by the plant as it matures. It is unclear what displaced NDF in the stem as it remained in the field.

A quadratic decrease in NDF digestibility occurred over time for cob, with the majority of the decline occurring prior to normal grain harvest ($P < 0.01$; Table 3). Digestibility of NDF of the other plant parts remained relatively constant for each sampling point, with the blade/sheath at 30% and stem less than 10%. The true digestibility of cob showed a quadratic decrease over time, with true digestibility remaining relatively constant once grain reaches 15.5% moisture ($P < 0.01$; Table 4). A linear decrease in true digestibility occurred for blade/sheath ($P < 0.01$), while there was a linear increase for the stem. As the plant matures, true digestibility is expected to decrease due to the increase in fiber and reduction in solubles. For this experiment, the increase in true digestibility of the stem is due to the decline of NDF content which suggests cell solubles are increasing in the stem. As previously stated, it is unclear what displaced NDF in the stem and it seems unlikely that the true digestibility of the stem increased over time based on previous research.

Table 1. Changes in residue proportion over time for Experiment 1.

	Days from Black Layer								*P*-value	
	-18	-4	10	38	52	66	81	S.E.	L	Q
Blade and sheath	39	19	34	10	24	22	25	1.27	<0.01	<0.01
Cob	14	17	15	17	18	16	19	1.27	0.8	1
Husk/shank	8	10	8	23	9	8	12	1.27	<0.01	<0.01
Stem	40	54	43	51	49	54	45	1.27	<0.01	<0.01

Table 2. Total neutral detergent fiber content of plant parts over time for Experiment 1.

	Days from Black Layer								*P*-value	
	-18	-4	10	38	52	66	81	S.E.	L	Q
Blade and sheath	61.1	63.3	65.3	71.3	73.3	73.5	73.1	1.43	<0.01	<0.01
Cob	69.2	78.6	83.1	80.7	84.3	77.6	80.3	1.43	<0.01	<0.01
Husk/shank	74	79.1	78.1	83.1	80.3	81.4	77.3	1.43	0.04	<0.01
Stem	70.6	68.7	65.6	72.1	64.7	59.4	64.3	1.43	0.01	0.5

Table 3. Total neutral detergent fiber digestibility of plant parts over time for Experiment 1.

	Days from Black Layer								*P*-value	
	-18	-4	10	38	52	66	81	S.E.	L	Q
Blade and sheath	29.5	30.8	31.8	33.1	34.2	31.3	31.9	1.38	0.4	0.7
Cob	30.7	26.5	25.2	23.2	24.1	22.3	22.6	1.38	0.01	< 0.01
Husk/shank	36	40.2	38.9	40.6	44.1	41.2	42.6	1.38	0.06	0.5
Stem	6.5	4	4.3	6.7	11	8.1	4.1	1.38	0.4	0.4

Table 4. True digestibility of plant parts over time for Experiment 1.

	Days from Black Layer								*P*-value	
	-18	-4	10	38	52	66	81	S.E.	L	Q
Blade and sheath	58.1	56.3	55.5	52.3	51.8	49.5	50.4	1.20	<0.01	0.03
Cob	51.9	42.3	37.8	38.1	35.9	39.8	37.7	1.20	0.001	<0.01
Husk/shank	53.4	52.7	52.3	50.8	55.1	52.1	55.7	1.20	0.4	0.3
Stem	33.8	34.1	37.2	32.8	42.6	45.3	38.3	1.20	0.01	0.3

Experiment 2

A quadratic decrease in proportion of residue DM was evident for stem, while a quadratic increase occurred for husk/shank and cob ($P < 0.01$; Table 5). After grain harvest, the DM proportions of the residue are believed to remain relatively constant unless acted upon by environmental effects. The low number of sampling time points taken after grain harvest may play a contributing role in the difference over time for the stem, husk/shank, and cob in terms of residue proportion.

A difference between hybrids was found for NDF content so results were separated. There was a linear increase in NDF content of stem for the 102 day hybrid over time ($P < 0.01$; Table 6). This is supported by previous research showing that NDF increases with increasing maturity, causing a corresponding decline in the amount of solubles. For the 119 day hybrid, NDF content of stem and husk/shank showed a linear decrease ($P < 0.01$;

Table 5. Change in residue proportion over time for Experiment 2.

	Days from Black Layer				*P*-value	
	51	93	108	S.E.	L	Q
Blade/sheath	23.9	22.4	20.5	1.26	0.9	0.9
Cob	16.1	20.7	20.5	1.26	<0.01	<0.01
Husk/shank	9.5	13	13.3	1.26	<0.01	<0.01
Stem	50.6	43.9	45.7	1.26	<0.01	<0.01

Table 6. Total neutral detergent fiber content of plant parts over time for 102 day hybrid in Experiment 2.

	Days from Black Layer				*P*-value
	51	93	108	S.E.	L
Blade/sheath	69.2	66.7	69.1	1.51	0.6
Cob	83.9	77.3	79.6	1.51	0.2
Husk/shank	75.2	70.4	72.8	1.51	<0.01
Stem	57.2	56.4	60.1	1.51	0.9

Table 7. Total neutral detergent fiber content of plant parts over time for 119 day hybrid in Experiment 2.

	Days from Black Layer				*P*-value
	51	93	108	S.E.	L
Blade/sheath	71.4	68.6	71.9	1.51	0.3
Cob	85.4	84.4	79.7	1.51	0.1
Husk/shank	80.3	74.4	76.2	1.51	<0.01
Stem	59	49.5	49.8	1.51	<0.01

Table 8. Total neutral detergent fiber digestibility of plant parts over time for Experiment 2.

	Days from Black Layer				*P*-value
	51	93	108	S.E.	L
Blade/sheath	18.5	21.4	25.1	2.41	0.6
Cob	20.5	15.9	19.8	2.41	0.04
Husk/shank	30.3	34.9	32.4	2.41	0.6
Stem	0	1.6	0.5	2.41	1.0

Table 9. True digestibility of plant parts over time for Experiment 2.

	Days from Black Layer				*P*-value
	51	93	108	S.E.	L
Blade/sheath	43	46.8	47.3	2.04	0.4
Cob	32.7	31.9	36.2	2.04	0.5
Husk/shank	46	52.9	49.8	2.04	0.04
Stem	41.9	47.9	45.3	2.04	0.1

Table 7). The NDF of stem of the 119 day hybrid is similar to results for the NDF content of stem in Exp. 1. No differences were found in NDF digestibility, with values remaining relatively constant (Table 8). The NDF digestibility of stem was close to zero for each sampling date. No differences were found in true digestibility, with values remaining relatively constant over time (Table 9).

Implications

Experiment 2 was planted one month earlier than Exp. 1 and was not sampled until after grain reached 15.5% moisture. While Exp. 1 evaluated the quality of the plant parts prior to black layer through the winter grazing period, Exp. 2 offers a smaller window for observation after normal grain harvest. The proportion of residue DM for both experiments remained relatively constant once grain reached 15.5% moisture. Therefore, any reduction in DM after normal grain harvest can be attributed to environmental effects.

Plant part is the major contributor to the quality of residue, with the husk being of the highest quality while stem is of the lowest. Cattle select and consume the highest quality components first based on what is available in the field.

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Effect of Harvest Method on *In Vitro* Digestibility of Corn Residues

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Summary

New corn residue harvesting methods were evaluated to determine the impacts of altering the proportions of plant part that are composed in a round bale. In vitro techniques were used to assess the organic matter digestibility of corn residue bale harvested with different proportions of stalks, leaves, and husk. As husk comprised a greater proportion of the bale, digestibility appeared to increase when compared with a conventional bale of cornstalks.

Introduction

Studies have shown the digestibility of the different parts of a corn plant differ, with the husk being the most digestible and the stalk being the least digestible (*2012 Nebraska Beef Cattle Report,* pp. 11-12). Advancements in harvest technology of the residues are now allowing the producer to decrease the amount of the stalk in the bale, compared to conventional baling methods. The objective of this trial was to determine if the harvest method has an impact on the digestibility and quality of the bale produced.

Procedure

Three harvest methods were utilized to obtain samples, with five replicates per sample. Samples included: husk, 2-, 4-, 6-, and 8-row bales. Husks were obtained from Hoegemeyer Seed. Husks were sifted through a 3 ft by 5 ft metal screen by hand to remove any remaining corn. In order to obtain the bales of 2, 4, 6, and 8 rows, a New Holland Cornrower Corn Head was used. The Cornrower head has attachments that cut the stem and blow them into a windrow between the wheels of the combine. The straw spreader is disengaged, so the residue exiting the combine falls on top of the windrow made of the stalks. The number of rows of stalks cut can be adjusted from 0 to 8 (8-row head). The material exiting the combine includes all of the cobs, most of the husks, some leaves, and some of the upper 1/3 of the stems. The Cornrower corn head allows for the producer to select how many corn rows go into the windrow, allowing different proportions of plant parts to be present in the bale. The 8-row bale includes all of the stem material and, therefore, may be equivalent to conventionally baled stalks. However, essentially all the residue exiting the combine is recovered with the Cornrower head and, therefore, more husk may be included than conventionally baled stalks. A sample of conventionally baled stalks from another field is included for comparison. The yield of stover DM per acre was calculated by weighing bales from the field, measuring the linear feet of windrow in the bale, and calculating the area that the windrow represented in the field by counting rows. Bale weights were corrected for DM.

Samples were dried in a 60°C oven for 48 hours, where they were then ground through a 1mm screen. An assay for *in vitro* OM (IVOMD) digestibility was then preformed on the samples. Test tubes were utilized to hold 0.5 grams of each sample and 50mL of an inoculum. The inoculum for the procedure was a combination of ruminal fluid from two donor steers that were consuming a 70:30 roughage: concentrate diet (DM basis). Ruminal fluid was filtered through four layers of cheesecloth to help eliminate excess feed particles. McDougall's buffer was mixed into the ruminal fluid at a 1:1 ratio, along with the inclusion of 1 gram of urea/L.

Once the test tubes were filled with the appropriate mixtures, they were placed in a water bath at 600°F for 48 hours to allow fermentation. To end fermentation, each test tube received 6 mL of 20% HCL then 2mL of 5% pepsin solution. Tubes were then returned to the water bath for an additional 24 hours. At the end of the 24 hours, the tubes were removed from the water bath and the residue was filtered through a non-ash filter. Filters containing the residues were placed in an oven at 212°F to dry to obtain the IVDMD. After obtaining the IVDMD, filters were placed into a cool muffle furnace at 1112°F for a minimum of six hours. The residue left allowed for calculation of IVOMD. Data were analyzed using the MIXED procedure of SAS (SAS Institute, Inc., Cary, N.C.). The response variable was IVOMD, with the tube being the experimental unit.

Results

Table 1 from McGee et al., (*2012 Nebraska Beef Cattle Report,* pp.11-12) is included to illustrate the digestibility and proportions of the individual corn plant parts. Husks are the most digestible part but are a small proportion of total plant weight. Conversely, stems represent a large proportion but are low in digestibility. The upper 1/3 of the stem is more digestible than the lower 2/3. Visual observation is that some of the upper stem goes through the combine. The IVOMD of the husk was significantly greater ($P < 0.01$) compared with the four bales (Table 2). When comparing the four bales produced with the Cornrower corn head, IVOMD

Table 1. Plant part IVDMD, % of total plant DM, and lb DM/bu grain.[1]

Plant Part	IVDMD	% of Plant DM	lb/bu
Top 1/3 stalk	37.57%	3.60%	1.21
Bottom 2/3 stalk	33.85%	41.83%	14.12
Leaf	45.70%	18.83%	6.30
Leaf sheath	38.56%	12.60%	4.23
Husk	59.03%	7.48%	2.51
Shank	49.75%	1.09%	0.37
Cob	34.94%	14.68%	4.93

[1]McGee et al., *2012 Nebraska Beef Cattle Report,* pp.11-12.

Table 2. The effect of harvest method on IVOMD.

Item	Husk	2 Row	4 Row	6 Row	8 Row	Conventional Stalks	SE	*P*-value
IVOMD	72.4%[a]	66.4%[b]	54.3%[c]	53.3%[c]	47.0%[d]	43.0%	0.01	<0.01
DM Stover yield, lb/acre	—	1188	1469	2973	3336	—	—	—

increased as the number of rows collected in the bale decreased, presumably because of the increase proportion of husk and leaf. A difference ($P < 0.01$) was seen between the 2-row and the 4-row bale with IVOMD of 66% and 54%, respectively. There was no difference ($P > 0.05$) between the 4- and 6-row bales (IVOMD of 54% and 53%, respectively). The 8-row bale had an IVOMD of 47%, differing ($P < 0.01$) from the 6-row bale. From the IVOMD, the harvest method appears to affect the digestibility of the residue being fed. The differences in IVOMD are likely due to changing the proportion of husk, leaf, and cob compared to the proportion of stem in the bale. As the number of rows in the windrow is reduced, the proportion of leaf and husk increases and the proportion of stem decreases, thereby increasing digestibility. It is unclear if an increased proportion of cob falls through the windrow as the number of rows is reduced. However, reducing the proportion of stem also affects the yield of stover harvested from a field. The DM stover yield per acre was reduced from 3,336 lb/acre to 1,188 lb/acre as the rows of stem collected in the bale decreased from 8 to 2. Reducing the proportion of stem in baled residue increases forage digestibility but decreases forage yield harvested from corn fields.

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Effects of Ingestion and Collection Bag Type on Nutrient Composition of Forage Samples from Esophageally Fistulated Cattle

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Summary

Ingestion and mastication of forage samples adds ash. Generally, levels of CP were lower and NDF and IVOMD were similar for post-ingested versus pre-ingested forage. Bag type (screen vs. solid) generally did not affect ash, NDF, or IVOMD. Bag did not affect CP of alfalfa but CP of grass samples from screen bags was lower than solid bags. More fresh than dry forage was recovered through the esophageal opening.

Introduction

Fistulated animals have been used extensively to quantify nutrient intake of grazing animals. This method accounts for the grazing animal's selectivity, which is not accounted for in clipped samples. Several factors inherent to using fistulated cattle may affect the degree to which forage masticate samples actually represent grazed animal diets. Changes in chemical composition of forage collected by this method have been attributed to mastication followed by salivary contamination and nutrient leaching. Salivary contamination and sample preparation technique could influence both the organic and inorganic components of grazed grass samples. Collection bags with screen bottoms have been used since the 1960s and allow for drainage of excess saliva, which speeds sample drying time. Nutrients leach from the forage into the saliva and are lost with the loss of the saliva from the bag. Forages of different quality may be affected to differing degrees. Previous research (*2012 Nebraska Beef Cattle Report,* pp. 49-50) has shown a higher loss of nutrients for fresh forage compared with hay or dormant forage. Therefore, objectives of this study were to compare the nutrient composition of forage fed to cattle with that of masticate samples collected through esophageal fistula and to determine the influence of collection bag type (screen vs. solid) on the nutrient composition of vegetative (FRESH) or dry (HAY) alfalfa or meadow grass masticate samples collected from esophageally fistulated cattle.

Procedure

Ten esophageally fistulated cattle were fitted with either solid (SOL; N = 5) or screen (SCR; N = 5) bottom collection bags. On day 1, cattle were presented with 0.90 lb (DM) grass hay (7.1% CP, 80% NDF) and allowed to completely consume it (15-20 minutes). Masticate was removed from the bag and cattle were then offered 0.38 lb (DM) vegetative grass (15.1% CP, 56% NDF) harvested immediately before being presented to the animals. Both hay and vegetative grass were harvested from the same sub-irrigated meadow and had similar grass species composition. On day 4, cows were offered 0.92 lb (DM) alfalfa hay (19.5% CP, 49% NDF) and allowed to completely consume it (15-20 minutes). Masticate was removed from the bag and cattle were then offered 0.24 lb (DM) fresh alfalfa (19.1% CP, 40% NDF) harvested immediately before presentation. Pre-ingested forage was sub-sampled for chemical analysis. Amount of each forage offered was chosen to ensure the forage would be completely consumed by the animal. No orts remained in the feed pan for any forage. Masticate samples were collected and weighed to calculate percentage of forage offered that was recovered in the collection bag. All masticate and pre-ingested forage samples were immediately frozen and stored until lyophilized. Samples were analyzed for CP, NDF, and IVOMD. Values for CP and NDF were expressed on an OM basis.

Results

No two-way or three-way interactions were present ($P > 0.10$) among bag type (solid vs. screen), forage harvest status (fresh vs. dry), and ingestion status (pre vs. post) within forage type (grass or alfalfa). Ingestion status (pre-ingested (PRE) vs. post-ingested (POST)) affected levels of ash (10.1% vs. 15.0% ash for PRE vs. POST, respectively; $P < 0.001$, Table 1). The higher ash content POST is in agreement with results reported by several others in the refereed literature. The post ingestion increase in ash content of forage samples may be adjusted for by expressing the other chemical components on an organic matter basis. The addition of minerals by the saliva makes samples collected through the esophageal fistula unacceptable for determination of mineral composition of the forage.

Crude protein levels were generally higher for PRE vs. POST ($P < 0.1$, Table 1) but were similar for grass hay (7.6% vs. 7.8% CP for PRE vs. POST, respectively; $P > 0.1$). This is in agreement with previous research (*2012 Nebraska Beef Cattle Report,* pp. 49-50) which reported a larger difference in CP between pre-ingested and post-ingested samples of higher quality than for lower quality forage samples.

Levels of NDF were similar for PRE vs. POST ($P > 0.1$, Table 1) except for fresh alfalfa (43.9% vs. 49.9% NDF for PRE vs. POST respectively;

Table 1. **Nutrient composition of pre-ingested and post-ingested fresh or dry alfalfa or grass.**

	Fresh		Hay			*P*-values		
	Pre	Post	Pre	Post	SE[1]	Type[2]	Ingest[3]	T x I[4]
Alfalfa								
Ash, % DM	9.4^{c}	17.4^{a}	10.6^{c}	14.0^{b}	0.9	0.21	< 0.001	0.01
CP, % OM	21.1^{a}	19.3^{b}	21.8^{a}	19.8^{b}	0.5	0.18	< 0.001	0.85
NDF, % OM	43.9^{c}	49.9^{b}	55.3^{a}	52.7^{ab}	1.5	< 0.001	0.17	0.002
IVOMD, %	68.3^{a}	68.5^{a}	62.0^{b}	63.4^{b}	1.0	< 0.001	0.44	0.61
Grass								
Ash, % DM	13.2^{b}	18.0^{a}	7.1^{d}	10.4^{c}	0.8	< 0.001	< 0.001	0.37
CP, % OM	17.5^{a}	14.8^{b}	7.6^{c}	7.8^{c}	0.2	< 0.001	< 0.001	< 0.001
NDF, % OM	64.8^{b}	62.8^{b}	86.1^{a}	83.3^{a}	1.6	< 0.001	< 0.14	0.81
IVOMD, %	77.8^{a}	76.8^{a}	55.7^{c}	61.1^{b}	0.9	< 0.001	0.004	< 0.001

[1]Standard error of the simple effect mean.
[2]Main effect of forage harvest status.
[3]Main effect of forage ingestion status.
[4]Forage harvest status by ingestion status interaction.
[a-c]Within rows, values with different superscripts differ ($P \leq 0.10$).

Table 2. **Nutrient composition of fresh or dry alfalfa or grass masticate samples collected in screen (SCR) or solid (SOL) bottom bags from esophageally fistulated cattle.**

	Fresh		Hay			*P*-values		
	SCR	SOL	SCR	SOL	SE[1]	Type[2]	Bag[3]	T x B[4]
Alfalfa								
Ash, % DM	14.5^{b}	20.8^{a}	13.5^{b}	14.5^{b}	1.3	0.04	0.02	0.07
CP, % OM	19.4	19.2	19.9	19.7	0.7	0.44	0.71	0.99
NDF, % OM	47.4^{b}	53.1^{a}	52.8^{a}	52.7^{a}	2.4	0.05	0.03	0.40
IVOMD, %	70.0^{a}	66.5^{ab}	63.1^{b}	63.7^{b}	1.9	0.02	0.37	0.34
Grass								
Ash, % DM	18.3^{a}	17.6^{a}	9.7^{b}	11.1^{b}	1.5	0.001	0.81	0.51
CP, % OM	15.0^{a}	14.6^{a}	8.0^{b}	7.6^{b}	0.2	< 0.001	0.02	0.88
NDF, % OM	64.3^{b}	61.2^{b}	83.7^{a}	82.8^{a}	2.9	< 0.001	0.39	0.76
IVOMD, %	77.6^{a}	76.2^{a}	59.5^{b}	62.6^{b}	1.6	< 0.001	0.48	0.25

[1]Standard error of the simple effect mean.
[2]Main effect of forage harvest status.
[3]Main effect of collection bag.
[4]Forage harvest status by collection bag interaction.
[ab]Within rows, values with different superscripts differ ($P \leq 0.10$).

Table 3. **Amount of fresh or dry alfalfa or grass offered to esophageally fistulated cows recovered in collection bag.**

	Fresh		Hay			*P*-values		
	Alfalfa	Grass	Alfalfa	Grass	SE[1]	Type[2]	Forage[3]	T x F[4]
Recovery, % DM	68.2^{a}	63.8^{ab}	53.1^{ab}	48.8^{b}	0.1	0.01	0.43	0.99
Recovery, % OM	74.5^{a}	66.4^{ab}	55.1^{b}	50.4^{b}	0.1	0.01	0.31	0.79

[1]Standard error of the simple effect mean.
[2]Main effect of harvest status (fresh vs. hay).
[3]Main effect of forage (alfalfa vs. grass).
[4]Harvest status by forage interaction.
[ab]Within rows, values with different superscripts differ ($P \leq 0.10$).

$P < 0.1$). Musgrave et al., (*2012 Nebraska Beef Cattle Report*, pp. 49-50) reported an increase in NDF of higher quality forages while lower quality forages remained unchanged. Cell solubles from fresh, vegetative forage may go into solution more rapidly than those of the dry hay, possibly accounting for some of the difference observed.

In general, IVOMD was not affected by ingestion status ($P > 0.1$, Table 1), except for grass hay (55.7% vs. 61.1% IVOMD for PRE vs. POST, respectively; $P = 0.01$).

Bag (SCR vs. SOL) did not affect ash and NDF ($P > 0.1$, Table 2) except for fresh alfalfa (14.5% vs. 20.8% ash; $P = 0.02$ and 47.4% vs. 53.1% NDF; $P = 0.03$ for SCR vs. SOL, respectively). Bag did not affect CP of alfalfa ($P = 0.71$) but did affect grass CP (11.5% vs. 11.1% CP for SCR vs. SOL, respectively; $P = 0.02$). Digestibility was not affected by bag (67.3% vs. 67.6% IVOMD for SOL vs. SCR, respectively; $P > 0.1$).

Forage type (FRESH vs. HAY) influenced the amount of the diet that was recovered through the esophageal opening (70.5% vs. 52.8% OM for FRESH vs. HAY, respectively; $P = 0.01$, Table 3).

Overall, masticate samples of high quality forage were lower in CP, whereas lower quality forage masticate samples were similar to pre-ingested forage values, which agrees with the findings of Musgrave et al., (*2012 Nebraska Beef Cattle Report,* pp. 49-50). Masticate NDF and IVOMD were similar to pre-ingested forage. Ash levels were higher in masticate than pre-ingested forage, likely due to the minerals added in the saliva. Lower recoveries suggest masticate samples may not always be representative, especially when dry forages are being consumed.

These data suggest forage samples collected through the esophageal fistula may underestimate the amount of CP present in high quality forages but be similar to CP levels in mid or low quality forages. In general, masticate samples appear to adequately represent the levels of NDF and IVOMD of forages sampled. Due to increased levels of ash, all values should be reported on an OM basis.

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Feeding Elevated Levels of Corn Silage and MDGS in Finishing Diets

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Summary

A finishing experiment evaluated substitution of corn silage and modified distillers grains with solubles (MDGS) in place of corn. The experimental arrangement was a 2 X 2 + 1 factorial with diets containing 15 or 45% corn silage and 20 or 40% MDGS as well as a control containing 5% cornstalks and 40% MDGS. There were no interactions between corn silage and MDGS inclusion for carcass adjusted performance. As corn silage inclusion increased in the diet, there was a modest reduction in ADG and an increase in F:G. When MDGS inclusion was increased, ADG and F:G were improved. Cattle fed 40% MDGS with 15% corn silage instead of 5% cornstalks had 5% improved F:G.

Introduction

Corn silage in beef finishing diets has been shown to be economical especially in times of high priced corn. It was previously reported (*2013 Nebraska Beef Cattle Report*, pp. 74-75) that when corn silage partially replaced corn in finishing diets containing distillers grains, ADG and feed efficiency were poorer as corn silage inclusion increased in calf-fed steers. However, the depression in feed efficiency was not as dramatic as previously reported with elevated levels of corn silage in diets containing no distillers grains (*2000 Nebraska Beef Cattle Report*, pp. 68-71). Despite poorer F:G, feeding elevated levels of corn silage was economical when fed with MDGS (*2013 Nebraska Beef Cattle Report*, pp. 76-77). The objectives of this experiment were to 1) determine the performance effects and carcass characteristics of feeding elevated levels of corn silage and the impact of dietary inclusion of MDGS and 2) assess the feeding values of corn silage and MDGS relative to corn.

Procedure

Crossbred yearling steers (766 ± 60 lb) were sorted into three weight blocks and assigned randomly to 25 pens (9 steers/pen). Treatments were designed as a 2 X 2 + 1 factorial arrangement consisting of 15% or 45% corn silage and 20% or 40% MDGS (15:20 - 15% corn silage, 20% MDGS; 15:40 - 15% corn silage, 40% MDGS; 45:20 - 45% corn silage, 20% MDGS; and 45:40 - 45% corn silage, 40% MDGS) and a control diet consisting of 5% cornstalks and 40% MDGS (Table 1). Elevated levels of corn silage and MDGS replaced a 1:1 blend of dry-rolled corn:high-moisture corn. All steers were fed a supplement formulated for 30 g/ton Rumensin® (DM basis) and a targeted intake of 90 mg/steer daily of Tylan®. Steers were implanted with Revalor-XS on day 1. One block (5 pens) of steers was harvested after 134 days on feed. Two blocks (20 pens) were harvested after 148 days on feed. Prior to being transported to a commercial abattoir (Greater Omaha Packing Co., Inc., Omaha, Neb.), pens of steers were weighed on a platform scale. A 4% pencil shrink was applied to this weight for final live BW and calculation of dressing percentage. Hot carcass weight was obtained the day of harvest. Carcass adjusted final BW, used in calculation of ADG and F:G, was calculated from HCW and a common dressing percentage (63%). Marbling score, 12th rib fat thickness, and LM area were recorded after a 48 hour carcass chill.

Performance and carcass data were analyzed as a 2 X 2 + 1 factorial in a randomized block design using the mixed procedure of SAS (SAS Institute, Inc., Cary, N.C.). Pen was the experimental unit and BW block was included as a fixed effect. Main effects of corn silage and MDGS inclusion were tested, as well as the interaction of corn silage and MDGS. There were no interactions for any of the tested variables; therefore, the interaction term was taken out of the statistical model. The control was compared to all treatments using an overall F-test across all treatments. Treatment differences were considered significant at $P < 0.10$.

Table 1. Diet composition (DM basis) fed to finishing yearlings.

	Treatment[1]				
	Control	15:20	45:20	15:40	45:40
Dry-rolled corn	25.5	30.5	15.5	20.5	5.5
High-moisture corn	25.5	30.5	15.5	20.5	5.5
Corn silage	0.0	15.0	45.0	15.0	45.0
Cornstalks	5.0	0.0	0.0	0.0	0.0
MDGS[2]	40.0	20.0	20.0	40.0	40.0
Supplement[3]	4.0	4.0	4.0	4.0	4.0

[1]15:20 = 15% corn silage, 20% MDGS; 15:40 = 15% corn silage, 40% MDGS; 45:20 = 45% corn silage, 20% MDGS; 45:40 = 45% corn silage, 40% MDGS.
[2]MDGS= Modified distillers grains with solubles.
[3]Formulated for 30g/ton of DM Rumensin and to provide 90 mg/steer daily Tylan.

Table 2. Effect of corn silage and modified distillers grains with solubles (MDGS) inclusion on cattle performance and carcass characteristics.

	Treatment[1]					SEM	*P*-value[2]			
	Control	15:20	45:20	15:40	45:40		F-test	Int.	Silage	MDGS
Performance										
Initial BW, lb	767.5	767.6	765.6	763.7	766.5	1.8	0.51	0.18	0.85	0.40
Final BW, lb[3]	1396	1387	1374	1405	1379	9.6	0.18	0.41	0.01	0.12
DMI, lb/day	27.2	26.1	26.9	26.4	26.7	0.3	0.13	0.41	0.07	0.86
ADG, lb[3]	4.32	4.26	4.19	4.42	4.22	0.06	0.11	0.18	0.01	0.06
Feed:Gain[3]	6.28[bc]	6.13[ab]	6.42[c]	5.98[a]	6.33[c]	0.002	<0.01	0.61	<0.01	0.07
Live final BW, lb	1422	1425	1418	1437	1411	9.0	0.35	0.20	0.04	0.75
Carcass Characteristics										
HCW, lb	879	874	866	885	869	6.0	0.18	0.41	0.01	0.12
Dressing percentage, %	61.9	61.3	61.1	61.6	61.6	0.2	0.22	0.54	0.51	0.08
LM area, in^2	13.0	13.1	13.1	13.0	12.7	0.21	0.62	0.39	0.38	0.15
12th-rib fat, in	0.66	0.63	0.63	0.70	0.63	0.03	0.43	0.27	0.25	0.26
Calculated YG	3.81	3.72	3.69	3.96	3.83	0.12	0.54	0.66	0.43	0.09
Marbling score[4]	451	437	455	459	432	17.4	0.74	0.12	0.74	0.99

[1]Control = 5% cornstalks, 40% MDGS; 15:20 = 15% corn silage, 20% MDGS; 15:40 = 15% corn silage, 40% MDGS; 45:20 = 45% corn silage, 20% MDGS; 45:40 = 45% corn silage, 40% MDGS.
[2]F-test= *P*-value for the overall F-test of all diets. Int. = *P*-value for the interaction of corn silage X MDGS. Silage = *P*-value for the main effect of corn silage inclusion. MDGS = *P*-value for the main effect of MDGS inclusion.
[3]Calculated from hot carcass weight, adjusted to a common 63% dressing percentage.
[4]Marbling score: 400 = Small00, 500 = Modest00
[a-c]Within a row, values lacking common superscripts differ ($P < 0.10$).

Results

There were no interactions between corn silage X MDGS inclusion for any of the tested variables ($P \geq 0.12$; Table 2). Steers fed 45% corn silage instead of 15% had slightly greater DMI (26.8 vs. 26.3; $P = 0.07$) and decreased ADG (4.21 vs. 4.34; $P = 0.01$). This translated to steers fed 45% corn silage being 5.2% less efficient in comparison to steers fed 15% corn silage (6.37 vs. 6.05; $P < 0.01$). The 30% substitution of corn silage for corn (1:1 blend of high-moisture corn:dry-rolled corn) in this experiment resulted in a calculated feeding value for corn silage of 83% of the corn blend. Carcass adjusted final BW and hot carcass weight was 19.3 and 12.2 lb less, respectively, for steers fed 45% corn silage ($P = 0.01$). Unexpectedly, dressing percentage was not different between silage inclusion levels ($P = 0.51$). All other carcass characteristics were similar across corn silage levels ($P > 0.25$).

There was no difference in DMI when steers were fed 20 or 40% MDGS ($P = 0.12$). When MDGS was increased in the diet from 20% to 40%, ADG was increased from 4.22 to 4.32 lb/day ($P = 0.06$). Steers fed 40% MDGS compared to 20% MDGS were 2.3% more efficient, with steers fed 40% MDGS having a F:G of 6.42 in comparison to a F:G of 6.28 for steers fed 20% MDGS ($P = 0.07$). The feeding value for the 20% substitution of MDGS for corn (1:1 blend of high-moisture corn:dry-rolled corn) in this experiment resulted in a calculated feeding value of 110% of corn for MDGS. This feeding value agrees well with previously reported feeding values for MDGS for the 20% substitution of corn between inclusion levels of 20% and 40% MDGS. There was no statistical difference in carcass adjusted final BW ($P = 0.12$) between MDGS levels; however, there was a numerical increase of 11.4 lb for cattle fed 40% in comparison to 20% MDGS. There was a slight increase in dressing percentage and calculated yield grade for cattle fed 40% MDGS in comparison to 20% MDGS ($P = 0.08$ and 0.09, respectively). There were no differences in other carcass characteristics for cattle fed 20 or 40% MDGS ($P \geq 0.15$).

The control treatment (5% cornstalks and 40% MDGS) was compared with all other treatments in the overall F-test. There were no differences in DMI, ADG, or final BW across all treatments ($P > 0.11$). Steers fed the control diet had 5.0% poorer F:G compared to steers fed the 15:40 treatment ($P < 0.01$), but similar F:G compared to the 15:20, 45:20, and 45:40 treatments ($P \geq 0.15$). Using the F-test statistics, steers fed the 15:40 treatment had similar F:G as steers fed 15:20, but improved F:G compared to all other treatments ($P < 0.01$). There were no differences in carcass characteristics according to the overall F-test ($P \geq 0.18$).

In contrast to our hypothesis, results from this study do not suggest additive synergy from elevated levels of both MDGS and corn silage. MDGS included as low as 20% of the diet may promote a more positive rumen environment compared to diets containing no MDGS. As corn silage inclusion increased in the diet, there was a modest reduction in ADG and an increase in F:G. When MDGS inclusion was increased, ADG and F:G were improved. Cattle fed 40% MDGS with the roughage source of 15% corn silage instead of 5% cornstalks had improved F:G.

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The Effects of Corn Price, Shrink, and Harvest Moisture on Corn Silage Economics

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Summary

Economic assumptions were applied to corn production to set corn silage prices for breakeven corn production, whether harvested for corn grain or corn silage. Price levels were used for the calculation of returns per finished steer as corn silage inclusion increased in finishing diets containing distillers grains. As corn price increased, the economics of feeding elevated concentrations of corn silage became more favorable. The economic importance of shrink and harvest moisture content were assessed. As corn price increases and the inclusion of corn silage increases, corn silage management decisions have greater economic importance.

Introduction

Corn silage has been shown to be an economical partial replacement of corn in finishing diets, especially when corn price is high. Although ADG and F:G get poorer with elevated concentrations of corn silage in finishing diets containing distillers grains, economic benefits were demonstrated with elevated concentrations of corn silage in our lab. However, economic outcomes are the result of price scenarios assumed for corn silage, and corn silage pricing is complex. Therefore, the objective of this dataset was to determine corn silage pricing scenarios that would allow for crop producers to price corn silage at a price level that would be breakeven compared to harvesting corn grain. Then, using these corn silage prices and cattle performance reported previously in *2013 Nebraska Beef Cattle Report*, pp. 74-75, assess the economics of cattle finishing with corn priced at \$3.50, \$4.50, and \$5.50/bu. Another objective was to calculate economic outcomes when varying corn silage shrink and harvested moisture content.

Procedure

Corn grain and corn silage harvesting costs were based on data from *2014 Nebraska Farm Custom Rates–Part II* (EC826) published by UNL Extension. Combining corn charges (including tractor and auger cart) were assumed at \$36.28/ac and a yield of 200 bu/ac corn for a calculated per bushel harvesting costs of \$0.181. Transportation charges from field to feedyard storage location were assumed at \$0.11/bu (assuming fields were in close proximity to the feedyard since they could potentially be harvested as corn silage). Drying grain for storage was assumed to be needed to remove two percentage points of moisture. Drying charges were \$0.05/bu per point of moisture removed for a total drying cost of \$0.10/bu. It was assumed that harvest, drying, and storage losses were 2.5%. When all harvest, transportation, drying, and storage costs were removed from the per bushel price of corn at the feedyard, a value of corn grain standing in the field was calculated. Harvesting and transportation costs remained constant as corn price changed. We also assumed purchase of the grain by the feedyard at harvest time and, consequently, no storage costs of the grain. Corn silage chopping, hauling, filling, and packing bunker charges were assumed at the rate of \$9.85/as-is ton of corn silage (up from \$8.13/as-is ton in 2012). The dry matter content of the corn silage would affect the dry matter harvesting costs of corn silage. When harvesting corn silage at 32% DM, \$9.85/as-is ton would equate to \$30.78/ton of corn silage on a DM basis; however, if corn silage was harvested at higher DM content, the harvest cost per DM ton of corn silage would decrease. Harvesting at 42% DM corn silage, the harvest cost would calculate to \$23.45/ton of corn silage on a DM basis.

Fertilizer value of stover removed with corn silage was calculated from values determined from the NRC (2001). Corn grain CP, P, and K concentration data (approximately 3,500 samples) were used to calculate the amount of N, P, and K contained in a ton (DM) of corn grain. This was also done for corn silage nutrient concentration data (approximately 32,000 samples). The amount of fertilizer nutrients removed from harvesting corn silage instead of corn grain was then assessed using a partial budget approach taking into account only nutrients removed with corn stover. These values were 11.4 lb of N, 1.1 lb of P, and 22.0 lb of K per ton of corn silage (DM) removed. To re-emphasize, these are calculated nutrients coming from the stover fraction (partial budget approach) of the corn silage and would not be representative of the total amount of nutrients removed from corn silage harvest. These potential fertilizer sources were then valued at \$0.37/lb of N (assuming \$600/ton for anhydrous ammonia), \$1.04/lb of P (assuming \$550/ton for DAP and valuing the 18% N contained in DAP at \$0.37/lb of N), and \$0/lb of K_2O (assuming adequate potassium soil levels; UNL Extension publication EC117, *Fertilizer Suggestions for Corn*). When calculated on a per acre basis, the stover removed from corn silage harvesting would remove \$40.21 per acre in fertilizer value using calculations based on 200 bu/ac assumed corn grain yields. Although in these calculations this fertilizer value was charged against the cost of the corn silage, in an integrated feedlot/crop system that applies cattle manure onto corn silage ground, the value of this nutrient removal would be a lower charge against the corn silage price and even potentially a benefit as more manure nutrients would be allowed to be applied back in the system.

The corn kernel has not reached physiological maturity or maximum DM accumulation at the time of most corn silage harvest. Due to this, the

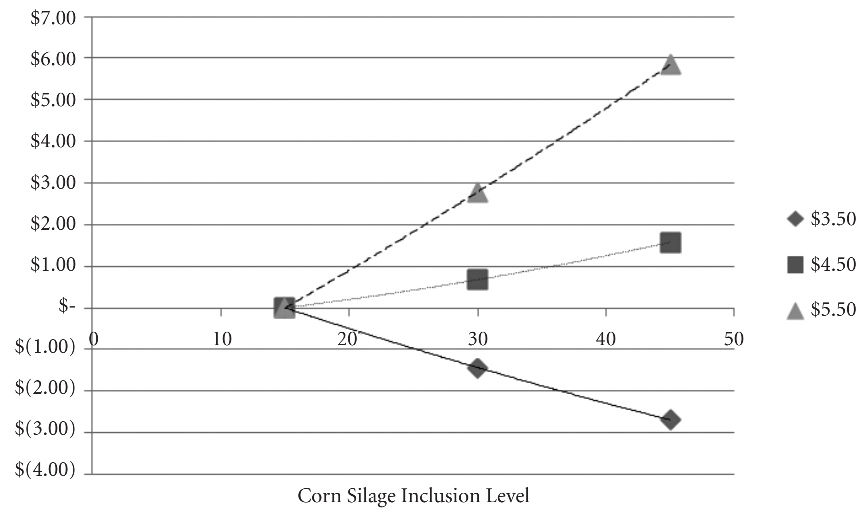

Figure 1. Effect of corn price ($/bu) on per steer returns from feeding elevated concentrations of corn silage in finishing diets containing 40% modified distillers grains with solubles.

yield of corn grain has not been maximized at the time of corn silage harvest. To account for this "yield drag" with corn silage harvest, corn silage was separated into grain and stover fractions. The stover fraction yield was assumed to stay constant across harvest DM concentrations. The stover fraction yield was equal to the amount of corn stover in corn silage from corn silage harvested at 35% DM and containing 51.86% corn grain ((200 bu/ac – (200 bu/ac * 16.9% grain yield drag) * 84.5% grain DM * 56 lb/bu) / 51.86% grain to stover ratio)) – (200 bu/ac – (200 bu/ac * 16.9% grain yield drag) * 84.5% grain DM * 56 lb/bu). The corn grain fraction within corn silage was determined from corn grain yield in bu/ac * "yield drag constant" (i.e., 200 bu/ac * 16.9% "yield drag constant for harvesting at 35% corn silage DM content" * 56 lb/bu * 84.5% grain DM; this scenario would yield 7,864 DM lb of corn grain at corn silage harvest time from 200 bu/ac corn at corn grain harvest time). Data from hand-harvested commercial corn grain yield trials (conducted in 2011 and 2012) were compiled for determination of a regression line and yield drag constants between corn silage dry matter content and corn grain yield drag from harvesting immature corn kernels.

Corn silage price per ton on a DM basis was calculated, and these values were then utilized to calculate returns per fed steer based off recent performance results, where 15, 30, or 45% corn silage was utilized in diets containing 40% distillers grains (*2013 Nebraska Beef Cattle Report*, pp. 74-75). Feedlot performance was adjusted in the analysis of different corn silage harvest DM. This was done by regressing the original performance data against the amount of corn silage roughage in the diet (assuming the corn silage fed in the performance study contained a stover concentration of 48.14%). As the harvest DM content of the corn silage increased, the proportion of corn grain contained in that silage increased (thereby increasing the amount of corn grain in the diet) and the feedlot performance improved by that difference in corn level in the diet. Due to the effect of variable carcass weight across treatments, DOF were adjusted on a pen basis so that all pens were fed to a constant average carcass weight of 866 lb (DOFc). Initial purchase cost was calculated using average initial weight of a pen multiplied by an initial price/lb determined to achieve a breakeven or net return of $0/head for the 15% corn silage control treatment at the different corn prices evaluated. Cattle interest charges were calculated as 7.5% interest * (purchase price-$200/steer for down payment) * (DOFc/365). Corn (1:1 blend of DRC and HMC) was charged an additional $2.85/ton (DM) for the cost of corn processing. Corn silage was priced at methods outlined above. Modified distillers grains with solubles feed costs were calculated as 90% the price of corn on a DM basis FOB the feedyard. Supplement was assumed to be equal to the price of corn on a DM basis. A pencil shrink was applied to all ingredients—1% was used for corn and supplement, 5% for MDGS, and 10% for corn silage—in the economic models assessing the effects of corn grain price on returns per steer and the effects of harvest moisture on returns per steer. Feed costs were determined by using diet DM costs * DMI * DOFc. A feed interest charge of 7.5% for one half of total feed charges was used. Processing and medicine charges were assumed at $20/steer. Yardage was calculated as $0.45/head/day utilizing DOFc. Cost of gain calculations included yardage, processing and medicine, and total feed costs (feed and feed interest charges). A sale price of $2.25/lb * 866 lb or $1,952.50/steer was used for all cattle. Profit per head was calculated as sales price – initial purchase cost (including cattle interest charges) – total feed costs – processing and medicine – yardage – 1% calculated death loss.

Results

The effect of corn price on per steer returns from feeding elevated concentrations of corn silage in 40% MDGS finishing diets are presented in Figure 1. As corn price increased, it becomes more economically appealing for cattle feeders to feed more corn silage in the diet. Utilizing corn silage pricing assumptions outlined above and corn priced at $3.50, $4.50, or $5.50/bu (leaving all other cost assumptions the same across corn price levels), corn silage would be priced into the bunker (i.e., breakeven for the crop producer producing either corn grain or corn silage and without corn silage shrink) at $39.59/as-is (35%DM) ton, $48.59/as-is ton, and $57.60/as-is ton at corn prices of $3.50, $4.50, and $5.50/bu, respectively. The breakeven amount for the crop producer selling corn silage standing in the field (feedyard pays harvesting costs) to the feedyard would be $29.74/as-is (35% DM) ton, $38.78/as-is ton, and $47.75/as-is ton

(Continued on next page)

when corn is priced at $3.50, $4.50, and $5.50/bu (respectively). The corn grain price level that would allow for break-even returns across corn silage concentrations is approximately $4.15/bu, or above $4.15/bu corn price, it becomes economical to feed elevated concentrations of corn silage utilizing a scenario in which the corn silage is harvested at 35% DM and with 10% shrink losses. The increased value from corn silage as corn price is increased is mainly due to corn silage harvest costs being a lesser proportion and the actual feed value being a larger proportion of the total costs of corn silage.

The effects of corn silage shrink on per steer returns from feeding elevated concentrations of corn silage in 40% MDGS finishing diets are presented in Figure 2. Controlling shrink of corn silage via proper harvest moisture and packing density, incorporating sealing strategies, and appropriate feedout management is strongly recommended based on economic outcomes. Reducing shrink from 20% to 10% would save $5.60, $11.54, and $17.84 per steer when corn is priced at $4.50/bu and corn silage is fed at 15%, 30%, or 45% of the diet, respectively.

Dry matter content of corn silage at harvest time affects the amount of corn grain harvested and silage energy content. The more immature the corn plant is harvested for corn silage, the less total amount of corn grain is harvested. From data compiled from our lab, scenarios were set up for harvesting corn silage at 32%, 35%, and 42% DM with corresponding corn grain yield drags of 22.2%, 16.9%, and 7.4% (which would be somewhat higher than past literature). Shrink was held constant at 10% across corn silage harvest dry matter content; however, it could be speculated that shrink would be increased at harvested DM contents below 30% DM and above 40% DM, but few data are available to document these shrink changes so shrink was kept at a constant value (Figure 3). Calculated net returns per steer for harvesting corn silage at 35% instead of 32% DM were $2.58, $5.33, and $8.28 per steer at corn silage inclusions of 15%, 30%, or 45% of the diet (respectively). These economic data emphasize the importance of not harvesting corn silage too early resulting in reduced corn silage yield with the potential of harvesting corn silage at higher dry matter content if shrink can be managed. If shrink can be managed when harvesting corn silage at 42% DM by proper packing, sealing, and oxygen exclusion strategies, then the price point of corn grain that it becomes economical to feed increased concentrations of corn silage is approximately $2.50/bu.

These data suggest that there is an economic incentive to feeding elevated concentrations of corn silage with distillers grains. The economic incentives are increased when corn price is elevated. These data emphasize the economic importance of proper harvesting and storage of corn silage to minimize shrink, as well as the economic consequence of harvesting corn silage at lower dry matter concentrations. As corn price is increased and the inclusion of corn silage is increased in finishing diets, corn silage management decisions have greater economic importance.

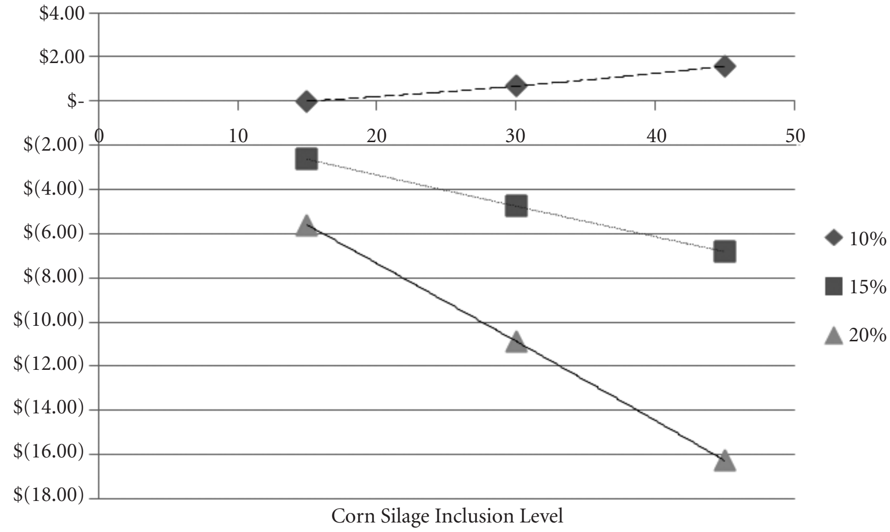

Figure 2. **Effect of corn silage shrink on per steer returns from feeding elevated concentrations of corn silage in finishing diets containing 40% modified distillers grains with solubles.**

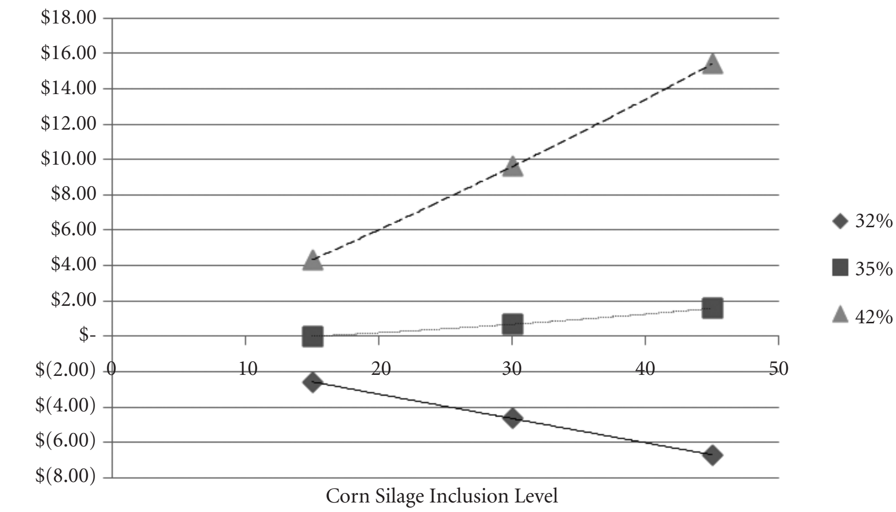

Figure 3. **Effect of corn silage DM content at harvest on per steer returns from feeding elevated concentrations of corn silage in finishing diets containing 40% modified distillers grains with solubles.**

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Evaluation of Rumen Metabolism and Digestibility of Corn Silage and MDGS Finishing Diets

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Summary

A metabolism experiment was conducted to evaluate rumen pH, digestibility, and in situ *nutrient disappearance in steers fed either a diet containing 95% corn silage or diets containing 15 or 45% corn silage and 20 or 40% modified distillers grain with solubles (MDGS). Steers fed 45% compared to 15% corn silage had increased ruminal pH, DMI, NDF intake, and NDF digestibility. Decreased DM and OM digestibility were observed in diets containing 40% MDGS compared to 20%. Disappearance of corn bran NDF was increased in diets containing 45% corn silage. These results imply enhanced fiber digestibility as diets increased in corn silage.*

Introduction

The use of corn silage in beef finishing diets has been shown to be economical in times of high priced corn. In three experiments (*2013 Nebraska Beef Cattle Report*, pp. 74-75; *2014 Nebraska Beef Cattle Report*, pp. 88-89; *2015 Nebraska Beef Cattle Report*, pp. 66-67) with corn silage inclusions of 15% to 45% of the diet in finishing diets containing distillers grains, ADG and F:G were poorer as corn silage inclusion increased. In these experiments with diets containing MDGS, corn silage had a calculated feeding value of approximately 83% that of corn, which is far greater than the 48% feeding value for corn silage calculated from performance for steers fed 15 to 45% corn silage in diets without distillers grains (*2000 Nebraska Beef Cattle Report*, pp. 68-71). As well, economic analysis has determined that despite poorer F:G, feeding increased concentrations of corn silage in the diet was economical when fed with MDGS in times of high priced corn (*2015 Nebraska Beef Cattle Report*, pp. 68-70). The objective of this trial was to compare digestibility and rumen metabolism of finishing diets containing corn silage and MDGS as partial replacements for corn grain.

Procedure

Six ruminally fistulated steers were used in a 5 × 6 latin rectangle experiment to determine diet digestibility of 5 diets. Steers were assigned randomly to five, 21-day periods. Periods consisted of a 15-day adaptation period and a 6-day collection period. Treatments were designed as a 2 × 2 + 1 factorial arrangement consisting of 15% or 45% corn silage and 20% or 40% MDGS (15:20 - 15% corn silage, 20% MDGS; 15:40 - 15% corn silage, 40% MDGS; 45:20 - 45% corn silage, 20% MDGS; and 45:40 - 45% corn silage, 40% MDGS) and a control diet consisting of 95% corn silage (Table 1). Elevated concentrations of corn silage and/or MDGS replaced dry-rolled corn. Diets were mixed twice weekly and stored in a cooler (32°F) to ensure fresh feed. All steers were fed a supplement formulated for 30 g/ton Rumensin (DM basis) and a targeted daily intake of 90 mg of Tylan. Urea was included at 1.66% (DM basis) in the control diet, 0.50% in diets containing 20% MDGS, and none for diets containing 40% MDGS.

Titanium dioxide was dosed at 5 g/steer twice daily at 0800 and 1600 hours for seven days before and during the collection period. Fecal grab samples were collected at 0800, 1200, and 1600 hours during day 1-5 of the collection period. Fecal samples were composited on a wet basis into daily composites and then freeze-dried. From daily composites, a steer within period fecal sample composite was prepared and subsequently analyzed for NDF, OM, and Ti concentration. Ruminal pH was recorded every minute using wireless pH probes (Dascor, Inc.; Escondido, Calif.) from day 1 to 5 of the collection period. Feeds offered and refused were analyzed for DM, OM, and NDF percentage. Dry matter of feed ingredients and orts were determined using a forced-air oven at 60°C for 48 hours.

An *in situ* study was conducted concurrently. Dacron bags (Ankom Techology, Fairport, NY) were filled with 1.25 g of as-is dry corn bran, dry-rolled corn (DRC), or corn silage. Four bags per feedstuff were placed in mesh bags and incubated in the ventral rumen of each of the 6 steers for incubation time periods of 24 and 36 hours. Bags were incubated

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Table 1. Diet composition (DM basis).

	Treatment[1]				
	Control	15:20	45:20	15:40	45:40
Dry-rolled corn	0.0	60.0	30.0	40.0	10.0
Corn silage	95.0	15.0	45.0	15.0	45.0
MDGS[2]	0.0	20.0	20.0	40.0	40.0
Supplement[3]	5.0	5.0	5.0	5.0	5.0

[1]15:20 = 15% corn silage, 20% MDGS; 15:40 = 15% corn silage, 40% MDGS; 45:20 = 45% corn silage, 20% MDGS; 45:40 = 45% corn silage, 40% MDGS.
[2]MDGS= Modified distillers grains with solubles.
[3]Three supplements were formulated for 30g/ton of DM Rumensin® and to provide a targeted daily intake of 90 mg/steer Tylan®. In the control diet, 1.66% urea was included in the diet. In diets containing 20% MDGS, 0.50% urea was included in the diet. No urea was included in diets containing 40% MDGS.

Table 2. Effect of corn silage and modified distillers grains with solubles (MDGS) inclusion on intake and digestibility of nutrients.

	Treatment[1]						*P*-value[2]			
	Control	15:20	45:20	15:40	45:40	SEM	F-test	Int.	Silage	MDGS
DM intake, lb/day	16.12[c]	21.59[b]	24.78[a]	22.02[b]	23.32[ab]	1.59	<0.01	0.40	0.07	0.69
DM digestibility, %	61.63[c]	72.52[a]	71.62[a]	70.42[ab]	66.78[b]	2.08	<0.01	0.47	0.10	0.04
OM intake, lb/day	15.08[c]	20.59[b]	23.37[a]	20.83[b]	21.82[ab]	1.51	<0.01	0.40	0.11	0.57
OM digestibility, %	64.89[c]	74.07[a]	73.57[a]	72.85[ab]	69.58[b]	2.08	0.02	0.46	0.15	0.09
NDF intake, lb/day	6.24[b]	4.44[d]	7.18[a]	5.40[c]	7.69[a]	0.48	<0.01	0.48	<0.01	0.03
NDF digestibility, %	39.86[c]	52.66[ab]	56.56[a]	49.72[b]	55.87[a]	2.98	<0.01	0.51	0.06	0.37

[1]Control = 95% corn silage; 15:20 = 15% corn silage, 20% MDGS; 15:40 = 15% corn silage, 40% MDGS; 45:20 = 45% corn silage, 20% MDGS; 45:40 = 45% corn silage, 40% MDGS.
[2]F-test = *P*-value for the overall F-test of all diets. Int. = *P*-value for the interaction of corn silage X MDGS. Silage = *P*-value for the main effect of corn silage inclusion. MDGS = *P*-value for the main effect of MDGS inclusion.
[a-c]Within a row, values lacking common superscripts differ ($P < 0.10$).

at different times and all bags were removed at the same time (0800 hours on day 6 of the collection period). Two nonincubated bags (0 hour) were also prepared for each sample. *In situ* bags containing DRC were rinsed with distilled water and dried at 60°C for 24 hour and then weighed for determination of DM disappearance. Neutral detergent fiber disappearance was determined for *in situ* bags containing corn bran and corn silage by refluxing bags in neutral detergent solution using the ANKOM ²⁰⁰ Fiber Analyzer (Ankom Technology). Dry matter disappearance of DRC and NDF disappearance of corn bran and corn silage within each dietary treatment was calculated by subtracting remaining residue of each sample (24 and 36 hours) from the initial value (0 hour).

Digestibility data were analyzed as a Latin rectangle using the mixed procedure of SAS (SAS Inst., Inc., Cary, N.C.) with period and treatment as fixed effects and steer as a random effect. Main effects of corn silage and MDGS inclusion and the interaction between corn silage and MDGS inclusion were also tested. The interaction was removed from the model due to lack of significance ($P > 0.10$). The mixed procedure of SAS was used for *in situ* data analysis with fixed effects of treatment, time of incubation (24 or 36 hours), and the treatment x time interaction. *In situ* bag was the experimental unit. Steer and steer x treatment were used as random effects in the *in situ* analysis. Ruminal pH data were analyzed as repeated measures using the GLIMMIX procedure with days as the repeated measure, treatment as a fixed effect, and steer as a random effect. Main effects of corn silage and MDGS inclusion and the interaction between corn silage and MDGS inclusion were also tested. To compare to the 95% silage control diet, means across all diets were separated with the pdiff option when the F-test was significant ($P < 0.10$).

Results

There were no corn silage concentration × MDGS concentration interactions for intake and total tract digestibility data ($P \geq 0.40$; Table 2). For the main effect of corn silage inclusion, steers fed 45% corn silage compared to 15% corn silage had increased DMI ($P = 0.07$) and NDF intake (NDFI; $P < 0.01$). There was a tendency for increased OM intake (OMI; $P = 0.11$), decreased DM digestibility (DMD; $P = 0.10$), and decreased OM digestibility (OMD; $P = 0.15$) for steers fed 45% corn silage compared to 15% corn silage. However, NDF digestibility (NDFD; $P = 0.06$) was improved as corn silage increased from 15% to 45%. For the main effect of MDGS inclusion, there were greater DMD ($P = 0.04$) and OMD ($P = 0.09$) and decreased NDFI ($P = 0.03$) for diets containing 20% MDGS compared to diets containing 40% MDGS; there were no differences in DMI ($P = 0.69$), OMI ($P = 0.57$), or NDFD ($P = 0.37$) when steers were fed either 20 or 40% MDGS.

When comparing across all treatments, DMI and OMI was greatest for steers fed 45:20 or 45:40, with steers fed 15:20 and 15:40 being intermediate and not different from 45:40; steers fed the control diet had the lowest DMI and OMI ($P < 0.01$). Digestibility of DM and OM was greatest for 15:20, 15:40, and 45:40; with steers fed 45:40 being intermediate and not different from 15:40; the 95% corn silage control diet had the lowest digestibility of DM and OM compared to all other treatments ($P \leq 0.02$). Intake of NDF was greatest for diets 45:20 and 45:40 ($P < 0.01$). Steers fed the control diet had increased NDFI compared to steers fed 15:20 or 15:40; steers fed the 15:20 diet had the least NDFI ($P < 0.01$). Digestibility of NDF ($P < 0.01$) was greatest for 15:20, 45:20, and 45:40; steers fed 15:40 were intermediate and not different from 15:20. Steers fed the control diet had the lowest NDF digestibility ($P < 0.01$), most likely due to corn silage NDF being less digestible than NDF coming from distillers grains or corn.

There was an interaction between corn silage concentration and MDGS concentration for average ruminal pH ($P = 0.06$; Table 3). When diets contained 15% corn silage, average ruminal pH was slightly decreased as MDGS was increased from 20 to 40% of the diet; however in diets containing 45% corn silage, average ruminal pH increased when MDGS increased from 20 to 40% of the diet. There were no interactions between corn silage concentration and MDGS concentration for maximum or minimum ruminal pH ($P \geq 0.15$). As forage:concentrate ratio is increased in ruminant diets, ruminal pH is usually increased due to less fermentable

Table 3. Effect of corn silage and modified distillers grains with solubles (MDGS) inclusion on pH measurements.

	Treatment[1]						*P*-value[2]			
	Control	15:20	45:20	15:40	45:40	SEM	F-test	Int.	Silage	MDGS
Maximum pH	7.25[a]	6.64[bc]	6.86[b]	6.50[c]	6.94[ab]	0.19	<0.01	0.15	<0.01	0.62
Average pH	6.73[a]	5.69[cd]	6.02[bc]	5.65[d]	6.28[b]	0.19	<0.01	0.06	<0.01	0.12
Minimum pH	5.96[a]	5.01[c]	5.23[bc]	5.06[c]	5.45[b]	0.14	<0.01	0.29	<0.01	0.05

[1]Control = 95% corn silage; 15:20 = 15% corn silage, 20% MDGS; 15:40 = 15% corn silage, 40% MDGS; 45:20 = 45% corn silage, 20% MDGS; 45:40 = 45% corn silage, 40% MDGS.
[2]F-test = *P*-value for the overall F-test of all diets. Int. = *P*-value for the interaction of corn silage X MDGS. Silage = *P*-value for the main effect of corn silage inclusion. MDGS = *P*-value for the main effect of MDGS inclusion.
[a-d]Within a row, values lacking common superscripts differ ($P < 0.10$).

Table 4. Effect of corn silage and MDGS inclusion on corn DM disappearance and corn silage and corn bran NDF disappearance.

	Treatment[1]						*P*-value[2]			
	Control	15:20	45:20	15:40	45:40	SEM	F-test	Int.	Silage	MDGS
Corn bran, % NDFD[3]										
24 hours	41.36[bcde]	36.12[ef]	42.77[cde]	39.52[df]	48.60[bcd]	4.28	0.11	0.73	0.04	0.32
36 hours	59.81[a]	42.17[bcd]	50.82[ab]	43.74[bce]	56.52[a]					
Corn silage, % NDFD										
24 hours	39.72	45.38	35.22	38.96	45.52	11.30	0.98	0.61	0.96	0.81
36 hours	51.16	47.62	40.81	44.55	53.61					
Corn, % DMD[4]										
24 hours	62.05[g]	73.78[ef]	77.72[cdef]	74.06[def]	79.52[bde]	2.83	<0.01	0.93	0.09	0.99
36 hours	71.95[f]	81.11[abcd]	85.43[ab]	80.60[abc]	83.14[ac]					

[1]Control = 95% corn silage; 15:20 = 15% corn silage, 20% MDGS; 15:40 = 15% corn silage, 40% MDGS; 45:20 = 45% corn silage, 20% MDGS; 45:40 = 45% corn silage, 40% MDGS.
[2]F-test = *P*-value for the overall F-test of all diets. Int. = *P*-value for the interaction of corn silage X MDGS. Silage = *P*-value for the main effect of corn silage inclusion. MDGS = *P*-value for the main effect of MDGS inclusion.
[3]Interaction between treatment and time point ($P = 0.03$).
[4]Interaction between treatment and time point ($P = 0.02$).
[a-g]Within each dependant variable, values lacking common superscripts differ ($P < 0.10$).

substrate. In this experiment, as corn silage was increased from 15 to 45%, maximum and minimum pH were increased ($P < 0.01$). When MDGS was increased in the diet from 20 to 40%, there was an increase in minimum ruminal pH ($P = 0.05$), but no difference in maximum ruminal pH ($P = 0.62$). As expected, when the control diet was fed, average and minimum ruminal pH were greater than all other treatments ($P < 0.01$). The control diet maximum pH was not different from 45:40 but was greater than all other treatments ($P < 0.01$).

For the *in situ* disappearance results, a treatment x time interaction was observed for NDF disappearance of corn bran ($P = 0.03$; Table 4). At an incubation period of 24 h, there was increased NDF disappearance of corn bran in 45:40 compared to 15:20 ($P = 0.05$). All other treatment comparisons were not different ($P > 0.10$). At 36 hours, steers fed the control diet and 45:40 had increased ruminal NDF disappearance of corn bran compared to 15:20 and 15:40 ($P \leq 0.02$); however, the control diet and 45:40 were not different for NDF disappearance of corn bran from 45:20 ($P \geq 0.15$). There was no corn silage concentration × MDGS concentration interaction for NDF disappearance of corn bran ($P = 0.73$). Increased corn silage in the diet resulted in increased disappearance of NDF from corn bran ($P = 0.04$).

There was no interaction between treatment and time for NDF disappearance of corn silage ($P = 0.89$). There were no differences between treatments for *in situ* NDF disappearance of corn silage ($P = 0.23$). As corn silage was increased in the diet, DM disappearance of corn increased ($P = 0.09$); however MDGS concentration did not affect DM disappearance of corn ($P = 0.99$). For DM disappearance of corn, there was no interaction observed between diet and time of incubation ($P = 0.32$). Diets containing 45% corn silage had the greatest corn DM disappearance, 15% corn silage diets being intermediate, and the control diet had the lowest corn DM disappearance ($P < 0.01$).

Maximum digestion of feed occurs when the rumen environment is optimum for rumen microbial populations that are most efficient at digesting the substrates offered in the diet. These data suggest increased fiber digestion in diets containing elevated concentrations of corn silage due to a more suitable environment for fiber-digesting microorganisms.

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Response to Increasing Concentrations of De-oiled Modified Distillers Grains Plus Solubles in Beef Feedlot Diets

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Summary

A 154-day finishing study, utilizing 378 calf-fed steers, was conducted to evaluate the response to feeding increasing concentrations of de-oiled modified distillers grains plus solubles (MDGS) on cattle performance and carcass characteristics. Two additional diets were fed to compare de-oiled MDGS to normal MDGS at either 15 or 30% inclusion. Increasing concentration of de-oiled MDGS in the diet resulted in a linear improvement in F:G. When comparing 30% de-oiled to normal MDGS, there was a tendency for 3.4% improvement in F:G for cattle fed normal MDGS diets over those fed de-oiled MDGS.

Introduction

Ethanol plants are centrifuging oil from the thin stillage constituent and selling this oil to non-ruminant feed sectors and the biofuel industry. Jolly-Breithaupt et al., *2014 Nebraska Beef Report,* pp. 81-82, compared feeding de-oiled (7.9% fat) wet distillers grains plus solubles (WDGS) to normal (12.4% fat) WDGS at 35, 50, or 65% concentrations in the diet. Dry matter intake was significantly greater ($P < 0.01$) in cattle consuming de-oiled WDGS diets over normal WDGS diets. Numerically, F:G was improved in cattle consuming normal WDGS by 2.6% ($P = 0.58$). Increasing WDGS in the diet caused a quadratic response to DMI ($P < 0.01$) and a linear improvement in F:G ($P < 0.01$). Previous research from Huls et al., *2008 Nebraska Beef Cattle Report,* pp.41-42, illustrated that increasing the concentration of normal fat modified distillers grains plus solubles (MDGS) from 0 to 50% caused a linear improvement in F:G ($P < 0.01$), thus the objective of this study was evaluate the effects of feeding de-oiled (MDGS) at increasing concentrations in the diet on cattle performance and carcass characteristics.

Procedure

Three hundred and seventy-eight crossbred steer calves (initial BW = 800 ± 38 lb) were utilized in a 154-day finishing trial conducted at the University of Nebraska–Lincoln Agricultural Research and Development Center (ARDC) near Mead, Neb. Five days prior to the start of the trial, steers were limit-fed at 2.0% BW a 50% alfalfa hay and 50% Sweet Bran® diet. Steers were then weighed on two consecutive days to obtain an accurate initial BW. Using day 0 BW, steers were blocked into three weight blocks (heavy, medium, or light) and within block assigned randomly to pens. Forty-two pens were then assigned randomly to one of seven treatments with nine steers per pen. There were six replications per treatment with two replications per block. Treatments (Table 1) consisted of de-oiled MDGS being fed at 0, 15, 30, 45, or 60% of the diet (DM basis). Two additional diets were evaluated where normal MDGS was fed at 15 or 30% of diet DM to allow for an embedded 2 × 2 factorial analysis with their de-oiled counterparts. In all diets, as distillers grains was added to the ration, the 1:1 blend of high-moisture corn and dry-rolled corn was substituted. Twelve percent corn silage and 5% of a formulated supplement comprised the remainder of all diets (DM basis). Diets containing 0 or 15% distillers grains were supplemented with urea to meet or exceed the ruminally degradable protein (RDP) and thus the MP requirements of the steers.

Steers were implanted with Revalor®-XS on day 0. On day 154 of the study, steers were shipped to the commercial abattoir (Greater Omaha Pack Co., Omaha, Neb.) where they were harvested the following morning. On the day of harvest, HCW measurements were recorded. After a 48-hour chill, camera measurements were collected for LM area, fat depth, and marbling scores. Yield grade was calculated using the USDA YG

Table 1. Dietary composition on a DM basis fed to finishing steers.

	De-oiled MDGS[1] (%, DM Basis)					Normal MDGS[1] (%, DM Basis)	
MDGS Concentration[2]	0[3]	15[3]	30	45	60	15[3]	30
Ingredient							
De-oiled MDGS[1]	0.0	15.0	30.0	45.0	60.0	—	—
Normal MDGS[1]	—	—	—	—	—	15.0	30.0
Corn silage	12.0	12.0	12.0	12.0	12.0	12.0	12.0
High-moisture corn	41.5	34.0	26.5	19.0	11.5	34.0	26.5
Dry-rolled corn	41.5	34.0	26.5	19.0	11.5	34.0	26.5
Supplement[3]	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Dietary Composition ,%							
Fat	3.24	3.78	4.32	4.86	5.40	4.50	5.76

[1] MDGS = modified distillers plus solubles for both de-oiled and normal varieties.
[2] Formulated to provide 360 mg/head/day or Rumensin® and 90 mg/head/day Tylan® in supplement.
[3]Urea was included in diets containing 0 and 15% MDGS diets to meet the MP requirements of the steers.

Table 2. Performance and carcass data for steers fed increasing inclusions of de-oiled MDGS.

Item	De-oiled MDGS[1], % Diet DM					SEM	*P*-value	
	0	15	30	45	60		Lin	Quad
Performance								
Initial BW, lb	793	794	792	792	794	1	0.40	0.86
Final BW, lb[3]	1291	1334	1331	1326	1325	14	0.02	0.57
DMI, lb/day	23.2	24.1	24.0	23.1	23.1	0.4	0.59	0.32
ADG, lb	3.25	3.53	3.52	3.44	3.48	0.08	0.02	0.57
F:G[4]	7.13	6.81	6.81	6.71	6.67		<0.01	0.86
Net Energy Values[5]								
NE maintenance, Mcal/lb	0.83	0.84	0.84	0.86	0.86	0.01	<0.01	0.41
NE gain, Mcal/lb	0.54	0.55	0.55	0.57	0.57	0.01	<0.01	0.38
Carcass Characteristics								
HCW, lb	813	840	839	835	835	8.2	0.02	0.57
LM area, in^2	12.80	12.95	12.53	12.72	12.75	0.21	0.17	0.85
12th-rib fat, in	0.49	0.54	0.62	0.58	0.57	0.03	<0.01	0.69
Marbling score[6]	490	527	535	523	506	12	0.05	0.17

[1]Modified distillers grains plus solubles.
[2]Lin = *P*-value for the linear response to de-oiled MDGS inclusion: Quad = *P*- value for the quadratic response to de-oiled MDGS inclusion.
[3]Final BW was calculated from HCW using a common dressing percentage of 63%.
[4]Analyzed as G:F, the reciprocal of feed conversion (F:G).
[5]Values calculated by pen, using 1996 NRC equations.
[6]Marbling Score: 400 - small°, 500 = modest°.

Table 3. Performance, carcass data, and feeding value of de-oiled MDGS for embedded 2 × 2 factorial.

Item	15% MDGS[1]		30% MDGS[1]		Int.[3]	*P*-value[2]	
	De-oiled	Normal	De-oiled	Normal		15	30
Performance							
Initial BW, lb	794	792	792	793	0.37	0.37	0.72
Final BW, lb[4]	1334	1314	1331	1342	0.26	0.31	0.57
DMI, lb/day	24.1	23.6	24.0	23.6	0.85	0.37	0.59
ADG, lb	3.53	3.41	3.52	3.59	0.28	0.32	0.59
F:G[5]	6.80^{ab}	6.90^{a}	6.80^{ab}	6.58^{b}	0.07	0.48	0.07
Net Energy Values[6]							
NE Maintenance, Mcal/lb	0.84	0.84	0.84	0.86	0.12	0.75	0.06
NE Gain, Mcal/lb	0.55	0.55	0.55	0.57	0.10	0.73	0.05
Feeding Value[7]	109%	—	89%	—			
Carcass Characteristics							
HCW, lb	840	828	839	845	0.26	0.30	0.57
LM area, in^2	12.95	12.68	12.53	12.55	0.49	0.36	0.95
12th-rib fat, in	0.54	0.54	0.52	0.60	0.92	0.82	0.71
Marbling Score[8]	527	516	535	525	0.97	0.53	0.56

[1]Modified distillers grains plus solubles.
[2]15 = *P*-value for pair-wise contrast between de-oiled and normal MDGS at 15% concentration; 30 = *P*-value for pair-wise contrast between de-oiled and normal MDGS at 30% concentration.
[3]Int. = *P*-value for interactions between concentration of MDGS and oil content of MDGS.
[4]Final BW was calculated from HCW using a common dressing percentage of 63%.
[5]Analyzed as G:F, the reciprocal of feed conversion (F:G).
[6]Values calculated by pen, using 1996 NRC equations.
[7]Feeding Value Calculation = divide treatment G:F value by the normal fat MDGS G:F value within each diet concentration, take that value and subtract 1, and then divide by the concentration of de-oiled MDGS in the diet.
[8]Marbling Score: 400 = small°, 500 = modest °.

equation: [YG = 2.5 + 2.5 (fat thickness, in) – 0.32 (LM area, in^2) + 0.2 (KPH fat, %) + 0.0038 (HCW, lb)]. Final BW, ADG, and F:G were calculated using HCW adjusted to a common dressing percentage of 63%.

Data were analyzed using a MIXED procedure of SAS (SAS Institute, Inc., Cary, N.C.) as a randomized complete block design with pen as the experimental unit. Linear and quadratic contrasts were made on performance and carcass data from cattle fed increasing levels of de-oiled MDGS. The embedded 2 × 2 factorial was analyzed for an oil (de-oiled vs. normal) by inclusion level (15% vs. 30%) interaction. Pre-planned, pair-wise comparisons were made for both the 15% and 30% inclusions.

The feeding value of de-oiled MDGS relative to normal MDGS was calculated as the difference between the G:F observed for de-oiled MDGS and normal MDGS divided by the G:F value of the normal MDGS diet. This value was then divided by the proportion of MDGS in the corresponding diet. This value plus one, and multiplied by 100, gives feeding value relative to the DRC and HMC blend replaced. Calculated feeding values for this comparison are found in Table 3. Treatment NEm and NEg values were also calculated, using equations found in the 1996 NRC, on a per pen basis. These energy values were also analyzed using the GLIMMIX procedure of SAS (SAS Institute, Inc., Cary, N.C.) so that treatment averages could be determined.

Results

De-oiled MDGS was 7.2% fat and 35.5% CP, whereas normal MDGS was 12.0% fat and 32.6% CP. As de-oiled MDGS increased, final BW, ADG, and F:G improved linearly (Table 2, $P \leq 0.02$) with no linear or quadratic trends observed in DMI between treatments ($P \geq 0.32$). Both NE_m and NE_g improved linearly with increasing inclusion of de-oiled MDGS

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($P = 0.01$, for both energy values). Hot carcass weight followed final BW as it linearly increase as de-oiled MDGS was added to the diet ($P = 0.02$). *Longissimus* muscle area was not statistically different between treatments ($P \geq 0.17$); however, linear increases in 12th-rib fat depth ($P < 0.01$) and marbling scores ($P = 0.05$) were observed as de-oiled MDGS concentration in the diet increased. Linear improvements in 12th-rib fat thickness and marbling scores are likely related to the linear improvements observed for ADG. Cattle performance and carcass characteristics values are similar to what has been observed in previous research conducted on normal fat distillers grains (Huls et al., *2008 Nebraska Beef Cattle Report,* pp. 41-42).

Analysis of the embedded 2 × 2 factorial showed a tendency for a interaction between oil content and concentration of MDGS in the diet on F:G ($P = 0.07$; Table 3). Cattle consuming normal MDGS diets at 30% inclusion were numerically 3.4% more efficient than their de-oiled MDGS counterparts. Numerical improvements in F:G were not as profound at 15% inclusion in the diet because cattle consuming the normal MDGS diet were only 1.4% more efficient than those consuming the de-oiled MDGS diet. The main effect of concentration illustrated a tendency for improvement in F:G when MDGS were fed at 30% of the diet ($P = 0.07$). In 30% MDGS diets, NE_m and NE_g had a tendency to be greater for the normal MDGS diet ($P = 0.12$ and $P = 0.10$, respectively) compared to the de-oiled MDGS diet. However, numerical differences in NE_m or NE_g were not observed at 15% concentrations when comparing normal and de-oiled MDGS diets. Twelfth-rib fat depth was significantly greater in cattle consuming 30% MDGS diets ($P = 0.01$). The results of this study suggest increasing the inclusion of de-oiled MDGS in a beef feedlot diet improves F:G similar to previous work with normal MDGS (*2008 Nebraska Beef Cattle Report,* pp. 41-42). Impacts of oil removal appear to be dependent upon dietary inclusion. No significant differences were observed when de-oiled and normal MDGS were fed at 15% of the diet; however, when the concentration of MDGS increased to 30% in the diet, cattle consuming normal MDGS diets were 3.4% more efficient.

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Feeding Value of De-oiled Wet Distillers Grains Plus Solubles Relative to Normal When Fed with Either Dry-Rolled Corn or Steam-Flaked Corn in Beef Finishing Diets

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Summary

A 128-day finishing study utilized 328 yearling steers to determine the effects of feeding de-oiled wet distillers grains plus solubles (WDGS) in dry rolled corn (DRC) or steam-flaked corn (SFC) diets relative to normal fat WDGS. No significant interactions were observed, but cattle fed DRC had greater DMI and were less efficient than those consuming SFC. Linear improvements in ADG and F:G were observed as concentration of de-oiled WDGS increased from 0 to 35%. Numerically cattle fed normal WDGS were more efficient than cattle fed de-oiled WDGS.

Introduction

A corn kernel is primarily comprised of starch, thus a steer's ability to utilize starch is crucial for optimizing feed efficiency in the feedlot. Corn processing increases the availability of starch for ruminal digestion. The three most common corn processing methods are steam flaking (SFC), dry rolling (DRC), and ensiling high moisture corn (HMC). Corrigan et al., *2007 Nebraska Beef Cattle Report* pg. 33-35, studied the effect of corn processing method with increasing concentrations of wet distillers grains plus solubles (WDGS) in finishing feedlot diets. Dry rolled corn, HMC, and SFC were fed with 0, 15, 27.5, or 40% WDGS. The authors reported that an optimal inclusion of WDGS was 40% with DRC, 27.5% with HMC, and 15% with SFC. More intensely processed corn has a negative associative interaction with distillers grains. Improvements in F:G diminish when distillers grains are fed with more intensely processed corn, thus the concentration of distillers grains needed to see optimal performance also decreases. With over half of Nebraska's ethanol plants currently removing oil from distillers grains via centrifugation of the thin stillage, the question arises as to how corn processing method will interact with de-oiled distillers grains. Thus, the objectives of this study were: 1) to determine the optimal concentration of de-oiled WDGS to feed with either DRC or SFC so as to maximize steer performance in the feedlot and 2) to determine the feeding value of de-oiled WDGS relative to normal WDGS when fed with either DRC or SFC in a beef finishing diet.

Procedure

Three hundred and twenty yearling steers (initial BW = 875 ± 84 lb) were utilized in a 128-day finishing study conducted at the Panhandle Research and Extension Center (PREC) research feedlot near Mitchell, Neb. Prior to the start of the trial, cattle were limit-fed at 2.0% of BW a diet consisting of 15% wheat straw, 35% corn silage and 50% WDGS for five days to minimize the effect of gut fill. Steers were weighed on day 0 and day 1 after the limit feeding period and these weights were averaged for an accurate initial BW. Using initial BW, steers were blocked into three weight blocks (heavy, medium, or light) and then assigned randomly to pen within block. There were 40 total pens with eight head assigned to each pen. Pens were then assigned randomly to one of eight treatments (Table 1) allowing for five replications per treatment.

Treatments were organized in a 2 × 3 + 2 factorial arrangement with factors being corn processing method of DRC or SFC (flake density targeted at 28 lb/bu) and concentration of de-oiled WDGS in the diet of 0, 17.5, or 35% on a DM-basis. Two additional diets containing normal WDGS fed at 35% of the diet were also examined. These additional diets allowed for the analysis of an embedded 2 × 2 factorial with factors of corn processing method (DRC vs. SFC) and

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Table 1. Dietary treatments and nutrient analysis.

	SFC[1]				DRC[1]			
De-oiled WDGS[2] Inclusion	0	17.5	35	35[3]	0	17.5	35	35[3]
SFC	74.44	60.75	44.0	44.0	—	—	—	—
DRC	—	—	—	—	74.44	60.75	44.0	44.0
De-oiled WDGS	0.00	17.50	35.00	—	0.00	17.50	35.00	—
Normal WDGS	—	—	—	35.00	—	—	—	35.00
Corn silage	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00
Soybean meal	3.56	0.10	—	—	3.56	0.10	—	—
Urea	1.00	0.65	—	—	1.00	0.65	—	—
Supplement	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
Dietary Composition								
Fat	2.86	3.75	4.54	5.10	3.53	4.29	4.94	5.50

[1]SFC = steam-flaked corn, DRC = dry-rolled corn.
[2]Wet distillers grains plus solubles.
[3]Normal WDGS diets.

Table 2. Effect of corn processing method with increasing concentrations of de-oiled WDGS[1] in the finishing diet.

Item	DRC[2]			SFC[2]			SEM	*P*-values			
	0	17.5	35	0	17.5	35		Int.[3]	CPM[3]	Linear[3]	Quadratic[3]
Performance											
Initial BW, lb	858	859	859	855	856	857	3	0.80	0.06	0.39	0.94
Final BW, lb[4]	1282	1315	1334	1302	1316	1336	14	0.57	0.37	<0.01	0.84
DMI, lb/day	27.6	27.1	27.2	26.4	26.5	27.0	0.4	0.25	0.02	0.68	0.42
ADG, lb	3.50	3.76	3.92	3.68	3.79	3.94	0.11	0.53	0.23	<0.01	0.84
F:G[5]	7.87	7.19	6.90	7.14	6.94	6.80	<0.01	0.15	0.01	<0.01	0.50
Net Energy Values[6]											
NE maintenance, Mcal/lb	0.76	0.80	0.82	0.81	0.82	0.83	0.01	0.25	<0.01	<0.01	0.35
NE gain, Mcal/lb	0.48	0.52	0.53	0.52	0.54	0.54	<0.01	0.22	<0.01	<0.01	0.38
Calculated Feeding Value[7]	—	154%	140%	—	116%	114%					
Carcass Characteristics											
HCW, lb	808	828	840	820	829	841	9	0.60	0.37	<0.01	0.82
LM area, in²	11.3	11.3	11.3	11.3	11.3	11.4	0.2	0.99	0.74	0.77	0.82
Fat depth, in	0.44	0.47	0.52	0.47	0.50	0.51	0.02	0.53	0.21	<0.01	0.91
Marbling Score[8]	416	451	425	440	468	446	15	0.94	0.03	0.47	<0.01
Yield grade	3.46	3.62	3.76	3.52	3.68	3.72	0.13	0.86	0.54	<0.01	0.56
Liver abscesses, %	7	16	10	14	18	22	5	0.97	0.10	0.28	0.26

[1]Wet distillers grains plus solubles.
[2]DRC = dry-rolled corn, SFC = steam-flaked corn.
[3]Int. = interaction between corn processing method and concentration of WDGS In the deti, CPM = main effect of corn processing method of DRC or SFC, Conc. = main effect of concentration f WDGS in the diet, Linear and Quadratic *P*-values for the main effect of concentration of WDGS in the diet.
[4]Calculated from hot carcass weight, adjusted to a common dressing percentage of 63%.
[5]Analyzed as G:F but reported as reciprocal.
[6]Values calculated by pen using 1996 NRC equations.
[7] Feeding Value Calculation = divide treatment G:F value by the 0% WDGS control G:F value within each corn processing method, take that value and subtract 1, and then divide by the concentration of de-oiled WDGS in the diet.
[8] Marbling score: 400 = small°, 500 = modest°.

inclusion of 35% WDGS (normal fat vs. de-oiled). The remainder of all diets consisted of 15% corn silage, and 6% supplement with increasing concentrations of WDGS replacing corn, urea, and soybean meal. Urea and soybean meal were added to diets containing 0 or 17.5% WDGS to meet or exceed the metabolizable protein requirements of the steers. Monensin and tylosin were fed with a micro-machine at 360 mg/head/day and 90 mg/head/d, respectively. Normal and de-oiled WDGS were received from two different plants for this study.

Steers were implanted on day 1 with Revalor®-XS. On day 109 the heavy block was shipped to a commercial abattoir (Cargill Meat Solutions, Fort Morgan, Colo.) for harvest. The medium and light blocks were shipped to the same plant on day 128. Hot carcass weights and liver scores were collected on the day of harvest and after a 48-hour chill the LM area, fat thickness, and marbling score data. Yield grade was calculated using the USDA YG equation [YG = 2.5 + 2.5 (fat thickness, in) – 0.32 (LM area, in²) + 0.2 (KPH fat, %) + 0.0038 (HCW, lb)]. A standard 2% KPH was used in the yield grade calculation.

Data were analyzed using a GLIMMIX procedure of SAS with pen as the experimental unit. No interaction between corn processing method and concentration of de-oiled WDGS was detected for the 2 × 3 factorial ($P > 0.15$). Thus linear and quadratic contrasts were used to evaluate the effect of concentration of de-oiled WDGS in the diet on performance and carcass characteristics. The embedded 2 × 2 factorial was analyzed to determine if an interaction existed between corn processing method and type of WDGS (de-oiled vs. normal fat) with significance declared at ($P < 0.05$).

The feeding value of increasing concentrations of de-oiled WDGS in comparison to both DRC and SFC controls was calculated as the difference between the G:F observed for each WDGS concentration and 0% WDGS divided by the G:F value of the 0% WDGS diet. This value was then divided by the concentration of WDGS in the corresponding diet and multiplied by 100, for the feeding value relative to DRC or SFC replaced (Bremer et al., *2011 Nebraska Beef Cattle Report*, pp. 40-41). Treatment NE_m and NE_g values were also calculated, using equations found in the 1996 NRC, on a per pen basis. These energy values were also analyzed using the GLIMMIX procedure of SAS so that treatment averages could be determined.

Results

No WDGS concentration by corn processing method interaction was observed when evaluating the 2 × 3 factorial ($P \geq 0.15$); (Table 2). For the main effect of corn processing method, steers fed DRC had greater DMI ($P = 0.02$) and similar ADG ($P = 0.23$) when compared to those

Table 3. Comparing De-oiled and Normal WDGS at 35% Concentration in DRC and SFC diets.

	DRC[1]		SFC[2]			*P*-values		
Item	De-oiled WDGS[3]	Normal WDGS[3]	De-oiled WDGS[3]	Normal WDGS[3]	SEM	Int.[4]	CPM[5]	Type[6]
Performance								
Initial BW, lb	859	860	858	859	2	0.86	0.53	0.46
Final BW, lb[7]	1334	1345	1335	1355	13	0.69	0.59	0.12
DMI, lb/day	27.2	26.9	27.0	26.5	0.5	0.54	0.26	0.12
ADG lb	3.92	3.99	3.94	4.01	0.11	0.62	0.46	0.18
F:G[8]	6.94	6.76	6.80	6.45	<0.01	0.43	0.05	0.14
Net Energy Values[9]								
NE maintenance, Mcal/lb	0.83	0.83	0.83	0.87	0.01	0.15	0.18	0.06
NE gain, Mcal/lb	0.53	0.54	0.54	0.58	0.01	0.18	0.07	0.03
Calculated Feeding Value[10]	92%	—	85%	—				
Carcass Characteristics								
HCW, lb	840	848	841	854	8	0.69	0.58	0.12
LM area, in[2]	11.33	11.40	11.37	11.53	0.23	0.80	0.61	0.52
Fat depth, in	0.52	0.52	0.51	0.54	0.03	0.37	0.52	0.37
Marbling score[11]	427	462	488	455	18	0.29	0.58	0.11
Yield grade	3.8	3.8	3.7	3.8	0.2	0.58	1.0	0.58
Liver abscesses, %	10.0	22.0	6.0	10.0	4	0.61	0.14	0.06

[1]DRC = dry-rolled corn.
[2]SFC = steam-flaked corn.
[3]WDGS = wet distillers grains plus solubles.
[4]Int. = interaction between corn processing method and WDGS type.
[5]CPM = main effect of corn processing method (DRC or SFC).
[6]Type = main effect of type of WDGS (de-oiled or normal fat).
[7]Calculated from hot carcass weight, adjust to a common dressing percentage of 63%.
[8]Analyzed as G:F but reported as reciprocal.
[9]Values calculated by pen using 1996 NRC equations.
[10]Feeding Value Calculation = divide treatment G:F value by the 0% WDGS control G:F value within each corn processing method, take that value and subtract 1, and then divide by the concentration of de-oiled WDGS in the diet.
[11]Marbling score: 400 = small°, 500 = modest°.

cattle consuming SFC diets. However, F:G was improved in steers fed SFC ($P = 0.01$) over DRC diets. When comparing the control diets of each corn processing method, a 10.2% improvement in F:G was observed in cattle fed SFC over DRC. This improvement in F:G agrees nicely with previous research, (Nichols et al., *2012 Nebraska Beef Cattle Report,* pp. 70-71) where the difference in F:G between corn processing methods was 10.0%. In further comparisons, steers fed SFC had greater marbling scores than those fed DRC diets ($P = 0.03$). Diets containing SFC had significantly greater NE_m and NE_g values compared to DRC diets ($P < 0.01$). Final BW,HCW, LM area, and fat depth ($P \geq 0.21$) did not differ between steers fed DRC or SFC diets.

For the main effect of concentration of WDGS in the diet, a linear increase in final BW, ADG, HCW and fat depth ($P < 0.01$) was observed as WDGS concentration in the diet increased (Table 2). Furthermore, a linear improvement in F:G was detected as the concentration of WDGS in the diet increased ($P = <0.01$.) Increasing the concentration of WDGS from 0 to 17.5% caused a 5.2% improvement in F:G and increasing the concentration of WDGS from 17.5 to 35% caused a 3.5% improvement in F:G. A linear increase in NE_m and NE_g for both DRC and SFC diets was observed as de-oiled WDGS was increasingly added to the diet ($P < 0.01$). Marbling scores increased quadratically ($P = 0.01$) with increasing concentrations of WDGS. Cattle fed 17.5% de-oiled WDGS marbled the highest.

Looking at the embedded 2 × 2 factorial (Table 3), which compared de-oiled WDGS (7.9% fat content) to normal WDGS (11.3% fat) fed at 35%, there were no corn processing method by WDGS type interactions ($P \geq 0.29$). Type of WDGS did not significantly impact F:G ($P = 0.14$) but numerically cattle fed normal WDGS were 2.7% more efficient than their de-oiled WDGS counterparts in DRC diets and numerically 5.2% more efficient in SFC-based diets. There was a tendency for cattle consuming normal fat WDGS diets to have greater final BW, HCW , DMI ($P = 0.12$), and marbling scores ($P = 0.11$) compared to cattle consuming de-oiled WDGS diets. Average daily gain, LM area, and fat depth ($P \geq 0.18$) did not significantly differ between WDGS types. There was a tendency for the normal WDGS diet to have a greater NE_m value compared to the de-oiled WDGS diet ($P = 0.06$), conversely the calculated NE_g value for the normal WDGS diet was significantly greater than for de-oiled WDGS diet ($P = 0.03$).

The main effect of corn processing method showed that steers fed SFC had improved F:G ($P = 0.05$) compared to those fed DRC. No differences in final BW, DMI, ADG, HCW, LM area, fat depth, or marbling scores ($P \geq 0.26$) was observed when comparing SFC and DRC diets. This study suggests that increasing the concentration of de-oiled WDGS in the diet while feeding either SFC or DRC improves F:G. However, as the intensity of corn processing increases the concentration of distillers grains in the diet should decrease due to the negative associative affect that is apparent between corn processing intensity and increasing concentrations of WDGS Removing a portion of the oil, via centrifugation of the thin stillage, did not significantly impact F:G in this study. Feeding normal WDGS, however, numerically improved F:G by 4.0% suggesting oil removal may have a small effect on the energy value of WDGS and subsequently on the effects of feed efficiency in finishing cattle.

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Nutrient Digestibility and Ruminal pH of Finishing Diets Containing Dry Milling Byproducts With and Without Oil Extraction

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Summary

A metabolism trial was conducted to determine the effects of corn oil removal in condensed distillers solubles (CDS) and modified distillers grains plus solubles (MDGS) on nutrient digestibility and ruminal pH. Oil removal had no impact on DM, OM, or NDF digestibility in steers fed CDS or MDGS. However, steers fed de-oiled CDS had a lower fat digestibility than steers fed normal CDS. Average ruminal pH was lower for steers fed de-oiled MDGS than for steers fed normal MDGS, however no difference within CDS was observed.

Introduction

For the last two years, ethanol plants have been removing a portion of corn oil via centrifugation to produce de-oiled distillers byproducts. Previous research has concluded that removal of corn oil by this centrifugation process had limited impact on ADG and F:G when 27% inclusion of CDS or 40% inclusion of MDGS were fed in finishing diets (*2013 Nebraska Beef Cattle Report*, pp. 64-65). No data have been reported on the nutrient digestibility of diets containing de-oiled byproducts. The hypothesis of this trial was that oil removal would improve NDF digestibility. Therefore, the objective of this study was to determine the effects of feeding de-oiled CDS and MDGS on nutrient digestibility and ruminal pH of finishing steers.

Procedure

A 112-day metabolism experiment utilized six ruminally fistulated steers in a 5 x 5 Latin Square design. Treatments were designed as a 2 x 2 + 1 factorial arrangement with steers assigned randomly to one of five treatments (Table 1). Factors consisted of oil concentration (de-oiled or normal) and byproduct type (27% CDS or 40% MDGS) plus a corn-based control. All diets contained (DM basis) a 1:1 blend of dry-rolled and high-moisture corn which was replaced by either CDS or MDGS, 12% corn silage, and a 5% supplement. All supplements contained Rumensin® and tylosin at 345 and 90 mg per steer daily, respectively. The byproducts utilized in this trial were procured from Green Plains, LLC (Central City, Neb).

Steers were housed in individual concrete slatted pens with *ad libitum* access to feed and water. Ingredient samples were taken during the collection period at time of mixing, composited by period, ground through a 1-mm screen, and analyzed for DM, fat, CP, S, and NDF. Fat concentration

Table 1. Diet composition on a DM basis fed to finishing steers.

		27% CDS[1]		40% MDGS[1]	
Ingredient, % of DM	Control	De-Oiled	Normal Fat	De-Oiled	Normal Fat
DRC[1]	41.5	28	28	21.5	21.5
HMC[1]	41.5	28	28	21.5	21.5
MDGS: De-oiled[1]	—	—	—	40	—
MDGS: Normal fat[1]	—	—	—	—	40
CDS: De-oiled[1]	—	27	—	—	—
CDS: Normal fat[1]	—	—	27	—	—
Corn silage	12	12	12	12	12
Supplement [2,3]	5	5	5	5	5
Analyzed Composition, %					
Fat	4.01	5.17	6.99	5.93	7.16
CP	12.4	14.8	13.8	19.0	18.5
NDF	13.1	10.2	11.9	19.9	22.6
S	0.14	0.30	0.25	0.28	0.27

[1]CDS = Condensed distillers solubles; MDGS = Modified distillers grains plus solubles; DRC = Dry-rolled corn; HMC = High-moisture corn.
[2]Formulated to contain 345 mg/steer daily of Rumensin® and 90 mg/steer daily of Tylan®.
[3]Control supplement contained 1.516% urea.

Table 2. Nutrient Composition of MDGS and CDS[1].

	De-Oiled CDS[2]	Normal CDS[2]	De-Oiled MDGS[2]	Normal MDGS[2]
Fat, %	8.7	15.4	9.2	12.3
CP, %	29.9	25.5	33.9	32.4
S, %	0.73	0.56	0.51	0.48
NDF, %	1.9	8.2	29.7	36.4

[1]All values expressed on a DM basis.
[2]CDS = Condensed distillers solubles; MDGS = Modified distillers grains plus solubles.

Table 3. Effects of dietary treatment on intake and total tract digestibility of DM, organic matter, fat, and NDF.

Item	Control	27% CDS[1] De-Oiled	27% CDS[1] Normal	40% MDGS[1] De-Oiled	40% MDGS[1] Normal	SEM	P-value Int.[2]	P-value CDS[3]	P-value MDGS[4]	P-value F-Test[5]
DM										
Intake, lb/day	22.2[bc]	19.9[a]	21.0[ab]	24.2[c]	22.8[bc]	1.3	0.33	0.34	0.29	0.05
Total tract digestibility, %	81.6	81.4	83.6	82.1	80.0	1.9	0.14	0.17	0.26	0.27
OM										
Intake, lb/day	21.3[bc]	18.7[a]	19.9[ab]	23.1[c]	21.8[c]	1.2	0.33	0.29	0.32	0.03
Total tract digestibility, %	82.9[ab]	84.6[bc]	86.0[c]	83.6[abc]	81.9[a]	1.8	0.21	0.30	0.30	0.08
NDF										
Intake, lb/day	2.9[b]	1.9[a]	2.1[c]	4.7[d]	5.1[e]	0.2	0.40	0.43	0.06	<0.01
Total tract digestibility, %	58.0	53.6	61.0	67.0	67.0	5.5	0.38	0.17	0.99	0.12
Fat										
Intake, lb/day	0.90[a]	1.02[a]	1.46[b]	1.46[b]	1.64[c]	0.08	0.07	<0.01	0.05	<0.01
Total tract digestibility, %	87.3[a]	89.6[ab]	93.1[c]	91.2[bc]	90.6[b]	1.2	0.03	0.02	0.68	0.01

[a-e]Means with different superscripts differ ($P < 0.10$).
[1]27% CDS = 27% inclusion of condensed distillers solubles; 40% MDGS = 40% inclusion of modified distillers grains plus solubles.
[2]Int = Interaction *P*-value for byproduct type and oil concentration.
[3]CDS = Pair-wise, contrast of de-oiled vs. normal CDS.
[4]MDGS = Pair-wise, contrast of de-oiled vs. normal MDGS.
[5]F-Test = Overall F-test representing variation due to treatment.

was analyzed using the biphasic lipid extraction procedure with NDF analyzed after fat had been extracted.

Period duration was 21 days with a 16 day adaptation phase and 5 day collection period. Beginning on day 10 of each period, titanium dioxide was dosed intraruminally at 0800 and 1600 hours to provide a total of 20 g/day. On day 17 to 21, fecal grab samples were collected three times/day at 0800, 1200, and 1600 hours and composited by steer and period. Fecal samples were analyzed for titanium dioxide to determine nutrient digestibility. Fecal samples were also analyzed for DM, organic matter (OM), fat, and NDF. Ruminal pH was measured continuously from day 17 to 21 with submersible wireless pH probes. Measurements for pH included average ruminal pH, minimum and maximum pH, magnitude of change, variance, and time and area below 5.6.

Digestibility, intake, and ruminal pH data were analyzed using the MIXED procedure of SAS (SAS Institute, Inc., Cary, N.C.). Treatment and period were included in the model as fixed effects while steer was treated as a random effect for all analyses. Pairwise comparisons of treatments were determined by Fisher's LSD and two pre-planned contrasts were used to evaluate the effect of oil removal when 27% CDS or 40% MDGS were fed. Treatment differences were considered significant at $P < 0.10$.

Results

Dietary fat was 5.17% for 27% de-oiled CDS, 6.99% for 27% normal CDS, 5.93% for 40% de-oiled MDGS, and 7.16% for 40% normal MDGS compared to 4.01% fat for the control treatment. The nutrient analysis of CDS and MDGS are included in Table 2.

Intakes

No byproduct by fat concentration interactions were observed for intakes of DM, OM, or NDF ($P \geq 0.33$; Table 3). There were no differences due to oil removal for both 40% MDGS and 27% CDS on DMI and OM intake ($P \geq 0.29$ and $P \geq 0.29$, respectively). However, cattle fed 40% normal MDGS had greater intakes of NDF compared to cattle fed 40% de-oiled MDGS ($P = 0.06$). A byproduct by fat concentration interaction was observed for fat intake ($P = 0.07$). A greater fat intake difference, due to oil removal, was observed for cattle fed 27% CDS compared to 40% MDGS. This response should be expected as the corn oil was only removed from the CDS portion of the MDGS production process. When comparing all treatments, cattle fed 27% CDS had the lowest ($P < 0.01$) NDF intakes with cattle fed 40% MDGS having the greatest intakes and the control being intermediate. Cattle fed 27% de-oiled CDS had the lowest ($P \leq 0.05$) DM and OM intakes with cattle fed 40% de-oiled MDGS having the greatest intakes and 27% normal CDS, 40% normal MDGS, and control being intermediate.

Digestibility

No byproduct by fat concentration interactions were observed for DM, OM, and NDF digestibilities ($P \geq 0.14$; Table 3). Oil removal had no impact on DM, OM, and NDF digestibility for either cattle fed 27% CDS or 40% MDGS ($P \geq 0.17$). This contradicts our hypothesis that oil removal would improve nutrient digestibility. A byproduct by fat concentration interaction was observed for fat digestibility ($P = 0.03$). The magnitude of difference between de-oiled and normal was greater for cattle fed CDS than for MDGS. Cattle fed 27% normal CDS had a greater fat digestibility compared to 27% de-oiled CDS ($P = 0.02$), whereas no difference

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Table 4. **Effects of dietary treatment on ruminal pH with steers fed 27% CDS and 40% MDGS with (de-oiled) or without (normal) a portion of oil removed.**

Item	Control	27% CDS[1]		40% MDGS[1]		SEM	*P*-value			
		De-Oiled	Normal	De-Oiled	Normal		Int.[2]	CDS[3]	MDGS[4]	F-Test[5]
Average pH	5.40[a]	5.39[a]	5.36[a]	5.54[a]	5.72[b]	0.09	0.14	0.85	0.09	0.02
Maximum pH	6.05	6.15	6.02	6.19	6.38	0.11	0.21	0.43	0.24	0.21
Minimum pH	4.99	4.95	4.98	4.93	5.09	0.09	0.16	0.78	0.18	0.68
pH magnitude	1.08	1.15	1.02	1.30	1.31	0.13	0.60	0.51	0.92	0.44
pH variance[6]	0.072	0.101	0.065	0.074	0.131	0.023	0.33	0.28	0.10	0.26
Time < 5.6, minutes/day[7]	708	748	1080	733	769	104	0.37	0.04	0.81	0.12
Area < 5.6, minutes/day[8]	275	312	450	212	302	77	0.20	0.23	0.42	0.32

[a-c]Means with different superscripts differ ($P < 0.10$).
[1]27% CDS = 27% inclusion of condensed distillers solubles; 40% MDGS = 40% inclusion of modified distillers grains plus solubles.
[2]Int = Interaction *P*-value for byproduct type and oil concentration.
[3]CDS = Pairwise, contrast of de-oiled vs. normal CDS.
[4]MDGS = Pairwise, contrast of de-oiled vs. normal MDGS.
[5]F-Test = Overall F-test representing variation due to treatment.
[6]Variance of daily ruminal pH.
[7]Time < 5.6 = minutes that ruminal pH was below 5.6.
[8]Area < 5.6 = ruminal pH units below 5.6 by minute.

was observed between 40% de-oiled and normal MDGS ($P = 0.68$). When comparing all treatments, no differences were observed for DM digestibility ($P = 0.27$) or NDF digestibility ($P = 0.12$). However, steers fed 27% normal CDS had the greatest ($P = 0.08$) OM digestibility, while steers fed 40% normal MDGS had the lowest OM digestibility. Steers fed 27% normal CDS had the greatest ($P = 0.01$) fat digestibility, while control had the lowest.

Ruminal pH

No byproduct by fat concentration interactions were observed for all ruminal pH variables ($P \geq 0.14$; Table 4). Oil removal had no impact on ruminal pH in steers fed 27% CDS ($P \geq 0.23$) except for time spent below a pH of 5.6 ($P = 0.04$). Steers fed 27% normal CDS spent more time with a ruminal pH below 5.6 than steers fed 27% de-oiled CDS. Oil removal had an effect on average ruminal pH ($P = 0.09$) and pH variance ($P = 0.10$) in steers fed 40% MDGS. Average ruminal pH and variance were lower for steers fed 40% de-oiled MDGS compared to 40% normal MDGS. A treatment effect was observed for average ruminal pH ($P < 0.02$) with steers fed 40% normal MDGS having a greater ruminal pH than steers fed control, 27% de-oiled or normal CDS, and 40% de-oiled MDGS.

These data indicate that oil removal via centrifugation in dry milling byproducts has limited impact on digestibility in finishing cattle diets. These findings do not support our hypothesis of improved digestibilities in cattle fed de-oiled byproducts; however, it supports the findings as to why there have been little differences observed in finishing performance between de-oiled and normal byproducts.

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Effects of Replacing Corn with a Pelleted Treated Corn Stover and Distillers Grains on Intake and Total Tract Digestibility of Finishing Diets

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Summary

A digestion study was conducted to evaluate the effects of replacing dry-rolled corn (DRC) with a pelleted feed containing treated corn stover, solubles, and distillers grains (DDG). Replacing DRC with the pelleted feed had no effect on intakes. Similarly, total tract digestibilities of DM, OM, or NDF were not affected by dietary treatment. There was a tendency for differences in average ruminal pH between treatments; however, proportions of acetate, propionate, and butyrate were not impacted. It was concluded that the DRC could be replaced with a pelleted stover and distillers in the finishing diet without altering total tract digestion.

Introduction

Over the past 10 years there has been a change in agriculture, with approximately 40-45% of corn production in the U.S. currently being used for ethanol. Increased cereal grain prices resulting from these changes in agriculture have caused livestock producers to find ways to feed less corn in their diets rather than more corn. The increased corn prices also have caused marginal cropland to be converted from forage production to crop production, which has increased the price of forage as well as increased the abundance of corn residue available. Therefore, non-traditional feeds such as corn milling byproducts and low quality forages from crop residues are commonly used in beef cattle diets. Pellet Technology USA (Gretna, Neb.) has developed a proprietary pelleted feed consisting of DGS and treated corn stover to replace corn in the common finishing diet. Their goal is to add value to the abundant corn residue by processing it and producing a pellet that can be shipped and stored like corn. Therefore, the objective of this study was to evaluate the effects of replacing dry-rolled corn (DRC) with a pelleted feed containing treated corn stover and DGS.

Procedure

Four ruminally fistulated steers were utilized in a 4 x 6 Latin rectangle with four treatments fed each period (Table 1). The first treatment was the control (CON) treatment consisting of 50.3% DRC, 40% MDGS, 5% untreated corn stover, and 1.7% limestone. The next three treatments replaced 25% of DRC, but with different feeds. One treatment contained only a calcium oxide (CaO) treated stover pellet (Pellet-A) replacing DRC. The second treatment contained a blend of CaO treated corn stover, DDG, and solubles in a pellet (Pellet-B) replacing DRC. The last treatment (COMP) replaced 25% of DRC with 10% treated stover pellet fed in the Pellet-A treatment, 10% DDGS, and 5% solubles. Limestone was added to the CON and COMP treatment to meet dietary requirements. All diets contained 3% dry meal supplement formulated to supply 375 mg/head/day Rumensin® and 90 mg/head/day Tylan®.

The pellets fed in the Pellet-A and COMP treatment were processed by

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Table 1. Diet (DM basis) fed to finishing steers to evaluate the effect of replacing 25% DRC with a CaO treated corn stover and DDG pellet on total tract digestibility.

Ingredient	Control	Pellet-A	COMB	Pellet-B
DRC	50.3	27	25.9	27
MDGS	40	40	40	40
Corn stalks	5	5	5	5
Treated stover pellet[1]	—	25	10	—
DDGS	—	—	10	—
Solubles	—	—	5	—
Pellet[2]	—	—	—	25
Limestone	1.7	—	1.1	—
Supplement[3]				
Fine ground corn	2.534	2.534	2.534	2.534
Salt	0.300	0.300	0.300	0.300
Tallow	0.075	0.075	0.075	0.075
Beef trace minerals[4]	0.050	0.050	0.050	0.050
Vitamins A-D-E[5]	0.015	0.015	0.015	0.015
Rumensin-90[6]	0.016	0.016	0.016	0.016
Tylan-40[7]	0.009	0.009	0.009	0.009

[1]Stover through Pellet Technology grinding process treated with CaO and water and pelleted.
[2]Pellet containing CaO treated corn stover and DDG produced by Pellet Technology.
[3]Supplement formulated to be fed at 3% of dietary DM.
[4] Premix contained 10% Mg, 6% Zn, 4.5% Fe, 2% Mn, 0.5% Cu, 0.3% I, and 0.05% Co.
[5] Premix contained 1,500 IU of vitamin A, 3,000 IU of vitamin D, and 3.7 IU of vitamin E•g-1.
[6]Formulated to supply 375 mg/head/day.
[7]Formulated to supply 90 mg/head/day.

hydrating corn stover with water, treating the stover with CaO, and pelleting the mixture. The pellets fed in the Pellet-B treatment were processed by hydrating corn stover with solubles instead of water, treating the stover with CaO, mixing in DDG, and pelleting the mixture. Nutrient composition of dietary treatments varied due to different feeds replacing DRC in the Pellet-A, Pellet-B, and COMB treatments (Table 2).

Each period was 14 days in length consisting of a 9-day adaptation and a 5-day collection. Steers were housed in individual slatted floor pens and fed once daily at *ad libitum* intake. Titanium dioxide (10 g/day) was dosed intraruminally at 0800 and 1600 hours on days 3 to 14. Fecal grab samples were collected at 0800, 1200, and 1600 hours on days 10 to 14. Samples were then composited by day, freeze-dried, and composited by steer each collection period. Fecal samples were analyzed for titanium dioxide concentration to predict DM excretion. Fecal and diet samples were analyzed for DM, OM, and NDF to estimate total tract digestibility. Rumen samples were collected at 0800, 1200, and 1600 hours on days 10 to 14 and analyzed for volatile fatty acid (VFA) concentration. Wireless pH loggers (Dascor, Inc., Escondido, Calif.) were placed in the rumen on day 10 prior to feeding, and recorded ruminal pH every minute until day 14.

Intake and digestibility data were analyzed using the MIXED procedures of SAS (SAS Institute, Inc., Cary, N.C.). Steer was the experimental unit. The model included period as a fixed effect. Steer and steer*treatment were included in the random statement. Volatile fatty acid and pH data were analyzed as repeated measures using the GLIMMIX procedures of SAS.

Results

There were no ($P \geq 0.15$) differences observed for DM, OM, or NDF intakes (Table 3) between the four treatments. Similarly, treatment did not affect the total tract digestibilities of DM, OM, or NDF ($P \geq 0.50$). There was a tendency ($P = 0.09$) for differences in average ruminal pH, with Pellet-A having the greatest average pH (6.01), Pellet-B having the lowest average pH (5.30), and the CON and COMB falling intermediate (Table 4). Correspondingly, there was a difference ($P < 0.05$) in maximum ruminal pH recorded, with treatment differences following the same trend as the average ruminal pH data. These differences in pH are attributed to the differing composition of the two pellets (Table 5). The treatment with the greatest ruminal pH, Pellet-A, contained 25% of the pelleted CaO and water treated stover (pH = 7.0). The treatment with the lowest ruminal pH, Pellet-B, contained 25% of the pellet consisting of DDG and corn stover treated with solubles and CaO (pH = 6.0). Dietary treatment had a tendency ($P = 0.06$) to impact minimum ruminal pH recorded, with the CON and Pellet-B having the lowest

Table 2. Nutrient composition of dietary treatments.

	Control	Pellet-A	COMB	Pellet-B
DM, %	64.6	63.6	60.6	63.8
OM, %	94.0	90.8	91.2	92.2
NDF, %	20.2	28.3	26.3	25.8
CP, %	16.9	16.0	19.1	19.9

Table 3. Effects of dietary treatment on intake and total tract digestibility of DM.

	Treatment[1]					
Item	Control	Pellet-A	COMB	Pellet-B	SEM	*P*-value
DM						
Intake, lb/day	22.26	16.42	18.72	18.78	2.55	0.21
Total tract digestibility, %	75.95	74.27	73.86	77.46	2.62	0.71
OM						
Intake, lb/day	20.88	14.90	17.01	17.34	2.36	0.15
Total tract digestibility, %	78.59	78.81	77.40	79.98	2.27	0.86
NDF						
Intake, lb/day	5.49	6.44	5.75	5.69	0.71	0.32
Total tract digestibility, %	62.35	72.63	68.35	68.11	4.74	0.50

[1]Control = 40% MDGS 50% DRC; Pellet-A = 25% treated stover pellet; COMB = 10% treated stover pellet, 10% DDGS, and 5% Solubles; Pellet-B = 25% treated stover/DDG pellet.

Table 4. Effect of dietary treatment on ruminal pH.

	Treatment[1]					
	Control	Pellet-A	COMB	Pellet-B	SEM	F-test
Average pH	5.54[ab]	6.01[a]	5.56[ab]	5.30[b]	0.16	0.09
Minimum pH	4.85[b]	5.38[a]	5.04[ab]	4.71[b]	0.14	0.06
Maximum pH	6.30[ab]	6.66[a]	6.29[ab]	5.96[b]	0.13	0.03
Variance	0.097	0.082	0.069	0.083	0.017	0.74

[a-d] means with differing superscripts are different.
[1]Control = 40% MDGS 50% DRC; Pellet-A= 25% treated stover pellet; COMB= 10% treated stover pellet, 10% DDGS, and 5% Solubles; Pellet-B=25% treated stover/DDG pellet.

Table 5. Nutrient composition of Pellet A and B.

%, DM basis	Pellet A	Pellet B
DM	82.70	84.30
OM	79.11	85.17
CP	5.06	20.65
NDF	47.48	35.7

Table 6. Effects of dietary treatment on rumen volatile fatty acid proportions.

	Treatment[1]					
	Control	Pellet-A	COMB	Pellet-B	SEM	*P*-value
Acetate, mMol/100 mMol	54.14	56.32	54.37	54.39	1.57	0.62
Propionate, mMol/100 mMol	27.32	24.84	28.01	26.26	2.00	0.51
Butyrate, mMol/100 mMol	11.78	12.16	11.39	13.12	0.87	0.36
Acetate : Propionate	2.32	2.42	2.01	2.23	0.26	0.55

[a-d]Means with differing superscripts are different.
[1]Control = 40% MDGS 50% DRC; Pellet-A= 25% treated stover pellet; COMB= 10% treated stover pellet, 10% DDGS, and 5% Solubles; Pellet-B=25% treated stover/DDG pellet.

minimum ruminal pH recorded (4.85 and 4.71, respectively), while Pellet-A had the greatest (5.38, respectively). Dietary treatment had no effect ($P \geq 0.36$) on ruminal acetate, propionate, or butyrate molar proportions (Table 6). Correspondingly, acetate to propionate ratio (A:P) was not influenced by dietary treatment ($P = 0.55$).

Throughout the duration of the study it was observed that the pellets treated with CaO and water were not as aerobically stable as the pellets treated with solubles and CaO. The CaO and water pellets tended to mold when stored, while the pellets treated with CaO and solubles were able to be stored at room temperature without any mold. Pellet A was stored in the cooler to minimize/eliminate any mold that was occurring.

In conclusion, replacing DRC with the pelleted stover and distillers had some impact on ruminal pH. However, using the pelleted treated corn stover and DDGS to replace DRC had no effect on intake or total tract digestibility. These data suggest that the pelleted corn residue and distillers could be a viable option for replacing DRC in finishing diets.

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Effects of Replacing Corn with a Pelleted Treated Corn Stover and Distillers Grains on Performance of Finishing Cattle

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Summary

A finishing study evaluated the effects of replacing 10, 20, or 30% corn (DM basis) with pelleted treated corn stover and distillers grains in a diet containing either 20 or 40% modified distillers grains plus solubles (MDGS) on finishing cattle performance. Steers consuming 10, 20, or 30% of the pelleted feed with 40% MDGS had equal or similar performance to the control diet with 40% MDGS. Cattle consuming 10% pelleted feed with 20% MDGS had similar efficiencies as the control diet; however, feeding the pellet at 20 or 30% of the diet DM with 20% MDGS decreased feed efficiency.

Introduction

Increased cereal grain prices have caused livestock producers to find ways to feed less corn in finishing diets. Increased corn prices have also caused marginal cropland to be converted from forage production to crop production, which has increased the abundance of corn residue available. Therefore, non-traditional feeds such as low quality forages from crop residues are commonly used in beef cattle diets. Pellet Technology USA (Gretna, Neb.) has developed a proprietary pelleted feed consisting of distillers grains (DGS) and treated corn stover to replace corn in finishing diets. Up to 25% of corn in a finishing diet can be replaced with pelleted distillers grains and treated corn stover without altering total tract digestion (*2015 Nebraska Beef Cattle Report,* pp. 83-85). Therefore, the objective of this study was to evaluate the effects of replacing corn with a pelleted feed containing treated corn stover and DGS on finishing cattle performance.

Procedure

A 183-day finishing study was conducted utilizing 336 crossbred steer calves (initial BW = 663 ± 55 lb). All steers were limit-fed a common diet consisting of 50% roughage and 50% byproduct at 2% of BW for five days prior to trial initiation to minimize gut fill. Following five days of limit feeding, steers were weighed two consecutive days. Steers were separated into two weight blocks (Light and Heavy) based on first-day weights, stratified by BW within block, and assigned randomly to pens. Pens were assigned randomly to one of seven treatments. There were eight steers per pen, and six pens per treatment. There were four pen replications per treatment in the light block and two pen replications in the heavy block. Pen was the experimental unit.

The seven treatments were set-up in a 2x3 plus 1 factorial design. The 2x3 factorial contained either 20 or 40% modified distillers grains (MDGS) with either 10, 20, or 30% pelleted treated corn stover and DDG (Table 1). The control diet (CON) consisted of a 50:50 blend of dry-rolled corn (DRC) and high-moisture corn (HMC) and 40% MDGS. All diets contained 5% wheat straw (3 inch grind) and 4% dry meal supplement formulated to provide 330 mg/steer daily Rumensin® and 90 mg/steer daily of Tylan®.

Feeding value of the pellet in diets containing 40% MDGS were calculated using the following equation: (((feed efficiency of pellet treatment-CON feed efficiency)/CON feed efficiency)/concentration of pellet) x 100 + 100. Unfortunately, a control diet containing 20% MDGS was not included in the treatment design. However, using meta-analysis data, we were able to estimate the expected feed efficiency of a control diet containing 20% MDGS. Feeding value of the pellet in diets containing 20% MDGS were calculated using the same equation described previously. Dietary NE_m and NE_g values were calculated for each treatment based on intake and performance of cattle, and analyzed as performance data.

During initial processing steers were vaccinated with Vision 7® and Vista 5®. Calves were also implanted with Revalor®-XS. Steers were pen weighed one day prior to harvest. Steers were harvested on day 184 at Greater Omaha Pack (Omaha, Neb). Carcass characteristics consisting of hot carcass weight (HCW), liver abscesses, USDA marbling score, 12th rib fat thickness, and LM area were collected. For USDA

Table 1. Dietary treatments (DM basis) to evaluate the effects of replacing 10, 20, or 30% corn (DM basis) with a pelleted treated corn stover and DDGS in diets containing 20 or 40% MDGS.

	40				20		
Ingredient	0[1]	10	20	30	10	20	30
DRC:HMC[2]	51	41	31	21	61	51	41
MDGS	40	40	40	40	20	20	20
Pellet	—	10	20	30	10	20	30
Wheat straw	5	5	5	5	5	5	5
Supplement[3]							
Fine ground corn	1.767	2.753	3.507	3.507	2.489	3.257	3.507
Limestone	1.740	0.754	—	—	0.768	—	—
Salt	0.300	0.300	0.300	0.300	0.300	0.300	0.300
Urea	—	—	—	—	0.250	0.250	—
Tallow	0.100	0.100	0.100	0.100	0.100	0.100	0.100
Trace mineral[4]	0.050	0.050	0.050	0.050	0.050	0.050	0.050
Vitamin A-D-E[5]	0.0150	0.0150	0.0150	0.0150	0.0150	0.0150	0.0150
Rumensin-90[6]	0.0165	0.0165	0.0165	0.0165	0.0165	0.0165	0.0165
Tylan-40[7]	0.0113	0.0113	0.0113	0.0113	0.0113	0.0113	0.0113

[1]Control treatment.
[2]50:50 blend of DRC and HMC.
[3]Supplement formulated to be fed at 4% of dietary DM.
[4]Premix contained 10% Mg, 6% Zn, 4.5% Fe, 2% Mn, 0.5% Cu, 0.3% I, and 0.05% Co.
[5] Premix contained 1,500 IU of vitamin A, 3,000 IU of vitamin D, and 3.7 IU of vitamin E•g-1.
[6]Formulated to provide 300 mg/head/day.
[7]Formulated to provide 90 mg/head/day.

Table 2. Effects of replacing corn with 10, 20, or 30% (dietary DM) with a pelleted treated corn stover and DDG with either 20 or 40% MDGS along with a control diet that included 5% untreated stalks and 40% MDGS.

	40% MDGS						20% MDGS						*P*-values	
	0[1]	10	20	30	Lin[2]	Quad[3]	10	20	30	Lin[4]	Quad[5]	SEM	F-Test[6]	Inter[7]
IBW, lb	679	681	680	678	0.31	0.11	681	679	678	0.27	0.89	1.2	0.58	1.0
FBW, lb[8]	1452	1461	1470	1448	0.77	0.12	1447	1442	1406	0.22	0.57	16.4	0.20	0.90
DMI, lb/day	23.27^{a}	23.48^{ab}	24.07^{bc}	24.13^{bc}	0.05	0.81	24.00^{b}	24.81^{c}	24.08^{bc}	0.84	0.03	0.28	0.02	0.70
ADG, lb/day	4.22	4.26	4.32	4.21	0.86	0.15	4.19	4.17	3.98	0.24	0.95	0.08	0.21	0.74
F:G	5.51^{a}	5.51^{a}	5.58^{a}	5.73^{ab}	0.04	0.30	5.73^{ab}	6.02^{b}	6.06^{b}	0.22	0.58	0.13	0.02	0.79
NE_m	2.05^{a}	2.04^{a}	2.01^{a}	1.98^{ab}	0.25	0.67	1.98^{ab}	1.93^{b}	1.91^{b}	0.17	0.59	0.03	<0.01	0.86
NE_g	1.38^{a}	1.38^{a}	1.36^{a}	1.33^{ab}	0.25	0.67	1.32^{ab}	1.28^{b}	1.17^{b}	0.17	0.59	0.02	<0.01	0.86
HCW, lb	916^{b}	922^{b}	927^{b}	914^{b}	0.77	0.12	913^{b}	930^{b}	887^{a}	0.03	<0.01	6.6	<0.01	0.73
LM area, in^2	14.0	13.9	14.0	13.7	0.32	0.52	13.9	14.0	13.7	0.44	0.47	0.19	0.80	0.99
12th rib fat, in	0.57	0.56	0.60	0.58	0.82	0.39	0.55	0.62	0.58	0.45	0.04	0.03	0.42	0.77
Marbling	464	478	472	457	0.59	0.16	500	484	469	0.09	0.95	10.70	0.13	0.91
YG	3.42	3.45	3.53	3.52	0.51	0.89	3.40	3.63	3.43	0.85	0.70	0.11	0.72	0.68

[a-d]From the F-test, means with differing superscripts are different ($P < 0.05$).
[1]Control treatment with no pellet.
[2]Linear contrasts for pellets with 40% MDGS.
[3]Quadratic contrasts for pellets with 40% MDGS.
[4]Linear contrasts for pellets with 20% MDGS.
[5]Quadratic contrasts for pellets with 20% MDGS.
[6]Overall F-test statistic comparing the Control (i.e., 0 pellet inclusion) to all other treatments.
[7]MDGS inclusion level by pellet inclusion level interaction.
[8]Calculated as HCW/common dress (63%).

calculated YG, KPH fat was assumed to be 2.5%. Hot carcass weights were used to calculate adjusted final BW by dividing HCW by a common dressing percentage (63%). Yield grade was calculated using the equation: USDA YG = 2.5+ 2.5(12th rib fat thickness, in) – 0.32(LM are, in^2) + 0.2 (KPH fat, %) + 0.0038 (HCW, lb).

Steer performance and carcass characteristics were analyzed as a 2 x 3 plus 1 factorial using the MIXED procedure of SAS (SAS Institute, Inc., Cary, N.C.) as a randomized block design with pen as the experimental unit. Weight block was considered a fixed effect. Orthogonal and linear contrasts were used to determine the response curve of the pellet with in the MDGS inclusion level.

Results

There were no interactions ($P \geq 0.68$) in cattle performance observed (Table 2) for the 2 x 3 factorial. No differences were observed in FBW ($P = 0.20$). However, there was a significant difference ($P = 0.02$) in DMI with the control diet consuming the least amount of feed and the treatment containing 20% MDGS and 20% pellet consuming the most. There was a linear increase ($P = 0.05$) in DMI as pellet inclusion increased in the treatments containing 40% MDGS. Increased intake as pellet inclusion increased would be expected, due to an increased passage rate of the pellet compared to the corn it is replacing, resulting from the small particle size of the pellet. However, DMI had a quadratic response ($P = 0.03$) as pellet inclusion increased in diets containing 20% MDGS. There were no significant differences ($P = 0.21$) in ADG between the control and the remaining six treatments. Cattle consuming diets containing 40% MDGS gained more ($P = 0.05$) than the cattle consuming diets containing 20%. Based on previous research, this was expected.

There was a linear increase ($P = 0.04$) in F:G as the level of pellet increased in diets containing 40% MDGS; however, there was no statistical difference between the control and diets containing 10 and 20% pellet with 40% MDGS. It was estimated that the pellet is 100% the feeding value of corn when fed at 10% of diet, 94% the value of corn when fed at 20% of the diet, and 88% the value of corn when fed at 30% of the diet with 40% MDGS. The control, 10% pellet, 20%, and 30% pellet in diets containing 40% MDGS had a statistically similar NE_m and NE_g.

The 10% pellet/20% MDGS treatment had a similar F:G compared to the 40% MDGS treatments. However, the treatments containing 20 and 30% pellet with 20% MDGS had ($P = 0.02$) greater F:G. Similarly, the calculated NE_m or NE_g were greater for the 10% pellet compared to the 20% and 30% pellet in diets containing 20% MDGS. Using an estimated F:G of 5.65 for a control diet containing 20% MDGS and 0% pellet, the pellet is 83% the feeding values of corn when fed at 10% of the diet, 69% the feeding value of corn when fed at 20% of the diet, and 77% the feeding value of corn when fed at 30% of the diet.

No interactions in carcass characteristics ($P \geq 0.68$) were observed when analyzing the 2 x 3 factorial. Similarly, there were no differences in LM area, 12th rib fat, marbling, or calculated yield grade. However, cattle consuming the treatment containing 30% pellet with 20% MDGS had lower ($P < 0.01$) HCW than all other treatments.

In conclusion, the pelleted DDG and treated corn stover is a viable option to replace corn in finishing diets; however, the level at which corn can be replaced depends on the level of distillers grains being fed. These data illustrate that up to 20% of corn can be replaced with a treated stover/DDG pellet when it is fed with 40% MDGS with no loss in performance. However, when feeding a diet containing 20% MDGS, up to 10% of corn can be replaced with the pellet without negatively impacting performance.

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Using Enspira to Improve Fiber Digestion

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Summary

A metabolism study was conducted to evaluate the effects of supplementing a fibrolytic enzyme (Enspira™) on total tract digestion of a finishing diet. In situ *NDF digestibilities of the corn bran, HMC, corn residue, and corn silage were not different between the treatments. Rate of digestion of the corn residue and corn silage was lower for the enzyme treatment compared to the control. Average ruminal pH was not significantly different between the two treatments. Correspondingly, there was no difference in VFA profile. There were no differences in DM, OM, NDF, ADF, or hemicellulose digestibilities between the control and enzyme treatment.*

Introduction

About one-third of corn production in the U.S. is used for ethanol production today. The utilization of corn in the production of ethanol, in addition to high and variable corn prices, has forced cattle producers to feed less corn. Non-traditional feeds like corn milling byproducts and low quality forages are being used to replace corn in beef cattle diets. However, these feed alternatives are higher in fiber content compared to the corn being replaced, thus resulting in more fiber-based diets. Therefore, if the digestibility of these fibrous components of cattle diets could be improved, cattle efficiencies could be increased. Enspira is a direct-fed enzyme designed to increase fiber (i.e., hemicellulose and cellulose) digestion. Previous research has shown that treating corn bran, husks, and WDGS with Enspira can improve *in vitro* (tube outside the animal) digestion (*2014 Nebraska Beef Cattle Report*, pp. 59-61). Therefore, the objective of this experiment was to evaluate the impact of dosing Enspira on *in vivo* (inside the animal) digestibilities.

Procedure

Four ruminally cannulated steers were utilized in a three period switchback design. All steers were fed a basal diet consisting of 40% Sweet Bran®, 45% HMC, 10% corn silage, and 5% supplement (DM basis). Steers were randomly assigned to one of two treatments, with treatments consisting of the basal diet treated with the enzyme or the basal diet without the enzyme treatment (Control). Enspira was added to the total mixed ration at a rate of 0.25 lb/ton of DM for the enzyme treatment. The rate of inclusion was determined by previous *in vitro* work (*2014 Nebraska Beef Cattle Report*, pp. 59-61). In order to ensure accurate incorporation into the diet, the enzyme was prepared as a premix, then incorporated into a dry supplement (added at 5% of diet DM), using fine ground corn as a carrier. Steers were housed in individual slatted floor pens and fed once daily at *ad libitum* intake.

Each period was 21 days in length consisting of a 14 day adaptation and 7 day collection. Titanium dioxide (10 g/day) was dosed intraruminally at 0800 and 1600 hours on days 9 to 21. Fecal grab samples were collected at 0800, 1200, and 1600 hours on days 16 to 20. Samples were then freeze-dried and composited by steer and period. Fecal samples were analyzed for titanium dioxide concentration to estimate DM excretion. Fecal and diet samples were analyzed for DM, OM, NDF, ADF, and hemicellulose to estimate total tract digestibility. Rumen samples were collected at 0800, 1200, and 1600 hours on days 16 to 20 and analyzed for volatile fatty acid (VFA) concentration. Wireless pH loggers (Dascor, Inc., Escondido, Calif.) were placed in the rumen on day 15 and recorded pH measurements every minute until day 21. *In situ* bags were incubated for 0, 6, 12, 16, 24, 48, and 96 hours in each steer starting on day 17. Samples incubated consisted of corn bran, high moisture corn (HMC), corn residue, and corn silage. *In situ* bags were removed from the

Table 1. Effect of dietary treatment on intake and total tract digestibility.

Item	Treatment			
	Control	Enzyme	SEM	*P*-value
DM				
Intake, lb/day	22.33	22.19	1.52	0.89
Total tract digestibility, %	80.3	78.3	1.6	0.47
OM				
Intake, lb/day	21.04	20.91	1.43	0.91
Total tract digestibility, %	82.3	80.2	1.6	0.44
NDF				
Intake, lb/day	5.08	4.91	0.57	0.76
Total tract digestibility, %	63.5	55.2	4.6	0.24
ADF				
Intake, lb/day	1.68	1.70	0.12	0.89
Total tract digestibility, %	56.3	51.2	4.7	0.52
Hemicellulose				
Intake, lb/day	3.89	3.79	0.26	0.61
Total tract digestibility, %	70.7	63.0	5.0	0.37

Table 2. Effect of Enspira on *in situ* NDFD (%) and rate (%/hour).

Sample	Treatment		SEM	*P*-value
	Control	Enzyme		
Corn Bran				
NDFD, %	48.75	47.75	14.37	0.56
Rate, %/hour	6.28	5.82	0.731	0.65
HMC				
NDFD, %	62.06	59.41	14.37	0.10
Rate, %/hour	3.65	3.37	0.667	0.76
Corn Residue				
NDFD, %	37.12	35.73	14.37	0.40
Rate, %/hour	3.81	1.40	0.667	0.01
Silage				
NDFD, %	41.36	40.16	14.37	0.46
Rate, %/hour	4.43	1.95	0.667	0.01

Table 3. Effect of dietary treatment on ruminal pH and volatile fatty acid (VFA) profile.

Item	Treatment		SEM	*P*-value
	Control	Enzyme		
Average pH	5.71	5.74	0.16	0.91
Maximum pH	6.72	6.53	0.15	0.41
Minimum pH	4.97	5.10	0.18	0.66
pH magnitude	1.75	1.43	0.21	0.39
pH variance	0.151	0.129	0.017	0.41
VFA Profile				
Total, mMol	113.89	110.94	5.51	0.74
Acetate, mMol/100 mMol	51.87	52.19	0.82	0.81
Proprionate, mMol/100 mMol	30.65	29.05	2.73	0.60
Butyrate, mMol/100 mMol	12.28	13.18	2.28	0.73
A:P	1.78	1.88	0.18	0.61

steers on day 21, rinsed with distilled water, and ran through an ANKOM fiber digester to estimate NDF digestibility. The nonlinear function of SAS was used to calculate rate of fiber digestion of the *in situ* bags. When calculating NDF digestibility, a 3%/hour rate of passage was assumed. All data were analyzed using the MIXED procedures of SAS (SAS Institute, Inc., Cary, N.C.). Steer was the experimental unit. Steer and steer*treatment were considered random.

Results

No differences ($P \geq 0.61$) in intakes were observed between the two treatments (Table 1). Total tract digestibilities of DM, OM, NDF, ADF, and hemicellulose were not different ($P \geq 0.24$) between the control and enzyme treatment. This could be attributed to the competition with the enzymes that are already present in the rumen. It also could be that the enzyme didn't have enough time to attach to the fibrous components of the feed since enzymes are normally excreted after the rumen microorganisms attach to the fibrous components. There was no impact ($P \geq 0.10$) of the enzyme on *in situ* NDF digestibility for the corn bran, HMC, corn residue, or silage (Table 2). Rate of digestion was not improved when incubating the corn bran or HMC ($P \geq 0.65$). However, the rate of digestion for the corn silage and corn residue samples decreased when incubated in steers fed the enzyme ($P \leq 0.01$). There was no difference ($P = 0.91$) in average ruminal pH (Table 3) between the control and enzyme treatment. Correspondingly, there was no difference ($P \geq 0.41$) in maximum and minimum pH recorded. There were no differences ($P \geq 0.60$) between the control and enzyme treatment in total VFA concentration, proportion of acetate, proportion of propionate, or proportion of butyrate. Similarly, the ratio of acetate to propionate was not significantly different ($P \geq 0.60$).

Implications

In conclusion, the impact of the enzyme is variable. Previous *in vitro* research suggested that including Enspira at 0.25 lb/ton of DM would improve ruminal digestion. However, when ruminally cannulated steers were fed Enspira at a rate of 0.25 lb/ton of DM it had no impact on total tract digestibilities of DM, OM, NDF, ADF, or hemicellulose.

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Effect of 300 or 400 mg Daily of Ractopamine Hydrochloride on Growth Performance and Carcass Characteristics of Finishing Steers During the Last 14, 28, or 42 Days

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Summary

The effects of ractopamine hydrochloride (Optaflexx®) dosage (0, 300, and 400 mg/head/day) and duration (14, 28, or 42 days) on growth performance were evaluated in feedlot finishing diets. Feeding 300 mg of Optaflexx for 28 or 42 days increased live final BW by 13 and 29 lb, while feeding Optaflexx at 400 mg resulted in 27 or 24 lb increases relative to 0 mg steers, respectively. Feeding 300 mg of Optaflexx for 28 or 42 days would suggest 11.1 or 16.6 lb improvements in HCW, while feeding 400 mg of Optaflexx would suggest 19.7 or 20.7 lb heavier carcasses compared to steers fed 0 mg Optaflexx, respectively.

Introduction

ß-adrenergic agonists have been shown to increase protein accretion and decrease fat accretion in animal growth (*Journal of Animal Science,* 1998, 76:160). Ractopamine hydrochloride (trade name Optaflexx; Elanco Animal Health, Greenfield, Ind.) is a ß-1 adrenergic agonists and is approved for feeding the last 28 to 42 days at the label dose of 70-430 mg/head/day to finishing cattle before harvest. When fed to finishing cattle, Optaflexx improves feed efficiency, final BW, and HCW when fed the last 28 to 42 days of the finishing period. However, few data exist evaluating the effects of feeding Optaflexx to yearling steers for less than 28 days due to FDA restrictions. Therefore, the objective of this experiment was to evaluate the effects of Optaflexx dose and duration (14-42 days) on animal growth performance of yearling steers.

Table 1. Basal diet and supplement.

Ingredient	% of diet DM
High-moisture corn	28.0
Dry-rolled corn	18.0
Modified distillers grains plus solubles	25.0
Sweet Bran	20.0
Wheat straw	5.0
Dry supplement[1]	
Fine ground corn	1.5118
Limestone	1.9980
Salt	0.3000
Tallow	0.1000
Beef trace mineral	0.0500
Vitamin A-D-E	0.0150
Rumensin-90	0.0165
Tylan-40	0.0087

[1]Supplement formulated to be fed at 4% of diet DM and formulated for 30 g/ton Rumensin and 90 mg/daily of Tylan.

Procedure

Crossbred yearling steers (n = 576; BW = 899 ± 64 lb) were utilized in a randomized block design (n = 4 BW blocks) with a 3 x 3 factorial treatment design to study the effects of Optaflexx dosage and duration on growth performance. Factors included Optaflexx feeding duration (14, 28, or 42 days prior to harvest) and Optaflexx dosage (0, 300, and 400 mg/head/day). Steers were received at the University of Nebraska's Agricultural Research and Development Center (ARDC) near Mead, Neb., in the fall of 2012. Prior to initiation of trial, steers were limit-fed at 2% BW for 5 days a diet consisting of 50% Sweet Bran® and 50% alfalfa hay (DM basis) to minimize variation in gastrointestinal fill. Steers were weighed two consecutive days (day 0 and 1) to establish initial BW. Steers were blocked by day 0 BW, stratified by BW, and assigned randomly within strata to pens. Pens were assigned randomly to treatments. The study consisted of eight pens per treatment with eight steers per pen. Cattle were adapted to a common finishing diet (Table 1) over a 19-day period consisting of four adaptation diets. The amount of modified distillers grains plus solubles (MDGS), Sweet Bran, wheat straw, and supplement included in each adaptation diet was held constant at 25, 20, 5, and 4% (DM basis), respectively. The amount of corn was gradually introduced in the diet while replacing alfalfa hay. The supplement was formulated for 30 g/ton Rumensin® and to provide 90 mg/steer daily of Tylan®. Cattle were fed once daily between 0700 and 0900 hours.

Optaflexx was initiated when steers were within 14 to 42 days of their projected endpoints. Two weeks prior to treatment initiation and every seven days thereafter, steers were removed from their pens (approximately 0700 hours) and pen weights were collected using a pen scale. On the morning of treatment initiation, each pen was removed and weighed. All residual feed remaining in the

Table 2. **Animal performance of steers fed 0, 300, and 400 mg/head/day of Optaflexx for 14, 28, or 42 days at the end of the finishing period.**

Duration:	14 day			28 day			42 day						
Dosage:	0	300	400	0	300	400	0	300	400	SEM	Int.	Dose	Dur
Live Performance													
Initial BW, lb	892	890	889	886	890	891	891	891	888	2	0.54	0.57	0.50
Live final BW, lb[1]	1385[e]	1390[e]	1391[e]	1414[d]	1427[cd]	1441[c]	1473[b]	1502[a]	1497[a]	6	0.03	0.01	<0.01
Over Control, lb	—	5	6	—	13	27	—	29	24				
DMI, lb/day	26.4[ab]	26.4[ab]	26.4[ab]	27.0[a]	26.1[b]	26.1[b]	26.5[ab]	26.8[ab]	27.1[a]	0.4	0.07	0.69	0.59
ADG, lb[2]	4.02[ab]	4.09[a]	4.10[a]	3.88[c]	3.94[bc]	4.04[ab]	3.88[c]	4.06[a]	4.06[a]	0.13	0.15	<0.01	0.08
Feed:Gain[3]	6.54[abc]	6.45[ab]	6.41[ab]	6.94[d]	6.58[bc]	6.41[a]	6.80[cd]	6.59[ab]	6.66[abcd]	0.006	0.04	<0.01	0.24
Carcass-Adjusted Performance													
Final BW, lb[4]	1339[e]	1346[e]	1353[e]	1399[d]	1417[c]	1424[c]	1454[b]	1480[a]	1486[a]	9	0.30	<0.01	<0.01
ADG, lb[5]	3.65[e]	3.73[de]	3.77[cd]	3.78[cd]	3.85[bc]	3.89[abc]	3.73[de]	3.90[ab]	3.97[ab]	0.10	0.51	<0.01	<0.01
Feed:Gain	7.25[d]	7.09[cd]	6.99[bcd]	7.14[d]	6.76[ab]	6.67[a]	7.04[cd]	6.80[abc]	6.76[ab]	0.005	0.63	0.01	0.03

[a-e]Means with different superscripts differ ($P < 0.05$).
[1]Live final BW measured by weighing cattle on pen scale day of shipping and applying a 4% pencil shrink.
[2]Calculated using live final BW.
[3]Analyzed as G:F, the reciprocal of F:G.
[4]Calculated from HCW divided by a common dressing percent (63%).
[5]Calculated using carcass-adjusted final BW.

bunk was removed and weighed. Pen weights (4% pencil shrink applied) were collected every seven days to evaluate animal performance over the Optaflexx treatment phase. Optaflexx was delivered daily during the treatment phase via top-dress at either 300 or 400 mg/head/day, depending on treatment, with fine ground corn used as the carrier. Three top-dress supplements were used during the treatment phase, one that contained no Optaflexx (1 lb/head/day of fine ground corn), one that contained 300 mg of Optaflexx (1 lb/head/day of a 600 g/t Optaflexx medicated supplement), and one that contained 400 mg of Optaflexx (1.11 lb/head/day of a 720 g/t Optaflexx medicated supplement). Steers that were fed 0 mg/head/day of Optaflexx were top-dressed daily with fine ground corn during the treatment phase.

One hundred days prior to the target marketing date for steers on the 28 day treatment, all steers were implanted with Component TE-S with Tylan®. The terminal implant window ranged from 86 to 114 days, depending on treatment duration. On day of shipping, cattle were fed 50% of the previous days feed call and then in the afternoon all cattle to be shipped were removed from their pens, pen weighed, and loaded onto the truck. All steers were harvested at Greater Omaha Packing Co. (Omaha, Neb.) the following morning. Hot carcass weight was obtained on day of harvest. After a 48 hour chill, USDA marbling score, 12^{th} rib fat depth, and LM area were recorded. Yield grade was calculated from the following formula: 2.50 + (2.50*fat thickness, in) + (0.2* 2.5 [KPH]) + (0.0038*HCW, lb) – (0.32*LM area, in^2). Final live BW were pencil shrunk 4% to calculate dressing percent and live animal performance. A common dressing percentage of 63% was used to calculate carcass-adjusted performance to determine final BW, ADG, and F:G.

Animal performance and carcass characteristics were analyzed as a 3 x 3 factorial using the MIXED procedure of SAS (SAS Institute, Inc., Cary, N.C.), with pen being the experimental unit and animals that were removed during the experiment not included in the analysis. The model included the effects of dose, duration, and dose x duration interaction. Block was treated as a fixed effect. Due to a significant difference in BW among steers when Optaflexx was initiated, Optaflexx initial BW was used as a covariate in the model. The significance of the linear and quadratic coefficients were tested for Optaflexx dose when looking at final live BW and HCW change over Optaflexx feeding duration using the MIXED procedure of SAS. Treatment differences were declared significant at $P \leq 0.05$.

Results

The interaction of dose x duration was observed for final live BW and F:G ($P < 0.05$; Table 2); therefore, simple effects will be presented. Intake was 0.9 lb/day greater ($P = 0.02$) for steers fed 0 mg Optaflexx compared to 300 and 400 for 28 days. Live final BW was not different ($P > 0.35$) for steers fed 0, 300, or 400 mg Optaflexx for 14 days. At 28 days, live final BW was 27 lb heavier ($P < 0.01$) for steers fed Optaflexx at 400 mg than steers receiving 0 mg Optaflexx. At 28 days, steers fed Optaflexx at 300 mg tended ($P = 0.07$) to be 13 lb heavier than steers receiving 0 mg. Feeding 400 mg Optaflexx for 28 days increased ($P = 0.05$) live final BW 14 lb compared to 300 mg. Live final BW was 29 and 24 lb greater ($P < 0.01$) for steers fed Optaflexx for 42 days at 300 and 400 mg compared to 0 mg. Live final BW were not different ($P = 0.51$) between steers receiving Optaflexx at 300 and 400 mg for 42 days. Weekly live BW response over 0 mg fed steers is presented in Figure 1. Feeding 300 mg of Optaflexx would provide 23.4, 26.7, and 28.9 lb of added live BW,

(Continued on next page)

Table 3. Carcass characteristics of steers fed 0, 300, and 400 mg/head/day of Optaflexx for 14, 28, or 42 days at the end of the finishing period.

Duration:	14 day			28 day			42 day			SEM	Int.	Dose	Dur
Dosage:	0	300	400	0	300	400	0	300	400				
Carcass Characteristics													
HCW, lb	843.4^{e}	848.1^{e}	852.3^{e}	881.7^{d}	892.8^{c}	901.4^{c}	915.7^{b}	932.3^{a}	936.4^{a}	5	0.30	<0.01	<0.01
Over Control, lb	—	4.7	8.9	—	11.1	19.7	—	16.6	20.7				
Dressing, %[1]	60.9^{b}	61.0^{b}	61.2^{b}	62.4^{a}	62.6^{a}	62.4^{a}	62.3^{a}	62.2^{a}	62.7^{a}	0.4	0.73	0.53	0.01
Marbling[2]	440^{cd}	430^{d}	432^{d}	465^{abc}	452^{bcd}	467^{abc}	484^{a}	485^{a}	475^{ab}	11	0.86	0.71	<0.01
LM area, in	13.3^{cd}	13.1^{d}	13.1^{d}	13.4^{bcd}	13.8^{abc}	13.6^{abc}	13.8^{abc}	13.9^{ab}	14.0^{a}	0.2	0.18	0.83	0.83
12th rib fat, in	0.48^{c}	0.50^{bc}	0.50^{bc}	0.59^{a}	0.55^{ab}	0.57^{a}	0.58^{a}	0.59^{a}	0.59^{a}	0.02	0.72	0.93	<0.01
Calculated YG	3.1^{cd}	3.3^{bc}	3.3^{abc}	3.5^{ab}	3.3^{abc}	3.4^{ab}	3.5^{a}	3.5^{a}	3.5^{a}	0.1	0.46	0.86	0.04

[a-e]Means with different superscripts differ ($P < 0.05$).
[1]DP = Dressing Percent; calculated from HCW divided by live final BW, with a 4% pencil shrink applied.
[2]Marbling Score: 300 = Slight, 400 = Small, 500 = Modest, etc.

while feeding 400 mg would provide 22.7, 24.0, and 23.6 lb of added live BW over 0 mg fed steers for a 28, 35, and 42 feeding duration, respectively.

Carcass-adjusted ADG was not different ($P = 0.19$; 3.65 vs. 3.73 lb) between steers fed Optaflexx at 0 mg and 300 mg for 14 days. Carcass-adjusted ADG was greater ($P = 0.05$) for steers fed Optaflexx at 400 mg (3.77 lb) compared to 0 mg (3.65); however, carcass-adjusted ADG was not different ($P = 0.47$) between steers receiving 300 and 400 mg of Optaflexx for 14 days. At 28 days, carcass-adjusted ADG was not different ($P > 0.20$) among cattle fed Optaflexx at 0 or 300 mg and 300 or 400 mg. Feeding 400 mg of Optaflexx tended to increase ($P = 0.06$; 3.89 vs. 3.78 lb) carcass-adjusted ADG compared to 0 mg for 28 days. Carcass-adjusted ADG was greater ($P < 0.01$) for steers fed Optaflexx for 42 days at 300 (3.90 lb) and 400 mg (3.97 lb) compared to 0 mg (3.73 lb). There was a tendency ($P = 0.10$) for an improvement in carcass-adjusted feed conversion (F:G) when steers were fed Optaflexx at 400 compared to 0 mg for 14 days. Carcass-adjusted feed conversion was not different ($P = 0.35$) between steers fed 0 and 300 mg of Optaflexx for 14 days. No difference ($P = 0.48$) in carcass-adjusted F:G was observed when feeding Optaflexx for 14 days at 300 or 400 mg. Compared to 0 mg of Optaflexx, carcass-adjusted F:G was improved ($P < 0.01$) by 5.3 and 7.0% when steers were fed 300 or 400 mg of Optaflexx for 28 days, but were not different

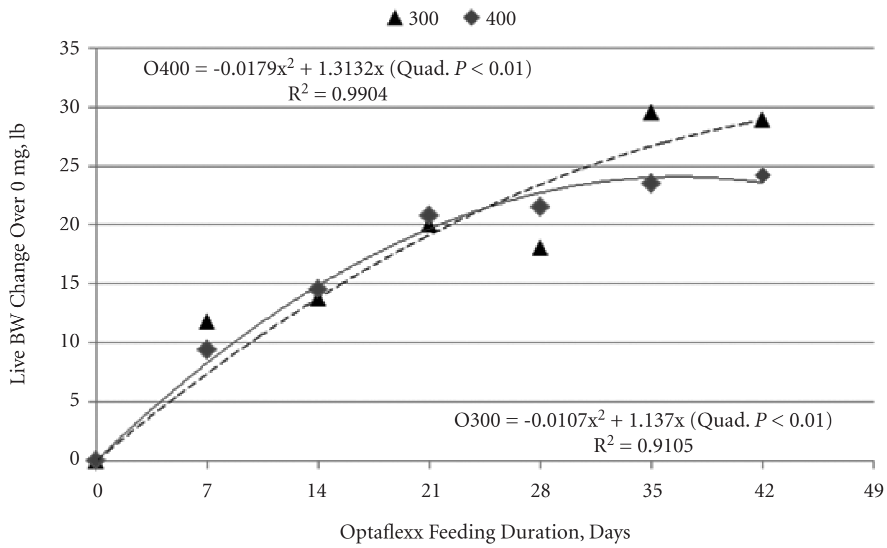

Figure 1. Live BW change when feeding 300 and 400 mg Optaflexx over 0 mg of Optaflexx[ab].

[a]Growth performance is calculated on a shrunk basis (4%).
[b]Day 7-14 has 24 Optaflexx 300 mg pens averaged together and 24 Optaflexx 400 mg pens averaged together, days 21-28 has 16 pens for 300 mg and 16 for 400 mg, and days 35-42 has 8 pens for 300 mg and 8 for 400 mg.

($P = 0.43$) between 300 and 400 mg for 28 days. There was a tendency ($P = 0.10$) for 3.4% improvement in carcass-adjusted F:G when steers were fed 300 mg of Optaflexx compared to 0 mg for 42 days. Feeding 400 mg of Optaflexx for 42 days resulted in a 4.0% improvement ($P = 0.03$) in carcass-adjusted F:G compared to 0 mg; however, carcass-adjusted F:G was not different ($P = 0.64$) between steers receiving 300 and 400 mg of Optaflexx.

There were no significant ($P > 0.17$; Table 3) dose x duration interaction for carcass data; however, the simple effects will be presented. Hot carcass weight was not different ($P = 0.33$; 843.4 vs. 848.1 lb) between yearlings fed Optaflexx at 0 and 300 mg for 14 days, but tended ($P = 0.07$) to be 8.9 lb heavier for steers fed 400 mg of Optaflexx compared to 0 mg. Hot carcass weight was 11.1 and 19.7 lb greater ($P < 0.02$) for steers fed 300 and 400 mg of Optaflexx for 28 days compared to 0 mg (881.7 lb). Carcasses from yearlings fed Optaflexx for 42 days at 300 and 400 mg were 16.6 and 20.7 lb heavier ($P < 0.01$) than 0 mg (915.7 lb) fed steers. Hot carcass weight change over 0 mg fed steers is presented in Figure 2. Feeding 300 mg of Optaflexx would provide 11.0, 13.7, and 16.4 lb of added HCW, while feeding 400 mg would provide 15.8, 19.7, and 23.6 lb

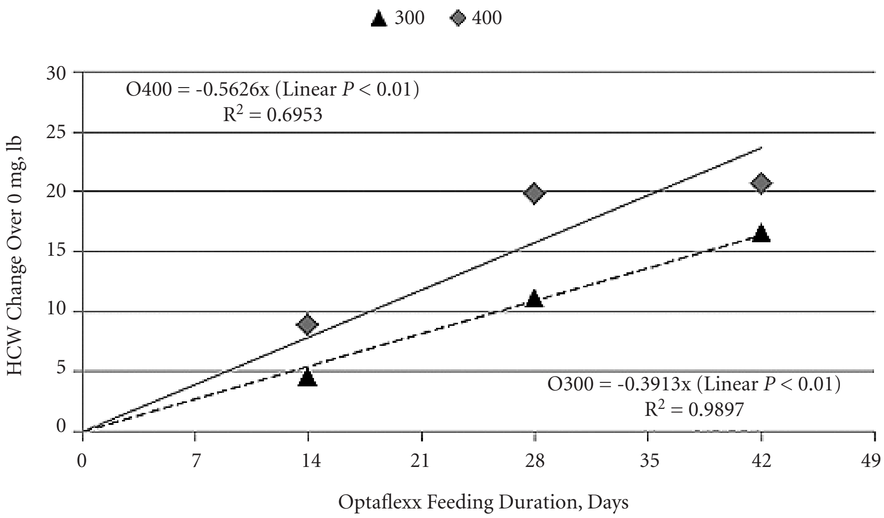

Figure 2. Hot carcass weight change when feeding 300 and 400 mg Optaflexx over 0 mg of Optaflexx[ab].

[a]Day 7-14 has 24 Optaflexx 300 mg pens averaged together and 24 Optaflexx 400 mg pens averaged together, days 21-28 has 16 pens for 300 mg and 16 for 400 mg, and days 35-42 has 8 pens for 300 mg and 8 for 400 mg.

of added HCW over 0 mg fed steers for a 28, 35, and 42 feeding duration, respectively. No other treatment differences ($P > 0.05$) were observed for LM area, dressing percent, marbling score, fat thickness, or calculated yield grade.

In this study, yearling steers were fed Optaflexx for 14 days in order to develop the response curves for both live BW and HCW change. A feeding duration of 14 days is not approved for Optaflexx; therefore, conclusions are based on 28 and 42 days of feeding Optaflexx. Feeding 300 mg of Optaflexx to yearling steers for 28 or 42 days increased live final BW (13 and 29 lb) and HCW (11.1 and 16.6 lb) compared to cattle fed 0 mg of Optaflexx. Feeding 400 mg of Optaflexx the last 28 or 42 days to yearling steers improved live final BW (27 and 24 lb) and HCW (19.7 and 20.7 lb) relative to 0 mg fed cattle. In yearling steers, Optaflexx improves F:G, final live BW, and HCW when fed at 300 or 400 mg for the last 28 or 42 days of the finishing period.

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Effects of Three Aggressive Implant Protocols on Feedlot Performance and Carcass Traits of Calf-Fed Steers

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Summary

A commercial feedlot study compared the effects of three initial implant strategies [Revalor® 200 (Rev200), Revalor® IS (RevIS), or Revalor® XS (RevXS)] followed by a Revalor 200 terminal implant on performance and carcass characteristics of feedlot cattle. No differences in final BW, DMI, ADG, or F:G were observed. The RevXS treatment resulted in larger LM area, lower calculated yield grades, less back fat, and a greater percentage of yield grade 1 carcasses. The Rev200 and the RevXS treatments had a higher percentage of carcasses that graded select compared to RevIS suggesting initial implant has little impact on feedlot performance but small effects on quality and fatness at equal days on feed.

Introduction

Steers have the ability to respond to higher dose single implant protocols compared to non-implanted steers, with increased growth performance and leaner body composition when cattle are harvested on an equal day basis. Results of increasing the amount trenbolone acetate (TBA) and estradiol (E) levels in reimplant protocols have resulted in mixed results. Regardless, industry use of steer protocols employing an initial Revalor 200 subsequently re-implanted with Revalor 200 in steers fed 180 to 200 days have become increasingly common. Aggressive protocols utilizing Revalor XS as an initial implant and reimplanted with Revalor 200 have been evaluated in only one study. A more intensive evaluation of aggressive implant protocols in calf-fed steers is needed. The objectives of this study were to determine the effect of three initial implants (Revalor IS, Revalor XS, and Revalor 200) followed by a terminal Revalor 200 on feedlot performance and carcass traits in calf-fed steers fed for approximately 180 to 200 days.

Procedure

A commercial feedlot experiment was conducted at Hi-Gain Feedlot near Farnam, Neb. Crossbred calves (n = 1,408; initial BW = 673 ± 23 lb) from ranches and auction barns in Nebraska, Nevada, and Utah were utilized for this trial. Steers were blocked (n = 3) by arrival date and projected harvest date. Steers were allocated to pens by sorting every two steers into one of three pens before processing. Pens were assigned randomly to one of three treatments (six pens/treatment). The treatments for this trial involved three different initial implants followed by a common terminal implant: Revalor IS (80 mg TBA and 16 mg E), Revalor 200 (200 mg TBA and 20 mg E), or Revalor XS (200 mg TBA and 40 mg E) given on day 1 with each treatment consisting of a subsequent Revalor 200 implant at day 115. Implants were placed in the upper middle one-third of the ear under the skin. At reimplant, all implants were placed in the opposite ear of the initial implant. Mean days on feed across all blocks was 195 days. A step-up period consisting of three adaptation diets was used to adapt cattle to the finishing ration. The finishing ration on average contained 49.9% dry-rolled corn (range 54.6-41.1%), 19.2% ADM-Synergy (range 28-0%), 19.6 % wet distillers grains with solubles (range 35-12%), 5 % liquid supplement (range 5.2-4.1%), 3.9% mixed hay (range 4.0-3.5%), and 2.4% corn silage (range 3.0-0%). All ration changes that occurred during the feeding period were the same for all cattle on trial. The supplement was formulated to provide 360 mg/steer daily of Rumensin® and 90 mg/steer daily of Tylan®. At the end of the feeding period, three replications of cattle were fed Zilmax at 7.56 g/ton DM for 20 days followed by a three-day withdrawal before harvest and, due to removal of Zilmax from the market, the remaining three replications were fed Optaflexx at 300 mg/head/day for the last 28 days of the feeding period. Feeding of beta-agonist was equal across treatments within a replication as all cattle were fed either Zilmax or Optaflexx. Pen weights were collected on day 1, and performance was calculated from pen BW. Final live body weight was determined at shipping using the average of the pen weight shrunk by 4% to adjust for gut fill. Carcass-adjusted performance was calculated using final BW, based on HCW divided by a common dressing percentage of 64.5%. Cattle were slaughtered at a commercial harvest facility on three dates. On day 1 of harvest, both liver scores and HCW were recorded and after a 48-hour chill, KPH fat, 12^{th} rib fat thickness, color score, LM area, USDA marbling score, and USDA quality and yield grades were recorded. Both feedlot and carcass data were analyzed on a pen basis as a randomized block design using the Glimmix procedure of SAS (SAS Institute, Inc., Cary, N.C.). The model included the fixed effects of treatment with block as a random effect. Treatment means were separated using LSD test when the F-test statistic was significant

Table 1. **Performance of steers implanted with either Revalor IS, 200, or XS on day 1 followed by Revalor 200 on day 115.**

Variable	Treatments			SEM	*P*-value
	RevIS	Rev200	RevXS		
Pens	6	6	6	—	—
Steers	473	471	464	—	—
Initial BW, lb	676	672	674	10.1	0.81
Live performance[1]					
Final BW, lb[2]	1474	1475	1468	14.9	0.70
DMI, lb/day	24.3	24.1	24.0	0.4	0.58
ADG, lb	4.08	4.11	4.06	0.05	0.51
F:G	5.95	5.88	5.91	0.07	0.49
Carcass adjusted performance[3]					
Final BW, lb	1491	1488	1496	21.2	0.64
ADG, lb	4.16	4.16	4.19	0.05	0.68
F:G	5.83	5.80	5.71	0.12	0.36

[1]Finishing performance was calculated with dead and rejected animals removed from the analysis.
[2]Final BW is the average pen weight shrunk 4%. Subsequent ADG, and F:G are calculated from 4% shrunk final BW.
[3]Calculated as HCW divided by the average dressing % of 64.55. Subsequent ADG, and F:G are calculated from carcass adjusted final BW.

Table 2. **Carcass characteristics of steers implanted with either Revalor IS, 200, or XS on day 1 followed by Revalor 200 on day 115.**

Carcass characteristics	Treatments			SEM	*P*-value
	RevIS	Rev200	RevXS		
HCW, lb	962	959	965	13.7	0.64
Marbling[1]	466	448	452	17.2	0.15
LM area, in[2]	15.0[a]	15.2[a]	15.6[b]	0.1	<0.01
Fat thickness, in	0.70	0.70	0.66	0.04	0.05
Yield Grade[2]	3.53[a]	3.46[a]	3.22[b]	0.13	0.01
Yield Grade[3]					
1	3.91[a]	5.91[a,b]	8.95[b]	1.12	0.03
2	22.07	25.45	29.59	2.19	0.07
3	45.06	40.68	44.27	2.39	0.40
4	25.75[a]	23.41[a]	15.83[b]	2.10	0.01
5	3.22	4.55	1.38	0.99	0.06
Quality Grade[3,4]					
Prime	2.50	1.13	1.37	0.74	0.28
Premium Choice	27.73	23.13	25.06	2.13	0.32
Low Choice	50.45	48.30	47.38	2.38	0.65
Select	19.32[a]	27.44[b]	26.20[b]	2.13	0.03

[1]Marbling score 300 = Select, 400 = Small.
[2]Yield grade was calculated as 2.5 + (2.5 x fat thickness) – (0.32 x LM area) + (0.2 x %KPH fat) + (0.0038 x HCW).
[3]All numbers are expressed as percentages. The Yield Grade and Quality Grade values represent the proportion of carcasses within each group that received a yield and quality grade.
[4]Quality Grade proportions were based on marbling scores.
[a,b] Means within a row with different superscripts differ ($P < 0.05$).

(protected F-test). Frequency data (Yield, Quality, and Health data) were analyzed using binomial proportions with Glimmix and the ILINK option of SAS was used to determine least square means and SE of the proportions. Alpha values ≤ 0.05 were considered significant.

Results

There were no differences in DMI ($P \geq 0.58$) between the three implant strategies over the entire feeding period (Table 1). Using carcass-adjusted performance, no differences in final BW or ADG were observed. Therefore, F:G also was unaffected by implant strategy. Likewise, similar results were observed when evaluating performance using final live BW.

There were no differences ($P \geq 0.15$) in HCW or USDA marbling score in carcasses when comparing the three strategies (Table 2). Steers within the RevXS treatment had a significant increase ($P \leq 0.05$) in LM area, and 12th rib backfat, which also led to a significant decrease ($P = 0.01$) in calculated yield grade when compared to the Rev200 and RevIS treatment groups. Steers that received Revalor XS as an initial implant followed by Revalor 200 at reimplant had an increase ($P = 0.03$) in the percentage of yield grade 1 carcasses when compared to cattle that received RevIS as initial implants. With this increase in percentage of yield grade 1 carcasses there was a similar decrease ($P = 0.01$) in the percentage of yield grade 4 carcasses in RevXS treated steers compared to Rev200 and RevIS. Overall, there were no differences in the percentage of cattle that graded choice or greater; however the cattle that received the Rev200 and RevXS treatment had an increase ($P = 0.03$) in the percentage of cattle that graded USDA Select compared with steers receiving the RevIS treatment.

In conclusion, the steers implanted with either Revalor 200, IS, or XS initially and commonly reimplanted with Revalor 200 had similar feedlot performance. Additionally, the use of more aggressive implants strategies could negatively impact quality grades in steer calves compared to a traditional low dose implant followed by a high dose terminal implant at equal days on feed.

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A Comparison of Two Implant Protocols: Synovex-Choice/Synovex-Plus vs. Synovex-S/Revalor-S on Steer Feedlot Performance and Carcass Characteristics

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Adam F. Summers
Rick N. Funston[1]

Summary

In a 2 year study, implant strategies were compared utilizing Synovex® Choice followed by Synovex Plus® or Synovex® S followed by Revalor® S. Spring-born crossbred steers were blocked by BW and randomly assigned to receive either Synovex Choice or Synovex S as the initial implant. Approximately 100 days later, steers were reimplanted with Synovex Plus or Revalor S. Steers were slaughtered after 205 days on feed. There was no difference in average daily gain or hot carcass weight between treatment groups. Furthermore, there were no differences in yield grade, marbling score, or proportion of steers grading USDA Choice. Both implant regimens resulted in similar feedlot and carcass characteristics.

Introduction

Implants are commonly used in the United States to increase muscling in cattle without adding excess backfat. However, the use of high potency implants has been linked to decreased marbling scores (*Journal of Animal Science,* 1995, 73: 2873-2881; *Journal of Animal Science,* 2000, 78: 1867-1874), resulting in lower quality grades and lost premiums when sold on a grid. The objective of this study was to compare the effects of using the higher potency implant strategy, Synovex Choice and Synovex Plus with the less potent strategy, Synovex S and Revalor S on steer feedlot and carcass characteristics.

Procedure

Over a 2-year period, 109 crossbred (5/8 Red Angus, 3/8 Continental) spring-born steers were blocked by BW and assigned randomly to pen, which received 1 of 2 implant protocols: Synovex Choice [100 mg of trenbolone acetate (TBA) and 14 mg of estradiol benzoate (EB)] implanted at the beginning of the feeding period (CHPL), or Synovex S (200 mg of progesterone and 20 mg of EB- SS) as initial implant. Steers were fed for approximately 100 days, and the CHPL treatment was reimplanted with Synovex Plus (200 mg of TBA and 28 mg of EB) while the SS treatment received Revalor S (120 mg of TBA and 24 mg of EB). Steers were housed in pens of nine by treatment with 2 and 4 pens per treatment in Year 1 and Year 2, respectively. Steers were fed a calf diet from the beginning of treatment in mid-December to early March at which time they were transitioned to a yearling diet (Table 1). At 209 and 213 (Year 1 and Year 2, respectively) days on feed, steers were shipped to a commercial abattoir for slaughter. Hot carcass weight was determined on day of slaughter; carcass characteristics were evaluated 24 hours following slaughter. Final BW was calculated from HCW, based on an average dressing percentage of 63%.

Economic Analysis

Individual expense and revenue was calculated for each steer. Treatment cost was $5.25/steer for CHPL and $3.92 for SS. Feed expense was based on the average pen DMI, feed cost was assumed to be $0.06/lb and a daily yardage charge of $0.50/steer was included. Revenue was calculated on the base grid price for the week that steers were slaughtered. Premiums and discounts for quality grade, yield grade, and HCW were also calculated for those weeks.

Statistical Analysis

The GLIMMIX procedure of SAS (SAS Institute, Inc., Cary, N.C.) was used to analyze all data with steer as the experimental unit, with the exception of average DMI, where pen was the experimental unit. The model

Table 1. Composition of calf and yearling diets.

	DM, %	
Item	Calf Diet	Yearling Diet
Dry-rolled corn	35	37
Prairie hay	10	6
Wet corn gluten feed	47	53
Supplement[1,2]	8	4

[1]Calf diet supplement included 71.74% dried distillers grain plus soluble, 14.90% limestone, 2.85% iodized salt, 2.35% ammonium chloride, and 1.06% trace mineral mix, Rumensin 90 (28g/ton), thiamine, Tylan 40 (10 g/ton), and Vitamin A, D, and E.
[2]Yearling diet supplement included 51.26% ground corn, 29.57% limestone, 5.59% iodized salt, 4.65% ammonium chloride, and 1.94% trace mineral mix, Rumensin 90 (28g/ton), thiamine, Tylan 40 (10 g/ton), and Vitamins A, D, and E.

Table 2. Feedlot performance of steers on CHPL[1] and SS[2] implant protocols.

Item	CHPL[1]	SS[2]	SEM	*P*-value
Initial BW, lb	534	533	24	0.94
Final BW,[3] lb	1,328	1,308	27	0.37
ADG, lb	3.85	3.75	0.18	0.39
DMI,[4] lb/day	21.82	21.51	0.58	0.59
F:G	5.75	5.78	0.23	0.89

[1]CHPL = steers received Synovex Choice as initial implant in mid-December and were re-implanted with Synovex Plus 100 days later.
[2]SS = steers received Synovex S as initial implant in mid-December and re-implanted with Revalor S 100 days later.
[3]Final BW calculated from HCW based on a common dressing percentage of 63%.
[4]F:G calculated as the average pen DMI.

Table 3. Carcass characteristics of steers on CHPL[1] and SS[2] implant protocols.

Item	CHPL[1]	SS[2]	SEM	*P*-value
HCW, lb	837	824	15	0.37
Yield Grade	2.52	2.70	0.26	0.16
LM Area, in^2	14.03	14.04	0.35	0.98
Marbling score[3]	501	525	13	0.19
Fat thickness, in	0.54	0.59	0.06	0.13
USDA Choice, %	93	96	4	0.42
Md[4] or greater, %	47	54	7	0.50

[1]CHPL = steers received Synovex Choice as initial implant in mid-December and were re-implanted with Synovex Plus 100 days later.
[2]SS = steers received Synovex S as initial implant in mid-December and re-implanted with Revalor S 100 days later.
[3]Marbling score: Slight^{00} = 400, Small^{00} = 500, etc.
[4]Md = Modest QG, USDA average Choice.

Table 4. Economic analysis of steers on CHPL[1] and SS[2] implant protocols.

Item	CHPL[1]	SS[2]	SEM	*P*-value
Implant, $	5.25	3.92		
Yardage,[3] $	105.50	105.50		
Feed expense,[4] $	264.90	261.22	1.80	0.08
Carcass return,[5] $	1,615.17	1,590.44	44.29	0.36
Net revenue,[6] $	1,245.64	1,227.18	37.24	0.49

[1]CHPL = steers received Synovex Choice as initial implant in mid-December and were re-implanted with Synovex Plus 100 days later.
[2]SS = steers received Synovex S as initial implant in mid-December and re-implanted with Revalor S 100 days later.
[3]Yardage calculated at $.50/head/day at 213 days (Year 1) and 209 d (Year 2).
[4]Feed Expense calculated at $0.06/lb of pen average DMI for 213 days (Year 1) and 209 days (Year 2).
[5]Carcass return calculated using the base grid price and premiums and discounts for quality grade, yield grade, and HCW for the weeks steers were harvested.
[6]Net revenue = carcass return – (implant expense + yardage + feed expense).

included year, pen, implant strategy, and year × implant strategy interaction. Differences in the proportion of Choice and upper two-thirds Choice USDA quality grade were analyzed using an odds ratio. Least squared means and SE of the proportion of Choice and upper two-thirds Choice by treatment were obtained using the ILINK function.

Results

Feedlot data are presented in Table 2. Steers began the feeding period at a similar ($P = 0.94$) BW, 534 vs. 533 ± 24 lb for CHPL and SS, respectively. Average daily gain was similar ($P = 0.39$) for CHPL (3.85 ± 0.18 lb/day) and SS (3.75 ± 0.18 lb/day) steers. There was no difference ($P = 0.59$) in average pen DMI for CHLP (21.82 ± 0.58 lb/day) and SS (21.51 ± 0.58 lb/day). Carcass characteristics are presented in Table 3. There was no difference ($P = 0.37$) in HCW for CHPL compared with SS steers (837 vs. 824 ± 15 lb, respectively). Yield grade was also not affected ($P = 0.16$) by treatment (2.52 and 2.70 ± 0.26 for CHPL and SS, respectively). Additionally, there was no difference in LM area ($P = 0.98$) between CHPL and SS (14.03 vs. 14.04 ± 0.35 in^2), and back fat was also similar ($P = 0.13$) between the treatments (0.54 vs. 0.59 ± 0.06 in, CHPL vs. SS, respectively). Marbling score was similar ($P = 0.19$) between treatments (501 vs. 525 ± 13, CHPL and SS, respectively) resulting in a similar percentage of steers grading USDA Choice (CHPL vs. SS, 93 vs. 96 ± 4%; $P = 0.42$) and upper 2/3 USDA Choice (CHPL vs. SS; 47 vs. 54 ± 7%; $P = 0.50$). Due to a numerical difference ($P = 0.59$) in pen average DMI (CHPL vs. SS, 21.82 vs. 21.51 ± 0.58), feed expense tends to differ ($P = 0.08$) between CHPL and SS ($264.90 vs. $261.22 ± 1.80). Although net revenue was similar ($P = 0.49$) between CHPL ($1,245.64 ± 37.24) and SS ($1,227.18 ± 37.24) steers, a numerical difference in net revenue of $18.46/steer is noted between the 2 treatments (Table 4). Both implant regimens utilized in the current study resulted in similar feedlot and carcass characteristics.

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Effect of Zinc and Copper Source on Finishing Steer Feedlot Performance and Incidence of Footrot

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Summary

A commercial feedlot study compared the effects of the combination of inorganic and organic copper and zinc trace minerals to basic copper chloride and zinc hydroxychloride trace minerals on performance and carcass characteristics and the incidence of footrot in feedlot cattle. There were no differences in DMI, ADG, and F:G. Hot carcass weight and carcass traits were also unaffected by source of trace mineral supplementation. Cattle treated for footrot were not different between treatments. Cattle that received basic copper chloride and zinc hydroxychloride trace mineral supplement performed similar to cattle that received a traditional trace mineral program.

Introduction

The current requirements for copper (Cu) and zinc (Zn) are 10 ppm (mg/kg) Cu and 30 ppm (mg/kg) Zn in beef cattle diets on a DM basis (NRC, 1996, pp. 63-68). However, in a 2007 survey of feedlot nutritionists, the average inclusions of Cu (17.6 mg/kg) and Zn (93.0 mg/kg) were 1.5 and 3 times, respectively, the concentration of current requirements (*Journal of Animal Science,* 2007, 85:2772-2781). Recently a new category of trace minerals, hydroxy trace minerals, has been marketed with basic copper chloride (Intellibond® C) and zinc hydroxychloride (Intellibond Z) available. Limited work has been done comparing these different forms of Cu and Zn in feedlot trials, thus there is little evidence to support one form of trace mineral over the other. The following experiment compared feedlot and carcass performance and footrot incidence in steers receiving either a supplement containing a standard feedlot trace mineral program of copper sulfate, zinc sulfate, and zinc methionine complex (ZINPRO®) or basic copper chloride (IntelliBond C) and zinc hydroxychloride (IntelliBond Z) in a commercial feedlot setting.

Procedure

Crossbred calves (n = 1,471; initial BW = 601 ± 21 lb) from ranches and auction barns in Nebraska, Montana, Colorado, Arizona, Utah, and Missouri were utilized for the trial. This commercial trial was conducted at Herb Albers Feedlots near Wisner,

Table 1. Composition and analyzed nutrient content (DM basis) of basal diets supplemented with copper sulfate, zinc sulfate, and zinc methionine complex (CON) or basic copper chloride and zinc hydroxychloride (IB).

Item	Growing Ration		Finishing Ration 1		Finishing Ration 2[1]	
Ingredient, %						
Dry-rolled corn	—		38.00		58.50	
High-moisture corn	—		20.00		—	
Synergy[2]	32.50		30.00		—	
Modified distillers grains plus solubles	—		—		30	
Corn silage	52.19		2.50		2.50	
Treated cornstalks[3]	10.00		—		—	
Ground cornstalks	—		4.00		3.50	
Supplement (CON or IB)[4,5]	5.31		5.50		5.50	
Targeted Trace Mineral, mg/kg						
Cu	25		19		19	
Zn	136		108		108	
Chemical Composition, %[6]	CON	IB	CON	IB	CON	IB
DM	63.2	66.2	65.1	65.0	65.1	65.0
CP	18.6	15.7	15.2	15.6	15.2	15.6
Ca	0.83	0.81	0.65	0.68	0.65	0.68
P	0.50	0.46	0.49	0.49	0.49	0.49
Zn, mg/kg	146.0	94.0	129.0	138.7	129.0	138.7
Cu, mg/kg	29.0	15.0	20.3	21.7	20.3	21.7

[1]Finishing Ration 1 was fed for the first 96 days of the finishing period and Finishing Ration 2 was fed for the last 45 days.
[2]Synergy = blend of 60% MDGS (Modified Distillers grains plus solubles and 40% WCGF (wet corn gluten feed) (ADM; Columbus, Neb.).
[3]Treated cornstalks = ground cornstalks treated with 5% calcium oxide at 50% moisture.
[4]Supplement (CON) = The supplement was formulated to contain (DM basis): Growing ration — 15.4% CP; 2.62% fat; 3.06% Ca; .96% P; 0.98% K; 465.5 mg/kg Cu from copper sulfate; 2,563 mg/kg Zn from zinc sulfate (65%) and zinc methionine (35%); 33,535 IU of vitamin A/lb; 94 IU of vitamin E/lb. Finishing ration - 11.3% CP; 2.0% fat; 13.32% Ca; 0.70% P; 1.98% K; 349.2 mg/kg Cu from copper sulfate; 1907 mg/kg Zn from zinc sulfate (65%) and zinc methionine (35%); 24,835 IU of vitamin A/lb; 70 IU vitamin E/lb.
[5]Supplement (IB) = The supplement was formulated to contain (DM basis): Growing ration — 15.5% CP; 2.63% Fat; 3.05% Ca; 0.96 % P; 0.99% K; 465.5 mg/kg Cu from basis copper chloride; 2,563 mg/kg Zn from zinc hydroxychloride; 33,535 IU vitamin A/lb; 94 IU vitamin E/lb. Finishing ration - 11.3% CP; 2.01% fat; 13.38% Ca; 0.70% P; 1.98% K; 349.2 mg/kg Cu from basic copper chloride; 1,907 mg/kg Zn from zinc hydroxychloride; 24,835 IU of vitamin A/lb; 70 IU vitamin E/lb.
[6]Chemical composition is based on laboratory analysis (Servi-Tech Labs, Hastings, Neb.) of the growing (single sample) and finishing diet (average of three samples) with either the CON or IB supplement.

Table 2. Performance of steers supplemented with copper sulfate, zinc sulfate, and zinc methionine complex (CON) or basic copper chloride and zinc hydroxychloride (IB).

	Treatment			
Variable	CON	IB	SEM	*P*-value
Pens	8	8	—	—
Steers	736	735	—	—
Initial BW, lb[1]	606	597	7.5	0.04
Final BW, lb[2]	1396	1401	7.5	0.55
Growing Performance[3]				
DMI, lb/day	17.83	17.77	0.13	0.63
ADG, lb	3.39	3.36	0.09	0.76
F:G	5.32	5.30	—	0.91
Finishing Performance[4]				
DMI, lb/day	25.51	26.02	0.15	0.06
ADG, lb	3.83	3.89	0.07	0.52
F:G	6.69	6.68	—	0.98
Overall Performance[5]				
DMI, lb/day	22.7	23.0	0.1	0.14
ADG, lb	3.68	3.70	0.03	0.56
F:G	6.19	6.23	—	0.44
Carcass Adjusted[6]				
Final BW, lb	1396	1400	6.1	0.55
ADG, lb	3.68	3.69	0.03	0.56
F:G	6.18	6.23	—	0.25

[1]Due to differences in initial body weight ($P = 0.04$), data were analyzed with initial BW as a covariant.
[2]Final BW is the average pen weight shrunk 4%. Subsequent ADG, F:G and G:F are calculated from 4% shrunk final BW.
[3]Growing performance was calculated during the first 75 days on feed.
[4]Finishing performance was calculated from day 75 to the end of the feeding period on day 216.
[5]Overall performance was calculated from day 0 to day 216.
[6]Calculated as HCW divided by the average dressing % of 64.55. Subsequent ADG, F:G and G:F are calculated from carcass adjusted final BW.

Table 3. Carcass characteristics of steers supplemented with copper sulfate, zinc sulfate, and zinc methionine complex (CON) or basic copper chloride and zinc hydroxychloride (IB).

	Treatments			
Carcass Characteristics	CON	IB	SEM	*P*-value
HCW, lb	901	904	4.0	0.55
Dressing %	64.57	64.52	0.21	0.79
Yield Grade[3]	2.83	2.93	0.12	0.17
USDA Yield Grade[1, 2]				
1	15.34[a]	10.85[b]	1.53	0.05
2	41.88	41.41	2.10	0.88
3	34.30	38.52	2.07	0.17
4 and 5	8.48	9.22	1.23	0.67
USDA Quality Grade[1, 2]				
Average Choice and above	16.76	16.64	1.59	0.96
Low Choice	36.76	38.88	2.07	0.48
Select or lower	46.49	44.48	2.12	0.52

[1]All numbers are expressed as percentages. The Yield Grade (YG) and Quality Grade (QG) values represent the proportion of carcasses within each group that received each YG or QG.
[2]For quality and yield grade analysis only, seven replications were analyzed due to missing data for one replication.
[a,b]Means within a row with different superscripts differ ($P < 0.05$).

Neb., from December 2012 to July of 2013. Steers were blocked by location and allocated to pens by sorting every five steers into one of two pens before processing. Steers were weighed (pen basis) in two to three drafts after sorting to determine initial BW. Adjacent pens were assigned randomly to one of two treatments (eight pens/treatment). Treatments consisted of two copper and zinc nutrition strategies: (CON) the feedlot's current copper and zinc trace minerals consisting of copper sulfate, zinc sulfate, and zinc methionine complex, (ZINPRO, Zinpro Corp., Eden Prairie, Minn.) or (IB) basic copper chloride and zinc hydroxychloride trace minerals (IntelliBond C and Z, respectively, Micronutrients, Indianapolis, Ind). Supplemental zinc in CON was provided as 65% zinc sulfate and 35% zinc methionine complex whereas supplemental zinc in IB was provided as IntelliBond Z. ZINPRO, fed at the recommended rate, provided 360 mg Zn daily during the growing and finishing periods in the CON treatment. Supplemental copper in CON was provided as copper sulfate, whereas supplemental IB copper was supplied as IntelliBond C. All steers were given the feedlot's standard processing protocol upon arrival into the feedlot. Upon initiation of the trial, all steers were given a lot tag in each ear, and were implanted with Revalor® IS. Cattle were fed a growing ration for the first 75 days of the trial and a step-up period consisting of four adaptation diets was used to adapt cattle to the finishing ration. The rations with copper and zinc concentrations are presented in Table 1. Cattle were re-implanted with Revalor IS after the growing period and implanted again with Revalor 200 after 154 days on feed. All cattle were fed Zilmax at 7.56 g/ton DM for 20 days followed by a three-day withdrawal prior to harvest. All steers were observed daily and cattle treated for footrot were diagnosed using the feedlot's standard health

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protocol for evaluating and treating animals with footrot. Mean days on feed across all cattle were 216. Final live BW was determined at shipping using the average of the pen weight shrunk by 4% to adjust for fill. Cattle were slaughtered at a commercial harvest facility (Nebraska Beef LLC., Omaha, Neb.) on three consecutive days due to limited number of trucks available. On day 1 of harvest, HCW was recorded, and after a 36-hour chill both USDA quality and yield grades were recorded.

At grading, the quality and yield grade data were not recorded for one replication so yield and quality analysis included only seven replications. Both feedlot and carcass data were analyzed on a pen basis as a randomized complete block design using the Glimmix procedure of SAS (SAS Institute, Inc., Cary, N.C.). The model included the fixed effects of treatment with block as a random effect. There was a 9 lb significant difference ($P = 0.04$) in initial BW, thus initial BW was used as a covariate in the model. Frequency data (Yield, Quality, and Health data) were analyzed using binomial proportions with Glimmix and the ILINK option of SAS was used to determine least square means and SE of the proportions. P values ≤ 0.05 were considered significant.

Table 4. Morbidity and footrot incidence in steers supplemented with copper sulfate, zinc sulfate, and zinc methionine complex (CON) or basic copper chloride and zinc hydroxychloride (IB).

	Treatments			
Variable	CON	IB	SEM	*P*-value
Death/Removal, %[1]	2.58	2.67	0.53	0.89
Morbidity[2]				
Total treatments, %	32.84	31.56	1.76	0.61
1st treatment	22.94	20.67	1.57	0.32
2nd treatment	6.99	7.54	0.99	0.70
3rd treatment	2.38	2.24	0.57	0.86
4th treatment	0.56	1.12	0.39	0.28
Footrot Incidence[3]				
Total treatments,%	5.43	4.49	0.84	0.42
1st treatment	4.89	3.95	0.80	0.39
2nd treatment	0.54	0.54	0.27	1.00

[1]Death/Removal is the average percent of animals that were removed or died. Death in CON trt accounted for .95% of total death and removals and included two bloats, one broken leg, one brainer, and three respiratory deaths. Death in BCHZ trt accounted for .82 % of total death and removals and included six respiratory deaths. Removals in CON trt accounted for 1.63% of total death and removals and Removals in BCHZ trt accounted for 1.85 % of total death and removals. Not all the reasons for removals were recorded.

[2]Morbidity; total treatment = the total percent of the pen that was treated for sickness, 1st treatment = the percent of animals that were treated for sickness once, 2nd treatment = the percent of the animals that received a second treatment for sickness, 3rd treatment = the percent of animals that received a third treatment for sickness, 4th treatment = the percent of animals that received a fourth treatment for sickness. All sick animals were evaluated by trained feedlot employees and were treated using the feedlots treatment protocols.

[3]Footrot incidence; total treatment = the total percent animals that received treatment for footrot, 1st treatment = the percent of animals that were treated once for footrot, 2nd treatment = the percent of animals that received a second treatment for persistent footrot incidence. All animals with footrot were evaluated by trained feedlot employees and were treated using the feedlots treatment protocols. is the average percent of animals that were removed or died. Animals that died or were removed from the study were not due to trace mineral supplementation.

Results

There were no differences ($P \geq 0.14$) in final live BW, DMI, ADG, and F:G in steers supplemented with CON or IB over the entire feeding period (Table 2). There was a tendency ($P = 0.06$) for cattle supplemented with IB to have greater intake during the finishing period; however, there were no differences ($P \geq 0.52$) in ADG and F:G during the finishing period. Similarly there were no differences ($P \geq 0.17$) in HCW, dressing percent, or USDA marbling score in carcasses that were supplemented with CON or IB (Table 3). Steers that received CON trace mineral had an increased ($P = 0.04$) number of yield grade 1 carcasses when compared to cattle that received IB. There was no difference ($P \geq 0.28$) in total morbidity or footrot treatments in terms of total number of pulls or re-treated animals when comparing CON to IB (Table 4).

In conclusion, cattle fed Intelli-Bond trace minerals will perform similar to cattle fed a standard inorganic/organic trace mineral package in regards to feedlot performance, carcass characteristics, and incidence of footrot.

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Effects of Next Enhance® Concentrations in Finishing Diets on Performance and Carcass Characteristics of Yearling Feedlot Cattle

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Summary

A feedlot study evaluated the effects of NEXT ENHANCE® 300 (NEXT) essential oil concentration in finishing diets containing Rumensin® and Tylan® on yearling steer performance and carcass characteristics. Treatments consisted of 0, 15, 30, or 45 gram per ton of NEXT. Increasing NEXT concentration in the diet had no effect on DMI, ADG, or F:G. These data suggest that feeding increasing concentrations of NEXT had little impact on feedlot performance of large yearling steers.

Introduction

Feed additives, such as Rumensin and Tylan, are commonly fed in feedlot diets today to improve feed conversions. Previous research has shown that natural plant extracts have exhibited similar antimicrobial activity as antimicrobial feed additives (*Clinical Microbiology Reviews,* 12:564-582). Providing these products in combination with ionophores may produce a synergistic effect that enhances animal performance. NEXT ENHANCE® is a natural plant extract composed of garlic oil and cinnamaldehyde. Previous research utilizing calf-fed steers suggests that feeding NEXT at 225 and 300 mg per steer daily improves feed conversions by 4.0 and 3.8%, respectively, compared to steers fed 0 NEXT (*2014 Nebraska Beef Cattle Report*, pp. 90-91). Improvements in feed conversions in this study were due to the reductions in DMI that were observed when NEXT was included in the finishing diet. Greater improvements in animal performance may be observed when large yearling steers are utilized; however, no data exist. Therefore, the objective of this experiment was to evaluate the effects of NEXT essential oil concentration in finishing diets with Rumensin and Tylan on yearling steer performance and carcass characteristics.

Procedure

Crossbred yearling steers (n = 288; BW = 983 ± 51 lb) were utilized in a randomized block design experiment at the University of Nebraska–Lincoln Panhandle Research and Extension Center feedlot near Scottsbluff, Neb. Upon arrival to the feedlot, yearling steers were vaccinated with Express® 5, poured with Ivomec®, and given a visual identification tag. Prior to initiation of trial, steers were limit-fed a 40% corn silage, 30% wet distillers grains plus solubles (WDGS), and 30% wheat straw (DM basis) diet at 2% BW for five days to minimize variation in gut fill. Steers were weighed two consecutive days (day 0 and 1) to establish initial BW. Steers were blocked by day 0 BW, stratified by BW within blocks (light, medium, heavy), and assigned randomly to 36 pens. Pens were assigned randomly to one of four treatments with nine replications (i.e., pen) per treatment and eight steers per pen. Light, medium, and heavy blocks consisted of three, four, and two replications, respectively.

A common basal diet was used for all four treatments (Table 1) consisting of 54% DRC, 25% WDGS, 15% corn silage, and 6% supplement (DM basis). Only one basal supplement was used and feed additives were included via micro-machine. Treatments consisted of feeding NEXT at concentrations of 0, 15, 30, and 45 g/ton of diet DM. The liquid supplement contained vitamins and minerals to meet animal requirements. Rumensin and Tylan were provided in all treatments via micro-machine at 360 and 90 mg per steer daily, respectively.

Table 1. Composition of dietary treatments.

Ingredient	% of diet DM
DRC[1]	54
WDGS[1]	25
Corn silage	15
Supplement	6
Nutrient Composition, %	
CP	13.4
Ca	0.61
P	0.39
K	0.95
Ether extract	3.84
NDF	18.0
Starch	45.0

[1]DRC = dry-rolled corn; WDGS = wet distillers grains plus solubles.

Steers were implanted on day 0 with Revalor®-XS. Steers in the medium and heavy blocks were fed for 98 days, while steers in the light block were fed for 118 days. On day of shipping, cattle were weighed and transported to a commercial abattoir (Cargill Meat Solutions, Fort Morgan, Colo.). Hot carcass weight and liver scores were recorded on day of harvest. After a 48 hour chill, LM area, marbling score, and 12th rib fat thickness were recorded. Yield grade was calculated from the following formula: 2.5 + (2.5 x 12th rib fat) – (0.32 x LM area) + (0.2 x 2.5 [KPH]) + (0.0038 x HCW). Final BW, ADG, and F:G were calculated from HCW adjusted to a common dressing percentage (63%).

Performance and carcass characteristics were analyzed using the MIXED procedure of SAS (SAS

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Institute, Inc., Cary, N.C.). Pen was the experimental unit and block was treated as a fixed effect. Orthogonal contrasts were constructed to determine the response curve (linear, quadratic, and cubic) for NEXT concentration in the diet. Occurrences of liver abscesses were analyzed using the GLIMMIX procedure of SAS.

Table 2. Effects of NEXT ENHANCE concentrations in finishing diets on steer performance.

	NEXT ENHANCE, g/ton					*P*-value	
Item	0	15	30	45	SEM	Lin.[1]	Quad.[2]
Performance							
Initial BW, lb	989	989	990	990	1	0.53	0.64
Final BW, lb[3]	1440	1447	1440	1446	8	0.76	0.99
DMI, lb/day	31.4	31.4	31.1	31.5	0.3	0.96	0.60
ADG, lb[3]	4.31	4.36	4.29	4.34	0.07	0.99	0.98
Feed:Gain[4]	7.25	7.19	7.25	7.25	—	0.96	0.72
Carcass Characteristics							
HCW, lb	907	911	907	911	5	0.76	1.00
Marbling[5]	484	494	490	510	9	0.06	0.60
LM area, in^2	12.7	12.5	12.3	12.6	0.1	0.57	0.06
12^{th} rib fat, in	0.51	0.53	0.52	0.53	0.01	0.31	0.76
Calculated YG	3.7	3.8	3.8	3.7	0.06	0.31	0.22
Liver Abscess,%	1.4	6.9	9.7	4.2	—	0.29	0.05

[1]Lin. = *P*-value for the linear response to NEXT ENHANCE concentration.
[2]Quad. = P-value for the quadratic response to NEXT ENHANCE concentration.
[3]Calculated from carcass weight, adjusted to 63% common dressing percent.
[4]Analyzed as G:F, the reciprocal of F:G.
[5]Marbling Score: 400 = Small, 500 = Modest, etc.

Results

Increasing NEXT concentration in the diet did not affect DMI ($P > 0.59$; linear or quadratic; Table 2) with intakes of 31.4, 31.4, 31.1, and 31.5 lb for 0, 15, 30, and 45 g/ton NEXT, respectively. Using the observed intakes, the calculated rate of NEXT provided was 0, 236, 467, and 709 mg per steer daily for treatments 0, 15, 30, and 45 g/ton NEXT, respectively. For comparison (*2014 Nebraska Beef Cattle Report*, pp. 90-91), NEXT feeding rates were 0, 75, 150, 225, and 300 mg per steer daily along with Rumensin and Tylan being provided in all treatments at 360 and 90 mg per steer daily. Steers fed NEXT at 225 and 300 resulted in a 4.2% and 2.9% reduction in DMI compared to cattle fed 0 NEXT. In the current study, as NEXT concentration increased, no differences ($P > 0.71$; linear or quadratic) in ADG or F:G were observed. These findings are in contrast to previous research, which utilized calf-fed steers, where improvements in feed conversions were observed when feeding increasing rates of NEXT (*2014 Nebraska Beef Cattle Report*, pp. 90-91). Feeding increasing concentrations of NEXT had no effect ($P > 0.75$; linear or quadratic) on final BW. Hot carcass weight, 12^{th} rib fat depth, and calculated yield grade were not affected ($P > 0.21$; linear or quadratic) by NEXT concentration. Marbling score tended ($P = 0.06$) to increase linearly as concentration of NEXT increased. As NEXT concentration increased, LM area tended ($P = 0.06$) to decrease quadratically. Yearling steers fed 0 or 45 NEXT had the greatest LM area, while feeding 30 NEXT produced the smallest LM area. The occurrence of liver abscesses increased quadratically ($P = 0.05$) as the concentration of NEXT increased in the diet. Occurrence of liver abscesses increased by 8.3 and 2.8% when feeding 30 and 45 NEXT (respectively) compared to steers fed 0 NEXT. However, poorer feed conversions were not observed due to the higher prevalence of liver abscesses. These data suggest that feeding increasing concentrations of NEXT had little impact on animal performance or carcass characteristics of large yearlings steers in feedlot finishing diets containing Rumensin and Tylan.

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Evaluating Two Rates of Monensin Fed During the Grain Adaptation Period on Cattle Performance and Carcass Characteristics

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Summary

Performance and carcass characteristics were evaluated when feeding two rates of monensin in feedlot adaptation diets. Monensin was supplemented at either 360 or 480 mg/head/day during the adaptation period. During the adaptation period, interim body weight was greater and dry matter intake was less for steers fed the 360 mg/head/day treatment of monensin. Subsequently, an improvement in average daily gain and feed efficiency was observed with the 360 mg/head/day treatment. However, there were no statistical differences in final performance and carcass characteristics. These results suggest it is not beneficial to feed the 480 mg/head/day rate of monensin in the adaptation period.

Introduction

Monensin is an ionophore commonly fed to improve F:G and prevent/control coccidiosis in feedlot cattle. Additionally, feeding monensin decreases acidosis by limiting the amount of time ruminal pH is below 5.6 (*1997 Nebraska Beef Cattle Report,* pp. 49-52). With less incidence of acidosis, it has also been observed that intake variation decreases when cattle are fed monensin (*Journal of Animal Science*, 2003, 81:2869-2879). Another study reported that higher concentrations of monensin were more beneficial during the step-up phase versus the entire feeding period (*Plains Nutrition Council Proceedings,* 2010, pp. 112-113). The approved monensin concentration was increased from 33 g/ton (DM) and 360 mg/steer to 44 g/ton and 480 mg/steer by the FDA in 2006. Feeding 480 mg/head/day monensin during the adaptation period did not improve feedlot performance or carcass characteristics when compared to 360 mg/head/day (2013 Nebraska Beef Cattle Report, pp. 60-61). The objective of the current experiment was to replicate the 2013 trial and determine if a difference exists between monensin rates of 360 or 480 mg/head/day during adaptation on cattle performance and carcass characteristics.

Materials and Methods

One hundred ninety-eight crossbred steers (initial BW = 912 ± 37 lb) were utilized in a feedlot finishing trial at the UNL Panhandle Research Feedlot near Scottsbluff, Neb. Cattle were limit-fed a diet at 2% BW consisting of 30% wheat straw, 20% corn silage, 20% dry-rolled corn (DRC), 15% wet distillers grains with solubles (WDGS), 10% corn condensed distillers solubles (CCDS), and 5% supplement (DM basis) for five days before the start of the experiment. Two-day initial weights were recorded on day 0 and 1 which were averaged and used as the initial BW. The steers were blocked by BW into light and heavy BW blocks, stratified by BW and assigned randomly to one of 18 pens with pen assigned randomly to one of two dietary treatments. There were 11 head per pen and nine replications per treatment. Dietary treatments included 360 or 480 mg/head/day monensin during the adaptation period. Treatments were fed a common diet and 360 mg/head/day monensin after adaption through finish. Monensin was added via micro machine to ensure the proper rate was administered.

The adaptation program consisted of five diets where DRC was increased as straw and silage were decreased (Table 1). Besides monensin rate, the diets were the same for all treatments. On day 24 and 25, upon completion of the adaptation period and after

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Table 1. Dietary treatments for steers fed two rates of monensin during grain adaptation (DM basis).

Days fed:	1 - 4 Step 1	5 - 8 Step 2	9 - 13 Step 3	14 - 18 Step 4	Finisher
Ingredient, %[1]					
Dry-rolled corn	34.3	44.3	54.3	64.3	69.3
WDGS[2]	10	10	10	10	10
CCDS[3]	10	10	10	10	10
Wheat straw	25	20	15	10	5
Corn silage	15	10	5	—	—
Supplement[4]	5	5	5	5	5
Urea	0.7	0.7	0.7	0.7	0.7
Limestone	1.6	1.6	1.6	1.6	1.6
Salt	0.3	0.3	0.3	0.3	0.3
Vitamin A, IU	1000	1000	1000	1000	1000
Vitamin D, IU	125	125	125	125	125
Vitamin E, IU	1.5	1.5	1.5	1.5	1.5

[1]Diets contained 360 or 480 mg/steer daily monensin and 90 mg/steer daily tylosin (DM) added via micro machine (Model 271 Weigh and Gain Generation 7; Animal Health International).
[2]Wet distillers grains with solubles.
[3]Corn condensed distillers solubles.
[4]The same liquid supplement was used for all diets and contained: 30 ppm Zn, 50 ppm Fe, 10 ppm Cu, 20 ppm Mn, 0.1 ppm Co, 0.5 ppm I, and 0.1 ppm Se.

being on a common diet for seven days, two-day weights were recorded, averaged, and used as the interim BW. Cattle were shrunk 4% for the performance analysis of the adaptation period.

All diets contained 10% WDGS, 10% CCDS, and 5% liquid supplement (DM basis). Urea was added at 0.7% of the diet DM to meet or exceed MP requirements of the animal. Steers were implanted with Revalor® XS (Merck Animal Heath, Summit, N.J.) on day 1. Animals in the heavy BW block were harvested on day 86 and the light BW block was harvested on day 114 (Cargill Meat Solutions, Fort Morgan, Colo.). Hot carcass weight and liver scores were recorded on the harvest date. Fat thickness, LM area, and marbling score were recorded after a 48-hour chill. Final BW, ADG, and F:G were calculated using HCW adjusted to a common 63% dressing percentage.

Data were analyzed using the MIXED procedure of SAS (SAS Institute, Inc., Cary, N.C.) as a randomized block design. Pen was the experimental unit and block was treated as a random effect. Intake variance and percentage of liver abscesses were both analyzed using the GLIMMIX procedure of SAS.

Table 2. Effect of two rates of monensin during grain adaptation on performance and carcass characteristics.

Item	Treatment			
	360[1]	480[2]	SEM[3]	F-Test
Interim Performance[4]				
Initial BW, lb	901	899	30	0.66
Interim BW, lb[5]	1000	989	26	<0.01
DMI, lb/day	22.65	22.77	0.14	<0.01
ADG, lb[6]	3.96	3.60	0.16	0.01
F:G[6,7]	6.13	6.76	0.01	<0.01
Overall Performance				
Final BW, lb[8]	1355	1355	44	0.98
DMI, lb/day	29.28	29.64	0.18	0.17
ADG, lb[8]	4.54	4.54	0.11	0.98
F:G[9]	6.59	6.63	0.003	0.45
Carcass Characteristics				
HCW, lb	854	854	28	0.98
Marbling Score[9]	533	527	27	0.61
12^{th} rib fat, in	0.52	0.52	0.05	0.95
LM area, in. sq.	12.62	12.51	0.08	0.35
Calculated YG[10]	3.40	3.44	0.23	0.67
Dressing Percent	61.30	61.44	0.54	0.50
Liver Abscess, %[11]	19.19	12.12	—	0.18
A, %	16.16	8.08	—	0.09
A+, %	3.03	4.04	—	0.70

[1]360 mg/head/day monensin.
[2]480 mg/head/day monensin.
[3]SEM = Standard error of the mean for the interaction.
[4]Interim Performance = calculated after 18 day adaptation period and after being on a common finishing diet for seven days.
[5]Weight taken seven days after adaptation period and pencil shrunk 4%.
[6]Calculated from interim BW.
[7]Analyzed as G:F, reciprocal of F:G.
[8]Final BW calculated from hot carcass weight adjusted to a common dressing percentage of 63%.
[9]Marbling score: 400 = Slight 0, 500 = Small 0.
[10]Calculated YG = 2.5 + 2.5 (fat thickness, in) – 0.32 (LM area in. sq.) + 0.2 (2.5 KPH fat, %) + 0.0038 (hot carcass weight, lb).
[11]Liver score: A = 3 or 4 abscesses; A+ = 4 or more abscesses.

Results

Performance measured after the adaptation period (day 25) showed lower ($P < 0.01$) interim BW when 480 mg/head/day of monensin was fed (Table 2). Dry matter intake was greater ($P < 0.01$) for steers fed the 480 mg/head/day rate. There were no differences ($P \geq 0.39$) in the DMI variance between treatments during the adaptation period or the first seven days on the finishing diet (data not presented). There was less variation when cattle started consuming the finishing feed when compared to the variation in intake during the adaptation period. Additionally, an improvement ($P \leq 0.01$) was observed for ADG and F:G with 360 mg/head/day monensin.

The steers on the 360 mg/head/day rate consumed less feed and gained more weight than the steers on the 480 mg/head/day rate making them more efficient during the adaptation period. This could decrease acidosis incidences.

No significant differences ($P \geq 0.17$) were observed for total performance over the feeding period. Additionally, HCW, marbling, 12^{th} rib fat, LM area, calculated YG, dressing percent, or overall liver scores were not affected ($P \geq 0.18$) by monensin rate. Cattle fed 480 mg/head/day monensin tended to have ($P = 0.09$) lower percentage of "A" liver scores which may suggest less acidosis for steers on this treatment.

Feeding 360 versus 480 mg/steer daily of monensin during the adaptation period had no impact on overall performance of the cattle.

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Effects of Dietary Fat Source and Monensin on Methane Emissions, VFA Profile, and Performance of Finishing Steers

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Summary

A finishing study was conducted to evaluate the effects of dietary fat source and presence or absence of monensin on performance, methane (CH_4) emissions, and ruminal VFA profile of cattle. No effects on performance or VFA profile were observed. Inclusion of modified distillers grain plus solubles (MDGS) in the diet tended to increase measures of CH_4 production when compared to other fat sources (corn oil or tallow), while inclusion of monensin in the finishing diet was not significant for CH_4 production.

Introduction

Interest in emissions of methane and other greenhouse gasses by livestock has increased. Livestock account for only 3.6% of greenhouse gas emissions in the U.S. or about one-third of all agriculture sources. Methane contributes to total greenhouse gas emissions, and cattle account for 20% of U.S. methane. Despite the relatively small contribution of methane from cattle to total emissions, this issue represents a situation where environmental concerns and animal productivity intersect, as the production of methane represents an energetic loss to the animal. Diet is one of the main determinants of methane production, thus prompting recent work evaluating nutritional mitigation strategies. However, much of this work has been conducted on a small scale using intensive techniques such as respiration chambers or headboxes. Therefore, the development of a method of gas collection and analysis to allow evaluation of methane emissions from a relatively large number of animals under conditions that more closely mimic a production setting would be beneficial. The objective of this study was to evaluate the effect of the source of dietary fat and the presence or absence of monensin on performance, methane production, and VFA profile in finishing cattle.

Table 1. Composition of diets that contain 0 or 50% MDGS[1], with or without monensin; as well as differing sources of fat (DM basis).

	Treatment					
	CON +	CON -	MDGS +	MDGS -	OIL	TAL
Monensin	Y	N	Y	N	Y	Y
DRC[2]	87	87	37	37	84	84
MDGS	—	—	50	50	—	—
Sorghum silage	8	8	8	8	8	8
Corn oil	—	—	—	—	3	—
Tallow	—	—	—	—	—	3
Supplement[3]	5	5	5	5	5	5

[1]MDGS = modified distillers grains plus solubles.
[2]DRC = dry-rolled corn.
[3]Formulated to contain 375 mg/head/day monensin and 90 mg/head/day Tylan.

Procedure

A 125-day finishing study was conducted using 60 crossbred steers (initial BW = 913 ± 35 lb) that were individually fed using the Calan gate system. Five days before trial initiation, cattle were limit-fed a common diet of 50% alfalfa hay and 50% Sweet Bran® at 2% of BW to reduce variation in gut fill and then weighed on three consecutive days, with the average used as initial BW. Steers were stratified by initial BW from day -1 and day 0, and assigned randomly to one of six treatments (Table 1), with 10 steers per treatment. A completely randomized design of four diets were used to compare sources of dietary fat: a corn-based control with no added fat (CON), a diet with 50% modified distillers grains plus solubles (MDGS), and two corn-based diets with either 3% corn oil (OIL) or 3% tallow (TAL), all containing 375 mg/head/day monensin. Two additional diets were added to create a 2×2 factorial that consisted of either 0 or 50% MDGS and 0 or 375 mg/head/day monensin. The MDGS, OIL, and TAL diets were formulated to provide 6.5% total dietary fat. Steers were implanted with Revalor®-S on day 1. On day 125, cattle were individually weighed and transported to a commercial abattoir (Greater Omaha Packing, Omaha, Neb.) to be harvested. Hot carcass weight (HCW) and liver abscess scores were collected on day of slaughter. Following a 48-hour chill, 12th-rib fat thickness, LM area, and USDA marbling score were recorded. Carcass adjusted final BW, ADG, and F:G were calculated using HCW and a common 63% dressing percentage.

To facilitate the collection of respired air by the cattle to be analyzed for methane and carbon dioxide, the individual Calan gate bunks were partially enclosed and outfitted with a small air pump that was used to gradually fill a gas collection bag. Gas collection was conducted at time of feeding, and gas sample bags were filled with air at a constant rate over approximately 10 minutes. Gas samples were collected only while steers were in their bunks. The collected gas consisted of a mixture of respired gasses and ambient air and was analyzed within 24 hours for concentration of methane and carbon dioxide in ppm using a gas chromatograph. Methane data are expressed as a ratio of methane to carbon dioxide (CH_4:CO_2) where CO_2 can be used as an internal marker since its production is relatively constant across cattle of

(Continued on next page)

similar size, type, and production level. Gas samples were collected from each steer approximately once per week throughout the feeding period. Volatile fatty acid profile was evaluated using rumen fluid collected via esophageal tubing on day 55, prior to feeding. A portion of rumen fluid was also frozen and stored at -80º C for rumen microbial community analysis.

Estimates of daily CH_4 and CO_2 production as well as liters of CH_4 per lb of intake and gain were made using the equation of Madsen, et al., (*Livestock Science* 2010, pp. 223-227). This method uses measured CH_4:CO_2, calculated diet TDN, and observed DMI, and ADG to determine methane production. The equation proposed by these authors considers any metabolizable energy that is not used for gain to be lost as heat. Since heat production and CO_2 production are closely linked, and we are able to measure CH_4:CO_2, we can calculate useful measures of CH_4 production to compare across animals and diets.

Performance, VFA, and emissions data were analyzed with the MIXED procedure of SAS (SAS Institute, Inc., Cary, N.C.) using preplanned contrasts and steer as the experimental unit. Methane to carbon dioxide ratio was analyzed using the heterogeneous compound symmetry covariance structure with sampling point as the repeated measure.

Results

Performance

No differences ($P > 0.10$) were observed for any performance or carcass traits due to dietary fat source (Table 2) or monensin (Table 3). The lack of difference between diets with added fat (MDGS, OIL, and TAL) is likely due to the similar energy content of those diets, as each was formulated to contain 6.5% dietary fat. However, it is surprising to observe no difference between 0 and 50% MDGS or the presence or absence of monensin, as these effects have been long established.

Table 2. Effect of source of dietary fat in the finishing diet on performance and carcass characteristics.

	Treatment					
	CON	MDGS	OIL	TAL	SEM	*P*-value
Performance						
Initial BW, lb	923	922	903	892	33.5	0.89
Final BW, lb[2]	1364	1363	1372	1310	39.5	0.67
DMI, lb	24.8	24.3	24.4	23.3	0.6	0.37
ADG, lb[2]	3.53	3.53	3.75	3.35	0.17	0.43
F:G[2]	7.03	6.91	6.49	6.54		0.47
Carcass Characteristics						
HCW, lb	860	859	864	825	24.9	0.67
Dressing %	61.6	62.3	62.6	61.1	0.60	0.33
LM area, in[2]	13.6	13.2	12.7	12.9	0.33	0.36
12th rib fat, in	0.51	0.65	0.56	0.54	0.05	0.19
Calculated YG	3.21	3.62	3.58	3.35	0.18	0.32
Marbling score[3]	465	438	412	406	24.4	0.30

[1]Treatments included: a corn-based diet with no added fat (CON), 50% modified distillers grains plus solubles (MDGS), and a corn-based diet with either 3% corn oil (OIL) or 3% tallow (TAL).
[2]Calculated from HCW, adjusted to a common 63% dressing percentage.
[3]Marbling score: 400 = Small00.

Table 3. Effect of diet type and presence of monensin on finishing performance and carcass characteristics.

	0 MDGS		50 MDGS			*P*-value[1]		
Monensin	Y	N	Y	N	SEM	Diet	Mon	D *M
Performance								
Initial BW, lb	923	926	922	909	35.0	0.79	0.88	0.81
Final BW, lb[2]	1364	1357	1363	1392	41.5	0.67	0.78	0.65
DMI, lb	24.8	24.0	24.3	25.4	0.77	0.56	0.86	0.22
ADG, lb[2]	3.53	3.45	3.53	3.88	0.19	0.26	0.48	0.26
F:G[2]	7.03	6.89	6.91	6.54		0.48	0.43	0.71
Carcass Characteristics								
HCW, lb	860	855	859	878	26.2	0.67	0.78	0.65
Dressing %	61.6	62.0	62.3	62.6	0.61	0.30	0.52	0.90
LM area, in[2]	13.6	13.5	13.2	13.6	0.36	0.69	0.60	0.50
12th rib fat, in	0.51	0.60	0.65	0.59	0.05	0.18	0.73	0.13
Calculated YG	3.21	3.42	3.62	3.46	0.18	0.21	0.89	0.29
Marbling score[3]	465	410	438	463	26.1	0.60	0.53	0.11

[1]*P*-value: Diet = main effect of diet (0 or 50% MDGS), Mon = main effect of presence of Monensin, D*M = effect of interaction between diet type and monesin.
[2]Calculated from HCW, adjusted to a common 63% dressing percentage.
[3]Marbling score: 400 = Small00.

Table 4. Effect of source of dietary fat in the finishing diet on methane production and VFA profile.

	Treatment[1]					
	CON	MDGS	OIL	TAL	SEM	*P*-value
CH_4:CO_2	0.047[b]	0.058[a]	0.054[a,b]	0.049[b]	0.003	0.07
L CH_4/day[2]	227	270	249	221	18	0.21
L CO_2/day[2]	4774	4654	4633	4521	130	0.60
L CH_4/lb DMI[2]	9.1	11.1	10.1	9.5	0.6	0.13
L CH_4/lb ADG[2]	64.1	78.8	67.2	67.6	5.5	0.27
Total VFA, Mm	131.3	135.5	179	108	35.2	0.55
Acetate, mol/100 mol	45.2	48.5	45.1	46.4	1.9	0.57
Propionate, mol/100 mol	40.3	36.4	42.7	39.9	2.1	0.22
Butyrate, mol/100 mol	8.1	8.2	6.1	7.3	1.1	0.45
Acetate:Propionate	1.21	1.40	1.08	1.20	0.13	0.42

[1]Treatments included: a corn-based diet with no added fat (CON), 50% modified distillers grains plus solubles (MDGS), and a corn-based diet with either 3% corn oil (OIL) or 3% tallow (TAL).
[2]Values were calculated using equation of Madsen et al., 2010.
[a,b]Means in a row with different superscripts are different ($P < 0.10$).

Table 5. Effect of diet type and presence of monensin on methane production and VFA profile.

	0 MDGS		50 MDGS			*P*-value[1]		
Monensin	Y	N	Y	N	SEM	Diet	Mon	D *M
CH_4:CO_2	0.047	0.053	0.058	0.056	0.003	0.03	0.56	0.19
L CH_4/day[2]	227	247	270	260	18	0.12	0.77	0.41
L CO_2/day[2]	4774	4610	4654	4780	167	0.87	0.90	0.37
L CH_4/lb DMI[2]	9.1	10.2	11.1	10.2	0.6	0.10	0.81	0.11
L CH_4/lb ADG[2]	64.1[b]	74.4[a,b]	78.8[a]	68.0[a,b]	6.2	0.49	0.97	0.08
Total VFA, Mm	131.3	109.2	135.5	121.0	35.1	0.81	0.59	0.91
Acetate, mol/100 mol	45.2	44.1	48.5	45.3	1.9	0.23	0.24	0.57
Propionate, mol/100 mol	40.3	41.7	36.4	40.2	2.1	0.20	0.20	0.56
Butyrate, mol/100 mol	8.1	7.3	8.2	7.6	1.0	0.85	0.46	0.91
Acetate:Propionate	1.21	1.10	1.40	1.14	0.12	0.34	0.12	0.56

[1]*P*-value: Diet = main effect of diet (0 or 50% MDGS), Mon = main effect of presence of monensin, D*M = effect of interaction between diet type and monensin.
[2]Values were calculated using equation of Madsen et al., 2010.
[a,b]Means in a row with different superscripts are different ($P < 0.10$).

Emissions

Average measured CH_4:CO_2 throughout the finishing period was greatest for cattle fed MDGS, lowest for those fed CON and TAL, with OIL being intermediate ($P = 0.07$; Table 4). This increase in CH_4 with MDGS may reflect the greater concentration of digestible fiber in that diet. The rationale behind supplying different fat sources is that unsaturated fat provides a hydrogen sink in the rumen, which should, in turn, reduce the production of methane as a means of disposing of hydrogen, as well as the idea that fat may be detrimental to methanogens. We hypothesized that cattle fed OIL would have a lower CH_4:CO_2 than those fed TAL due to the differences in degree of saturation of those fats. However a higher inclusion in the diet may have been necessary to see the full impact of that mechanism of hydrogen sink. Neither daily CH_4 nor CO_2 production were different due to fat source ($P = 0.21$ and 0.60, respectively). Dry matter intake is a main determinant of CH_4 production, so it is useful to calculate L CH_4/lb DMI, and there was a tendency for cattle fed MDGS ($P = 0.13$) to have the greatest CH_4/lb DMI, while there was no difference between CON, OIL, and TAL diets. Since there were no differences observed for ADG or F:G, again no differences were observed for L CH_4/lb ADG, ($P = 0.27$). We did not observe differences in CH_4 due to fat inclusion in this study, but rather the increased CH_4 production by cattle fed MDGS may presumably be in response to elevated digestible fiber content. However, fat and protein are metabolized more efficiently than carbohydrate and may produce less CO_2. Therefore, replacing corn (starch) with MDGS or fat sources may have reduced CO_2 production. This would increase the methane:CO_2 ratio and result in overestimation of methane production. Further emissions and digestibility work is planned to confirm this hypothesis.

A basal diet × monensin interaction was observed for L CH_4/lb ADG ($P = 0.08$; Table 5), where the addition of monensin to a diet containing 50% MDGS increased CH_4, but decreased CH_4 when included in a corn-based diet. Again, there were no corresponding differences in performance due to monensin, so this is mostly a reflection of the main effect that basal diet had on CH_4:CO_2 ($P = 0.03$). This main effect of inclusion of 0 vs. 50% MDGS was also observed as a tendency for greater daily CH_4 production ($P = 0.12$) as well as L of CH_4/lb DMI ($P = 0.10$) for cattle fed MDGS, while no effect due to monensin ($P > 0.56$) was observed. While ionophores may be expected to reduce CH_4 production due to their expected effects on VFA profile, this lack of response is not necessarily surprising, as the data on the impact of monensin on CH_4 have been inconsistent.

VFA Profile

No effects of dietary fat source on VFA profile (P > 0.22; Table 4) and only a tendency ($P = 0.12$) for monensin to increase acetate to propionate ratio, contrary to expectation, were observed. We hypothesized that a shift in CH_4 production due to diet would also be seen as a shift in VFA profile; generally away from acetate and towards production of propionate, another hydrogen sink. However, these data are from one sampling time point at the time of feeding, which may not be optimal for observing the effect that diet has on VFA profile.

These data do not support the idea that differences in saturation of a dietary fat source affect CH_4 production in finishing diets with a total dietary fat of 6.5%. The effect of MDGS is complex, as the feed's fat and fiber components have conflicting implications for CH_4 production. In this study, DMI and fat content were constant, suggesting that the effect on CH_4 is driven more by the elevated digestible fiber content of MDGS. The diet × monensin interaction on L CH_4/lb ADG is difficult to explain but, on the whole, the inclusion of monensin did not affect CH_4 production. The method described in this article to calculate methane production from methane to carbon dioxide ratio is but one approach that can be used, and work is ongoing to develop a more complete model for predicting methane emissions.

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Mineral Composition of Beef Cattle Carcasses

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Summary

Mineral retention was measured in 76 beef steers. Cattle were grown at different rates of gain and then finished on a common diet. Calcium and P retention were not affected by treatment and were similar between the growing and finishing periods averaging 4.2 g P and 10.8 g Ca /100 g protein gain across both experiments. As ADG during the growing period was decreased, K, Mg, and S mineral retention during the finishing period were increased. Expressing mineral retention as g/100 g protein gain reduced variation due to animal size and ADG and suggests that current NRC predictions are accurate.

Introduction

Mineral requirements for growing beef cattle are not well understood, one component of which is requirements for gain. Very few carcasses have been analyzed to determine mineral retention, with Ca and P being the most commonly analyzed minerals. Other minerals such as K, Mg, and S are very rarely measured or reported in serial slaughter trials. Retention of minerals is important in order to identify mineral requirements at different rates of gain, in addition to maintenance requirements. Retention is also used to calculate mineral excretion values, with excretion being predicted from the difference between intake and retention. Developing better estimates of mineral retention allows for better estimates of manure nutrient values, and thus better recommendations for manure application rates. This trial utilized existing serial slaughter samples in order to calculate mineral retention of beef cattle harvested at various time points and grown in several different production systems.

Procedure

Seventy-six beef cattle were slaughtered at Oklahoma State University, and whole carcasses were divided into carcass, offal, and viscera. These samples were ground and frozen and then analyzed for Ca, P, K, Mg, and S by Ward Laboratory (Kearney, Neb.). Sample analysis included acid digestion of all organic matter, followed by mineral analysis using Inductively Coupled Plasma-Atomic Emission Spectroscopy. Total offal included blood, head, hide, feet, ears, internal organs, and trim. Visceral organs included reticulo-rumen, omasum, abomasum, small intestine, cecum, large intestine, pancreas, spleen, omental and mesenteric fat. Weights of total carcass, visceral organs, and offal were recorded. Cattle were on two separate experiments and were harvested at various time points after being grown in several different production systems.

Experiment (Exp.) 1 (*Journal of Animal Science,* 82:262) utilized 30 British crossbred steers wintered at three different levels of gain and then finished on a common diet. Cattle grazed wheat pasture to gain 2.89 lb/day (high gain wheat; HGW) or 1.19 lb/day (low gain wheat; LGW), or grazed dormant native range supplemented with 2 lb of cottonseed meal each day and gaining 0.35 lb/day (native range; NR). At the end of the winter grazing season, four steers were slaughtered from each treatment group. The remaining steers were placed on a common finishing diet and six additional steers from each treatment were slaughtered at approximately 0.6 inches of backfat. Cattle from HGW reached 0.6 inches of backfat after 89 days on feed, LGW cattle after 116 days on feed, and NR cattle after 163 days on feed. Cattle performance during the growing and finishing phases is shown in Table 1; live performance measurements were taken on 48 steers, including the 30 steers used for serial slaughter.

Experiment 2 (*Journal of Animal Science* 88:1564) utilized 46 British crossbred steers grown at different rates and on different diets. Four steers were slaughtered at initiation of the trial to determine initial carcass composition. Remaining cattle were split between calf-feds placed directly into the feedlot (CF) and three growing treatments: grazing wheat pasture

Table 1. Cattle performance during the growing and finishing phases of Experiment 1[1].

	HGW[2]	LGW	NR	SEM	*P*-value
Growing phase					
Days	120	120	120	—	—
ADG, lb	2.89	1.19	0.35	—	—
12th-rib fat, in	0.46[a]	0.10[b]	0.004[b]	0.04	< 0.05
HCW, lb	522[a]	381[b]	302[c]	10.8	< 0.05
Finishing phase					
Days	89	116	163	—	—
ADG, lb	3.94	3.97	4.01	0.13	0.43
12th-rib fat, in	0.64	0.62	0.59	0.07	> 0.05
HCW, lb	754[a]	701[b]	725[ab]	8.2	< 0.05

[1]All data measuring cattle performance collected by Oklahoma State University and published in *Journal of Animal Science,* 82:262.
[2]Treatments were due to diet fed during the growing phase and included cattle grazing wheat pasture at a high rate of gain (HGW), cattle grazing wheat pasture at a low rate of gain (LGW), and cattle grazing dormant native range pasture (NR). All cattle were finished on a common diet.
[a-c]Means within a row without a common superscript differ ($P < 0.05$).

Table 2. Cattle performance during the growing and finishing phases of Experiment 2[1].

	WP[2]	SF	PF	CF	SEM	*P*-value
Growing phase						
Days	112	112	112	—	—	—
ADG, lb	2.54[a]	2.43[b]	2.60[a]	—	0.04	0.01
12th-rib fat, in	0.17	0.20	0.23	—	0.03	0.32
HCW, lb	489[ab]	467[a]	522[b]	—	17.2	0.10
Finishing phase						
Days	123	104	104	196	—	—
ADG, lb	3.62[a]	4.45[b]	4.08[c]	3.59[a]	0.09	< 0.01
12th-rib fat, in	0.53[a]	0.50[a]	0.49[a]	0.64[b]	0.019	< 0.01
HCW, lb	851	836	829	818	9.7	0.12

[1]All data measuring cattle performance collected by Oklahoma State University and published in *Journal of Animal Science,* 88:1564.
[2]Treatments were due to diet fed during the growing phase and included grazing wheat pasture (WP), a sorghum silage based diet (SF), program fed a high concentrate diet (PF), or placed directly into the feedlot as calf-feds (CF). All cattle were finished on a common diet.
[a-c]Means within a row without a common superscript differ ($P < 0.05$).

Table 3. Mineral retention within the empty body of beef cattle during the finishing phase while on a common high concentrate diet (Experiment 1).

	HGW[1]	LGW	NR	SEM	*P*-value
Calcium					
g/day	31.8	58.9	24.6	15.38	0.09
g/kg EBW gain	17.1	30.4	14.9	8.06	0.15
g/100 g protein gain	9.8	17.3	13.1	6.06	0.48
Phosphorus					
g/day	14.8	9.8	10.2	2.70	0.15
g/kg EBW gain	8.0	5.0	6.2	1.48	0.17
g/100 g protein gain	4.1	3.2	5.1	1.32	0.39
Potassium					
g/day	1.6[b]	4.9[a]	5.2[a]	0.821	< 0.01
g/kg EBW gain	0.9[b]	2.5[a]	3.2[a]	0.494	< 0.01
g/100 g protein gain	0.5[b]	1.4[ab]	2.9[a]	0.746	0.02
Magnesium					
g/day	-0.2[b]	1.3[a]	0.7[a]	0.330	< 0.01
g/kg EBW gain	-0.1[b]	0.7[a]	0.5[a]	0.176	< 0.01
g/100 g protein gain	-0.1[b]	0.4[a]	0.4[a]	0.141	0.01
Sulfur					
g/day	1.2[b]	4.1[a]	3.6[a]	0.546	< 0.01
g/kg EBW gain	0.6[b]	2.1[a]	2.2[a]	0.308	< 0.01
g/100 g protein gain	0.3[b]	1.2[a]	1.9[a]	0.365	< 0.01

[1]Treatments were due to diet fed during the growing phase and included cattle grazing wheat pasture at a high rate of gain (HGW), cattle grazing wheat pasture at a low rate of gain (LGW), and cattle grazing dormant native range pasture (NR). All cattle were finished on a common diet; mineral retention was calculated for the finishing phase.
[a-c]Means within a row without a common superscript differ ($P < 0.05$).

(WP), fed a sorghum silage growing diet (SF), or program fed (PF) a high concentrate (steam-flaked corn) diet to gain at a similar rate as SF cattle. At the end of 112 days, six steers from each of the three growing diets were slaughtered, and remaining cattle were placed onto the finishing diet CF cattle were already on. At approximately 0.5 inches of backfat, six calves from each of the four treatments were slaughtered. Cattle on the CF treatment were on feed for 196 days. After the 112 day growing phase, cattle on WP were on feed for 123 days, SF and PF for 104 days. Cattle performance during the growing and finishing phases is shown in Table 2; live performance measurements were taken on 260 steers, including the 46 steers used for serial slaughter.

Mineral retention within the body was calculated as the difference between mineral composition at slaughter and predicted mineral composition at day 0. Mineral composition at day 0 was predicted from body composition of steers harvested at day 0 multiplied by live weight of individual animals at day 0. For Exp. 1, mineral retention was calculated for each treatment during the finishing period. In Exp. 2, mineral retention was calculated for the growing and finishing periods separately for each treatment except CF, which only consisted of a finishing period. Mineral retention was then expressed as grams per day, grams per kg empty body weight (EBW) gain, and grams per 100 g protein gain. In live animals EBW is calculated as full BW multiplied by 0.855; however, for these trials EBW was measured by weighing the whole carcass after the contents of the gastrointestinal tract had been removed.

For statistical analysis in Exp. 1, mineral retention among treatments was compared with individual animal as the experimental unit. In Exp. 2, mineral retention within the growing phase, within the finishing phase, and overall mineral retention were compared by treatment using an F-test with individual animal as the experimental unit. Because all comparisons within each of the phases were non-significant ($P \geq 0.19$) only mineral retention for the growing and finishing phases combined is shown. Mineral retention within the growing phase was also compared to retention during the finishing phase, but was found to be non-significant ($P \geq 0.28$). For both trials all differences were declared significant at $P < 0.05$.

Results

The NRC currently expresses P and Ca retention as g/100 g protein gain. In the current trials, expressing mineral retention on a protein gain basis reduced variation due to diet, rate of gain, and days on feed.

(Continued on next page)

Experiment 1

Mineral retention was calculated for the finishing period following three different diets being fed during the growing phase. There were no differences due to treatment for P or Ca retention ($P \geq 0.15$ and $P \geq 0.09$, respectively) expressed as g/day, g/kg EBW gain, or g/100 g protein gain (Table 3). Retention of P and Ca averaged 4.1 g P/100 g protein gain and 13.4 g Ca/100 g protein gain, respectively, over all three treatments. Mineral retention was significantly different among treatments for K, Mg, and S ($P < 0.02$) during finishing. Potassium, Mg, and S retention were greatest for NR and LGW cattle and least for HGW cattle. This indicates an increase in mineral retention during the finishing period because diet quality and ADG during the growing period were reduced.

Experiment 2

Mineral retention was calculated for the growing and finishing periods separately for each treatment, except CF, which consisted only of a finishing period. There were no differences due to treatment for combined mineral retention in the growing and finishing periods and no differences between the growing and finishing periods for P ($P \geq 0.36$), Ca ($P \geq 0.23$), K ($P \geq 0.38$), Mg ($P \geq 0.12$), or S ($P \geq 0.20$) retention when expressed as g/kg EBW gain, or g/100 g protein gain (Table 4). Retention of Mg was impacted by treatment when expressed as g/day ($P = 0.05$). Phosphorus retention over the growing and finishing periods combined averaged 4.3 g P/100 g protein gain for all four treatments. Calcium, K, Mg, and S retention averaged 8.2, 1.3, 0.3, and 1.1 g/100 g protein gain for all four treatments, respectively. Cattle were on different diets during the growing period, but small differences in ADG during the growing period (< 7%; $P < 0.01$) resulted in no differences in mineral retention due to treatment.

Table 4. Mineral retention within the empty body of beef cattle during the growing and finishing phases combined (Experiment 2).

	WP[1]	SF	PF	CF	SEM	*P*-value[3]
Calcium[2]						
g/day	12.5	21.1	17.5	12.9	5.34	0.34
g/kg EBW gain	15.2	26.3	20.0	13.9	6.34	0.23
g/100 g protein gain	7.2	10.7	8.3	6.7	3.03	0.56
Phosphorus						
g/day	7.0	10.3	8.9	6.9	2.55	0.50
g/kg EBW gain	8.8	12.9	10.2	7.5	3.05	0.36
g/100 g protein gain	4.0	5.3	4.2	3.6	1.44	0.70
Potassium						
g/day	2.5	2.4	2.9	2.4	0.514	0.73
g/kg EBW gain	3.5	3.0	3.2	2.5	0.785	0.61
g/100 g protein gain	1.3	1.2	1.3	1.2	0.220	0.88
Magnesium						
g/day	0.5	0.6	0.8	0.5	0.095	0.05
g/kg EBW gain	0.7	0.8	0.9	0.5	0.144	0.12
g/100 g protein gain	0.3	0.3	0.4	0.3	0.056	0.37
Sulfur						
g/day	2.1	2.0	2.4	2.2	0.222	0.34
g/kg EBW gain	2.8	2.5	2.7	2.3	0.402	0.56
g/100 g protein gain	1.1	1.0	1.1	1.2	0.112	0.50

[1]Treatments were due to diet fed during the growing phase and included grazing wheat pasture (WP), a sorghum silage based diet (SF), program fed a high concentrate diet (PF), or placed directly into the feedlot as calf-feds (CF). All cattle were finished on a common diet.
[2]Mineral retention was calculated separately for the growing and finishing phases. Combined mineral retention for the growing and finishing phases is shown, except for the CF treatment which consisted only of a finishing phase.
[3]*P*-values shown compare mineral retention of treatments for the combined growing and finishing phases. There were no differences in mineral retention due to treatment during the growing phase ($P \geq 0.19$) or comparing the growing and finishing phases ($P \geq 0.28$).

The current NRC (2000) reports P retention as 3.9 g P/100 g protein gain and Ca retention as 7.1 g Ca/100 g protein gain. These values are calculated from serial harvest data and represent retention within 132 dairy cattle at various stages of growth. Data from the current two trials complement these data, with similar overall values, 4.2 g P/100 g protein gain and 10.8 g Ca/100 g protein gain, suggesting little change in mineral retention within cattle or in the methods used to measure mineral retention. Variation among animals, measurement techniques, or a combination of both appears to be greater than variation due to diet as no differences were detected by treatment for P and Ca retention. Retention of other minerals (K, Mg, and S) can be impacted by diet quality and ADG during the growing period, as shown in Exp. 1. Expressing mineral retention relative to rate of gain equalizes changes in retention due to rate of gain and decreases variation due to treatment. These data suggest that the current method of expressing mineral retention as g/100 g protein gain used by the NRC is the most appropriate.

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Mineral Composition of Serial Slaughter Holstein Carcasses

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Summary

Carcasses of 115 Holstein steers were divided into lean, bone, internal cavity, hide, and fat tissues for analysis of P, Ca, K, Mg, and S retention. Every 28 days, five steers from each of two treatments, fed Zilmax for 20 days prior to harvest or not fed Zilmax, were harvested. There were no differences due to treatment or days on feed when mineral retention was expressed as g/100 g of protein gain. Expressing mineral retention relative to protein gain reduced variation due to rate of gain and animal size.

Introduction

Mineral requirements for beef cattle are composed of maintenance and gain requirements and mineral retention relative to gain has not been widely researched. Some data are available on P and Ca retention, predominately in Holstein cattle. Very few, if any, data have been published on K, Mg, and S retention within the whole body of cattle. Mineral retention data are used to calculate mineral requirements of growing cattle for both maintenance and gain and for calculating mineral excretion in manure. In order to accurately predict mineral excretion from cattle and make valuable recommendations on mineral availability within manure, knowing mineral retention is critical. This trial utilized existing serial slaughter samples in order to calculate mineral retention of Holstein steers harvested at 28 day intervals over a 308 day feeding period.

Procedure

One hundred fifteen Holstein steers were utilized in a serial harvest trial conducted by the Beef Carcass Research Center, West Texas A&M University, Canyon, Tex. Five steers were harvested after 226 days on feed, which was designated day 0, or initiation of the trial. Two treatments were imposed on the remaining cattle, a control group (CON) and cattle fed Zilmax (8.3 mg/kg diet DM) for 20 days followed by a three day withdrawal, immediately prior to harvest (ZH). All cattle were fed in a GrowSafe system (GrowSafe Systems Ltd., Airdrie, AB, Canada) in open lot pens. Cattle were harvested every 28 days starting on June 25, 2012 (initial slaughter), with five steers per treatment in every slaughter group after the initial harvest. There were 12 total harvest points including the initial slaughter ranging from day 0 to day 308; the seventh slaughter group (day 168) was omitted from calculations and analysis due to outliers in the data (more than three SD away from the mean). Slaughter groups 1 through 7 were harvested at the Beef Carcass Research Center. At this point steers were too big for the facility to handle, and slaughter groups 8 through 12 were harvested at a nearby commercial facility. Whole carcasses were divided into lean, bone, internal cavity (liver, gallbladder, pancreas, bladder, lungs, heart, spleen, empty stomach, empty intestine, and kidneys), hide, and fat trim components. Each tissue type was weighed and sampled. These samples were ground, frozen, and analyzed for Ca, P, K, Mg, and S by a commercial laboratory (Servi-Tech, Amarillo, Tex.). Samples were acid digested to remove all organic matter and analyzed for minerals using Inductively Coupled Plasma-Atomic Emission Spectroscopy.

Mineral retention within the body was calculated as the difference between mineral composition at slaughter and predicted mineral composition at day 0. Mineral composition at day 0 was predicted from body composition of steers harvested at day 0 multiplied by the live weight of individual animals at day 0. Due to the short interval between harvest points (28 days) and no differences in P and Ca composition of the bone portion of the body over time ($P \geq 0.89$), initial P and Ca composition of the bone fraction was predicted using each steer's mineral composition instead of the average of the day 0 harvested cattle. With no changes over time in bone Ca and P content, individual steer data better predicted day 0 compositions than using day 0 data to predict individual steer mineral content. This method was not appropriate for other minerals or other tissues as these did have changes in mineral content over time ($P < 0.10$). Mineral retention was calculated for each individual tissue and then summed for statistical analysis on an empty body weight (EBW) basis. In live animals EBW is calculated as full BW multiplied by 0.855; however, in this serial slaughter trial EBW was measured by weighing the whole carcass after the gastrointestinal tract contents had been removed. Mineral retention was expressed as grams per day, grams per kg EBW gain, and grams per 100 g protein gain.

For statistical analysis, fixed effects included treatment and days on feed with individual animal as the experimental unit. The treatment by days on feed interaction was significant for K retention ($P < 0.01$) but not for other minerals ($P \geq 0.16$). Linear, quadratic, and cubic contrasts over time were also analyzed.

Results

Weights of all tissues increased linearly over time ($P < 0.01$) with increasing days on feed (Figure 1). As a % of EBW, lean, bone, and hide tissues decreased linearly over time ($P < 0.01$) while internal cavity and fat tissues linearly increased over time ($P < 0.01$). Fat trim increased from 2.9 to 11.6% of EBW while lean tissue decreased from 47.2 to 37.7% of EBW

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from day 0 to day 308. Cattle on ZH had a greater percent of EBW as lean tissue ($P < 0.01$) and less bone, internal cavity, and hide ($P < 0.01$). Fat trim, as a % of EBW, was not significantly different between treatments ($P = 0.42$).

Mineral composition of tissues, with the exception of Ca and P content of bone, fluctuated over time. As a % of DM, P content of lean, hide, internal cavity, and fat tissues decreased linearly over time ($P < 0.01$). Linear decreases in Ca, K, and Mg content were observed in lean and hide tissues ($P \leq 0.02$). Sulfur content of the hide increased linearly over time ($P < 0.01$) presumably due to accumulation of sulfur containing amino acids in the hair coat of animals, especially evident as cattle were housed outdoors with initial slaughter in June and subsequent slaughter groups every 28 days until the following April. Sulfur content of all other tissues decreased linearly over time ($P < 0.01$). Differences in mineral content due to treatment were minimal, except ZH lean tissue had greater concentrations of P, K, and Mg ($P < 0.05$) and ZH internal cavity tissue had greater P content ($P < 0.01$) than CON. Averaged across treatment and days on feed, 92% of P and 99% of Ca present in the body was in the bone.

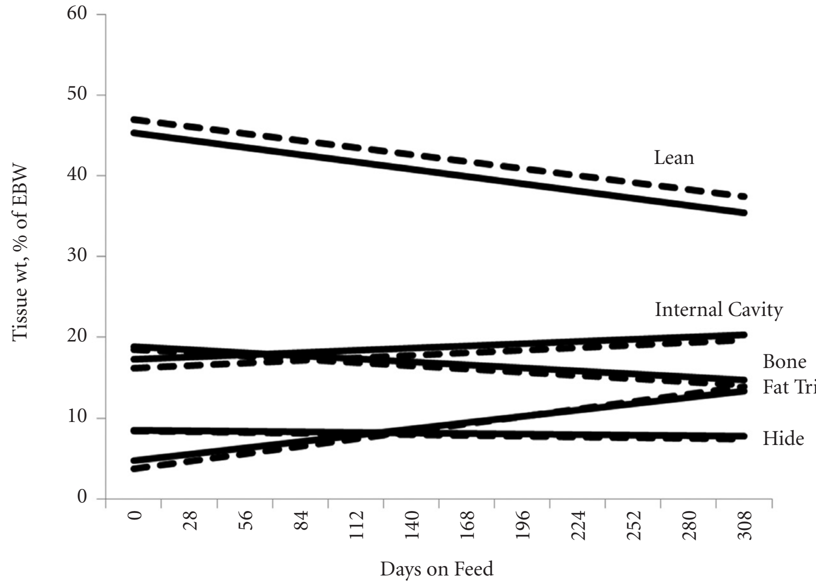

Figure 1. Weight of individual tissues of serially harvested Holstein Steers, expressed as a percent of empty body weight (EBW). Changes in tissue weight are shown across days on feed and by treatment. Treatments included control cattle (—) and cattle fed Zilmax for 20 days prior to harvest (---). Lean, bone, internal cavity, and hide differed by treatment ($P \leq 0.01$); fat trim did not differ by treatment ($P = 0.42$). Lean, bone and hide linearly decreased over days on feed while internal cavity and fat trim linearly increased ($P < 0.01$).

Calculating mineral retention relative to protein gain (g/100 g protein gain) resulted in no statistical differences due to treatment or days on feed ($P > 0.10$). Figures 2 to 6 show P, Ca, K, Mg, and S retention, as both g/kg EBW gain and g/100 g of protein gain, across days on feed by treatment. Mineral retention as g/kg EBW gain is shown for individual tissues while g/100 g protein gain is shown as retention within the entire body. There were no differences due to treatment for P retention ($P \geq 0.12$) with a linear decrease over days on feed ($P < 0.01$) when expressed as g/kg EBW gain. However, when expressed relative to protein gain there were no differences over time ($P \geq 0.15$; Figure 2). There were no differences in Ca retention due to treatment ($P \geq 0.39$) or days on feed ($P \geq 0.11$) when expressed relative to protein gain; when expressed on an EBW gain basis CON cattle had greater

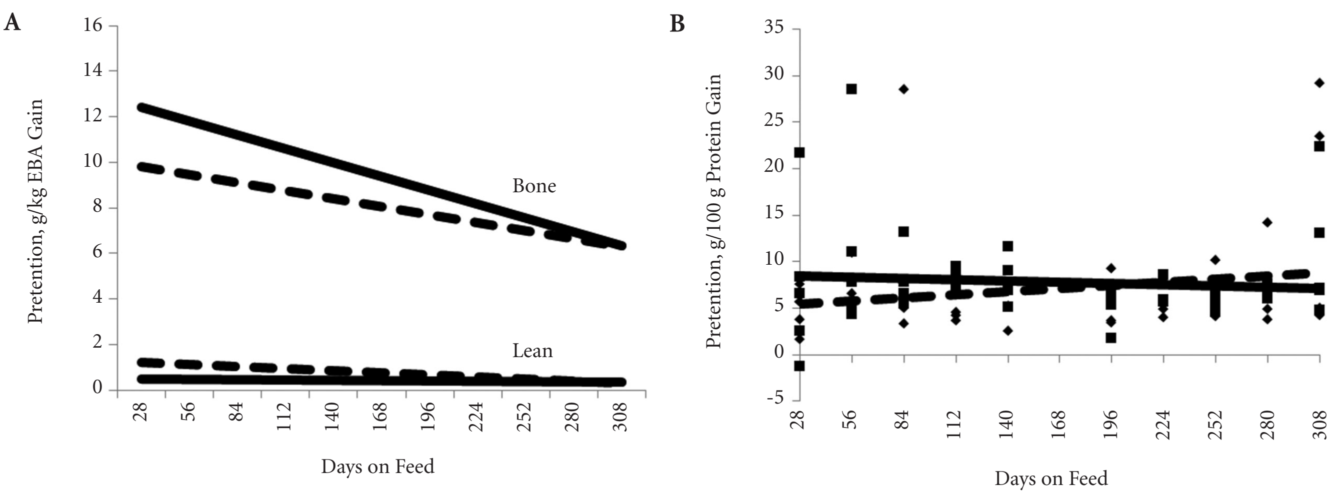

Figure 2. Phosphorus retention of serially harvested Holstein steers, expressed as g/kg empty body weight (EBW) gain or g/100 g protein gain. Changes in P retention are shown across days on feed and by treatment. Treatments included control cattle (—) and cattle fed Zilmax for 20 days prior to harvest (---).
A. Retention relative to EBW gain is broken down into bone and lean tissues, retention within hide, internal cavity, and fat were minor, less than 0.4 g. No differences were observed by treatment ($P \geq 0.12$) with linear decreases across days on feed ($P < 0.01$).
B. Retention relative to protein gain is shown for all tissues summed together. Individual animals are represented by points, square denote control cattle and diamonds denote Zilmax fed cattle. There were no differences due to treatment ($P \geq 0.52$) or days on feed ($P \geq 0.15$).

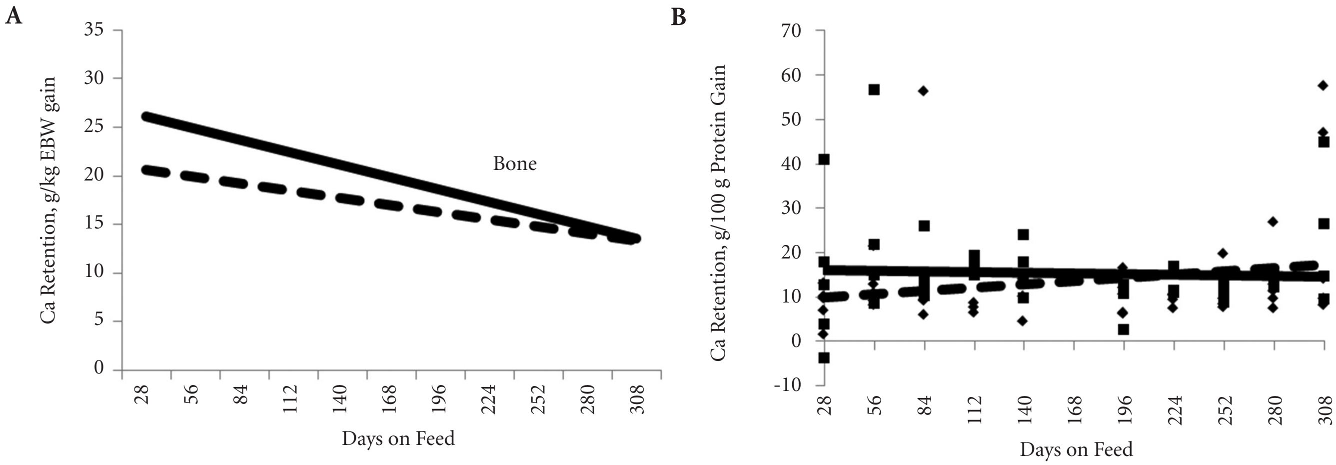

Figure 3. Calcium retention of serially harvested Holstein steers, expressed as g/kg empty body weight (EBW) gain or g/100 g protein gain. Changes in Ca retention are shown across days on feed and by treatment. Treatments included control cattle (—) and cattle fed Zilmax for 20 days prior to harvest (---).
A. Retention relative to EBW gain is shown only for bone tissue, which accounted for 99% of total body Ca retention. Control cattle had greater Ca retention (*P* = 0.02) than Zilmax fed cattle; Ca retention for both treatments linearly decreased across days on feed (*P* < 0.01).
B. Retention relative to protein gain is shown for all tissues summer together. Individual animals are represented by points, square denote control cattle and diamonds denote Zilmax fed cattle. There were no differences due to treatment (*P* ≥ 0.39) or days on feed (*P* ≥ 0.11).

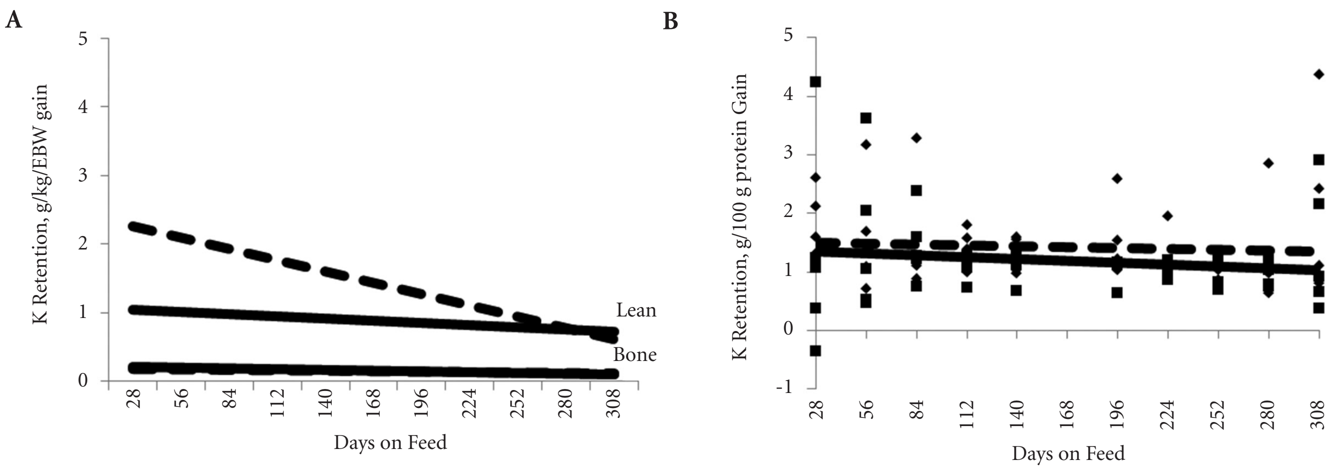

Figure 4. Potassium retention of serially harvested Holstein steers, expressed as g/kg empty body weight (EBW) gain or g/100 g protein gain. Changes in K retention are shown across days on feed and by treatment. Treatments included control cattle (CT; —) and cattle fed Zilmax for 20 days prior to harvest (ZH; ---).
A. Retention relative to EBW gain is broken down into lean and bone tissues. Retention within the lean tissue accounted for 62 and 72% of total body K retention for CT and ZH, respectively. Retention of K was greater for ZH cattle (*P* < 0.01) with linear decreases across days on feed (*P* < 0.02) for both treatments. The interaction between treatment and days on feed was significant (*P* < 0.01) with ZH cattle having greater decreases in K retention over time compared to CT cattle.
B. Retention relative to protein gain is shown for all tissues summed together. Individual animals are represented by points, squares denote control cattle and diamonds denote Zilmax fed cattle. There were no differences due to treatment (*P* ≥ 0.14) or days on feed (*P* ≥ 0.60).

Ca retention (*P* = 0.02) with both treatments linearly decreasing across days on feed (*P* < 0.01; Figure 3). Potassium retention was greater for ZH cattle (*P* < 0.01) when expressed as g/kg EBW gain with retention in both treatments linearly decreasing over time (*P* < 0.01; Figure 4). There were no differences in K retention due to treatment (*P* ≥ 0.14) or days on feed (*P* ≥ 0.60) when expressed relative to protein gain. Retention of Mg did not differ by treatment (*P* ≥ 0.64) and decreased linearly across days on feed when expressed relative to EBW gain (*P* < 0.01), but was not different across days on feed when expressed relative to protein gain (*P* ≥ 0.34; Figure 5). Retention of S did not differ by treatment or days on feed when expressed relative to EBW gain or protein gain (*P* ≥ 0.21; Figure 6).

When mineral retention was expressed as g/day or g/kg EBW gain, there were statistical differences (*P* ≤ 0.02) across days on feed for P, Ca, K, Mg, and S, mostly due to changes in tissue weights. There were no differences in P, Mg, and S retention expressed as g/day or g/kg EBW gain due to treatment (*P* ≥ 0.09). Differences in K and Ca retention due to treatment were largely due to differences in amount of lean tissue, with ZH cattle having a greater percent of EBW as lean, 41.8% compared to 39.7% of EBW for CON. Lean tissue averaged 0.82% K for CON and 0.87% K for ZH (*P* = 0.04). The bone fraction was a larger percent of EBW for CON cattle, leading to greater Ca retention in CON cattle.

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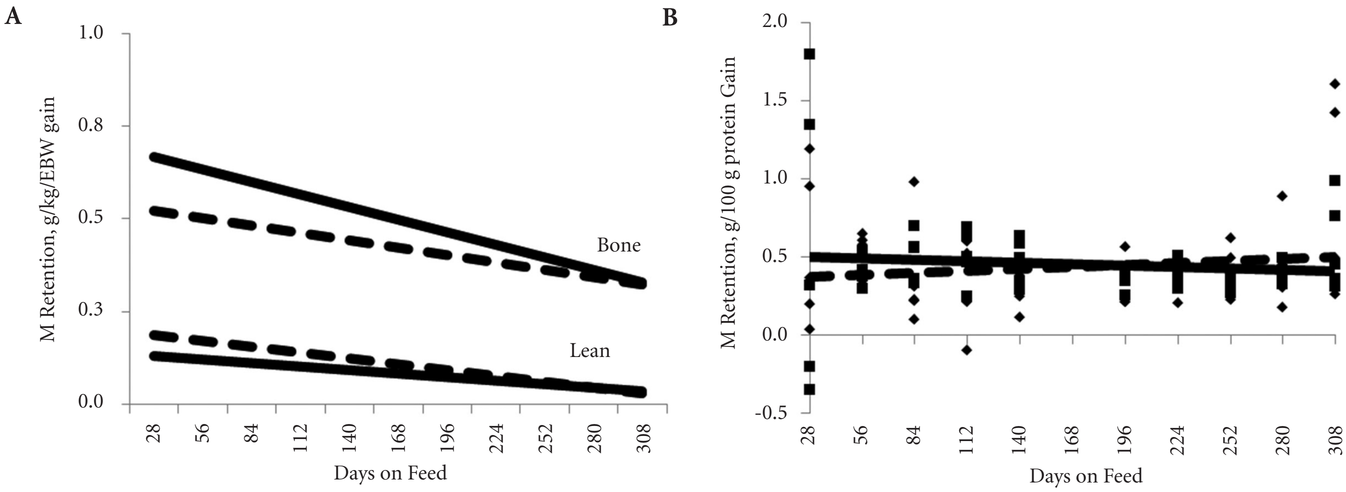

Figure 5. Magnesium retention of serially harvested Holstein steers, expressed as g/kg empty body weight (EBW) gain or g/100 g protein gain. Changes in Mg retention are shown across days on feed and by treatment. Treatments included control cattle (—) and cattle fed Zilmax for 20 days prior to harvest (---).
A. Retention relative to EBW gain is broken down into bone and lean tissues. These 2 tissues combined accounted for 94% of Mg retention within the entire body. No difference were observed by treatment (*P* ≥ 0.64) with linear decreases across days on feed (*P* < 0.01).
B. Retention relative to protein gain is shown for all tissues summed together. Individual animals are represented by points, squares denote control cattle and diamonds denote Zilmax fed cattle. There were no differences due to treatment (*P* ≥ 0.82) or days on feed (*P* ≥ 0.34).

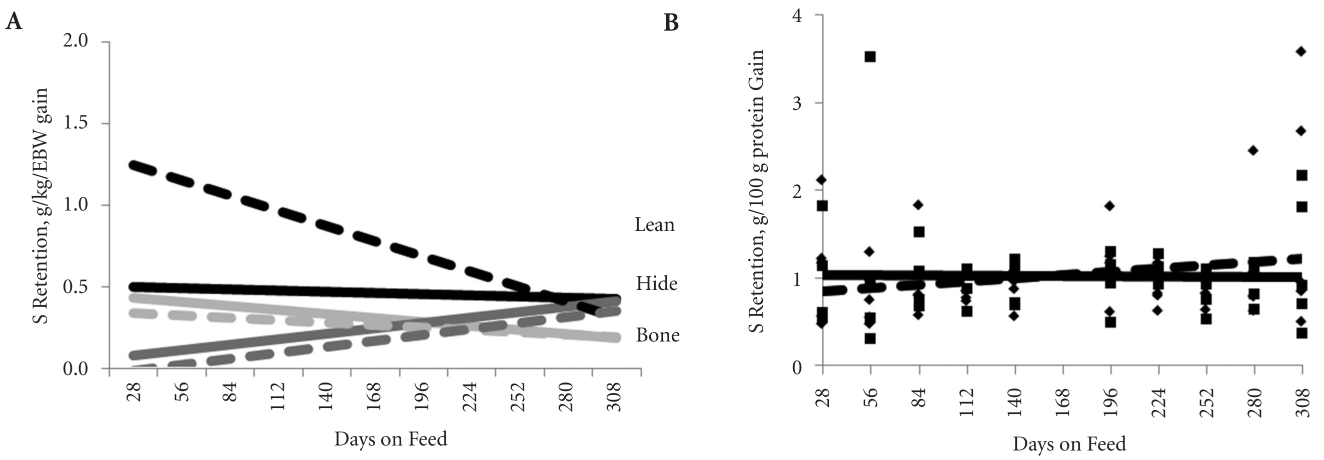

Figure 6. Sulfur retention of serially harvested Holstein steers, expressed as g/kg empty body weight (EBW) gain or g/100 g protein gain. Changes in S retention are shown across days on feed and by treatment. Treatments included control cattle (—) and cattle fed Zilmax for 20 days prior to harvest (---).
A. Retention relative to EBW gain is broken down into lean (black), hide (dark gray), and bone (light gray) tissues. Together these 3 tissues repretned 85% of S retention wtihin the entire body. No differences were observed by treatment (*P* ≥ 0.21) or days on feed (*P* < 0.31).
B. Retention relative to protein gain is shown for all tissues summed together. Individual animals are represented by points, squares denote control cattle and diamonds denote Zilmax fed cattle. There were no differences due to treatment (*P* ≥ 0.90) or days on feed (*P* ≥ 0.57).

Expressing mineral retention relative to protein gain resulted in no statistical differences due to treatment or days on feed (*P* ≥ 0.11), thus most of the variation in mineral retention was due to differences in rate and type of gain. Retention of P, Ca, K, Mg, and S averaged 7.5, 14.4, 1.3, 0.5, and 1.0 g/100 g of protein gain respectively. The current NRC (2000) reports P retention as 3.9 g/100 g protein gain and Ca retention as 7.1 g /100 g protein gain. These values are based on data from the 1940s, primarily measured in Holstein cows. Differences between trials may be due to differences in age and gender of cattle measured, diets fed, or methods used to measure mineral retention. Retention of Ca and P in the current trial with Holstein cattle was higher than retention measured in beef cattle (*2015 Nebraska Beef Cattle Report,* pp. 108-110). This is rational as a majority of both Ca and P is found in the skeleton and dairy breeds have a lower ratio of lean to bone (<3.4) compared to beef cattle (>3.6). Values for K, Mg, and S retention are not widely available for comparison.

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Anaerobic Digestion of Feedlot Manure

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Summary

Cattle diet can impact manure quality and quantity but has minimal impacts on methane production from anaerobic digestion of manure. Quality of manure, measured as OM, does affect methane production and is largely impacted by the environment cattle are housed in and methods used to collect manure. As the amount of ash contamination of manure was increased, or OM content of the manure was decreased, organic matter degradation and methane production were decreased. With adequate daily cleanout of ash from digesters, open-lot beef cattle manure can be used for anaerobic digestion.

Introduction

Anaerobic digestion of manure is more common in the dairy and swine industries compared to beef. Utilizing feedlot manure for anaerobic digestion is more challenging due to ash contamination from soil-based pens. Within Nebraska, the feedlot industry produces significant amounts of manure each year. Transforming the energy within this manure into methane and using that energy has significant economic and environmental implications. This research studied the effects of adding anaerobic digestion of manure to a cattle, crop, and ethanol system, similar to facilities in place within Nebraska. Currently, distillers grains are commonly fed to feedlot cattle that are located in close proximity to ethanol plants. Methane production from manure resulting from cattle fed distillers grains was compared to manure from cattle fed a corn-based diet. Varying levels of ash contamination were also evaluated to identify if ash contamination of manure can be overcome in order for open lot feedlot manure to be used as anaerobic digestion feedstock.

Procedure

Nine, 12-gallon anaerobic digesters were utilized to study biogas generation from feedlot cattle manure. Prior to the start of Experiment 1, digesters were inoculated and maintained for two months to ensure steady-state. In Experiment 1, varying concentrations of ash were added to manure to equal 65, 40, or 15% OM manure fed to digesters. In Experiment 2, treatments were cattle diet that consisted of either a corn-based control diet (CONT) or a diet with modified distillers grains plus solubles (MDGS) replacing 40% of the corn. For both trials, digesters were allowed to stabilize for 41 days after which measurements were collected on five consecutive days. During both trials, digesters were stirred for two minutes every four hours and temperature was maintained at 99°F. Digesters were designed for effluent removal through a 2-inch ball valve located at the bottom of a cone-shaped tank. Intermittent mixing and the cone bottom on the tank allowed for inorganic particles to settle out and be removed in the effluent. Manure slurry was fed to the digesters each day through a tube at the top of the digester. Measurements of OM degradation and methane production were collected for five days at the end of each 41-day period. Weight, DM, and OM of manure fed to digesters and effluent removed from digesters were measured on these days. Concentration of methane within a known flow of N_2 gas was measured twice daily, prior to mixing. Each day, approximately 0.6 gallons (5% of total volume) of effluent was removed from each digester and 0.6 gallons of manure slurry was added to each digester to maintain a constant volume of material.

Manure for Experiment 1 was collected from the settling basin of the individually fed cattle barn at the research feedlot at the ARDC near Mead, Neb. This barn has a sloped floor and water flush system, with minimal soil contamination. Manure averaged 18% DM and 65% OM. Soil (90% DM, 97% ash) was also collected and added to digesters to have three treatments: 65, 40, and 15% OM manure fed to digesters. Water was added to the manure-soil mixture to equal 9% DM when fed into the digesters. All digesters received the same amount of OM each day (i.e., varying amount of soil and constant amount of manure).

In Experiment 2, the 65% OM manure collected for Experiment 1 was compared to manure collected from cattle fed two different diets. Manure for Experiment 2 was collected over an eight-day period with three steers per dietary treatment. Cattle diets included a corn-based control (CONT) and a 40% modified distillers grains plus solubles diet (MDGS; Table 1). Cattle were housed indoors and tied in stanchions with complete manure (urine and feces) collection in a cement pit behind the cattle. Manure was collected, mixed, and subsampled for DM, OM, and mineral analysis. Manure that was collected averaged 11% DM and 85% OM, water was added to the manure to lower percent DM of manure slurry fed to the digesters to 9%.

In both experiments there were three treatments with three digesters per treatment. Experiment 1 was a switchback design with three periods; each digester was evaluated on each treatment. Three measurement periods were made with 40 days of acclimation followed by five days of measurements. Experiment 2 consisted of a 41 day acclimation period followed by one five day measurement period. Data were analyzed as a repeated measure using a compound symmetry covariance pattern with day repeated in both Experiment 1 and 2. Measures of OM degradation were taken on five consecutive days and methane concentration was measured twice per day for five days in both Experiment 1 and 2.

Results

Experiment 1—Ash Contamination

Increased ash contamination of manure decreased organic matter degradation (OMD) from 63.2 to

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54.1% for the 65 and 15% OM treatments (respectively; $P = 0.02$; Table 2). The 40% OM treatment was intermediate and not statistically different from 65 or 15% OM treatments ($P > 0.06$; linear $P = 0.02$).

The high level of ash contamination also decreased daily methane production from 0.589 to 0.425 L CH_4 per L digester volume per day for the 65 and 15% OM treatments, respectively (linear $P < 0.01$). This is equal to 0.187 and 0.139 L CH_4 per g of OM fed (linear $P = 0.02$) for the 65 and 15% OM treatments respectively. The 40% OM treatment was intermediate for both L CH_4 per L digester volume daily and L CH_4 per g of OM fed.

Effluent removal from the cone bottom of the digesters aided in separating organic and inorganic particles within the digesters. Of ash added to digesters, 9.5, 18.3, and 20.5% was not removed from the 15, 40, and 65% OM treatments, respectively ($P = 0.11$). This resulted in ash buildup (mineral or inorganic material that was added to the digester, but not removed in the effluent and not degraded within the digester) of 64.7, 45.5, and 17.0 g/day, respectively, as % OM in the manure increased (linear $P < 0.01$). A majority of the ash was removed; however, eventually digesters are expected to fill up with ash and have to be shut down and cleaned out. The better ash removal is, the less often shut down will need to occur.

Feedlot manure has greater ash contamination and lower OM content than manure that has traditionally been used for anaerobic digestion. With adequate daily cleanout of ash from digesters, open-lot beef cattle manure can be used for anaerobic digestion, although small decreases in methane production are to be expected. Increasing the amount of effluent removed from digesters each day results in less ash buildup within digesters. However, reducing retention time of manure within digesters also limits degradation and methane production per g of OM fed. The 20 day retention time used in the current study attempts to balance between ash buildup and methane production. The OM content of feedlot manure varies depending on frequency of pen cleaning, time of year, and area of the pen the manure is removed from; however, open lot manure is generally 25% OM.

Experiment 2 — Diet Impact

Ash buildup was greater and OMD was lower for the 65% OM manure compared to the CONT and MDGS manure, which averaged 85% OM. Organic matter degradation averaged 63.8% for CONT and MDGS ($P = 0.48$). The 65% OM manure had 45.0% OMD. Ash buildup, as a percent of total ash fed into the digester was 18.5% for the 65% OM treatment. The CONT and MDGS treatments had less ash buildup ($P < 0.01$) and averaged 6.3%. Even with small amounts of ash buildup, eventually digesters will likely need to be shut down and cleaned out.

There were no statistical differences in methane production, measured as daily production per L of digester volume ($P = 0.92$) or daily production per g of OM fed ($P = 0.37$). For all three treatments, daily methane production averaged 0.486 L/L of digester volume or 0.131 L/g of OM fed.

Cattle diet can impact manure quality and quantity but has minimal impacts on methane production from anaerobic digestion of manure. Quality of manure, measured as OM, has a larger impact on methane production and is largely impacted by the environment the cattle are housed in and methods used to collect the manure (i.e., ash contamination).

Table 1. Composition of diets fed to cattle for manure collection and digester feeding in Experiment 2.

Ingredient, % of DM	CONT[1]	MDGS[2]
Dry-rolled corn	80	40
Corn silage	15	15
MDGS[2]	—	40
Supplement	5	5
Urea	1.66	—
Monensin, g/ton	30	30
Tylosin, g/ton	8	8

[1]Treatments were due to cattle diet, CONT, and MDGS.
[2]MDGS = modified distillers grains plus solubles.

Table 2. Degradation of manure and methane production within anaerobic digesters fed cattle manure[1].

Experiment 1	15% OM	40% OM	65% OM	SEM	*P*-value	Linear	Quad
DM fed, g/day	824	388	223	—	—	—	—
OM fed, g/day	140	140	140	—	—	—	—
Ash buildup, g/day	64.7^{b}	45.5^{ab}	17.0^{a}	17.1	0.02	< 0.01	0.74
Ash buildup, % of ash fed	9.46	18.3	20.5	5.94	0.11	0.12	0.16
OMD[2], %	54.1^{a}	56.5^{ab}	63.2^{b}	3.8	0.05	0.02	0.45
Methane, L/L digester volume daily	0.425^{a}	0.501^{ab}	0.589^{b}	0.051	< 0.01	< 0.01	0.86
Methane, L/g OM fed	0.139^{a}	0.167^{b}	0.187^{b}	0.017	0.02	< 0.01	0.71
Experiment 2	**CONT**	**MDGS**	**65% OM**	**SEM**	***P*-value**		
DM fed, g/day	228	216	220	—	—		
OM fed, g/day	205	183	132	—	—		
Ash buildup, g/day	1.37^{a}	2.16^{a}	16.3^{b}	2.24	< 0.01		
Ash buildup, % of ash fed	5.96^{a}	6.55^{a}	18.5^{b}	1.10	< 0.01		
OMD[2], %	61.7^{b}	65.9^{b}	45.0^{a}	5.9	< 0.01		
Methane, L/L digester volume daily	0.506	0.491	0.462	0.11	0.92		
Methane, L/g OM fed	0.112	0.123	0.158	0.033	0.37		

[1]In Experiment 1, manure was collected from a sloped floor cattle barn with a water flush system and averaged 65% OM. Soil was added to this manure to create the 40 and 15% OM treatments. Treatments in Experiment 2 were due to cattle diet, a corn- based control diet (CONT), a 40% modified distillers grains plus solubles diet (MDGS), or a mixture of diets collected from a sloped floor barn (similar to 65% OM treatment in Experiment 1).
[2]OMD = organic matter degradation.
[a,b]Within a row, means without a common superscript differ ($P < 0.05$).

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A Basic Mechanism of Beef Tenderization: Feeding Wet Distillers Grains Plus Solubles Contributes to Sarcoplasmic Reticulum Membrane Instability

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Chris R. Calkins[1,2]

Summary

Feeding wet distillers grains plus solubles (WDGS) could increase polyunsaturated fatty acid (PUFA) concentration in the sarcoplasmic reticulum (SR) membrane, thereby altering membrane integrity, resulting in more rapid post-rigor calcium leakage, greater enzyme activity and improved tenderness. Steers were finished on either 0% WDGS or 50% WDGS. Steaks from steers fed WDGS were more tender and had greater free calcium concentrations. Feeding WDGS also increased proportions of PUFA in SR membrane and altered SR lipid and phospholipid profiles. These findings suggest that feeding increased concentrations of WDGS in the finishing diet can possibly increase meat tenderness through the proposed mechanism.

Introduction

Muscle is an elegant biological system with mechanisms in place to control calcium for contraction and relaxation. After rigor, calcium ions slowly diffuse from the sarcoplasmic reticulum (SR) to the sarcoplasm where the ions activate the calcium-dependent proteolytic enzymes (the calpain system) and enhance tenderness. It is well-known that feeding cattle with feed containing greater concentrations of polyunsaturated fatty acid (PUFA) such as wet distillers grains plus solubles (WDGS) increases PUFA concentrations in beef (2011 *Nebraska Beef Cattle Report*, pp. 96-99). Research results from our lab have reported that beef from cattle fed 30% WDGS tended to be more tender than beef from cattle not fed WDGS or WDGS with dietary antioxidants (2012 *Nebraska Beef Cattle Report*, pp. 124-126). Our hypothesis is that including WDGS in feedlot diets increases PUFA concentration in the SR membrane, making the membrane more prone to oxidation. An unstable SR membrane occurs because of altered membrane integrity, resulting in more rapid calcium leakage post-rigor and, thus, improves tenderness through greater activation of the calpain system.

Table 1. Diet composition on a DM basis.

	50% WDGS	0% WDGS
Ingredients, % of DM		
Dry-rolled corn	16.5	41.5
High-moisture corn	16.5	41.5
Wet distillers grains plus solubles	50	0
Corn silage	12	12
Supplement[1]	5	5

[1]Formulated to contain 380 mg/head/day of Rumensin® and 90mg/head/day of Tylan®.

Procedure

This trial was designed to provide samples with differing levels of oxidation capacity to allow examination of the mechanisms by which SR membrane oxidation influences beef tenderization postmortem. Ninety-six steers were randomly assigned to one of two treatments: 0% WDGS or 50% WDGS (Table 1). For both treatments, there were six pens (replicates) with each pen having eight steers. Fifteen strip loins (*Longissimus lumborum*) from each treatment (n = 30; 2-3 per pen) were collected and aged for 2, 7, 14, or 21 days. Steaks were removed at each aging period and placed under retail display conditions for 0, 4, and 7 days.

Steak samples for tenderness assessment (via Warner Bratzler Shear Force [WBSF]), free calcium concentrations (via inductively coupled plasma spectroscopy) and proteolysis (via immunoblotting to quantify troponin-T degradation) were obtained on day 0 and 7 of retail display for each aging period. Steak samples for lipid oxidation (via t*hiobarbituric acid reactive substances assay [TBARS])* were obtained on day 0, 4 and 7 of retail display for each aging period. Steak samples for SR membrane fatty acid (via gas chromatography), lipid, and phospholipid (via thin-layer chromatography) profiles were obtained at day 0 of retail display after 14 days of aging.

Data were analyzed by GLIMMIX procedure of SAS (version 9.2; SAS Institute, Inc., Cary, N.C.) as a split-split-plot design with dietary treatments as the whole plot, aging period as the subplot and retail display time as the repeated measures. Separation of means was conducted using LSMEANS procedure with PDIFF or SLICEDIFF options at $P \leq 0.05$.

Results

Compared to steaks from steers fed 0% WDGS, steaks from steers fed 50% WDGS were more tender ($P < 0.01$; Figure 1) at two days of aging with 0 day of retail display. Meat from WDGS fed steers also had increased ($P < 0.01$) free calcium concentration (Figure 2) at two days aging after seven days of retail display. However, there were no differences in tenderness or free calcium

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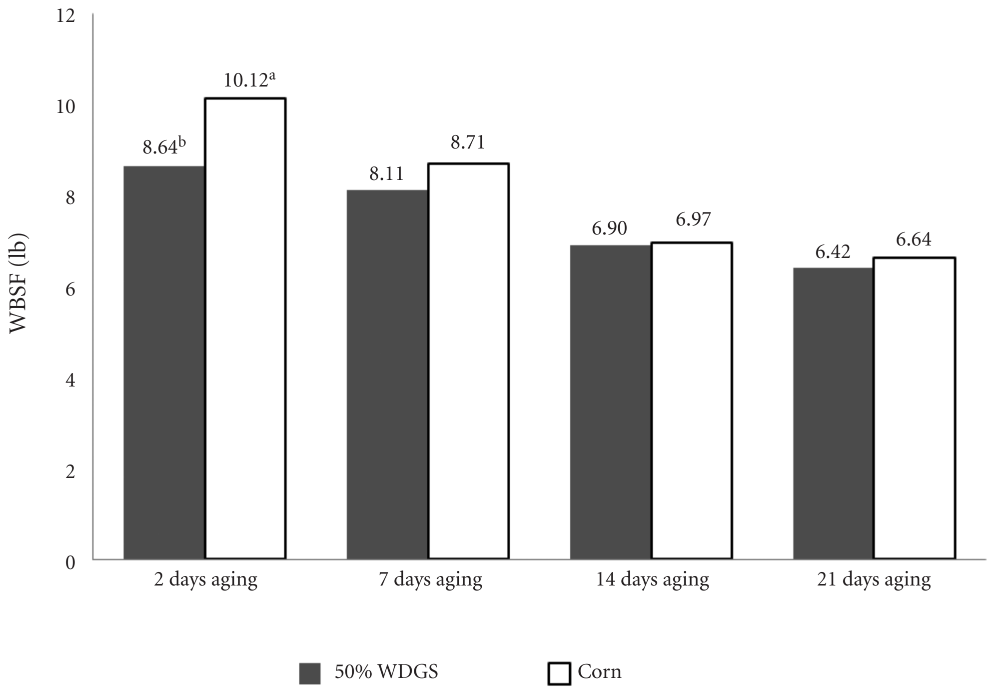

Figure 1. Warner-Bratzler shear force (WBSF) of strip loins (*m. longissimus lumborum*) from steers fed with or without wet distillers grains plus solubles (WDGS) in finishing diets without retail display.

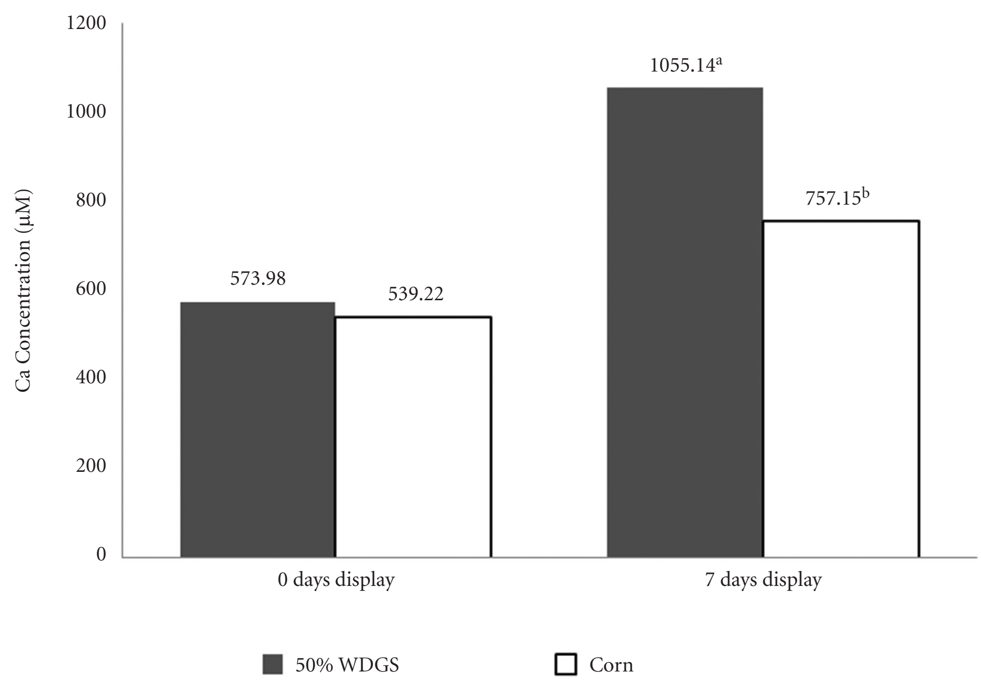

Figure 2. Free calcium concentration of strip loins (*m. longissimus lumborum*) aged for two days from steers fed with or without wet distillers grains plus solubles (WDGS) in finishing diets.

Table 2. Fatty acid profile of sarcoplasmic reticulum membrane from strip loins (*m. longissimus lumborum*) from steers fed with or without wet distillers grains plus solubles (WDGS) in finishing diets.

Fatty Acids (%)	50% WDGS	0% WDGS	*P*-value
C15:0	0.50	0.53	0.56
C15:1	1.51[b]	2.81[a]	0.04
C16:0	22.16	23.25	0.13
C16:1	2.32[b]	3.32[a]	< 0.01
C17:0	0.95	0.94	0.94
C17:1	0.97[b]	1.19[a]	< 0.01
C18:0	10.30[a]	9.06[b]	0.04
C18:1	26.48[b]	30.30[a]	0.03
C18:1V[2]	1.93[b]	2.47[a]	< 0.01
C18:2	16.81[a]	12.46[b]	0.03
C18:3	0.42	0.39	0.63
C20:3	1.30	1.39	0.59
C20:4	4.97	5.57	0.37
C20:5	0.48	0.52	0.71
C22:4	0.80	0.85	0.75
C22:5	0.22	0.19	0.08
SFA[1]	36.04	35.53	0.72
UFA[1]	63.96	64.47	0.72
SFA:UFA[1]	0.57	0.56	0.70
MUFA[1]	33.09[b]	38.52[a]	0.01
PUFA[1]	28.73	23.91	0.09

[1]SFA = saturated fatty acids, UFA = unsaturated fatty acids, MUFA = monounsaturated fatty acids, and PUFA = polyunsaturated fatty acids.
[2]C18:1V is cis vaccinic acid.
[a-b]Within a row, means without a common superscript differ at $P \leq 0.05$.

Table 3. Phospholipid and lipid profile of sarcoplasmic reticulum membrane from strip loins (*m. longissimus lumborum*) from steers fed with or without wet distillers grains plus solubles (WDGS) in finishing diets.

	50% WDGS	0% WDGS	*P*- value
Phospholipids (%)			
Phosphatidylcholine	43.00[a]	36.07[b]	< 0.01
Phosphatidylethanolamine	31.89[b]	38.78[a]	0.03
Phosphatidylinositol	2.86	2.66	0.56
Phosphatidylserine	1.03	1.15	0.53
Sphingomyelin	21.89	21.71	0.93
Lipid (%)			
Phospholipid	47.90	53.74	0.10
Mono, Di & Triacylglyceride	47.55	41.06	0.08
Cholesterol	4.36	5.01	0.36
Free Fatty Acids	0.18	0.19	0.90
Total Neutral Lipid	52.10	46.26	0.10

[a-b]Within a row, means without a common superscript differ at $P \leq 0.05$.

concentration between treatments for any other aging and retail display period. Extended aging beyond two days appeared to mitigate the tenderness effects.

In addition, feeding WDGS decreased ($P \leq 0.05$) concentrations of fatty acids C15:1, C16:1, C17:1, C18:1, C18:1V and total monounsaturated fatty acid, but increased ($P \leq 0.05$) concentrations of fatty acids C18:0, C18:2 and tended to increase ($P \leq 0.1$) total PUFA in SR membrane (Table 2). The increase in PUFA content of the SR membrane supports our hypothesis that feeding WDGS may impair SR membrane integrity and, thus, accelerate free calcium release.

Feeding WDGS also tended to decrease ($P \leq 0.1$) phospholipid concentration and tended to increase ($P \leq 0.1$) mono, di and triacylglyceride and neutral lipid concentration in SR membrane (Table 3). Also, feeding WDGS increased ($P < 0.01$) phosphatidylcholine, but decreased ($P \leq 0.05$) phosphatidylethanolamine percentages in SR phospholipids (Table 3). It has been reported that the phospholipids in the SR membrane are degraded during postmortem aging and that calcium leaks through channels formed by this degradation in the SR membrane. Phosphatidylethanolamine is bound to the transmembrane helices of the membrane-bound structure that pumps calcium into the SR. When calcium is bound, the phosphatidylethanolamine is released. We hypothesize that a reduction in phosphatidylethanolamine is related to the increase in free calcium concentration. It is likely, then, that the difference in SR fatty acid profile is not the only contributor to the differences in tenderness and free calcium concentration.

There were no differences in troponin-T degradation between treatments in any of the aging and retail display periods, which indicated that the calpain activity was not different between treatments. Steaks from 0% WDGS steers had increased lipid oxidation values compared to steaks from steers fed WDGS ($P \leq 0.05$) at 21 day aging, and the reason behind it is still unclear.

Although lipid oxidation values did not agree with our hypothesis, it is likely that measuring lipid oxidation on muscle tissue is not the best way to measure SR membrane oxidative status. A sensitive, simple, and reliable method that can detect lipid oxidation in extremely small sample volume is needed for direct measurement of SR membrane oxidative status. These findings suggest that feeding WDGS in the finishing diet can possibly increase meat tenderness through the proposed mechanism.

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[2]This project was funded in part by The Beef Checkoff.

The Effects of Source and Amount of Nitrite on Quality Characteristics of All-Beef Frankfurters

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Summary

In an effort to meet consumers' demand for foods with more natural ingredients, processors have begun manufacturing meat products cured with natural nitrite sources. The objective of this study was to evaluate the quality characteristics of all-beef frankfurters cured with traditional or alternative sources of nitrite and using equivalent amounts of nitrite. Frankfurters cured with alternative sources of nitrite had a slightly darker, less red exterior and slightly more yellow interior than those containing sodium nitrite. No differences were observed for pH or water activity. Both curing methods can be used to manufacture all-beef frankfurters with similar characteristics when using equivalent amounts of nitrite.

Introduction

Sodium nitrite alters product color, aroma, and flavor; inhibits the growth of specific pathogens; and reduces lipid oxidation that leads to rancidity in cured meat. There is a customer segment that has become more conscious of ingredients used in processed foods. These consumers are demanding foods with more natural ingredients and fewer overall added ingredients. Sodium nitrate and nitrite, which are commonly used in cured meats, are two major ingredients of concern to this group. This perception stems from research that began in the 1950s indicating sodium nitrate and nitrite may be detrimental to the health of consumers even though some current research suggests dietary nitrate and nitrite may have health benefits. Without the inclusion of sodium nitrite, cured meat flavor, color, aroma, and antimicrobial control is not achievable. In order to maintain cured meat characteristics, meat processors have turned to natural nitrate sources, including celery juice powder, and nitrate-reducing starter cultures to add nitrite from alternative sources than from sodium nitrite. The USDA requires these products to include "uncured" and "no nitrate or no nitrite added except those naturally occurring in [ingredients]" on the label, even though these products have typical cured meat characteristics. To this point, studies comparing the curing methods did not evaluate equivalent amounts of ingoing nitrite from multiple sources. Therefore, the objective of this study was to examine the physical characteristics of all-beef frankfurters manufactured with sodium nitrite or celery juice powder added at equivalent concentrations of ingoing nitrite.

Procedure

This study was conducted in a two-by-four factorial design measuring two different cure methods (sources of nitrite) and four nitrite concentrations (amount of nitrite). The two nitrite sources utilized were sodium nitrite (traditional curing) and celery juice powder (alternative curing; VegStable 506, Florida Food Products, Inc., Eustis, Fla.). Both sources were evaluated at 0, 52, 104, and 156 ppm ingoing sodium nitrite concentration or the equivalent amount of nitrite from celery juice powder. Additionally, 469 ppm of sodium erythorbate was added to the conventional treatments, and cherry powder (VegStable 515, Florida Food Products, Inc., Eustis, Fla.) was added to achieve 469 ppm of ascorbic acid in the alternative cure treatments. Frankfurters were manufactured at the University of Nebraska–Lincoln Loeffel Meat Laboratory. Beef trim, 25 lb batches, and non-meat ingredients were added to a bowl chopper and emulsified to a final temperature of 65°F. The emulsion was stuffed into 0.94 inch cellulose casings using a vacuum stuffer. Treatments were placed in a single-truck smokehouse cooked/smoked to an internal temperature of 160°F. Products were then removed from the smokehouse and stabilized overnight in a 30°F cooler. The following day frankfurters were removed from the casings, vacuum packaged, and stored covered under refrigeration (30°F) until the appropriate day of analysis. Analysis was performed for external and internal color using CIE L*, a*, and b* (lightness, redness, and yellowness, respectively); pH on day 0, 14, 28, 42, 56, 70, and 84 and water activity on day 0. Data were analyzed using PROC GLIMMIX procedure of SAS (SAS Institute, Inc., Cary, N.C.).

Results

Exterior and Interior Color

The source of ingoing nitrite (sodium nitrite or celery juice powder) had minimal impact on the physical characteristics of all-beef frankfurters (Table 1). External L* ($P = 0.033$) and a* ($P = 0.021$) values were greater for the frankfurters with sodium nitrite than with celery juice powder, meaning the alternatively cured frankfurters were darker and less red than those cured with sodium nitrite. Also, the alternatively cured frankfurters did indicate a more yellow interior color than the traditionally cured frankfurters, likely due to the inclu-

Table 1. Impacts of source and amount of nitrite on physical characteristics of all-beef frankfurters.

		External Color			Internal Color			
Source of Nitrite	pH	L*	a*	b*	L*	a*	b*	Water Activity
P-value	0.818	0.033	0.021	0.387	0.257	0.204	<0.0001	0.219
Sodium nitrite	6.34	53.89^{a}	18.21^{a}	17.84	64.68	14.89	11.23^{b}	0.971
Celery juice Powder	6.33	53.09^{b}	17.21^{b}	17.41	64.43	14.74	11.98^{a}	0.969
		External Color			Internal Color			
Nitrite Concentration[1]	pH	L*	a*	b*	L*	a*	b*	Water Activity
P-value	0.463	0.015	<0.0001	0.721	0.0003	<0.0001	<0.0001	0.447
0 ppm	6.32	52.85^{b}	11.53^{d}	17.66	65.37^{a}	9.07	12.95^{a}	0.972
52 ppm	6.33	54.16^{a}	17.42^{c}	18.06	64.51^{b}	16.15	10.96^{c}	0.970
104 ppm	6.35	54.03^{a}	20.32^{b}	17.27	64.29^{b}	16.63	11.20^{bc}	0.971
156 ppm	6.34	52.91^{b}	21.56^{a}	17.52	64.04^{b}	17.41	11.31^{b}	0.968

$^{a-d}$Means in the same column with lacking common superscripts are significantly different (*P < 0.05*) for the given trait.
[1]Amount of ingoing sodium nitrite or equivalent from celery juice powder.

sion of the celery juice powder and cherry powder ($P < 0.0001$). Nitrite concentration had greater effects on the frankfurters' characteristics. The amount of nitrite had a significant effect ($P = 0.015$) on L* values. Internal color was lighter at 0 ppm ingoing nitrite than all amounts of nitrite ($P = 0.0003$). At the same time, interior color was more yellow at the same concentration (0 ppm) of ingoing nitrite than for all other concentrations ($P < 0.0001$). There was a significant concentration x day interaction for internal a* ($P = 0.031$). The internal a* did not change for 0 ppm frankfurters over time, whereas all other ingoing nitrite concentrations became less red with storage time. Length of storage also had an effect on the physical characteristics of all-beef frankfurters as well. As the dark storage time increased, frankfurters became lighter ($P < 0.0001$) for all treatments and ingoing nitrite concentrations. At the same time, all samples exhibited fading of external color as it became less red, as expected ($P < 0.0001$).

Water Activity and pH

Neither source nor amount ($P \geq 0.219$) of nitrite had a significant effect on day 0 water activity. Likewise, source and amount of nitrite had no effects on pH ($P \geq 0.463$). These findings suggest that although minor changes in color can result, alternative curing methods provide similar cured meat characteristics as using sodium nitrite when equivalent amounts of sodium nitrite are added.

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Effect of Feeding Distillers Grains in Different Phases of Production on the Fatty Acid Profile and Oxidation of Frozen, Cooked Beef Links

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Tommi F. Jones
Gary A. Sullivan[1,2]

Summary

Lipid oxidation of cooked ground beef links made from cattle fed different diets and with different concentrations of added natural antioxidants was compared to evaluate product shelf life. Fatty acid composition was analyzed on raw lean, composite, and fat portions from each shoulder clod. Samples without antioxidants were the most oxidized, with no differences between other antioxidant concentrations throughout frozen storage. An increase in polyunsaturated fatty acids was found in beef when finished on modified distillers grains but did not result in increased oxidation. Therefore, the addition of natural antioxidants was effective at reducing oxidative rancidity regardless of animal diet.

Introduction

As a result of the rapid growth of the ethanol industry, ethanol byproducts have become imperative in cattle diets. Previous research results suggest that cattle fed wet distillers grains (WDGS) have an increase in polyunsaturated fatty acids, which may decrease oxidative stability (*2009 Nebraska Beef Cattle Report,* pp. 107-109 and 110-112). Polyunsaturated fatty acids are fatty acids that contain more than one double bond in their carbon chain. The polyunsaturated fatty acids will more readily undergo free-radical chain reactions resulting in deterioration of the lipid quality. Lipid oxidation and off-flavor development after cooking is accelerated due to the release of iron, free and heme-bound, from myoglobin during cooking (*2014 Nebraska Beef Cattle Report,* pp. 103-104). Lipid oxidation reduces shelf life and decreases overall consumer acceptability of the product by increasing the evidence of "warmed over" or "rancid" flavors. The use of plant extracts, such as rosemary or green tea, is becoming increasingly popular in meat processing as a natural antioxidant to increase shelf life of cooked meat products. This becomes particularly beneficial for companies seeking to clean up labels or use "natural" labeling claims for their product. Therefore, the objective of this study was to evaluate the impact of feeding modified wet distillers grains during different production phases on the fatty acid profiles of beef and on the oxidation of cooked beef links during frozen storage.

Procedure

Cattle were randomly assigned to one of four dietary treatments that included either 2 or 5 lb/head/day (DM basis) of wet distillers grains during the winter backgrounding phase and either Sweet Bran® or modified wet distillers grains (MDGS) during the finishing phase (40% dietary inclusion, DM basis). All cattle were supplemented with MDGS at a rate of 0.6% of BW during the summer months. A total of 16 USDA Choice clods from four carcasses from each dietary treatment group were collected. Composite, subcutaneous fat, and lean sample were collected for fatty acid analysis. Each clod was independently ground and divided into three 5 lb batches. All treatments contained 0.75% salt, 0.25% phosphate and either 0%, 0.13% or 0.20% rosemary plus green tea extract (FORTIUM RGT12 Plus Dry Natural Plant Extract; Kemin, Des Moines, Iowa). Beef and non-meat ingredients were mixed for 1 minute and the mixture was stuffed into skinless links using a piston stuffer. Links were placed in individual foil trays for each clod and cooked in a smokehouse to an internal temperature of 160°F. Links were placed in zip-top bags with the presence of oxygen and placed in dark, frozen storage. Lipid oxidation was evaluated on 0, 28, 56, 84, 112, 140 and 168 days using the thiobarbituric acid reactive substances (TBARS) analysis. Data were analyzed as a 2 X 2 X 3 factorial with repeated measures (day) using the PROC MIXED procedure of SAS for TBARS and a 2 X 2 factorial using the PROC GLIMMIX procedure of SAS for fatty acid analysis.

Results

No significant dietary treatment effects or interactions were observed ($P \geq 0.18$). However, an antioxidant concentration × day interaction ($P < 0.041$) was observed for oxidation (Figure 1). Both 0.13% and 0.20% concentrations of antioxidant were less oxidized than the control for all time periods except day 0 ($P > 0.05$), where the means ranged from 0.34 to 0.41of mg of malonaldehyde/kg of product. The threshold for when lipid oxidation becomes evident to consumers is 1 mg of malonaldehyde/kg of product. As expected, all samples exceeded this threshold by day 28, although the control exceeded the threshold by a larger margin ($P < 0.0001$) than the samples with an antioxidant addition which were near 1 mg through day 56. There were no differences ($P > 0.64$) in lipid oxidation between samples with 0.13 or 0.20% added antioxidants on any day of evaluation. These results sug-

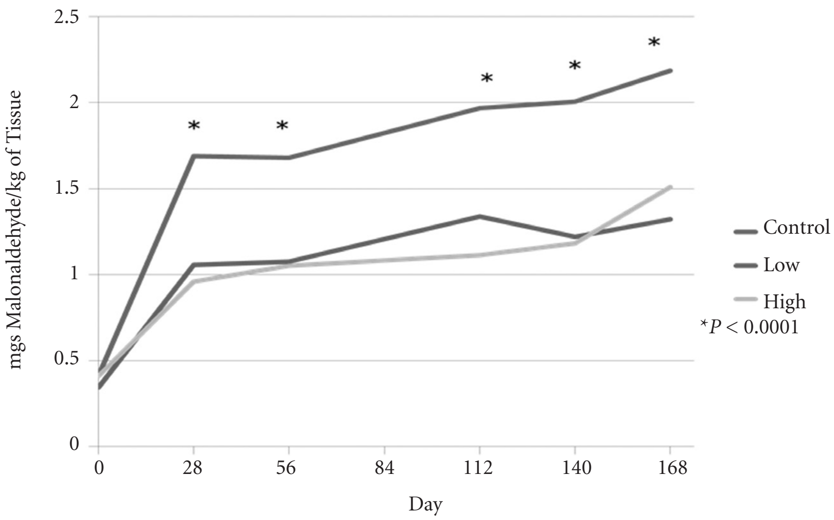

Figure 1. Effect of adding no, low, or high concentrations (0%, 0.13%, 0.2%) natural plant extract on the lipid oxidation (mg of malonalydehyde/ kg of product) in ready-to-eat beef links.

Table 1. Effect of finishing diet on fatty acid composition (g/100g raw sample) of shoulder clod composite sample.

	Finishing Diet		
Fatty Acids	Sweet Bran	Modified Distillers Grains	*P*-value
C16:0 (g/100g)	5372	4770	0.104
C16:1 (g/100g)	598[b]	738[a]	0.043
C17:0 (g/100g)	373[a]	276[b]	0.002
C17:1 (g/100g)	341[b]	236[a]	0.006
C18:0 (g/100g)	3476	3222	0.375
C18:1 (g/100g)	11170	10163	0.183
C18:2 (g/100g)	524[b]	747[a]	0.005
SFA[1] (g/100g)	9894	8914	0.137
PUFA[2] (g/100g)	592[b]	843[a]	0.002
MUFA[3] (g/100g)	12893	11506	0.093

[ab]Means in the same row with different superscripts are significantly different ($P \leq 0.05$).
[1] Saturated Fatty Acids: C14:0, C15:0, C16:0, C17:0, C18:0.
[2] Polyunsaturated Fatty Acids: C18:2, C20:4.
[3] Monounsaturated Fatty Acids: C14:1, C16:1,C17:1, C18:1T, C18:1, C18:1V, C20:1.

gest that the addition of rosemary and green tea extract can suppress lipid oxidation in frozen, cooked beef products.

For the lean, fat, and composite portion fatty acid analysis, a finishing effect was observed where beef from cattle finished on MDGS had greater amounts of C18:2 ($P \leq 0.022$) and total PUFA ($P \leq 0.028$). The composite sample also had a finishing effect where cattle finished on MDGS had greater amounts of C16:1 ($P = 0.043$) and lesser amounts of C17:0 and C17:1 ($P = 0.002$ and 0.006, respectively; Table 1). The fat portion had a backgrounding effect where supplementing with greater amounts of WDGS resulted in a greater amount of UFA, less C18:0, and a lower UFA:SFA ($P = 0.005$, 0.006, and 0.014, respectively) in comparison to lesser amounts of WDGS supplementation. Therefore, feeding MDGS in the finishing phase increases PUFAs in fat, lean, and composite portions of beef.

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[2]This project was funded in part by the Beef Checkoff and the University of Nebraska Agricultural Research Division.

Effect of Feeding Distillers Grains and Supplementing with Dietary Antioxidants on Ground Beef Color During Retail Display

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Summary

Ground beef patties from cattle fed corn-based diets with no wet distillers grains (control), wet distillers grains (WDGS), WDGS + 1000 IU/head/day vitamin E, WDGS + 150 ppm/head/day, Ethoxyquin/TBHQ (Agrado Plus, Novus International, St. Louis, Mo.), or WDGS + 500 IU/head/day vitamin E + 150 ppm/head/day Ethoxyquin/TBHQ during the finishing phase were compared to analyze color stability during retail display. As display time increased, patties from all dietary treatments had greater discoloration and became darker, less red, and more yellow. Therefore, beef patties discolored during retail display, but the rate and degree of discoloration were unaffected by diet or antioxidant supplementation.

Introduction

Each bushel of corn (56 lb) used in dry-mill ethanol production generates about 17.4 lb of distillers grains available for livestock feed (USDA Economic Research Service). This availability provides an economical feed source for cattle. Consequently, cattle fed distillers grains have an increase in polyunsaturated fatty acids, which may decrease oxidative stability (*2009 Nebraska Beef Cattle Report,* pp. 107-109 and 110-112). The polyunsaturated fatty acids are more easily oxidized and allow off-flavors to develop. In addition, beef from cattle fed distillers grains discolors at greater rate due to oxidation of the muscle pigments. Previous research indicates that dietary antioxidants increase the oxidative stability in fresh, whole muscle meat products. The objective of this trial was to evaluate the effects of vitamin E and Ethoxyquin/TBHQ (Agrado Plus, Novus International, St. Louis, Mo.) supplementation on ground beef color from cattle fed distillers grains during the finishing phase.

Procedure

Cattle (n = 100) were randomly assigned to one of five finishing diets: corn based diet with no WDGS (control), wet distillers grains (WDGS), WDGS + 1000 IU/head/day vitamin E, WDGS + 150 ppm/head/day Agrado Plus, or WDGS + 500 IU/head/day vitamin E + 150 ppm/head/day Agrado Plus. At the conclusion of the finishing phase, cattle were harvested at commercial abattoir. Forty-eight hours post-harvest, seven USDA Choice clods from each dietary treatment group were collected from the right side of carcasses, vacuum packaged, and shipped to the University of Nebraska–Lincoln Loeffel Meat Laboratory. On day 14, each clod was independently ground and formed into 4 oz patties using a manual, single-patty press. Two patties from each clod were overwrapped with oxygen permeable PVC film and placed under simulated retail display for seven days at 37°F. During retail display, percent discoloration (%Dis; 5 person panel; 0% = no discoloration to 100% = full discoloration) and objective color (L* a* b*) were evaluated for seven days. The a*/b* ratio, hue angle, and saturation index were then calculated. Data were analyzed by treatment with repeated measures (day) utilizing the PROC MIXED procedures of SAS (SAS Institute, Inc., Cary, N.C.).

Results

There were no dietary treatment effects for any of the color traits measured ($P > 0.39$) suggesting that diet did not affect the retail shelf life of fresh ground beef. This is in contrast to the increased discoloration rate in cattle finished on modified wet distillers grains from a previous study (*2014 Nebraska Beef Cattle Report,* pp. 105-106). As expected, there was a time effect for percent discoloration, L*, a*, b*, a*/b* ratio, hue angle and saturation index ($P < 0.0001$ for all). As retail display time increased, patties from all dietary treatments had greater percent discoloration and became darker, less red, and more yellow. Lower values of a*/b* ratio and saturation and greater values of hue angle are indicators of discoloration, and all were shown over time in the beef patties (Table 1). Regardless of diet, retail display life of beef patties was similar for both instrumental and visual color analysis.

Table 1. Visual and instrumental color of ground beef patties.

	Color Analysis						
Treatment	%Dis	L*	a*	b*	Hue Angle	Saturation Index	a*/b* ratio
Corn	24.66	50.21	17.54	10.37	32.65	20.55	1.66
WDGS	25.37	51.30	16.92	10.41	33.84	20.07	1.60
WDGS+Vit E	25.39	51.14	16.73	10.32	33.90	19.85	1.60
WDGS+Agrado	20.28	50.18	18.11	10.57	31.96	21.12	1.69
WDGS+Vit E+Agrado	20.98	49.73	17.82	10.39	32.12	20.80	1.69

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[2]This project was funded in part by the University of Nebraska Agricultural Research Division.

Statistics Used in the Nebraska Beef Report and Their Purpose

The purpose of beef cattle and beef product research at University of Nebraska–Lincoln is to provide reference information that represents the various populations (cows, calves, heifers, feeders, carcasses, retail products, etc.) of beef production. Obviously, the researcher cannot apply treatments to every member of a population; therefore, he/she must sample the population. The use of statistics allows the researcher and readers of the *Nebraska Beef Report* the opportunity to evaluate separation of random (chance) occurrences and real biological effects of a treatment. Following is a brief description of the major statistics used in the beef report. For a more detailed description of the expectations of authors and parameters used in animal science see *Journal of Animal Science Style and Form* at: *http://jas.fass.org/misc/ifora.shtml*.

— **Mean —** Data for individual experimental units (cows, steers, steaks) exposed to the same treatment are generally averaged and reported in the text, tables and figures. The statistical term representing the average of a group of data points is mean.

— **Variability —** The inconsistency among the individual experimental units used to calculate a mean for the item measured is the variance. For example, if the ADG for *all* the steers used to calculate the mean for a treatment is 3.5 lb then the variance is zero. But, this situation never happens! However, if ADG for individual steers used to calculate the mean for a treatment range from 1.0 lb to 5.0 lb, then the variance is large. The variance may be reported as standard deviation (square root of the variance) or as standard error of the mean. The standard error is the standard deviation of the mean as if we had done repeated samplings of data to calculate multiple means for a given treatment. In most cases treatment means and their measure of variability will be expressed as follows: 3.5 ± 0.15. This would be a mean of 3.5 followed by the standard error of the mean of 0.15. A helpful step combining both the mean and the variability from an experiment to conclude whether the treatment results in a real biological effect is to calculate a 95% confidence interval. This interval would be twice the standard error added to and subtracted from the mean. In the example above, this interval is 3.2-3.8 lb. If in an experiment, these intervals calculated for treatments of interest overlap, the experiment does not provide satisfactory evidence to conclude that treatments effects are different.

— ***P* Value —** Probability (*P* Value) refers to the likelihood the observed differences among treatment means are due to chance. For example, if the author reports $P \leq 0.05$ as the significance level for a test of the differences between treatments as they affect ADG, the reader may conclude there is less than a 5% chance the differences observed between the means are a random occurrence and the treatments do not affect ADG. Hence we conclude that, because this probability of chance occurrence is small, there must be difference between the treatments in their effect on ADG. It is generally accepted among researchers when *P* values are less than or equal to 0.05, observed differences are deemed due to important treatment effects. Authors occasionally conclude that an effect is significant, hence real, if P values are between 0.05 and 0.10. Further, some authors may include a statement indicating there was a "tendency" or "trend" in the data. Authors often use these statements when *P* values are between 0.10 and 0.15, because they are not confident the differences among treatment means are real treatment effects. With *P* values of 0.10 and 0.15 the chance random sampling caused the observed differences is 1 in 10 and 1 in 6.7, respectively.

—**Linear & Quadratic Contrasts** — Some articles contain linear (L) and quadratic (Q) responses to treatments. These parameters are used when the research involves increasing amounts of a factor as treatments. Examples are increasing amounts of a ration ingredient (corn, by-product, or feed additive) or increasing amounts of a nutrient (protein, calcium, or vitamin E). The L and Q contrasts provide information regarding the shape of the response. Linear indicates a straight line response and quadratic indicates a curved response. P-values for these contrasts have the same interpretation as described above.

—**Correlation (r)** — Correlation indicates amount of linear relationship of two measurements. The correlation coefficient can range from B1 to 1. Values near zero indicate a weak relationship, values near 1 indicate a strong positive relationship, and a value of B1 indicates a strong negative relationship.

Animal Science

http://animalscience.unl.edu

Curriculum: The curriculum of the Animal Science Department at the University of Nebraska–Lincoln is designed so that each student can select from a variety of options oriented to specific career goals in professions ranging from animal production to veterinary medicine. With unique opportunities to double major in ***Grazing Livestock Systems*** (*http://gls.unl.edu*) or complete the ***Feedlot Management Internship Program*** (*http://feedlot.unl.edu/intern*)

Careers:

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Education
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Meat Processing
Meat Safety
Quality Assurance
Research and Development
Veterinary Medicine

Scholarships: The Animal Science Department also offers scholarships to incoming freshmen and upperclassmen. The department awards over $30,000 each year to Animal Science students.

ABS Global Scholarship
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