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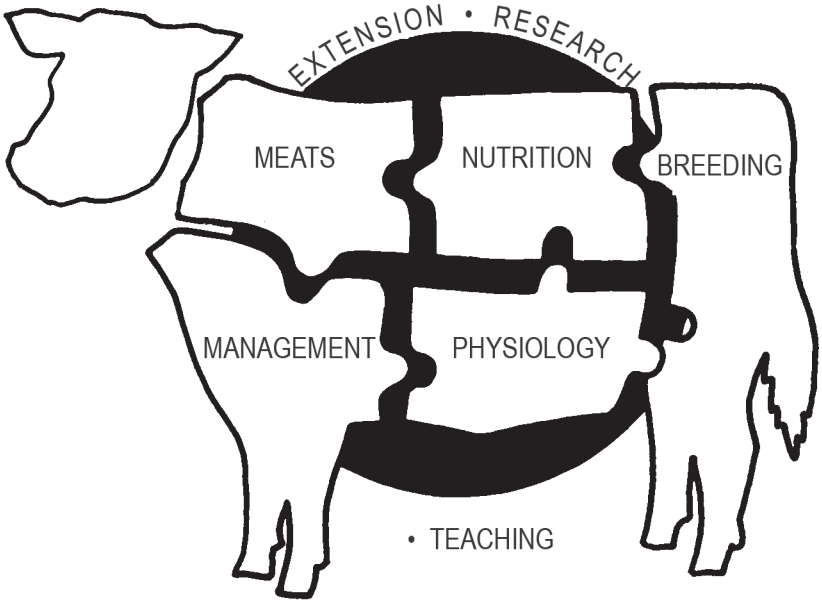

Agricultural Research Division
University of Nebraska Extension
Institute of Agriculture and Natural Resources
University of Nebraska–Lincoln

2017 Beef Cattle Report

University of Nebraska Lincoln

Animal Science
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Effect of Heifer Development System on Reproduction and Subsequent Gain as a Pregnant Heifer

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Hazy R. Nielson
T. L. Meyer
Mike Kirby
Jim Teichert
Rick N. Funston

Summary with Implications

Weaned heifers grazed corn residue, upland range, or were fed 1 of 2 drylot diets differing in energy. Heifer development diets did not impact their resulting AI or final pregnancy rates. Cost per pregnant heifer was similar among treatments. A subset of AI-pregnant heifers was placed in a Calan Broadbent individual feeding system during late gestation. As a pregnant heifer, feed efficiency was not impacted by development system. These results indicate producers may utilize their most readily available and/or cost-effective feed resources with no detriment to pregnancy rates or feed efficiency as first-calf heifers.

Introduction

Retaining and developing replacement heifers presents one of the largest expenses to the cow-calf producer. Developing heifers to a lower target BW than previously recommended has been shown to reduce costs, without reducing pregnancy rate. Previous research comparing corn residue and drylot systems has found heifers in the drylot gained more during the development period than heifers grazing corn residue (2013 Nebraska Beef Report, pp. 5–7). However, heifers developed on corn residue experienced increased post-AI ADG while on summer range compared with heifers developed in confinement, possibly due to compensatory gain or retained learned grazing behavior. Greater effort has been made to select heifers with higher feed-efficiency. However, selecting for greater efficiency may decrease DMI in the mature cow. Understanding the long term effects of heifer development on cow efficiency will allow producers to make better management decisions. Whether a difference lies in behavioral effects, or previous diet quality, mature cow intake as a result of development systems, have the potential to impact beef producers' profitability. Therefore, objectives of the current study were to determine if post-weaning heifer development system affected ADG, pregnancy rates, and subsequent feed efficiency as a pregnant heifer.

Procedure

Post-Weaning Development

A 4-yr study conducted at the West Central Research and Extension Center (WCREC), North Platte, NE utilized Angus-based crossbred, spring born heifers. In Yr 1, weaned heifers grazed corn residue (CR, n = 50) or were fed in a drylot (DLHI, n = 50). In Yr 2, 3, and 4, heifers grazed CR (n = 75), upland range (RANGE; n = 75), or were fed 1 of 2 drylot diets (Table 1) differing in energy, high (DLHI, n = 75) or low (DLLO, n = 75). Heifers developed on CR (n = 125) grazed corn residue from mid-November through mid-February and then grazed winter range until estrus synchronization. RANGE heifers (n = 75) grazed winter range from mid-November until estrus synchronization. While grazing corn residue or winter range, heifers received the equivalent of 1 $lb \cdot hd^{-1} \cdot d^{-1}$ of a 29% CP, dried distillers grain-based supplement containing monensin, with hay provided in times of deep snow. All heifers were managed together in a drylot during estrus synchronization and AI.

Prior to estrus synchronization, 2 blood samples were collected 10 d apart to determine plasma progesterone concentration. Heifers with greater than 1 ng/mL at either collection were considered pubertal. Heifers were synchronized using the melengestrol acetate-prostaglandin $F_{2\alpha}$ (MGA-PG) protocol. Heat detection aids (Estrotect, Rockway Inc., Spring Valley, WI) were applied at PG injection (Lutalyse, Zoetis, Florham Park, NJ). Heifers in standing estrus were AI 12 h later. Heifers not expressing estrus received a PG injection 6 d following the first PG injection and placed with bulls. Remaining heifers were combined with the non-AI heifers and bulls 10 d following AI on range at a 1:50 bull to heifer ratio for 60 d. Pregnancy diagnosis was conducted via transrectal ultrasonography (ReproScan, Beaverton, OR) 45 d following AI. Forty-five d after bull removal a second pregnancy diagnosis determined final pregnancy rate.

Pregnant Heifer Feed Efficiency

In mid-October, following final pregnancy diagnosis, a subset of AI-pregnant heifers from each treatment (RANGE, n = 36; CR, n = 46; DLHI, n = 48; DLLO, n = 23) were placed in a Calan Broadbent individual feeding system. Heifers were allowed a 20 d acclimation period before beginning a 90 d trial at approximately gestational d 170. Heifers were offered ad libitum hay (7.9% CP); individual amounts offered were recorded daily and orts collected weekly.

Table 1. Drylot diet composition (DM basis) offered to replacement heifers

Ingredient, %	DLHI[1]	DLLO[2]
Hay	74	83
Wet CGF	21	12
Heifer supplement[3]	5	5

[1] DLHI = heifers in Yr 1, 2, 3, and 4 received a high-energy diet in the drylot for 170 d.
[2] DLLO = heifers in Yr 2, 3, and 4 received a low-energy diet in the drylot for 170 d.
[3] Supplement = dry rolled corn (81.35% of supplement, DM basis), limestone (11.11%), iodized salt (5.55%), trace mix (1.39%), Rumensin-90 (0.37%), and Vitamins A-D-E (0.22%).

Table 2. Effect of development system on heifer gain and reproductive performance

Item	RANGE[1]	CR[2]	DLHI[3]	DLLO[4]	SEM	*P*-value
n	75	125	125	75		
Initial BW, lb	516	520	518	516	11	0.88
Post-development BW[5], lb	664[b]	659[b]	763[a]	708[a,b]	18	< 0.01
Development ADG, lb	0.97[b]	0.86[b]	1.57[a]	1.26[a,b]	0.11	0.01
Pre-breeding BW, lb	714[b]	725[b]	820[a]	765[a,b]	20	0.01
Percent of mature, %	59[b]	60[b]	67[a]	63[a,b]	2	0.01
Pubertal status, %	28	41	86	77	10	0.20
Synchronization ADG, lb	1.57	1.79	1.52	1.72	0.24	0.20
AI pregnancy diagnosis BW, lb	802[b]	818[b]	873[a]	829[a,b]	13	0.02
Final pregnancy diagnosis BW, lb	941	941	985	952	24	0.13
Breeding ADG[6], lb	1.68[a,b]	1.76[a]	1.01[c]	1.26[b,c]	0.22	< 0.01
AI pregnancy, %	67	63	61	49	7	0.39
Final pregnancy, %	84	90	91	91	5	0.59
Calved in first 21 d, %	81[a]	69[ab]	70[ab]	53[b]	12	0.02

[1] RANGE = heifers were offered the equivalent of 0.99 lb · hd^{-1} · d^{-1} while grazing winter range for 170 d before entering the drylot for estrus synchronization and AI.
[2] CR = heifers were offered the equivalent of 0.99 lb · hd^{-1} · d^{-1} while grazing corn residue for 90 d and winter range for 80 d before entering the drylot for estrus synchronization and AI.
[3] DLHI = heifers were developed in the drylot for 170 d and through estrus synchronization and AI on a high-energy diet.
[4] DLLO = in Yr 2, 3, and 4 heifers received a low-energy diet in the drylot for 170 d through estrus synchronization and AI.
[5] BW at the time of blood collection.
[6] ADG in the period between prebreeding and first pregnancy diagnosis.
[a,b,c] Means in a row with different superscripts are different ($P \leq 0.05$).

Table 3. Effects of heifer development system on pregnant heifer feed efficiency

Item	RANGE[1]	CR[2]	DLHI[3]	DLLO[4]	SEM	*P*-value
n	36	46	48	23		
Initial BW, lb	994	1,008	1,041	1,023	22	0.35
Mid BW, lb	1,032	1,052	1,085	1,063	20	0.25
Final BW, lb	1,076	1,096	1,127	1,107	31	0.24
DMI, lb	21.47	21.98	22.44	22.05	1.68	0.27
ADG, lb	0.84	0.99	0.95	0.90	0.37	0.36
RFI[5]	0.094	0.091	-0.056	-0.074	0.160	0.61
F:G	21.4	18.2	21.1	21.3	4.8	0.38

[1] RANGE = heifers were offered the equivalent of 0.99 lb · hd^{-1} · d^{-1} while grazing winter range for 170 d before entering the drylot for estrus synchronization and AI.
[2] CR = heifers were offered the equivalent of 0.99 lb · hd^{-1} · d^{-1} while grazing corn residue for 90 d and winter range for 80 d before entering the drylot for estrus synchronization and AI.
[3] DLHI = heifers were developed in the drylot for 170 d and through estrus synchronization and AI on a high-energy diet.
[4] DLLO = heifers received a low-energy diet in the drylot for 170 d through estrus synchronization and AI.
[5] RFI = Residual Feed Intake

Economic Analysis

Due to price fluctuations during the experiment (2010–2014), an average 5 yr price was used for economic analysis. Heifer value was obtained for the wk heifers were received. Pasture values were calculated as half the cost of a cow-calf pair in the Southwest region of Nebraska and obtained from the Nebraska Farm Real Estate Market Highlights. Wet corn gluten prices were obtained from the USDA-AMS for the third wk in September using Kansas City values. Hay prices were obtained for the third wk of September in the Platte Valley from the Nebraska and Iowa Hay report. Actual supplement costs, both drylot and cube, were used. Other expenses included interest (6.5% of heifer value), vaccine, yardage, trucking for CR heifers, breeding expenses, and other miscellaneous expenses. Cull values of non-pregnant heifers were obtained for the wk of final pregnancy diagnosis. The value of one, non-pregnant heifer was divided by 1 minus pregnancy rate to determine the value of cull heifers per pregnant heifer. This value was subtracted from the total development cost. Finally, the adjusted development cost was divided by pregnancy rate to determine the net cost of one pregnant heifer.

Statistical Analysis

Treatments were the specific heifer development system where CR and DLHI were replicated for 4 yr and RANGE and DLLO were replicated for 3 yr. Treatment group within year was considered the experimental unit, with development treatment fitted as a fixed effect. Data were analyzed using the GLIMMIX procedure of SAS (SAS Inst. Inc., Cary NC). Pregnancy analyses included AI technician as a random effect. Pregnant heifer feed efficiency analyses included pen as a random effect. A *P*-value ≤ 0.05 was considered significant.

Results

Post Weaning Development Treatment

Heifers had a similar initial BW ($P = 0.88$, 518 ± 11 lb, Table 2). During development, ADG was greater ($P = 0.01$) for DLHI heifers (1.57 ± 0.11 lb/d) compared with RANGE and CR (0.97 and 0.86 ± 0.11 lb/d, respectively). Differences in ADG resulted

in a similar trend in post-treatment BW; DLHI heifers were heavier than RANGE and CR heifers ($P < 0.01$) but similar to DLLO heifers. At pre-breeding, percent of mature BW was greater ($P = 0.01$) for DLHI heifers compared with RANGE and CR heifers. Many measures were similar among treatments ($P \leq 0.20$), including pubertal status prior to synchronization, ADG from AI to first pregnancy diagnosis, AI pregnancy rate and final pregnancy rate. Body weight at the first pregnancy diagnosis was greatest ($P = 0.02$) for DLHI heifers compared with other treatments. The proportion of heifers that calved within the first 21 d was greater for RANGE heifers compared with DLLO heifers ($P = 0.02$).

Pregnant Heifer Feed Efficiency

In the feed efficiency trial (Table 3), initial and final BW were similar ($P > 0.24$). Both DMI ($P = 0.27$) and residual feed intake (RFI; $P = 0.61$) did not differ between treatments. There was no difference ($P \geq 0.33$) in ADG or F:G. Recent emphasis on genetic selection for feed efficient cattle to optimize feedlot profit has led to the idea of increased feed efficiency in the cow herd. This may cut feed costs, but reproductive performance could be compromised. Some research has found heifers selected for high feed efficiency had lower pregnancy ($P = 0.09$) and calving ($P = 0.05$) rates than low efficiency contemporaries. In the current study, development treatment did not impact feed efficiency as a pregnant first calf heifer. Future studies investigating how heifer development system impacts lifetime feed efficiency are needed.

Economic Analysis

Heifers began development with the same value and receiving diet expense. Diet cost was different ($P < 0.01$) among treatments with the exception of RANGE and CR, which had similar ($P = 0.56$) treatment costs. The most expensive diet, DLHI, and the mean of the 2 least expensive diets, RANGE and CR, indicated a $41 difference. Summer pasture and additional expenses were similar across treatments. Due to numerical differences in pregnancy rates and BW at pregnancy diagnosis, cull heifer value was different ($P < 0.01$) among treatments where RANGE heifers, with the numerically lowest pregnancy rate, had the greatest cull heifer value. These data differ from previous studies that reported similar cull heifer value on intensive and extensive heifer development (2010 Nebraska Beef Report, pp. 8–10). Numerically higher final pregnancy rates resulted in lower cull value for DLHI and DLLO heifers. Net cost per pregnant heifer was similar ($P = 0.99$) among treatments using 5 yr average prices. This contradicts previously reported data suggesting extensive development reduced ($P = 0.01$) cost by $45 per pregnant heifer (2010 Nebraska Beef Report, pp. 8–10). Differences may be due to the extreme price fluctuation in the years this experiment was conducted.

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Table 4. Economic analysis (5 yr avg, 2010 to 2014) of heifer development systems

Item	RANGE[1]	CR[2]	DLHI[3]	DLLO[4]	SEM	*P*-value
Heifer value, $/heifer	876	876	877	877	138	1.00
Feed cost:						
Receiving diet,[5] $/heifer	32	32	32	32	3.43	1.00
Treatment diet, $/heifer	113[a]	109[a]	152[b]	137[c]	4.87	< 0.01
Summer pasture,[6] $/heifer	68	68	68	68	3.69	1.00
Other expenses,[7] $/heifer	311	319	311	311	8.96	0.91
Total development cost	1,401	1,404	1,440	1,425	152	0.99
Less: cull heifer value	228[a]	127[b]	100[b,c]	69[c]	19	< 0.01
Net cost	1,173	1,277	1,340	1,356	137	0.77
Net cost per pregnant heifer, $	1,420	1,413	1,447	1,432	150	1.00

[1] RANGE = heifers were offered the equivalent of 0.99 lb · hd^{-1} · d^{-1} while grazing winter range for 170 d before entering the drylot for estrus synchronization and AI.
[2] CR = heifers were offered the equivalent of 0.99 lb · hd^{-1} · d^{-1} while grazing corn residue for 90 d and winter range for 80 d before entering the drylot for estrus synchronization and AI.
[3] DLHI = heifers were developed in the drylot for 170 d and through estrus synchronization and AI on a high-energy diet.
[4] DLLO = heifers received a low-energy diet in the drylot for 170 d through estrus synchronization and AI.
[5] Heifers received a common receiving diet for 30 d prior to the initiation of the treatments.
[6] Summer pasture was calculated as half the cost of a cow-calf pair.
[7] Other expenses included breeding expense, interest (6.5% of heifer value), yardage, trucking for heifers on CR, vaccinations and other miscellaneous health expenses.
[a,b,c] Means in a row with different superscripts are different ($P \leq 0.05$).

Impact of Heifer Development System in Two Different Breeding Seasons

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Summary with Implications

Replacement heifers from March and May calving herds were offered ad libitum meadow hay and 4 lb/d supplement or grazed meadow and offered 1 lb/d supplement from mid-January to mid-April. Heifers fed hay gained more during the treatment; however, heifers grazing meadow experienced compensatory gain, resulting in similar body weight at pregnancy diagnosis in both calving herds. Pregnancy rates were similar between treatment groups in March and May heifers. A reduced input winter management system is a viable option to maintain pregnancy rates in early and late summer breeding seasons.

Introduction

Traditional recommendations suggest heifers reach 55 to 65% of mature body weight (BW) at the time of breeding. Due to the cost of retaining replacement heifers, more efforts have been made to devise economical methods of developing heifers. Previous studies have indicated heifers developed to lower target BW have comparable reproductive performance to heifers developed in higher input systems. Furthermore, it has been reported heifers fed to 51% vs. 57% mature BW showed no difference in puberty attainment. However, heifers developed on corn residue had a reduced percentage that reached puberty compared with winter range or drylot developed heifers. Therefore, the objective of the current study was to determine the impact of heifer development system on subsequent growth and reproductive performance in early and late summer breeding seasons.

Procedure

A 4-yr study was conducted at the Gudmundsen Sandhills Laboratory (GSL), Whitman, NE, that utilized replacement heifers from 2 calving seasons. March-born (n = 225) and May-born (n = 258), crossbred (5/8 Red Angus, 3/8 Continental) heifers were stratified by BW and randomly assigned to 1 of 2 post-weaning nutritional treatments (2 pastures·treatment^{-1}·year^{-1}) from mid-January to mid-April. Heifers were offered ad libitum meadow hay (HAY) and 4 lb/d (29% CP, DM) supplement or allowed to graze meadow (MDW) and offered 1 lb/d of the same supplement. Prior to and following treatment, heifers were managed together within their respective breeding group. Prior to each breeding season, 2 blood samples were collected 10 d apart to determine pubertal status. Heifers with plasma progesterone concentrations greater than 1 ng/mL at either collection were considered pubertal. Heifers were synchronized with a single $PGF_{2\alpha}$ injection 5 d after being placed with bulls for a 45 d breeding season. Pregnancy diagnosis was conducted via transrectal ultrasonography 40 d following bull removal.

Statistical Analysis

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.

Results

March-born Gain and Reproductive Performance

March-born HAY heifers had greater (P = 0.01) ADG during the treatment period than MDW heifers (Table 1). However, following treatment, MDW heifers tended (P = 0.07) to have a greater ADG compared with HAY heifers. Summer ADG (May 22 to Sept. 10) was similar (P = 0.12) between treatments. Significant year effects are noted on summer ADG among heifers developed in 2012 compared with other development years, presumably due to the severe drought. Post-treatment and prebreeding BW was greater (P = 0.02) for HAY heifers. At pregnancy diagnosis, HAY heifers tended (P = 0.06) to have greater BW compared with MDW heifers. Percent of mature BW prior to the breeding season was greater (P = 0.02) for HAY compared with MDW. Pubertal status prior to breeding was not different (P = 0.51) between treatments. Furthermore, pregnancy rates were similar for HAY and MDW heifers (P = 0.97, 88 ± 4%). Calving rate and the proportion of heifers that calved within the first 21 d was also similar ($P \geq 0.54$) between treatments.

May-born Gain and Reproductive Performance

Data for BW gain and reproductive performance on May-born heifers are presented in Table 2. Similar to March-born heifers, May-born heifers on HAY had greater (P = 0.01) ADG during the treatment period. Spring and summer ADG was greater (P = 0.03) for MDW heifers, due to a compensatory gain effect. Post-treatment and pre-breeding BW was greater (P = 0.02) for HAY heifers compared with MDW heifers. At pregnancy diagnosis, BW was similar (P = 0.16) between treatments. Percent of mature BW prior to the breeding season was greater (P = 0.02) for

Table 1. Effect of over-winter treatment on developing March-born heifer gain and reproductive performance

	Development Year						Treatment			
Item	2012	2013	2014	2015	SEM	*P*-value	Hay[1]	MDW[2]	SEM	*P*-value
n	50	50	101	24			113	112		
ADG										
Treatment ADG,[3] lb/d	1.37	1.43	1.57	1.28	0.11	0.42	1.70	1.12	0.07	0.01
Spring ADG,[4] lb/d	2.03^{x}	0.66^{xy}	0.33^{y}	0.31^{y}	0.31	0.06	0.46	1.21	0.20	0.07
Summer ADG,[5] lb/d	0.60^{b}	1.37^{a}	1.23^{a}	1.48^{a}	0.06	<0.01	1.12	1.21	0.03	0.12
Body Weight										
Weaning BW, lb	425^{b}	412^{b}	467^{a}	463^{ab}	9	0.01	443	441	4	0.86
Post-treatment BW, lb	644^{yz}	639^{z}	697^{x}	648^{xz}	13	0.07	683	631	8	0.02
Pre-breeding BW,[6] lb	701^{ab}	664^{b}	712^{a}	677^{ab}	11	0.049	705	672	7	0.02
Percent of Mature BW,[7] %	57^{ab}	54^{b}	58^{a}	55^{ab}	1	0.049	58	55	1	0.02
Pregnancy Diagnosis BW, lb	767^{b}	816^{ab}	847^{a}	851^{a}	12	0.02	831	809	6	0.06
Pubertal,[8] %	66^{a}	30^{b}	68^{a}	54^{ab}	7	<0.01	53	57	5	0.51
Pregnancy Rate, %	92	82	84	96	7	0.21	88	88	4	0.97
Calving rate, %	90	80	82	—	6	0.36	86	83	4	0.54
Calved in first 21 d, %	80	75	78	—	7	0.83	78	78	5	0.98

[1]HAY = heifers received ad libitum hay and 4 lb/d supplement from Jan. 15 to April 15.
[2]MDW = heifers grazed meadow and received 1 lb/d supplement from Jan. 15 to April 15.
[3]Treatment ADG from Jan. 16 to April 22 (96 d), includes the treatment period.
[4]Spring ADG from April 22 to May 22 (30 d).
[5]Summer ADG from May 22 to Sept 10 (111 d).
[6]Pre-breeding 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.
[a,b,c] For Development Year, means in a row with different superscripts are different ($P \leq 0.05$).
[x,yz] For Development Year, means in a row with different superscripts are different ($0.05 \leq P < 0.1$).

Table 2. Effect of over-winter treatment on developing May-born heifer gain and reproductive performance

	Development Year						Treatment			
Item	2012	2013	2014	2015	SEM	*P*-value	HAY[1]	MDW[2]	SEM	*P*-value
n	66	65	68	59			128	130		
ADG										
Treatment ADG,[3] lb/d	1.17^{xz}	0.86^{yz}	1.10^{xz}	1.41^{x}	0.09	0.09	1.39	0.86	0.07	0.01
Spring ADG,[4] lb/d	1.92^{b}	2.43^{a}	2.56^{a}	1.90^{b}	0.07	0.01	2.07	2.34	0.04	0.03
Summer ADG,[5] lb/d	0.68^{c}	0.84^{c}	1.76^{a}	1.34^{b}	0.07	<0.01	1.06	1.26	0.04	0.03
Body Weight										
Weaning BW, lb	434^{x}	434^{x}	406^{xy}	397^{y}	11	0.05	417	419	4	0.90
Post-Treatment BW, lb	580	522	527	540	13	0.13	575	514	9	0.02
Pre-breeding BW,[6] lb	697	672	686	666	11	0.32	703	657	7	0.02
Percent Mature BW,[7] %	57	55	56	55	1	0.32	58	54	1	0.02
Pregnancy Diagnosis BW, lb	765^{b}	772^{ab}	866^{a}	787^{ab}	13	0.05	811	785	11	0.16
Pubertal,[8] %	78^{a}	37^{b}	96^{a}	54^{b}	5	<0.01	72	60	4	0.02
Pregnancy Rate, %	71	62	70	76	6	0.38	72	68	4	0.44
Calving Rate, %	68	57	67	—	6	0.35	65	63	5	0.77
Calved in 1st 21 d, %	75	74	60	—	8	0.27	60	78	6	0.03

[1]HAY = heifers received ad libitum hay and 4 lb/d supplement from Jan. 15 to April 15.
[2]MDW = heifers grazed meadow and received 1 lb/d supplement from Jan. 15 to April 15.
[3]Treatment ADG from Jan. 5 to May 10 (125 d), includes the treatment period.
[4]Spring ADG from May 10 to July 9 (30 d).
[5]Summer ADG from July 9 to Sept 10 (63 d).
[6]Pre-breeding BW determined July 9.
[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] For Development Year, means in a row with different superscripts are different ($P \leq 0.05$).
[x,yz] For Development Year, means in a row with different superscripts are different ($0.05 \leq P < 0.1$).

HAY (58%) compared with MDW (54%). May-born heifers on HAY had greater (P = 0.02) pubertal status prior to breeding than MDW. Significant development year effects are noted for spring and summer ADG due to the severe drought year in 2012. Pregnancy and calving rates were similar ($P \geq 0.44$) between treatments, although, the proportion of heifers that calved in the first 21 d was greater ($P = 0.03$) for MDW compared with HAY.

Heifer development system did not impact pregnancy rate in the March or May replacement heifers; however, March heifer pregnancy rate was greater ($P < 0.01$) than in May (87 vs. 70 ± 3%). The lower pregnancy rate in May heifers may be due to declining forage quality and quantity during the breeding season.

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Timed Insemination vs. Modified Estrus Detection in Beef Heifers

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Summary with Implications

The objective of this study was to compare a modified estrus detection and fixed time AI vs. no estrus detection and fixed time AI on subsequent pregnancy rates. Yearling heifers were estrus synchronized and AI at 72 ± 2 h after prostaglandin injection. In one group estrus was not detected and all heifers received gonadotropin releasing hormone at the fixed-time AI; in the other group estrus was detected at 58 ± 2 and 70 ± 2 h after prostaglandin and inseminated in the following order at 72 ± 2 h: heifers in estrus at 58 h, heifers in estrus at 70 h, and heifers not appearing in estrus at either observation. Similar AI conception and final pregnancy rates were achieved without the added labor of estrus detection.

Introduction

Artificial insemination (AI) allows producers to utilize superior genetics for less cost than purchasing a herd sire of similar quality. Using AI can decrease the chance for dystocia by using high accuracy calving ease sires. Additionally, estrus synchronization can shorten the calving season, increase calf uniformity (2010 Nebraska Beef Report, pp. 13–15), and facilitate the use of AI.

Estrus synchronization and AI require planning and additional time and labor. Fixed-time AI (**FTAI**) protocols eliminate estrus detection and reduce the number of times cattle are handled, but may result in lower conception rates than protocols involving estrus detection (2016 Nebraska Beef Report, pp. 17–18). Melengestrol acetate (**MGA**) is an alternative progestin commonly used to synchronize estrus in beef heifers and has proven to be as effective as controlled internal drug release (**CIDR**) device in fixed-time AI protocols (2014 Nebraska Beef Report, pp. 8–10). The objective of this study was to compare pregnancy rates using modified estrus detection and FTAI vs. no estrus detection and FTAI utilizing a MGA-prostaglandin F2α (**PG**) synchronization protocol.

Procedure

Yearling, Angus-based crossbred heifers (n = 971, 761 ± 31 lb) were managed in 3 groups at the Kelly Ranch near Sutherland, NE. During the development period, heifers were fed to achieve 60% mature BW at breeding.

Heifers in Group 1 (n = 297) were managed in 3 drylot pens and offered a diet consisting of wet distillers grains (**WDG**), grass hay, corn silage (**CS**), and a pellet to balance for minerals. Heifers in Group 2 (n = 317) grazed dormant meadow and were offered supplement containing WDG, CS, and a balancer pellet. In early February, heifers in Group 2 were moved to 2 drylot pens and offered a diet containing WDG, grass hay, CS, and balancer pellet. Heifers in Group 3 (n = 357) were managed in 5 drylot pens and offered a diet comprised of WDG, mixed hay (50, 25, and 25% alfalfa, grass, and millet hay, respectively), CS, and liquid finisher supplement.

All heifers were synchronized using a MGA-PG protocol. From d 1 through d 14 each heifer was offered 0.5 mg/d MGA (Zoetis, Florham Park, NJ) pellets included in their diet. On d 33, heifers received a

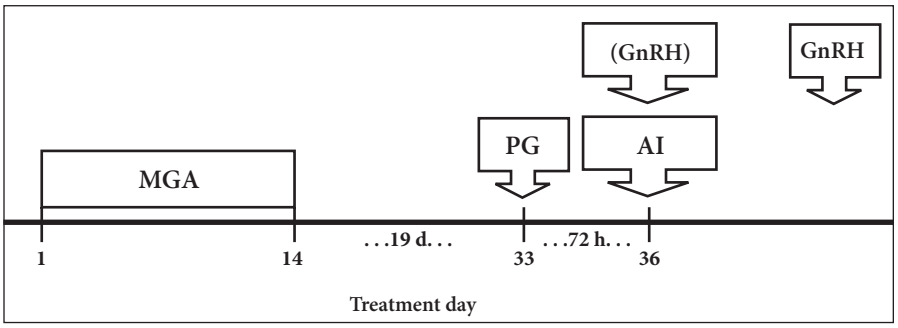

Figure 1. Melengestrol acetate-prostaglandin $F_{2\alpha}$ (MGA-PG) estrus synchronization and fixed time AI protocol

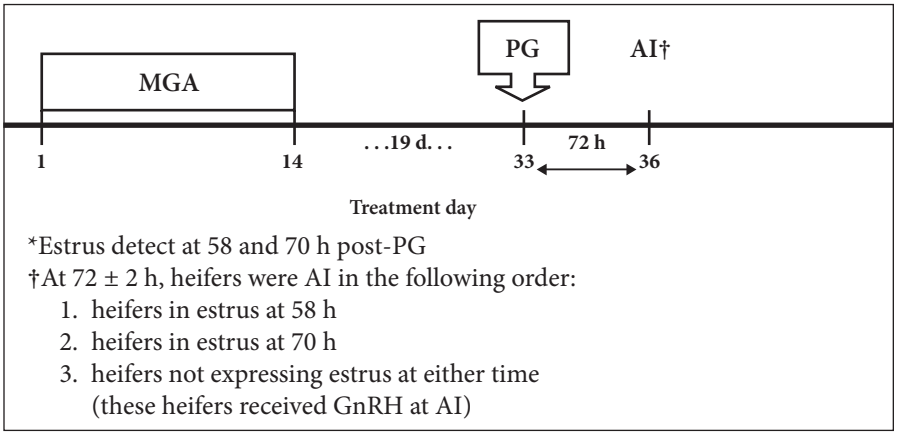

Figure 2. Modified melengestrol acetate-prostaglandin $F_{2\alpha}$ (MGA-PG) estrus synchronization and AI protocol

Table 1. Comparison of FTAI[1] or MTAI[2] protocols on heifer performance

Item	FTAI	MTAI	SEM	*P*-Value
n	486	485		
Pre-breeding BW, lb	763	758	31	0.87
Pregnancy test BW, lb	807	814	15	0.27
ADG[3], lb	0.88	0.66	0.11	0.59
Percent mature BW[4], %	62	63	5	0.86
AI pregnancy rate, %	62	62	5	0.49
Final pregnancy rate, %	96	97	3	0.98

[1] Synchronized using melengestrol acetate-prostaglandin $F_{2\alpha}$ (MGA-PG) protocol. Approximately 72 ± 2 h after PG heifers received GnRH and AI.
[2] Synchronized using MGA-PG protocol. Heifers were detected for estrus at 58 ± 2 and 70 ± 2 h post PG. At 72 ± 2 h after PG, heifers were AI in the following order: heifers in estrus 58 h post-PG, heifers in estrus 70 h post-PG, and heifers not expressing estrus, which received GnRH at AI.
[3]ADG from pre-breeding to pregnancy diagnosis.
[4] Based on 1,220 lb mature BW.

Table 2. Effect of estrus status (patch score[1]) at AI on heifer pregnancy rates in heifers on a FTAI[2] or MTAI[3] protocol

	FTAI				MTAI					
Patch score	*1*	*2*	*3*	*4*	*1*	*2*	*3*	*4*	SEM	*P*-Value
n	44	144	283	15	44	110	326	5		
AI pregnancy rate, %	42[b]	48[b]	71[a]	40[b]	52[b]	53[b]	66[a]	55[b]	8	< 0.05
Final pregnancy rate, %	96	96	97	86	93	90	95	99	3	0.97

[1] Reflected the percentage of rub-off coating removed from the estrus detection aid, or patch: patch score 1 = not rubbed, 2 = ≤ 50% rubbed, 3 = ≥ 50% rubbed, and 4 = missing.
[2] Synchronized using melengestrol acetate-prostaglandin $F_{2\alpha}$ (MGA-PG) protocol. Approximately 72 ± 2 h after PG heifers received GnRH and AI.
[3] Synchronized using MGA-PG protocol. Heifers were detected for estrus at 58 ± 2 and 70 ± 2 h post PG. At 72 ± 2 h after PG, heifers were AI in the following order: heifers in estrus 58 h post-PG, heifers in estrus 70 h post-PG, and heifers not expressing estrus, which received GnRH at AI.
[a,b] Means in a row with differing superscripts differ ($P < 0.05$).

5 mL i.m. PG (Lutalyse, Zoetis, Florham Park, NJ) injection. At PG injection, estrus detection aids, or patches, were applied (Estrotect, Rockway Inc, Spring Valley, WI). At AI, a patch score was recorded for each heifer to indicate estrus status. The score reflected the percentage of rub-off coating removed from the patch. A patch score 1 meant a patch had no rub-off coating removed, a score of 2 described a patch with < 50% of the coating removed, a patch score 3 represented a patch with ≥ 50% of the coating removed, and a patch score of 4 reflected a missing patch. Heifers receiving a patch score of 3 were considered to have expressed estrus.

At 72 ± 2 h after PG, all FTAI heifers (Figure 1) received 2 mL GnRH (Fertagyl, Intervet/Merck Animal Health, Madison, NJ) i.m. injection and were AI. Heifers in the modified-time AI (**MTAI**, Figure 2) treatment were detected for estrus at 58 ± 2 and 70 ± 2 h after PG. Heifers expressing estrus were penned separately. Approximately 72 ± 2 h after PG, MTAI heifers were AI in the following order: heifers in estrus at 58 h post-PG, heifers in estrus at 70 h post-PG, and heifers not expressing estrus at either observation. Heifers not expressing estrus in at either detection time (58 and 70 h post-PG) received GnRH at AI. Thirteen days following AI, bulls were placed with heifers at a bull to heifer ratio of 1:50 for a 42 d breeding season. A minimum of 51 d after AI, BW was measured and pregnancy was detected via transrectal ultrasonography (Aloka, Hitachi Aloka Medical America Inc., Wallingford, CT). Heifers not pregnant by AI were diagnosed for pregnancy again 45 d following bull removal.

Statistical Analysis

All data were analyzed using the GLIMMIX procedure of SAS (SAS Institute, Inc., Cary, N.C.) accounting for group, pen, treatment, and treatment × group interaction. Origin, group, and AI technician were included as random variables. Pregnancy rate was analyzed using an odds ratio. Least square means and SE of the proportion of pregnant heifers by treatment were obtained using the ILINK function.

Results

Pre-breeding BW was similar ($P = 0.48$) between FTAI and MTAI heifers (763 and 758 ± 31 lb, respectively; Table 1). Furthermore, BW was similar ($P = 0.26$) at first pregnancy diagnosis (807 and 814 ± 15 lb; FTAI and MTAI, respectively). Heifers from both groups reached a similar ($P = 0.86$) percentage mature BW (62 ± 5%, based on 1,220 lb mature BW) prior to breeding. The AI conception rate was also similar (62 ± 5%, $P = 0.49$) for both treatments.

Conception rates by patch score are shown in Table 2. Heifers exhibiting an activated patch (score 3) had greater ($P < 0.01$; 71 and 66 ± 5% for FTAI and MTAI, respectively) AI conception rate in both FTAI and MTAI treatments vs. 47 and 53 ± 9 % AI conception rates in non-estrus heifers (score 1, 2, and 4) for FTAI and MTAI, respectively.

At first estrus detection (58 ± 2 h) 132 heifers exhibited a patch score of 3 (66 ± 5% conception rate), at second estrus detection (70 ± 2 h) 156 heifers exhibited a patch score 3 (66 ± 5% conception rate), and at AI, 38 additional heifers exhibited a patch score 3 for MTAI protocol (68 ± 5% conception rate). Estrus activity at AI did not influence final pregnancy rates (96 and 97 ± 3% for FTAI vs. MTAI, respectively; $P = 0.97$).

Conclusion

Reproductive technologies such as estrus synchronization and AI have limited adoption in the beef industry, partially due to added labor. Protocols that limit labor and cattle processing have a greater potential of being adopted. The present study provided a synchronization and AI protocol that limits cattle handling and eliminates estrus detection without compromising conception rates.

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Growth and Reproductive Performance of Yearling Beef Heifers Implanted with Revalor G in the Nebraska Sandhills

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Summary with Implications

This study evaluated effects of a single stocker implant (Revalor G) on growth and reproductive performance of yearling beef heifers in the Nebraska Sandhills. Crossbred heifers, grazing native Sandhills range, were randomly assigned to either be implanted 82 ± 2 days prior to estrus synchronization, or not implanted, to determine the effects of growth implants on heifer performance. Heifers were bred via artificial insemination followed with clean-up bulls. Implanted heifers gained more and were heavier at the end of the trial, but had a reduced pregnancy rate than non-implanted heifers. Implanted heifers also had a lower pregnancy rate in their second breeding season. Implanting yearling beef heifers increased average daily gain; however, it decreased initial and subsequent pregnancy rate compared with heifers not implanted. When deciding to implant replacement females, the current (or expected) market conditions for pregnant and feeder heifers must be considered.

Introduction

Administering growth implants in stocker systems results in increased growth, improved efficiency, and increased profitability. Initially, growth implants were utilized in the finishing phase of production, but over the past several decades, growth implants have been incorporated at earlier stages of growth and development. Growth implants have not been widely used in heifer calves due to reproductive concerns, but suckling calf implants approved in breeding heifers have little or no effect on subsequent reproduction when implanted according to the label, which in general is from 30 to 45 d of age and prior to weaning. Since traditional heifer development programs focus on maximizing reproductive rates, reproductive risk associated with implants not intended for breeding females has been avoided.

The objective of the present study was to evaluate effects of a single stocker implant (Revalor G) on growth and reproductive performance of yearling beef heifers in the Nebraska Sandhills.

Procedure

In 2011, 12 mo old crossbred beef heifers (n = 3,242; 525 ± 4 lb) grazing native Sandhills range at 3 locations were randomly assigned to be implanted with Revalor G (40 mg trenbolone acetate and 8 mg estradiol, **IMP**) or not implanted (control, **CON**). Heifers were implanted at the beginning of the grazing period (May 1). At the time of implant, all heifers were vaccinated (Pyramid 5, Boehringer Ingelheim, St. Joseph, MO; and VL5 Staybred, Zoetis, Florham Park, NJ) and treated with a topical endectocide (Ivermax, RXV Products, Westlake, TX). At each location, heifers grazed common upland pastures for 164 ± 4 d.

Breeding season began 82 ± 2 d following trial initiation. Heifers at location 1 (**L1**, n = 942) were synchronized with 2 prostaglandin $F_{2\alpha}$ (**PG**) injections administered 17 d apart (5 ml, Lutalyse, Zoetis, Florham Park, NJ) followed by 5 d of estrus detection and AI. Mature bulls were then placed with heifers at a 1:52 bull to heifer ratio for 20 d to conclude the breeding season. At location 2 (**L2**; n = 1,184) and 3 (**L3**; n = 1,116), mature bulls were placed with heifers at a 1:82 bull to heifer ratio 6 d before heifers received a single PG injection followed by 6 d of estrus detection and AI. Estrus detection aids were utilized at all 3 locations (Estrotect, Rockway Inc., Spring Valley, WI) at PG injection. Heifers were considered to have expressed estrus when greater than 50% of the rub-off coating had been removed from the Estrotect patch and were AI 12 h later. Following the AI period, mature bulls were then placed with heifers at ratios of 1:49 and 1:35 at L2 and L3, respectively, for 19 d to conclude a 25 d breeding season.

Heifers were managed on native Sandhills range throughout the summer grazing period. Pregnancy diagnosis was conducted via transrectal palpation approximately 45 d following bull removal and ending BW measured. Non-pregnant heifers were marketed as stocker cattle. During the second production year, heifers (n = 1,667; 706 and 961, for IMP and CON, respectively) retained as replacements were managed in 3 groups and grazed native upland range throughout the year without further treatment. Cows were offered 1 lb/d of a 32% CP supplement range cube for 30 d (15 d prior to breeding until 15 d following bull turnout). Pregnancy diagnosis was performed via transrectal palpation approximately 45 d following bull removal.

Economic Evaluation

Winter grazing cost was estimated to be one-half the grazing costs for a mature cow ($0.46/d) based on heifer BW at weaning. Winter range with supplement was valued at $0.75/d. Summer grazing costs were $0.55/d for upland grass. Additional development costs, including feed delivery costs, breeding costs, and health and veterinarian costs, were charged at $0.36/head/d. Average heifer purchase and cull prices were based on USDA Agricultural Marketing Service prices reported in Nebraska for each date. The total value of cull heifers was subtracted from the total cost of all developed heifers. Total costs were then divided by the number of heifers exposed to determine the total cost of 1 pregnant heifer. This value was divided by final pregnancy rate to determine the total net cost of 1 pregnant heifer.

Statistical Analysis

Data were analyzed using the GLIMMIX procedure of SAS. Individual heifer was the experimental unit and synchronization protocol was included as a random variable in the model. Location was experimental unit for economic analysis and in Table 2 where data are presented by location. Least squares means and SE for ADG, BW, and pregnancy rate were obtained using the Tukey function of SAS.

Results

The main effects of heifer growth and reproductive performance are presented in Table 1 and are presented by location in Table 2. Initial heifer BW was similar ($P > 0.10$) between treatments (525 ± 4 lb). Implanted heifers had greater ADG and ending BW ($P < 0.05$; 1.48 vs. 1.39 ± 0.02 lb/d and 765 vs. 750 ± 7 lb for IMP and CON, respectively). Heifers in the current study grazed native upland Sandhills pasture during the trial without supplement. Forage quality of Sandhills rangeland early in the grazing period is high, but decreases with increasing plant maturity (1997 Nebraska Beef Report, pp. 3–5). Therefore, heifers on a higher plane of nutrition for the entire grazing period would likely have a greater growth response to implants.

In a previous study (1984 Nebraska Beef Report, pp.45–47), implants were administered to crossbred beef heifers at 1, 6, or 9 mo, or at multiple intervals. Heifers receiving a combination of 2 implants had greater ADG from weaning to breeding than control or heifers implanted 3 times. Conception rates in a 62-d breeding season were comparable for implanted vs. non-implanted control heifers (93 vs. 96%), with the exception of heifers receiving implants at both 1 and 6 mo of age (56%). Calf birth weight, dystocia score, cow re-breeding rate, and calf weaning weight were not affected by implant treatment.

In the present study, pregnancy rate was greater ($P < 0.01$) for CON vs. IMP heifers (64 vs. 46 ± 3%). In the 1984 Nebraska Beef Report, pp.45–47 which observed similar conception rates among non-implanted controls and heifers implanted at 1, 6, or 9 mo of age, implants were administered earlier than in the present study. Strength and type of hormone provided by different

Table 1. Effects of Revalor-G on reproduction and summer BW gain of beef heifers grazing native Sandhills rangeland

Item	CON[1]	IMP[2]	SEM	*P*-value
n	1,621	1,621		
Spring BW, lb	522	525	4	> 0.10
Fall BW, lb	750	765	7	< 0.01
ADG[3], lb	1.39	1.48	0.02	< 0.01
Pregnancy rate, %	64	46	3	< 0.01
2nd preg. rate, [4] %	96	93	2	0.02

[1]CON = Heifers did not receive a growth implant prior to breeding season.
[2] IMP = Heifers received a Revalor G implant 82 ± 2 d prior to breeding season (Merck Animal Health, Summit, NJ).
[3] Grazing season ADG (Location 1–162 d, Location 2–160 d, Location 3–168 d).
[4]Second season pregnancy rates (n = 1,667).

Table 2. Effects of Revalor G on reproduction and summer BW gain of beef heifers grazing native Sandhills rangeland by location

Item	CON[1]			IMP[2]			SEM	*P*-value
Location	L1	L2	L3	L1	L2	L3		
Spring BW, lb	511	518	540	511	520	545	9	0.20
Fall BW, lb	719	774	791	732	794	805	33	0.02
ADG, lb[3]	1.28	1.59	1.48	1.34	1.70	1.54	0.13	0.03
Pregnancy rate, %	59	64	67	44	44	51	3	< 0.01

[1]CON = Heifers did not receive a growth implant prior to breeding season.
[2]IMP = Heifers received a Revalor G (Merck Animal Health, Summit, NJ) implant 82 ± 2 d prior to breeding season.
[3]Grazing season ADG (Location 1, 162 d; Location 2,160 d; Location 3, 168 d).

Table 3. Economics of implanting beef heifers with Revalor G at 12 mo of age[1]

Item	CON[2]	IMP[3]	SEM	*P*-value
Winter feed costs /$heifer[4]	102	102	.02	1.0
Summer feed cost /$heifer	91	91	.1	1.0
Total feed costs, $/heifer	193	193	.02	1.0
Total development cost[5] $/heifer	1,019	1,019	3	1.0
Avg. cull heifer value $	1,102	1,123	46	0.66
Cull heifer value $/heifer exposed	402	601	18	< 0.01
Net cost of 1 pregnant heifer[6], $	969	901	36	0.13

[1]Heifers developed at Rex Ranch on native Sandhills rangeland.
[2]CON = Heifers did not receive a growth implant prior to breeding season.
[3]IMP = Heifers received a Revalor G (Merck Animal Health, Summit, NJ) implant 82 ± 2 d prior to breeding season.
[4]Heifers grazed winter range for 135 d with the equivalent of 1 lb/d 32% CP supplement 3 times per wk.
[5]Includes all fixed and variable cost associated with initial heifer price, feed, feed delivery, breeding, transportation, and supplement.
[6]Total value of cull heifers was subtracted from the total cost of all developed heifers. Total costs were then divided by the number of heifers exposed to determine the total cost of 1 pregnant heifer.

implants may also contribute to variation in pregnancy rates observed between studies. Ralgro was utilized in the 1984 study, whereas Revalor G was used in the present study. Both Ralgro and Revalor G are synthetic hormones; however Ralgro contains zeranol, an estrogenic hormone that mimics estradiol, and Revalor G contains trenbolone acetate, an androgenic hormone that mimics testosterone

Subsequent pregnancy rate after the first calving season was also lower ($P = 0.02$) in IMP (93%) vs. CON (96%) heifers, which suggests implanting heifers may have a residual or development effect on growing heifers beyond the production yr the implant was administered.

Economic Analysis

The economic analysis is presented in Table 3. Heifers were developed together by location; therefore, winter and summer feed costs and total development costs were similar between treatments ($P = 1.0$). However, the net cost of 1 pregnant heifer tended ($P = 0.13$) to be greater in CON heifers due to increased gains in IMP heifers. Cull value did not differ ($P = 0.66$) despite a $21 numerical advantage for IMP heifers.

Stocker enterprises commonly market cattle in late summer when pasture availability or forage quality may be declining. A disadvantage in the design of the present study is quantifying treatment differences in the expense and resource allocation associated with retaining heifers for an extended period beyond normal stocker marketing windows to accommodate pregnancy diagnosis. It is likely that heifers continued to gain during the extended period prior to pregnancy detection; however, the increased gain due to implant had presumably diminished due to implant potency and declining forage quality.

Conclusion

In recent years, the beef industry has seen a decline in cattle numbers and high demand for replacement females. Some beef stocker enterprises have utilized their resources to market pregnant replacement females and many cow-calf producers have marketed excess pregnant females in response to market demand. It is important to note the implant used in this study is not approved for breeding females, so when pregnant heifer value exceeds feeder heifer value, it is unlikely the additional BW gain in cull females will compensate for the decreased pregnancy rate. However, when pregnant heifer value is comparable to feeder heifer value, the additional BW gain from the implant increases the value and efficiency of stocker heifers.

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Development of Terminal and Maternal Economic Selection Indices in Beefmaster Cattle

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Summary with Implications

Two economic selection indices were developed for Beefmaster cattle, one for a terminal objective and one for a maternal objective. The terminal index was developed assuming bulls would be mated to mature cows with all resulting progeny harvested. The maternal index was developed assuming bulls would be mated to a combination of heifers and mature cows, with resulting progeny retained as replacements or sold at weaning. Relative economic values for the terminal objective traits hot carcass weight, marbling score, ribeye area, 12th-rib fat and feed intake were 91.29, 17.01, 8.38,-7.07 and-29.66, respectively. Relative economic values for the maternal objective traits calving difficultly direct, calving difficulty maternal, weaning weight direct, weaning weight maternal, mature weight and heifer pregnancy were-2.11,-1.53, 18.49, 11.28,-33.46 and 1.19, respectively. The application of economic selection indices facilitates genetic improvement of beef cattle by aiding producers with their sire selection decisions.

Introduction

Economic selection indices are used to maximize genetic improvement in a specific objective. Most currently available selection indices are designed to be used by multiple breeders for specific marketing endpoints. Selection emphasis may differ between production systems and goals set forth for a particular operation. Before using economic indices to make selection decisions, it is important to define the operation goals and choose an index that closely aligns with those goals.

While EPD are the traditional genetic tools used to select seedstock, they represent genetic merit in only one trait while in reality multiple traits influence an animal's economic value as a parent. Selection indices simplify comparisons of animals by accounting for multiple traits simultaneously and by considering both biological production levels and economics. Currently, Beefmasters Breeders United (BBU) reports ten EPD, but provides no tool for multitrait selection. Therefore, economic selection indices are needed by Beefmaster producers to aid them in selecting seedstock. The objective of this study was to develop 2 economic selection indices for Beefmaster cattle tailored to terminal and maternal production systems.

Procedure

Economic Values of Objective Traits

Traits chosen for the breeding objective of each index should be those that affect the income and expense of the production system. Five objective traits were considered for the terminal index including hot carcass weight (HCW), marbling score (MS), ribeye area (REA), 12th-rib fat (FAT) and feed intake (FI). Six objective traits were considered for the maternal index including calving difficultly direct (CDd), calving difficulty maternal (CDm), 205-day weaning weight direct (WWd), 205-day weaning weight maternal (WWm), mature weight (MW) and heifer pregnancy (HP). Economic values for each trait in the breeding objective ensure selection emphasis is proportional to the economic importance of each trait. Derivation of economic values requires identifying sources of income and expense for each production system in order to develop a profit equation.

In the production system assumed for the terminal index, all calves were born from mature cows, retained through the feedlot phase, and sold on a grid based system. Phenotypes for the objective traits were simulated from a random normal distribution with the means and SD for each respective trait obtained from literature. Income was derived from marketing animals based on carcass weight, quality grade and yield grade. The 5-year (2010-2014) average price for steers and heifers at slaughter was obtained from the Livestock Marketing Information Center (LMIC) and used as the base price for all slaughter animals. Premium and discount values based on yield grade, quality grade and carcass weight were obtained from United States Department of Agriculture-Agricultural Marketing Service (USDA-AMS). Costs of the system included feed, veterinary, medicine, bedding, marketing, custom operations, fuel, repairs, processing and yardage. Five-year averages of prices for feedstuffs used in the production system were calculated using information obtained from the USDA—National Agricultural Statistics Service (USDA-NASS).

In the production system assumed for the maternal index, calves were born from a combination of heifers and mature cows, with resulting progeny retained as replacements or sold at weaning. Phenotypes for the maternal objective traits were simulated from a random normal distribution with the means and SD for each respective trait obtained from literature. Income was derived from marketing calves at weaning and non-pregnant females based on their weight and the market price of that weight category. Average prices of weaned calves ranging in weight from 350 to 700 lbs were calculated from 5 years of filtered data from the USDA-AMS. Data was filtered to include only states in the region where Beefmaster cattle are the most prevalent. States included were Alabama, Arkansas, Georgia, North Carolina, South Carolina, Florida, Mississippi and Texas. Average prices of cull females were estimated as a 5-year average obtained from the LMIC. Costs of the system were feed and expenses associated with calving difficultly. A 5-year average of prices for feedstuffs used in the production system was calculated using information obtained from the USDA-NASS.

Table 1. Relative economic values (REV) and relative emphasis of the objective traits.

	REV	Relative emphasis (%)
Terminal objective		
FI, lbs	-29.66	19.3
HCW, lbs	91.29	59.5
REA, sq. in.	8.38	5.5
FAT, in.	-7.07	4.6
MS, units[1]	17.01	11.1
Maternal objective		
CDd, %	-2.11	3.1
CDm, %	-1.53	2.2
WWd, lbs	18.49	27.2
WWm, lbs	11.28	16.6
MW, lbs	-33.46	49.2
HP, %	1.19	1.7

[1]4.0 = Sl^0 and 5.0 = Sm^0

Profit of each system (terminal and maternal) was determined by subtracting simulated cost from simulated income for 100,000 animals. Economic values were determined by approximating the partial derivatives of the profit function by perturbing one trait at a time, by one unit, holding the other traits constant at their respective means. The relative economic value of each trait was estimated as a product of the respective economic value and genetic SD. The relative contribution of each objective trait was calculated as a percentage of the sum of the absolute value of the relative economic values for the objective traits.

Selection Index Coefficients

Ideally, selection criteria would include all traits in the breeding objective, but in practice some traits in the objective are not readily observed so selection criteria may include indicator traits. In this study, selection criteria were chosen from EPD currently reported by BBU. Terminal selection criteria were yearling weight (YW), ultrasound ribeye area (UREA), ultrasound 12th-rib fat (UFAT) and ultrasound intramuscular fat (UIMF). Maternal selection criteria were birth weight (BWT), WWd, WWm, YW and scrotal circumference (SC). Index coefficients for selection criteria EPD were calculated as the product of an inverted genetic (co)variance matrix among selection criteria, a genetic (co)variance matrix between selection criteria and objective traits, and the vector of economic values for each objective trait. The genetic (co)variances assumed in these calculations were based on estimates reported in literature.

Results

The relative economic values and the relative emphasis of objective traits for the terminal and maternal selection indices are presented in Table 1. In the terminal objective, decreasing FAT and FI while increasing HCW, REA and MS would increase profitability. Hot carcass weight is the primary contributor to profit, receiving 59.5% of the emphasis. Feed intake receives the next highest emphasis at 19.3%. This implies improving efficiency is crucial to increasing the profitability of an operation with a terminal objective.

In the maternal objective, decreasing CDd, CDm and MW while increasing WWd, WWm and HP would increase profitability of the operation. Mature weight is the primary driver receiving 49.2% of the emphasis, implying that for the assumed parameters decreasing MW will do the most to improve profitability of operations with a maternal objective. Weaning weight direct is the second highest priority objective trait receiving 27.2% of the emphasis. These two traits are antagonistic to each other relative to the breeding objective, but since the assumed correlation between them is not unity progress can be made in both traits simultaneously.

The selection index value for an animal is the weighted sum of its EPD for the selection criteria, with each EPD being weighted according to the index coefficient of that EPD (Table 2). The accuracy of the terminal index lies between 0.338 and 0.503, and the accuracy of the maternal index lies between 0.218 and 0.428. The accuracy of an index reflects the correlation between the index and the aggregate genotype. The lower bound of the accuracy estimate assumes that phenotypic measures are the selection criteria. The upper bound of the accuracy estimate assumes that EPD known without error are the selection criteria. However, EPD would never be known with complete certainty given the heterogeneity of the residual variance. Thus, the upper bound of the index accuracy would be the 'best case scenario,' presuming that the accuracy of each EPD included in the index for each animal was unity. We would expect the true accuracy of the index to lie somewhere between the two accuracies presented herein that were produced by assuming the index was comprised of either phenotypic measures or by EPD that are known without error.

As expected, the accuracy of the maternal index was slightly lower than the terminal index because a greater number of indicator traits were included among the

Table 2. Index coefficients for EPD of selection criteria.

Terminal index	
YW	1.715
UREA	0.806
UFAT	-36.60
UIMF	12.375
Maternal index	
BWT	-1.371
WWd	1.426
WWm	0.945
YW	-0.660
SC	2.725

selection criteria. Some indicator traits (e.g., SC) were used because they were the only traits with a non-zero correlation to important breeding objective traits (e.g., HP). However, SC and HP are lowly correlated, meaning SC is not a strong indicator of HP. The accuracy of selection based on an index including SC as selection criteria could be greatly improved if instead EPD for HP were reported and could be included in the selection criteria. Having EPD available for other economically relevant traits such as stayability (STAY) would also greatly improve the accuracy. However, in this case STAY was not even included among the objective traits because there were no correlated EPD available as selection criteria.

Conclusion

Adding more EPD for economically relevant traits is an important next step for all beef breed associations to improve the accuracy of selection indices, and thus increase profitability of operations utilizing selection indices as a tool when making breeding decisions. For the available selection criteria, implementation of the selection indices presented herein will increase profitability and facilitate genetic improvement of Beefmaster cattle.

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Effects of Wintering System on Cow and Calf Performance in a Summer-Calving Intensive Production System

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Summary with Implications

A study evaluated the effects of two wintering systems (cornstalk grazing and drylot feeding) on cow-calf performance in a summer-calving intensively managed cowherd at two locations. Grazing cow-calf pairs on cornstalks resulted in lower ending BW of cows and reduced ADG of calves when compared to drylot cow-calf pairs at weaning. A partial budget of incorporating winter cornstalk grazing into an intensive production system suggests that cows wintered on cornstalks were $136.85 more profitable when compared to cows wintered in the drylot.

Introduction

The conversion of grassland to crop production has stimulated the cattle industry to seek alternative production systems. Research has shown that intensive management of cows can be utilized as an alternative system to traditional pasture beef production (2015 *Nebraska Beef Cattle Report*, pp. 16-18). More acres used for grain crop production has also resulted in greater availability of corn residue for fall/winter grazing. An economic analysis of an alternative production system would suggest that integrating cornstalk residue grazing in a partial intensive management system could reduce production cost for a cow-calf enterprise (2015 *Nebraska Beef Cattle Report* pp. 19-21). However, research is limited on the performance of a lactating cow and her calf while grazing cornstalk residue. Therefore, the objective of this study was to investigate a winter management system incorporating winter cornstalk residue grazing on cow and calf performance in a summer-calving intensively managed cow-calf production system.

Procedure

A study was conducted within two locations: the Eastern Nebraska Research and Extension Center (ENREC) feedlot and the Panhandle Research and Extension Center (PREC) feedlot. Seventy-six (n=47 at ENREC; n=29 at PREC) lactating, composite (Red Angus x Red Poll X Tarentaise x South Devon x Devon) beef cows with summer-born calves were utilized in the study. Within each location, cow-calf pairs were blocked by cow BW (ARDC=4; PREC=3 blocks for drylot and 2 blocks for cornstalk grazing), stratified by calf age, and assigned randomly to one of two treatments: 1) dry lot feeding (DL) or 2) cornstalk grazing (CS).

Prior to trial initiation, cows were grouped in a single drylot pen within location during the summer calving season (mean calving date: ENREC=July 7; PREC=July 11). A distillers and corn residue based diet was limit-fed to cow-calf pairs during this time.

Trial initiation corresponded to the beginning of cornstalk grazing within each location (ENREC=Nov 11 and PREC=Dec 4). Cow-calf pairs assigned to the CS treatment were hauled to irrigated cornstalk fields, while cow-calf pairs assigned to DL treatment remained in drylot pens.

Drylot pairs within location were limit-fed a common diet (Table 1) formulated to maintain a lactating cow in early gestation. Dry matter offered increased monthly throughout the study to account for the increasing intake of the growing calves.

Stocking rate for cow-calf pairs grazing cornstalks was calculated using estimated residue intakes of the cow and calf (2009 *Nebraska Beef Cattle Report*, pp. 13-14) and assuming 8 lb of husk and leaf residue (DM) were available per bushel of corn yield.

Table 1. Ingredient and nutrient composition of diets fed to cow-calf pairs in drylot by location[1]

	Location	
Ingredient, %	ENREC	PREC
Modified wet distillers grains plus solubles	55.0	
Wet distillers grains plus solubles	—	58.0
Wheat Straw	40.0	40.0
Supplement	5.0	2.0
Calculated Composition		
DM, %	62.4	47.0
CP, %	19.3	18.8
TDN, %	79.1	81.0
NDF, %	54.0	54.9
ADF, %	31.0	21.6
Ca, %	0.79	0.77
P, %	0.52	0.49

[1]All values presented on a DM basis
[2]Supplements included limestone, trace minerals, and vitamin A,D,E premix

A dried distillers grain based pellet (Table 2) was supplemented in bunks (space: 2 linear feet per pair) to pairs wintered on cornstalks at a rate of 5.3 lb. (range of 3.7 lb. to 7.1 lb.) DM/pair daily. The amount supplemented each day was calculated to provide the pairs on cornstalks the same energy intake of the DL pairs. Estimated DM intake of the cow and calf (*2009 Nebraska Beef Cattle Report*, pp. 13-14) and estimated digestibility values of the cornstalk residue throughout the grazing period (*2004 Nebraska Beef Cattle Report*, pp. 13-15) were used to calculate supplementation rate. Supplemental feed was only fed to grazing pairs if snow cover prevented grazing.

The trial was completed when winter cornstalk grazing ended on April 12 (ENREC) or April 14 (PREC). Weaning of the calves also coincided with the completion of the grazing season.

Cow BW and body condition score (BCS) were recorded over two consecutive days at trial initiation and completion to determine changes in BW and BCS. Calf weights were also collected over two consecutive days at trial initiation and completion to calculate gain.

Prior to being weighed at trial initiation, all pairs were limit-fed for a minimum of 5 consecutive days to reduce weight variation due to gastrointestinal tract fill. At trial completion, cow and calves were separated and limit-fed a minimum of 5 days before being weighed.

Cows were exposed to bulls (approximately 1 bull: 10 cows) from Sept 25 to Nov 30 for a 66 day breeding season at both locations. All bulls were examined for breeding soundness and approved by a licensed veterinarian prior to breeding season.

Results include 2 years of data from ENREC (1 year of previous data; *2016 Nebraska Beef Cattle Report*, pp. 5-7) and 1 year of data from PREC. Data were analyzed as a randomized block design using the mixed procedure of SAS. The model included pen or paddock as the experimental unit, wintering system as the fixed effect, and block as a random effect. Significance was declared at $P \leq 0.05$.

Table 2. Supplement fed to cow-calf pairs grazing cornstalks

Ingredient, %	
Dried distillers grains plus solubles	94.06
Limestone	5.49
Pelleting binder (urea formaldehyde polymer and calcium sulfate)	0.21
Vitamin A,D,E	0.12
Trace mineral[3]	0.11

[1]All values presented on a DM basis
[2]Fed at 5.3 lb per pair per d (DM)
[3]Cobalt, Copper, Manganese, Zinc, Iodine, Limestone Carrier

Table 3. Performance of cows by wintering system[1]

Item	CS[2]	DL[3]	SEM	*P*-value
Cow BW, lb				
Initial	1183	1187	62	0.93
Ending	1121	1322	57	<0.01
Cow BW Change, lb	-64	132	16	<0.01
Cow BCS[4]				
Initial	5.3	5.3	0.3	0.92
Ending	4.6	5.9	0.2	<0.01
Cow BCS change[4]	-0.7	0.5	0.2	<0.01

[1]Two years of data from ENREC and 1 year of data from PREC
[2]CS= pairs wintered on cornstalks
[3]DL= pairs wintered in drylot
[4]BCS on a 1 (emaciated) to 9 (obese) scale

Table 4. Performance of calves by wintering system[1]

Item	CS[2]	DL[3]	SEM	*P*-value
Initial age, d[4]	125	129	5	0.49
Ending age, d[5]	282	284	3	0.51
Calf BW, lb				
Initial	331	326	9	0.68
Ending	541	642	13	<0.01
Calf ADG, lb	1.33	2.04	0.1	<0.01
BW•d^{-1}•age^{-1}, lb[6]	1.96	2.32	0.1	<0.01

[1]Two years of data from ENREC and 1 year of data from PREC
[2]CS= pairs wintered on cornstalks
[3]DL= pairs wintered in drylot
[4]Initial age= age at initiation of cornstalk grazing period
[5]Ending age= age at collecting weights following weaning
[6]Weight per d of age at collecting weights following weaning

Table 5. Partial budget of winter cornstalk grazing

Inputs, $/pair/day	CS[1]	DL[2]
Cornstalk rent[3]	0.20	—
Yardage	0.30	0.50
Ration[4]	—	1.66
Supplement[4]	0.37	—
Net cost, $/pair/day	0.87	2.16
Net cost, $/pair/wintering season	143.55	356.40
Extra post-weaning feed, $/pair[5]	16.00	—
Lighter weaning wt, $/pair[6]	60.00	—
Net change, $/pair	136.85	

[1]CS= pairs wintered on cornstalks
[2]DL= pairs wintered in drylot
[3]Cornstalk rent = $12 per acre
[4]Distillers priced at 100% of corn assuming $3.50 per bu of corn
[5] Cost to feed an additional 3.6 lb. (DM) of ration at $0.06 per lb. for 75 days to compensate for body condition reduction of cow
[6]The difference in calf value at weaning between treatments; calf price, April 30; $20/cwt price slide

Results

Cow-calf pairs at ENREC grazed from Nov 11 to April 19 (160 d). An ammoniated corn stalk bale was fed (approximately 147 lb DM per pair) due to snow cover. The cornfield at ENREC produced a grain yield of 217 bu per acre. Estimated removal of available corn residue was 32%. At PREC, the grazing period was 133 days (Dec 4 to April 15). The average yield for the cornfield was 245 bu per acre. Cow-calf pairs removed approximately 20% of the available residue.

Drylot cow-calf pairs were limit-fed 27.9 lb DM (ENREC) or 28.3 lb DM (PREC) throughout the trial. Drylot cows had a greater ending BW and BCS compared to cows grazing cornstalks (Table 3). Cows wintered on cornstalks lost BW and had a 0.7 unit decrease in BCS, while cows in the drylot gained BW and had a 0.5 unit increase in BCS. Calves in the drylot had a greater ending BW compared to calves grazing cornstalks (Table 4). Similarly, DL calves had greater ADG and BW per d of age compared to CS calves. The breeding season was nearly complete before the experimental treatments were applied. Therefore, the effect of treatment on reproduction could not be measured until the following breeding season. Only 29 cows (of the total 112) meet these criteria. Overall, pregnancies were 90%, but the number of cows was too small to make a treatment comparison.

A partial budget (Table 5) was utilized to economically compare the reduced performance, as well as decreased winter production cost of the CS wintering system. Winter production inputs for grazing cornstalks were estimated to be approximately $0.87 per pair per day, resulting in a total of $143.55 per pair for a 165 winter grazing season. In contrast, the DL wintering system was estimated at $2.16 per pair day or $356.40 per pair per grazing season.

In the CS wintering system, additional feed was required for the cow to compensate for BW and body condition reductions observed throughout the winter. Consequently, additional post-weaning feed for the CS cow cost approximately $16. The lighter weaning weight of CS calves resulted in a reduced return of $60 per calf when a $20/cwt price slide is used between the calf weaning weights of the CS and DL wintering systems. A net change of $136.85 per pair was observed when winter cornstalk grazing was incorporated into an intensive production system.

Conclusion

Cow-calf pairs winter grazing cornstalks had poorer performance than pairs fed a complete diet throughout the winter in the drylot. However, lower winter production inputs may be significant enough to compensate for the reduced performance of calves when cow-calf pairs are wintered on cornstalks.

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Methods to Increase Productivity of Spring Calving Production Systems in the Nebraska Sandhills

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Summary with Implications

Feeding supplement to cattle grazing dormant winter range increased cow BW and BCS and calf performance, but not pregnancy rate. Using a CIDR to shorten the post-partum interval in a cow herd with existing acceptable reproductive performance did not improve pregnancy rate. Feeding creep feed to calves increased weaning BW but should be considered within the context of a cost/benefit analysis. Additional years of data collection may be necessary to draw definitive conclusions.

Introduction

Extending the grazing season to include grazing dormant pasture decreases production costs. Research has determined supplemental RDP is necessary to maintain BCS of gestating cows grazing winter range in the Nebraska Sandhills. Feeding supplement to cows grazing winter range during the last trimester of gestation has been shown to increase calf BW at weaning but it is not known if the timing of supplement feeding optimized progeny performance. Under-nutrition during gestation causes suboptimal conditions in the maternal uterine environment, which translates to depressed progeny performance. Potential cost savings could be achieved if the amount and duration of supplement feed was reduced. Further efficiency might be achieved if supplemental feed delivered directly to the calf could undo the negative effects of under-nutrition to dam during gestation.

Administration of exogenous progesterone can shorten the post-partum interval. If weaning occurs at a constant day for all calves in a herd, those born to cows with a shorter post-partum interval will be older and therefore weigh more than contemporaries born to cows that became pregnant later in the breeding season, thus increasing net returns of calves sold at weaning.

Objectives of this study were to determine effects of late-gestation supplementation, post-partum progestin administration, and creep feeding on productivity in spring calving systems.

Procedure

A 2-yr experiment used 120 crossbred (Red Angus, Simmental), March calving cows at the Gudmundsen Sandhills Laboratory, near Whitman, Nebraska. Cows were stratified by BW within age and treatments were assigned randomly in a 4 x 2 x 2 factorial arrangement: 1) No supplement from Dec 1 to Mar 1 (**DM0**), 1 lb of supplement from Dec 1 to Mar 1 (**DM1**), 1 lb of supplement from Jan 15 to Mar 1 (**JM1**), or 2 lb of supplement from Jan 15 to Mar 1 (**JM2**) (32% CP; 89% TDN); 2) administration of exogenous progesterone post-partum via a controlled internal drug release device (EAZI-Breed CIDR insert containing 1.38 g of progesterone; Zoetis Inc., Florham Park, NJ) for 7 d and prostaglandin $F_{2\alpha}$ (5 mL Lutalyse, Zoetis Inc.) administered on day seven (**CIDR**), or no progesterone administration (**NoCIDR**); and 3) unrestricted access by the calf to creep feed which contained an intake limiter (Accuration, Purina Animal Nutrition LLC, Gray Summit, MO) from July 15 to Nov 1 (**Creep**) or no access to creep feed (**NoCreep**). The study began in December when cows were turned in to 1 of 8 upland range pastures (86 ac) where supplement treatments were delivered on a pasture basis 3 days/week until March 1. Beginning March 1 cows were managed as a single group and fed hay until the end of the calving season. On May 28 CIDR inserts were administered to cows assigned to the CIDR treatment. On June 4 CIDR inserts were removed and cows were administered prostaglandin $F_{2\alpha}$. All cows were exposed to fertile bulls (1:25 bull:cow ratio) for 45 days in a common pasture, with breeding season ending July 15. The non-creep treatment occupied 1 pasture and creep treatments occupied 2 separate pastures, for a total of 3 pastures.

Cow BW and BCS were measured at the beginning and end of the supplementation period pre-breeding and at weaning. Calf BW was measured at birth, the start of the breeding season, and weaning. BW was taken after at least 12 hr without feed and water.

Cows were removed from the study for failure to wean a calf or to become pregnant and were not replaced. Therefore, the number of cows decreased throughout the 2 years of data collection. Cows external to the experiment were introduced into pastures to maintain constant stocking rates for each pasture during the experiment.

Cows assigned to the same winter supplement, CIDR and creep treatment within winter pasture served as the experimental unit. Replicated treatment means within year were used for analyses of cow and calf response variables. There were 4 observations per treatment replication. Model fixed effects included winter supplement treatment, CIDR treatment, creep treatment and all possible interactions. Year and residual error were included in the model as random effects. Effects of treatment were considered significant when $P < 0.05$. There were no interactions ($P > 0.18$) among treatments; therefore, data are reported as main effects.

Results

Regardless of supplement amount offered, there was a notable fluctuation in cow initial BW to cow weaning BW. Cows assigned to the DM0 treatment had the greatest differences in BW from Dec to May. The greatest loss in BW occurred during the period between start of calving (March) to start of breeding (May) for all 4 treatments of supplement (Table 1). Treatments fed supplement maintained

Table 1. Effects of winter supplement[1], post-partum progesterone administration[2], and calf access to creep feed[3] on cow body weight, body condition score (BCS), calving date, calving rate, weaning rate, pregnancy rate, and calf body weight

	Supplement				Progesterone		Calf feed			P-Value		
	DM0	DM1	JM1	JM2	CIDR	No CIDR	Creep	No Creep	SE[4]	Supp	Progest	Feed
Cow BW, lb												
Initial (Dec)	1,049	1,078	1,054	1,043	1,047	1,065	1,054	1,058	8	0.06	0.07	0.61
Calving (Mar)	992[c]	1,098[a]	1,034[b]	1,043[b]	1,041	1,043	1,027	1,056	7	< 0.01	0.91	0.03
Breeding (May)	950[c]	1,023[a]	981[b]	990[b]	979	992	979	994	5	< 0.01	0.22	0.16
Weaning (Nov)	1,052[b]	1,102[a]	1,067[b]	1,067[b]	1,065	1,078	1,078	1,067	15	0.02	0.24	0.29
Cow BCS[5]												
Initial (Dec)	4.9	5.0	5.0	5.0	5.0	5.0	5.0	5.0	0.1	0.78	0.80	0.39
Calving (Mar)	4.8[b]	5.2[a]	5.0[b]	5.2[a]	5.0	5.1	5.0	5.1	0.1	< 0.01	0.45	0.73
Breeding (May)	4.5[b]	4.9[a]	4.7[ab]	4.8[a]	4.7	4.7	4.7	4.7	0.1	< 0.01	0.48	0.33
Weaning (Nov)	5.2	5.2	5.3	5.4	5.3	5.3	5.3	5.2	0.2	0.33	0.62	0.51
Calving date[6], d	82	88	86	83	83	87	86	84	2	0.16	0.13	0.31
Born in 21 d[7], %	0.80	0.70	0.82	0.84	0.80	0.78	0.74	0.84	0.06	0.34	0.68	0.08
Calving rate[8], %	0.97	1.00	0.98	0.98	0.98	0.98	0.98	0.99	0.1	0.58	1.00	0.32
Weaning rate[9], %	0.94	0.98	0.95	0.97	0.95	0.97	0.95	0.97	0.1	0.51	0.58	0.44
Pregnancy rate[10], %	0.86	0.96	0.91	0.88	0.90	0.91	0.92	0.89	0.1	0.26	0.77	0.43
Calf BW, lb												
Birth (Mar)	77	79	75	77	77	77	77	77	1	0.12	0.61	0.22
Breeding (May)	163	161	154	163	161	159	159	163	2	0.46	0.60	0.17
Weaning (Nov)	522	516	518	522	518	520	542	496	7	0.92	0.83	< 0.01

[1]DM0: 0 kg/(cow • d) Dec 1 to Mar 1; DM1: 1lb DM/(cow • d) Dec 1 to Mar 1; JM1: 1 lb DM/(cow • d) Jan 15 to Mar 1; JM2: 2 lb DM/(cow • d) Jan 15 to Mar 1.
[2]CIDR: CIDR insert containing 1.38 g of progesterone for seven d and prostaglandin F_{2a} administered on d 7 from May 28 to June 4.
[3]Creep: unrestricted access by the calf to creep feed which contained an intake limiter from July 15 to Nov 1.
[4]Standard error of the least squares mean (n = 4 observations per treatment replication [2/yr]).
[5]Scale of 1 (emaciated) to 9 (extremely obese).
[6]Day of yr calving occurred where January 1 = d 1.
[7]Cows calving within 21 d calculated by finding difference between birth date and breeding date and subtracting from 285.
[8]Calving rate calculated by dividing the number of cows to calve by the number of cows at the beginning of the production yr.
[9]Weaning rate calculated by dividing the number of cows to wean a calf by the number of cows at the beginning of the production yr.
[10]Pregnancy rate calculated by dividing the number of cows determined pregnant by the number of cows at the beginning of the production yr.
[abc]Within a row, means lacking a common superscript letter differ ($P < 0.05$).

BW. Differences in BW among supplement treatments were most notable at the start of the breeding season where DM0 cows had the lightest ($P < 0.05$) BW, JM1 and JM2 cows intermediate, with DM1 cows having the heaviest BW. Cow BCS was lower ($P < 0.05$) at the start of the breeding season for DM0 cows than for cows assigned to DM1 and JM2 treatments, with JM1 cows being intermediate. Differences in BW and BCS caused by the supplementation treatment did not affect measures of reproductive efficiency such as calving date ($P = 0.16$), calving rate ($P = 0.58$), weaning rate ($P = 0.51$), and pregnancy rate ($P = 0.26$). Previous research examining effects of supplement fed to cows grazing winter range has demonstrated decreased weaning rate in cows not fed supplement in some studies but no effects in others (2002 Nebraska Beef Report, pp.3–4). Supplement treatment did not affect calf BW at birth ($P = 0.12$), at beginning of dam's breeding season ($P = 0.46$), or at weaning ($P = 0.92$). Similar research (2006 Nebraska Beef Report, pp.7–9, 2012 Nebraska Beef Report, pp. 15–17) has consistently demonstrated decreased BW at weaning of calves born to cows not fed supplement during winter. Similar BW at weaning between calves born to cows not fed supplement and those fed supplement in this experiment was not expected. Being year 2 of a 3-year study, more definitive conclusions may be drawn after the third year of data.

Whether or not cows were administered a CIDR did not affect ($P > 0.13$) BW, BCS, reproductive measures, or calf BW. Exogenous progesterone was not expected to affect cow BW or BCS. Potential increased calf age and therefore, increased BW at weaning as a result of earlier conception in the breeding season due to progesterone administration was not realized ($P = 0.83$). Allowing calves access to creep feed increased calf BW at weaning by 46 lb ($P< 0.05$). Even with the increased BW at weaning, the value of gain needs to outweigh the extra cost of creep feeding to be a recommended practice. These benefits can vary from year to year depending on cost of gain. Total amount of creep that disappeared from feeder was 2.65 lbs DM/(calf • d).

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Effect of Crude Glycerin Concentration on Growing Steer Performance in Forage Diets

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Summary with Implications

The effect of increasing crude glycerin concentration was evaluated in a 91-d growing trial utilizing 60 steers. Crude glycerin was included at 0, 4, 8, and 12% of dietary DM in diets consisting of 50% wheat straw; 22.9-37.0% wet corn bran, and 8.0-10.1% soybean meal. Crude glycerin replaced wet corn bran and soybean meal was added to maintain dietary CP. Steer ending BW was not different among treatments. There was a quadratic increase in DMI from 0 to 8% crude glycerin and subsequent decrease at 12%. There was no difference in ADG or feed efficiency among crude glycerin concentrations. Therefore, crude glycerin appears to have an energy value slightly less than wet corn bran in a forage-based diet.

Introduction

During the transesterification process of biodiesel, fatty acids are cleaved from a triacylglyceride and bound to methanol, which is the biodiesel product. The remaining byproduct from the reaction is glycerol, also known as crude glycerin (GLY). The use of GLY has been evaluated in beef diets with mixed results depending on dietary ingredients being displaced. When evaluating 0, 4, 8, and 12% GLY in forage-based diets, GLY did not impact NDF digestibility and decreased acetate to propionate ratio as GLY inclusion increased (*2016 Nebraska Beef Cattle Report, pp 40-41*). However, data comparing GLY in forage-based growing diets are limited. Therefore, the purpose of this experiment was to determine the effect of GLY concentration on steer performance in forage-based growing diets.

Procedure

The experiment utilized 60 crossbred steers (initial BW = 795 lb; ± 92 lb) in a randomized complete block design to evaluate the effects of increasing concentrations of GLY in a 91-d growing trial. Steers were individually fed using the Calan gate system. Treatments included the inclusion of 0, 4, 8, and 12% dietary DM of GLY in forage-based diets (Table 1). The control diet consisted of 50% wheat straw, 37% wet corn bran (Cargill; Blair, NE), 8% soybean meal, and 5% supplement. Wheat straw was ground through a 3-inch screen while wet corn bran was utilized to increase palatability and reduce sorting of dietary ingredients. The GLY replaced wet corn bran while the soybean meal and urea increased with increasing GLY to maintain equal dietary CP across treatments. Supplements were formulated to provide 200 mg per day monensin and equilibrate Na concentrations across treatment diets to minimize intake variances due to GLY inclusion.

Steers were limit-fed a diet containing 50% alfalfa and 50% Sweet Bran (Cargill; Blair, NE) at 2% BW for 5 d at the beginning and end of the trial with a 3-d BW collection to serve as initial and ending BW. Ending BW was calculated as the average of the 3-d weight minus 1 lb for each day steers were fed the limit diet to correct for weight gain during those 7 d. The adjustment of 1 lb per d is based on previous steer performance data when limit-feeding 50% alfalfa hay and 50% Sweet Bran diet at 2% BW. Steers were implanted with Ralgro® (Merck Animal Health; Summit, NJ) on day 1 of the trial.

Dietary energy values for treatment diets were calculated using the 1996 NRC. Using performance equations, individual steer BW, intake, and gain were used to

Table 1. Dietary composition of forage-based growing diets

	Crude Glycerin Concentration			
	0%	4%	8%	12%
Dietary Ingredient, % DM				
Wheat Straw	50.0	50.0	50.0	50.0
Wet Corn Bran	37.0	32.3	27.6	22.9
Soybean Meal	8.0	8.7	9.4	10.1
Crude Glycerin	0.0	4.0	8.0	12.0
Supplement[1]	5.0	5.0	5.0	5.0
Supplement Ingredient,				
Urea	0.79	0.87	0.94	1.01
NaCl	0.78	0.52	0.26	0.00
Limestone	0.76	0.76	0.76	0.76
Dicalcium Phosphate	0.39	0.38	0.38	0.37
Dietary Inclusion[2]				
CP, %	12.9	13.0	13.0	13.0
MP balance, g/d	334	327	321	316
RDP balance, g/d	249	280	311	342

[1] Supplements formulated to provide 200 mg monensin per day.
[2] Dietary inclusion calculated utilizing 2000 Beef NRC model.

Table 2. Effect of crude glycerin concentration on steer performance in forage-based growing diets

	Glycerin Concentration (Diet DM)					*P*-value	
	0%	4%	8%	12%	SEM	Linear	Quadratic
Initial BW, lb	796	794	793	797	3	0.83	0.23
Ending BW, lb	1060	1048	1053	1047	9	0.40	0.74
DMI, lb/d	20.6[ab]	21.6[ab]	22.0[a]	20.4[b]	0.6	0.93	0.03
ADG, lb	2.90	2.79	2.86	2.75	0.1	0.37	0.99
F:G[1]	7.06	7.62	7.62	7.34	-	0.50	0.14
NEm, Mcal/lb[2]	0.79	0.74	0.74	0.77	0.02	0.61	0.08
NEg, Mcal/lb[2]	0.50	0.47	0.46	0.49	0.02	0.61	0.08

[1] Analyzed as gain:feed, the reciprocal of F:G.
[2] Dietary NEm and NEg calculated based on animal performance using 1996 Beef NRC model equations.
[ab] Means within rows differ $P < 0.05$.

calculate dietary NEm and NEg for each GLY concentration.

Data were analyzed using the GLIMMIX procedure of SAS (SAS Institute, Inc., Cary, N.C.). Steer was the experimental unit. Block was included as a fixed effect. Orthogonal contrasts were used to test linear and quadratic effects of GLY concentration.

Results

Steer ending BW was not different ($P = 0.40$) among GLY concentrations (Table 2). There was a quadratic increase ($P = 0.03$) in DMI from 0% GLY (20.6 lb/d) to 8% GLY (22.0 lb/d) and subsequent decrease at 12% GLY (20.4 lb/d). There was no difference in ADG ($P = 0.37$) or feed efficiency ($P = 0.14$) among GLY concentrations. Dietary NEm and NEg had a tendency for a quadratic decrease ($P = 0.08$) from 0% GLY to 8% GLY with an increase at 12% GLY concentration. The greatest NEm and NEg were noted for 0% GLY concentration at 0.79 and 0.50 Mcal/lb, respectively.

Conclusion

Feed conversion and dietary net energy tended to change quadratically, and were poorer at 4% and 8% GLY. Therefore, GLY appears to have an energy value slightly less than wet corn bran in a forage diet.

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Effect of Increasing Supplemental Rumen Undegradable Protein (RUP) on Performance of Calves Fed a Silage Growing Diet

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Summary with Implications

A growing study evaluated the effects of increasing supplemental rumen undegradable protein (RUP) on performance of calves fed an 85% corn silage diet. Five levels of supplementation were evaluated with 12 individually fed steers per level of supplement. Supplement levels consisted of 0, 3.25, 6.5, 9.75 and 13% supplemental RUP (% of diet DM) fed as a blend of 60% Soypass and 40% Empyreal. Increasing supplemental RUP in the diet increased ending body weight and average daily gain linearly, and decreased F:G linearly while DMI remained constant among treatments. As cattle grew from 600 to 730 lb, F:G was improved 30% by supplying RUP. The same amount of RUP improved F:G by 11% as cattle grew beyond 730 lb. By meeting MP requirements, supplementing RUP linearly improved both ADG and F:G of growing calves, especially early in the growing period.

Introduction

Although ADG may be diminished, feeding increased amounts of corn silage can be economically beneficial. Feeding corn silage allows cattle feeders to harvest the entire corn plant at the time of greatest forage quality and also provides a large quantity of affordable forage. Silage averages 6.5 to 8.5% crude protein, with most of it being rumen degradable protein (RDP) which is utilized for microbial protein synthesis. Corn silage is very low in rumen undegradable protein (RUP), which bypasses rumen degradation. Current estimates using a technique appropriate for silage suggests corn silage protein is 22% RUP (% of CP). Without adequate amounts of supplemental RUP, dietary protein will be limiting and will not meet metabolizable protein requirements, therefore negatively impacting cattle performance. Because supplemental protein provides a large amount of the total dietary protein, source and amount of supplemental protein is important. A similar study (2016 Nebraska Beef Report, pp. 49-51) looked at 0 to 10% supplemental RUP in 88% corn silage growing diets. They observed a linear increase in ADG and ending BW, suggesting that MP requirements were not met with the greatest level of supplement (10% supplemental RUP from Soypass and Empyreal®). Therefore, the objective of this study was to evaluate the effects of increasing supplemental RUP (up to 13% of diet DM) on growing performance of calves fed a silage based-diet.

Procedure

An 83-d growing study was conducted utilizing 60 crossbred steers (initial BW = 639; ± 40 lb). All steers were individually fed using the Calan gate system. Five days prior to trial initiation, steers were limit fed at 2% of BW to reduce gut fill variation. Steers were weighed on 3 consecutive days and the average was used as initial BW. The diet consisted of 85% corn silage with the remaining 15% fed as supplement (DM basis). The supplement included protein sources, urea, minerals, vitamins A-D-E, and a finely-ground corn carrier that was replaced with the RUP sources (Table 1). The RUP supplement consisted of 52% SoyPass (50% CP; 75% RUP as % of CP) and 34.7% Empyreal (Cargill; 75% CP; 65% RUP as % of CP). SoyPass is a enzymatically browned soy bean meal and Empyreal is a more processed corn gluten meal. Five levels of supplement were evaluated with 12 steers per level. Supplement levels consisted of 0, 3.25, 6.5, 9.75 and 13% Soypass + Empyreal (RUP sources as a % of diet DM). Steers were stratified by d-2 and-1 BW and assigned randomly to 1 of 5 treatments. All steers were implanted with Ralgro on d 0 and fed ad-libitum once daily at 8 a.m. Feed refusals were collected weekly, weighed, and then dried in a 60° C forced air oven for 48

Table 1. Diets fed to individually fed growing steers

	Treatment[1]				
Ingredient	0.0%	3.25%	6.5%	9.75%	13%
Diet composition, % of diet DM					
Corn Silage	85.0	85.0	85.0	85.0	85.0
RDP supplement[2]	15	11.25	7.5	3.75	0
RUP supplement[3]	0	3.75	7.5	11.25	15.0
Supplemented RUP[4]	0.4	1.7	3.0	4.2	5.5
Protein sources, % of diet DM					
Soypass	0	2.0	3.9	5.9	7.8
Empyreal	0	1.3	2.6	3.9	5.2
Urea	1.5	1.2	0.9	0.6	0.3

[1] Supplement levels consisted of 0, 3.25, 6.5, 9.75 and 13% Soypass + Empyreal (RUP sources as a % of diet DM).
[2] RDP supplement consisted of 79.2% corn, 2.9% limestone, 2.5% tallow, 9.7% urea, 2.0% salt, 3.2% dicalcium phosphate, trace minerals, vitamin A-D-E, and Rumension-90.
[3] RUP supplement consisted of 52% Soypass, 34.7% Empyreal, 1.9% corn, 3.2% limestone, 2.5% tallow, 1.7% urea, 2.0% salt, 1.5% dicalcium phosphate, trace minerals, vitamin A-D-E, and Rumension-90.
[4] % of RUP provided in the Supplement

hours to calculate an accurate DMI for individual steers. Interim weights were taken on d 36 and 37 and shrunk 4% to account for gut fill. At the conclusion of the study, steers were once again limit fed a diet of 50% alfalfa hay and 50% Sweet Bran (Cargill) at 2% of BW to account for gut fill. Weights were collected on 3 consecutive days and averaged to calculate an ending BW.

Data were analyzed using the mixed procedure of SAS as a randomized block design. To evaluate RUP supplementation, linear and quadratic contrasts were developed to determine the effect of RUP inclusion. Significance was declared at $P \leq 0.05$.

Results

No differences in DMI ($P = 0.84$) were observed among treatments for period 1 (d 1-37). However, ADG ($P < 0.01$) and F:G ($P < 0.01$) both improved linearly as RUP inclusion increased during period 1 (Table 2). Using the NRC model, MP balance (supply minus requirement of MP) for period 1 increased from-200 to +65 g/d as RUP inclusion increased from 0 to 13%. At 9.75% RUP inclusion, MP requirements were met (MP balance of +2 g/d). There were no differences in DMI, ADG or F:G for period 2 ($P \geq 0.11$; d 38-83). As RUP supplementation increased, F:G improved 30% in period 1. The increased improvement in feed efficiency in period 1 may be due to increased amino acid requirements of younger, lighter calves.

For the overall growing period (d 1-83), as supplemental RUP inclusion increased from 0 to 13%, a linear increase was observed in ending BW ($P < 0.01$). With no difference in DMI ($P = 0.54$) among the 5 treatments, averaging 17.1 lb/d, and a linear increase in ADG ($P < 0.01$), F:G linearly improved ($P < 0.01$) by 11% as RUP inclusion increased from 0 to 13%. The MP balance increased from-186 to +98 g/d as RUP inclusion increased from 0 to 13%. Providing 9.75% supplemental RUP in the diets was adequate to meet the MP requirements based on the 1996 NRC model (MP balance of +26 g/d). Even though MP requirements were met with both the 9.75 and 13% treatments, ADG continued to linearly increase up to 13% inclusion of RUP sources. This may be due to not meeting a lysine requirement with the 9.75% treatment. In period 1, the 13% RUP treatment had a lysine balance of +1.4 g/d. Diets were sufficient in lysine at only the greatest inclusion (13%) of supplemental RUP. Another explanation for additional improvement in ADG and F:G as supplemental RUP increased from 9.75 to 13% of diet DM is that excess MP provided from supplemental RUP can also be used as energy once MP requirements are met.

Conclusion

Further research with supplemental RUP needs to be done to determine if excess metabolizable protein would continue to increase growth due to protein (meeting lysine requirements) or used as energy. Increasing the amount of RUP in silage growing diets linearly improved ending BW, ADG, and F:G by meeting MP requirements of growing calves.

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Table 2. Effects of increasing RUP in silage based growing diets on steer performance

	Treatments[1]						*P*-value	
Variable	0%	3.25%	6.5%	9.75%	13%	SEM	Lin.	Quad.
Initial BW, lb	605	606	604	608	604	11.8	0.99	0.93
Ending BW, lb	800	825	821	850	834	16.6	0.01	0.68
d 1-37								
Interim BW, lb	692	707	713	730	729	14.7	0.03	0.69
DMI, lb/d	15.5	15.8	16.0	16.3	15.6	0.56	0.68	0.33
ADG, lb	2.35	2.73	2.95	3.30	3.38	0.21	< 0.01	0.52
F:G	6.59	5.79	5.43	4.94	4.62	—	< 0.01	0.76
d 38-83								
DMI, lb/d	16.9	18.8	18.3	18.5	18.3	0.70	0.22	0.16
ADG, lb	2.30	2.51	2.30	2.55	2.23	0.14	0.11	0.87
F:G	7.35	7.49	7.96	7.25	8.19	—	0.60	0.32
d 1-83								
DMI, lb/d	16.3	17.5	17.3	17.5	17.1	0.59	0.34	0.19
ADG, lb	2.32	2.61	2.58	2.88	2.74	0.12	< 0.01	0.55
F:G	7.02	6.70	6.69	6.09	6.25	—	< 0.01	0.61

[1] All cattle were fed 85% corn silage with a combination of RDP and RUP supplements to achieve either 0, 3.25, 6.5, 9.75, or 13% supplemental RUP (% of diet DM). The RUP source was a blend of Soypass + Empyreal in the final diet.

Effects of Modified Distillers Grains and Corn Ratios as Supplements in Diets Varying in Forage Quality on Performance of Growing Beef Steers

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Summary with Implications

Distillers grains (DG) have been intensively used for beef production, but prices relative to corn vary such that it may be beneficial to displace a portion of DG with corn in certain circumstances. Four ratios of supplemental energy (40% of diet DM) from modified distillers grains and corn (100:0, 80:20, 60:40, and 40:60) were supplemented in one of 3 forage diets (56% of diet DM) and evaluated for performance. Forages were high (brome hay + sorghum silage) or low quality. Low quality forages were corn residue baled through conventional rake and bale, or by disengaging the spreader on the combine and baling the tailings (easy bale). Steers fed the high quality forage had greater ADG due to greater DMI, but similar F:G as both residue forage diets, which were not different. Decreasing the ratio of modified DG:corn linearly decreased ADG and resulted in poorer F:G.

Introduction

Ethanol production in the US increased from 6.1 billion gallons in 2007 to 13.5 billion gallons in 2014. Since then, corn residue and distillers grains (DG) have been intensively used for beef production. Corn residue is composed of plant parts with distinct digestibilities, with the husk being the most digestible, followed by leaf blade, cob and lastly stem (2015 Nebraska Beef Cattle Report, pp. 59-61). The proportion of plant parts in the windrow to be baled plays an important role on performance, since it determines the digestibility of forage consumed by the animal.

In the past, DG was included in ruminant diets due to its low price, but the increasing export demand in recent years has raised the price. However, it is not known if corn can displace a portion of DG as supplemental energy in forage diets for growing steers. We hypothesize that corn may replace 60% of distillers grains without negatively impacting performance because DG will still meet the protein requirements of the steers. The objective of this research was to determine the effects of displacing the supplemental energy from modified DG in diets of different forage qualities on performance of growing beef steers.

Procedure

The experiment was conducted at the University of Nebraska—Lincoln Eastern Nebraska Research and Extension Center near Mead, Neb. One hundred twenty individually fed crossbred beef steers (initial BW = 620; ± 32 lb) were used in a randomized complete block design with a 4 × 3 factorial treatment arrangement (n = 10 steers per simple effect treatment). Factors included 4 ratios of supplemental energy from modified distillers grains (MDG) and dry-rolled corn and 3 forage types (Table 1). Ratios of MDG:corn were 100:0, 80:20, 60:40 or 40:60 as supplemental energy comprising 40% of the diet DM. Energy supplements were fed in diets consisting of high quality (HQ; 70% brome hay and 30% sorghum silage) or one of two low quality forages. Low quality forages consisted of corn residue baled through conventional rake and bale system (CB), or by disengaging the spreader on the combine and baling the tailings (easy bale-EZB). Four samples of each type of bale were collected and separated into cobs, shanks and husks, leaf blades and leaf sheaths, and stems. Plant parts were weighted and proportions calculated (Table 1).

Steers were fed a common diet at 2% of BW composed of 60% forage and 40% wet corn gluten feed (Sweet Bran, Cargill Wet Milling, Blair, Neb) for 5 d at the beginning and end of the trial and weighed on 3 consecutive days to minimize differences in gut fill. Steers were blocked by initial BW, identified with numbered tags and implanted with 36 mg zeranol (Ralgro; Merck Animal Health). The experimental diets contained 56% forage, 40% supplemental energy from different ratios of dry-rolled corn or MDG and 4% supplement with urea, vitamins, minerals and Rumensin (14 mg/hd/d) on a DM basis. Animals were individually fed using Calan gates for 84 days.

Feed delivery and refusals were weighed daily and recorded. Response variables included initial BW, ending BW, DMI, ADG and F:G ratio.

Data were analyzed using the MIXED procedure (SAS Inst. Inc., Cary, NC) with steer as the experimental unit, therefore 10 replications per treatment. The experiment was designed as a 3 X 4 factorial with 3 forage types (HQ, CB, and EZB) and four MDG:corn ratios (100:0, 80:20, 60:40, and 40:60). Orthogonal comparisons across MDG levels were analyzed to determine linear, quadratic or cubic trends for varying MDG:corn ratios in the diet. Interactions between supplemental energy ratios and forage type were also tested. Data were considered statistically significant when $P < 0.05$.

Results

No interactions (linear or quadratic; $P > 0.32$) were observed between forage quality and ratio of MDG:corn supplementation for ADG and F:G. A significant quadratic interaction ($P < 0.01$) was observed for DMI (data not shown). The differences in DMI across ratios were small within each forage quality. However, the interaction was due to a quadratic increase, then decrease in DMI as MDG was replaced with corn within the HQ diets (range in DMI from 18.7 to 20.6 lb / d). For steers fed EZB, a cubic response to ratio of MDG:corn was observed with DMI of 12.2, 11.0, 12.2, and

Table 1. Ingredient composition of experimental diets fed to steers (DM basis)

Item	HQ[1]				EZB				CB			
	100[2]	80	60	40	100	80	60	40	100	80	60	40
Forage	56.0	56.0	56.0	56.0	56.0	56.0	56.0	56.0	56.0	56.0	56.0	56.0
MDG[3]	40.0	32.0	24.0	16.0	40.0	32.0	24.0	16.0	40.0	32.0	24.0	16.0
DRC[4]	0.0	8.0	16.0	24.0	0.0	8.0	16.0	24.0	0.0	8.0	16.0	24.0
Supplement												
Ground corn	2.1	2.1	2.1	2.1	2.60	2.60	2.54	2.28	2.60	2.60	2.54	2.28
Limestone	1.46	1.46	1.46	1.46	0.92	0.92	0.82	0.39	0.92	0.92	0.82	0.39
Tallow	0.10	0.10	0.10	0.10	0.10	0.10	0.1	0.10	0.10	0.10	0.1	0.10
Salt	0.30	0.30	0.30	0.30	0.30	0.30	0.3	0.30	0.30	0.30	0.3	0.30
Urea	0.0	0.0	0.0	0.0	0.0	0.0	0.15	0.85	0.0	0.0	0.15	0.85
Minerals	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Vitamin A-D-E	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015
Rumen-sin-90	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014

[1] HQ = high quality forage, 70% brome hay and 30% sorghum silage; EZB = easy bale, corn residue baled by disengaging the spreader on the combine and baling the tailings; CB = conventional rake and bale system
[2] Percent modified distillers grains in the supplement
[3] MDG = modified distillers grains
[4] DRC = dry rolled corn

Table 2. Effects of forage type on cattle performance

Item	Forage type[1]			SEM	*P*-value
	HQ	EZB	CB		Forage
Initial BW, lb	620	620	620	1.25	0.98
Ending BW, lb	865[a]	763[b]	772[b]	4.73	<0.01
DMI, lb/d	19.67[a]	11.46[c]	12.22[b]	0.27	<0.01
ADG, lb	2.89[a]	1.68[b]	1.79[b]	0.05	<0.01
F:G[2]	6.85	6.71	6.76	-	0.92

[1] HQ = high quality forage, 70% brome hay and 30% sorghum silage; EZB = easy bale, corn residue baled by disengaging the spreader on the combine and baling the tailings; CB = conventional rake and bale system
[2] Analyzed as G:F, the reciprocal of feed conversion (F:G).
[a,b,c] Means within a row with different superscripts differ.

Table 3. Proportions of the parts of the corn residue in each type of bailing method.

Item	CB[1]		EZB[2]	
	%	SD[3]	%	SD
Stem	46.32	1.59	41.90	3.08
Cob	5.29	0.76	13.96	3.28
Husk	9.53	0.58	14.45	1.02
Leaf	38.86	1.00	29.69	1.98

[1]EZB = easy bale, corn residue baled by disengaging the spreader on the combine and baling the tailings;
[2]CB = conventional rake and bale system;
[3]SD = Standard deviation.

10.5 observed as MDG:corn ratio decreased from 100:0 to 40:60, suggesting simply that intakes varied as MDG:corn differed. No difference in DMI was observed due to ratio of MDG:corn within CB diets. Performance due to main effects of either ratio of MDG:corn or forage quality are presented.

The HQ forage increased ending BW by 12.7% ($P < 0.01$), ADG by 60.0% ($P < 0.01$) and DMI by 62.73% ($P < 0.01$) compared to the low quality forages (Table 2). There were no differences between the two corn residue forages for ending BW and ADG. Feeding EZB treatment decreased DMI compared to CB. As expected, husk proportion was increased by the EZB method, being 14.45 vs. 9.53% for EZB and CB, respectively. But, the proportion of stem + cob (the parts of the plant with lowest digestibilities) was actually slightly greater for the EZB (55.9 *vs*. 51.6% Stem + cob for EZB and CB, respectively; Table 3) which can explain the lack of difference between the low quality forages on performance. However, the F:G ratio was not affected by type of forage ($P = 0.92$) despite changes in DMI and ADG.

There was a linear decrease in ending BW ($P < 0.01$) and ADG ($P < 0.01$) as MDG was displaced with corn (Table 4).

Table 4. Effects of MDG level on cattle performance

Item	MDG Level[1]				SEM	*P*-value	
	100	80	60	40		Linear	Quad
Initial BW, lb	620	620	620	620	1.44	0.98	0.99
Ending BW, lb	813	804	799	784	5.46	<0.01	0.58
DMI, lb/d	14.78	14.42	14.71	13.88	0.54	0.09	0.45
ADG, lb	2.27	2.17	2.11	1.93	0.06	<0.01	0.55
F:G[2]	6.54	6.54	6.90	7.19	-	0.03	0.58

[1] Percent modified distillers grains (MDG) in the supplement.
[2] Analyzed as G:F, the reciprocal of feed conversion (F:G).

Similarly, the F:G ratio increased linearly ($P = 0.03$) and DMI ($P = 0.09$) tended to decrease linearly as MDG inclusion decreased in the diet and corn increased. The F:G response to ratio of MDG:corn was not quadratic ($P = 0.58$) even though F:G was similar at 100:0 and 80:20 ratios and then F:G increased as corn replaced more MDG. When wet distillers grains or dry distillers grains were evaluated at two different inclusions (15 or 30% in the diet) with grass hay and sorghum silage based diets, the highest distillers inclusion improved ending BW, ADG and F:G ratio regardless of the form of distillers grains fed (*2011 Nebraska Beef Cattle Report, pp. 20-21*). Another trial (*2011 Nebraska Beef Cattle Report, pp. 24-25*) evaluated the performance of growing steers grazing smooth bromegrass supplemented with dry distillers grains at 0.6% of BW per day and supplementation increased ADG by 1.4 lb / d compared to non-supplemented cattle. The improved performance of cattle supplemented distillers grains can be attributed to the energy from fat and rumen undegradable protein of the distillers grains *(2006 NebraskaBeef Cattle Report, pp. 27-29)*. In the current study, steers fed the 40:60 ratio of MDG:corn should have met their metabolizable protein requirements, suggesting that the response in ADG and F:G is due to energy differences between MDG and corn, and not a protein requirement response. The 40% inclusion of modified distillers grains resulted in greater performance compared to the other levels.

Conclusions

As expected, the high quality forage increased steer performance compared to the two corn residue bailing methods. However, while it was expected that the easy bale treatment would result in improved residue quality, there was no difference between the easy bale and conventional rake and bale systems for average daily gain or feed efficiency. Additionally, when distillers grains was displaced with dry-rolled corn, cattle performance decreased.

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Rumen Undegradable Protein and Bambermycins Supplementation of Calves Grazing Corn Residue

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Summary with Implications

Steer calves grazing non-irrigated corn residue were supplemented with a corn residue and by-product pellet that contained either Soypass, soybean meal, or processed soybean meal at a rate of 4 lb / d. Additionally, a supplement was fed at 1 lb / d that provided 0 or 20 mg / steer daily of bambermycins (Gainpro®). There was no interaction between bambermycins inclusion and pellet type. Likewise, there was no effect of pellet type or bambermycins on ending BW or ADG. In order to maximize gain of calves grazing corn residue it is important to provide a supplement that ensures adequate levels of both energy and rumen undegradeable protein.

Introduction

The crude protein content of corn residue is not sufficient to meet the requirements of a growing animal, thus necessitating supplementation. Previous research (*2016 Nebraska Beef Report,* pp. 38-39) evaluated the effect of supplementing steers grazing corn residue with bambermycins and a pellet containing distillers grains and alkaline treated corn stover. Increasing supplement as a percent of BW resulted in a linear increase in ADG while supplementing bambermycins at a rate of 10 mg / steer daily had no effect on ADG. However, ADG of calves supplemented with the pellet was still less than reported ADG of calves supplemented with distillers grains at similar levels. Previous research has demonstrated that an increase in RUP fed to growing steers grazing corn residue increases ADG compared to supplements providing similar energy levels but lower RUP concentrations (*2016 Nebraska Beef Report,* pp. 31-32). Therefore, the objective of this study was to determine if ADG of steers grazing corn residue could be increased through an increase in rate of bambermycins fed and strategic supplementation of calves with increased levels of RUP in a pellet containing alkaline treated stover and soy byproducts.

Procedure

An 84-d corn residue grazing trial was conducted from November 10, 2015 to February 1, 2016 at the University of Nebraska-Lincoln Eastern Nebraska Research and Extension Center near Mead, NE. Sixty crossbred steers (initial BW = 489 lbs; SD = 31) were evaluated in a 2 x 3 factorial design. The first factor was inclusion of bambermycins fed at either 0 or 20 mg / steer daily. Bambermycins was included in a common soyhull-based supplement that was formulated to provide supplemental vitamins, minerals, and, depending on treatment, bambermycins and fed at 1 lb DM / d. The second factor was amount of RUP provided in the pellet when fed at 4 lb DM / d. Soypass, soybean meal (SBM), or SBM that was further processed by Pellet Technologies to increase the RUP content were included in the pellet at 40% of pellet DM with the remainder consisting of 44.5% corn stover treated with calcium oxide, and 15.5% solubles (provided by Pellet Technology, USA Gretna, Neb.). The SBM pellet was formulated to contain 7.5% RUP (as a % of DM) and provide 136 g of RUP. The Soypass and further processed SBM pellet were formulated to contain 15.3% RUP (as a % of DM) and provide 278 g of RUP. Crude protein for all 3 pellets was 26%. All cattle were individually supplemented daily with the treatment pellet and supplement. Steers were limit-fed a diet at 2% of BW consisting of 50% alfalfa and 50% Sweet Bran® for 5 days to equalize gut fill. Steers were weighed 2 consecutive days and assigned randomly to treatments after being stratified by weight. Steers were allowed continuous access to daily supplement via Calan gates. All steers were implanted with 36 mg of zeranol (Ralgro®) on d 1 of the experiment.

Stocking rate was calculated using estimates of residue amount and grazing efficiency from previous research (*2012 Nebraska Beef Report, pp. 11-12*). Estimated available forage was divided by estimated DMI (10 lb / steer daily) to determine the number of grazing days the field could support.

Ending BW was determined similarly to initial BW. Steers were limit fed a 50% alfalfa and 50% Sweet Bran® diet at 2% of BW for 6 consecutive days and weighed 3 consecutive days thereafter. Ending BW was calculated by averaging the 3 day weights.

Performance (BW and ADG) data were analyzed using the GLIMMIX procedure of SAS (SAS Institute, Inc., Cary, N.C.) with steer as the experimental unit. Effects of Gainpro and RUP source were analyzed for interaction and main effects.

Results

There was no interaction between inclusion of bambermycins and pellet type for ending BW or ADG ($P \geq 0.61$; Table 1). Similarly, there was no main effect of bambermycins inclusion on ending BW or ADG ($P \geq 0.79$) when fed at 20 mg / steer daily. Steers receiving bambermycins gained 0.76 lb / d and steers receving no bambermycins gained 0.74 lb / d. Likewise, there was no main effect of pellet type on ending BW or ADG ($P \geq 0.57$). For steers receiving the pellet with supplemental protein provided by SBM, ADG was 0.78 lb / d while steers fed a pellet with supplemental protein provided from either Soypass or further processed SBM gained 0.76 and 0.72 lb / d, respectively. Metabolizable protein has been shown to increase gains in steers grazing corn residue. The lack of a gain response from feeding an increased

Table 1. Effects of supplementing growing cattle with a corn byproduct pellet containing different protein sources with or without Gainpro.

	Gainpro			No Gainpro				*P*-Value		
Supplement[1]	SBM	PT	SP	SBM	PT	SP	SEM	Int.[2]	Gainpro	Supp.
Initial BW, lb	488	488	489	489	489	490	10.29	0.99	0.94	0.99
Ending BW, lb	553	555	548	554	550	551	10.30	0.90	0.96	0.92
ADG, lb/d	0.77	0.80	0.70	0.78	0.72	0.73	0.06	0.61	0.79	0.57

[1] SBM = soybean meal, PT = further processed SBM, SP = soypass
[2] Supplement type by Gainpro inclusion interaction.

level of RUP was unexpected and would suggest that the protein level available in all 3 pellets was sufficient for the amount of available energy.

Conclusions

Due to the limited nutrient content of corn residue, a supplement must provide additional protein and energy to optimize performance of growing calves grazing residue. These data demonstrate that additional energy may be beneficial in a supplemental pellet in order to maximize response to elevated RUP levels.

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Pooled Gain Analysis of Steers Grazing Corn Residue and Supplemented with Distillers Grains

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Summary with Implications

A pooled analysis combined data from three trials in which steer calves grazing corn residue were supplemented with distillers grains at varying amounts as a percent of BW. A regression equation was calculated in order to provide an accurate estimate of gain for calves fed distillers grains at various rates. Steers supplemented with distillers grains in a range from 0.3 to 1.1% of BW (1.5 to 6.5 lb / steer daily) had estimated gains that ranged from 1.07 to 1.94 lb / d. This prediction equation provides an estimate of gain for calves supplemented with distillers grains at various rates while grazing corn residue under normal environmental conditions.

Introduction

Corn residue is a relatively inexpensive, grazable forage source in many parts of Nebraska. However, due to its low levels of protein and energy, it is necessary to provide a supplemental nutrient source for growing calves to meet their growth requirements (*2016 Nebraska Beef Report,* pp. 31–32). Distillers grains plus solubles (DGS) fits well as a supplement for calves grazing corn residue, as it is high in both protein (~30% CP) and energy (108% TDN). An estimate of calf ADG, relative to amount of DGS fed, is important to have so that producers can achieve a desired level of gain. The objective of this analysis was to combine ADG data from previous trials into a pooled analysis that would provide an equation from which ADG could be estimated depending on rate of DGS supplementation (as a percent of BW).

Procedure

A pooled analysis was conducted utilizing data from 3 corn residue grazing trials conducted from early November to early February at the University of Nebraska-Lincoln Eastern Nebraska Research and Extension Center near Mead, NE. In all 3 trials, steer calves grazing corn residue were supplemented with distillers grains at differing rates. The first trial (*2006 Nebraska Beef Report, pp. 36–37*) utilized 120 steers (512 lb, ± 37) that were fed dried distillers grains (DDGS) at either 0.29, 0.49, 0.69, 0.88, 1.08, or 1.27% of BW which equated to a range of 1.5 to 6.5 lb of DDGS / steer daily (DM basis). The second trial (*2014 Nebraska Beef Report, pp. 48–49*) utilized 120 steers (435 lb, ± 16) fed either modified distillers grains (MDGS) or DDGS at 0.3, 0.7, or 1.1% of BW (1.4 to 5.4 lb / steer daily on a DM basis). There were no differences in ADG due to distillers type (P =0.51), therefore gains were pooled together for this analysis. The third trial (*2015 Nebraska Beef Report, pp. 25–26*) utilized 60 steers (519 lb, ± 11) fed DDGS at 0.3, 0.5, 0.7, 0.9, or 1.1% of BW (1.7 to 6.8 lb / steer daily on a DM basis). Steers in the second and third trial received monensin at 200 mg / steer and limestone at 60 g / steer daily and were implanted with Ralgro® at the beginning of the trial. In all trials, steers were individually supplemented daily via Calan gates. Results for each trial can be seen in Figure 1.

Estimated available forage was divided by estimated DMI (10 lb / steer daily) to determine the number of grazing days the field could support. Data were pooled using the MIXED procedure of SAS (SAS Institute Inc., Cary, N.C.). Calf was the experimental unit and data were blocked by weight within trial and trial was included in the model. A regression equation was calculated using the average calculated ADG of calves in the 3 trials when DGS was supplemented at 0.3, 0.5, 0.7, 0.9, and 1.1% of BW.

Results

A regression line and equation were calculated utilizing the 3 pooled datasets (Figure 2). As rate of DGS supplemention increased, there was a quadratic increase in ADG (P = 0.06). Estimates of ADG for steers fed DGS at 0.3, 0.5, 0.7, 0.9, and 1.1% of BW were 1.07, 1.36, 1.60, 1.80, and 1.94 lb / d, respectively. This analysis agrees with previous research in which DDGS was fed at 0.52% of BW to steers grazing corn

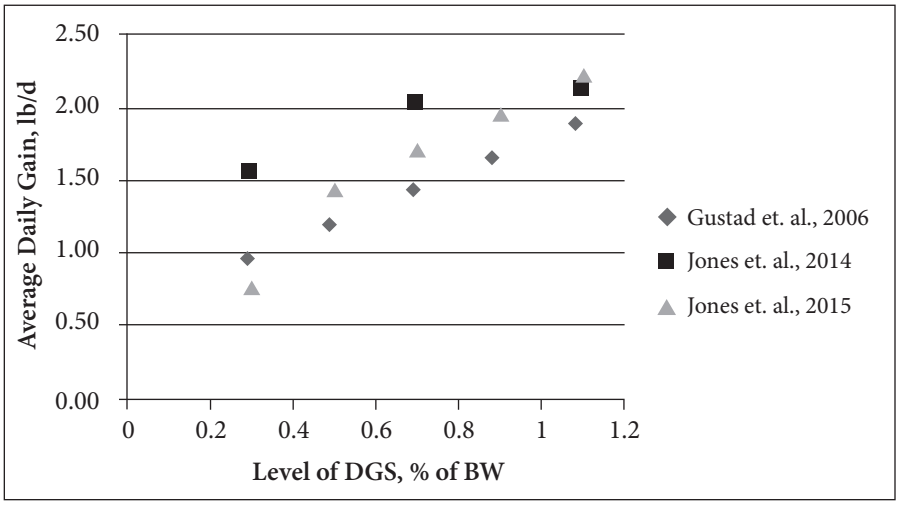

Figure 1. Effect of level of DGS supplement on ADG of steers across trials

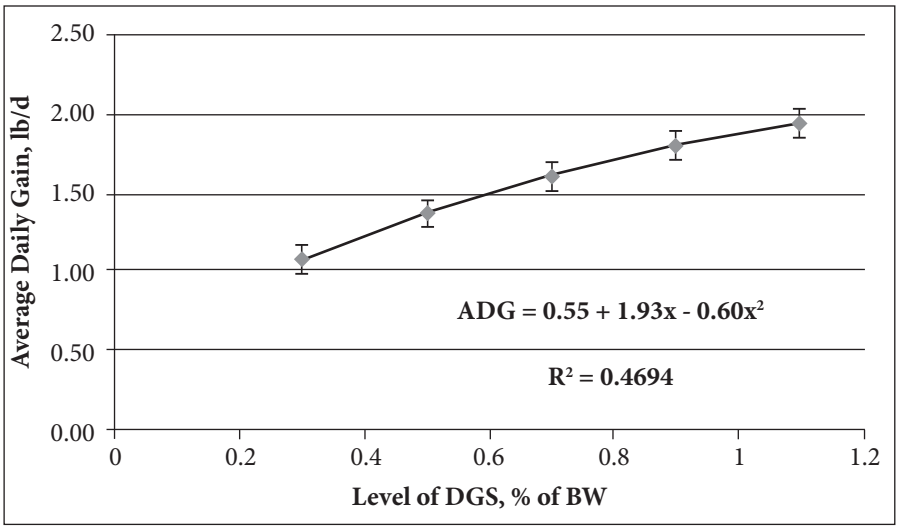

Figure 2. Effect of rate of DGS supplement on ADG of steer calves grazing corn residue (Linear response—$P < 0.01$; Quadratic response—$P = 0.06$)

residue and ADG was 1.32 lb / d (predicted ADG = 1.39 lb/d) (*2016 Nebraska Beef Report, pp. 31–32*). Additionally, in another study evaluating performance of calves grazing corn residue, steers were supplemented with DDGS at 0.86% of BW and gained 1.77 lb / d which matches the ADG calculated using this prediction equation (*2016 Nebraska Beef Report, pp. 55–56*).

Conclusion

Overall, as supplementation rate of DGS increases, so does ADG. However, at higher rates of supplementation, added gain increases at a decreasing rate. This prediction equation can provide, under normal environmental conditions, a reasonable estimate of gain for calves supplemented with DGS at various rates while grazing corn residue.

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Evaluating the Impacts of Field Peas in Growing and Finishing Diets on Performance and Carcass Characteristics

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Summary with Implications

The impact of field peas as a grazing supplement and a component of finishing diets on performance and carcass characteristics was evaluated over two years. During grazing, cattle supplemented with field peas had a greater ending body weight and average daily gain than cattle that received no supplement. However, cattle supplemented with corn had greater average daily gain than both peas and control cattle. Overall, those cattle not supplemented during grazing compensated 53% and 88% when compared to those cattle supplemented corn and peas, respectively. Inclusion of field peas in grower supplement or finishing diets may be advantageous if appropriately priced as cattle supplemented field peas had more desirable performance on pasture than unsupplemented cattle, and inclusion of peas in the finisher did not affect performance.

Introduction

Field peas have increased in popularity in recent years with an 81% increase in production across the nation from 2011 to 2012. While a large component of this production is directed to the human consumption and pet food market, this also increases the availability of commodity level peas for the livestock feed market. Previous research has provided initial evidence that feeding field peas may positively affect sensory attributes, such as subjective and objective tenderness as well as flavor profile. Peas provide a viable rotation in wheat production because they fix nitrogen in the soil and naturally break up pest cycles. Determining the best use of field peas for the livestock sector is important for both the cattle producer and field pea farmer. The utility of field peas most likely fits the integrated crops and livestock producer more than commercial feedyards due to the limited bushels of peas produced for livestock feed at this time. Therefore, the objectives of this study were to determine the efficacy of field peas as a pasture supplement and to determine if feeding field peas during the grazing phase impacted carcass characteristics.

Procedure

In Yr. 1, 114 steers (initial BW = 766 ± 48 lb) were used, and in Yr. 2, 114 heifers (initial BW = 548 ± 24 lb) were used in a 3 × 2 factorial experiment. Cattle were sorted into three weight blocks and randomly assigned to initial pasture. The first factor was three supplementation treatments applied during a summer grazing season. Supplementation occurred at a rate of 0.5% BW (DM Basis). The three treatments consisted of: 1) Whole, unprocessed field peas; (FP); 2) a mixture of dry rolled corn (DRC; 70.8%), solubles (24%), and urea (5.2%); (CMIX; the mixture was balanced to ensure RDP was not limiting); and 3) control group receiving no supplement (CON). Cattle grazed twelve 100 acre crested wheatgrass pastures at the High Plain Agriculture Lab (HPAL) near Sidney, NE. Cattle were rotated through pastures biweekly to ensure that pasture differences did not affect the treatments. In year 1 the grazing period was 117 days and in year 2, 142 days.

The second factor was two treatments assigned during finishing that occurred at the Panhandle Research and Extension Center (PREC) feedlot near Scottsbluff, NE. Cattle remained in their grazing groups across 12 pens and were fed a DRC-based finishing diet with or without 20% whole, unprocessed FP (DM basis). The complete composition of the finishing treatments is displayed in Table 1. Days on feed for both years were 119 and 131, respectively.

Cattle were slaughtered and carcass performance was evaluated at Tyson Foods in Lexington, NE. Data were analyzed using the MIXED procedure of SAS. The grazing and finishing models included treatment as a fixed effect with block and year as random effects.

Results

During the grazing phase ending BW and ADG ($P < 0.01$) were greatest for calves supplemented CMIX (909 lb, SED = 9.05; 1.96 ± 0.11 lb, respectively) followed by FP (878 lb, SED = 9.05; 1.72 ± 0.11 lb, respectively) and CON (834 lb, SED = 9.05; 1.36 ± 0.11 lb, respectively; Table 1). Due to unbalanced cattle numbers in pastures across years, standard error of the difference is being reported.

In the finishing phase there was an interaction between growing and finishing treatments for feed to gain (F:G; $P = 0.03$), a result of cattle supplemented with FP during the growing phase and with no FP in the finisher having improved feed conversion compared to cattle supplemented with FP during growing and with FP also included in their finishing diet (6.75 vs. 7.57, respectively; Table 2). The CMIX and FP cattle were most efficient when peas were not included in the finishing diet while the CON cattle were the most efficient when peas were included. When peas were not included in the finisher, only cattle supplemented with corn during the growing phase had reduced feed conversions.

Table 1. Finishing Diet Composition (DM Basis)

	Finishing Treatment	
Ingredient, %	No Peas	Peas
Dry-Rolled Corn	60.0	40.0
Field Peas	0.0	20.0
WDGS	20.0	20.0
Corn Silage	14.0	14.0
Mineral Supplement	6.0	6.0

Table 2. Effect of corn and pea supplementation on performance of growing calves

					P-value		
Treatment[1]	Control	Corn	Peas	SED[2]	Treatment	Year	Interaction
Initial BW, lb	656	654	654	3.44	0.84	0.10	0.91
Ending BW, lb	836[c]	910[a]	879[b]	9.50	<0.01	0.14	0.62
ADG, lb/d	1.36[c]	1.96[a]	1.72[b]	0.08	<0.01	0.14	0.34

[1] Treatments: Cattle grazed either without supplement or supplemented at 0.5% of body weight with either dry rolled corn or field peas.
[2] Due to unbalanced cattle numbers in pastures across years, standard error of the difference is being reported.
[abc] Within a row, means without a common superscript differ.

A possible explanation for this biological function is that the cattle supplemented on pasture entered the feedlot at a heavier initial body weight. This increase in weight would allow for more of their growth in the finishing phase to be a higher proportion of fat deposition. On the other hand, those cattle unsupplemented on pasture would experience a larger proportion of their growth as skeletal muscle development due to lower initial body weights in the finishing phase. Also, those cattle receiving peas in the feedlot would have lower diet starch content and perhaps less available energy for fat deposition.

There were no other interactions of finishing and growing treatments on other variables ($P \geq 0.10$). Feedlot ADG was affected by growing treatment ($P < 0.01$). Cattle in the CON treatment had greater ADG (4.29 ± 0.09 lb) than cattle supplemented CMIX (3.96 ± 0.09 lb) and FP (3.92 ± 0.09 lb), which were similar. Final BW and HCW tended ($P = 0.07$) to be affected by growing treatment in a similar manner to feedlot ADG. Inclusion of FP in the finishing diet had no impact on carcass characteristics. Cattle supplemented CMIX during grazing had greater ADG than cattle supplemented FP or CON. However, in the finishing phase, CON cattle compensated 53% compared to cattle supplemented CMIX and 88% compared to cattle supplement FP during grazing.

Conclusion

Field peas can be an alternative protein supplement option for grazing cattle on cool season pasture as cattle will potentially perform better than those cattle receiving no supplement. Improved performance could be explained from results in a companion study in which field peas increased dry matter intake and organic matter digestibility in diets with high and low quality forages (2017 Nebraska Beef Cattle Report, pp. 38–39). In finishing diets, field pea inclusion will not affect performance up to 20% inclusion rate. However, cattle receiving supplement on grass may gain less during the finishing phase, demonstrating the impacts of compensatory gain.

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Table 3. Effect of field peas on performance in finishing diets

Finishing trt[1]	No peas			Peas				*P*-value		
Growing trt[2]	Control	Corn	Peas	Control	Corn	Peas	SED[8]	Growing	Finishing	Interaction
Initial BW, lb[3]	846	906	873	824	912	889	14.59	<0.01	0.97	0.18
Final BW, lb[4]	1369	1396	1378	1371	1413	1371	23.43	0.07	0.74	0.77
ADG, lb[5]	4.20	3.89	4.07	4.37	4.03	3.81	0.15	<0.01	0.84	0.10
DMI, lb	29.4	29.2	28.7	29.8	29.5	29.4	0.63	0.39	0.19	0.88
F:G, lb:lb	6.99[ab]	7.41[c]	7.04[ab]	6.75[a]	7.30[bc]	7.57[c]	-	-	0.60	0.03
Carcass Performance										
HCW, lb	862	880	868	864	890	864	14.77	0.07	0.73	0.77
12th Rib fat, in.	0.53	0.58	0.56	0.57	0.55	0.59	0.04	0.68	0.61	0.36
Ribeye area, in^2	14.1	13.7	13.8	13.4	13.9	13.6	0.35	0.89	0.18	0.20
Marbling[6]	486	504	499	525	493	482	29.04	0.75	0.81	0.31
Calculated YG[7]	3.10	3.41	3.25	3.40	3.29	3.43	0.19	0.69	0.27	0.26

[1] Finishing Treatment: Cattle with peas in the diet had 20% of the dry matter of the diet as peas (by displacing dry rolled corn). The "No Peas" diet still included that 20% as dry rolled corn.
[2] Growing Treatment: Cattle were grazed for 142 days either without supplement or supplemented at 0.5% of body weight with either dry rolled corn or field peas depending on assigned treatment.
[3]Initial BW: Values differ across treatments because cattle were carried over from the growing phase to evaluate effect of growing treatment in the finishing phase.
[4] Final BW: Calculated as HCW ÷ 0.63
[5]ADG: Results in the finishing phase were affected by growing treatment.
[6] Marbling: 400 = Slight[00] : 500 = Small[00]
[7]Calculated Yield Grade: 2.50 + (2.5 × 12th Rib Fat, in.)–(0.32 × REA, in^2) + (0.2 × 2.5) + (0.0038 × HCW, lb)
[8] Due to unbalanced cattle numbers in pastures across years, standard error of the difference is being reported.
[abcd] Within a row, means without a common superscript differ.

Effects of Field Pea Supplementation on Digestibility and Rumen Volatile Fatty Acid Concentration of Diets Containing High and Low Quality Forages

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Summary with Implications

Five ruminally cannulated steers were used to evaluate the effects of supplementation (no supplement, field peas, or dry rolled corn; 0.43% BW) with high and low quality forages on diet digestibility and rumen volatile fatty acid concentrations. The inclusion of field peas increased dry matter intake and organic matter digestibility over dry rolled corn and unsupplemented steers. Propionate proportions were less for field peas and control treatments than dry rolled corn, while acetate proportions increased in field peas, and control treatments as compared to dry rolled corn. As a result, acetate to propionate ratio was reduced when dry rolled corn was supplemented. Inclusion of field peas alters the volatile fatty acid concentrations, increases dry matter intake, and improves organic matter digestibility when supplemented to forage fed steers.

Introduction

With recent increases in availability of field peas as a livestock feed, a renewed interest has developed in their use in beef production. More in-depth determination of digestion kinetics would improve the prediction of the value of field peas as both a grazing supplement and a component in finishing diets. Previous research has shown that feeding field peas in beef cattle diets up to 30% of the diet (DM basis) produces similar results to starch grains, such as corn. Corn has a negative impact on the digestion of fiber due to the starch content. However, corn supplementation also alters the proportion of acetate to propionate favoring propionate. The impacts of field pea supplementation on volatile fatty acid (VFA) concentration are not well established. Therefore, one objective of this study was to determine how field pea supplementation alters VFA concentrations and diet digestibility relative to corn when supplemented to high and low quality forages.

Procedure

Five ruminally fistulated steers (Initial BW = 444 ± 44 lb) were utilized in a 5 × 6 Latin rectangle metabolism study to evaluate the effects of supplementation on total tract digestibility of diets containing either high or low quality forages. Treatments were set up as a 2 × 3 factorial (forage quality × supplement type). The first factor was high quality forage (HQ; 50% alfalfa, 50% sorghum silage, DM basis) or low quality forage (LQ; 50% brome grass hay, 50% wheat straw, DM basis). The second factor was one of three supplements: Unsupplemented control (CON), Dry-rolled Corn (DRC), or Ground Field Peas (FP). Those steers being supplemented DRC were dosed with a urea solution to ensure that they were not deficient in rumen degradable protein in comparison to those being supplemented with FP. Both FP and DRC supplements were coated in molasses to increase palatability. Forage was offered *ad* libitum through the entire study and steers were supplemented at 0.43% of BW (DM basis). The non-supplemented cattle on the LQ forage received an adequate supply of RDP in their diet. Steers were weighed at the beginning of each period to adjust supplement amount accordingly. Supplement was fed at 0800 hours, steers were given two hours to consume supplement. Any supplement not consumed was inserted into the rumen cannula. Forage was then fed at 1000 hours. Periods lasted 14 days with a 9 day adaptation period and 4 day collection period. Animals were housed in individual slatted floor stalls. Steers were ruminally dosed continuously with 5 g of TiO_2 twice daily at 0800 and 1600 hours. During collection, rumen fluid samples and fecal grab samples were taken at four time points including 0700, 1100, 1500, and 1900 hours.

Hourly fecal samples were composited by day by steer on a wet basis, freeze dried, and ground. Daily composites were ground and composited on a week basis by steer and analyzed for NDF, ADF, OM, and percent titanium. Feed ingredients samples were taken each period, dried, ground, and analyzed for NDF, ADF, OM, and CP.

In an effort to analyze supplement effect on fiber digestibility, in-situ bag procedures were used. Both HQ and LQ were weighed into the bags that were then sealed and incubated in the rumen for 24 hours. Bags were removed, rinsed, washed with NDF solution in an Ankom Fiber Analyzer, dried, and weighed back to determine remaining NDF after incubation.

All data were analyzed using the MIXED procedure of SAS and probabilities were considered significant if $P \leq 0.10$. Steer was the experimental unit with supplement type, forage type and their interaction as fixed effects. Steer and collection period were random effects.

Results

Digestibility

There were no interactions between forage quality and supplement type on digestibility. Dry matter intake (DMI), forage DMI, DM digestibility (DMD), OM intake (OMI), OM digestibility (OMD), and 24 hour in-situ NDF digestibility (NDFD) were greater with HQ forage than in LQ forage (Table 1). The FP supplement increased DMI, DMD, OMI, OMD, and NDFD compared to steers receiving DRC or CON; DRC and CON did not differ in intake, DMD, OMI or OMD. Forage DMI tended to be least for DRC while FP tended to increase forage DMI, but was similar to CON (Table 2). The in-situ 24 hour NDFD is an indicator of the associative effects on fiber digestion that might occur when

Table 1. Diet digestibility and concentration of rumen VFA's in steers due to forage quality

Forage Trt[1]	High Quality	Low Quality	SEM	*P*-value
DMI (lb)	13.50	10.37	1.07	<0.01
Forage DMI (lb)	12.13	9.00	1.07	<0.01
DMD (%)	63.09	49.09	1.65	<0.01
OMI (lb)	12.24	9.24	0.95	<0.01
OMD (%)	64.18	50.10	1.61	<0.01
NDFI (lb)	7.06	7.00	7.06	0.82
In-situ NDFD[2] (%)	38.59	33.81	0.85	<0.01
Total, mMol	124.49	126.81	9.39	0.86
Acetate, %	64.1	72.26	0.58	<0.01
Propionate, %	18.48	17.89	0.22	0.06
A:P	3.61	4.09	0.05	<0.01

[abcd] Within a row, means without a common superscript differ.
[1]High Quality Forage Diet: 50/50 blend of sorghum silage and alfalfa hay. Low Quality Forage Diet: 50/50 blend of brome grass hay and wheat straw. Water was added to the Low Quality treatment to ensure equal amount of dry matter across both forage treatments.
[2]NDF digestibility: measured at 24 hours, in-situ.

Table 2. Diet digestibility of steers due to supplement type

Supplement Trt[1]	Control	Corn	Peas	SEM	*P*-value
DMI (lb)	10.56[a]	11.72[a]	13.50[b]	1.07	0.01
Forage DMI (lb)	10.57	9.67	11.45	1.12	0.14
DMD (%)	53.05[a]	55.13[a]	60.10[b]	2.01	0.06
OMI (lb)	9.42[a]	10.60[a]	12.20[b]	1.00	<0.01
OMD (%)	53.81[a]	56.07[a]	61.54[b]	1.61	0.03
NDFI (lb)	6.81	6.59	7.62	0.68	0.14
In-situ NDFD[2] (%)	36.09[ab]	34.48[a]	38.03[b]	1.06	0.09
Total, mMol	128.56	120.12	128.27	11.55	0.84
Acetate, %	68.82[b]	66.39[a]	69.38[b]	0.72	<0.01
Propionate, %	17.96[a]	18.93[b]	17.72[a]	0.27	<0.01
A:P	3.97[b]	3.58[a]	3.99[b]	0.05	<0.01

[abcd] Within a row, means without a common superscript differ.
[1]Control received no supplement. Corn received dry rolled corn coated in molasses. Peas received ground peas coated in molasses.
[2]NDF digestibility: measured at 24 hours, in-situ.

other feedstuffs are added to the diet such as supplements. While the level of supplementation was low (0.43% BW), there was still a difference in forage NDF digestibility between the DRC and FP supplements, with FP having greater fiber digestibility over the DRC supplemented cattle.

Rumen VFA Concentrations

Forage quality of the diet altered acetate and propionate relative proportions along with the acetate to propionate ratio (A:P). Acetate relative proportions increased in the LQ while propionate relative proportions increased in the HQ. The changes in relative proportions shifted the A:P in favor of the propionate and produced lower values in the HQ diets than the LQ diets (Table 1).

Acetate and propionate proportions, as well as the A:P ratio were affected by supplement type. Acetate proportions were greatest in the CON and FP, which were similar and greater than DRC. Propionate proportions were greatest in the DRC supplemented cattle with CON and FP being similar. The A:P ratio was decreased by all supplement types with DRC and FP being similar (Table 2).

Conclusion

Supplementing FP in forage diets of both low and high quality increased DMI, DMD, OMI, OMD, and 24 hour NDFD. These alterations from the CON and DRC could be associated with the lower starch level of FP as compared to DRC. VFA concentrations with field pea supplementation remain similar to the DRC treatment as opposed to having similar results to the CON treatments. Field peas did not appear to have the same negative associative effects on digestibility as DRC, but also did not produce VFA concentrations similar to DRC. The changes in VFA concentrations for FP could potentially be explained due to the shifts in microbial populations toward starch digesting bacteria which favors the production of propionate.

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Effect of Backgrounding System on Steer Performance and Carcass Characteristics

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Summary with Implications

The impact of 3 backgrounding systems: grazing corn residue with distillers grains supplementation at 0.86% BW/d, grazing an oats-brassica forage, or feeding a grower ration in a drylot on finishing performance and carcass characteristics were evaluated. Backgrounding phase gains were greatest for steers fed a grower ration in the drylot (3.58 lb/d), intermediate for steers grazing oats-brassica forage and then fed the grower ration for short period (2.65 lb/d), and least for steers grazing corn residue while supplemented distillers grains and then fed the grower ration for short period (2.22 lb/d). These backgrounding treatment differences did not affect ADG during the finishing period (3.73 lb/d). However, the 2 grazing treatments had greater DMI resulting in poorer F:G. Overall, these backgrounding systems did not affect carcass quality. Increased finishing phase cost for the 2 grazing treatments due to poorer F:G, can be offset by less input cost during backgrounding, but ultimately the cost effectiveness is dependent on the production resources and scenarios of each individual producer.

Introduction

In Nebraska there is significant opportunity to background spring born calves in the winter using forages produced from crop acres, including crop residues and double-cropped annual forages (cover crops). Therefore it is important to understand how backgrounding systems affect subsequent finishing performance and carcass characteristics. Research has suggested greater rates of gain during the backgrounding phase typically reduce finishing ADG. However, data regarding subsequent finishing performance and carcass characteristics of short yearlings grazing fall double-cropped forages, such as late summer planted oats and brassicas (turnips and radishes) are not available. Therefore, the objective of this study was to evaluate the subsequent finishing performance and carcass characteristics of backgrounding spring born calves by 1) grazing corn residue and feeding a distillers grains based supplement at 0.86% BW/d, 2) grazing an oats, turnip, radish mix double-crop planted after corn silage harvest, or 3) drylotting calves on a corn silage based grower ration.

Procedure

This experiment was conducted at the Meat Animal Research Center near Clay Center, Neb., utilizing 355 spring-born, MARC II composite steer calves. Calves receiving a grower ration were stratified by BW (610 ± 61 lb) and genetic line, and then assigned to 1 of 3 treatments: 1) corn residue grazing with distillers supplementation (CRD), 2) oat-brassica forage grazing (OBF) or 3) consuming a grower ration in the drylot (DGR). Each treatment had 4 replicates. On November 20, 2014, calves were sorted to their assigned group and were started on their treatment.

Calves in the DGR treatment were placed in 4 feedlot pens with 30 calves per pen. They were backgrounded on the grower ration (Table 1) for 54 d. Weight at the start for finishing was targeted to be 800 lb for all treatments. Thus an intermediate weight of DGR calves was taken prior to feeding on d 25 and used to calculate ADG to predict when the target weight of 800 lbs would be achieved.

Calves on CRD were placed in an irrigated corn field that was divided into 4 quarters with 31 acres and 30 calves per quarter. The corn yield from this field averaged 225 bu/ac. Calves were supplemented 6 d a week with 6.1 lb DM/steer/d of dried distillers grains mixed with limestone at 2% on DM basis. Calves on OBF were placed in an irrigated field planted after corn silage. The forage in the double-cropped field consisted of 55% oats, 15% radish, and 30% purple top turnips (DM basis). This field was divided into 4, 31-acre quarters. Each quarter was stocked at a rate of 3,617 ± 21 lb DM/steer and there were 25, 30, 30, and 30 calves per quarter. Double-cropped forage samples were taken on Nov. 6, Dec. 9, and Jan. 13, with the average nutritive value being 22.9% CP and 67.4% TDN [calcu-

Table 1. Composition of grower and finishing ration

Ingredient	Grower Ration DM basis, %	Finishing Ration DM basis, %
Dry Rolled Corn	—	55.8
Corn Silage	51.0	8.7
Alfalfa Hay	25.0	—
WDGS[1]	20.0	32.3
Supplement[2]	4.0	3.2
Analyzed composition		
NEm, Mcal/lb	0.75	2.15
NEg, Mcal/lb	0.47	1.48

[1]Wet distillers grains plus solubles.
[2]Supplement provided Rumensin at 28 g/ton of diet DM.

Table 2. Finishing performance of calves backgrounded by grazing corn residue and supplemented with dry distillers grains at 0.86% of BW (CRD), grazing a fall oats and brassica forage (OBF), or fed a grower ration in drylot (DGR).

	CRD	OBF	DGR	SEM[4]	*P*-value
Finishing Period[1]					
Starting BW, lb	805[b]	840[a]	805[b]	5.3	<0.01
Final Live BW[2], lb	1338[b]	1376[a]	1349[ab]	9.3	0.05
Final BW[3], lb	1358[b]	1404[a]	1367[b]	9.3	0.01
DMI, lb/d	22.3[a]	22.7[a]	20.9[b]	0.35	0.02
ADG[3], lb	3.47	3.54	3.53	0.062	0.68
F:G[3]	6.45[a]	6.41[a]	5.99[b]	0.055	<0.01

[a,b,c]Means within a row lacking a common superscript differ.
[1]All treatments were in the finishing phase for 160 d.
[2]Final live BW taken prior to feeding the morning before hauling to the packing plant, with a calculated 4% shrink.
[3]Carcass adjusted Final BW, ADG, and F:G using a common dressing percent of 63%.
[4]Standard error of the least squares mean.

Table 3. Carcass characteristics of calves backgrounded by grazing corn residue and supplemented with dry distillers grains at 0.86% of BW (CRD), grazing a fall oats and brassica forage (OBF), or fed a grower ration in drylot (DGR).

	CRD	OBF	DGR	SEM[2]	*P*-value
HCW, lb	858[b]	886[a]	862[b]	6.0	0.01
12th rib fat, in	0.58	0.61	0.61	0.019	0.62
LM area, in^2	13.2	13.2	12.8	0.11	0.06
Calculated YG	3.29[b]	3.48[a]	3.49[a]	0.047	0.02
Marbling	402	419	423	5.6	0.06
% Choice	44	59	56	4.1	0.06

[ab]Means lacking common letters are different
[1]Marbling Score: 400 = Slight[00], 450 = Slight[50], 500 = Small[00]
[2] Standard error of the least squares mean.

lated using the equation: TDN = 98.625-(ADF%*1.048)]. The CRD and OBF calves were removed from grazing after 64 d when the OBF biomass was thought to be limiting intake (1,287 ± 93 lb DM/ac; about 3 inches of growth remaining) and moved to the feedlot. Calves were maintained in their previous groups when placed into feedlot pens. Calves were weighed at entry to the feedlot, fed the grower ration for 6 days and prior to feeding on the 7th day weighed again. To allow the CRD and OBF calves to reach the 800 lb target BW before starting the finishing diet, CRD and OBF calves were fed the grower ration (Table 1) an additional 14 d (d 86 of trial) and a single weight was taken prior to feeding and then calves were transitioned to a finishing diet.

All treatments were provided Rumensin either by a free choice mineral for the two grazing treatments or a supplement in the grower ration. Performance during the background phase was reported previously (2016 Nebraska Beef Cattle Report, pp. 55–57). Backgrounding gains were greatest for DGR at 3.58 lb/d, intermediate for OBF at 2.65 lb/d (grazing plus grower ration), and least for CRD at 2.22 lb/d (grazing plus grower ration).

All calves were implanted with Revalor®-XS (Merck Animal Health) at the start of finishing and fed a common finishing diet (Table 1) for 160 d. Final weights were taken prior to feeding the morning before steers were hauled to the packing plant. Steers were not limit fed due to all calves consuming the same finishing ration for an adequate amount of time that gut fill stasis should have been met. Hot carcass weight, 12th rib back fat, LM area, marbling score, yield grade, and quality grade data was collected when calves were harvested.

A partial budget analysis was conducted to evaluate the costs of each backgrounding system. The feed cost in the budget included: distillers supplementation ($129/ton), and corn residue cost ($0.20/hd/d) for CRD calves, seed plus seeding costs ($38.90/ac or $41.58/hd), and N fertilizer ($27.36/ac or $29.25/hd) for OBF calves as well as costs of the grower ration ($114/ton DM) for all treatments. During the backgrounding period CRD and OBF calves were charged $0.10/d for yardage (fence and water maintenance) and CRD calves were charged an additional $0.10/d for the extra labor to feed their supplement. The yardage cost for feed calves in the feedlot was charged at $0.40/d. The finishing ration was $140.72/ton DM for all treatments.

Results

Finishing Performance

Body weight at the start of the finishing phase was greatest ($P < 0.01$) for steers grazing oats-brassica forage (840 lb) due to greater gains in the backgrounding phase than CRD calves and more days in the growing phase than DGR calves (Table 2). Body weight at the start of finishing was not different ($P = 0.92$) between DGR and CRD (805 lb). There was no difference in carcass adjusted ADG among the 3 treatments during finishing, resulting in the initial finishing BW ranking to be maintained throughout finishing. Dry matter intake did not differ ($P = 0.40$) between OBF (22.7 lb/d) and CRD (22.3 lb/d) calves, but were greater ($P = 0.02$) than calves placed directly in the drylot (20.9 lb/d). With the ADG similar among treatments, this 1.6 lb/d difference in DMI caused the calves in the grazing treatments (OBF and CRD) to have poorer ($P < 0.01$) F:G than DGR steers.

Carcass Characteristics

Calves on OBF had greater ($P = 0.01$) HCW (886 lb) than DGR (862 lb) and CRD (858 lb), which were similar ($P = 0.51$) (Table 3). This is due to the OBF steers having 30 lb more BW when entering the finishing phase.

Twelfth rib fat was not different ($P = 0.62$) among the treatments, with an average 12th rib fat of 0.60 inch. Marbling score tended ($P = 0.06$) to differ among treatments, with DGR (423) and OBF (419) not differing ($P = 0.59$), but DGR being greater ($P = 0.02$) than CRD (402) while OBF tended ($P = 0.06$) to be greater than CRD.

Table 4. Partial budget economic analysis[1] of three backgrounding systems: grazing corn residue plus supplemented with dry distillers at 0.86% of BW (CRD), grazing a fall oats and brassica forage (OBF) or fed a grower ration in drylot (DGR).

	CRD	OBF	DGR	SEM[6]	*P*-value
Growing period					
Grazing period					
Feed cost[2,3], $/hd	22.97	71.89	—	—	—
Yardage[4], $/hd	12.10	6.50	—	—	—
Drylot period					
Feed cost[5], $/hd	22.70	23.45	56.06	—	—
Yardage[4], $/hd	8.40	8.40	21.60	—	—
Total cost, $/hd	66.17	110.24	77.66	—	—
Cost of gain, $/lb	0.34[c]	0.48[a]	0.41[b]	0.011	<0.01
Finishing period					
Feed cost[5], $/hd	251.52	255.18	237.46	—	—
Yardage[4], $/hd	64.00	64.00	64.00	—	—
Total cost, $/hd	315.52	319.18	301.46	—	—
Cost of gain, $/lb	0.570[a]	0.565[a]	0.535[b]	0.0053	<0.01
Overall					
Total cost, $/hd	380.42	428.15	381.19	—	—
Cost of gain, $/lb	0.510[b]	0.540[a]	0.503[b]	0.0043	<0.01

[1]Excludes vet cost, interest and transportation.
[2]Distillers supplement $110/ton and corn residue $0.20/hd/d.
[3]Seed plus seeding $38.90/ac ($41.58/hd) and N fertilizer $27.36/ac ($29.25/hd).
[4]Yardage: drylot $0.40/d; feeding supplement $0.10/d and checking fence, water and calves while grazing $0.10/d.
[5]Grower ration $114/ton DM and Finishing ration $141/ton DM; Corn at $3.62/bu, Corn Silage at 10% the price of corn, Alfalfa hay at $97/ton, WDGS (85% DM) at 75% the price of corn, and Supplement at $250/ton.
[6]Standard error of the least squares mean.

The differences observed in marbling score are most likely explained by the numerical differences in 12th rib fat (i.e. degree of finish). Research has indicated that a 0.039 inch change in 12th rib fat will result in a 30 unit change in marbling score and a 12 percentage unit change in percent choice (2000 Nebraska Beef Cattle Report, pp. 20-22). Calves on the DGR treatment had a 0.028 inch more back fat than CRD calves. Therefore, we would predict a 20 unit greater marbling score for DGR than for CRD, which is similar to the 21 unit difference observed between these 2 treatments.

The LM area tended ($P = 0.06$) to differ among treatments, with OBF and CRD not differing ($P = 0.87$) but were greater ($P \leq 0.05$) than DGR. Calculated yield grade of OBF (3.48) and DGR (3.49) did not differ ($P = 0.88$) but were slightly greater ($P \leq 0.0.1$) than CRD (3.29). However, yield grade differences were extremely small and did not result in a difference in discounts or premiums.

Economics

A partial budget comparison of the treatments can be found in Table 4. These comparisons do not include veterinary costs, interest, or transportation. During the growing period the cost of gain for CRD was the lowest at $0.34/lb ($P < 0.01$), while the cost of gain for DGR calves was intermediate ($0.41/lb), and OBF had the greatest cost of gain ($0.48/lb). There are some scenarios such as when manure will be fall applied to provide nutrients for the next cash crop (and thus will be a source of N for the oat-brassica forage) or when seed cost is offset by payments from conservation stewardship programs, which alter the backgrounding costs of OBF and make this system competitive with the CRD steers during the growing phase. More details pertaining to these scenarios are presented in the 2016 Beef Report (2016 Nebraska Beef Cattle Report, pp 55–57).

During the finishing phase, the 2 grazing treatments had a greater ($P < 0.01$) cost of gain (OBF: $0.57/lb and CRD: $0.57/lb) than DGR ($0.54/lb). This difference is due to the greater DMI of grazing treatments and lack of difference in ADG during the finishing period. The overall cost of gain from weaning to slaughter was greatest ($P < 0.01$) for OBF steers ($0.54/lb) followed by CRD ($0.51/lb) and DGR ($0.50/lb), which were not different ($P = 0.25$). The lower cost of gain during the growing period for CRD calves did help offset the increased finishing cost due to DMI during the finishing period. Opportunity for reduced total cost of gains could have been achieved for the CRD steers if the winter grazing period had of been extended.

Conclusions

Utilizing corn residue with distiller supplementation or oats-brassica forages during the winter for backgrounding calves will not significantly impact gains or carcass characteristics during the subsequent finishing phase. However, increased DMI during the finishing phase could increase finishing input cost for the 2 grazing treatments over calves fed a corn silage-based ration during the backgrounding period. These increased finishing phase costs were offset by the lower growing cost of the calves grazing corn residue in this study. Ultimately, the cost effectiveness depends on the production resources and scenarios of each individual producer.

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Nutrient Content of Summer-Planted Oats after Corn Harvest and Grazing Performance

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Summary with Implications

Annual forages provide producers with an alternative grazing source in the fall. A cover crop grazing study was conducted following corn harvest to evaluate the steer ADG and yield of summer sown oats and turnips planted after either high moisture corn or corn silage production. The gain of steers grazing oats after silage was 1.29 lb/day, while the gain of steers grazing corn residue and oats after high moisture corn was 0.72 lb/day. Average oat forage production after silage harvest was 2857 lb/acre, while oat production following corn harvest was 523 lb/acre. Fall forage production of oats following corn silage harvest provided 133 lb of steer gain per acre, while corn residue plus oats following corn harvest provided 57 lb of steer gain per acre. Utilizing oats following silage harvest provides an opportunity for greater forage production and grazing as compared to following corn grain harvest.

Introduction

Planting annual forages in September following corn silage or grain harvest may provide producers with an alternative grazing source for backgrounding spring born calves in the winter. Oats and turnips are cool season species that can be planted in late-summer to produce fall forage. Utilizing oats alone or an oat and turnip mix after corn harvest may enable producers to have additional ground cover and produce grazeable forage. The timing of corn harvest can affect the amount of fall forage produced. Early harvested, corn silage (end of August to early-September) results in more growing degree days available for fall forage growth when compared to high moisture corn grain harvest (mid to late September). The objectives of this study were to: determine forage production and forage quality of late summer planted oats-turnip mix or oat monoculture planted after corn silage or high moisture corn harvest and evaluate performance of steers grazing oats produced after corn silage harvest or oats with corn residue produced in a high moisture corn system from November to January.

Procedure

Field and planting details

Pivot irrigated fields at the Eastern Nebraska Research and Extension Center (ENREC) near Mead, NE were drilled with 60 lb / ac of Horsepower oat and 5 lb / acre purple top turnip in a 7.5 inch row spacing on September 9, 2014 after corn silage (CS) harvest. On September 18, 2014 after high moisture corn (HMC) harvest, Horsepower oat and purple top turnip were drilled into the corn residue at 70 lb /ac and 5 lb / ac, respectively. Restrictions related to the herbicides used on the corn precluded grazing of the turnips, therefore no grazing occurred in year 1. In year 2, 90 lb / ac of Horsepower oat were drilled with a 7.5 inch row spacing on September 3, 2015 and September 17, 2015 following CS and HMC harvest, respectively. The 104-acre field was split in half (east and west) with half being planted to corn and half to soybeans and crops were alternated yearly. The 52 acres of corn were further split into two 13 acre replications of the two corn harvest treatments (HMC vs. CS). Three acres of each rep were not grazed, half having a fall crop planted and half not. Fertilizer was applied at 45 and 40 lb nitrogen per acre to all treatments in years 1 and 2, respectively.

Forage production measures

Initial forage mass was measured the last week of October. To measure biomass, three randomly selected 36 inch x 22.5 inch areas in each paddock were sampled. All above ground biomass was harvested at ground level, dried at 60°C, and weighed. The growing degree days (GDD) that accumulated between time of planting and yield measurement calculated by subtracting 32 from the average daily temperature for each day from planting date to date of biomass measurements and summing the resulting degrees. The resulting number (GDD) indicates the amount of heat that was available for plant growth.

A quality sample was collected in late October by randomly clipping forage at ground level at three locations within the paddocks. All quality samples were freeze dried and analyzed for DM in 105°C oven, crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), and organic matter (OM).

In March, ground cover was measured by marking points of ground cover over a 100-foot length.

Stocking rate and grazing

In year 1, there was no grazing of the oats-turnip mixture due to restrictions of herbicides use on the corn and the carryover effects on the cover crop. In year 2, steers grazed treatment paddocks beginning in November. Steers grazing oats after CS were stocked at 1.7 steers per acre, while steers grazing oats and corn residue after HMC were stocked at 1.3 steers per acre. Steers grazing after corn silage were allocated 1751 lb oat forage DM / steer based on the initial forage mass measurements. Steers grazing after HMC were allocated 399 lb oat forage DM and 2707 lb corn husk and leaf DM / steer (assuming 16 lb of leaf and husk material produced per bushel of corn with 220 bushel per acre corn yield).

Prior to grazing, all steers (initial BW= 468 ± 14 lb) were limit fed a 50:50 diet of alfalfa hay and Sweet Bran for five days, and then weighed three consecutive days prior to grazing to adjust for rumen fill. On day two of weighing, steers were assigned to

Table 1. Nutrient analysis of fall forage planted after corn silage or high moisture corn for both years[1]

	Treatment[2]			
	CS	HMC	SEM	*P*-value
Year 1[3]				
OM, %	84.8	86.5	0.26	0.05
CP, %	22.5	18.7	2.25	0.35
NDF, %	43.7	45.1	0.58	0.23
ADF, %[4]	24.8	21.6	0.66	0.08
IVOMD, %[5]	82.1	82.2	0.61	0.87
Year 2				
OM, %	83.8	84.4	0.39	0.36
CP, %	18.0	23.2	2.15	0.23
NDF, %	43.7	37.5	2.18	0.18
ADF, %	25.6	22.1	0.74	0.08
IVOMD, %	78.9	84.6	0.66	0.03

[1]All nutrients on a dry matter basis
[2]CS: Forage grazed after corn silage harvest; HMC: forage grazed after high moisture corn harvest.
[3]Year 1 mix composed of 60 lbs oats and 5 lbs turnips after corn silage and 70 lbs oats and 5 lbs turnips in HMC treatment. Year 2 composed of 90 lbs oats planted after corn silage and HMC.
[4]ADF (Acid Detergent Fiber): measure of less or indigestible fiber which is negatively correlated to energy of diet
[5]IVOMD (in vitro organic matter digestibility): measure of the digestibility of the organic matter in the diet

Table 2. Performance of steers grazing oats after corn harvest in 2015

	Treatment[1]			
	CS	HMC	SEM	*P*-value
Initial BW, lb	468	469	0.50	0.29
Ending BW, lb	548	513	16.8	0.27
ADG, lb	1.29	0.72	0.27	0.27
Gain, lb/acre	133	57	23.5	0.15

[1]CS: Forage grazed after corn silage harvest; HMC: forage grazed after high moisture corn harvest.

paddocks based on weight blocks. On day three of weighing, steers were implanted with Ralgro®. Grazing was initiated on November 13, and steers were removed from paddocks on January 4 after 62 days when oats and corn residue were fully utilized, meaning little to no leaf or husk and only oat stubble were present. At termination of grazing, steers were returned to the feedlot and were limit fed a 50:50 alfalfa and Sweet Bran diet for eight days followed by weighing three consecutive days to determine ending BW.

Data were analyzed with the MIXED procedure of SAS (SAS Institute, Inc., Cary, N.C.) with paddock as the experimental unit for forage analysis and steer performance.

Results

Forage production

In year 1, oats-turnip forage production of CS was 941 lb DM / ac (SEM = 104) and 343 lb DM / ac (SEM = 58) for HMC in late October. Growing degree days (GDD) were calculated to be 1358 for the oats-turnip planted after CS and 1142 after HMC.

In year 2, oats forage production was 2857 lb DM / ac (SEM = 93) for CS and 523 lb DM / ac (SEM = 95) for HMC. Greater oats production on CS paddocks as compared to the HMC paddocks was likely due to the earlier planting and thus the greater accumulation of GDD for fall growth (1714 vs. 1162 GDD, after CS and HMC, respectively).

Post-graze ground cover measurements showed that there was 63.2% ground cover by oat stubble after grazing on the CS paddocks, while there was 81.9% ground cover due to corn residue and minimal oat stubble after grazing HMC treatment. The HMC treatment had significantly more ground cover ($P < 0.01$; SEM = 2.68) than CS. These data show that after 62 days of grazing, there was a significant amount of ground cover to prevent erosion.

Forage quality

The nutrient content of samples collected in October of the oats-turnip mix in year 1 and oats in year 2 are reported in Table 1. In year 1, the oat turnip mix produced in the HMC (86.5%) treatment had a greater percentage of OM as compared to CS (84.8%), as well as, tended ($P = 0.08$) to have a lower ADF compared to CS (21.6% vs. 24.8% for HMC vs. CS, respectively). However, there was no difference in the IVOMD of oat-turnip mix planted after CS vs. HMC, 82.1 and 82.2%, respectively. In year 2, the OM content of the late summer planted oats did not differ between HMC and CS. Whereas, ADF tended ($P = 0.08$) to be lower for HMC (22.1%) than CS (25.6) and IVOMD was greater for HMC (84.6%) than CS (78.9%). Although, there were some differences in nutrient content in the fall forage produced due to planting date (CS vs. HMC), the quality of the forage was extremely high at either planting date. The nutrient analysis shows that late summer planted oats, with or without turnips, are high in protein, ranging from 18 to 23% CP and high in energy with IVOMD ranging from 78.9 to 84.6%.

Cattle performance

In year 2, the ADG of steers grazing oats planted after CS was 1.29 lb / d and 0.72 lb / d for steers grazing the oats plus corn residue in HMC paddocks (Table 2). However, given the low number of replicates (n = 2) ADG did not statistically differ among

treatments ($P = 0.27$; Table 2). Likewise, gain per acre was numerically greater but not statistically significant ($P = 0.15$) for steer grazing oats planted after CS (133 lb / ac) than for steers grazing HMC residue and oats (57 lb / ac).

In a previous experiment, (2016 Nebraska Beef Report, pp. 31-32) calves grazing corn residue with no supplement lost 0.18 lb of ADG. This suggests that the low amount of oats produced in the HMC system increased gains over grazing residue alone. With the stocking rate used in the present study, the seed plus seeding would have cost $23 / steer in the HMC system. Distillers supplementation of 0.5 lb DM / d (31 lb / steer for the entire period) would have resulted in the same gain but cost roughly $2.60 / steer at $150 / ton of DDGS. Steers grazing oats after CS gained 1.29 lb /d, and at the stocking rate used in this study, the cost of seed plus seeding cost $18 / steer. If calves would have been grazed on corn residue and supplemented with distillers to achieve a rate of gain of 1.29 lb / d, they would have needed to be supplemented at 3.0 lb DM / d (186 lb / steer for entire period), resulting in a cost of $14 / steer. Suggesting that from an economic standpoint, supplementing distillers on cornstalks provides a cheaper gain for producers. However, unlike corn harvested for grain where corn residue provides significant amounts of ground cover, there is a need to plant something in the fall to provide ground cover in corn silage systems. These data suggest that in early harvested fields, oats can be used to produce ground cover and provide a relatively low cost source of gains for calves.

Conclusions

These data suggest that there is an opportunity for fall forage production after corn silage harvest, but minimal fall production after HMC harvest. Moderate gains (1 to 1.5 lb / d) are possible for growing calves grazing summer planted oats in the late fall/early winter.

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Effect of Corn Residue Grazing or Baling on Subsequent Crop Yield and Nutrient Removal

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Summary with Implications

A 2-year study evaluated the effect of corn residue baling or grazing on subsequent yields, as well as, nutrient removal by baling at five locations in Nebraska. Three treatments were applied to each field: baled, grazed, and control (no baling and no grazing). Grain and stover yields were measured by hand harvest at maturity. No differences were observed among treatments for corn yield with baled having yields of 234 bu grain / acre, grazed with 239 bu grain / acre and control with 223 bu grain / acre. There was no difference in stover yield among treatments (8,326, 8,135, and 7,945 lb stover DM / acre for baled, grazed, and control, respectively). Results indicate that removing corn residue provides a potential feed resource with no negative impact on grain yield in the short term.

Introduction

The amount of corn residue in the Midwest has increased with increased corn production over the years. Opportunities exist to remove the corn residue from the field for feeding later, or grazing residue in the field. There continues to be questions about the effect of residue removal on corn grain yields in subsequent years. Baling of corn residue means that nutrients associated with residues are removed and require fertilization to be replaced. Because yields are the most important profit indicator for a crop farmer, it is necessary to evaluate possible changes in grain yield with residue removed either by baling or grazing. With corn residue baling, it is important to determine the amount of nutrients removed per acre from the field to determine potential impacts on fertilizer needs for the next planting. The objectives of this 2-year study were to determine how grazing or baling of corn residue affects subsequent grain yield, stover yield, and harvest index at multiple locations across Nebraska, and to calculate the amount of nutrients removed by baling corn residue.

Procedure

Study locations included Ainsworth, Norfolk, Odessa, Scottsbluff, Nebraska City, and Clay Center, all in Nebraska. In year 1 (2013), there were four locations (Ainsworth, Norfolk, Odessa, and Scottsbluff) and in year 2 (2014), two additional locations (Nebraska City and Clay Center) were added. At each location, there were 3 treatments: grazed, baled, and control (no grazing or baling) with 2 replications per treatment per location, except for the Nebraska City field, which had two fields with one field having 2 reps and the other having 3 reps, and the Clay Center location, which had 3 fields with each field having one replication. Treatments were applied to a site in Scottsbluff, but no hand harvest measurements were taken at this site, only baled samples were collected for nutrient analysis. Each field was in a continuous corn rotation, except for the Nebraska City site, which was in a corn-soybean rotation and the Scottsbluff site that was in a corn, dry bean, and sugar beet rotation. The Nebraska City location was rain-fed, Odessa had sub-surface drip irrigation and the other four sites were pivot irrigated. All locations were in no-till, except for the Ainsworth site, which was disked.

Grazed areas were fenced off, and cows were stocked based on corn yield and targeting 50% removal of husk and leaf components of the corn residue. Stocking rate was determined using the University of Nebraska's corn stalk grazing calculator. The baled replications were baled following corn grain harvest by the cooperator. The bales from each replication were counted and weighed. Bales were sampled by taking a core from each bale, and core samples were composited into a bag for each replication. Residue samples were sent to Ward Laboratories (Kearney, NE) for nutrient analysis (N, Ca, P, and K) which was used to determine pounds of N, $CaCO_3$, P_2O_5, and K_2O removed per acre.

Yield data were collected by hand harvest. For continuous corn sites, hand harvest was done once corn reached black layer stage of maturity. Corn plants were cut from 17.5 foot rows (3 rows per replication) at the top of the crown root node. Corn ears were removed, then the ear and remaining plant stover (husk, leaf, and stalk) were weighed separately. Subsequently, three cornstalks and three ears were taken as a subsample from each 17.5 foot bundle for dry matter analysis at 60°C. Ear corn samples were dried in the 60°C oven for 48 hours, then the corn grain was shelled. Cobs and grain went back into the oven separately for another 24 hours or until dry. Cob weights were included in the dry stover yields. Dry matter measurements from the grain and stover were used to calculate corn grain yield and stover (total biomass minus the grain) yield per acre. Harvest index was calculated based on the percentage of dry grain in total dry biomass (grain plus stover).

Soybeans were harvested when they reached about 13% moisture. Hand harvest yield of soybeans consisted of cutting two-17.5 foot rows at the base of the plant at ground level. Rows were bundled and each subsample was dried at 60°C until threshing of the soybeans. At threshing, samples of grain and stover were collected and dried in an oven at 60°C to measure dry matter. Dry matter oven weights for the grain and stover were used to calculate soybean grain yield and stover (total biomass minus the grain) yield per acre for the field.

Table 1. Corn and soybean yield data collected at locations across Nebraska.

	Treatment				
Item	Grazed	Baled	Control	SEM[1]	*P*-value
Corn grain yield, bu/acre[2]	239	234	223	5.09	0.18
Corn stover yield, lbs DM/acre[2]	8,135	8,326	7,945	218	0.59
Harvest Index, %[3]	62.3	61.3	61.0	0.62	0.44
Soybean grain yield, bu/acre[4]	59.1	61.3	62.0	3.46	0.83
Soybean stover yield, lbs DM/acre[4]	3,335	3,807	3,452	288	0.51

[1]SEM = Pooled standard error mean for response variable
[2]Corn grain and stover yield were measured at 4 cooperator sites: Ainsworth, Clay Center, Norfolk, Odessa
[3]Harvest index is the measure of the percentage of corn grain to total biomass (grain + stover).
[4]Soybean grain and stover yields measured only at Nebraska City site

Table 2. Pounds per acre of corn residue (DM basis) removed through baling from each location

	Year			
Cooperator	2013	2014	2015	SEM[1]
Ainsworth	3,461	7,306	5,234	483
Norfolk	4,631	3,873	4,578	483
Odessa	4,247	4,088	1,768	483
Nebraska City[2]	3,431	1,047	4,058	483
Clay Center[3]	—	5,716	4,585	395
Scottsbluff[4]	3,858	5,893	6,681	684

[1]SEM = Pooled standard error mean for response variable
[2]Two fields in rotation each year at NE City.
[3]Clay Center site was not set up until 2014.
[4]Field rotates each year, so same field not used every year.

Table 3. Nitrogen (lb N/ac) removed by baling corn residue across cooperator locations in Nebraska

	Nitrogen Removal				
Cooperator	2013	2014	2015	SEM[1]	*P*-value
Ainsworth	40.7[b]	84.1[a]	46.5[b]	4.40	< 0.01
Norfolk	46.7	45.2	48.7	4.40	0.26
Odessa	32.3[a]	39.2[a]	12.5[b]	4.40	0.02
NE City[2]	32.1[a]	10.9[b]	36.1[a]	4.40	< 0.01
Clay Center[3]	—	65.8	47.0	3.58	0.12
Scottsbluff[4]	30.2[b]	52.5[a]	46.8[a]	6.20	0.05

[ab]Means within row with differing superscripts are different ($P < 0.05$).
[1]SEM = Pooled standard error mean for response variable
[2]Two fields in rotation each year at NE City.
[3]Clay Center site was not set up until 2014.
[4]Field rotates each year, so same field not used every year.

In the spring following year 1, the percentage of ground cover was measured by marking points of ground cover over a 100-foot length.

Data were analyzed using the MIXED procedure of SAS with the response variables being yield, harvest index and nutrient removed. Location (nested within year) and treatment were considered fixed effects.

Results

There were no interactions ($P > 0.11$) between location and treatment for all yield and harvest index analyses, but the main effect of location was significant ($P < 0.01$), as expected. The weather patterns and topographic and soil characteristics among locations across Nebraska made each location unique. Corn grain yields ranged from 152 to 286 bu per acre across locations. However, no differences were observed among treatments ($P = 0.18$) for corn grain yield (Table 1). Most locations were irrigated, therefore, the effects of residue cover on soil moisture may not have been observed, additionally the two years of collection were both wetter than previous years.

There was a difference among treatments ($P < 0.01$) in the amount of ground cover in the spring with grazed having 77.5% cover, baled having 45.8% cover and control having 88.7% cover (SEM = 1.42). This demonstrates that grazing corn residue does not reduce soil cover as much as baling does and that a significant amount of cover remains after grazing.

The baled treatments had numerically greater corn grain yields than control plots. This may be due to more available N and less ground cover enabling the ground to warm up earlier. Nitrogen is needed to degrade C, and with less residue being recycled, a short term bump in yields may be recorded.

There was no difference ($P = 0.59$) in corn stover yield among treatments. Stover yields ranged from 5,236 to 10,656 lb dry matter per acre across locations. There was no difference ($P = 0.44$) in harvest index among treatments (62.3, 61.3 and 61.0 ± 0.62% for grazed, baled, and control, respectively). Harvest index is a measure of the percentage of grain produced relative to plant biomass. The proportion of corn grain is roughly two-thirds of the plant

Table 4. Calcium removed as $CaCO_3$ by baling corn residue across cooperator locations

	$CaCO_3$ Removal[1]				
Cooperator	2013	2014	2015	SEM[2]	*P*-value
Ainsworth	29.0[b]	59.3[a]	43.5[ab]	6.06	0.04
Norfolk	60.1	51.2	54.9	6.06	0.32
Odessa	31.3[a]	27.0[a]	10.6[b]	6.06	< 0.01
NE City[3]	44.3[a]	11.5[b]	34.0[a]	6.06	< 0.01
Clay Center[4]	—	46.2	37.6	4.95	0.44
Scottsbluff[5]	33.8	53.4	58.9	8.58	0.33

[ab]Means within row with differing superscripts are different ($P < 0.05$).
[1]Nutrient removed by baling in lbs / acre
[2]SEM = Pooled standard error mean for response variable
[3]Two fields in rotation each year at NE City.
[4]Clay Center site was not set up until 2014.
[5]Field rotates each year, so same field not used every year.

Table 5. Phosphorus removed as P_2O_5 by baling corn residue across cooperator locations

	P_2O_5 Removal[1]				
Cooperator	2013	2014	2015	SEM[2]	*P*-value
Ainsworth	7.89	8.77	6.62	0.977	0.13
Norfolk	4.33	3.72	3.30	0.977	0.29
Odessa	3.31	3.49	1.38	0.977	0.19
NE City[3]	2.72[a]	0.75[b]	2.93[a]	0.977	0.05
Clay Center[4]	—	6.90	5.26	0.798	0.39
Scottsbluff[5]	4.17	4.71	3.11	1.38	0.65

[ab]Means within row with differing superscripts are different ($P < 0.05$).
[1]Nutrient removed by baling in lbs / acre
[2]SEM = Pooled standard error mean for response variable
[3]Two fields in rotation each year at NE City.
[4]Clay Center site was not set up until 2014.
[5]Field rotates each year, so same field not used every year.

Table 6. Potassium removed as K_2O by baling corn residue across cooperator locations

	K_2O Removal[1]				
Cooperator	2013	2014	2015	SEM[2]	*P*-value
Ainsworth	70.1[c]	204[a]	157[b]	25.7	< 0.01
Norfolk	54.4	73.9	73.0	25.7	0.29
Odessa	88.5[ab]	136[a]	32.4[b]	25.7	< 0.01
NE City[3]	46.6[b]	71.6[a]	22.0[c]	25.7	< 0.01
Clay Center[4]	—	249	199	21.0	0.31
Scottsbluff[5]	95.4	171	285	36.3	0.10

[abc]Means within row with differing superscripts are different ($P < 0.05$).
[1]Nutrient removed by baling in lbs / acre
[2]SEM = Pooled standard error mean for response variable
[3]Two fields in rotation each year at NE City.
[4]Clay Center site was not set up until 2014.
[5]Field rotates each year, so same field not used every year.

aboveground biomass produced, but ranged from 55.1 to 66.0% across locations. The Norfolk location had the most variable harvest index due to the site receiving hail in 2014.

Soybean grain yield did not differ ($P = 0.83$) for grazed, baled, and control having grain yields of 59.1, 61.3, and 62.0 bushels per acre, respectively (Table 1). Soybean stover produced did not differ ($P = 0.51$) between treatments (3,335, 3,807, and 3,452 lb dry mass per acre, respectively).

Based on yield data, there is no evidence that baling, grazing, or leaving residue will change grain yield in the short term. However, Drewnoski et al. (2015 Nebraska Beef Report, pp. 53–55) observed that in the long term, over a 10-year period, grazing corn residue at UNL recommended rates did not impact the subsequent corn yields but improved soybean yields of field's managed in a corn-soybean rotation.

Among the six cooperator sites over the three years of baling, the average amount of corn residue removed per acre by baling ranged from 1,047–7,306 lbs per acre with the average removed being 4,390 ± 1, 577 lb DM per acre (Table 2). There was substantial variation among cooperators in the amount of residue removed relative to the total residue produced per acre with a range from 15–80%, suggesting that there were considerable differences in baling methods.

Nutrient removal from baling corn residue means that nutrients will eventually need to be replaced with fertilizer. Nitrogen, P, K, and Ca are four major nutrients that plants need for growth. The concentration of N in the baled residue ranged from 0.68–1.18% with an average of 0.96 ± 0.162%. The concentration of Ca in the bales ranged from 0.24–0.53% with an average of 0.37 ± 0.09%. The concentration of P in the baled residue ranged from 0.04–0.19% with an average of 0.08 ± 0.033% P and the K in the baled residue averaged 1.11 ± 0.45% with a range of 0.51 to 1.91% K.

The amount of N removed by baling corn residue is listed in Table 3 and varied across location ($P < 0.01$) ranging from 10.9 to 84.1 lb N /acre with an average of 42.3 ± 17.3 lbs removed per acre. The amount of Ca (reported as $CaCO_3$ equivalents) is shown in Table 4 and ranged from 10.6 to 60.1 lb $CaCO_3$/acre with an average of 37.3 ± 16.3 lbs $CaCO_3$ /acre. Phosphorus removal (reported as P_2O_5 equivalents) is

shown in Table 5. The amount of P removed ranged from 0.75 to 8.77 lbs P_20_2 /ac with an average of 4.31 ± 2.18 lbs P_2O_5. Lastly, K removal (reported as K_2O equivalents) is shown in Table 6 with the range among locations being 22 to 285 lb K_2O/ acre.

Conclusions

Results indicate that, in the short term, removing corn residue through grazing or baling provides a potential feed resource with no negative impact on grain yield or harvest index. However, baling results in more loss of ground cover than does grazing. Baling also results in removal of N, P, K, and Ca. Nutrient removal by baling varied considerably among cooperators and among year within cooperators. These data demonstrate that it is important to weigh and sample bales to have an accurate estimate of the amount nutrients that need to be replaced after baling of corn residue.

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Effect of Long-Term Corn Residue Grazing on Soil Properties

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Summary with Implications

An experiment was conducted to evaluate the effect of long-term (16 years) corn residue grazing with cattle on soil compaction, soil structure, soil organic matter, and nutrients. Three treatments: 1) fall grazing (November through January; 1.8 to 2.5 AUM/ac), 2) spring grazing (February to middle April; 2.3 to 3.1 AUM/ac), and 3) control (no grazing) under a no-till irrigated corn-soybean system in eastern Nebraska were studied. Crop yields were increased and soil bulk density and cone index (parameters of soil compaction), wet soil aggregate stability (parameter of soil structural quality), and organic matter content were not affected by grazing during the fall. Spring grazing slightly increased crop yields while wet soil aggregate stability, bulk density, and organic matter content were unaffected. During spring grazing, only cone index was increased, but not above threshold levels. Crop residue grazing in the fall has no effect on soil and any effect from spring grazing is biologically unimportant.

Introduction

Corn residue grazing is an important forage option under increasing costs of feed grains and hay and decreasing grassland area. However, determining the impact of grazing corn residue on soils and crop yields is very important. Data from long-term grazing experiments are needed to better understand the impacts of residue grazing on soil properties and their relations with crop yields. This information can assist with developing integrated crop-livestock systems in Nebraska and in the Midwest. Particularly, little is known about the potential effects of cattle grazing on soil quality parameters in irrigated systems in the western Corn Belt. Thus, a study was conducted to determine the impact of cattle grazing on soil compaction, structural quality, organic matter, nutrients and to determine whether changes in soil properties due to grazing can impact corn and soybean yield in an irrigated no-till corn-soybean system after 16 years of residue grazing management in eastern Nebraska.

Procedure

This study was conducted in late spring 2015 on a long-term corn residue grazing experiment established in 1997. The experiment was established on 90 ac of irrigated cropland managed at the Agricultural Research and Development Center of the University of Nebraska-Lincoln located near Mead, NE. The soil is a Tomek silt loam (0 to 2% slope). The experiment had three treatments: 1) fall/winter grazing (November through late February), 2) spring grazing (late February to the middle of April), and 3) control (no grazing) replicated twice. Grazing treatments were applied using stocker cattle (500 to 700 lb BW). Fall grazing treatment had a stocking rate of 1.8 to 2.5 AUM/ac (1997-2015). From 1997-1999, spring grazing treatment had a stocking rate of 0.9 to 1.3 AUM/ac. Beginning in 2000, the stocking rate for spring grazing treatment was modified to 2.3 to 3.1 AUM/ac. The crop rotation at the experimental site was corn-soybean. Impacts of the three treatments on long-term crop yields were previously presented (2015 Nebraska Beef Report pp. 53-55). For the present study, only the corn phase plots, which had been managed under no-till since the experiment inception for 16 years, were studied.

To assess the impacts of grazing on soil compaction, indicators of soil compaction such as cone index and bulk density were studied. Cone index was measured using a hand cone penetrometer, which mimics the root penetration in the soil. The penetrometer was pushed into the soil at a rate of approximately 1 inch per second. Five measurements were performed per plot. The measurement soil depths were: 0-2, 2-4, 4-6, and 6-8 inches. The penetration resistance values were converted to cone index (MPa) by dividing penetration resistance with basal cone area. Bulk density refers to the mass of dry soil per unit volume of soil. It was measured using intact soil cores (2 inch by 2 inch) from the 0-2, 2-4, 4-6, and 6-8 inch soil depths. Two cores were collected per plot. The cores were trimmed, weighed, and oven dried at 221° F for at least 24 h to determine the gravimetric moisture content and bulk density of the soil.

Bulk soil samples collected from the 0-2 and 2-4 inch depth were used for the analysis of soil organic matter, nutrients, and wet aggregate stability (soil structural quality parameter). Soil samples were air dried, passed through 2 mm sieve, and analyzed for pH, organic matter, nitrogen, potassium, phosphorus, calcium, magnesium, and sulfur. To assess the impact of grazing on soil structure, wet aggregate stability was determined using 4.75-8 mm aggregates by the wet sieving procedure. The wet aggregate stability indicates the resistance of soil against external disruptive forces (i.e., raindrop impacts during erosion) as well as efficiency of soil to hold soil C and other nutrients. Cone index measurements and soil sampling were conducted on non-wheel trafficked positions within each plot.

Data on soil properties were analyzed with grazing treatments (spring grazing, fall grazing, and control) as main effect and replications as random effect using PROC MIXED in SAS. Treatment effects were considered significant at the 0.10 probability level.

Results

Fall grazing did not affect cone index (Figure 1) which mimics resistance to root penetration, bulk density (Figure 2) which indicates the amount of pore space in the

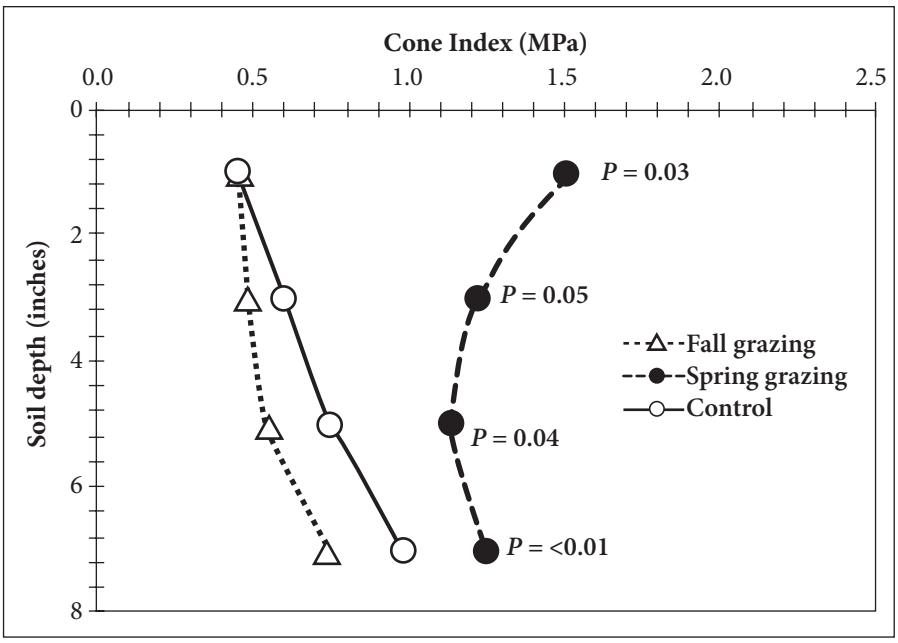

Fig. 1. Soil-depth distribution of cone index (soil compaction parameter) for the 0 to 8 inch depth as affected by 16 years of cattle grazing of corn residues under irrigated no-till system on a Tomek silt loam in eastern Nebraska. The *P*-values are reported for each depth interval.

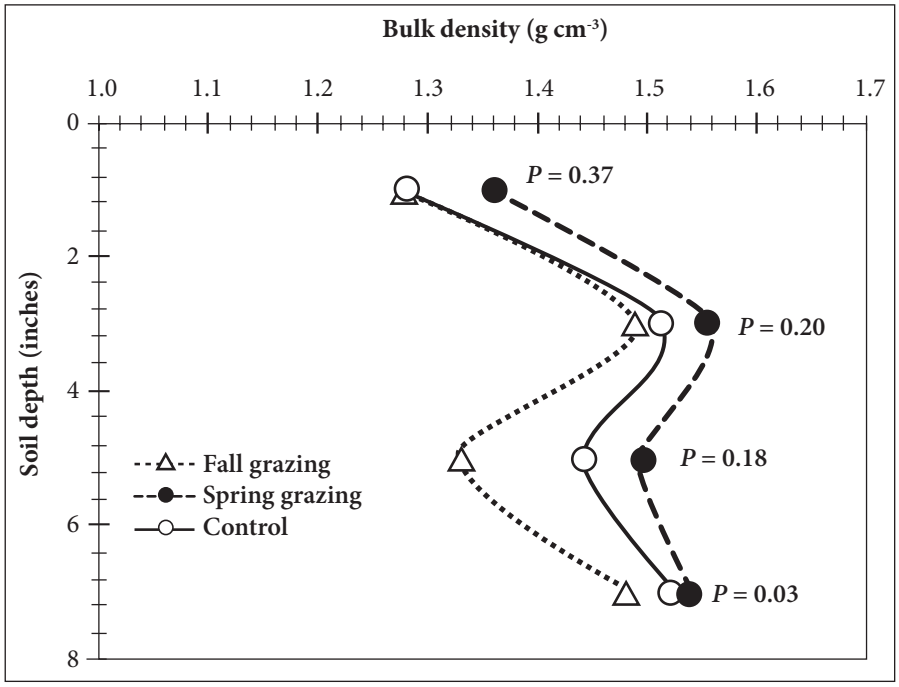

Fig. 2. Soil-depth distribution of bulk density for the 0 to 8 inch depth as affected by 16 years of cattle grazing of corn residues under irrigated no-till system on a Tomek silt loam in eastern Nebraska. The *P*-values are reported for each depth interval

soil and wet soil aggregate stability which is an indicator of the soils ability to resist water erosion. Both corn and soybean yields following corn grazing were significantly ($P < 0.10$) improved by fall grazing (2015 Nebraska Beef Cattle Report, pp 53-55). The spring grazing treatment was specifically designed to determine if heavy stocking in the spring after the soil is thawed would affect soil properties. Soybean yield increased while corn yield was unaffected by spring grazing. Soil bulk density (Fig. 2) and wet aggregate stability were not affected by spring grazing. Only cone index (Fig.1) was significantly increased. The values (1.2 to 1.5 MPa) are, however, below the threshold level of 2.0 MPa. The threshold level is the level where plant root growth is expected to be inhibited. Thus, this finding indicates that that even long term spring grazing at high stocking rates had no effect on soil properties of biological significance.

Concerning soil fertility, grazing treatments had no significant effect on soil organic matter concentration, but the numerical values were greater under fall and spring grazing than under control (Table 1). This indicates that long-term removal of corn residues by grazing did not have any negative effects on soil organic matter levels, which may be due to the following reasons. First, cattle grazing does not remove large amount of residue. The residue removal rate by cattle grazing is often <25%. In the current study, it was estimated that the stocking rates utilized would result in 10 to 13% removal of corn residue in the fall grazing treatment, while the residue removal rate in the spring grazing treatment would range between 6 and 9% in the first 3 years and between 16 and 22% in the last 11 years. Thus, significant amounts (≥ 3.2 ton/ac or >78%) of residue were present on the soil surface to protect soil from erosion and as a source of C to soil. Second, grazing cattle adds manure to soil, which can be a source of more stable C than crop residues. In addition, cattle trampling may incorporate the residues into the soil, preventing them from photo-oxidation. Such mechanisms reduce the decomposition rate of soil organic matter, which can help with maintaining the organic matter level in the soil.

Grazing treatments had no significant effect on soil pH and nutrient concentrations except for calcium and sulfur (Table 1). While one can assume that grazing

Table 1. Impact of 16 years of corn residue grazing on soil fertility and related soil chemical properties (averaged across 0-2 inch and 2-4 inch soil depth) on Tomek silt loam in eastern Nebraska[1]

Treatment	Organic matter	pH	Nitrate-N	Available P	Exchangeable K	Exchangeable Ca	Exchangeable Mg	S
	%				ppm			
Fall grazing	4.2 ± 0.8	6.3 ± 0.4	5.6 ± 2.0	14.3 ± 7.5	354.9 ± 72.8	2337[b] ± 250	352.1 ± 73.0	10.6[b]± 1.7
Spring grazing	4.5 ± 1.0	6.4 ± 0.4	8.1 ± 5.4	18.5 ± 13.1	398.4 ± 90.9	3009[a] ± 477	499.0 ± 139.9	12.9[a] ± 2.5
Control	3.8 ± 0.6	6.7 ± 0.5	4.2 ± 2.2	22.8 ± 18.4	354.3 ± 58.6	2685[a] ± 481	417.3 ± 157.0	9.3[c]± 1.7
P-value	0.14	0.47	0.16	0.70	0.37	0.09	0.20	0.02

[1] Reported as mean ± Standard deviation
[abc]Means followed by different letters in a column indicate significant differences among treatments

should reduce the soil nutrients as grazing cattle remove nutrients with corn residues, it is also important to consider that most of the nutrients taken up by grazing cattle are returned to the soil as manure. In addition, the growing steers received supplements of minerals and protein. The retention of these nutrients in cattle is small and, in essence, cattle excreta acts as a fertilizer source to soil. These results concerning soil fertility and grazing suggest that corn residue grazing has no or positive effects on soil fertility.

Conclusion

The results of this study can have large implications for the development of integrated crop-livestock systems in the western Corn Belt in general and in Nebraska in particular. Our findings suggest that grazing of corn residues does not have detrimental effects on soil properties even in the long term under the conditions of this study. Overall, grazing of corn residues under no-till corn—soybean systems at the stocking rates targeted to remove 10 to 20 % of residue can provide additional feed for livestock in this region.

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Effect of Harvest Method on Digestibility of Corn Residue

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Summary with Implications

Corn residues can be an economical forage source for producers and advanced harvest methods have increased the quality of baled residue. A digestion study was conducted to evaluate the effects of harvest method of corn residues (low-stem, high-stem, and conventional) on digestibility in lambs. Samples from total fecal collection were dried 1 of 3 ways to determine effects on digestibility estimates. Corn residue containing low-stem had greatest overall digestibility with high-stem residue being intermediate and conventional harvesting having the lowest digestibility. Drying method had no effect on digestibility estimates.

Introduction

Advancements in harvest technologies have improved the feeding quality of baled corn residue. The New Holland Cornrower corn head allows producers to adjust the proportion of stem being cut and baled. Changing the bale composition by increasing the ratio of husk and leaf to stem allows for improved digestibility, due to the greater digestibility of husk (*2016 Nebraska Beef Cattle Report*, pp. 76–78). Previous experiments (*2016 Nebraska Beef Cattle Report*, pp. 81–83) have reported when the proportion of stem in the baled residue is reduced, *in vitro* OM digestibility (IVOMD) improves. Additionally, improved ADG was observed with low-stem residue (1.71 lb), compared with conventionally baled corn residue (1.39 lb).

In vitro procedures are variable, an issue often corrected by using known standards from *in vivo* trials. Developing standards for residues is important to allow for proper adjustments to *in vitro* digestibility estimates. Various methods are used to dry samples during *in vivo* trials which may affect the digestibility estimates. The objectives of this study were to 1) determine the effect of harvest method (low-stem, high-stem, and conventional) on digestibility and quality of corn residues and 2) determine the effect of drying method for feces on digestibility estimates.

Procedure

An 85-d digestion study was conducted utilizing 9 crossbred wethers (initial BW = 93.4 lb, ± 16.3 lb) divided into 3 blocks based on initial BW. Wethers were assigned randomly to 1 of 3 treatments. The treatments consisted of 3 residue-based diets containing corn residue harvested with 1 of 3 methods (low-stem, high-stem, and conventional). All diets contained 70 % residue, 27% Sweet Bran®, and 3% brome grass hay (DM basis, Table 1). Corn residues and brome grass hay were ground using a 1-in screen. Low-stem and high-stem corn residues were obtained using a New Holland Cornrower Corn Head (Straeter Innovation, Inc.). The Cornrower corn head was described in the 2015 *Nebraska Beef Cattle Report* (pp. 62–63) and harvested 2 rows of stem for the low-stem corn residue bales and all 8 rows of stem for the high-stem corn residue. Conventional harvest method was also used on the same field to obtain conventionally harvested corn residue bales (raked and baled). The digestion study consisted of 4 periods in which the experimental treatments were applied. Sweet Bran® and brome grass hay were fed at a 9:1 ratio in a fifth period for determination of residue digestibility by difference. This allowed for calculation of total fecal output from the Sweet Bran® and brome grass that contributed to fecal output of the other 4 periods. Digestibility of the residue diets were correct by subtracting the contribution of Sweet Bran® and brome grass hay in feces.

The periods were 17 d in length allowing for 10 d of adaptation and 7 d for total fecal collection. Wethers were placed in metabolism crates with fecal bags on the evening of d 10. Feed was offered twice daily at 0800 and 1600 hrs with 50% of daily DM fed at each feeding. Feed refusals were collected each morning at 0800 and fed back to wethers with adjusted 0800 feeding to prevent sorting of least digestible plant parts. Samples of individual feedstuffs were taken on d 10 and d 14 and dried to correct for DM of each period. At the end of each period, feces were composited and mixed. Subsamples were taken and dried utilizing

Table 1. Diet composition (% DM)

	Low-stem	High-stem	Conventional	SBB[1]
Low-stem corn residue	64.18			
High-stem corn residue		64.18		
Conventional corn residue			64.18	
Sweet Bran®	29.76	29.76	29.76	86.24
Brome grass hay	3.31	3.31	3.31	9.59
Limestone	0.75	0.75	0.75	2.17
Supplement	2.00	2.00	2.00	2.00

[1]SBB represents a 9:1 ratio diet of Sweet Bran® to brome grass hay.

Table 2. Effect of drying method on digestibility estimates.

	60°C	100°C	Freeze Dry	SEM	*P*-value
OMD, %	52.0	52.8	52.7	0.69	0.63
NDFD, %	52.8	52.4	51.8	0.73	0.62

Table 3. Effect of harvest method of corn residue on intake and total tract digestibility.

	Low-stem	High-stem	Conventional	SEM	*P*-value
DM					
Intake, %BW/d	1.36	1.43	1.49	0.11	0.45
digestibility, %	51.74[a]	47.22[ab]	46.05[b]	1.85	0.05
OM					
Intake, %BW/d	1.31	1.32	1.40	0.10	0.60
digestibility, %	55.56[a]	51.05[b]	51.41[b]	1.72	0.06
NDF					
Intake, %BW/d	1.13	1.12	1.10	0.08	0.94
digestibility, %	58.53[a]	52.37[b]	44.46[c]	1.85	< 0.01

[a,b,c]Means with differing superscripts differ ($P < 0.05$)

1 of 3 techniques: 1) 60°C forced air oven for 72 h; 2) 100°C forced air oven for 72 h; or 3) freeze drying. Dried samples were composited and ground through a 1-mm screen of a Wiley mill. Feedstuff samples were ground first through a 2-mm screen of a Wiley mill and additionally through a 1-mm screen. Samples were then analyzed for DM, OM, and NDF.

Data were analyzed using the MIXED procedure of SAS (SAS Institute, Inc., Cary, NC). Lamb served as the experimental unit with period included in the model as a fixed effect. The effect of drying method, harvest method, and lamb were examined.

Results

Drying method did not affect digestibility determination for either OM digestibility (OMD) or NDF digestibility (NDFD; $P = 0.63$ and 0.62; respectively; Table 2). Intakes and digestibility estimates are reported for residue with Sweet Bran® and brome grass hay component removed (Table 3). Intakes were calculated from feed samples dried with the 60°C forced air oven. The Sweet Bran® and brome grass hay component had digestibility estimates of 76.0, 79.1, and 75.5% for DM, OM, and NDF; respectively. No differences in DM intake, OM intake or NDF intake were observed among residue types ($P > 0.45$). Low-stem had greater DM digestibility (DMD) than conventional ($P = 0.02$) and had a tendency to be greater than high-stem ($P = 0.06$). There were no differences in DMD ($P = 0.63$) or OMD ($P = 0.86$) between high-stem and conventional residue. High-stem and conventional both contained all 8 rows of stem, supporting the findings that DMD and OMD were similar allowing an average estimate (47 and 51%, respectively), to be used for the high-stem and conventional residues. High-stem had a NDFD greater than conventional ($P < 0.01$). This observation may suggest the conventional harvest method lost husk and resulted in a larger proportion of stem being gathered into the bale during raking. Low-stem had the greatest OMD and NDFD ($P < 0.05$) compared with high-stem and conventional which supports previous findings that by decreasing the proportion of stem in the bale, the quality of the corn residue increases.

Conclusions

Harvest methods available allow the proportion of stem to be adjusted in the bale. The lack of difference in overall digestibility between high-stem and conventional would suggest similar proportion of plant components were harvested. Decreasing the number of stems cut to produce a low-stem bale, led to an increased overall digestibility which is likely due to the increased proportion of husk, leaf, and cob compared to the proportion of stem. Increasing the proportion of highly digestible components of corn residue in a bale can lead to increased quality.

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Summer Cocktail Forage Research in the Panhandle of Nebraska

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Summary with Implications

Four annual forage mixtures containing brown mid-rib sorghum sudangrass or German foxtail millet, cowpeas or soybeans, and forage collards were compared to the sorghum sudangrass or millet as monocultures in the Nebraska High Plains on dryland acres to determine the tonnage, crude protein, and digestibility available for beef cattle. The forage mixtures and the millet resulted in greater crude protein than the sorghum sudangrass. Total digestible nutrients of the mixers were similar. Sorghum sudangrass resulted in the most tonnage. These forage options could have been hayed or windrow grazed in the fall and would have likely resulted in 1.5–2.0 lb/d gain for 500 lb calves. Grazing these forages in the summer would have likely resulted in better quality but would require rotational grazing management. Agronomic impacts of these mixtures on the subsequent crop were not measured. Foxtail millet was the most economical crop to produce.

Introduction

The Nebraska Panhandle is in a unique environment in that it has low rainfall (12–14" annually) and also a high elevation (3800-just over 5000 ft.). The challenge this creates is that most permanent pastures are cool season predominate and therefore have a summer slump resulting in low quality and quantity. The additional challenge is in planting annual forages to supplement the permanent pastures. The high elevation delays soil warm up and the lack of moisture can make emergence a challenge.

Across the Midwest, forage cocktail mixtures have been gaining popularity in crop rotations. Typically at least three components are included in these mixtures: an annual grass for biomass production, a legume to add nitrogen to the soil, and a brassica or some deep rooted crop to alleviate soil compaction. While it is important to leave some residue of these crops to prevent erosion and capture moisture, if at least some utilization of the crop could be realized for cattle production, it would reduce grazing pressure on permanent pastures that often need relief from drought. Therefore, four summer annual mixtures were compared with two monocultures and evaluated for yield, crude protein (CP) and total digestible nutrients (TDN) calculated from acid detergent fiber (ADF) for beef cattle.

Procedure

Six treatments were evaluated as forage options for beef cattle in western Nebraska. The forages planted were 1) a monoculture of brown mid-rib (BMR) sorghum sudangrass (9 lb/ac), 2) a monoculture of German foxtail millet (8 lb/ac), 3) BMR sudangrass, soybeans, and a forage collard (10/20/2 lb/ac, respectively, 4) German foxtail millet, soybeans, a forage collard, 6/20/2 lb/ac, respectively, 5) BMR sudangrass, cowpeas, and a forage collard (10/18/2 lb/ac, respectively, or 6) German foxtail millet, cowpeas, and a forage collard (6/18/2 lb/ac, respectively). The plots were planted into proso millet stubble and hard red winter wheat was the subsequent crop planted that respective fall. Each treatment was replicated three times each year for two years. The forages were planted June 27and harvested September 9 in 2014 and were planted June 26 and harvested September 5, 2015 on dryland acres.

Results

Visual observation indicated the soybeans come up in 2014 but the cowpeas did very well. In 2015, both legumes emerged but production was somewhat limited in some plots. The tons of dry matter produced, crude protein (CP), TDN, and ADF of both years combined are shown in Table 1. The BMR sudangrass and the BMR sudangrass, soybeans, and forage collard produced the most tonnage with the German foxtail millet being statistically similar to the BMR sudangrass, soybeans, forage collard mix. Possibly, the reduced yield of the soybeans in the mixture made those treatments similar. The crude protein was lowest in the BMR sudangrass monoculture, most likely a function of the increased tonnage for that treatment. Total digestible nutrients were above 65% for all treatments making all the forage combinations a good quality forage resource for grazing cattle or to be used as a

Table 1. Tons/ac, CP, TDN, and ADF of summer annual monocultures and mixtures

	Tons/acre DM	CP, %DM	TDN, % DM	ADF, % DM
BMR Sudangrass	2.3[a]	7.3[a]	65.4[a]	33.2[a]
Foxtail Millet	1.8[bcd]	9.7	66.2[a]	32.7[a]
Sudan/soybeans/collards*	2.0[ac]	9.8	67.3[ab]	31.5[ab]
Millet/soybeans/collards*	1.5[d]	11.9	69.4[b]	29.6[b]
Sudan/cowpeas/collards	1.5[d]	10.4	69.1[b]	29.7[b]
Millet/cowpeas/collards	1.3	11.7	67.3[ab]	31.3[ab]

Means with unlike superscripts differ ($P < 0.05$).
*Soybeans did not contribute any dry matter in year 1.

Table 2. Seed, dry matter production, crude protein, and total digestible nutrients cost per acre of summer monocultures and mixtures

	Seed cost/acre, $	Cost/acre for DM tons produced, $	Cost/acre CP tons produced,$	Cost/acre tons of TDN produced, $
BMR Sudangrass	13.50	5.87	80.41	8.97
Foxtail Millet	4.50	2.50	25.77	3.78
Sudan/soybeans/ collards*	31.00	15.50	158.16	23.03
Millet/soybeans/ collards*	19.00	12.67	106.44	18.25
Sudan/cowpeas/collards	34.00	22.67	217.95	32.80
Millet/cowpeas/collards	22.50	16.92	144.64	25.15

hay crop. Acid detergent fiber was lowest for treatments containing mixtures.

The cost of the seed and the subsequent cost of the tons of forage DM, CP, and TDN were calculated (Table 2). Fertilizer, planting, and harvesting costs were not included in the calculations as they were assumed to be the same for each treatment. The monoculture of German Foxtail Millet produced the least expensive tons of DM, CP, and TDN. Adding the legumes and brassica to the annual grass substantially increased the cost of producing the forage. This study did not look at agronomic impacts of planting cocktails, only the quality of the forage mixtures for beef cattle. The agronomic benefits on the subsequent crop would need to be substantial to offset the production costs of the mixtures. As previously mentioned, the crops were planted the last week of June. Possibly, more summer growth would have occurred if the crops had been planted the second week of June. Previous research at the High Plains Ag Lab near Sidney, NE has indicated that the window of opportunity for planting summer annuals in the Panhandle is fairly narrow. In 2014 the rainfall totals for the area were 3.42, 0.35, and 2.91 inches for June, July, and August, respectively. As a result of the limited rainfall in July, the forage did not experience a lot of growth in July and would have been difficult to graze at that time. Rainfall returned to the area in early August and the forages grew rapidly. For producers trying to manage summer annuals for grazing, this would have been challenging. In 2015 the rainfall totals were 2.10, 1.64, and 0.54 inches for June, July, and August, respectively, resulting in more consistent growth.

These results suggest if a producer wanted the forages in this experiment for fall windrow grazing or winter hay, they did produce acceptable tonnage and quality by early September. However, the expense of the seed must be carefully evaluated relative to the producers' production and agronomic goals. This research was funded by the Nebraska Cattlemen's Foundation and the seed was supplied by Green Cover Seed in Bladen, NE.

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In Situ Digestibility of Residue Parts of Corn Planted in Different Populations and Row Widths

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Summary with Implications

Plant density can be changed by altering row width and/or number of plants within a row. The use of narrower rows at seeding may increase yield and reduce plant- to-plant competition. Corn seeds were planted at 2 row widths (15 and 30-inch rows) and 3 plant populations (25,200, 35,000 and 54,000 seeds / acre). Samples of corn residue were collected 4 dates (October 8, October 24, November 5 and November 19) post-harvest and separated into cob, stem, leaf and husk to determine changes in quality over time. The greatest plant population increased the NDF content and NDF digestibility of husk, NDF and true digestibilities of cob, NDF content of stem, and decreased the true digestibility of the stem. The NDF content of the leaves and stem increased over time while the NDF and true digestibilities of cob decreased over time. Row width did not affect the corn residue. Planting densities and management strategies can affect the digestibility of leaf and husk and may impact residue quality.

Introduction

Plant density can be changed by either altering row width and/or number of plants within a row. The use of narrower rows at seeding may increase yield per area and reduce plant- to-plant competition by increasing the distance between plants in a row, which allows more efficient use of light, water and nutrients. However, corn silage quality is usually inversely proportional to plant yield (2013 *Nebraska Beef Cattle Report*, pp. 42–43) and decreases as plants mature and NDF content increases (2015 *Nebraska Beef Cattle Report*, pp. 56–58). Digestibility also may differ between parts of the corn residue, and had been demonstrated to be greater for husk and lower for stem and cob (2015 *Nebraska Beef Cattle Report*, pp. 59–61). However, the impacts of plant population and row spacing on NDF content and digestibility of corn residue have not been evaluated. Therefore, the objectives of this project were to evaluate the NDF digestibility of residue parts for corn planted in different row widths and populations over time.

Procedure

The experiment was conducted at the University of Nebraska—Lincoln Eastern Nebraska Research and Extension Center near Mead, Neb. Corn seeds of hybrid Stine 9733 and 9728 were planted on May 6, 2013 at 2 row widths: 15 and 30-inch rows, and 3 populations: 25,200, 35,000 and 54,000 seeds / acre. Additionally, corn plants were harvested for grain and corn residue samples collected at four dates October 8, October 24, November 5 and November 19 (Julian Dates 281, 297, 309 and 323 days, respectively). Plots were divided into 4 quarters; each quarter was a replication of the treatments. Samples from each quarter consisted of ten plants in a row representative of the field and were separated into stem, leaf blade/sheath, husk/shank and cob. Samples were dried in a forced air oven at 60°C for 48 hours and ground through a 2-mm screen in a Wiley mill and analyzed for *in situ* NDF digestibility. The NDF *in situ* digestibility was expressed as a percentage of the original NDF content determined using a fiber analyzer (ANKOM Technology Corp., Fairport, NY, USA). Two ruminally cannulated steers were used for this study were fed a mixed diet consisting of 70:30 forage- to-concentrate ratio (DM-basis). Approximately 1.25 g of sample were weighed into Dacron bags (50 µm pore size) with 2 bags per sample per steer. Due to the number of bags, four runs of incubations were performed, one run per replication. Forty-eight bags were placed in a mesh bag and four mesh bags were placed in each steer during each incubation period. After 36 hour incubation, bags were removed from the steers, rinsed 5 times in washing machine using a 1 min agitation and 2 min spin cycle and analyzed for NDF content. Bags were dried in a forced air oven at 100°C for 12 hours and then weighed. 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 (NDF content X NDF digestibility). The leaf samples collected on October 8 were not retained and therefore could not be analyzed.

Data were analyzed using the MIXED procedure of SAS (SAS Institute, Inc., Cary, N.C.). The experimental unit consisted of field replication incubated within animal. The model included the effects of plant parts, row spacing, plant population and collection date, and their interactions. Covariate regression was used to determine how plant parts changed over time in regards to NDF content, *in situ* NDF digestibility.

Results

There was a significant interaction ($P < 0.05$) of plant parts (PP) and plant population (POP) on NDF content, NDF digestibility and true digestibility of corn residue (Table 1). The PP by POP interaction influenced NDF content and NDF digestibility of husk. When seeds were planted at 54,600 plants / acre, the NDF content of husk increased; however NDF digestibility also improved. Similarly, the greatest population increased NDF content and decreased the true digestibility of stem. At higher population both NDF digestibility and true digestibility of cob were improved. There was no effect of row width on NDF content

Table 1. Effect of plant parts and population on neutral detergent fiber and *in situ* neutral detergent fiber digestibility.

Item	Cob			Husk			Leaf			Stem			SEM	*P*-value[2]		
	25,200[1]	35,000	54,600	25,200	35,000	54,600	25,200	35,000	54,600	25,200	35,000	54,600		PP	POP	PP x POP
NDF	85.49	87.32	86.63	77.09[b]	78.75[b]	81.02[a]	73.95	73.96	76.02	54.42[ab]	53.16[b]	55.94[a]	0.72	<0.01	<0.01	0.05
NDFD[3]	36.47[b]	36.32[b]	40.22[a]	49.86[b]	51.33[ab]	52.07[a]	47.26	47.70	47.93	34.26	34.76	33.64	0.73	<0.01	0.01	<0.01
TD[4]	45.68[b]	44.41[b]	48.19[a]	61.33	61.70	61.36	61.07	61.40	60.42	64.18[ab]	65.31[a]	63.04[b]	0.74	<0.01	<0.01	0.05

[a,b] Means with different superscripts are different within each plant part.
[1] Plant population (number of seeds / acre).
[2]PP = main effect for plant part; POP = main effect for plant population; PP x POP = interaction of plant part and plant population.
[3] NDFD = Neutral detergent fiber digestibility.
[4] TD = True digestibility.

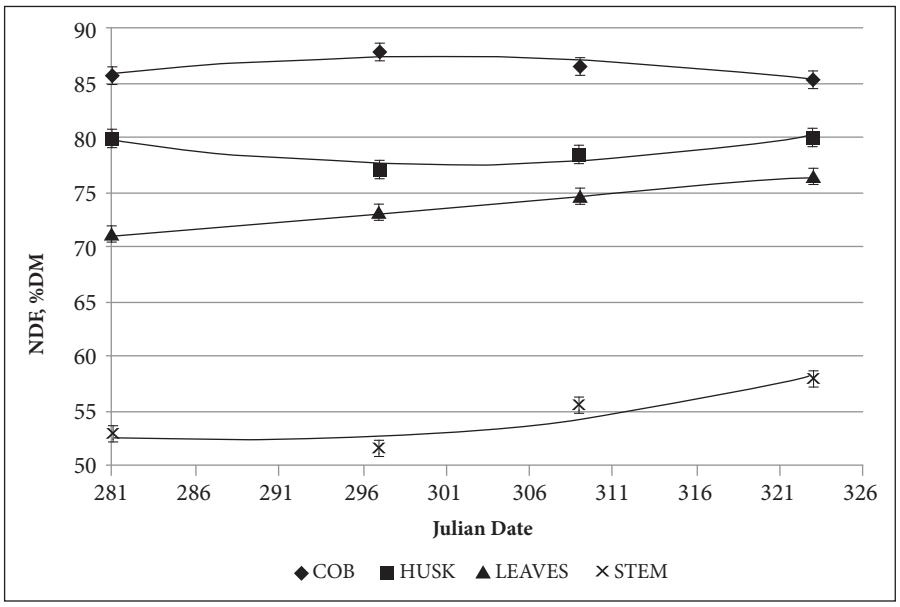

Figure 1. Neutral detergent fiber content of corn residue plant parts over time.

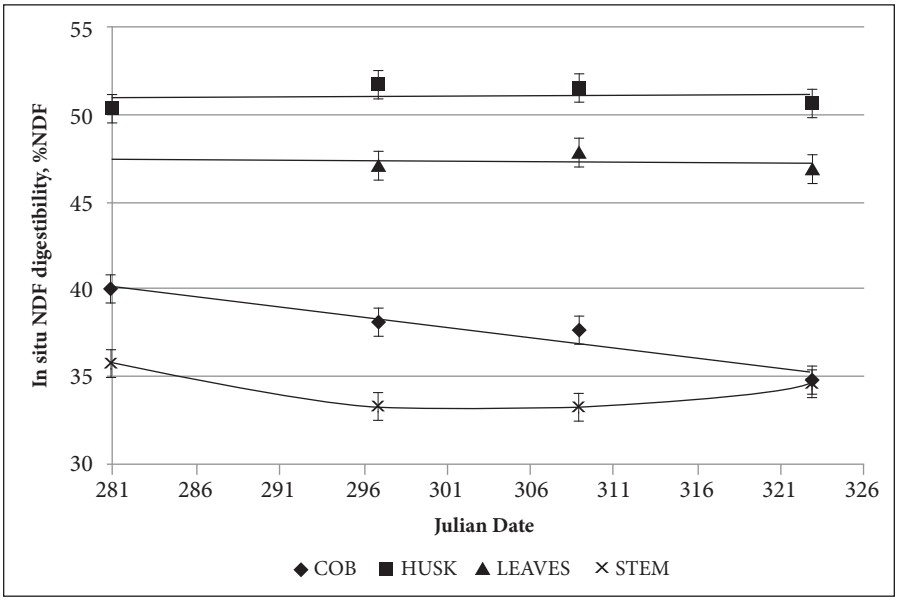

Figure 2. Neutral detergent fiber digestibility of corn residue plant parts over time.

(*P* = 0.19), *in situ* NDF digestibility (*P* = 0.37) or true digestibility (*P* = 0.84).

Time affected the quality of parts of corn residue. The NDF content increased linearly for leaf (*P* < 0.01, Figure 1) and quadratically for stem (*P* =0.05) over time. The NDF content of stem increased from 51.54 to 57.93% and leaf NDF from 73.17 to 76.52%. There was a quadratic response of NDF content of cob (*P* < 0.01) and husk (*P* = 0.01) over time. However, this variation was small compared to other parts of the plant, ranging from 85.44 to 87.96% for cob and from 77.20 to 80.14% for husk. The digestibility is expected to decrease due to the increase in NDF as plant matures, which is correlated with decreased soluble content in the plant. However, when all samples were collected the plant was already mature and dry so minimal changes may have occurred due to plant metabolism. It is not clear, but a possible explanation could be the solubles decrease by volatilization or microbial activity increasing the proportion of NDF and altering digestibility.

There were linear decreases (*P* < 0.01) and quadratic responses (*P* < 0.01) of *in situ* NDF digestibility of cob and stem over time (Figure 2), respectively. Cob *in situ* NDF digestibility decreased 13.2%, ranging from 40.1 to 34.8% from the first to the last collection date, being the most negatively affected part of the plant over time regarding NDF digestibility. The NDF digestibility of husk and leaf remained unaffected by dates of collection (*P* > 0.05, Figure 2) which are also the parts of the plant of greatest quality. These results are supported by previous work (2015 *Nebraska Beef Cattle Report*, pp. 59–61) which also found a quadratic decrease of cob digestibility and no effect on leaf and husk over time.

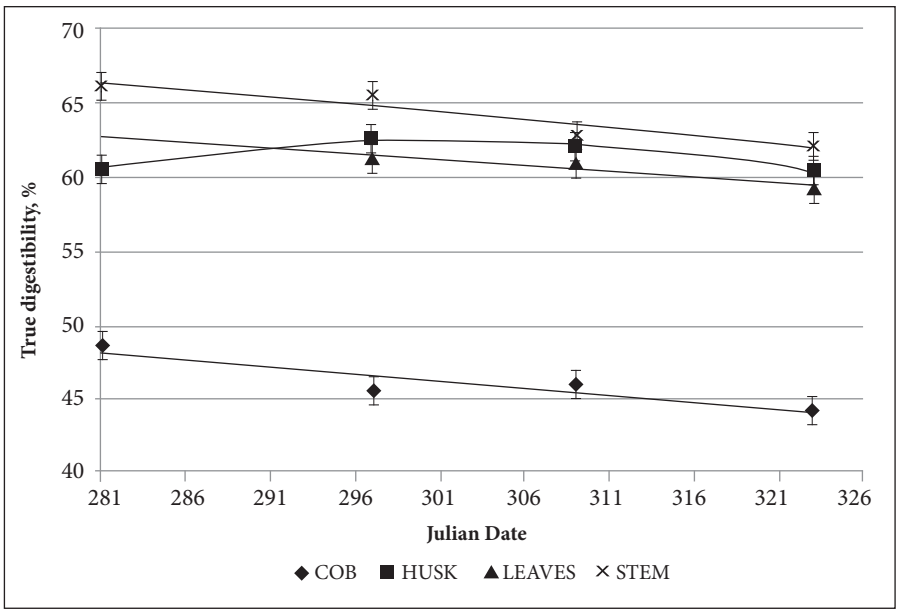

Figure 3. True digestibility of corn residue plant parts over time.

The true digestibility of cob, leaf and stem were linearly decreased ($P < 0.01$, Figure 3) across time, decreasing 9.0, 3.13 and 6.1%, respectively. The true digestibility of husk had a quadratic response ($P > 0.01$), with a small range from 60.56 to 62.67%. The true digestibility of stem was greater than reported in previous research (2015 *Nebraska Beef Cattle Report*, pp. 59–61), that found true digestibility of approximately 42% and can be explained by the lower NDF content.

Conclusions

When seeds were planted in a greater population, the NDF digestibility of husk and cob increased regardless the row width. The cob was the most negatively affected part of the plant by time, with small changes for leaf and husk. Harvest techniques could be developed to increase the proportion of leaf and husk of corn residue to increase animal intake and performance.

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Corn Residue Quality throughout the Grazing Season

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Summary with Implications

Changes in in vitro organic matter digestibility and digestible organic matter of corn residue were evaluated throughout the fall grazing and spring grazing seasons. In vitro organic matter digestibility and digestible organic matter were greatest at the beginning of fall grazing and declined over time. Slight weathering resulted in lower quality corn residue available at the beginning of spring grazing compared to the beginning of fall grazing. The in vitro organic matter digestibility of available residue declined 21% over the fall grazing season and 51% throughout the spring grazing season. As the availability of nutrients declines over time, adjustments in feeding management or rotational grazing may be necessary to meet energy requirements of grazing cattle.

Introduction

With the conversion of much grassland to cropland, supply of traditional forage resources has been challenged. However, an increase in acres being planted for corn production has resulted in greater availability of corn residue, which can be a valuable feed resource for grazing situations. Over time, corn residue quality will vary due to selective grazing of the higher quality plant parts (husk and leaves) and weathering. Characterizing a corn residue field for nutrient quality throughout a grazing period is important because adjustments in feeding management or rotational grazing may be necessary to meet the nutrient requirements of animals grazing the field. Therefore, the direct objective of this study was to determine diet quality of a corn residue field throughout fall and spring grazing periods. A secondary objective was to evaluate the effects of crop rotation on subsequent corn residue quality.

Procedures

Corn plant samples

An irrigated cornfield located at the Eastern Nebraska Research and Extension Center (ENREC) was utilized in the study. The field consisted of 2 sections with different crop rotations: 1) corn-corn rotation and 2) corn-soybean rotation. Three treatments (fall grazed, spring grazed, and non-grazed) with four replications of each treatment have been applied to the field annually. Ten consecutive whole corn plant samples harvested above the anchor root were collected from each field replication prior to grain harvest. Plant samples were separated into individual plant parts (leaf, sheath, husk) and weighed for DM. Plant parts were then composited within replication and analyzed for in vitro organic matter digestibility (IVOMD), digestible organic matter (DOM), and starch.

Corn residue diet samples

Following grain harvest of the corn field, cow-calf pairs grazed the fall grazed (November to February) and the spring (March) field replications at a stocking rate of 1.4 and 0.5 acres per cow-calf pair, respectively. To determine changes in forage quality throughout each grazing period, 6 ruminally fistualed steers were allowed to graze the field replications at the initiation and completion of each grazing season. Prior to sampling, rumen contents were removed from each steer. Fistulated steers were then transferred to the corn residue field where 3 steers per replication were allowed to graze. After approximately 30 minutes of grazing, freshly consumed feed was collected from each steer's rumen and placed in a cooler for later analysis. Former rumen contents were returned to the rumen. Collected samples were analyzed for in vitro organic matter digestibility (IVOMD) using the Tilley and Terry method, which was modified with the inclusion of 1 gram of urea to the buffer. The IVOMD values were also adjusted using in vivo corn residue and grass hay standards. Digestible organic matter (DOM) was then calculated by multiplying the IVOMD and percent organic matter of the original residue sample. A starch analysis (Megazyme Total Starch Assay, Megazyme International Ireland Ltd., Ireland) was conducted to determine the percentage of grain within diet samples.

All data were analyzed using the mixed procedure of SAS. Corn plant data included treatment (spring and fall grazed), crop rotation, and plant part (husk, leaf blade, and leaf sheath) as fixed effects. Data from corn residue diet samples included treatment (spring and fall) and time (beginning and end of grazing season) as fixed effects.

Table 1. Yield of residue measured by clipping individual corn plants (% of grain)

	Treatment[1]				
	Fall grazed	Spring grazed	Non-grazed	SEM	*P*-value
Husk	5.8	6.1	5.3	0.32	0.22
Leaf	17.6	18.2	16.9	1.04	0.68
Sheath	8.6	8.7	8.2	0.49	0.77
Cob	9.1	9.4	8.5	0.39	0.31

[1] Treatments were due to timing of cattle grazing residue 2 years prior to these samples being collected. Ten plants were collected from each of 4 replications per treatment.

Table 2. In vitro organic matter digestibility and digestible organic matter of corn plant samples by area

	Area			
Item	C-SB[1]	C-C[2]	SEM	*P*-value
IVOMD[3], %	44.3	44.0	3.0	0.96
DOM[4], %	40.8	40.5	3.2	0.95

[1]Area that was in a corn-soybean rotation
[2]Area that was in a corn-corn rotation
[3]In vitro organic matter digestibility
[4]Digestible organic matter (as a % of dry matter); calculated as OM content (%) × IVOMD (%)

Table 3. In vitro organic matter digestibility and digestible organic matter of corn plant parts

	Husk	Leaf Blade	Leaf Sheath	SEM	*P*-value
IVOMD[1], %	60.0[a]	39.7[b]	32.7[c]	0.6	<0.01
DOM[2], %	58.1[a]	33.7[b]	30.2[c]	0.6	<0.01

[1]In vitro organic matter digestibility
[2]Digestible organic matter (as a % of dry matter); calculated as OM content (%) × IVOMD (%)
[abc]Means within a row with unique superscripts differ ($P < 0.05$)

Table 4. In vitro organic matter digestibility and digestible organic matter of corn residue diet samples by treatment and time[1]

	Fall		Spring			*P*-value[2]		
Item	Beginning	End	Beginning	End	SEM	Trt	Time	Int.
IVOMD[3], %	62.1[a]	48.9[b]	58.6[a]	29.0[c]	3.0	<0.01	<0.01	<0.01
DOM[4], %	58.5[a]	40.0[c]	53.5[b]	25.7[d]	2.9	<0.01	<0.01	0.04

[1]Treatments are due to timing of grazing (fall or spring) and timing of sample collection (at the beginning or end of grazing).
[2]Trt= fixed effect of treatment; Time= fixed effect of time; Int. = treatment × time interaction
[3]In vitro organic matter digestibility
[4]Digestible organic matter (as a % of DM); calculated as OM content (%) × IVOMD (%); adjusted for ash content of saliva
[abcd]Means within a row with unique superscripts differ ($P < 0.05$)

Results

Amount of residue (as a percentage of grain) per plant is shown by treatment (Table 1). The average amount of leaf blade, leaf sheath, and husk was 31.8 % of the grain. That is 21 lb of residue dry matter/bu of corn at 15.5% moisture. This differs with previous research in which 15.8 lb of leaf and husk were produced per bu of corn (*2016 Nebraska Beef Cattle Report,* pg 71-73). Grain yield averaged 217 bu/acre and was not influenced by any treatments.

No significant difference was observed for corn residue IVOMD or DOM between the corn-soybean rotation and corn-corn rotation (*P*-value ≥ 0.95; Table 2). Previous treatment (fall, spring, or non-grazed) also did not affect IVOMD or DOM of corn residue harvested prior to grazing ($P \geq 0.97$). Plant parts did differ in IVOMD and DOM ($P < 0.01$; Table 3). The IVOMD and DOM were greatest for the husk, intermediate for leaf blade, and least for leaf sheath.

A treatment by time interaction was observed for IVOMD of the corn residue diet samples ($P < 0.01$; Table 4). The IVOMD was greatest at the beginning of the fall and spring grazing seasons, intermediate at the end of the fall grazing, and least for the end of the spring grazing season.

A treatment by time interaction was also observed for DOM of the corn residue ($P = 0.01$). The beginning of the fall grazing season had the greatest DOM compared to all other time points within both grazing seasons. The beginning of spring grazing had greater DOM than the end of fall grazing. Digestible OM was least for the end of the spring grazing compared to all other grazing time points. From initiation of grazing to the end of the grazing season, IVOMD declined 21% while DOM declined 32% for the fall grazed treatment. The decline in quality over time was greater for spring grazing, 51 and 52% for IVOMD and DOM, respectively.

Starch in the diet samples ranged from 0.04% to 6.44% (average of 1.6%) at the beginning of both grazing seasons. The broad range in starch content indicates significant variability expressed in grazing selection among steers. Given that corn consists of 70% starch, approximately 2.2 % of the steer's diet contained corn at the start of the grazing season.

The higher DOM of the corn residue diet samples observed at the beginning of both grazing seasons would suggest that cattle are selectively eating the husk and grain within the field. The difference in DOM observed between the beginning and end of both grazing seasons is evident that as the availability of husk and grain decreases, cattle begin to consume the leaves. Leaves are lower in IVOMD than husks and even lower in DOM because they have a high ash content (approximately 15% ash). In addition, the lower DOM observed at the beginning of the spring grazing compared to the beginning of the fall grazing would indicate that weathering may be responsible for a portion of DOM reduction.

Conclusion

The energy content that a corn residue field provides to grazing cattle is greatest at the beginning of the fall grazing season. However, as cattle selectively consume the higher digestible plant parts and weathering deteriorates the corn residue, the field provides less and less energy to the cattle. Characterizing a field for its nutrient profile is important during the grazing season. As the availability of nutrients declines over time, adjusting feeding management or utilizing rotational grazing may be necessary to continue to meet energy requirements of the grazing cattle.

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Effect of Harvest Method and Ammoniation on Digestibility and Intake of Corn Residue

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Summary with Implications

The effects of three harvest methods, both with and without ammonia treatment, on the in vivo digestibility and intake of baled corn residue were assessed in a digestion trial with lambs. Treatments included three corn residue harvest methods (conventional rake and bale, New Holland Cornrower™ with eight rows or with two rows of corn stalks chopped into the windrow containing the tailings [leaf, husk and upper stalk] from eight harvested rows) and the effects of ammoniation at 5.5% of DM compared to no ammoniation of the residue. The 2-Row baled residue (51.7%) had greater dry matter digestibility than both 8-Row (47.3%) and CONV (44.7%). Ammoniation increased dry matter digestibility by 24% (10 percentage units) across all residue types. Additionally, ammoniation increased intake. Utilizing alternative harvesting technologies and ammoniation can improve the digestibility of baled residue. These effects are additive and combining the two technologies resulted in the greatest improvement in digestibility.

Introduction

Technologies designed to improve the feeding value of corn residue are becoming more relevant for beef producers. The New Holland Cornrower™ varies the proportion of lower stalk to leaf, husk, and upper stalk (tailings) in the corn residue bale by chopping 2, 4, 6, or 8 rows of stalk from the 8 harvested corn rows in to the windrow that will be baled. The digestibility of different parts of the corn plant varies and increasing the proportion of tailings (relative to lower stalk) results in improved *in vitro* digestibility (2015 Nebraska Beef Cattle Report, pp. 62–63). Although no difference in *in vivo* dry matter digestibility (DMD) was observed between corn residue harvested with 4 Rows (49.9%) vs. 8 Row (48.5%; 2016 Nebraska Beef Cattle Report, pp. 74–75), more recent results (2017 Nebraska Beef Cattle Report, pp. 53–54) demonstrate residue harvested with 2 rows of stalks being chopped had greater DMD (51.7%) when compared to conventionally baled residue (46.1%). Additionally, ammoniation improves both digestibility and intake of low quality forages, such as baled corn residue. The objective of this study was to determine the effect of harvest method and ammoniation on the intake and digestibility of baled corn residue in lambs.

Procedure

Nine crossbred wether lambs (108.6 ± 16.5 lbs BW) were fed in a 126-d digestion trial using an unbalanced 9 x 6 Latin rectangle design with a 3 x 2 factorial treatment structure. Treatment diets consisted of corn residue harvested using three different methods: conventional rake and bale (CONV), a New Holland Cornrower™ chopping stalks from all 8 rows (8ROW), and stalks from 2 rows (2ROW) of corn being harvested by the combine into a windrow containing the tailings (leaf, husk and upper stalk) from 8 rows. Anhydrous ammonia was added at 5.5% of DM to a portion of each of the baled residues and allowed to sit for 33 d in black plastic in July of 2015, resulting in three more treatment diets: conventional ammoniated (CONVAM), 8-Row ammoniated (8RAM) and 2-Row ammoniated (2RAM). Diets consisted of 64.2% corn residue, 29.8% Sweet Bran, 3.3% smooth-bromegrass hay, and 2.8% mineral mix (DM basis). Six 21 d periods consisted of 14 d adaptation and 7 d total fecal collection. Lambs were fed *ad libitum* (110% of the previous day's DMI) during d 1–12 and reduced to 95% of *ad libitum* intake for d 13–21. During the adaptation period, lambs were housed in individual pens with grate floors, individual feed bunks and automatic waterers. Feeding occurred twice daily at approximately 0800 and 1500, and orts were collected, weighed, and fed back during the adaptation period.

At the end of the adaption period, lambs were moved to individual metabolism crates and fitted with harnesses and fecal collection bags. Total fecal output was collected twice a day beginning on d 14 at approximately 0800 and 1500, weighed and retained. Orts were collected at feeding, weighed, and retained for analysis. Total fecal material and orts were composited at the end of the collection period and three sub-samples were taken for analysis. Samples were dried in a 60˚C forced air oven (orts for 48 h and feces for 72 h) and then ground through a 1-mm screen in a Wiley mill. Diet and fecal samples were analyzed for dry matter (DM), organic matter (OM) and neutral detergent fiber (NDF). Ground feed and fecal samples were dried in a 100˚C oven for 24 h to determine lab-adjusted DM, and then incinerated in a muffle furnace at 600˚C to determine the ash content to calculate OM. Neutral detergent fiber was determined by refluxing samples in beakers for 1 h. Total tract apparent digestibility was calculated using DM, OM, and NDF disappearance. Treatment diets were fed over 6 periods, with the non-residue proportion (Sweet bran, Brome grass and mineral) of the diet fed in an additional period at 2% of BW to determine the digestibility of the corn residue by difference.

Data were analyzed using the MIXED procedure of SAS (SAS Inst., Inc., Cary, N.C.). Lamb was the experimental unit, and the model included harvest method, ammoniation, period and a harvest method by ammoniation interaction. Period and lamb were treated as fixed effects, and interactions were assessed for inclusion in the model. Significance was declared when $\alpha \leq 0.05$.

Table 1. Effect of harvest method on dry matter (DMD), organic matter (OMD) and neutral detergent fiber (NDFD) digestibility of baled corn residue[1].

	CONV	8-Row	2-Row	SEM	*P*-value
Residue DMD,%	44.7	47.3	51.7	1.9	0.03
Residue OMD,%	50.5	51.5	55.4	1.7	0.12
Residue NDFD, %	42.7	54.1	62.7	2.8	<0.01

[1]The non-residue portion of the diet was fed alone in a separate feeding period to determine digestibility. Residue digestibility was calculated by removing the contribution of non-residue component of the diet.

Table 2. Effect of post-harvest ammoniation treatment at 5.5% of DM on the dry matter (DMD), organic matter (OMD) and neutral detergent fiber (NDFD) digestibility of corn residue[1].

	Non-ammoniated	Ammoniated	SEM	*P*-value
Residue DMD,%	42.8	53.0	1.4	<0.01
Residue OMD,%	47.4	57.4	1.7	<0.01
Residue NDFD, %	44.8	61.4	2.3	<0.01

[1]The non-residue portion of the diet was fed alone in a separate feeding period to determine digestibility. Residue digestibility was calculated by removing the contribution of non-residue component of the diet.

Results

There was a harvest method by ammoniation interaction ($P < 0.01$) for *ad libitum* whole diet DMI (d 7–11). The intake of diets containing non-ammoniated residue did not differ ($P \geq 0.92$) among harvest methods and were consistent at 2.6% BW. Conversely, ammoniation increased intake for all harvest methods, and the amount of response varied among harvest method. This resulted in intake being greatest for 2RAM at 4.1% BW, intermediate for COVAM at 3.6% BW and 8RAM showing the smallest increase in DMI at 3.1% BW, which were all significantly different both from each other and from non-ammoniated diets ($P = 0.03$). There was no harvest method by ammoniation interaction ($P \geq 0.82$) for OM, DM or NDF digestibility (NDFD). Harvest method affected DMD ($P = 0.04$) and NDFD ($P < 0.01$) of the residue (Table 1). Harvesting with the New Holland Cornrower™ with 8 rows of stalks chopped resulted in a 6% increase (2.6 percentage units; $P = 0.34$) in DMD and harvesting with 2 rows increased DMD by 15% (7 percentage units; $P = 0.01$) compared to conventional rake and bale method. The effect was more pronounced in NDFD, with 8-Row increasing NDF digestibility by 27% (11.9 percentage units; $P = 0.01$) and 2-Row increasing NDFD by 46% (19.9 percentage units; $P < 0.01$) over conventionally harvested residue. Digestibility of OM was not affected ($P = 0.12$) by harvest method. Ammoniation improved ($P < 0.01$) DM, OM, and NDF digestibility for all harvest methods (Table 2), resulting in a 24% and 21% (10.1 percentage units; $P < 0.01$) increase in digestibility for DM and OM, respectively, and a 37% increase (16.6 percentage units; $P < 0.01$) in NDF digestibility.

Conclusions

Consistent with other studies, changing the proportion of husk and leaf to stalk in baled residue can influence digestibility characteristics. No difference DM and OM digestibility was observed between 2-Row and 8-Row (non-ammoniated) in this study but there was a significant improvement in DM, OM, and NDF digestibility between the 2-Row and conventional rake and bale. Moreover, ammoniation increased intake and all digestibility characteristics of the corn residue regardless of harvest method, and was additive with harvest method.

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Comparison of diets collected from esophageally fistulated cows to forage quality estimated from fecal analysis

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Summary with Implications

Differences in forage quality (crude protein and energy) were analyzed between esophageally fistulated diets, analysis of fecal samples with Nutrition Balance Analyzer (NUTBAL) analysis, and analysis of hand-clipped forage samples. On upland range sites, hand-clipped samples provided forage quality estimates that were closer to esophageally fistulated diets than samples analyzed with the NUTBAL analysis. After one year of data collection, it appears that there may be some inconstancies with the NUTBAL analysis for estimates on rangeland forage quality in the Nebraska Sandhills. More data is needed to verify these results; however, making management supplementations decisions solely on the NUTBAL analysis may not always be accurate on Sandhills rangeland.

Introduction

Forage quality is difficult for beef cattle producers to measure. Researchers use fistulated animals to collect diets directly from the esophagus or rumen, but most cattlemen do not have access to fistulated animals. Hand-clipped rangeland forage samples that are analyzed at forage analysis laboratories (e.g., Ward Labs, etc.) do not always reflect the selectivity of grazing animals. The Nutrition Balance Analyzer (NUTBAL) forage quality analysis method attempts to measure forage crude protein and energy through the analysis of fecal samples collected by producers. Near Infrared Reflectance Spectroscopy (NIRS) is conducted on fecal samples and combined with client information and research/technology developed by the Grazing Animal Nutrition Lab (GAN Lab) in Temple, TX.

The objective of this study was to compare forage quality estimations from forage samples collected with fistulated grazing animals, hand-clipping, and fecal samples collected for NUTBAL analysis on Nebraska Sandhills rangelands.

Procedure

Comparisons were made between forage diets collected from esophageally fistulated cows, fecal samples from cows grazing in the same pastures, and from hand-clipped quadrats. The esophageal diets (forage the cow ate, chewed, and expelled into a collection bag when swallowed) and the hand-clipped samples were evaluated for crude protein (CP) and energy (total digestible nutrients [TDN]) by wet chemistry analysis in a commercial laboratory (Ward Labs, Kearney NE). The fecal samples were evaluated for crude protein and energy (in the form of digestible organic matter [DOM]) through the NUTBAL program utilizing NIRS. Two locations were evaluated; upland pastures (warm-season grass dominated) and subirrigated wet meadows (cool-season grass dominated) at the Gudmundsen Sandhills Lab near Whitman, NE. Hand-clipped forage samples were only collected within the upland pastures. Diet, fecal and clipped samples were collected in July, September, and November. Fecal samples were dried at 50 degree C for 72 hours prior to shipping for NUTBAL analysis.

Collections for upland pasture

Fecal samples were directly collected from 10 cows early in the months of July, September, and November of 2015. Cows were grazing upland rangeland at moderate stocking rates. Cows were in the same pasture from June to November. The cows ranged in age from 3 to 9 years old. Three esophageally fistulated cows grazed the upland pasture and diets were collected, the same time the fecal samples were collected from the cows. Forage was also clipped by hand in an effort to collect a sample representative of plants and plant parts consumed by cattle. This collection was subjective, and attempted to collect what the cows were potentially grazing.

Collections for subirrigated meadow

Fecal samples were directly collected from 10 cows early in the months of July, September, and November of 2015 grazing subirrigated meadow. Three esophageally fistulated cows grazed the meadow pasture and diets were collected, the same time the fecal samples were collected from the cows. The meadows were divided into 4 pastures. The pasture rotation allowed each pasture to be grazed twice in the growing season.

ASSUMPTIONS

Two assumptions were made: 1) the models used in the NUTBAL program represented similar forage quality and values as native Sandhills grassland in Nebraska; and 2) Fistulated animals were selecting the same diets as the grazing cows.

Other considerations included: 1) To minimize the loss of nitrogen from the manure (cow patty on the ground), fecal samples were taken directly from the cow's rectum while restrained in a cattle handling facility. 2) Total Digestible Nutrients (TDN) reported for fecal samples was calculated from the NUTBAL energy DOM. The NUTBAL DOM was converted to TDN by multiplying the DOM value reported by the GAN lab by 1.06. (NRCS Enhancement Activity 65, 2015). 3) Some nitrogen can be recycled in the saliva of the cows, therefore potentially increasing the CP estimates of the esophageally fistulated cow's diet.

STATISTICAL ANALYSIS

Data were analyzed using the Mixed Procedure in SAS with sample collection method used as the fixed effect. Differences were considered significant when $P < 0.10$ were observed.

Table 1. Crude protein (CP) and total digestible nutrient (TDN) content of diets collected from upland range by esophageally fistulated cattle compared with NUTBAL analysis of fecal samples and clipped forage

Item	Diet	NUTBAL	Clipped	SE	*P*-value
CP					
Jul	9.0[a]	7.5[b]	7.6[ab]	0.5	0.09
Sep	7.2[a]	7.4[a]	5.1[b]	0.4	< 0.01
Nov	6.0[b]	4.2[a]	5.3[ab]	0.5	0.01
TDN[1]					
Jul	60.1[b]	62.6[a]	55.8[c]	0.9	< 0.01
Sep	55.8[b]	62.0[a]	54.4[b]	1.3	< 0.01
Nov	52.9[b]	60.0[a]	47.8[b]	1.3	< 0.01

[1]Digestible organic matter reported by the Grazing Animal Nutrition Lab report was converted to TDN by multiplying DOM by 1.06.

Table 2. Crude protein (CP) and total digestible nutrient (TDN) content of diets collected from subirrigated meadows by esophageally fistulated cattle compared with NUTBAL analysis of fecal samples

Item	Diet	NUTBAL	SE	*P*-value
CP				
Jul	10.7	6.7	0.6	< 0.01
Sep	9.6	8.5	0.5	0.09
Nov	8.3	4.7	0.3	< 0.01
TDN				
Jul	58.7	61.5	0.6	< 0.01
Sep	64.0	62.4	0.7	0.09
Nov	57.8	57.7	1.6	0.99

Table 3. Actual body weight and body condition score of cows grazing upland range or meadow

Item	Jun	Jul	Sep	Nov
Upland range				
Body Weight, lbs.	954	909	968	1006
Body Condition Score	5.1	5.2	5.4	5.2
Meadow				
Body Weight, lbs.	1020	975	1022	1086
Body Condition Score	5.1	5.2	5.3	5.5

Results & Discussion

The first year (of a three year study) of data collected from esophageally fistulated steers compared to NUTBAL analyzed and hand-clipped samples resulted in significantly different measures in forage quality.

Upland Range: Crude Protein and Energy (TDN):

In July and November, diet samples contained substantially more ($P \leq 0.09$) CP than NUTBAL samples, but in September CP content of both diet and NUTBAL samples were similar ($P > 0.10$) (Table 1). In all three months TDN were inflated ($P < 0.05$) by the NUTBAL analysis. In July the NUTBAL estimate of TDN was 2.5 percentage units greater than the fistulated cow samples, but in November the value was elevated by 7.1 percentage units. A TDN estimate off by 7.1 percentage units has dramatic impact on nutritional status of an animal and would result in erroneous supplementation recommendations.

Hand-clipped samples were lower in CP and TDN than diet samples in all instances, however, the clipped samples were similar to diet samples more often than were NUTBAL estimates.

Meadows: Crude Protein and Energy (TDN):

In all three months the NUTBAL method underestimated ($P \leq 0.09$) the amount of CP in the diet (Table 2). Differences between fistulated diets and NUTBAL estimates of TDN content were not consistent. NUTBAL overestimated ($P < 0.01$) TDN in July, underestimated ($P = 0.09$) TDN in September, and was similar ($P = 0.99$) to the diet in November. No hand-clipped samples were taken on the wet meadows.

Except for upland range samples collected in the month of September, NUTBAL consistently under estimated the amount of CP being consumed by grazing cattle for both upland range and meadow. Generally, NUTBAL overestimated the amount of TDN cattle were consuming on upland range, but was not consistent in the estimate of TDN on meadow. The lack

of consistency excludes the possibility of developing an adjustment factor that can be applied to GAN lab reports to make them useful in cattle management decisions.

Reports received during this study from the GAN lab after NUTBAL analysis of fecal samples recommended feeding supplemental nutrients to prevent substantial body weight and body condition score loss. Supplemental nutrients were not fed and the animals did not lose the body weight and body condition score projected by the NUTBAL report (Table 3).

Conclusion

The NUTBAL analysis of crude protein and energy values from fecal sampling differed from a wet chemistry analysis of esophageally fistulated and hand-clipped forage samples. This raises some questions in the accuracy of this technique to correctly estimate forage quality at a given time during the year. Miscalculating available nutrients in the forage may influence supplementation strategies and either over- or under-feed cattle as a result. More research is needed to verify the accuracy of the NUTBAL analysis compared to other methods of forage quality analysis on Sandhills rangelands.

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Impact of Inoculum Source for *in vitro* and *in situ* Digestion Procedures Performed on Corn Residue and Grass Samples

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Summary and Implications

A study was conducted to assess the effects of inoculum source at time of incubation on neutral detergent fiber digestibility, dry matter digestibility, and organic matter digestibility of corn residue samples. Digestibility of neutral detergent fiber was greater for both grass and corn residue when inoculum source came from steers consuming a high corn residue diet. Digestibility of dry matter and organic matter were not different between grass and corn residue. It is not necessary to maintain two sets of donors for in vitro or in situ procedures involving corn residue. However, donor diet affects neutral detergent fiber digestibility estimates of residue samples. Therefore, when trying to assess energy values using in situ or in vitro techniques, a set of standards with established in vivo digestibility values should be used for adjustment when steers are maintained on a mixed diet.

Introduction

Because forage, grass or residue, plays a major role in most cattle diets, knowing the energy value of forages is critical when estimating feeding values. Whether multiple donor diets are necessary to get accurate digestibility estimates of diverse forage samples such as grass or residue is essential. An interaction of forage type and inoculum source may indicate a need to obtain rumen fluid from donors fed the same forage being tested. A previous study assessed the effects of NDF digestibility using four cannulated steers and found an increase in NDF digestibility for both grass and residue forage types incubated in an inoculum source from steers fed a high residue diet (2016 Nebraska Beef Report, pp. 84-86). However, byproduct use varied with diet, making the impacts of residue or grass less clear.

Therefore, the objective of this study was to evaluate the effects of inoculum source on in vitro and in situ digestibility estimates (IVDMD, IVOMD, and NDF digestibility), when comparing a 70% hay diet and a 70% corn residue diet, to determine if two sets of donor steers would need to be routinely maintained for these procedures.

Procedure

Six ruminally canulated steers were fed, daily at 8 AM, either a mixed diet consisting of 70% brome grass hay and 30% Sweet Bran or a high corn residue diet with 70% conventionally baled stalks and 30% Sweet Bran. Steers were fed at 2% BW on a DM basis. The effects of donor diet were assessed as inoculum source using in vitro techniques and as diet for in situ techniques. There were two periods in a crossover design with two runs per period. Periods were 4 weeks long with a 2 week adaptation and 2 weeks for in vitro and in situ runs. One in vitro run and one in situ run were done in each week of the last two weeks of the period.

Residue samples consisting of 2-row, 8-row, conventional bale, husk and husklage were used for residue forage type. To obtain 2 and 8 row bales a New Holland Cornrower Corn Head was used as previously described (2016 Nebraska Beef Report, pp. 76-78). 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 as previously described (2016 Nebraska Beef Report, pp. 76-78)

Five chopped hays, with known in vivo values were described previously (2016 Nebraska Beef Report, pp. 84-86) and consisted of immature smooth bromegrass (good brome), mature smooth bromegrass (poor brome), immature meadow hay (meadow hay), mature brome hay used in an individual barn feeding system (mature brome), and prairie grass hay (prairie hay). The prairie hay consisted of a mixture of warm and cool season grass species.

All samples were ground through a CT 193 Cyclotec™ Sample Mill using a 2 mm screen for in vitro and a Wiley Mill using a 2 mm screen for in situ. Inoculum for in vitro NDF digestibility was obtained by collecting whole rumen contents from each steer, with three steers per treatment for each run. Each of the strained ruminal fluid samples were then mixed with McDougall's buffer (1:1 ratio) containing 1 g urea / L and incubated for 48 h. This process was repeated in two runs for each period, and steer inoculum source was the experimental unit (n = 8). Three in vitro tubes per experimental unit were averaged for digestibility estimates.

The NDF digestibility of samples was also determined utilizing in situ rumen incubation. Three bags of each sample were placed in the rumen of each of the six steers, with three steers per treatment and 120 bags per steer separated into four time points (n = 8). Individual bags were placed in mesh zipper bags fitted with weights and incubated for 36h, 48h, 60h, and 72h. After the incubation period bags were pulled from steers and placed in a washing machine where they were agitated with water in a washing machine for 1 min and spun for 1 min for five cycles. They were then rinsed with distilled water and stored in the freezer. The Ankom Fiber Analyzer was used to analyze NDF of the remaining residue. This process was repeated in two runs a week apart for each period.

All data were analyzed using the MIXED procedures of SAS. This experiment used a crossover design with two periods and two runs per period. The effects of run, diet, time, and sample were examined. Diet by time and diet by time by sample interactions were also tested.

Results

In vitro

No interaction was observed for inoculum source and forage type for IVDMD ($P = 0.99$). There was no interaction between inoculum source and forage type for IVOMD ($P = 0.98$). There was no effect of

Table 1. Main effect of inoculum source on *in vitro* estimates[1]

	Diet[2]			
	Brome	Residue	SEM	*P*-value
IVDMD, %DM	49.7	50.9	0.79	0.41
IVOMD, %DM	51.5	52.4	0.74	0.25

[1]Averaged across run
[2]Brome diet consists of 70% brome and 30% Sweet Bran; Residue diet consists of 70% stalks and 30% Sweet Bran

Table 2. Interaction of diet and forage type on *in situ* NDF digestibility[1] (%).

	Diet[2]		
Sample[3]	Brome	Residue	*P*-value
2 Row	55.3	58.8	<0.01
8 Row	52.5	56.0	<0.01
Conventional	50.6	54.5	<0.01
Good Brome	53.5	57.0	<0.01
Husk	64.6	71.6	<0.01
Husklage	48.0	51.7	<0.01
Mature Brome	51.1	53.9	0.02
Meadow Hay	58.7	61.5	0.02
Poor Brome	48.7	52.3	<0.01
Prairie Hay	50.4	52.8	<0.01

[1]DMD averaged across run
[2]Brome diet consists of 70% brome and 30% Sweet Bran; Residue Diet consists of 70% stalks and 30% Sweet Bran
[3]Diet x sample $P = 0.19$, SEM=1.2

Table 3. Interaction of diet and incubation time on *in situ* NDF digestibility[1] (%).

	Diet[2]		
Time (h)	Brome	Residue	*P*-value[3]
24	37.7	37.5	0.90
48	49.2	51.7	0.03

[1]NDF digestibility averaged across all forage samples
[2]Brome diet consists of 70% brome and 30% DDGS; Residue Diet consists of 70% stalks and 30% Sweet Bran
[3]Diet x time interaction; $P = 0.11$, SEM= 1.2

Table 4. Main effect of diet on in situ NDF digestibility[1] (%).

	Diet[2]			
	Brome	Residue	SEM	*P*-value
NDF Digestibility	53.3	57.0	0.38	<0.01

[1]NDF digestibility averaged across all forage samples
[2]Brome diet consists of 70% brome and 30% Sweet Ban; Residue Diet consists of 70% stalks and 30% Sweet Bran

inoculum source ($P = 0.41$) for IVDMD or for ($P = 0.25$; Table 1) IVOMD. Forage type had a significant effect (data not shown; $P < 0.01$) showing that different qualities of forage had different IVOMD.

In situ

There was no 3-way interaction observed for forage type by incubation time by diet ($P = 0.85$). There was no interaction for diet by forage type ($P = 0.19$; Table 2). There was an interaction for diet by incubation time ($P = 0.01$; Table 3). Digestibility of NDF was greatest at 36 h for both forage types incubated in steers consuming a residue diet ($P = 0.03$). There was no significant difference between NDF digestibility at 48 h ($P = 0.13$). However, at 60 and 72 h NDF digestibility was greatest for both forage types incubated in steers consuming a residue diet ($P < 0.01$). There was a main effect for incubation time ($P < 0.01$) where NDF digestibility increased over time and was greatest at 72 h (data not shown). There was also a main effect for diet where NDF digestibility was greatest for both forage types when incubated in steers consuming a residue based diet ($P < 0.01$; Table 4).

Conclusions

There was no difference in IVDMD or IVOMD due to inoculum source. The diet of the donor animal did not affect NDF digestibility estimates of corn residue samples. However there was no interaction for forage type and inoculum source or diet. Greater NDF digestibility estimates for *in situ* procedures were observed for both forage types when incubated in a steer consuming a residue diet compared to the brome diet. Maintaining donor animals on different diets to perform these procedures is not necessary; one set of animals on a 30% concentrate diet is sufficient. Therefore, when trying to assess energy values using these techniques, a set of standards should be used for adjustment to account for any variation caused by animal diet.

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Evaluation of Plant-waxes to Estimate Forage Intake in Grazing Cattle

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Summary with Implications

Although key to the efficiency of a cattle operation, feed intake is challenging to evaluate in a grazing setting. However, even within forage-based systems, plant-wax markers may be used to predict dietary choices and feed intake. Plant-waxes are a complex mixture of lipids found on the surface of plants. When sufficiently unique among plants, the composition of diets can be determined from the pattern of these compounds in the forages ingested. These markers were used to delineate the parts of the corn plant and, separately, 8 western rangeland grasses and legumes. Using plant waxes, the components of the corn plant were clearly distinguished. This technique therefore could be useful in a monoculture, such as a corn residue field, to determine the plant parts predominating in the diet. Delineating plants in a complex sward was more difficult, particularly among like species. The use of more markers may help to more explicitly distinguish plants within diverse pastures, such as western rangelands.

Introduction

Within the beef and dairy industry, it has become increasingly important to determine the factors that affect animal intake. One approach for doing so is based on plant-wax markers. Plants contain a complex mixture of aliphatic lipid compounds on their external surface that are essentially inert within the digestive system. Of particular interest are the *n*-alkanes (**ALK**; saturated straight-chain hydrocarbons) and long-chain alcohols (**LCOH**). The concentrations of these compounds can differ greatly among plant species, and even among plant parts, often providing a unique marker profile or signature of a plant. When these profiles are distinctive enough, the composition of cattle diets can be predicted from the pattern of these compounds in the forages ingested. The number of plants that can be delineated depends on the number and profiles of ALK and LCOH measured in the individual plants or plant-parts. As the complexity of a sward increases, such as within mixed species grassland, the number of markers needed to distinguish plants increases. The objective of this study was to assess the ability to delineate the plant composition of corn residue and of a diverse western rangeland.

Procedure

Corn plant

Cob, stalk, husk and leaf samples were taken from a 98.8 acre irrigated corn field located at the Eastern Nebraska Research and Extension Center located near Mead, NE. Ears and leaf blade were removed on site prior to transport to prevent loss. Stalks were cut at the top of the crown roots and bundled. Leaves and stalks were stored to air dry in an open air barn. Ears were husked and separated. Samples were bagged and left open inside a climate controlled building to allow the plant parts to dry. Stalk, cob and leaf samples were all chopped using the Ohio Mill, and then through a Wiley Mill using 1 mm screen. Samples were then composited by plant part.

Western rangeland

Forage samples were collected at the West Central Research and Extension Center (WCREC) in North Platte, NE. Collection sites were primarily native mixed-grass rangeland within the rolling plains and breaks of Major Land Resource Area 73. Ecological sites included loamy upland, loamy lowland and loess breaks. The forages were 3 cool-season (C3) grasses (cheatgrass (*Bromus tectorum*); needle-and-thread (*Hesperostipa comata*); western wheatgrass (*Pascopyrum smithii*)), 3 warm-season (C4) grasses (blue grama (*Bouteloua gracilis*); little bluestem (*Schizachyrium scoparium*); sideoats grama (*Bouteloua curtipendula*)), and 2 legumes (leadplant (*Amorpha canescens*); sweet clover (*Melilotus officinalis*)). Forage samples were collected at peak vegetative and mature states between late-April and late-August 2015. Peak vegetative stage of growth was defined as just before stem elongation for the grasses and before flowering for the legumes. At the mature stage, grasses were fully headed and beginning seed ripening. Legumes were past flowering and in seed development.

Plants were clipped at ground level, shipped overnight on ice to the Ruminant Nutrition Laboratory at the University of Nebraska-Lincoln. Half of the sample was separated by hand into leaf and stem. Depending on the stage at which the plant was collected, the reproductive portion (flower, seed) was also separated. All plant parts and whole plant samples were placed in a 60° C forced air oven for 48 h to determine dry matter. After 48 h, all samples were removed from the oven and ground through a Wiley Mill using a 1 mm screen.

Laboratory Analysis

Extractions were performed in duplicate with 0.200–0.204 g of ground sample. Docosane (C_{22}) and tetratriacontane (C_{34}) were added by weight at a concentration of 0.3 mg / g to serve as internal alkane standards. An internal alcohol standard, n-heptacosanol (1-C_{27}-ol) at a concentration of 1.5 mg / g was added by weight. Samples were extracted overnight using 1M KOH. Hydrocarbons were collected by solid phase extraction using heptane.

Crude alcohol extractions were obtained by solid phase extraction using heptane/ethyl acetate followed by sterol/stanols separation and derivatization with pyridine and acetice anhydride. *n*-Alkane elutes and LCOH fractions were evaporated to dryness, and re-dissolved in *n*-dodecane for chromatographic analysis.

Table 1. Mean *n*-alkane and long-chain alcohol concentrations (mg • kg^{-1} DM) for corn plant parts.

	n-alkane				Long-chain alcohol		
Plant part	C_{27}	C_{29}	C_{31}	C_{33}	$C_{26}OH$	$C_{28}OH$	$C_{30}OH$
Cob	4.61	11.1	7.42	5.42	19.7	3.23	3.87
Husk	4.25	17.1	19.5	9.80	70.3	25.7	30.9
Leaf	9.29	30.1	56.5	45.6	54.9	57.2	74.2
Stalk	2.59	3.21	3.65	4.77	20.1	5.10	5.52
Grain	3.00	2.28	2.29	3.31	18.3	2.24	4.34

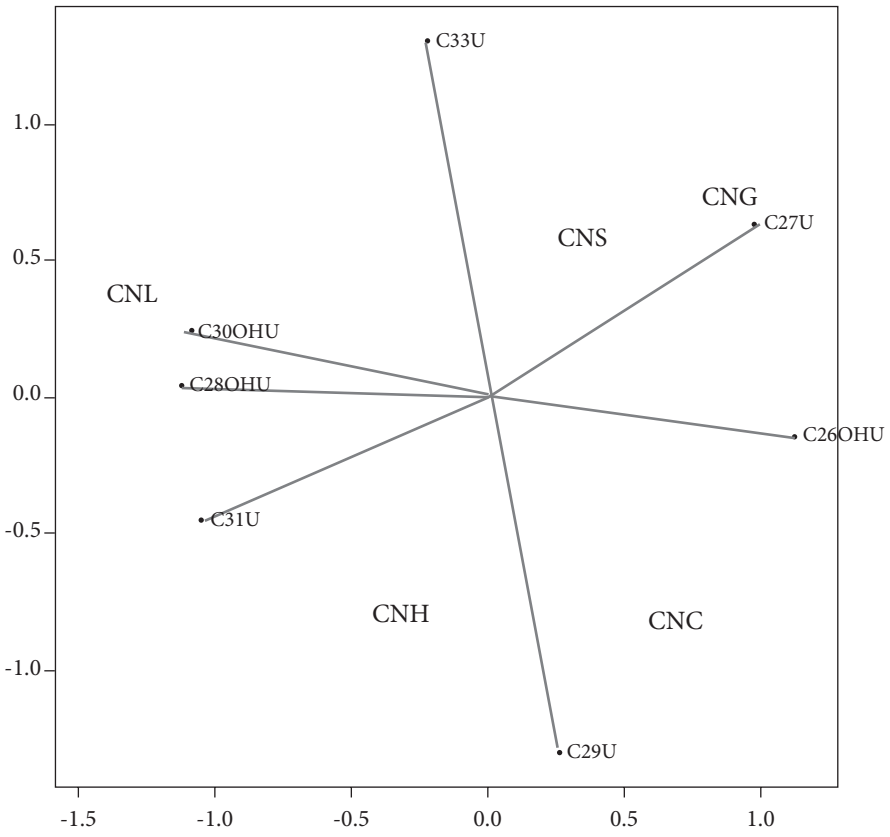

Figure 1. Biplot showing the 5 corn plant parts in a 2-dimensional space derived from principal component analysis based on concentrations of 4 *n*-alkanes (C27U, C29U, C31U and C33U) and 3 long-chain alcohols (C26OHU, C28OHU and C30OHU) once normalized to a unit scaled. The corn plant parts were Corn Plant Cob (CNC), Corn Plant Leaf (CNL), Corn Plant Husk (CNH), Corn Plant Stalk (CNS) and Corn Plant Grain (CNG).

Quantification of ALK and LCOH was carried out by gas chromatography (**GC**), using an Agilent 7820A GC. Samples of an ALK and LCOH standard solution mixture (C_{21} to C_{36}; $C_{20}OH$ to $C_{30}OH$) were included in the GC analyses to determine peak identification and standard response factors. Peak areas were determined with auto-integration and manual review of chromatograms. The ALK and LCOH concentrations were calculated relative to known amounts of the internal standards (C_{22}, C_{34} and $C_{27}OH$).

Statistical analyses were based on principal component analysis (**PCA**) conducted using GenStat for Windows 17th Edition. The PCA technique is used to explain the variation found in a set of observations by drawing out their strongest or most dominant patterns. It is often used to make data easier to visualize. In this study, PCA was used to generate 2-dimesional plots (biplots) based on the ALK and LCOH concentrations of plants or plant-parts. Through these biplots, it was possible to see whether the plant-wax profiles of the individual plant and plant-parts were distinct enough to separate them.

For the parts of the corn plant, 4 ALK (C_{27}, C_{29}, C_{31} and C_{33}) and 3 LCOH ($C_{26}OH$, $C_{28}OH$ and $C_{30}OH$) concentrations were considered. For the plant species in the western rangelands, an additional ALK (C_{35}) and 2 additional LCOH were used ($C_{24}OH$ and $C_{32}OH$) as markers given the greater complexity of the plant mixture. The concentrations of $C_{24}OH$ and $C_{32}OH$ compound were estimated from nearby standard response factors. Because the concentrations of ALK and LCOH differed appreciably among the plant species, the concentrations were normalized to a unit scale within ALK and within LCOH by dividing individual concentrations by their respective sum.

Results

Corn Plant

The ALK and LCOH concentration of the 5 corn plant parts are provided in Table 1. There was large variation in the plant-wax contents of the plant parts. The concentration of C_{27} was relatively low in all plant components. The $C_{26}OH$ compound was predominant in the husk compared to all other parts. The concentrations of all compounds were consistently higher in the leaf of the plant with the exception of $C_{26}OH$. Grain, stalks and cobs seemed to have the lowest overall concentrations of all compounds.

Based on the PCA, 79.9% of the variation in the plant-wax concentrations among plant parts was described along the first or x-axis, while a further 18.1% of the variation was defined along the second or y-axis (Figure 1). With effectively all variation (98%) being explained in just these 2-dimensions, the plant-wax profiles of the various parts of a corn plant allowed them to be clearly distinguished. Leaf had greater concentrations of $C_{30}OH$ and $C_{24}OH$ making its cluster very distinct. Husk and cob clusters were also discernable because of the higher concentrations in C_{29} in both, yet still distinct from each other due to their differing C_{31} and $C_{26}OH$ concentrations,

Table 2. Mean *n*-alkane and long-chain alcohol concentrations (mg • kg^{-1} DM) for 8 forage species at peak vegetative and mature (shown in parentheses) stages of growth.

		n-alkane					Long-chain alcohol				
Class[1]	Specie	C_{27}	C_{29}	C_{31}	C_{33}	C_{35}	$C_{24}OH$	$C_{26}OH$	$C_{28}OH$	$C_{30}OH$	$C_{32}OH$
C3	Cheatgrass	47.2 (42.2)	57.7 (152.4)	39.6 (94.1)	39.9 (22.3)	3.2 (1.7)	351.2 (77.9)	74.0 (144.4)	1308.5 (5066.2)	58.5 (72.0)	0 (0)
	Needle-and-thread	30.7 (30.7)	84.9 (92.1)	89.8 (113.7)	28.5 (22.4)	29.8 (15.5)	0 (75.9)	84.8 (411.6)	4126.4 (8962.5)	180.3 (252.9)	0 (54.1)
	Western wheatgrass	9.6 (50.9)	31.1 (56.6)	59.1 (34.5)	25.5 (6.3)	1.4 (0.8)	0 (0)	40.9 (28.7)	560.1 (39.3)	29.5 (21.6)	0 (0)
C4	Blue grama	13.8 (12.4)	49.0 (47.0)	179.4 (148.7)	121.2 (75.1)	21.1 (18.8)	0 (28.6)	0 (0)	727.2 (111.9)	141.2 (125.4)	2703.3 (11252.9)
	Little bluestem	18.2 (57.7)	28.0 (44.8)	50.5 (58.8)	8.4 (18.9)	1.2 (4.4)	0 (68.9)	44.2 (140.5)	337.0 (134.7)	196.2 (120.4)	5871.8 (13200.2)
	Sideoats grama	29.1 (35.5)	28.6 (45.5)	21.2 (35.6)	15.7 (19.4)	7.0 (3.7)	0 (26.1)	77.7 (324.5)	1268.9 (1624.2)	157.7 (262.3)	900.5 (1244.9)
Leg.	Leadplant	93.4 (48.8)	143.8 (273.4)	38.3 (181.4)	5.5 (16.5)	0.4 (0.1)	193.0 (234.8)	658.2 (757.4)	2856.0 (2057.4)	1076.6 (537.6)	0 (94.9)
	Sweet clover	38.8 (37.0)	268.3 (440.0)	53.0 (51.3)	22.2 (7.5)	1.4 (1.2)	188.6 (219.1)	2464.0 (689.7)	159.8 (108.1)	522.6 (116.0)	0 (0)

[1]Specie classifications were cool-season (C3) and warm-season (C4) grass, and legume (Leg.).

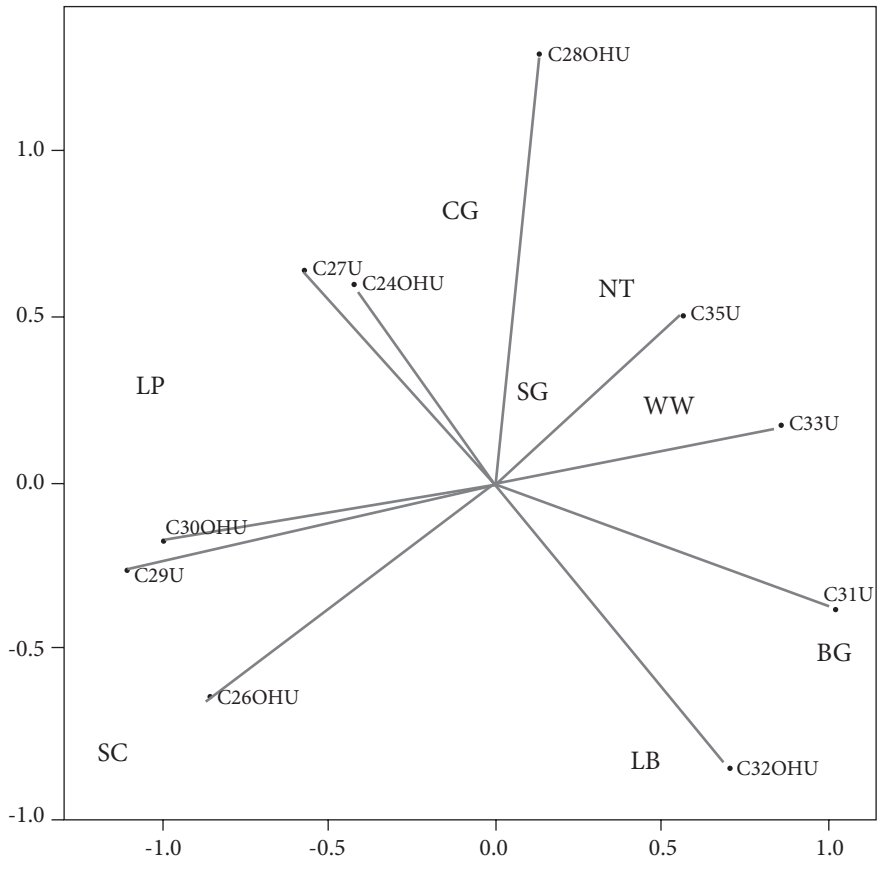

Figure 2. Biplot showing the 8 forage species at their peak vegetative state in a 2-dimensional space derived from principal component analyses based on concentrations of 5 *n*-alkanes (C27U, C29U, C31U, C33U and C35U) and 5 long-chain alcohols (C24OHU, C26OHU, C28OHU, C30OHU and C32OHU) once normalized to a unit scaled. The forage species were Sweet Clover (SC), Leadplant (LP), Cheatgrass (CG), Sideoats grama (SG), Needle- and-thread (NT), Western Wheatgrass (WW), Blue Grama (BG) and Little Bluestem (LB).

respectively. Stalk and grain were the most closely related with higher concentrations in C_{27}. However, stalks contained more C_{33} allowing it to appear separate from grain.

Western Rangeland

The ALK and LCOH concentrations of the 8 plant species found in western rangelands are provided in Table 2. There was large variation in the plant-wax content of plants within and across growth stages. Leadplant and sweet clover contained higher concentrations of C_{29} during both vegetative and mature states. Blue grama had higher concentrations of C_{33} when compared to other plants. All plants had low concentrations of C_{35}. The LCOH amounts, when present, were considerably higher than ALK concentrations. The concentration of $C_{28}OH$ was highest in cheatgrass and needle- and-thread at maturity. The compound $C_{32}OH$ only appeared at extremely high concentrations in mature warm-season grasses (blue grama, little bluestem and sideoats grama).

The PCA for vegetative plants showed 55.3% of the variation between plant parts was described on first or x-axis (Figure 2). An additional 35.2% was defined along the second or y-axis, for a total of 90.5% of variation being defined in these 2-dimsensions. For mature plants, 65.8% of

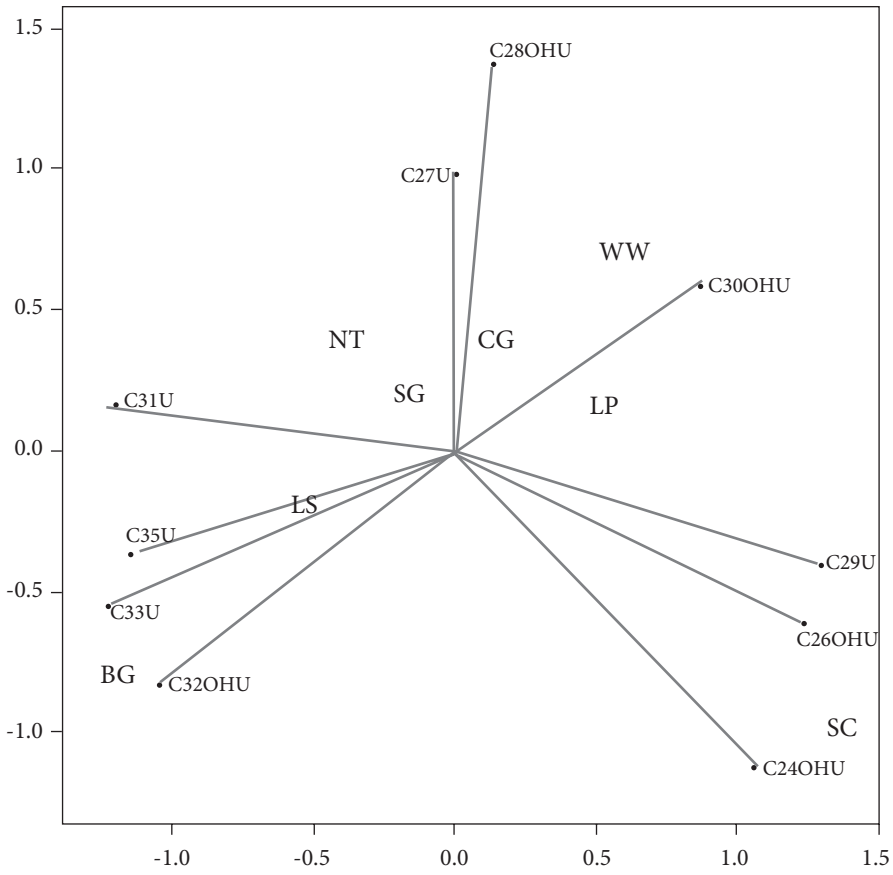

Figure 3. Biplot showing the 8 forage species at their mature state in a 2-dimensional space derived from principal component analyses based on concentrations of 5 *n*-alkanes (C27U, C29U, C31U, C33U and C35U) and 5 long-chain alcohols (C24OHU, C26OHU, C28OHU, C30OHU and C32OHU) once normalized to a unit scaled. The forage species were Sweet Clover (SC), Leadplant (LP), Cheatgrass (CG), Sideoats grama (SG), Needle- and-thread (NT), Western Wheatgrass (WW), Blue Grama (BG) and Little Bluestem (LB).

the variation was described along the first axis, followed by 27.4% explained along the second axis, totaling 93.2% of the variation being defined along the first two axes (Figure 3).

The spread of the 8 forage species in the biplots clearly showed the ability to discriminate legumes from grasses. The greater concentrations of C_{29}, $C_{24}OH$ and $C_{26}OH$ in legumes resulted in their clustering. High concentrations of $C_{32}OH$ made C4 grasses stand out, particularly blue grama that also had high concentrations of C_{33}. Stronger separation of the grasses was captured along the y-axis, but they still could not be unequivocally differentiated. Cheatgrass, western wheatgrass, little bluestem and sideoats grama clustered together and were not separable based on their ALK and LCOH profiles alone.

Conclusions

Using ALK and LCOH concentrations, the parts of the corn plant could be clearly delineated. However, the specie-specific profiles of the plant-wax markers were not distinct enough to distinguish among plants comprising a complex western rangeland. That issue is explored further elsewhere (2017 Nebraska Beef Report, pp. 73–75). The plant-wax characteristics appear useful for assessing dietary choices in cattle grazing a monoculture like corn residue. Such information may benefit management decisions, including deciding when animals might be moved to alternative grazing areas. However, to delineate choices in a complex sward such as western rangelands, additional plant markers will be needed to more clearly distinguish plant species.

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Delineating Complex Forage Mixtures Using Plant-Wax Markers

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Summary with Implications

Plant waxes provide a marker profile of individual plants that, when sufficiently distinct, can be used to estimate the diet composition of grazing cattle. They also may provide a tool for reliably predicting feed intake. The traditional method (nonnegative least squares) to use these markers to predict diet composition has limitations. A newer statistical approach (Bayesian linear unmixing) deemed more efficient was tested with simulation. Samples from 8 forage species in Nebraska were analyzed for their plant-wax marker contents. Those concentrations were used to simulate 1000 diets for 4 mixtures containing 2, 3, 5 or 8 plants. The efficiency of the two methods to predict diet composition was compared. The newer approach outperformed the traditional one in all of the mixtures considered. However, predictions were considerably worse when the number of plants in the mixture was 5 or 8. When forage mixtures are complex, additional steps will be needed to predict diet composition, and thereby feed intake, in grazing cattle.

Introduction

Estimating diet composition and feed intake under grazing conditions is challenging but necessary to determine feed efficiency. Plant-wax markers, particularly *n*-alkanes (**ALK**) and long-chain alcohols (**LCOH**), have been used successfully to estimate the botanical composition of the diet in grazing conditions. The ability of ALK and LCOH to delineate the plants in the diet depends on their marker profiles being sufficiently different among the plants on offer. Importantly, to estimate feed intake using the plant-wax marker technique, the botanical makeup of the diet needs to be estimated first. Given that botanical mixtures are compositional in nature (i.e., are positive and sum to one), constraints have to be imposed during estimation. Traditional methods, do not address some of these constraints. Conversely, more recent statistical methods do and have successfully been used to estimate the composition of mixtures in, for instance, image analysis and geochemistry but, as of yet, not in animal diets. The proposed approach would directly account for such constraints. However, validating the methodology is necessary to make sure it performs (at least) as well as the traditional technique. This validation was performed through a simulation study.

Procedure

As described elsewhere (2017 Nebraska Beef Report, pp. 69–72), 8 plant species commonly found in Nebraska were collected. These forages were 3 cool-season (C3) grasses (cheatgrass (*Bromus tectorum*); needle- and-thread (*Hesperostipa comata*); western wheatgrass (*Pascopyrum smithii*)), 3 warm-season (C4) grasses (blue grama (*Bouteloua gracilis*); little bluestem (*Schizachyrium scoparium*); sideoats grama (*Bouteloua curtipendula*)), and 2 legumes (leadplant (*Amorpha canescens*); sweet clover (*Melilotus officinalis*)).

Plant-wax marker concentrations (mg / kg) were measured using gas chromatography at two development stages (at peak vegetative and maturity). Four mixtures were simulated using i) sweet clover and cheatgrass, ii) sweet clover, cheatgrass and blue grama, iii) sweet clover, cheatgrass, blue grama, sideoats grama and western wheatgrass, and iv) all 8 species. For all mixtures, 1000 diets were simulated. Analyses were performed using both the traditional and the newer method.

The ability (efficiency) to delineate the mixtures for each of the methods was assessed based on 4 statistics. Firstly, the discrepancy between the true (simulated) values and their estimates, or the estimation error (**EE**), was assessed. Lower EE correspond with improved efficiency. Secondly, the proportion of times that the estimates were within a fixed distance of the true values was determined (**FD**). For reliable predictions, FD should be between 0.93 and 0.97. Thirdly, the importance (significance) of a particular plant-wax marker to separate plants into distinct categories was evaluated. Lastly, procedures that graphically cluster plants depending on similarities in their plant-wax marker contents were used.

Table 1. Efficiency of a newer (Bayesian linear hierarchical unmixing) and a traditional (non-negative least squares) method to estimate diet composition.

Statistic[1]	Plant mixture	Newer	Traditional
EE	2	0.018	0.033
	3	0.034	0.052
	5	0.094	0.175
	8	0.216	0.485
FD	2	0.907	0.698
	3	0.923	0.818
	5	0.652	0.518
	8	0.669	0.491

[1] Statistics: estimation error (EE) and the proportion of times that the estimates were within a fixed distance of the true values (FD).

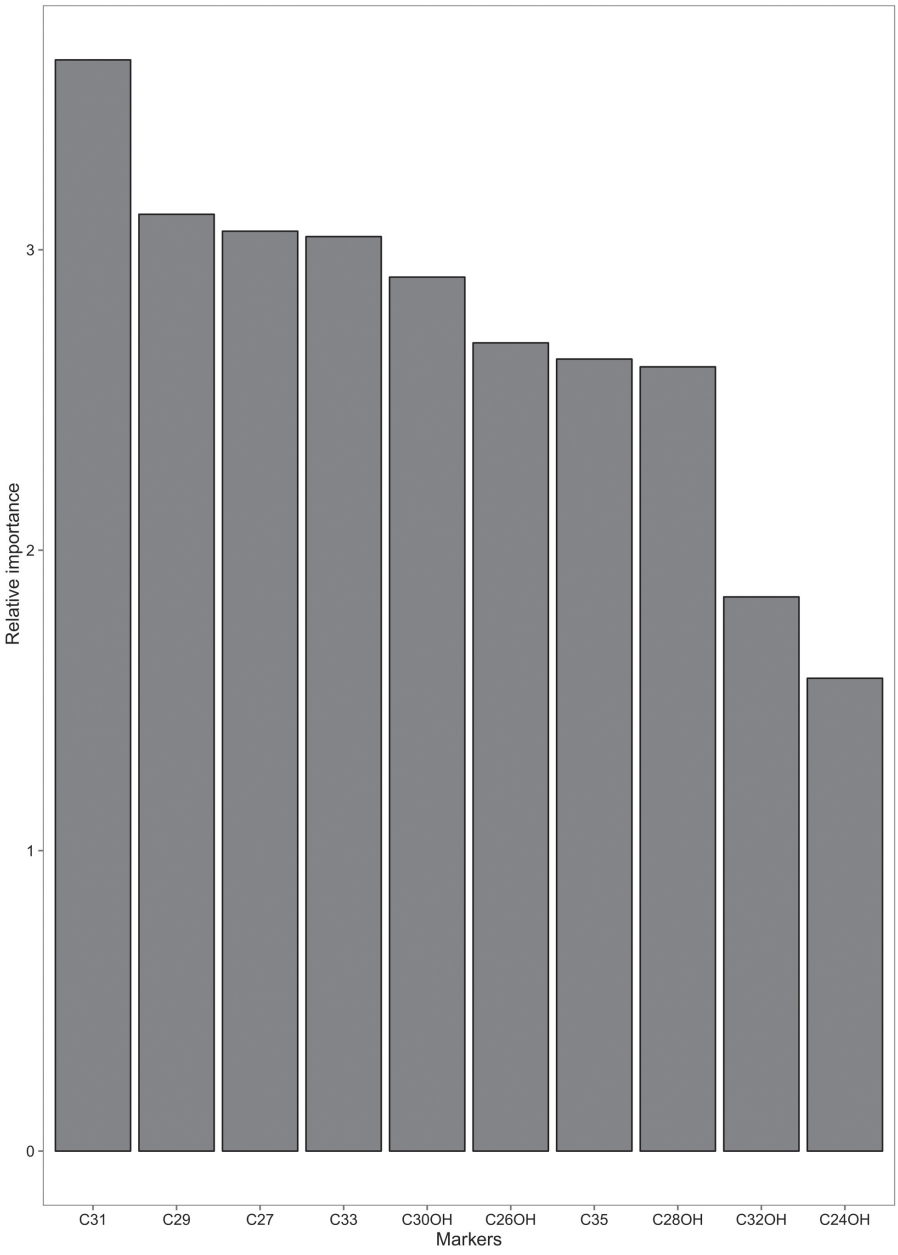

Figure 1. Plant-wax marker importance for 8 plant species at their early (vegetative) stage of growth) based on concentrations of 5 *n*-alkanes (C_{27}, C_{29}, C_{31}, C_{33} and C_{35}) and 5 long-chain alcohols (C_{24}OH, C_{26}OH, C_{28}OH, C_{30}OH and C_{32}OH).

Results

Mean ALK and LCOH concentrations for the 8 plant species were presented in 2017 Nebraska Beef Report, pp. 69–72. In general, ALK concentrations are lower than those of LCOH, which is in accordance with other studies.

With regards to the efficiency of delineating forage mixtures, for the 2-plant mixture the newer method was clearly more efficient, with EE of 0.018 compared to that of traditional method of 0.033 (Table 1). That represented a 50% improvement in efficiency. The FD also was better with the new method, although somewhat lower than the expected range. For the 3-plant mixture similar results were obtained although the reduction in EE was smaller, 0.034 and 0.052 for the new and traditional method, respectively. Still the difference between the two methods represented a 35% improvement in efficiency. In addition, the FD for the new method was close to the range expected, while that for the traditional method was well below.

For the 5-plant mixtures, the EE were 0.094 and 0.175 for the new and traditional method, respectively; however, FD was considerably reduced for both methods to 0.652 (new) and 0.518 (traditional). A similar result was obtained for the 8-plant mixture, with lower efficiencies for both methods: the estimation errors increased substantially and the proportion of times true and estimated values coincided decreased considerably. However, the new method was still around 50% more efficient than the traditional. One likely reason for this significant decline in ability to determine diet composition may be insufficient differences in the ALK and LCOH profiles among the plants when more and similar species were combined.

With this particular set of plant species, delineating relatively simple mixtures (2 or 3 plants) using the new method is quite feasible. However, increasing the number of plants in the mixture dramatically reduced the efficiency of the both methods. As shown in Figure 1, the C_{32}OH and C_{24}OH help the least in species delineation, possibly due to many of the plant species not having these two markers present. When evaluating the similarities in plant-waxes profiles for the different plants, C_{31}, C_{33}, C_{35} and C_{28}OH were common to the cool-

and warm-season grasses, while $C_{26}OH$ was important to distinguish the legumes. Although the $C_{32}OH$ was less important than many other markers to delineate plant species generally, in was unique to C4 grasses; therefore, it facilitated separating the cool- and warm-season grasses.

One possible way to increase the efficiency of the plant-wax methodology, when considering mixtures of more plants, is to add other plant markers such as long-chain fatty acids and alkenes. Additionally, plants could be grouped based on their taxonomy or function to simplify the complexity of the sward being characterized. Such an approach may be particularly valuable when the primary aim is to predict feed intake.

Conclusion

In conclusion, the reliability of predictions of diet composition was improved by using a more sophisticated statistical approach in the evaluation. However, further developments in the application of the plant-wax marker technique are still needed to determine the dietary choices and feed intakes of cattle grazing complex swards typical to western rangelands.

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Relationship between Dietary Total Digestible Nutrients and Digestible Organic Matter in Beef Cattle Finishing and Growing Diets With or Without Distillers Grains

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Summary and Implications

The relationship between organic matter digestibility and total digestible nutrients is unestablished for diets containing distillers grains. Three cattle digestion studies were used to evaluate the relationship between total digestible nutrients and digestible organic matter. Results suggest digestible organic matter is consistent relative to total digestible nutrients content for traditional, corn based diets. In finishing and growing diets containing distillers grains additional digestible energy supplied by distillers grains is not accounted for when evaluating only digestible organic matter. Measuring digestible energy content of diets used in digestion trials is essential.

Introduction

Total digestible nutrients (TDN) are directly related to digestible energy (DE). Then, TDN can be converted to DE using 1 lb of TDN equal to 2 Mcal of DE. Previously, TDN was based on proximate analysis, which is no longer commonly used. These analyses were also based on diets containing primarily corn, fat, and alfalfa, but none containing distillers grains. Organic matter digestibility (OMD) is related to TDN and is commonly measured in digestion studies to estimate feeding values. However, the relationship between OMD and TDN is unestablished for diets containing distillers grains. When the amount of wet distillers grains plus solubles (WDGS) is increased in a diet there is an increase in feed efficiency but a decrease in OMD. Total energy content of the feed and feces can be measured using bomb calorimetry to directly measure DE. The objective of this study was to compare digested organic matter (DIGOM), determined by previous digestibility trials utilizing diets with or without distillers grains, DE, and calculated TDN values using bomb calorimetry.

Procedure

This study utilized three previously conducted digestion trials where total tract collection and OM analysis of feed and feces were measured to determine OMD. Organic matter digestibility values were then multiplied by dietary OM content to determine digested organic matter (DIGOM, % DM). Dietary DE was calculated from heat of combustion of feed and feces, measured using a bomb calorimeter. Conversion of DE to TDN was assumed to be 2.0 Mcal DE / lb TDN. Regression models were developed using GLM Procedures of SAS. Digestion data were analyzed using the Mixed Procedures of SAS with treatment as a fixed effect and steer as experimental unit. Comparisons were made across and within experiments.

Description of Experiments

The first experiment fed a basal diet consisting of 40% Sweet Bran®, 45% high moisture corn (45% HMC), 10% corn silage, and 5% supplement (DM basis) with or without enzyme. The second experiment (18% MDGS) had four dietary treatments. The negative control (negcontrol) contained 60% untreated corn stover, 18% MDGS, 18% distillers solubles and 4% supplement (DM basis). The positive control (poscontrol) consisted of 60% CaO treated corn stover, 18% MDGS, 18% distillers solubles, and 4% supplement. The third treatment (pelletC) was a pellet containing the same proportions of CaO treated corn stover, solubles, MDGS and supplement. Treatment four (pelletS) was also a pellet containing the same proportions of CaO treated corn stover, solubles, DDG, and supplement. The corn stover for this treatment was harvested using a single pass round baler pulled behind the combine. The corn residue that was left was raked into wind rows and baled with a conventional square baler. The third experiment used five dietary treatments comparing an 80% DRC-based diet (Corn) with one of two supplemental fat sources (Tallow or Cornoil) to diets with 25.5% distillers solubles (Solubles), or 56% wet DGS (WDGS).

Regression

Regression was used to relate digestible OM to TDN. The initial model included experiment, animal within experiment, and treatment within experiment. Individual points were used to represent animal within period for each experiment in Figures 2–4. For Exp. 1 and 2, a combined treatment average was used for each experiment and experiments will be henceforth referred to as 45% HMC and 18% MDGS, respectively. Regression models for the relationship between the differences in DIGOM, TDN, and GE were developed used treatment average as the observation.

Results

Intercepts for a unified regression model were not significant ($P = 0.316$). A significant treatment within experiment effect ($P < 0.01$) resulted in independent regression models for each experiment. An isopleth was indicated with a dotted line to show relative differences of slope. Treatments for Exp. 1 were significantly different ($P < 0.01$) for DIGOM relative to TDN. However, Exp. 1 showed no treatment effect for DIGOM. Therefore, a single slope with a linear relationship was used (Figure 1) and designated as a treatment average (45% HMC) for further analysis. Treatments for Exp. 2 were significantly different ($P < 0.01$) for DIGOM relative to TDN. However, Exp. 2 showed no treatment effect for DIGOM. Therefore,

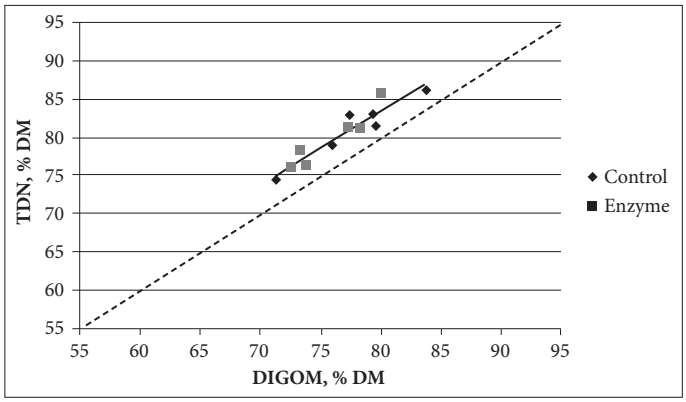

Figure 1. TDN vs DIGOM in 2 finishing diets without DGS (Exp. 1). Control (diamonds) and enzyme (squares) data are shown in the graph where individual data points indicate animal as the experimental unit. The regression equation for the data was TDN = [0.967 (±0.106) × DIGOM] + 6.16 (±8.20) % (R^2 =0.892).

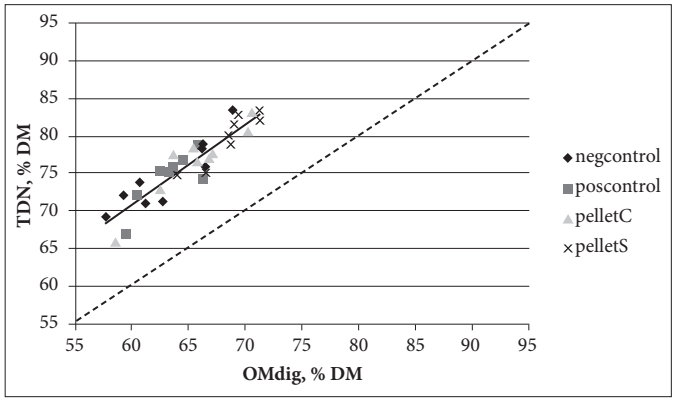

Figure 2. TDN vs DIGOM of growing diets with DGS (Exp. 2). NEGCONTROL (diamond), POSCONTROL (square), pelletC (triangle), and pelletS (exes) data are shown in the graph where individual data points indicate animal as the experimental unit. The regression equation for the data was TDN = [1.10 (±0.0786) × DIGOM] + 4.59 (±5.14) % (R^2 =0.852).

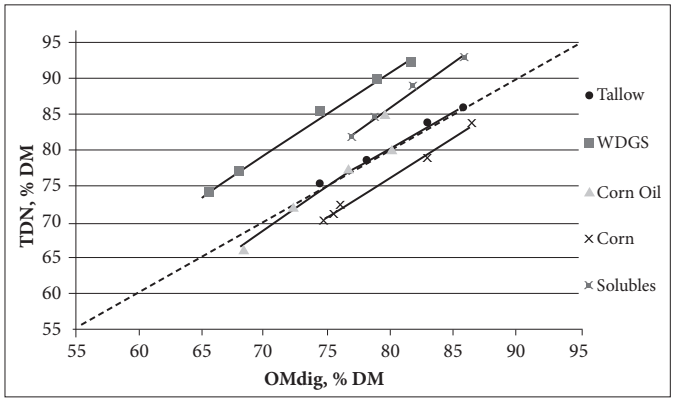

Figure 3. TDN vs DIGOM in 5 finishing diets (Exp. 3). Tallow (circles), WDGS (squares), Corn Oil (triangles), Corn (exes), and Solubles (asterisks) data are shown in the graph where individual data points indicate animal as the experimental unit. The regression equation for the Tallow treatment was TDN = [0.990 (±0.0433) × DIGOM] + 1.09(±3.44) % (R^2 =0.994). The regression equation for the WDGS treatment was TDN = [1.15 (±0.0471) × DIGOM]-0.887(±3.49) % (R^2 =0.995). The regression equation for the Corn Oil treatment was TDN = [1.10 (±0.0712) × DIGOM]-7.70(±5.44) % (R^2 =0.987). The regression equation for the Corn treatment was TDN = [1.11 (±0.0519) × DIGOM]-12.5(±4.12) % (r2 =0.993). The regression equation for the Solubles treatment was TDN = [1.24 (±0.0833) × DIGOM]-13.9(±6.72) % (R^2 =0.987).

a single slope with a linear relationship was used (Figure 2) and designated as a treatment average (18% MDGS) for further analysis. In Exp. 3, there was a tendency for a treatment effect ($P > 0.14$). Therefore treatments were evaluated using separate regression lines (Figure 3) and treatments remained separate for further analysis (Corn, CornOil, Tallow, Solubles, WDGS).

The difference between TDN (% of DM) and DIGOM (% of DM) was greatest for the 18% MDGS (Exp. 2) with 11.1 percentage units (PPT) difference (Table 1). The WDGS treatment followed with 10.0 PPT difference. The solubles, 45% HMC (Exp. 1), and Tallow treatments were 5.9, 3.6, and 0.3 PPT difference, respectively. Corn oil and corn treatments had greater DIGOM than TDN showing a PPT difference of-0.4 and-4.0, respectively.

There were no significant differences for OM intake (kg) across all treatments ($P = 0.88$; Table 2). There were no significant differences in energy intake (Mcal) across all treatments ($P = 0.28$). However, OM excreted (kg) was significantly different ($P < 0.01$), with WDGS and 18%MDGS treatments having the greatest OM excreted, Corn, 45% HMC, Corn Oil and Tallow being intermediate, and solubles having the least OM excreted. There were significant differences ($P < 0.01$) in energy excreted (Mcal) with WDGS and 18% MDGS having the greatest energy excreted, Corn, Corn Oil, Tallow, and 45% HMC being intermediate, and Solubles having the least energy excreted. The ratio for consumed energy relative to consumed OM was different across treatments ($P < 0.01$), with WDGS and 18% MDGS having the greatest ratio, solubles the next greatest ratio, followed by 45% HMC. Corn oil and tallow had the fourth greatest ratio and Corn had the lowest ratio. The ratio for excreted OM relative to excreted energy was significantly different ($P < 0.01$), with solubles and WDGS having the greatest ratio, corn, corn oil, tallow, and 45% HMC being intermediate, and 18% MDGS having the lowest ratio (Table 2).

The DIGOM is consistent relative to TDN content of traditional corn based diets. Results from Exp. 2 and 3 with diets containing DGS showed there was some portion of DE that was not accounted for when using only DIGOM. Additional DE is likely due to the protein and fat content of DGS which

Table 1. Average TDN and DIGOM for treatments for experiments 1–3.

Treatments[1]	TDN[2], % of DM	DIGOM[2], % of DM	Difference[3]
Exp. 1			
45% HMC	80.5	76.9	3.6
Exp. 2			
18% MDGS	76.4	65.3	11.1
Exp. 3			
Corn	75.2	79.2	-4.0
CornOil	75.9	76.2	-0.4
Tallow	79.7	79.3	0.3
Solubles	86.6	80.7	5.9
WDGS[4]	83.7	73.8	10.0

[1]Treatments from Exp. 1; Contains control and enzyme treatments which both contain 45% HMC; HMC: High moisture corn; Treatments from Exp. 2; Contains poscontrol, negcontrol, pelletS and pellet which all contain 18% MDGS; MDGS: Modified distillers grains; Treatments from Exp. 3; WDGS: Wet distillers grains
[2]Treatment average across animal and period; TDN: Total digestible nutrients; DIGOM: Digested organic matter
[3] Percentage unit difference
[4] 56% inclusion (DM basis) of WDGS in the diet

Table 2. Difference in diet and fecal energy relative to OM[1] content for all experiment treatments.

	Treatment								
	Corn	45% HMC[2]	Corn Oil	Tallow	Solubles	WDGS[3]	18% MDGS[4]	SEM	*P*-Value
Consumed									
OM, lb	10.7	9.53	9.34	10.0	9.34	10.0	9.93	0.84	0.88
Energy, Mcal	46.4	44.9	42.7	45.6	45.1	51.0	50.9	4.23	0.28
Excreted									
OM, lb	1.92^{bc}	1.80^{bc}	2.01^{bc}	1.87^{bc}	1.35^{c}	2.32^{ab}	2.71^{a}	0.30	<0.01
Energy, Mcal	9.61^{bc}	9.17^{bc}	10.5^{bc}	9.58^{bc}	7.30^{c}	12.4^{ab}	13.5^{a}	1.49	<0.01
Energy, Mcal/lb OM [5]									
Consumed	4.32^{e}	4.72^{c}	4.56^{d}	4.56^{d}	4.83^{b}	5.07^{a}	5.11^{a}	0.025	<0.01
Excreted	5.00^{bc}	5.11^{bc}	5.25^{ab}	5.18^{abc}	5.40^{a}	5.36^{a}	5.00^{c}	0.087	<0.01

[1] OM: Organic matter
[2]Treatment average for Exp. 1; Contains control and enzyme treatments which both contain 45% HMC; HMC: High moisture corn
[3] 56% inclusion (DM basis) of WDGS in the diet
[4] Treatment average for Exp. 2; Contains poscontrol, negcontrol, pelletS and pelletC which all contain 18% MDGS; MDGS: Modified distillers grains
[5] Consumed: Consumed energy (Mcal) was divided by consumed OM (lb). Excreted: Excreted energy (Mcal) was divided by consumed OM (lb).

supplies additional energy relative to OM content. All treatments consumed the same amount of OM but varied in energy intake. This was more apparent when expressed as a ratio with energy intake. The average of all treatments in Exp. 2 had the greatest ratio for energy intake relative to OM intake. Conversely, the average of all treatments had the smallest ratio for energy excreted relative to OM excreted. These data suggest that there is more energy being consumed but not being excreted in the feces. The fiber content of DGS could reduce energy supplied, but would remain in feces as OM, which is why greater OM was excreted from treatments containing DGS.

Conclusions

The difference between TDN and DIGOM is much greater for diets containing DGS. When the percent difference between TDN and DIGOM is expressed in terms of GE within an individual experiment, the relationship becomes uniform across diets. Therefore, it is essential to measure digestible energy content of diets in digestion trials, especially diets including distillers grains.

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Comparison of Titanium® 5 PH-M versus Titanium® 5 plus NUPLURA® PH with the Presence or Absence of Monensin on Health and Performance of Newly Received Feedlot Calves Fed RAMP®

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Summary with Implications

A receiving study was conducted to evaluate the effects of RAMP® with Rumensin® concentration (0 or 25.0 g/ton) given with one of two viral vaccinations (Titanium® 5 PH-M or Titanium® 5 plus NUPLURA® PH) on steer growth performance and morbidity. There were no significant vaccine by diet interactions observed. Neither vaccine treatment nor Rumensin® level affected intake, gain, or feed conversion. Vaccine type did not affect first pull (P = 0.19) or second pull morbidity rates (P = 0.52). These findings suggest that neither vaccine type nor Rumensin® concentration had any effect on steer growth performance or morbidity rate.

Introduction

Rumensin® *(Elanco Animal Health)* is an ionophore that has been shown to alter the rumen microbial population and is widely used in the feedlot industry to improve feed efficiency. However, there has been limited current research evaluating the performance and morbidity impacts of feeding Rumensin® during the adaptation or receiving period in feedlot steers. A common perception is that calves cannot be started on Rumensin® without decreasing intake dramatically. The most prevalent disease in the beef industry is bovine respiratory disease (BRD). Respiratory disease can be caused by a combination of viral and bacterial pathogens, usually as a result of stress factors all interacting to cause morbid cattle. Titanium® 5 PH-M (VacPH-M) and Titanium® 5 + NUPLURA® PH (VacPH) (Elanco Animal Health) are both BRD vaccinations intended for beef cattle. The vaccine VacPH-M is labeled to deliver effective immune response against bacteria (*Mannheimia haemolytica* and *Pasteurella multocida*) and viruses (bovine viral diarrhea (BVD) types 1 and 2, infectious bovine rhinotracheitis (IBR), parainfluenza-3 virus (PI_3) and bovine respiratory syncytial virus (BRSV)). The vaccine VacPH is labeled similarly to VacPH-M excluding protection against *Pasteurella multocida*. One common practice for receiving cattle today is feeding RAMP®, a complete starter product (Cargill Corn Milling) which contains a high level of Sweet Bran® and a minimal amount of forage (*2013 Nebraska Beef Report*, pp. 84–85). The objective of this study was to evaluate the effects of VacPH-M versus VacPH on steer growth performance and morbidity over a 28-d receiving period when steers are fed RAMP with or without Rumensin®.

Procedure

A feedlot receiving study was conducted to determine the effectiveness of vaccine at arrival on growth performance and health of steers over a 28-d receiving period when fed RAMP with 0 or 25 g/ton (DM basis) of Rumensin®. The experiment was conducted at the University of Nebraska-Lincoln Eastern Nebraska Research and Extension Center (ENREC) near Mead, NE. Crossbred steers (n = 704; initial BW = 593 ± 49 lb) were utilized in a randomized block design with a 2×2 factorial treatment design. Upon arrival, steers were allowed access to water and processed within 6 hours. Steers were weighed on d 1 to establish initial BW. Steers were assigned to one of four treatments (pen) based on processing order with steers assigned singly to treatment in sets of 4, and repeated until 4 pens were filled (1 replicate). Once a pen replicate was filled, new pen replicates were started until all steers were assigned to 40 pens (10 pens per simple effect treatment) with 14–21 steers per pen (equal steers/pen within block). During processing on d 1, all steers were identified with an individual ear tag (3 tags total), individually weighed, and vaccinated with Somnu Shield® (Novartis Animal Health) administered at 2ml/steer and Dectomax® injectable (Zoetis Animal Health) administered at 1ml/110 lb of BW. Steer ID was utilized for treatment assignment to vaccine treatment based on odd or even numbers. All odd number ID tags were vaccinated with VacPH-M (2ml/steer), while all even numbered tags were vaccinated with VacPH (2ml/steer).

All four treatments were fed a common diet consisting of 97% RAMP and 3% fine ground corn based supplement (DM Basis). Supplements contained either 0 or 25 g/ton of Rumensin® (DM basis). Both supplements contained 435 g/ton of decoquinate (Deccox®; Zoetis Animal Health). After the 28-d receiving trial, steers were limit-fed (to minimize gut fill variation) a diet of 50% forage, 50% Sweet Bran (DM basis) at 2% of BW for 5 consecutive days before weighing for ending BW. Ending BW was an average of 2 consecutive day weights collected before feeding each day.

Performance data (BW, DMI, ADG, G:F) were analyzed using the MIXED procedure of SAS (SAS Inst., Inc., Cary, N.C.) with pen as the experimental unit. The model included Rumensin®, vaccine, and Rumensin® × vaccine interaction. Block (arrival) was included in the model as a fixed effect. Morbidity incidence was evaluated as the number of first treatments or the number of steers treated in the pen divided by the total number of steers in the pen. Additionally, the morbidity rate of two or more treatments was calculated as the number of steers treated two times divided by the total number of steers treated once. Morbidity data were analyzed with the GLIMMIX procedure of SAS using a binomial distribution and a logit-link function.

Table 1. Main effect comparisons of feeding Rumensin® and vaccine type on performance and morbidity over a 28-d receiving period.

	Rumensin®			Vaccine[1]				
Item	0 g/ton	25 g/ton	*P*-value	VacPH-M	VacPH	*P*-value	SEM	Interaction
Initial BW, lb	592	594	0.75	596	591	0.46	5.0	0.55
Ending BW, lb	680	682	0.83	683	679	0.58	6.0	0.59
DMI, lb/day	13.7	13.4	0.28	13.6	13.4	0.52	0.2	0.94
ADG, lb	3.28	3.27	0.94	3.28	3.27	0.95	0.09	0.81
Feed:Gain[2]	4.14	4.08	0.65	4.13	4.09	0.79	-	0.79
Morbidity								
First pull, %[3]	22.6	17.4	0.10	22.0	17.9	0.19	2.3	0.38
Second pull, %[4]	22.5	13.8	0.21	15.7	20.0	0.52	5.3	0.27

[1] VacPH-M is Titanium 5 PH-M and VacPH is Titanium 5 +Nuplura PH.
[2] Gain:Feed analyzed statistically, which is the reciprocal of Feed:Gain.
[3] Percentage of steers treated one or more times as a % of total steers within the pen.
[4] Percentage of steers treated two or more times, expressed as a % of steers pulled once.

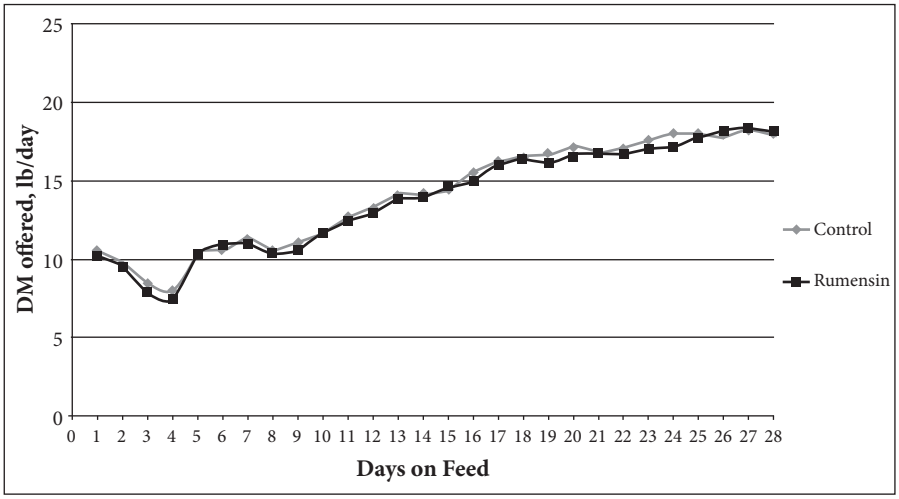

Figure 1. Daily DM offered to steers consuming a RAMP diet with or without Rumensin®.

Results

No significant Rumensin® × vaccine interactions ($P > 0.27$) were noted for growth performance or morbidity (Table 1). Rumensin concentration did not affect DMI ($P = 0.28$), ADG ($P = 0.94$), F:G ($P = 0.65$), or ending BW ($P = 0.83$). While steers fed Rumensin® ate less feed numerically, the difference was small (2%) and was not statistically significant. The DM offered across the 28-day receiving period is shown in Figure 1. The DM offered was consistent across both treatments. There was a tendency ($P = 0.10$) for steers fed 25.0 g/ton of Rumensin® to have a lower percentage of first and second pulls as compared to steers receiving 0 g/ton of Rumensin®.

Vaccine type did not affect DMI ($P = 0.52$), ADG ($P = 0.95$), F:G ($P = 0.79$), or ending BW ($P = 0.58$). The number of steers pulled and treated for BRD one or more times was not different ($P = 0.19$) for VacPH-M compared to VacPH. However, the numerical difference between vaccine types was similar to the numerical difference between steers fed Rumensin® or not. While not significant, steers vaccinated with VacPH had numerically lower first pulls. No difference ($P = 0.52$) was observed when comparing second pull rates between vaccine types.

Conclusion

Results suggest that neither vaccine type nor Rumensin® concentration had any effect on steer growth performance or morbidity rate for the first 28-d of receiving. Including Rumensin® from day 1 of receiving does not dramatically alter DMI of newly received calves.

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Effect of Three Initial Implant Programs with a Common Terminal Revalor®-200 on Feedlot Performance and Carcass Traits of Weaned Steers

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Summary with Implications

A commercial feedlot study utilizing 1,350 calf-fed steers (initial BW = 623 lb; ±23 lb) compared three initial implant strategies: Revalor®-IS (day 1), Revalor®-IS (day 1) and Revalor®-200 (day 67), or Revalor®-XS (day 1). Each initial implant strategy was followed by a terminal Revalor®-200 implant (day 133) to determine effects on performance and carcass traits. No differences in final body weight, intake, gain, or feed conversion were observed on either a live, or carcass adjusted basis. There were also no differences in hot carcass weight, USDA quality grade, or USDA yield grade. Results from this study suggest initial implant strategy has minimal impact on feedlot and carcass performance when following with a terminal Revalor®-200 implant.

Introduction

Steers have shown the ability to respond to higher dose single implant protocols with increased growth performance and leaner body composition when cattle are harvested on an equal day basis. Increasing trenbolone acetate (TBA) and estradiol (E) levels in re-implant protocols have resulted in mixed results. Regardless, industry use of steer protocols providing a Revalor®-IS initially, followed by 2 Revalor®-200 implants, approximately 65 days apart in steers fed for 200 to 220 days, has become increasingly common. Only two studies have evaluated aggressive protocols utilizing Revalor®-XS as an initial implant and re-implanted with Revalor®-200. A more intensive evaluation of implant protocols in calf-fed steers is needed. The objectives of this study were to determine the effect of three initial implant programs: Revalor®-IS (day 1), Revalor®-IS (day 1) and Revalor®-200 (day 67), or Revalor®-XS (day 1), all followed by a terminal Revalor®-200 (day 133) on feedlot performance and carcass traits of weaned calf-fed steers fed for 200 to 220 days.

Procedure

A commercial feedlot experiment was conducted at a commercial feedlot in central Nebraska (Hi-Gain Feedlot, Farnam, NE). Crossbred steer calves (n = 1,350; initial BW = 623 lb; ±23 lb) from ranches and auction barns in NE, IA, UT, SD, ID, and CA were utilized for this trial. This study was conducted as a randomized complete block design, with the blocking factor being source/arrival time of the steers. Steers were assigned to pens by sorting every two steers into one of three pens before processing. Pens were assigned randomly to one of three treatments within arrival block. Steers were administered one of three implant treatments; 1) Revalor®-IS (80 mg of TBA and 16 mg of E) on day 1; 2) Revalor®-IS on day 1 and Revalor®-200 (200 mg of TBA and 20 mg of E) on day 67; 3) Revalor®-XS (200 mg of TBA and 40 mg of E) on day 1. All treatments received a terminal implant, Revalor®-200, at 133 days on feed. At initial processing all steers received a Vista 3, Safeguard oral suspension of wormer (Safeguard) in conjunction with an Avermectin product, along with the assigned initial implant. Mean days on feed across all blocks was 215, with the second and third implants administered on average at day 67 and 133, respectively. A

Table 1. Performance of steers Implanted with either Revalor®-IS (Rev-IS), Revalor®-IS and Revalor®-200 (Rev-IS/200), or Revalor®-XS (Rev-XS) followed by a terminal Implant of Revalor®-200.

Variable	Rev-IS	Rev-IS/200	Rev-XS	SEM	P-value
Pens	6	6	6		
Steers	451	449	450		
Initial BW, lb	625	621	624	3.0	0.47
Live performance[1]					
Final BW, lb[2]	1460	1459	1463	6.0	0.91
DMI, lb/d	22.9	22.7	22.8	0.1	0.19
ADG, lb	3.89	3.91	3.92	0.03	0.95
G:F	0.170	0.172	0.172	0.002	0.55
F:G	5.88	5.81	5.84	-	0.55
Carcass adjusted performance					
Final BW, lb[3]	1457	1461	1462	7.9	0.60
ADG, lb	3.88	3.92	3.91	0.04	0.38
G:F	0.170	0.173	0.172	0.002	0.16
F:G	5.90	5.80	5.83		

[1]Finishing performance was calculated with dead and rejected animals removed from the analysis.
[2]Final BW is the average pen weight shrunk 4.0%. Subsequent ADG and F:G are calculated from 4.0% shrunk final BW.
[3]Calculated as HCW divided by the average dressing % of 64.25. Subsequent ADG and F:G re-calculated from carcass adjusted final BW.

Table 2. Carcass characteristics of steers Implanted with either Revalor®-IS (Rev-IS), Revalor®-IS and Revalor®-200 (Rev-IS/200), or Revalor®-XS (Rev-XS) followed by a terminal Implant of Revalor®-200.

Variable	Rev-IS	Rev-IS/200	Rev-XS	SEM	*P*-value
HCW, lb	936	939	940	5.10	0.59
Dressing %	64.17	64.34	64.24	3.10	0.93
Yield Grade[1,2]					
1	2.1	1.8	1.2	0.78	0.71
2	15.9	19.8	15.1	1.89	0.22
3	57.2	60.6	61.9	2.76	0.48
4	23.9	16.5	20.9	2.68	0.19
5	0.9	1.3	1.0	0.43	0.88
Quality Grade[1,2]					
Prime	2.0	0.5	0.0	0.44	0.21
Choice	67.2	68.8	68.7	2.21	0.85
Select	29.0	28.6	28.0	2.02	0.95
Standard	0.9	0.9	2.4	0.64	0.21
Commercial	0.9	1.2	0.9	0.71	0.95

[1]Yield grade and quality grade are called USDA values.
[2]All numbers are expressed as percentages.

Table 3. Interim performance of steers Implanted with either Revalor®-IS (Rev-IS), Revalor®-IS and Revalor®-200 (Rev-IS/200), or Revalor®-XS (Rev-XS) followed by a terminal Implant ofRevalor®-200.

Variable	Rev-IS	Rev-IS/200	Rev-XS	SEM	*P*-value
D 1–67					
Initial BW, lb	625	621	624	3.0	0.47
D 67 BW, lb	922	911	923	2.7	0.06
DMI, lb/d	21.9	21.6	21.9	0.06	0.06
ADG, lb	4.43	4.35	4.43	0.05	0.49
G:F	0.203	0.201	0.202	0.002	0.87
F:G	4.94	4.97	4.94	-	0.87
D 67–133					
D 133 BW, lb	1139[b]	1165[a]	1162[a]	1.6	<0.01
DMI, lb/d	22.4	22.4	22.7	0.24	0.62
ADG, lb	3.42[c]	4.01[a]	3.76[b]	0.05	<0.01
G:F	0.153[b]	0.179[a]	0.166[ab]	0.004	0.02
F:G	6.56	5.59	6.06	-	0.02
D 1–133					
D 133 BW, lb	1139[b]	1165[a]	1162[a]	1.6	<0.01
DMI, lb/d	22.0	21.8	22.0	0.26	0.76
ADG, lb	3.93[b]	4.18[a]	4.10[ab]	0.04	0.03
G:F	0.177[b]	0.191[a]	0.185[ab]	0.003	0.05
F:G	5.65[a]	5.26[b]	5.42[ab]	-	0.05
D 133–215					
D 215 BW, lb	1460	1459	1463	6.0	0.91
DMI, lb/d	24.5	24.2	24.5	0.26	0.78
ADG, lb	3.53	3.21	3.21	0.09	0.11
G:F	0.146	0.133	0.132	0.005	0.21
F:G	6.85	7.52	7.58	-	0.21

[a,b,c] Means within a row with different superscripts differ ($P \leq 0.05$).

step-up period consisting of three adaption diets was used to adapt cattle to the finishing ration. The finishing ration was identical across treatments and contained 58.2% steam flaked corn (range 74.6–26.0%), 17.5% WDG (range 25.0–9.0%), alfalfa hay 7.6% (range 32.0–0.0%), mixed hay 5.1% (range 7.0–4.0%), corn silage 4.7% (range 7.0–3.0%), steer liquid supplement 4.9% (range 5.2–4.1%), micro 0.04%, and 1.86% fat (range 2.7–0.0%), all on a DM basis. All ration changes that occurred during the feeding period were the same for all cattle on trial. Pen weights were collected on day 1 and performance was calculated from pen BW. Final live BW was determined at shipping using the average of the pen weight shrunk by 4.0% to adjust for gut fill. Carcass-adjusted performance was calculated using final BW, based on HCW divided by a common dressing percentage of 64.25 (overall trial average dressing percentage). Cattle were slaughtered at a commercial harvest facility on three dates. On day 1 of harvest HCW was recorded, after a 48-hour chill USDA quality and yield grades were recorded. Statistical analyses of both feedlot and carcass data were conducted using the GLIMMIX procedure of SAS (SAS Institute, Inc., Cary, N.C.). In addition, morbidity, mortality plus removals, and bullers were evaluated using PROC GLIMMIX of SAS. Alpha values ≤ 0.05 were considered significant.

Results

No differences were observed in any of the performance variables measured, including final BW, DMI, ADG, or F:G ($P > 0.19$; Table 1). No differences were observed for final BW, ADG, or F:G ($P > 0.16$) on a carcass-adjusted basis (Table 1). As expected, with a lack of difference in performance, there were no differences in HCW, dressing percentage, USDA yield grades 1–5, or in USDA quality grading ($P > 0.19$).

No differences were noted in interim performance from day 1–67 ($P > 0.05$) as expected due to implant payout (Table 3). A statistical difference in BW was observed on day 133. Cattle initially implanted with Revalor®-IS were lighter compared to the other two treatments ($P < 0.01$). The difference in BW was driven by the fact that cattle initially implanted with Revalor®-IS gained less ($P < 0.01$) from day 67 through

133 compared to the other two treatments. Consequently, F:G was poorer ($P \leq 0.02$) through that same time as well. Interestingly, cattle that received a Revalor®-200 on day 67 gained better than the other two treatments from day 67 through 133 ($P < 0.01$) and were more efficient ($P \leq 0.02$) than cattle that initially received a Revalor®-IS, but were similar in efficiency ($P > 0.05$) to cattle that initially received a Revalor®-XS. No differences were noted in any of the performance variables measured between days 133 and 215 ($P > 0.05$). Steers that initially received a Revalor®-IS had numerically greater ADG and lower F:G compared to the other treatments which likely resulted in no overall differences in performance from day 1–215.

Conclusion

In conclusion, steers implanted with Revalor®-IS, Revalor®-IS/200, or Revalor®-XS followed by a common terminal implant, Revalor®-200, had similar overall feedlot and carcass performance. Interim data suggest the cattle more aggressively implanted early gained faster through the first two-thirds of the trial, but by conclusion of the study had lost the gain and feed efficiency advantage. These data suggest the use of more aggressive initial implant strategies has minimal impact on both feedlot and carcass performance.

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Evaluation of 0 or 300 mg of Optaflexx® on Growth Performance and Carcass Characteristics of Steers Fed to Different Degrees of Finish

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Summary with Implications

A feedlot study evaluated the effects of ractopamine hydrochloride (Optaflexx®) dosage (0 or 300 mg/steer daily) and days on feed (118, 139, 160, 174 DOF) as a 2 × 3 + 1 factorial (steers fed 174 d were not fed Optaflexx) on performance of big yearlings. No interaction was observed between Optaflexx and days on feed. Feeding Optaflexx improved live final BW, carcass-adjusted ADG, carcass-adjusted feed conversion, and calculated yield grade. Increasing days on feed linearly increased live final BW, carcass-adjusted feed conversion, HCW, dressing percent, and marbling score but not ADG. Furthermore, a quadratic increase in LM area, 12th rib fat, and calculated yield grade was observed with days on feed. The response in added carcass weight due to feeding Optaflexx is the same with different lengths of time cattle are fed, and for large yearlings placed on feed.

Introduction

Feeding β–adrenergic agonists has been shown to increase protein accretion and decrease fat deposition in animal growth (*Journal of Animal Science,* 1998, 76:160). Ractopamine hydrochloride (trade name Optaflexx®; Elanco Animal Health) has been widely used in the industry since 2004 to increase final BW, HCW, and improve feed efficiency in finishing cattle. Optaflexx has been approved for feeding the last 28 to 42 days at the label dose of 70–430 mg/head to finishing cattle before harvest. However, limited data exist evaluating the effects of feeding Optaflexx to large yearling steers, and fed to larger finished weights common today with increased days on feed (DOF). Therefore, the objective of this experiment was to evaluate the effects of increasing DOF and feeding Optaflexx on performance of large yearlings.

Procedure

A feedlot study was conducted at the University of Nebraska-Lincoln Eastern Nebraska Research and Extension Center (ENREC) near Mead, NE. Crossbred yearling steers (n = 342; initial BW = 917 ± 74 lb) were utilized in a randomized block design (3 BW blocks) with a 2 × 3 + 1 factorial treatment design. Factors included Optaflexx dosage (0 or 300 mg/steer daily) and days on feed (118, 139, or 160 d) plus cattle fed 2 weeks longer (174 d) without Optaflexx. Prior to initiation of trial, steers were limit fed at 2% of BW for 5 days a diet consisting of 50% Sweet Bran® (Cargill) and 50% alfalfa hay (DM basis) to minimize variation in gastrointestinal fill. Steers on the 118 d treatment were fed to a target endpoint of approximately 1000 lb HCW or 0.5 in. of fat thickness. Steers on the 139 d treatment were fed to a target endpoint of 1050 lb HCW, and 160 d steers were fed to a target of 1100 lb HCW. Lastly, steers on the 174 d treatment were not fed Optaflexx to compare the impact of just feeding cattle longer. 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 42 pens. Pens were assigned randomly to one of 7 treatments with 6 pens per treatment (8 steers/pen). Light, medium, and heavy blocks consisted of 2, 3, and 1 replications, respectively. All steers were adapted to a common finishing diet over a 21-day period consisting of four adaptation diets. The amounts of Sweet Bran and supplement included in each adaptation diet were held constant at 40 and 5% (DM basis), respectively. The amount of high moisture corn was gradually introduced in the diet while replacing grass hay and corn silage. The supplement was formulated for 30 g/ton of DM as Rumensin® (Elanco Animal Health) and to provide 90 mg/steer daily of Tylan® (Elanco Animal Health). Steers were fed once daily between 0700 and 0900 hours.

Optaflexx was initiated when steers were 35 days from their projected endpoints. Steers were pen weighed on the day of treatment initiation and every 7 d thereafter. Steers were removed from their pens (approximately 0700 hours) prior to feeding and pen weights were collected using a pen scale. Pen weights (4% pencil shrink applied) were collected every 7 d to evaluate live performance over the Optaflexx treatment phase. All residual feed remaining in the bunk was removed and weighed. Optaflexx was delivered daily during the treatment phase via dry supplement in the total mixed ration at 300 mg/steer daily, with fine ground corn as the carrier. Two dry supplements were used during the treatment phase, one that contained no Optaflexx and one that provided 300 mg of Optaflexx.

Initially, all steers were implanted with Component® TE-IS (Elanco Animal Health). Given variable harvest dates, multiple terminal implanting dates were established to standardize the terminal implant window to 90 days. All steers were re-implanted with the terminal implant Component® TE-200 (Elanco Animal Health). On day of shipping, steers to be shipped were pulled out of pens, weighed to determine final live BW, then placed back in pens and were fed 50% of the previous days feed called. In the afternoon all steers to be shipped were pulled from pens and loaded onto the truck. All steers were harvested at a commercial abattoir (Greater Omaha) after 118, 139, 160, or 174 days on feed, depending on treatment. Hot carcass weight and liver scores were recorded on day of harvest. After a 48-hour chill, LM area, USDA marbling score, and 12th rib fat thickness were recorded. Yield grade

Table 1. Performance of yearling steers fed 0 or 300 mg/steer daily of Optaflexx for the last 35 days and fed overall for 118, 139, 160 or 174 d.

Days on Feed:	118 d		139 d		160 d		174 d		*P*-value			
Optaflexx Dosage:	0	300	0	300	0	300	0	SEM	Int.	Dose	Days on Feed	
Live Performance:											Linear	Quad.
Initial BW, lb	917	917	917	918	916	916	919	1.7	0.98	0.90	0.89	0.57
Final BW, lb [1]	1407	1433	1457	1501	1539	1553	1587	14.5	0.51	0.01	<0.01	0.39
DMI, lb/d	29.9	30.3	29.4	30.0	28.4	28.4	28.6	0.4	0.56	0.25	<0.01	0.75
ADG, lb [2]	4.16	4.38	3.91	4.23	3.92	4.00	3.87	0.10	0.43	<0.01	<0.01	0.25
F:G [3]	7.23	6.98	7.59	7.13	7.29	7.11	7.42	—	0.57	<0.01	0.33	0.28
Carcass-Adjusted Performance:												
Final BW, lb [4]	1394	1418	1449	1481	1567	1581	1611	15.5	0.82	0.05	<0.01	0.22
ADG, lb [5]	4.04	4.25	3.83	4.05	4.07	4.15	3.98	0.11	0.76	0.04	0.78	0.15
F:G [3]	7.58	7.23	7.87	7.48	7.07	6.97	7.24	—	0.92	0.05	0.02	0.16
Live Treatment Phase Performance [6]:												
Initial BW, lb	1327	1336	1382	1404	1446	1434	1473	13.3	0.40	0.51	<0.01	0.59
DMI, lb/d	28.4	29.9	26.0	27.7	23.5	24.1	23.8	0.5	0.45	< 0.01	<0.01	0.05
ADG, lb [2]	2.29	2.77	2.18	2.85	2.75	3.47	3.37	0.19	0.78	< 0.01	<0.01	<0.01
F:G [3]	12.6	11.1	12.1	9.97	8.82	7.07	7.20	—	0.43	< 0.01	<0.01	<0.01

[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.
[6]Performance the last 35 days based on live performance when Optaflexx was fed.

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 2 × 3 + 1 factorial using the MIXED procedure of SAS (SAS Institute, Inc., Cary, N.C.), with pen as the experimental unit. Steers that were removed during experiment were not included in the analysis. The model included Optaflexx dose treatment, days on feed, and dose × days on feed interaction. Block was treated as a fixed effect. Treatment differences were declared significant at $P \leq 0.05$.

Results

Cattle performance was negatively influenced by wet, cold, muddy conditions in December and January, which lowered ADG and HCW compared to targeted finish weights/HCW for the study. Cattle ADG was dramatically lowered during the time periods of d 90–97 and 111–118. Days 90–97 (1/6/16–1/13/16) of the trial, cattle on both treatments had a negative ADG response (control =-0.12 and Optaflexx =-0.09) as well as a loss of 1 lb in live interim BW. During days 111 to 118 (1/27/16–2/3/2016), cattle performance suffered a reduction in live interim BW for steers fed 118 d for both Optaflexx and control treatments (2 and 10 lb, respectively). Furthermore, cattle fed 139 d only had a slight increase in live interim BW for both control and Optaflexx treatments, 2 and 3 lb respectively. The reduction in live interim BW could be the result of negative ADG for 118 d fed cattle and low positive ADG for 139 d cattle. During these time points, weather was adverse with low comprehensive climate index (CCI) numbers resulted in lack of change in BW or low ADG. The negative impact of weather on ADG impacted cattle performance measured on cattle fed for 118 or 139 d more so than cattle fed longer as cattle fed longer than 139 d had time to recover in performance.

Despite weather challenges, there were no significant dose × days on feed interactions ($P > 0.40$) observed for growth performance; therefore, main effects will be discussed. Live final BW was 28 lb heavier ($P = 0.01$) for steers fed 300 mg of Optaflexx as compared to steers fed 0 mg. Steers fed 300 mg of Optaflexx had greater ($P = 0.04$) carcass-adjusted ADG (4.15 lb) compared to steers fed 0 mg (4.00 lb). Feeding 300 mg of Optaflexx resulted in an improvement ($P = 0.05$) in carcass-adjusted F:G. Carcass-adjusted DMI was not different ($P = 0.24$)

Table 2. Carcass characteristics of yearling steers fed 0 or 300 mg/steer daily of Optaflexx for the last 35 days and fed overall for 118, 139, 160 or 174 d.

Days on Feed:	118 d		139 d		160 d		174 d		*P*-Value			
Optaflexx Dosage:	0	300	0	300	0	300	0	SEM	Int.	Dose	Days on Feed	
Carcass Characteristics:											Linear	Quad.
HCW, lb	878	894	913	933	987	996	1015	9.8	0.82	0.06	<0.01	0.22
Dressing, %[1]	62.4	62.3	62.7	62.1	64.2	64.1	63.9	0.3	0.56	0.34	<0.01	0.48
Marbling[2]	505	492	558	537	578	577	612	14.8	0.76	0.31	<0.01	0.57
LM area, in^2	13.1	13.8	12.9	13.4	13.5	14.0	13.7	0.2	0.85	<0.01	<0.01	0.01
12th rib fat, in	0.48	0.46	0.63	0.60	0.64	0.61	0.64	0.02	0.92	0.08	<0.01	<0.01
Calculated Yield Grade	3.4	3.2	4.0	3.8	4.1	3.8	4.1	0.09	0.99	<0.01	<0.01	<0.01

[1]DP = Dressing Percent; calculated from HCW divided by live BW, with a 4% pencil shrink applied.
[2]Marbling Score: 300 = Slight, 400 = Small, 500 = Modest, etc.

between Optaflexx doses. Carcass-adjusted final BW was 23 lb greater ($P = 0.05$) for steers fed 300 mg of Optaflexx compared to 0 mg (Table 1).

There were no significant dose × days on feed interactions for carcass data; therefore main effects will be discussed. Hot carcass weight tended to be 15.3 lb greater ($P = 0.06$) for steers fed 300 mg of Optaflexx as compared to 0 mg. Calculated yield grade was improved ($P < 0.01$) for steers fed 300 mg of Optaflexx (3.7) as compared to 0 mg (3.9). Fat thickness tended to be lower for steers fed Optaflexx compared to steers not fed Optaflexx. Dressing percentage and marbling score were not impacted ($P > 0.31$) by Optaflexx treatment (Table 2).

As days on feed increased, live final BW and carcass-adjusted final BW increased linearly ($P < 0.01$). Intake and live ADG decreased linearly ($P < 0.01$) as days on feed increased, which lead to no change ($P > 0.28$) in F:G (on a live basis) with increased days on feed. Because of increased dressing percent, carcass-adjusted ADG was constant ($P > 0.15$) which lead to a small linear improvement ($P = 0.02$) in F:G, due to the reduction in DMI. Hot carcass weight, dressing percent, and marbling score were increased ($P < 0.01$) linearly as days on feed increased. LM area, 12th rib fat, and CYG increased ($P < 0.01$) quadratically as days on feed increased.

Steers fed 174 d had a greater ($P < 0.01$) live ADG during the treatment phase (last 35 d) as compared to the 118, 139 and 160 d fed steers. Steers fed 118 d had the highest ($P < 0.01$) DMI (29.1 lb) during the treatment phase, with 160 d steers having the lowest. Steers fed 174 d had the lowest ($P < 0.01$) F: G as compared to steers fed 118, 139, and 160 d.

Numerically, steers fed 174 d that received 0 mg of Optaflexx were 34.8 lb heavier ($P = 0.07$) compared to steers that were fed 160 d and received 300 mg of Optaflexx. There were no differences ($P = 0.23$) in carcass-adjusted ADG between steers fed 174 d receiving 0 mg of Optaflexx compared to 160 d steers fed 300 mg of Optaflexx. Additionally, 174 d steers tended to have an improved ($P = 0.09$) F:G as compared to steers fed 160 d fed 300 mg of Optaflexx. These changes can be confounded with changes in weather observed during the study, as cattle were not fed during the same conditions when fed longer.

Conclusions

Feeding Optaflexx improved live final BW, carcass-adjusted ADG, carcass-adjusted F:G, and calculated yield grade similar to other studies suggesting a similar response in big yearlings. Feeding steers longer increased fatness and weights. While feeding longer decreased ADG calculated on live BW, carcass-adjusted ADG remained constant as days fed increased.

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Predicting Feedlot Growth Performance over the Feeding Period Utilizing Steer Age and Body Weight

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Summary with Implications

A pooled-analysis of UNL feedlot pens examined the effects of steer age and body weight on feedlot growth performance. For data analysis, pens were divided into 3 subclasses based on steer age (calf-fed, short yearling, or long yearling) and, grouped based upon initial body weight (500 to 1200 lb, in 100 lb increments) within each age class. As initial body weight increased, DMI (lb/d) for the whole feeding period increased quadratically in calf-fed steers and increased linearly in short and long yearlings. A quadratic increase in ADG was observed in calf-feds as initial body weight increased. No differences in ADG were observed for short and long yearlings due to initial body weight. As heavier cattle were placed within age group, feed conversion increased linearly. Predicting DMI is more consistent when expressed as % of body weight. Predicting intake and growth performance over the entire feeding period, in order to facilitate management decisions, is dependent upon steer age and initial weight when starting the finishing diet.

Introduction

Predicting feedlot growth performance over the feeding period is critical when determining the nutritional requirements of the animal at different stages of growth. For diet formulation, knowing DMI and ADG at the beginning of the feeding period is more critical than knowing overall average performance for the entire feeding period, as the requirement for protein is greatest at the beginning of the feeding period. Also, the capability for feedlot managers to predict feedlot performance of varying ages of steers entering the feedlot is valuable for marketing decisions. Numerous factors affect steer growth performance during the finishing period such as diet, age, temperature, weather, etc. A common practice is to background steers on forages, such as crop residue or pastureland, for a certain period of time before starting the finishing phase. In Nebraska, the abundance of crop residues, such as cornstalks, allows producers to background spring-born calves during the winter months at a relatively inexpensive cost of gain. Furthermore, grazing pasture allows producers to further prolong the backgrounding period and add weight to the animal. Therefore the objective of this pooled analysis was to determine how age and body weight (**BW**) of steers at feedlot entry affects DMI, ADG and F:G over the finishing phase.

Procedure

A pooled-analysis from pens at the University of Nebraska-Lincoln Eastern Nebraska Research and Extension Center feedlot examined the effects of steer age and initial BW on feedlot growth performance in studies conducted from 2002 to 2015. Spring born, predominately black, crossbred steers were purchased each fall by the feedlot. For data analysis, pens were divided into 3 subclasses based on steer age (calf-fed, short yearling, or long yearling) when they started the finishing diet. Calf-feds were defined as starting the finishing diet in the fall, usually November, and then finished the following spring, typically May. Average initial BW for calf-feds was 689 lb. Short yearlings grazed corn residue or were grown in dry-lot from November to April, and then started on the finishing diet in May and were harvested in September or October. Short yearlings had an initial BW of 820 lb. Long yearlings backgrounded from November to April similar to short yearlings, grazed pasture from May to September, and then started finishing in October and were harvested in January or February. Average initial BW for long yearlings was 904 lb. Furthermore, within each steer age class, pen means were grouped based upon initial BW (500 to 1200 lb, in 100 lb increments) when starting the finishing diet. The data set included 1,002 pens of calf-feds, 1,144 pens of short yearlings, and 435 pens of long yearlings. In total, the data set included 92 experiments consisting of 23,438 steers. Dietary treatments within each experiment were ignored in the data set.

Weekly DMI during the feeding period, as a percentage of current BW, was calculated for each pen in the data set. Using initial pen BW and carcass adjusted ADG over the entire feeding period, weekly pen BW were calculated by increasing carcass-adjusted ADG by 0.00658 lb/d up to 50% of DOF and then decreasing carcass-adjusted ADG by 0.00658 lb/d beyond 50% DOF (Wilken et al., 2015 *PAS* pp. 224–236). Body weight gain for each pen was calculated weekly and added to pen BW from the previous week. Finally, weekly DMI for each pen was divided by the pen BW for the same week to determine DMI as a percent of current BW.

Average daily gain was calculated from HCW adjusted to a common dressing percentage (63%). Performance data from each pen of steers were used in the pooled-analysis. Experiments were weighted by the number of initial BW classes within each experiment to prevent artificial responses from experiments that consisted of few pen means in each initial BW class. Linear and quadratic regression coefficients were calculated using the mixed procedures of SAS (SAS Institute, Inc., Cary, N.C.). The significances of the linear and quadratic coefficients were tested for each response variable using the mixed procedures of SAS. Experiment was included in the model as a random effect.

Results

As initial BW class increased, DMI (lb/d) increased quadratically ($P < 0.01$; Table 1) in calf-fed steers and averaged 22.8

Table 1. Effect of initial BW class (lb.) when starting the finishing phase on steer growth performance

Initial BW Class	500	600	700	800	900	1000	1100	1200	SEM	Linear[1]	Quad[2]
Calf-feds											
Pens, n	81	500	349	72							
Head, n	826	4794	3379	805							
DMI, lb/d	21.5	22.2	23.1	24.4	-	-	-	-	0.2	<0.01	<0.01
ADG, lb[3]	3.75	3.79	3.81	3.97	-	-	-	-	0.06	<0.01	0.03
F:G[4]	5.71	5.85	6.05	6.18	-	-	-	-	-	<0.01	0.48
DMI, % CBW[5]	2.26	2.28	2.25	2.23	-	-	-	-	-	-	-
Short Yearlings											
Pens, n		21	521	400	180	22					
Head, n		210	4320	3261	1522	206					
DMI, lb/d	-	24.3	25.1	25.8	26.6	27.6	-	-	0.5	<0.01	0.54
ADG, lb[3]	-	3.83	3.84	3.84	3.86	3.89	-	-	0.13	0.64	0.87
F:G[4]	-	6.35	6.51	6.71	6.88	7.12	-	-	-	<0.01	0.93
DMI, % CBW[5]	-	2.57	2.43	2.35	2.28	2.19	-	-	-	-	-
Long Yearlings											
Pens, n			77	141	141	63	8	5			
Head, n			780	1318	1337	561	74	45			
DMI, lb/d	-	-	25.3	26.6	28.1	29.2	29.7	31.1	0.73	<0.01	0.16
ADG, lb[3]	-	-	3.78	3.82	4.02	4.03	3.93	4.01	0.17	0.05	0.13
F:G[4]	-	-	6.68	6.96	6.94	7.25	7.48	7.60	-	<0.01	0.99
DMI, % CBW[5]	-	-	2.56	2.48	2.32	2.20	2.23	2.30	-	-	-

[1]Linear contrasts for initial BW class within steer age group.
[2]Quadratic contrasts for initial BW class with steer age group.
[3]Calculated using carcass-adjusted final BW.
[4]Analyzed as G:F, the reciprocal of F:G.
[5]Dry matter intake calculated as a percent of current BW (CBW) over the entire feeding period.

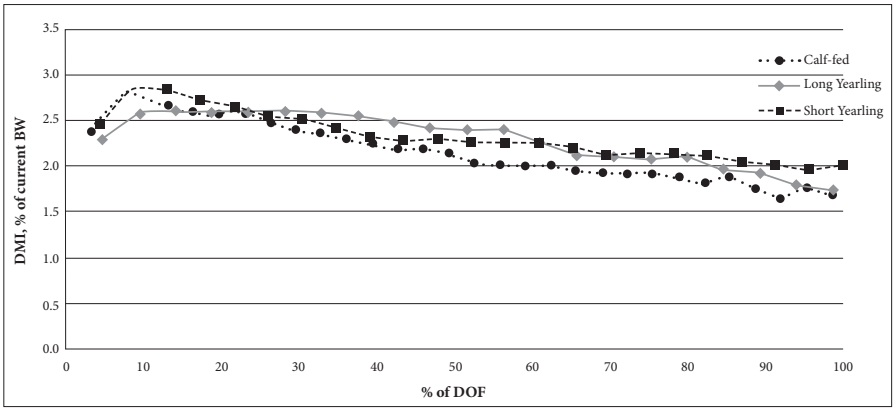

Figure 1. Dry matter intake as a percent of current BW across DOF

lb/d over the entire feeding period. However, in short yearlings, DMI increased linearly ($P < 0.01$) as initial BW class increased, with DMI averaging 25.9 lb/d. Likewise, DMI increased linearly ($P < 0.01$) as initial BW class increased for long yearlings and averaged 28.3 lb/d. A quadratic increase ($P = 0.02$) in carcass-adjusted ADG was observed in calf-feds as initial BW class increased. Numerically, ADG was greatest for calf-fed steers that started the finishing phase at an initial BW class of 800 lb. No differences ($P > 0.63$) in carcass-adjusted ADG were observed for short yearlings. Carcass-adjusted ADG increased linearly ($P = 0.05$) as initial BW class increased for long yearlings. Feed conversion (F:G) increased linearly ($P < 0.01$) as initial BW class for calf-fed steers increased. Feed conversion in calf-feds was 7.7% poorer for steers starting the finishing phase at an initial BW of 800 lb compared to steers at 500 lb. For short yearlings, F:G increased linearly ($P < 0.01$) as initial BW class increased. Feed conversions were 12.1% poorer for steers starting the finishing phase at 1000 lb compared to 600 lb short yearlings. Lastly, F:G increased linearly ($P < 0.01$) as initial BW class increased for long yearlings. Feed conversions were 13.8% poorer for long yearlings starting the finishing phase at 1200 lb compared to 700 lb. These data support what many producers already know, bigger cattle are less efficient (greater F:G) than lighter cattle. This common observation holds true within cattle age group though as well. Overall, DMI was quite variable for all age groups of steers with a range of 21.4 to 31.0 lb/d being observed. However, when calculating DMI as a percent of current BW (Table 1), DMI was relatively constant over the entire feeding period with a range of 2.2 to 2.6% for all age groups and initial BW class of steers. Dry matter intake as a percent of current BW is presented in Figure 1. Intake as percent of current BW was greatest early in the finishing period and decreased as days on feed increased. Throughout much of feeding period, DMI as percent of current BW was lowest for calf-fed steers.

Conclusion

Delaying the time (i.e., increasing age) in which steers start the finishing phase resulted in poorer feed conversions. Evaluating DMI as a percent of current BW reduces variation due to steer age and BW; however, as days on feed increases, intake as a percent of current BW decreases. Predicting intake and growth performance over the entire feeding period is critical for producers to meet the nutritional requirements of the animal at certain stages of growth and varies depending on steer age and BW when started on the finishing diet.

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Evaluation of the Value of Fiber in Distillers Grains Plus Solubles on Performance of Finishing Cattle

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Summary with Implications

A finishing study was conducted to determine the value of the fiber in distillers grains plus solubles on cattle performance. Five treatments were evaluated: a corn control diet, 20 or 40% modified distillers grains plus solubles, plus two diets containing corn germ meal and corn bran balanced to equal the fiber content of the two modified distillers grains plus solubles diets. There was a significant improvement in ADG and F:G for cattle fed modified distillers grains plus solubles compared to control. Cattle fed the corn germ meal and bran diets had increased DMI, slightly lower ADG, and poorer F:G compared to the control. The isolated fiber component had 83–90% the feeding value of corn, while modified distillers grains plus solubles had 107–108%. Other components in distillers besides fiber must improve the value of distillers compared to corn.

Introduction

Distillers grains are commonly fed in finishing diets. The ethanol industry has recently started removing components of distillers grains, such as fiber components and corn oil, which changes the nutrient content of distillers grains plus solubles that are available to be fed. In recent years, research has been done using these components to formulate diets that give the same performance as feeding distillers grains. Feeding the fiber portion resulted in the closest performance to the DGS diet in one study (2016 Nebraska Beef Cattle Report, pp. 122–23). A different experiment concluded that feeding individual components did not mimic performance of WDGS, but including fiber, protein, fat and solubles combined together gave the same performance as feeding WDGS (2016 Nebraska Beef Cattle Report, pp. 124–127). These findings demonstrate that the interactions between fiber, protein, fat, and solubles in WDGS are important, and have a similar feeding value to WDGS. The objective of this study was to determine the value of the fiber in modified distillers grains plus solubles for finishing cattle performance.

Procedure

A finishing experiment conducted at the Eastern Nebraska Research and Extension Center utilized 800 crossbred yearling steers (initial BW = 915 lb ± 53 lb). For five days before the beginning of the trial, cattle were limit-fed a diet of 50% alfalfa and 50% Sweet Bran (DM Basis) at 2% of BW to reduce variation in gastrointestinal fill. Cattle were weighed on day 0 and 1 to establish an accurate initial BW. Steers were split into four blocks according to their initial BW with each block consisting of 200 head. A total of 100 pens were used on the study with 8 steers per pen. Pens were assigned randomly to treatment with five treatments and 20 pens per treatment. All cattle were adapted to the finishing treatments over a five step adaptation process by replacing alfalfa with dry-rolled-corn (DRC).

The five treatments consisted of a corn control diet (CON), 20% (20MDGS) or 40% (40MDGS) modified distillers grains plus solubles (MDGS), plus two diets formulated with corn germ meal and corn bran to equal the fiber content of the two MDGS diets (20FIB and 40FIB; Table 1). To mimic the nutrient composition of the 20MDGS treatment, the 20FIB treatment contained 1.5% solvent extracted germ meal (SEM) and 7% wet corn bran from the wet milling industry. Likewise, the 40FIB treatment was formulated to mimic 40MDGS by adding 3% SEM and 14% wet corn bran. On a DM basis, all diets contained 12% high moisture corn (HMC), 8% corn silage, 3% alfalfa hay, and supplement fed at either 5% or 8%. The control, 20FIB, and 40FIB had a greater inclusion of supplement because 3% soybean meal was fed in addition to urea as a RDP source. The supplement also provided Tylan-40® (Elanco Animal Health) at 90 mg per steer daily and Rumensin-90® (Elanco Animal Health) at 30 g per ton DM.

Blocks 1, 2, and 3 were implanted with Revalor-200 99 days prior to harvest and block 4 was implanted 113 days prior to harvest. Cattle in the three heavier blocks were fed for 134 days and the light block was on feed for 148 days. Steers were shipped to Greater Omaha for slaughter, and carcass data were recorded. On day of harvest, hot carcass weight and liver score were collected. Following a 48-hour chill, USDA marbling score, LM area, and 12th rib fat thickness were recorded. Animal performance and carcass characteristics were analyzed as an unstructured treatment design using a protected F-test, where block was included as a fixed effect. Treatment design was also analyzed as a 2x2+1 with two feed sources (MDGS or Fiber) and two inclusion levels (20 or 40%) plus a control. Interactions for the 2x2 factorial design were evaluated. Linear and quadratic orthogonal contrasts were used to evaluate inclusion of MDGS or fiber in the diet with the control being the 0% inclusion level. Data were analyzed using the MIXED procedure of SAS (SAS Institute, Inc. Cary, N.C.), where pen was the experimental unit. Treatment differences were declared significant at $P \leq 0.05$. One steer from the control treatment died on day 147 and a steer from the 40MDGS treatment was removed on day 86 due to repeated bloating. These two steers were removed from performance data.

Table 1. Composition (% of diet DM) of dietary treatments fed to yearling steers.

Ingredient	Treatment[1]				
	CON	20MDGS	40MDGS	20FIB	40FIB
Dry-rolled corn	68.5	51.5	31.5	60	51.5
High-moisture corn	12	12	12	12	12
MDGS[2]	-	20	40	-	-
SEM[3]	-	-	-	1.5	3
Wet Corn Bran	-	-	-	7	14
Corn Silage	8	8	8	8	8
Alfalfa hay	3.5	3.5	3.5	3.5	3.5
Supplement[4]	-	-	-	-	-
Fine Ground Corn	1.228	2.635	2.899	1.361	1.856
Limestone	1.615	1.599	1.585	1.633	1.604
Tallow	0.2	0.125	0.125	0.2	0.2
Urea	1.377	0.25	-	1.2	0.75
SBM	3	-	-	3	3
Potassium Chloride	0.189	-	-	0.215	0.199
Salt	0.3	0.3	0.3	0.3	0.3
Beef Trace Minerals	0.05	0.05	0.05	0.05	0.05
Vitamin A-D-E	0.015	0.015	0.015	0.015	0.015
Rumensin-90®[5]	0.017	0.017	0.017	0.017	0.017
Tylan-40®[6]	0.009	0.009	0.009	0.009	0.009
Nutrient Composition, % of DM					
CP	14.1	15.1	19.8	14.1	13.3
NDF	11.0	16.7	22.0	16.6	22.2
ADF	4.5	6.6	8.6	6.0	7.5
Lignin	1.7	2.3	2.9	1.9	2.2

[1] Treatments included CON-control; 20MDGS-20% modified distillers grains plus solubles; 40MDGS-40% modified distillers grains plus solubles; 20FIB-fiber fed from concentrated ingredients to mimic fiber provided by 20MDGS; 40FIB-fiber fed from concentrated ingredients to mimic fiber provided by 40MDGS.
[2] MDGS: Modified distillers grains plus solubles,
[3] SEM: solvent extracted germ meal
[4] Supplement fed at 8% of dietary DM for CON, 20FIB, and 40FIB and 5% of dietary DM for 20MDGS and 40MDGS
[5] Formulated to supply Rumensin-90® (Elanco Animal Health) at 30 g per ton DM
[6] Formulated to supply Tylan-40® (Elanco Animal Health) at 90 mg per steer daily

Results

Initial BW ($P = 0.63$; Table 2) was not influenced by treatment, based on allocation. Intakes were impacted by treatment ($P < 0.01$) and DMI increased with MDGS inclusion, with steers fed 20MDGS having the greatest DMI. Steers fed 40MDGS or 40FIB had similar DMI ($P = 0.76$), whereas steers fed 20MDGS consumed more ($P < 0.01$) than steers fed 20FIB. When 40FIB was fed, DMI increased linearly ($P = 0.01$) relative to CON. Dietary treatment impacted ADG ($P < 0.01$), as ADG increased with MDGS inclusion, and equal ADG between 20MDGS and 40MDGS ($P = 0.96$). Feeding 20FIB and 40FIB slightly reduced ADG but not statistically ($P > 0.14$) compared to CON. As a result of increased ADG, F:G improved linearly ($P < 0.01$) for steers fed MDGS. When steers were fed 20FIB or 40FIB, F:G increased linearly ($P < 0.01$) due to an increase in DMI and numerical decrease in ADG compared to CON. The feeding value of MDGS relative to corn (difference between test G:F and control G:F divided by control G:F, then divided by by-product inclusion level) was 107% for 20MDGS and 108% of corn for 40MDGS. The isolated fiber treatments had feeding values that were lower than the control at 83% for 20FIB and 90% for 40FIB. The cattle performed as expected with the MDGS treatments showing the best performance and the fiber treatments having reduced performance. Steers on the MDGS treatments had the greatest HCW ($P < 0.01$) and fat thickness ($P < 0.01$) compared to the other three treatments. Cattle fed 20MDGS had the highest marbling ($P < 0.01$), with the other four treatments being lower and not significantly different from each other.

Table 2. Effect of feeding modified distillers grains (MDGS) at 20 or 40% compared to fiber to mimic NDF provided by 20 or 40% MDGS on feedlot performance and carcass characteristics

	Treatment[1]						P-values[2]			
	CON	20MDGS	40MDGS	20FIB	40FIB	SEM	F-TEST	INT	SOURCE	INCLUSION
Feedlot Performance										
Initial BW, lb	915	916	916	915	915	0.9	0.63	0.53	0.26	0.89
Final BW, lb[3]	1439^{b}	1473^{a}	1472^{a}	1428^{b}	1429^{b}	5.5	<0.01	0.90	<0.01	0.96
DMI, lb/d	25.7^{c}	26.9^{a}	26.4^{b}	26.0^{bc}	26.3^{b}	0.2	<0.01	0.03	0.01	0.54
ADG, lb	3.81^{b}	4.05^{a}	4.04^{a}	3.73^{b}	3.74^{b}	0.04	<0.01	0.93	<0.01	0.98
F:G	6.75^{b}	6.64^{ab}	6.53^{a}	6.97^{c}	7.03^{c}	-	<0.01	0.09	<0.01	0.47
Carcass Characteristics										
HCW, lb	907^{b}	928^{a}	928^{a}	900^{b}	901^{b}	3.5	<0.01	0.90	<0.01	0.96
LM area, in^{2}	13.7	13.7	13.5	13.6	13.6	0.1	0.42	0.12	0.73	0.45
Marbling[4]	477^{b}	496^{a}	476^{b}	465^{b}	476^{b}	6.0	<0.01	0.01	0.01	0.45
12th rib fat, in	0.53^{b}	0.58^{a}	0.59^{a}	0.52^{b}	0.55^{b}	0.01	<0.01	0.27	<0.01	0.12
Liver Abscess (n)[5]	10	7	15	12	9	-	0.59	0.14	0.99	0.54

[a-c]Means with different subscripts differ (P < 0.05)

[1] Treatments included CON-control; 20MDGS-20% modified distillers grains plus solubles; 40MDGS-40% modified distillers grains plus solubles; 20FIB-fiber fed from concentrated ingredients to mimic fiber provided by 20MDGS; 40FIB-fiber fed from concentrated ingredients to mimic fiber provided by 40MDGS.

[2] INT=interaction between fiber source and inclusion, SOURCE = P-value for main effect of fiber source, INCLUSION = main effect of fiber or MDGS inclusion.

[3] Calculated from HCW/common dressing percentage (63%)

[4] Marbling score: 400 = Slight^{00}, 450 = Slight^{50}, 500 = Small^{00}, 550 = Small^{50}

[5] Liver Abscess Score: total number of A-, A, or A+ liver scores per treatment (159 or 160 steers per treatment group). Only two steers were observed with A+ abscesses.

Conclusion

These data illustrate that F:G was poorer if only the fiber components that typically comprise distillers grains replace corn. These data suggest that the isolated fiber component does not give equal performance to feeding MDGS. It is unclear what impact a removal of a portion of the fiber from distillers may have, if other components are concentrated. These data are based on fiber isolated from the wet milling process, but presumably applies for fiber from distillers grains plus solubles as both are isolated from corn grain.

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The Effect of Supplementing Mannan Oligosaccharide or Finely Ground Fiber, during the Summer on Body Temperature, Performance, and Blood Metabolites of Finishing Steers

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Summary with Implications

Crossbred beef steers (12 pens, n=96) were used to determine the effect of adding Agrimos or 5% ground (1 in.) wheat straw compared to a control on body temperature, panting score and performance. There were no differences in final BW, ADG, and DMI among treatments. Feed conversion was increased for cattle fed 5% additional ground straw when compared to control and Agrimos. Hot carcass weight, dressing %, LM area, and marbling score were not different among treatments. Cattle fed the control had greater 12th rib fat depth and USDA yield grade than cattle fed straw or Agrimos. Both average and maximum body temperatures were slightly greater for cattle fed Agrimos than for cattle fed control or added straw. Panting scores were decreased slightly for cattle fed the extra straw when compared to control and Agrimos. The addition of Agrimos or wheat straw to the diet had minimal effects on heat stress measures.

Introduction

Feeding prebiotics in an effort to reduce the negative effects of heat stress has primarily been studied in poultry. Studies have shown that feeding mannan oligosaccharide in the diet of poultry helped reduce some of the detrimental effects of heat stress in terms of reducing oxidative damage to the small intestine. In addition to feeding probiotics, feeding increased levels of fiber has been shown to increase the amount of short chain fatty acids present in the cecum which can provide oxidative protection to intestinal cells. The addition of fiber to a finishing diet may also displace some energy therefore reducing metabolic heat load. This is supported by a study where a decrease in steer body temperature with the addition of increased fiber levels to the diet was observed (*1997 Nebraska Beef Cattle Report*, pp. 85–88).

Environmental stress has been a researched topic for the past few decades however, little is known about how feeding a yeast supplement or fine ground wheat straw will affect feedlot steer performance and body temperature. Therefore, the objective of the current study was to determine the effect of feeding a yeast supplement or adding finely ground wheat straw on steer performance, body temperature, panting scores, and blood metabolites.

Procedure

A finishing study was conducted utilizing crossbred beef steers (96 steers, 12 pens) to study the effects of feeding mannan oligosaccharide (Agrimos; Lallemand Animal Nutrition; Montreal, Canada) and finely ground wheat straw on steer performance, body temperature, panting score, and blood metabolites during summer conditions. Steers were fed at the University of Nebraska-Lincoln (UNL) Eastern Nebraska Research and Extension Center research feedlot near Mead, Nebraska.

Cattle were limit-fed a diet consisting of 50% Sweet Bran (Cargill, Blair, Neb) and 50% alfalfa hay at an estimated 2% of BW for five days prior to an initial BW being collected. Initial BW were collected over a 2 d period on day 0 and 1 of the experiment and averaged. Steers were stratified by initial BW and assigned randomly to pen within strata. Treatment was assigned randomly to pen.

Table 1. Main effect of treatment on animal performance and carcass characteristics

	Control	Straw	Agrimos	SEM	P-Value
Performance					
Initial BW, lb	1056	1057	1056	5	0.98
Final BW, lb	1525	1501	1519	13	0.38
DMI, lb/d	27.3	28.0	27.1	0.5	0.43
ADG, lb	3.97	3.76	3.93	0.10	0.24
Hot Period DMI[1], lb/d	26.2	27.7	26.3	0.6	0.19
NEg Intake, Mcal/d	14.50	14.02	14.38	0.25	0.39
F:G,	6.89[b]	7.46[a]	6.94[b]	0.12	0.02
Carcass Characteristics					
HCW, lb	961	945	957	8	0.38
Dressing %	62.3	61.7	62.0	0.3	0.36
LM Area, in^2	13.5	13.7	13.8	0.2	0.45
12th Rib Fat, in	0.60[b]	0.51[a]	0.53[a]	0.02	0.01
Marbling[2]	474	471	476	8	0.38
USDA Yield Grade[3]	3.9[b]	3.5[a]	3.5[a]	0.3	0. 36

Values within rows with unique superscripts are different ($P < 0.05$)
[1]Period between 6/25/2015 and 7/27/2015
[2]300 = slight, 400 = Small, 500 = Modest.
[3]Calculated as 2.5 + (2.5 x 12th rib fat) + (0.2 x 2.5[KPH]) + (0.0038 x HCW)–(0.32 x REA)

Table 2. Main effect of treatment on body temperature and panting measurements

					P-Value	
	Control	Straw	Agrimos	SEM	Trt	Interaction[1]
Overall[2]						
Average	102.3[a]	102.3[a]	102.6[b]	0.1	<0.01	<0.01
Maximum	105.0[a]	104.9[a]	105.5[b]	0.1	<0.01	<0.01
AUC[3]	2456	2455	2462	1	0.18	0.95
Panting Score[4]	1.75[b]	1.72[a]	1.76[b]	0.01	<0.01	<0.01
Hot Period[5]						
Average	102.5[a]	102.5[a]	102.8[b]	0.05	<0.01	<0.01
Maximum	105.5[a]	105.4[a]	105.9[b]	0.07	<0.01	<0.01
AUC[3]	2460	2460	2467	3	0.18	0.95
Panting Score[4]	1.87[ab]	1.84[a]	1.90[b]	0.01	0.05	<0.01

Values within rows with different superscripts are different ($P < 0.05$)
[1] Interaction between day and treatment
[2] Mean values for the entire feeding period
[3] Area under the curve = Total magnitude of individual animal body temperature change within each treatment
[4] Panting scores based on 0 to 4 scale with 0 = no panting and 4 = severe distress
[5] Values for the selected warm period between days 31 and 62 of the trial (6/25/2015–7/27/2015)

The trial was conducted during the summer of 2015 utilizing summer yearlings (initial BW = 1055±25 lb). Cattle were on feed for 121 days with the trial starting on May 26, 2015 and cattle harvested on September 23, 2015 at Greater Omaha.

The study was a completely randomized design with three treatments and four replications per treatment. The basal diet consisted of 34.25% high-moisture corn (HMC), 34.25 dry-rolled corn (DRC), 20% modified distillers grains plus solubles, 7.5% sorghum silage, and 4% supplement. Cattle were adapted onto the finishing diet over a 21-d period by reducing alfalfa inclusion in the diet and increasing levels of HMC/DRC blend. The first treatment was a control (CON) consisting of only the basal diet. The second treatment included feeding Agrimos (MOS; Lallemand Animal Nutrition, Montreal, Canada) at 30g/steer daily added into the supplement. The third treatment consisted of feeding ground (1 in.) wheat straw (STRAW) at 5% of the diet DM replacing 5% of the DRC/HMC blend.

Blood samples were collected from each steer via jugular venous puncture. An initial measure was collected on day 23, after cattle were fully adapted to the finishing diet. Blood samples were collected from every steer on days 23, 37, 44, 51, 58, 65, and 79 of the trial. This blood collection schedule resulted in a total of 7 blood collections throughout the duration of the trial.

Environmental temperature, humidity, solar radiation, wind speed and barometric pressure were collected automatically every 30 min throughout the duration of the trial using a Davis Vantage Pro 2 (Davis Instruments Vernon, IL) weather station located on site directly behind the pens. All cattle received a SmartStock (SmartStock; LLC. Pawnee, OK) temperature monitoring rumen bolus during the first blood collection on d 21 of the trial. Boluses were programmed to transmit individual body temperature in twenty minute intervals to a receiver and transmitted to a central computer. In addition to body temperature, panting scores were collected by a trained individual each weekday at 1400. Scores were taken from outside the pen in the feed alley as to not disturb the animals.

Performance and carcass data were analyzed using the MIXED procedure of SAS (SAS Institute, Inc. Carry, N. C.) with pen as the experimental unit. Body temperatures were analyzed using the GLIMMIX procedure of SAS (SAS Institute, Inc.) with pen as the experimental unit. Average, maximum and area under the curve (AUC) were evaluated for body temperature. Panting scores were also analyzed using the GLIMMIX procedure of SAS. A warm period was chosen between June 25, 2015 and July 27, 2015 and body temperatures and panting score were analyzed separately from the previously stated analysis for this timeframe.

Results

There was no difference ($P \geq 0.19$; Table 1) between treatments for initial BW, final BW, ADG, DMI, warm period DMI, or NEg intake. However, F:G became poorer ($P < 0.05$) for STRAW when compared to CON or MOS cattle. Hot carcass weight, dressing %, LM area, and marbling score were not different ($P \geq 0.36$) between treatments. However, a difference ($P < 0.02$) in 12th rib fat depth and USDA yield grade was observed. Cattle fed CON had the greatest 12th rib fat depth and USDA yield grade when compared to MOS and STRAW cattle which were not different ($P > 0.05$).

Average and maximum body temperature were greatest ($P < 0.05$; Table 2) for cattle fed MOS when compared to CON and STRAW treatments, which were not different ($P > 0.05$). Cattle fed STRAW had reduced panting scores ($P < 0.05$) when compared to cattle fed CON and MOS, which were not different ($P > 0.05$). Average and maximum body temperature were also greater ($P < 0.01$; Table 2) for MOS cattle during the selected warm period. Panting scores also followed a similar pattern and were the greatest ($P < 0.05$) for MOS cattle and least for STRAW, with CON cattle being intermediate. There was no observed difference in area under the curve for body temperature ($P > 0.05$) between treatments. Numerically, cattle fed MOS had greater area under the curve body temperature ($P = 0.18$) suggesting that the addition of MOS to the diet had little impact on physical heat stress experienced by the animal.

There was a treatment × time interaction ($P < 0.05$; Table 3) observed for hemoglobin and hematocrit levels. These interactions would suggest that over time and as environmental conditions changed, there are differences in how these dietary treatments affect how the steers react metabolically. The observed interaction for hemoglobin, and hematocrit levels could be of importance as other research would suggest these metabolites are correlated with environmental temperature. Bilirubin has also been found

Table 3. Simple effect means for blood measure in the presence of a collection time × diet interaction

					P-Value	
Blood Measure	Control	Straw	Agrimos	SEM[1]	Trt	Int[2]
Bilirubin, mg/dL				0.01	0.26	0.02
d 23	0.18[a]	0.20[a]	0.19[a]			
d 37	0.15[a]	0.15[a]	0.17[a]			
d 44	0.16[a]	0.18[a]	0.17[a]			
d 51	0.19[a]	0.18[a]	0.19[a]			
d 58	0.17[a]	0.18[a]	0.20[b]			
d 65	0.19[a]	0.19[a]	0.20[a]			
d 79	0.19[a]	0.15[b]	0.18[a]			
Red blood cell, cells/L				0.16	0.15	<0.01
d 23	8.34[ab]	8.61[b]	8.11[a]			
d 37	8.22[a]	8.21[a]	7.81[b]			
d 44	8.13[a]	8.24[a]	7.92[a]			
d 51	8.03[ab]	8.24[a]	7.78[b]			
d 58	8.35[ab]	8.41[a]	8.01[b]			
d 65	8.09[a]	8.35[a]	8.00[a]			
d 79	8.18[a]	7.94[a]	7.92[a]			
Hematocrit, %				0.5	0.10	<0.01
d 23	37.5[a]	37.1[ab]	36.2[b]			
d 37	37.2[a]	35.8[b]	35.6[b]			
d 44	37.7[a]	36.7[a]	37.0[a]			
d 51	37.5[a]	37.0[a]	36.6[a]			
d 58	39.3[a]	37.9[b]	37.9[b]			
d 65	37.9[a]	37.7[a]	37.8[a]			
d 79	38.6[a]	36.7[b]	37.1[b]			
Hemoglobin, g/dL				0.2	0.07	<0.01
d 23	13.2[a]	13.0[ab]	12.7[b]			
d 37	13.4[a]	12.9[b]	12.8[b]			
d 44	13.5[a]	13.2[a]	13.2[a]			
d 51	13.5[a]	13.3[a]	13.1[a]			
d 58	14.1[a]	13.6[b]	13.5[b]			
d 65	13.6[a]	13.5[a]	13.5[a]			
d 79	14.0[a]	13.3[b]	13.4[b]			

Values within rows with unique superscripts differ $P < 0.05$

[1] Pooled SEM, n = 7 collections/mean

[2] Interaction between blood collection and treatment

to change in response to environmental conditions. In the current study, an interaction ($P = 0.02$; Table 3) was observed between treatment and time for bilirubin levels. Bilirubin may be important as injury to the small intestine remains an issue that can result in decreased animal performance due to heat stress and some research would suggest that bilirubin has a protective effect in the small intestine towards oxidative injury.

Conclusion

In the present study there were no observed performance benefits for cattle supplemented with MOS or STRAW. The addition of MOS to the diet slightly increased body temperature both overall and during the selected warm period. The addition of STRAW increased F:G. However, no other performance traits were affected. While body temperature remained unchanged by the addition of STRAW to the diet, panting scores were decreased slightly when compared to both the CON and MOS diets, possibly suggesting that the addition of finely ground wheat straw to the diet may elevate some of the environmental stress experienced by the steers.

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Effects of Distillers Grains or Fiber on Enterohemorrhagic Escherichia coli in Steers

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Summary with Implications

Increased probability for fecal shedding and colonization by Escherichia coli O157:H7 has been observed in previous studies when steers are fed increased inclusions of distillers grains. A feeding study was conducted to determine if distillers grains or fiber from distillers grains in the finishing ration of feedlot steers affected fecal shedding prevalence of seven serogroups of enterohemorrhagic Escherichia coli (EHEC-7). For EHEC O45 and EHEC O103, the greatest prevalence of shedding occurred when steers were fed increased distillers grains For all EHECs except for O111, fecal shedding prevalence was similar between the corn control and either of the corn fiber isolate diets. Decreased prevalence for shedding O111 was observed in steers fed increased distillers grains at higher fiber level compared to steers fed corn fiber isolate diets. Dietary treatment did not impact EHEC O145 or EHEC O157 shedding. These data suggest that dietary factors affecting EHEC fecal shedding differ by serogroup.

Introduction

Enterohemorrhagic *Escherichia coli* (EHEC) are important foodborne pathogens capable of causing severe human illness. Cattle populations are known to be important reservoirs for EHEC. There are seven serogroups of EHEC (EHEC-7) that have been declared adulterants in raw beef by USDA FSIS that include: O26, O45, O103, O111, O121, O145, and O157. Distillers grains are used frequently in the finishing ration of feedlot cattle. Previous studies have shown that increased inclusion of distillers grains (40 to 50% DM) in the finishing diet increased probability for colonization (*Journal of Food Protection, 2007; 70:2568*) and fecal shedding (*Applied and Environmental Microbiology, 2010, 76:8238*) of *E. coli* O157:H7 compared to feeding a control corn diet or 20% DM distillers grains; however, the mechanism by which this occurs is not understood *Journal of Food Protection, 2007; 70:2568; Applied and Environmental Microbiology, 2010, 76:8238*). The objective of this study was to determine whether the presence of distillers grains in the diet explains the probability to detect the seven serogroups of EHEC in the feces of feedlot steers, and if this is primarily caused by changes in dietary fiber that occur when distillers grains are fed.

Procedures

The study was a 2 x 2 plus 1 factorial design within a randomized block design. There were two inclusions of modified distillers grains plus solubles (MDGS); two diets formulated with corn germ meal and corn bran to equal NDF content of the MDGS diets, and a corn control diet. A total of 100 pens of 800 steers (initial BW=915 lb; SD=53 lb) were fed during the summer of 2015 at the University of Nebraska-Lincoln Eastern Nebraska Research and Extension Center (ENREC). Two-day body weights were measured and steers were allocated into blocks according to BW. Within each of 4 blocks, 25 feedlot pens (n=8 steers/pen) were assigned randomly to the following diets: (1) corn control (CON); (2) 20% MDGS as % of diet DM (20MDGS); (3) 40% MDGS as % of DM (40MDGS); (4) corn fiber isolate

Table 1. Composition (% of diet DM) of dietary treatments fed to yearling steers.

Ingredient	Treatment[1]				
	CON	20MDGS	40MDGS	20FIB	40FIB
Dry-rolled corn	68.5	51.5	31.5	60	51.5
High-moisture corn	12	12	12	12	12
MDGS[2]	-	20	40	-	-
SEM[3]	-	-	-	1.5	3
Wet Corn Bran	-	-	-	7	14
Corn Silage	8	8	8	8	8
Alfalfa Hay	3.5	3.5	3.5	3.5	3.5
Supplement	8	5	5	8	8
Nutrient Composition, % of DM					
CP	14.1	15.1	19.8	14.1	13.3
NDF	11.0	16.7	22.0	16.6	22.2
ADF	4.5	6.6	8.6	6.0	7.5
Lignin	1.7	2.3	2.9	1.9	2.2

[1] Treatments included CON-control; 20MDGS-20% modified distillers grains plus solubles; 40MDGS-40% modified distillers grains plus solubles; 20FIB-fiber fed from concentrated ingredients to mimic fiber provided by 20MDGS; 40FIB-fiber fed from concentrated ingredients to mimic fiber provided by 40MDGS.
[2] MDGS: Modified distillers grains plus solubles,
[3] SEM: solvent extracted germ meal

Table 2. Mean pen-level prevalence (SE_p) of EHEC serogroups detected in fecal samples from 800 feedlot steers during each sampling period.

	Sampling Period			
EHEC Serogroup	d0	d35	d70	d105
EHEC O26	0.5% (0.3)	0%	0%	0%
EHEC O45	26% (1.6)	2.5% (0.6)	2.3% (0.5)	3.9% (0.7)
EHEC O103	32% (1.7)	27% (1.6)	16% (1.3)	13% (1.2)
EHEC O111	0.5% (0.3)	8.5% (1.0)	22% (1.5)	19% (1.4)
EHEC O121	62% (1.7)	0.1% (0.1)	0%	0%
EHEC O145	6.6% (0.9)	3.4% (0.6)	2.3% (0.5)	3.8% (0.7)
EHEC O157	16% (1.3)	4.1% (0.7)	4% (0.7)	4.1% (0.7)

[1]EHEC: Enterohemorrhagic *Escherichia coli*
[2]SE_p: Standard Error of the proportion; calculated as: sqrt [p(1-p)/n]

Table 3. Unadjusted prevalence (SE_p) of EHEC shedding among steers by sampling period, NDF level, and presence or absence of MDGS in the diet.

DIET			EHEC O45	EHEC O103	EHEC O111	EHEC O145	EHEC O157
70d							
	NDF[1] 11						
CON		MDGS[2] 0	1.9% (1.1)	12.5% (2.6)	25.6% (3.5)	0.6% (0.6)	1.9% (1.1)
	NDF 17						
20FIB		MDGS 0	0.6% (0.6)	6.9% (2.0)	34.4% (3.8)	0.6% (0.6)	3.8% (1.5)
20MDGS		MDGS 1	0.6% (0.6)	13.8% (2.7)	25% (3.4)	2.5% (1.2)	5.0% (1.7)
	NDF 22						
40FIB		MDGS 0	1.9% (1.1)	10.6% (2.4)	19.4% (3.1)	3.1% (1.4)	2.5% (1.2)
40MDGS		MDGS 1	6.3% (1.9)	36.3% (3.8)	5.0% (1.7)	4.4% (1.6)	5.6% (1.8)
105d							
	NDF 11						
CON		MDGS 0	2.5% (1.2)	10.6 (2.4)	18.1% (3.1)	3.8% (1.5)	3.1% (1.4)
	NDF 17						
20FIB		MDGS 0	0.6% (0.6)	7.5% (2.1)	11.9% (2.6)	4.4% (1.6)	4.4% (1.6)
20MDGS		MDGS 1	1.3% (0.9)	6.3% (1.9)	12.5% (2.6)	2.5% (1.2)	3.1% (1.4)
	NDF 22						
40FIB		MDGS 0	3.8% (1.5)	13.1% (2.7)	31.9% (3.7)	5.0% (1.7)	3.8% (1.5)
40MDGS		MDGS 1	11.4% (2.5)	27.2% (3.5)	20.9% (3.2)	3.2% (1.4)	6.3% (1.9)

[1]Treatments included CON-control; 20MDGS-20% modified distillers grains plus solubles; 40MDGS-40% modified distillers grains plus solubles; 20FIB-fiber fed from concentrated ingredients to mimic fiber provided by 20MDGS; 40FIB-fiber fed from concentrated ingredients to mimic fiber provided by 40MDGS.
[2]SE_p: Standard Error of the proportion; calculated as: sqrt [p(1-p)/n]
[2]EHEC: Enterohemorrhagic *Escherichia coli*
[3]NDF for CON was 11%, 20MDGS was 17% NDF, 20FIB was 17% NDF, 40MDGS was 22% NDF, 40FIB was 22% NDF
[4]MDGS coded as 0 for absent from the diet, 1 for present in the diet

added to match NDF of 20% MDGS diet (20FIB); and (5) corn fiber isolate to match NDF of 40% MDGS diet (40FIB) (2017 Nebraska Beef Report, pp. 90–92). The main dietary nutrient that fluctuated across treatments was dietary NDF. The diets contained 11.0, 16.7, 22.0, 16.6, or 22.2% NDF for CON, 20MDGS, 40MDGS, 20FIB, or 40FIB, respectively. Table 1 provides nutrient composition and description of diet composition. Fecal samples were collected individually from steers on d 0, 35, 70, and 105. EHEC-7 testing was performed using the NeoSEEK™ STEC Detection and Identification test (Neogen® Corp., Lansing, MI). Fecal sample test results were recorded as presence or absence for each of the seven serogroups of EHEC.

The effects of MDGS, NDF, and sampling period on fecal shedding of EHEC-7 were evaluated. The absence or presence of MDGS within the diet was coded as a binary class variable, 0 or 1, respectively. Fiber (NDF) was included as a continuous variable, with NDF for steers fed CON assigned a value of 11, NDF for 20MDGS or 20FIB was assigned a value of 17, and NDF for 40MDGS or 40FIB was assigned a value of 22. Each EHEC serogroup was tested as a separate outcome variable.

Results

Mean pen-level prevalence of each serogroup are included in Table 2. Highest prevalence of every EHEC serogroup, except EHEC O111, was during sampling period 1. Cattle were adapted to finishing diets over a 21 d period (day 0 to 21), so only sampling periods at d70 and d105 were analyzed to determine effects of MDGS and NDF.

Table 3 provides the observed proportion of each EHEC serogroup detected in RAMS samples accounting for sampling period, MDGS, and NDF. There was greater prevalence of EHEC O45 at d105 (3.9%) than d70 (2.3%). The highest prevalence during either sampling period was found when steers were fed NDF 22% and MDGS was present (40MDGS diet). Similarly, for the outcome of EHEC O103, the highest prevalence of shedding was found in steers fed 22% NDF and MDGS. There was higher prevalence of EHEC O103 at d70 compared to d105. The highest prevalence of EHEC O111 observed throughout the entire study was at d70 (22%). At d70 the highest prevalence was

observed in steers fed 20FIB diet; however, at d105 the highest prevalence was seen in steers fed the 40FIB diet. There was a higher prevalence of EHEC O145 detected at d 105 (3.8%) than at d70 (2.3%). At d70 steers fed 40MDGS had higher prevalence of shedding, but at d105 steers fed 40FIB had higher prevalence of shedding. Similar EHEC O157 shedding prevalence was observed for 70 and d105, and steers fed 40MDGS had highest prevalence. Neither EHEC O26 nor EHEC O121 was detected in any fecal samples at d70 or d105.

Discussion

For EHEC O45, EHEC O103, EHEC O145 (at d70), and EHEC O157, the highest shedding prevalence was observed when cattle are fed 40% MDGS. This suggests that the increased risk for fecal shedding of EHEC by cattle on 40% MDGS diets was not due to higher fiber levels from distillers grains, but some other components of the ration contributed by MDGS. Compared to the other EHEC serogroups, different effects were observed regarding shedding prevalence of EHEC O111 in relation to fiber levels and presence of MDGS.

Conclusion

These results suggest that the dietary factors affecting fecal shedding are not the same for every EHEC serogroup.

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The Influence of Diet and Oxidation on Calcium Retention of the Mitochondria in Fresh Beef

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Summary with Implications

Feeding dried distillers grains (DG) may influence calcium flux postmortem by disrupting the stability of the sarcoplasmic reticulum (SR) membrane, thus leading to a higher post-rigor calcium leakage, resulting in greater activation of calpains and improved tenderness. Mitochondria provide the opportunity to study calcium flux in a controlled, tightly defined environment as a model system for the SR. Cattle were finished on diets containing either 0% DG or 50% DG. Feeding DG increased proportions of PUFA in the SR and mitochondrial membrane. Oxidized mitochondria retained less calcium than non-oxidized mitochondria. Mitochondria from cattle finished on corn tended to retain more Ca than mitochondria from cattle finished on DG. These findings suggest that feeding DG in the finishing diet can possibly increase meat tenderness through altered calcium flux.

Introduction

Research at the University of Nebraska-Lincoln has found that feeding distillers grains (DG) increases polyunsaturated fatty acid (PUFA) content within the sarcoplasmic reticulum (SR) membrane. The amount of PUFA influences SR membrane fluidity and can compromise the ability of the organelle to retain calcium (its primary contents). The PUFA are highly susceptible to oxidation, which can lead to membrane collapse postmortem. If the SR membrane collapses early postmortem calcium (Ca) leakage may occur. Calcium activates proteolytic enzymes known as calpains. Calpains aide in the tenderization of meat postmortem. Therefore, altering the PUFA content in the SR membrane could lead to improved tenderness postmortem by increasing the amount of calcium available to activate calpains. Even though the SR is difficult to study, mitochondria, the secondary Ca-sequestering organelles in the muscle, are relatively easy to isolate intact and provide the opportunity to study Ca release under carefully controlled and tightly defined conditions. The objective was to isolate mitochondria from cattle fed DG and corn to determine the influence of diet and oxidation on Ca release.

Procedure

Steers (n = 48) were fed a corn-based finishing diet with or without deoiled, dried DG (50% DM basis) for 156 days. After harvest, strip loins were collected and steaks from each loin were aged for 2, 8, 14, and 21 days, powdered using liquid nitrogen, and stored at -112° F for lab analysis. Samples (n = 12) were randomly selected from each diet group for all aging periods. Mitochondria were isolated using high speed ultracentrifuge from day 2, 8, and 14. The SR was isolated from each day 2 sample. Both mitochondria and SR samples were analyzed for PUFA content using gas chromatography, and phospholipid content using thin layer chromatography. Mitochondria from days 2 and 8 were artificially oxidized using an iron and ascorbic acid mixture. Calcium measurements were performed at Ward Labs (Kearny, NE) using Inductively Coupled Plasma Optical Emission Spectra (ICP-OES).

Statistical Analysis

The Proc Glimmix procedure in SAS (SAS Institute, Inc., Cary, N.C.) was used to test the main effects of dietary treatment, aging period, PUFA content, phospholipid content, and oxidation and their interactions on the calcium retention of the mitochondria. All means were separated using the LS MEANS statement and the TUKEY adjustment with an alpha level of 0.05.

Results

In both organelles, the DG diet samples had higher 18:2 and total PUFA content

Table 1. Effect of diet on 18:2 and polyunsaturated fatty acid (PUFA) content of the SR and mitochondrial membranes.

Organelle	Fatty acid (%)	Corn	DDGS 50%[x]
SR	18:2	8[a]	17[b]
	PUFA	10[a]	17[b]
Mitochondria	18:2	9[a]	15[b]
	PUFA	15[a]	24[b]

[a,b] Means within a row with different superscripts differ *(P < 0.05)*.
[x] DDGS= dried distillers grains plus solubles

Table 2. Effect of aging on 18:2 and polyunsaturated fatty acid (PUFA) content of the mitochondrial membrane.

Aging (days)	18:2 (%)	PUFA (%)
2	12[a]	19[a]
8	9[a]	16[a]
14	15[b]	23[b]

[a,b] Means within a column with different superscripts differ (*P < 0.05*).

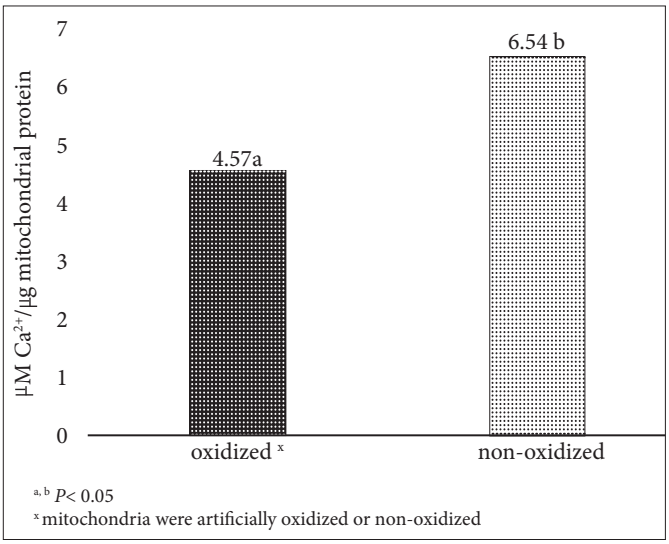

Figure 1. Effect of Oxidation on Mitochondrial Calcium Retention.

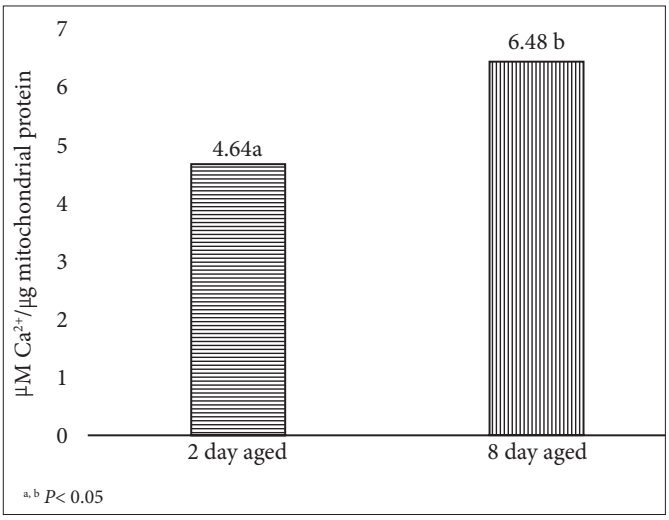

Figure 2. Effect of Aging on Mitochondrial Calcium Retention.

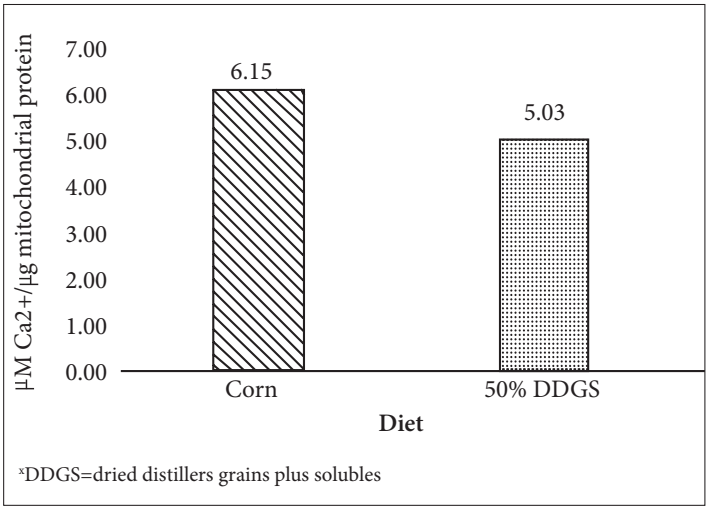

Figure 3. Effect of Diet on Mitochondrial Calcium Retention.

($P < 0.01$) compared to corn samples (Table 1), which was consistent with previous studies. Day 14 mitochondrial lipids had higher 18:2 ($P < 0.01$) and total PUFA ($P < 0.05$) contents compared to day 2 and 8 mitochondrial lipids (Table 2). This was expected because during aging of meat oxidation propagates the formation of additional trans double bonds in other fatty acids, creating more unsaturated fatty acids. Phospholipid contents (phosphatidylethanolamine, phosphatidylcholine, and phosphatidylinositol) of the mitochondria and SR were unaffected by diet ($P > 0.10$). Oxidized mitochondria retained significantly less Ca than non-oxidized ($P < 0.01$) mitochondria (Fig. 1). This supported the hypothesis that as oxidation increases, the membrane stability decreases, thus allowing calcium to leak from the organelle. Day 2 mitochondria retained significantly less Ca than day 8 ($P < 0.01$) mitochondria (Fig. 2), which is opposite of the results that were expected, because the total PUFA content was not significantly different between the two aging periods. Overall, mitochondria from cattle finished on corn tended ($P = 0.08$) to retain more Ca than mitochondria from cattle finished on DG, which supported the hypothesis (Fig. 3).

Conclusion

Results indicate that greater PUFA content deposited in organelles may affect Ca flux by increased susceptibility to oxidation. A DG diet may influence Ca flux and ultimate tenderness by this mechanism.

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Effect of Feeding Field Peas on Fresh Beef Quality

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Summary with Implications

This study was conducted over two years to evaluate the use of field peas during two phases of production (grazing and finishing) on overall fresh beef quality. The backgrounding treatments included: no supplement, field peas, or dry-rolled corn and finishing treatments included the presence or absence of field peas. Loin samples (n = 232) were aged for 14 d and placed under retail display conditions for 7 d. Dietary treatments had no effect on tenderness (WBSF or SSF) or visual discoloration and minimal effects on objective color, lipid oxidation and fatty acid composition. These data indicate field peas may be used as an alternative feed for growing and finishing cattle with minimal to no negative impact on fresh meat quality.

Introduction

Field peas have become a viable feed supplement for beef cattle. Field peas are an annual cool-season legume crop primarily produced in South Dakota, North Dakota and the western panhandle of Nebraska. They compare favorably with other grains for several nutrients including crude protein, starch and fat. However, the impact of feeding field peas on fresh meat quality has not been well studied. Therefore, this study was conducted to determine the effect of feeding field peas on shelf-life, tenderness, lipid oxidation, and fatty acid profiles of beef.

Procedure

A total of 232 crossbred cattle (replicated over 2 yrs; steers during year one, heifers during year 2) were subjected to one of three background treatments on crested wheatgrass pastures with either: 1) no supplement, 2) field peas at 0.5% BW, or 3) dry-rolled corn supplemented at 0.5% BW and one of two finishing treatments: 1) supplemented with field peas (20% on a DM basis) or 2) no peas were added to the diet. Each background treatment consisted of 4 replications with 10 hd per pasture for a total of 40 hd per treatment per year. A 3-inch thick slice of the anterior portion of the strip loin was collected at the 12/13th rib area from every side of every carcass. All samples were immediately fabricated and then aged for 14 days. Right loin samples were fabricated into ¾-inch thick steaks and 1-inch steaks. The ¾-inch steak was used for laboratory analysis of fatty acid composition while the 1-inch steak was used for tenderness measurement [Warner-Bratzler Shear Force (WBSF) and Slice Shear Force (SSF)] for day 0 of retail display. Left loin samples were fabricated into ½-inch thick steaks and 1-inch steaks. The ½-inch steak was used to measure lipid oxidation while the 1-inch steak was used for visual discoloration and tenderness measurements for day 7 of retail display.

Tenderness—Warner-Bratzler Shear Force (WBSF) & Slice Shear Force (SSF)

For all steaks (never frozen), an internal raw temperature and weight were recorded. Steaks were cooked to a target temperature of 160°F on a Belt Grill (TBG60-V3 Magi-Gril, MagiKitch'n Inc., Quakertown, PA). After cooking, an internal temperature and weight were recorded and slice shear force evaluation was conducted using a Food Texture Analyzer with a Slice Shear Force blade. The remainder of the steak was individually bagged and stored in a cooler (maintained at 33°F). Approximately 24 hours after SSF evaluation was conducted, six cores (1/2-inch diameter) were removed parallel to the muscle fiber orientation of each steak and were measured with a Food Texture Analyzer with a Warner-Bratzler blade.

Subjective Discoloration (Visual Discoloration)

Percent discoloration was estimated daily for seven days by six graduate students during the first year and eight graduate students during the second year, all of whom had previous experience with subjective color scoring.

Objective Color (L, a*, b* values)*

During retail display, objective color was assessed daily with a Minolta Colorimeter (CR-400, Minolta Camera Company, Osaka, Japan). The D65 illuminant setting and 2° observer were used with an 8 mm diameter measurement area. The colorimeter was calibrated daily and color measures were obtained by averaging 6 readings from different areas of the steak surface. The CIE L* measured lightness (black = 0, white = 100), a* measured redness (red = positive values, green =negative values) and b* measured yellowness (yellow = positive values, blue = negative values).

Lipid Oxidation (TBARS)

Frozen samples (from retail display days 0, 4 and 7) were diced into small pieces, with no subcutaneous fat, and flash frozen in liquid nitrogen. The frozen pieces were homogenized in a Waring commercial blender and a 5 g sample was weighed in duplicate to conduct the TBARS protocol.

Fatty Acid Profile

Frozen samples, with no subcutaneous fat, were diced into small pieces and flash frozen in liquid nitrogen. Samples were then homogenized in a Waring commer-

Table 1. Amount[1] of fatty acids of beef from cattle fed corn, field peas or no supplement (*L. dorsi*)

	No supplement on pasture		Field Peas on pasture		Corn on pasture		*P*-value			
Fatty Acid	Corn Finishing	Field Peas Finishing	Corn Finishing	Field Peas Finishing	Corn Finishing	Field Peas Finishing	Pasture	Finishing	Pasture* Finishing	*SEM*[2]
C10:0	3.97	5.11	5.40	5.11	4.41	4.45	0.28	0.52	0.44	0.69
C12:0	4.20	5.56	4.70	4.87	4.53	4.35	0.69	0.30	0.31	0.61
C14:0	185.96	204.88	179.51	184.02	180.12	184.34	0.34	0.28	0.73	11.40
C14:1	44.88	49.22	40.92	45.31	42.25	44.67	0.41	0.16	0.94	3.50
C15:0	32.89	32.62	29.51	29.41	31.40	29.48	0.23	0.63	0.88	2.12
C15:1	40.40	49.64	51.02	43.43	45.72	45.02	0.76	0.90	0.03	3.48
C16:0	1,688.57	1,852.63	1,655.76	1,627.45	1,653.85	1,677.08	0.32	0.47	0.55	98.37
C16:1	240.45	271.14	241.89	254.20	251.59	260.25	0.81	0.13	0.70	15.12
C17:0	99.61	110.05	104.09	95.75	103.14	94.50	0.61	0.68	0.24	7.00
C17:1	94.98	102.52	98.79	85.78	89.13	85.12	0.21	0.55	0.29	7.10
C18:0	1,059.83	1,158.86	1,059.53	1,006.33	1,010.95	1,009.54	0.25	0.77	0.46	66.97
C18:1	2,892.93	3,209.57	2,886.72	2,801.20	2,876.43	2,973.08	0.41	0.39	0.44	169.91
C18:1v	114.01	124.05	115.85	115.97	100.62	104.09	0.16	0.54	0.86	9.98
C19:0	44.65	36.22	32.02	39.54	33.51	33.20	0.30	0.91	0.22	5.06
C18:2TT	273.28	252.67	267.17	255.87	272.13	238.71	0.93	0.20	0.87	23.96
C18:2	230.40	239.45	298.65	252.77	223.82	225.08	0.04[a]	0.49	0.37	23.02
C18:3ω3	11.37	15.39	15.59	15.00	14.16	14.04	0.25	0.24	0.10	1.35
C20:0	22.94	20.97	26.18	20.64	24.52	23.83	0.47	0.06	0.37	1.95
C20:1	26.04	26.02	24.20	23.55	22.01	27.76	0.70	0.41	0.31	2.83
C20:3ω6	14.01	15.24	14.47	14.28	14.96	13.46	0.91	0.84	0.35	1.03
C20:4ω6	41.11	42.05	43.15	41.96	43.01	41.34	0.91	0.73	0.83	2.44
C22:5	12.45	14.57	11.98	12.07	12.28	11.56	0.13	0.50	0.26	0.94
Total	7,106.65	7,749.47	7,092.94	6,894.24	7,000.84	7,059.18	0.41	0.57	0.49	387.66
Other	22.77	49.72	46.15	27.79	52.25	50.93	0.32	0.80	0.14	12.48
SFA[2]	3,123.64	3,372.91	3,075.65	2,994.65	3,024.53	3,040.94	0.33	0.65	0.60	179.91
UFA[2]	3,983.02	4,376.57	4,017.30	3,899.59	3,976.32	4,018.24	0.49	0.51	0.42	214.44
SFA:UFA[2]	0.78	0.78	0.77	0.77	0.77	0.76	0.54	0.69	0.95	0.02
MUFA[2]	3,433.64	3,817.86	3,429.83	3,358.83	3,419.25	3,505.81	0.44	0.38	0.46	199.74
PUFA[2]	549.38	558.70	587.47	540.77	557.07	512.43	0.60	0.26	0.57	32.44
ω6	52.56	52.93	54.63	54.21	55.24	51.30	0.83	0.57	0.72	3.07
ω3	11.37	15.39	15.59	15.00	14.16	14.04	0.25	0.24	0.10	1.35
ω6:ω3	4.59	3.90	3.96	3.81	4.66	4.00	0.34	0.06	0.64	0.38

[1]Amount (mg/100 g tissue) of fatty acid in powdered loin sample determined by gas chromatography.
[2]SEM = Standard Error of the Mean, SFA = Saturated fatty acids, UFA= Unsaturated fatty acids, SFA:UFA = Saturated fatty acids: Unsaturated fatty acids, MUFA= Monounsaturated fatty acids, and PUFA=Polyunsaturated fatty acids
[a]For C18:2, peas on pasture treatment were higher than the corn on pasture ($P = 0.04$), no supplement on pasture was not different to peas or corn on pasture.

cial blender and a 1 g sample was weighed out to conduct fatty acid determination via gas chromatography. Total fatty acids converted to methyl esters were separated on a fused silica column (Chromopack CP-Sil; 0.25mm x 100m) which was placed in an oven programmed from 284°F for 10 min to 428°F at a rate of 35°F/min and held at 428°F for 20 min. Total run time was 70 min. The injector and detector were programmed to work at 518°F and 572°F, respectively. Each lipid extract was separated into fatty acids by using helium as the carrier gas at a flow rate of 1mL/min. Individual fatty acids of each sample were determined by comparison of retention times with known standards and the percent of fatty acid was determined by the peak area in the chromatograph.

Statistical Analysis

This study was conducted with a treatment design of a 3 x 2 factorial (backgrounding diet x finishing diet) and analyzed using SAS® 9.4 package, SAS Institute, Inc., USA. Objective color and percent discoloration were analyzed for treatment main effects using the PROC GLIMMIX procedure of SAS with day as repeated measures when traits were measured over time. All other analyses were conducted with PROC GLIMMIX as well; all means were separated with the LS MEANS statement and TUKEY adjustment with an alpha level of 0.05 and tendencies were considered at an alpha level of 0.1.

Results

In general, there were minimal effects due to diet. Tenderness (measured with WBSF and SSF) only presented differences due to retail display, showing an increase in tenderness with days of retail display ($P < 0.0001$). Neither backgrounding, nor finishing treatment influenced tenderness measurements. A strong correlation between WBSF and SSF was observed (r = 0.65; $P = < 0.0001$).

Discoloration, L* and a* had triple interactions of retail display, by pasture, by finishing diets ($P < 0.0001$, p=0.0524 and p=0.024, respectively). In general, samples placed under retail display did not exhibit meaningful discoloration as samples only reached 1.47% discoloration by d 7 irrespective of dietary treatment during both combined years. Although these interactions were statistically significant, no consistent patterns due to treatments could be identified. Similarly, the magnitude of difference would require extended aging periods to visually influence the color differences perceived by consumers.

Meat from cattle finished with field peas had slightly greater lipid oxidation than samples from cattle not receiving field peas during finishing (1.56 vs. 1.44 mg malonaldehyde/kg tissue, respectively; $P = 0.0541$), although this is not a meaningful difference. As expected, lipid oxidation increased over time of simulated retail display (0d = 0.94, 4d = 1.46 and 7d = 2.11 mg malonaldehyde/kg tissue; $P < 0.0001$).

Dietary treatment had no effect on content of saturated fatty acids, unsaturated fatty acids, monounsaturated fatty acids or polyunsaturated fatty acids ($P > 0.05$; Table 1). There was a significant interaction between pasture and finishing treatments for C15:1 but the range in values was relative low and no implications from these differences could be identified. Supplementing cattle on pasture with field peas resulted in significantly more C18:2 fatty acids than when cattle were supplemented with corn, while cattle without supplement were intermediate. However, these differences did not carry over into total PUFA content, and differences among treatments could not be identified. Thus, subtle differences in fatty acid composition that occurred from the treatments did not influence meat quality.

Overall, there were minimal changes in discoloration, color, or tenderness. In conclusion, these data indicate field peas may be used as an alternative diet for growing and finishing cattle with minimal to no negative impact on fresh meat quality.

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Fatty Acid Composition of Beef Fed OmniGen-AF at Receiving or Finishing

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Summary with Implications

Beef fatty acid profiles and superoxide dismutase activity were determined for cattle receiving OmniGen-AF supplementation (a patented nutritional supplement) at receiving (first 28 d at the feedlot) or throughout finishing (all 210 d of finishing) vs. a control group (non-supplemented). The most meaningful change in fatty acid composition from inclusion of OmniGen-AF was total poly-unsaturated fatty acid (PUFA) content where beef from the finishing group had more PUFA content in relation to the receiving group and was not different from the control group. Despite this increase in PUFA, cattle supplemented through finishing tended to have less lipid oxidation than the other two treatments yet this difference could not be explained by the superoxide dismutase activity.

Introduction

OmniGen-AF (Phibro Animal Health, Quincy, IL) is a patented nutritional supplement designed to augment and support the immune system of cattle. This nutritional supplement consists of live yeast and premixes of vitamins and minerals that have been carefully selected through nutrigenomics to aid in the nutritional modulation of genetic expression to promote cellular health. Although originally designed with dairy cattle in mind, the beef cattle industry might benefit from using this supplement to further improve the immune response of cattle under stress as well as potentially incorporating antioxidants into muscle foods to maintain meat quality over longer aging periods and retail display times. Thus, the objectives of this research were to assess the impact of feeding OmniGen-AF on beef fatty acid profiles as well as attempting to decipher a mechanism of how added oxidative stability could be achieved by quantifying superoxide dismutase activity.

Procedure

A total of 288 steers were sorted into three treatment groups (96 hd/treatment): a control group that received no OmniGen-AF supplementation and two groups supplemented with OmniGen-AF either at receiving (first 28 d at the feedlot) or throughout finishing (210 d). At the receiving phase, cattle were fed 30 % alfalfa hay, 30% dry rolled corn, 36% Sweet Bran® (corn gluten feed, Cargill, Blair, NE), and 4% supplement. The finishing diet consisted of 50% high moisture corn, 40% Sweet Bran®, 5% wheat straw, and 5% supplement. At both the receiving and finishing phases, OmniGen-AF was top dressed at 4 g/45.4 kg BW/hd/d. Cattle were sorted 8 hd/pen for a total of 12 pens/treatment. After harvest, 24 USDA low Choice carcasses were selected within each dietary treatment (n = 72) and strip loins were obtained. Vacuum packaged loins were aged 8, 22 and 29 days (33°F). At 8 days of age, a portion of the strip loin was fabricated at which time a ½-inch steak was trimmed of subcutaneous fat (for fatty acid analysis) and was vacuum packaged and stored immediately in an ultra-low freezer (-112°F) until analysis. Similarly, at 29 days of age and after 7 days of retail display, ½-inch steak were vacuum packaged and stored in an ultra-low freezer (-112°F) for superoxide dismutase activity determination.

Fatty acid profile

Frozen samples were diced into small pieces, with no subcutaneous fat, and flash frozen in liquid nitrogen. Gas chromatography was done using a Chromopack CP-Sil (0.25 mm x 100 m) column. Fatty acids were identified by their retention times in relation to known standards and the percent of fatty acid was determined by the peak area in the chromatograph. Data were converted from percentage of individual fatty acids to mg/100 g of tissue after determining the overall fat content of each sample.

Superoxide Dismutase Activity

Superoxide dismutase (SOD) activity was determined with a colorimetric assay kit (ab65354; Abcam, Cambridge, MA). The SOD units of activity are reported over mg of protein (SOD U/mg protein).

Statistical analysis

The experimental design was a completely randomized design where the PROC GLIMMIX procedure in SAS (SAS Inst., Inc., Cary, N.C.) was used to determine the effects of dietary treatment on fatty acid content as well as superoxide dismutase activity. All means were separated with the LS MEANS statement and the TUKEY adjustment with an alpha of 0.05.

Results

In an earlier beef report (2016 *Nebraska Beef Report*, pp. 161–163) the fatty acid data were presented on this set of cattle on a percentage basis. However, after adjusting composition data with total fat content of samples, several fatty acids were found to differ in terms of total content on a mg/100 g sample basis (Table 1). Beef from cattle supplemented throughout the entire finishing phase had more ($P < 0.05$) C18:1, C18:2, C19:0, total, unsaturated fatty acids (UFA), and mono-unsaturated fatty acids (MUFA) in relation to beef from cattle supplemented through the receiving phase. However, beef from non-supplemented cattle did not differ from supplemented cattle ($P > 0.05$).

There was more ($P = 0.05$) C20:5ω3 fatty acid in beef from the non-supplemented

Table 1. Fatty acid changes due to supplementation with OmniGen-AF on steaks aged for 8 d

Fatty acid[2]	Dietary Treatment[1]			*SEM*	*P*-value
	Control	Omni Gen-AF at Receiving	Omni Gen-AF at Finishing		
C4:0	40.68	40.18	55.84	13.61	0.64
C10:0	6.48	7.39	6.64	1.23	0.57
C12:0	7.50	7.38	7.78	0.52	0.82
C13:0	7.29	6.42	7.58	0.78	0.48
C14:0	328.19	309.13	324.29	15.76	0.68
C14:1	97.61	98.07	96.90	6.78	0.99
C15:0	62.36	61.35	60.70	4.22	0.94
C15:1	62.03	52.88	61.18	3.56	0.14
C16:0	2,823.89	2,766.27	2,889.82	74.91	0.51
C16:1T	54.08	40.47	45.83	7.45	0.44
C16:1	429.65	414.61	443.86	19.58	0.58
C17:0	156.40	150.63	159.87	6.66	0.61
C17:1	134.23	124.41	131.46	7.27	0.65
C18:0	1,471.92	1,469.44	1,582.63	49.94	0.19
C18:1T	230.04	220.63	254.45	14.85	0.23
C18:1	4,290.04[ab]	4,141.40[b]	4,546.06[a]	113.48	0.05
C18:1V	725.56	625.80	763.83	44.97	0.09
C18:2TT	24.45	16.27	15.67	2.89	0.08
C18:2	414.88[ab]	376.39[b]	443.09[a]	15.40	0.01
C18:3ω6	8.68	8.57	9.41	0.41	0.35
C18:3ω3	18.09	17.40	19.64	0.70	0.08
C19:0	16.66[ab]	16.20[b]	18.26[a]	0.62	0.05
C20:1	56.28	57.96	62.03	3.33	0.46
C20:2	3.89	3.83	6.77	2.30	0.39
C20:3ω6	27.50	22.97	27.84	1.62	0.07
C20:4ω6	80.23	67.05	78.89	4.94	0.13
C20:5ω3	7.92[a]	6.04[b]	7.50[ab]	0.54	0.05
C22:5	34.38	17.13	19.54	7.68	0.24
C24:1	13.23	11.80	12.29	0.67	0.31
Total	11,570.06[ab]	11,112.04[b]	12,107.25[a]	263.78	0.04
Other	113.44	103.14	123.68	12.72	0.52
SFA	4,895.38	4,826.70	5,082.91	127.02	0.34
UFA	6,674.69[ab]	6,285.33[b]	7,024.34[a]	158.61	0.01
SFA:UFA	0.74[ab]	0.77[a]	0.73[b]	0.01	0.05
MUFA	6,076.35[ab]	5,758.73[b]	6,414.27[a]	146.87	0.01
PUFA	598.34[a]	526.60[b]	610.07[a]	20.05	0.01
Trans	213.25	245.05	312.04	21.17	0.09
ω6	113.10	97.84	110.89	5.85	0.14
ω3	22.41	21.34	23.22	1.16	0.54
ω6: ω3	5.28	4.73	4.71	0.31	0.32

[1]Control: no OmniGen-AF supplementation; OmniGen-AF at Receiving: first 28 d at the feedlot; OmniGen-AF throughout Finishing: all 210 d at the feedlot. OmniGen-AF was top dressed at 4 g/45.4 kg BW/hd/d.
[2]Fatty acids reported on a mg/100 g tissue basis
[a-b]Different superscripts indicate differences within each row ($P < 0.05$)

group than the receiving group, with the finishing group being intermediate. The saturated to unsaturated fatty acid ratio (SFA:UFA) was greater ($P = 0.05$) in beef from the receiving group, intermediate in beef from the non-supplemented group, and lowest in beef from the finishing group.

More importantly in terms of evaluating beef shelf life, dietary treatment did alter total poly-unsaturated fatty acid (PUFA) content in beef samples. Beef from the finishing and non-supplemented groups had greater ($P = 0.01$) PUFA content than the receiving group.

Typically, greater PUFA content leads to greater lipid oxidation under retail display conditions and thus shortens meat shelf life. However, based on lipid oxidation measures previously reported (2016 *Nebraska Beef Report*, pp. 161–163), beef from cattle supplemented throughout the finishing phase with OmniGen-AF had a tendency ($P = 0.10$) of having decreased lipid oxidation values despite having greater PUFA content. Superoxide dismutase activity (SOD) was determined in an attempt to further understand and explore the added oxidative stability seen in the supplemented finishing group. Superoxide dismutase is an enzyme that helps combat the accumulation of excessive amounts of reactive oxygen species (the initiators of lipid oxidation). It is thought to be the primary line of defense that converts superoxide's (most toxic reactive oxygen form) to less toxic forms of oxygen, at which point other enzymes such as catalase and glutathione peroxidase can further detoxify the reactive oxygen forms to less toxic compounds for the cell and thus provide cells a built-in antioxidant mediation system. Figure 1 shows the primary and secondary antioxidant mediators that can be explored to better understand oxidative stability, with SOD being the leading innate mechanism of interest. Figure 2 depicts the major reactive oxygen species, where the top of the pyramid represents the most toxic reactive oxygen form (superoxide anion) and the bottom contains secondary reactive oxygen species that are derived as by-products of primary free radicals.

Despite the fact that meat from the finishing group had increased PUFA content as well as decreased lipid oxidation, meat from cattle fed OmniGen-AF throughout finishing did not show meaningful differences ($P = 0.92$) in superoxide dismutase

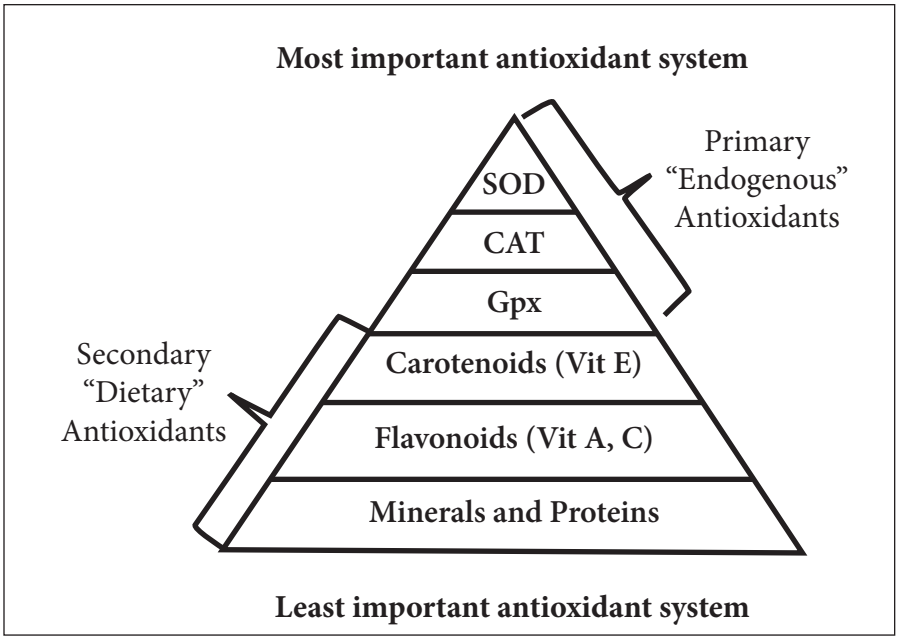

Figure 1. Mechanisms to protect against toxic oxygen forms. Primary or endogenous mechanisms include: Superoxide dismutase, Catalase and Glutathione peroxidase. Secondary or dietary mechanisms include: Vitamins, Minerals and Proteins.

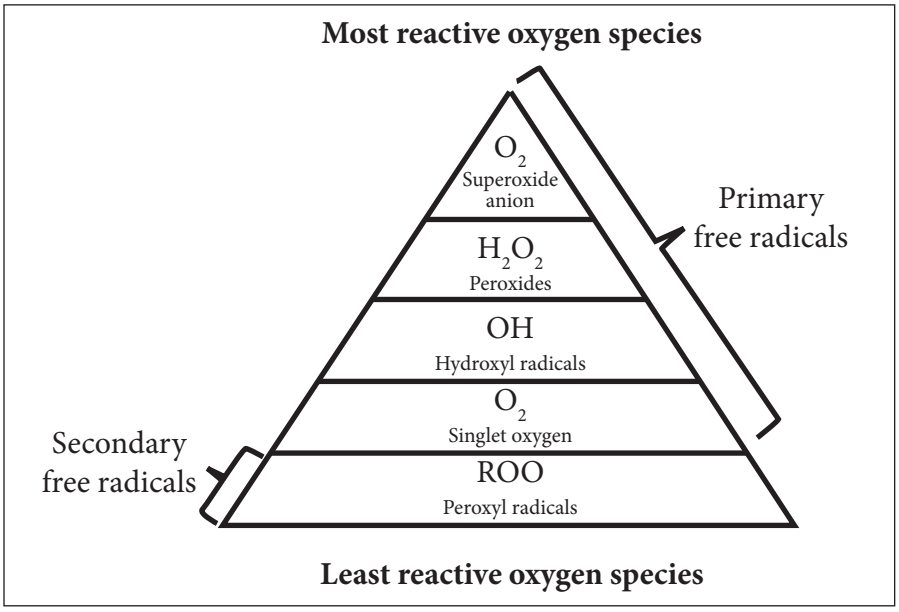

Figure 2. Reactive oxygen forms. Toxicity of free radicals increases towards top of pyramid. Primary free radicals are highly reactive and eventually form secondary free radicals. The function of SOD is to convert superoxide's to less toxic forms such as peroxides and singlet oxygen.

activity compared to meat from cattle that were not supplemented (18.98 vs. 19.11 U/mg protein, respectively).

In summary, dietary supplementation with OmniGen-AF did alter the fatty acid composition with the most meaningful difference being the increased PUFA content in beef from cattle supplemented throughout finishing. Despite greater propensity for lipid oxidation due to increased PUFA content, supplementing with OmniGen-AF for long periods of time tended to enhanced lipid stability (determined by TBARS). Even though SOD activity was not found to differ with the extended supplement feeding, it could be speculated that the tendency for added lipid stability could potentially be coming from downstream enzymes following SOD such as catalase and glutathione peroxidase. Another alternative could simply be that phenolic-rich compounds in the supplement can successfully be incorporated into tissues thus providing oxidative stability during retail display.

Conclusion

In conclusion, OmniGen-AF did not negatively impact beef shelf life despite causing an increase in PUFA content when supplemented throughout the finishing phase. In order for OmniGen-AF to be considered as a potential antioxidant source for beef cattle the supplement may need to be fed at greater concentrations.

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Organic Acids and Applications used for Reduction of *E. coli* on Beef Shoulder Clods used for Ground Beef

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Summary with Implications

Small processors normally grind beef shoulder clods for ground beef that have not been previously tested for shiga toxin-producing E. coli. Three antimicrobial solutions were applied using three application methods to beef sub-primals to evaluate the effectiveness of reducing E. coli and the effects on quality attributes. Antimicrobials effectively reduced Rifampicin resistant E. coli. However, none of the treatments changed color attributes or total plate counts compared to a control. These results suggest that an appropriate antimicrobial solution and application method can be selected for use by small meat processors without affecting quality attributes.

Introduction

Small meat processing operations often purchase beef shoulder clods for grinding that have not been tested for shiga toxin-producing *E. coli* (STEC). However, *E. coli* O157:H7 and other STEC are considered to be adulterants in raw, non-intact beef products due to significant health risks. The use of antimicrobial interventions applied to the surface of beef shoulder clods may offer small processors a method to reduce the risk of STEC in ground beef. The objectives of this research were to evaluate the effect of organic acid type and application method applied to the surface of beef shoulder clods as a means to reduce the risk of STEC and the effects on color and shelf life of the ground beef produced.

Procedure

Rifampicin Resistant E. coli

Eleven beef shoulder clods were cut in half prior to inoculation to form clod roasts. Since fat and lean tissue have different buffering capabilities, one half was used as the outer fat surface and the other half was used as the inner lean surface of clod roasts for inoculation and application of an organic acid. Each half was inoculated with a five strain cocktail (~5.6 log CFU/cm^2) of Rifampicin resistant *E. coli* (*E. coli^{Rif}*). After inoculation, five core samples (3.92 in^2) were taken from the inoculated surface for initial inoculation concentrations. Then 4.5% lactic acid (LA), 2.5% Beefxide™ (BX, lactic acid + citric acid), or 380 ppm peroxyacetic acid (PAA) was applied at 67–74˚F to each clod roasts using spray (5 sec, 20 psi), dip (15 sec), or electrostatic spray (ESS, 10 sec). Additionally, a non-inoculated control was used to assure that there were no *E. coli^{Rif}* naturally present and inoculated control was used to compare treatments to assure that the antimicrobial was effective. After antimicrobial treatment, five core samples (3.92 in^2) were taken from the treated surface to determine the reduction of *E. coli^{Rif}* concentrations. Each clod roast was then ground and a 25 gram sample was collected for microbial analysis. All samples were extracted in peptone water containing Rifampicin and then enumerated on ACP and *E. coli*/coliform Petrifilm. This process was replicated three times.

Color and Total Plate Counts

Beef shoulder clods were treated with the same concentrations of LA, BX and PAA using spray (11 sec/side, 20 psi), dip (15 sec), or ESS (10 sec/side). Beef shoulder clods were ground and a 25 gram sample was collected for microbial analysis using ACP Petrifilm. Microbial analysis was done on days 0, 1, 3, 5, and 7. Approximately one pound portions were formed using a Colosimo press and were placed in simulated retail display where a subjective color panel (8–10 panelists) evaluated discoloration daily. In addition, L*, a*, and b* values were measured daily using a Minolta colorimeter. Delta E values were then calculated from the L*, a*, and b* values using the following formula: $\Delta E = \sqrt{[(L_1-L_0)^2 + (a_1-a_0)^2 + (b_1-b_0)^2]}$. Day 0 was used as the initial value from each sample to compare the rate of discoloration. Six independent replicates were conducted.

Statistical Analysis

The PROC GLIMMIX of SAS 9.4 (SAS Inst., Inc., Cary, NC) was used to determine the effects of organic acids and application methods on the reduction of *E. coli^{Rif}* and ground beef color. All means were separated with the LS-means (LSM) statement and the Tukey adjustment with an alpha of 0.05.

Results

All treatments reduced (P <0.01) *E. coli^{Rif}*counts when compared to the inoculated control (0.39–1.13 log CFU/cm^2 reduction) when using *E. coli*/coliform petrifilm. When using ACP petrifilm, all treatments reduced (P < 0.01) *E. coli^{Rif}* counts except BX ESS (P = 0.423 log CFU/cm2), LA ESS (P = 0.328 log CFU/cm2) and PAA ESS (P = 0.088 log CFU/cm2). There were no interactions between organic acids and application methods, however, dip and spray applications were more effective (P < 0.001) at reducing *E. coli^{Rif}* when compared to the ESS method (Table 1) using both ACP and *E. coli*/coliform petrifilm. Additionally, LA had the greatest reduction while BX had the smallest reduction for organic acid type on *E. coli^{Rif}* (Table 2) using both ACP and *E. coli*/coliform petrifilm. Reductions of *E. coli^{Rif}* on the outer fat surface (0.85 log CFU/cm^2) was greater (P < 0.01) than reduction of *E. coli^{Rif}* on the inner lean surface (0.59 log CFU/cm^2) of the clod roast. This may be due to the buffering capabilities of the lean tissue versus fat tissue. Microbial

Table 1. Effect of application method on the reduction of *E. coli*^{Rif} (log CFU/cm^2) on beef shoulder clods using 15 s dip, 10 s ESS at 6–12 inches, and 5 s spray at 6–12 inches.

	Application Method			SEM	*P*-value
	Dip	Electrostatic Spray	Spray		
E. coli/coliform Petrifilm	0.875[a]	0.466[b]	0.830[a]	0.075	< 0.001
ACP Petrifilm	0.621[a]	0.115[b]	0.608[a]	0.071	< 0.001

[a,b] Means within a row without a common superscript are significantly different

Table 2: Effect of organic acid type on the reduction in *E. coli*^{Rif} (log CFU/cm^2) on beef shoulder clods using 2.5% Beefxide™, 4.5% lactic acid, and 380 ppm peroxyacetic acid.

	Organic Acid Type			SEM	*P*-value
	Beefxide™	Lactic Acid	Peroxyacetic Acid		
E. coli/coliform Petrifilm	0.547[b]	0.863[a]	0.762[ab]	0.075	< 0.001
ACP Petrifilm	0.289[b]	0.493[ab]	0.563[ab]	0.071	< 0.05

[a,b] Means within a row without a common superscript are significantly different

samples of ground beef produced from the clod roasts showed that *E. coli*^{Rif} counts for only the spray and dip treatments were different than the inoculated control ($P < 0.001$). Additionally, ground beef *E. coli*^{Rif} counts were greater ($P < 0.001$) from roasts treated on the lean surface (3.74 log CFU/g) than roasts treated on the fat surface (3.32 log CFU/g). It is possible that the application time or the application distance used for ESS from the meat surface reduced the amount of organic acid that adhered to the surface of the clod roasts to reduce the impact of the organic acid on *E. coli*^{Rif}.

In an organic acid by application method interaction ($P < 0.001$) for L* values of ground beef, PAA Spray (LSM = 48.23) resulted in a darker colored surface area than LA spray (LSM = 49.88), BX spray (LSM = 49.91), and PAA dip (LSM = 49.96). An organic acid by application method interaction ($P < 0.01$) showed BX dip and BX spray increased in b* values (yellowness) while LA ESS decreased in b* values. As expected, L*, a*, and b* values all decreased ($P < 0.001$) with increasing days of display. Delta E values, a measure of color change, showed an organic acid by application method interaction ($P < 0.05$) but no means separation occurred after applying Tukey's adjustment. There was no organic acid type or application method effect on discoloration ($P > 0.23$). Delta E values and discoloration percentages both increased ($P < 0.001$) with increased days of display.

Total plate counts of ground beef in display exhibited an organic acid by application method interaction ($P <0.01$) showing that LA ESS had more aerobic growth than all other treatments. Total plate counts increased growth ($P < 0.001$) from day 0 (LSM = 2.03 log CFU/g) to day 7 (LSM = 4.11 log CFU/g).

Conclusions

Small meat processors can select an antimicrobial treatment to reduce the risk of STEC on the surface of beef sub-primals and in ground beef. Processors should consider either the LA or PAA organic acids as these were more effective at reducing *E. coli*^{Rif} counts on the surface of beef shoulder clods. In addition, when looking at the shelf life and color of the ground beef, a small meat processor can consider the use of any of the organic acids or application treatments as the impacts on ground beef quality as measured by L*, a*, or b* values, Delta E values, or discoloration percentages were minimal. The use of antimicrobials to minimize the risk of STEC may be applied to beef sub-primals by small meat processors without impacting the color characteristics of ground beef in retail display.

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Effect of Salt Reduction on the Quality and Shelf Life Characteristics of Deli-Style Roast Beef

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Summary with Implications

Concerns with excessive sodium intake have led to increased pressure on meat processors to reduce added salt in meat products. Quality characteristics and microbial growth were evaluated on deli-style roast beef slices formulated to contain varying concentrations of added salt. Salt concentration had no effect on microbial community composition, however increasing salt slowed microbial growth over time. Increasing salt increased cooking yield and decreased water activity. Salt reduction negatively impacts the texture, yield, and shelf life of deli-style roast beef, however salt concentrations within this range do not significantly alter spoilage flora community composition.

Introduction

Excess sodium intake has been a health concern for many years, however renewed efforts to reduce sodium in the diet have emerged recently. Much of the sodium in processed meat products is from added salt, therefore to achieve sufficient sodium reduction, added salt must be reduced. Yet, salt is essential to produce processed meats. The multi-functional properties of salt have been well documented and are necessary to provide the texture, flavor, bind, water holding capacity, and extended shelf life of processed meat. Salt can also alter the microbial composition of meat products, potentially shifting the spoilage flora toward slower growing, less detrimental groups of bacteria. Processed meats are essential in adding value to lower quality or less marketable cuts of beef, and sodium reduction is a major step in reducing the negative health stigma sometimes associated with processed meats. The objectives of this study were to determine the effects of salt reduction on the quality, textural, and shelf life properties of deli-style roast beef, and identify changes in the microbial community caused by varying salt concentrations.

Procedure

Ground and formed deli-style roast beef was produced at the UNL Loeffel Meat Laboratory using four different salt concentrations, 1.0%, 1.5%, 2.0%, and 2.5%, calculated on a meat block basis. For each treatment, a brine for 25% extension was formulated to contain the appropriate salt concentration plus 1.0% sugar and 0.35% sodium phosphates (on a meat block basis) and added water. Brine was mixed and added to 20 lbs. of ½" ground beef top round, and vacuum tumbled for 90 min. Tumbled meat was stuffed into 3.5" diameter pre-stuck fibrous casings using a vacuum stuffer, pressed, clipped, weighed, and hung on a smokehouse truck. Roast beef rolls were cooked to 160° F, chilled overnight at 35° F, and sliced the following day. Slices were vacuum packaged and stored in a covered opaque plastic container under refrigeration at 35° F for shelf life analyses. Water activity, cooking yield, and final salt concentration were analyzed on the day of slicing. The following were measured every two weeks starting on the day of slicing for 18 w of shelf life: Hardness, cohesiveness, springiness, and chewiness using texture profile analysis (TPA), pH, aerobic plate count (APC), anaerobic plate count (AnPC), and objective color (CIE L*, a*, b*). Change in color (ΔE) during storage was calculated using objective color values. For 14 w of storage time, bacterial communities were analyzed by sequencing of 16S rRNA using the Illumina MiSeq platform. Data were analyzed for interactions and main effects of salt concentration as a continuous variable, and storage time as a repeated measure, using the PROC GLIMMIX procedure of SAS. Statistical significance was determined at $P \leq 0.05$.

Results

Salt has a bacteriostatic effect in meat products, and some greater concentrations will slow or even halt bacterial growth. There was a storage time by salt concentration interaction for APC in samples ($P = 0.016$; figure 1). Aerobic bacterial growth for all treatments increased until week 8, where growth reached a plateau. At weeks 0 and 2, there was a positive linear response, where growth was increased as salt increased. From weeks 6 to 18, there was a negative response where increasing salt concentration reduced aerobic bacterial growth. Similarly, there was a storage time by salt concentration interaction for AnPC ($P = 0.020$). Anaerobic bacterial growth generally increased until around week 8 for all treatments. On weeks 4, 10, 12, 14, and 16 there was a negative linear response to salt concentration where anaerobic bacterial growth decreased as salt increased. On the remaining weeks, there was no significant salt concentration response.

The majority of vegetative cells are destroyed during the cooking process, therefore most bacteria present on the finished product is introduced during slicing or packaging. Furthermore, growth throughout storage time may be altered by packaging, ingredients, storage temperature and many other intrinsic or extrinsic factors. In the current study, family *Pseudomonadaceae* was dominant throughout storage time, regardless of salt concentration. Figure 2 shows the relative abundances of various microbial families based on salt concentration and storage time. There were no changes in the microbial flora due to salt concentration; pseudomonads dominated spoilage regardless of treatment. At week 0, *Pseudomonadaceae* relative abundance was 58.9%, increased at week 2, and remained between 84% and 99.7% of all bacteria for the remainder of storage time. The current results indicate that salt concentrations

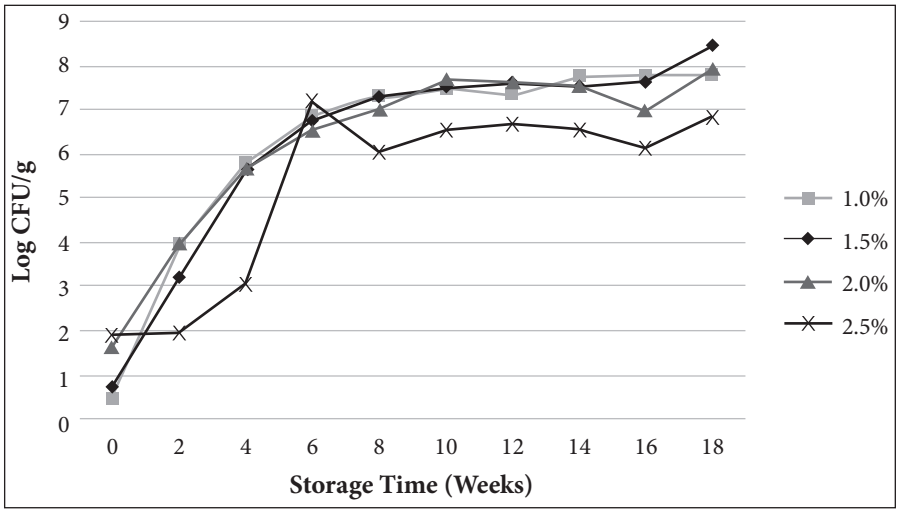

Figure 1. Interaction of salt concentration (%) and storage time on aerobic plate count in deli-style roast beef

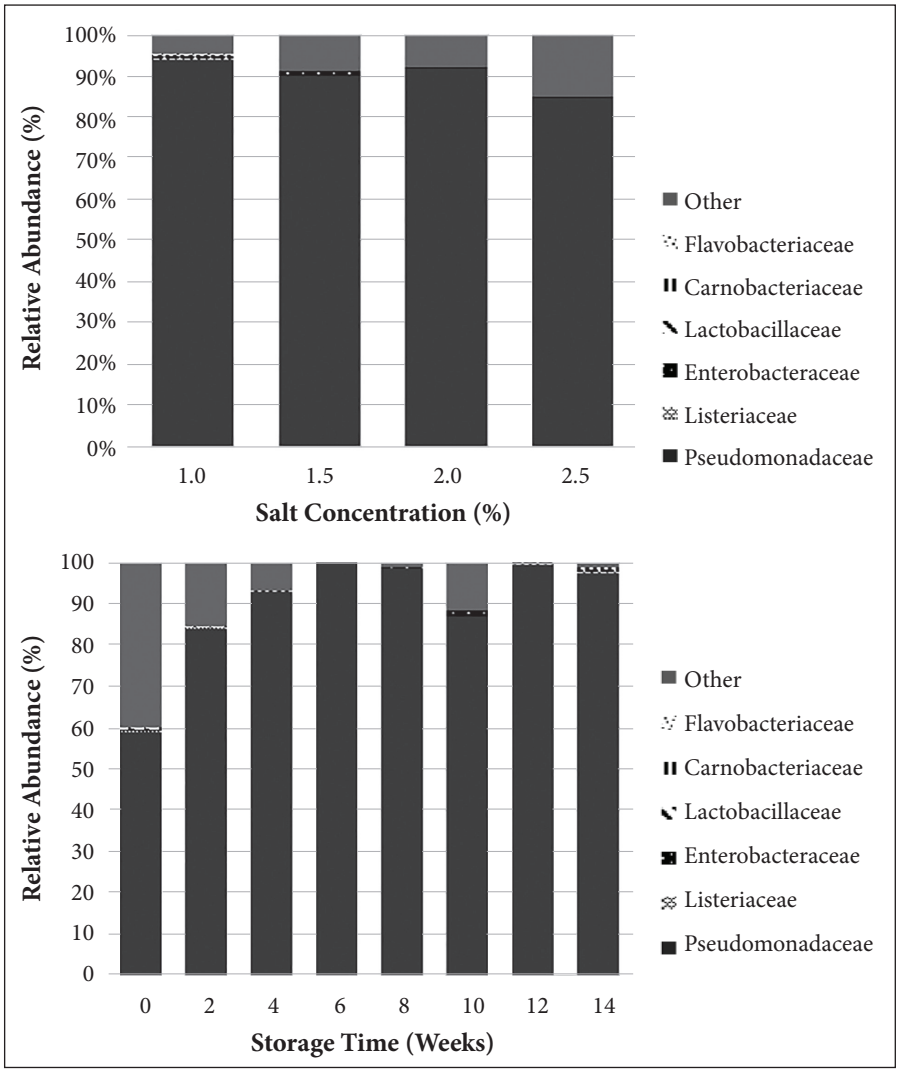

Figure 2. Relative abundances of bacterial families as affected by salt concentration and storage time in deli-style roast beef slices

within this range do not affect microbial community composition, but rather the makeup up of the initial load may have the most impact.

In processed meats, salt is responsible for protein extraction, which alters product bind and texture. Texture profile analysis (TPA) was used to instrumentally determine the texture differences caused by increasing salt concentration. Hardness showed a quadratic response to salt concentration ($P < 0.001$) where hardness decreased from 1.0% to 1.5% and 1.5% to 2.0% salt, but decreased less rapidly from 2.0% to 2.5%. Cohesiveness and springiness both displayed a linear response ($P < 0.001$ and $P = 0.002$, respectively) where cohesiveness decreased and springiness increased as salt concentration increased. Chewiness had a quadratic response, which increased greatly from 1.0% to 1.5% and 1.5% to 2.0% salt, and increased less rapidly from 2.0% to 2.5%.

Salt concentration affected objective color, having a cubic response for L* (lightness; $P = 0.034$), a quadratic response for b* (yellowness; $P < 0.001$), and a linear response for a* (redness; $P < 0.001$). Samples decreased in lightness from 1.0% to 2.0% salt, and then increased in lightness from 2.0% to 2.5%. Yellowness decreased from 1.0% to 2.0%, and increased from 2.0 to 2.5%. As salt concentration increased, redness decreased. Salt concentration did not affect ΔE (overall color change during storage time).

Throughout storage time, the growth of lactic acid bacteria results in lactic acid production, reducing meat pH. Sample pH was affected by storage time, where pH increased from week 0 to week 6, and then decreased from week 6 for the remainder of storage time. There was a cubic response on pH from salt concentration, where pH decreased from 1.0% to 1.5%, increased from 1.5% to 2.0%, and decreased again from 2.0% to 2.5%. Cooking yield displayed a cubic response ($P < 0.001$), where yield increased greatly from 1.0% to 1.5% salt, but increased at a diminishing rate from 1.5% to 2.0%, and 2.0% to 2.5%. Both water activity and measured salt concentration in the finished product showed a linear response ($P < 0.001$), where water activity decreased as salt increased, and measured salt in the finished product increased as ingoing salt concentration increased.

Table 1. Main effects of salt concentration on various quality and microbiological measurements of deli-style roast beef slices.

	Salt Concentration					P Value		
	1.0%	1.5%	2.0%	2.5%	SE	Linear	Quadratic	Cubic
Cooking Yield (%)	72.79	84.43	87.16	90.60	0.67	<0.001	<0.001	0.014
Water Activity	0.986	0.983	0.983	0.980	0.001	<0.001	0.487	0.099
Measured Salt (%)	0.78	1.06	1.36	1.68	0.04	<0.001	0.625	0.987
pH	6.06	6.00	6.05	6.03	0.03	0.715	0.288	0.026
L*	60.02	59.40	58.18	58.57	0.36	<0.001	0.031	0.034
a*	8.61	8.34	8.12	8.03	0.12	<0.001	0.277	0.836
b*	9.42	8.78	8.43	8.64	0.16	<0.001	<0.001	0.558
Color Change (ΔE)	1.76	1.43	1.54	1.41	0.24	0.185	0.524	0.339
Hardness	1917.0	1664.9	1483.1	1424.0	47.5	<0.001	0.007	0.161
Cohesiveness	0.313	0.308	0.293	0.288	0.007	0.012	0.458	0.074
Springiness	0.355	0.356	0.380	0.391	0.017	<0.001	<0.001	0.678
Chewiness	213.17	182.43	164.73	160.36	13.07	<0.001	0.970	0.211
APC (log CFU/g) [1]	6.26	6.22	6.25	5.29	0.27	—	—	—
AnPC (log CFU/g)[1]	2.77	1.41	1.90	1.12	0.61	—	—	—

[1]Indicates a significant salt concentration by storage time interaction ($P \leq 0.05$) for aerobic plate count (APC) and anaerobic plate count (AnPC), therefore main effect P values are not reported.

Conclusions

Results of this study indicate that besides reducing total bacterial growth, salt concentration between 1.0% and 2.5% has a minimal effect on microbial community composition. Furthermore, although *Pseudomonadaceae* growth is typically suppressed in cooked, vacuum packaged products, a significant initial load of pseudomonads may cause them to dominate microbial populations. Decreasing salt concentration resulted in poorer textural properties of roast beef likely related to reduced protein solubilization and cross-linking during processing and cooking. Increasing salt concentration resulted in increased cooking yield through improved moisture retention during cooking process. The negative effects of salt reduction were amplified as salt concentration was reduced. Although salt concentration had a statistically significant effect on instrumental color, differences in color values in this study are likely of little practical value. Microbial community dynamics of cooked deli meats should be further explored, especially with regard to antimicrobials or other ingredients that may have a more profound effect on microbial communities, as well as any changes in product quality caused by such ingredients.

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Perceptions of crop consultants and producers on grazing corn residue in Nebraska

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Summary with Implications

A survey was conducted to explore factors influencing corn residue grazing recommendations by crop consultants and producer practices in Nebraska. Approximately 80% of consultants recommended grazing corn residue, while 63% of producers allowed grazing. Of producers who did not graze, about 50% cited concerns related to soil compaction, inconvenience (lack of water, fencing, and land/equipment damage), and lack of access to livestock. Producers who allowed and consultants who recommended grazing were more likely to perceive that grazing residue increased subsequent grain yields. Most consultants (56.0%) and producers (43.8%) reported making decisions in regards to grazing based on their own observation. Findings from this survey can be used to design extension education and research involving the impacts of grazing corn residue on subsequent grain yield and soil attributes. Extension could also be a conduit linking cattle owners with crop producers that reported not having access to livestock for grazing.

Introduction

While crop yields, soil properties, and animal impacts due to grazing of corn residue have been assessed by research studies, consultants and producers perceptions and factors influencing producer decision to graze or not graze corn residue are still unclear. Currently, it is estimated that only 25% of Nebraska's corn residue acres are grazed. It can only be postulated that concerns of degrading soil and associated impacts on subsequent grain yield or the limited number of cows in the area to graze the residue could be some reasons for the low percentage of corn residue being grazed.

Even though corn residue is a potential forage source for grazing cattle, how the residue is used or managed post-harvest is determined by the land owner. Therefore, this survey was developed to better understand the factors influencing perceptions and behaviors of crop consultants and producers in Nebraska regarding grazing corn residue.

Procedures

Crop consultants (940) and crop producers (545) in Nebraska were surveyed. The survey had 16 questions for consultants and 14 for producers. There were some similar questions across surveys to allow for comparison between responses of consultants and producers. Online-survey software was used to create, distribute, and store data for both surveys. Surveys were distributed using an electronic mailing list of crop consultants and producers developed by University of Nebraska Extension educators. The survey was open from January 15, 2015 to February 15, 2015. The Institutional Review Board (IRB) at the University of Nebraska-Lincoln approved this study.

Results

Background Information

The survey return rate was 24.9% (234/940) for the consultant survey. Most consultants directly farmed either 0 acres (31.5%) or 1–999 acres (45.3%). Consultants indicated that the majority of their land was either irrigated by sprinkler or rain-fed. Seventy-six percent of consultants influenced 4000 or more acres. The majority of influenced acres were either sprinkler irrigated or rain-fed acres with,

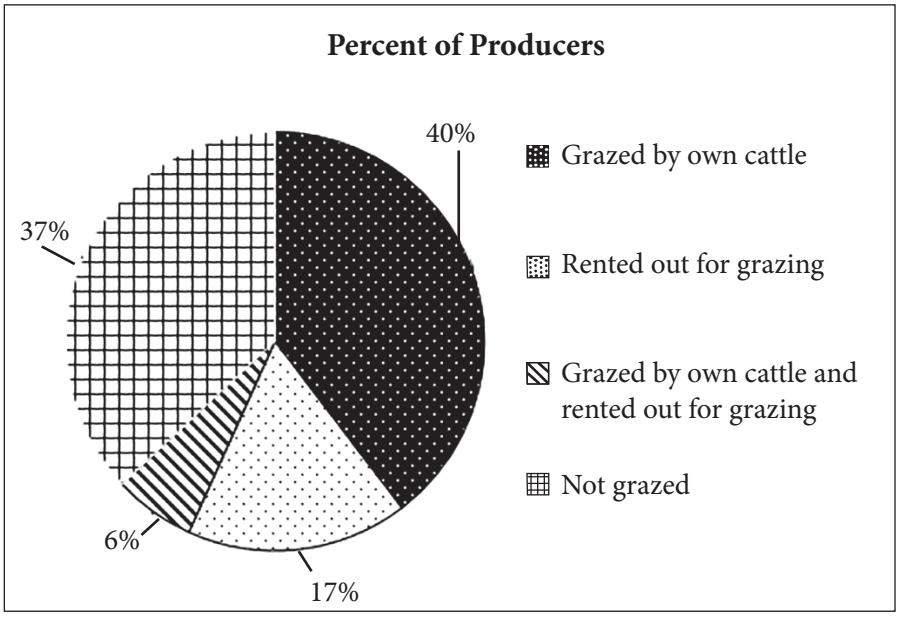

Figure 1. Percent of farmers grazing corn residue with their own livestock, renting corn residue to others or not grazing corn residue.

Table 1. Producers and consultants response to: How large of an impact does grazing cornstalks have on the yield of next year's grain crop?

Corn	Producer	Consultant
	# Responses (% of Respondents)	
Decrease yield	17 (18.5%)	38 (20.7%)
No impact	46 (50.0%)	75 (40.8%)
Increase yield	29 (31.5%)	71 (38.6%)
Soybean	Producer	Consultant
Decrease yield	17 (19.1%)	28 (15.1%)
No impact	43 (48.3%)	89 (48.1%)
Increase yield	29 (32.6%)	68 (36.8%)

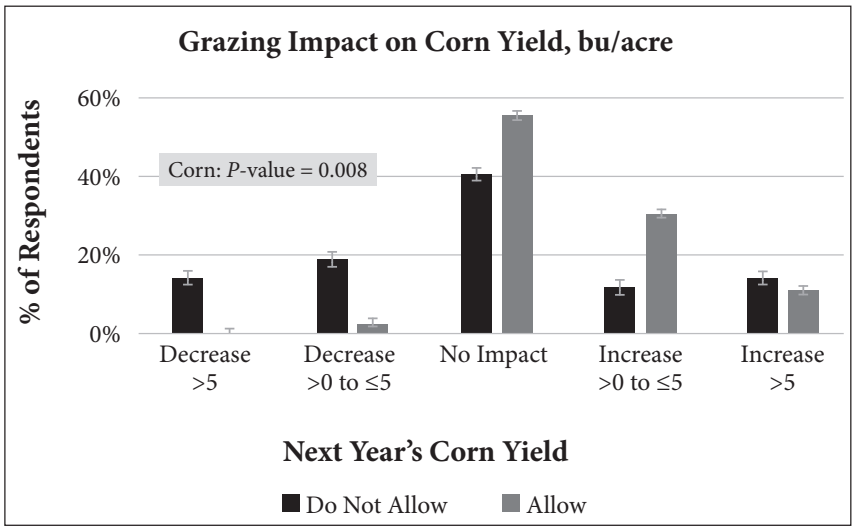

Figure 2. Producers that allowed grazing (n = 36) versus producers that didn't allow grazing (n = 42) and their thoughts on how grazing corn residue impacts the following year's corn crop yield (bu/acre).

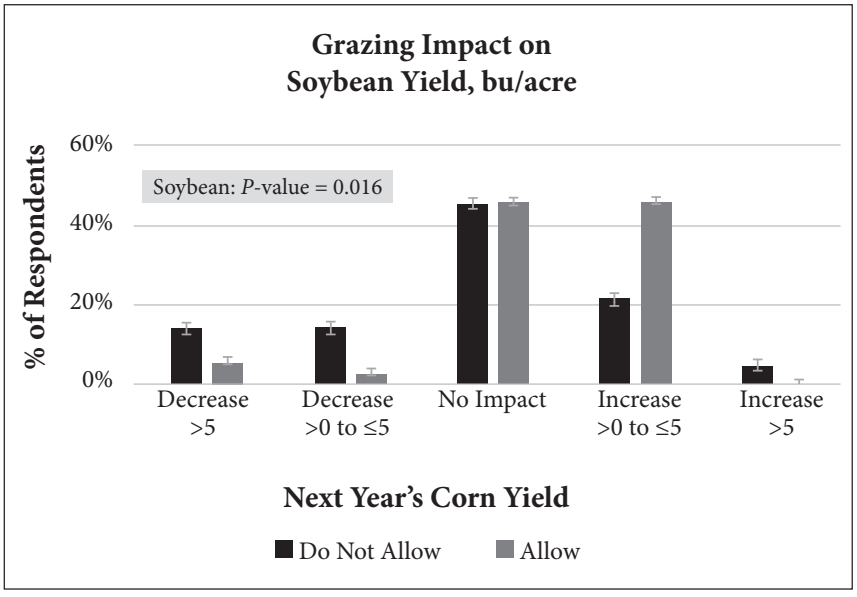

Figure 3. Producers that allowed grazing (n = 36) versus producers that didn't allow grazing (n = 42) and their thoughts on how grazing corn residue impacts the following year's soybean crop yield (bu/acre).

about 50% under no-till management. Eighty-two percent of consultants reported that they recommend clients graze corn residue with livestock.

The producer survey had a return rate of 23.9% (130/545). Forty percent of producers farmed 200–999 acres, 30.7% farmed 1000–3999 acres, and 20.2% farmed 1–199 acres, and 3.5% farmed 4000 or more acres. The majority of their land was either sprinkler irrigated or rain-fed. About 80% of producers reported utilizing a no-till farming practice. About 40% reported that corn residue was grazed by their own cattle, 17% indicated they rented their corn residue out for grazing, and 6% stated that they did both (graze their own cattle and rent out). While about 37% indicated their corn residue was not grazed (Figure 1).

Perceptions of Land Productivity/ Monetary Impact

Comparisons and frequencies were analyzed between responses indicating the perception of participants of grazing impact on yield and if they recommended or allowed grazing (Table 1). Consultants that recommended grazing corn residue and producers that allowed grazing had similar perceptions that grazing had a neutral to positive impact on subsequent grain yields (Table 1). Producers that did not allow grazing were more likely ($P = 0.008$) to reply that grazing corn residue had no impact to a slight decrease on the subsequent corn yield (bushels per acre), while producers that allowed grazing replied that grazing corn residue perceived that grazing had no impact or resulted in a slight increase on the subsequent corn yield (bushels per acre) (Figure 2). This difference was also present ($P = 0.016$) for producers perception regarding subsequent soybean yields (Figure 3) after grazing corn residue. Research suggests that grazing has no impact or may even slightly increase corn and soybean yields (2013 Nebraska Beef Cattle Report, pp 38–39; 2015 Nebraska Beef Cattle Report, pp 53–55). Based on the results from this survey, a portion of crop consultants and producers perceive decreased subsequent grain yields; even though the few published studies on corn residue grazing report grazing has neutral to positive impacts on subsequent grain yields.

Producers were also asked to address

Table 2. Comparisons between producers that currently rent out grazing and currently do not allow grazing and their perceptions on grazing rental rates.

Grazing rental fee[1]	Currently rent out for grazing (n=26), %	Currently Do Not Allow (n=50), %
Free	23.5	14.0
$1 to $15 per acre	58.8	28.0
$16 to $25 per acre	17.7	8.8
$26 to $35 per acre	0.0	4.0
> $35 per acre	0.0	6.0
Would not allow grazing regardless of rental fee	—	40.0

[1]What rental fee do you charge (currently rent) vs. what rental fee would you need (do not allow) for cattle to graze corn residue.

Table 3. Comparisons between producers who currently do not graze but would consider grazing for a fee and those that would not consider grazing regardless of the rental fee.

What are the reasons your corn residue is not grazed?[1]	Do not Allow, but would Rent for a Fee (n=30), %	Would not Allow Regardless of Rental Fee (n=20), %
Reduces subsequent year's crop yields	0.0	10.0
Negative impact on farming practice	10.0	55.0
Lack of water for livestock	26.7	40.0
Lack of fencing	10.0	30.0
Livestock producers will not pay the perceived value of stalks	30.0	25.0
Interferes with fall field work	23.3	25.0
Causes compaction	20.0	65.0
Other	60.0	30.0

[1]This question was a select all that apply so percentages will be over 100%.

corn residue rental rates (Table 2). Of the producers that currently rent out grazing, 23.5% reported not charging a rental fee, 58.8% had a rental fee rate ranging from $1 to $15 per acre, and 17.7% charged $16 to $25 per acre. Forty-two percent of producers that did not allow corn residue grazing indicated they would allow cattle to graze corn residue if offered $15 per acre or less, 18% would allow cattle to graze corn residue for $16 to $35 plus per acre, and the remaining 40% would not allow grazing regardless of the rental fee offered.

Of the producers that were currently not grazing residue, the reasons for not grazing corn residue were compared between those that would allow grazing for a rental fee with those that would not allow grazing regardless of the rental fee (Table 3). The majority of respondents that would not allow grazing regardless of rental fee indicated that they felt grazing caused compaction (65%) on their field or had a negative impact on their farming practices (tillage or planting; 55%). Sixty percent of the producers that would allow grazing for a rental fee selected "other", and based on their comments approximately 70–75% of those respondents indicated they did not have access to livestock for grazing. Consultants that did not recommend grazing indicated the following reasons were very or somewhat important: grazing had a negative impact on farming practices (73%), grazing reduces subsequent grain yields (63%), and livestock producers would not pay the perceived value of corn residue (56%).

Source of Information Regarding Grazing Corn Residue

Fifty-six percent of consultants indicated they based client recommendations regarding grazing corn residue on their "own observation", while 31.6% indicated they received information from the University of Nebraska Extension (Figure 4). Producer responses to this question were similar to consultants, with 43.8% basing their decisions regarding grazing corn residue on their "own observation", followed by 22.3% basing decisions on information received from University of Nebraska Extension. For both consultants and producers, their own observation and the University of

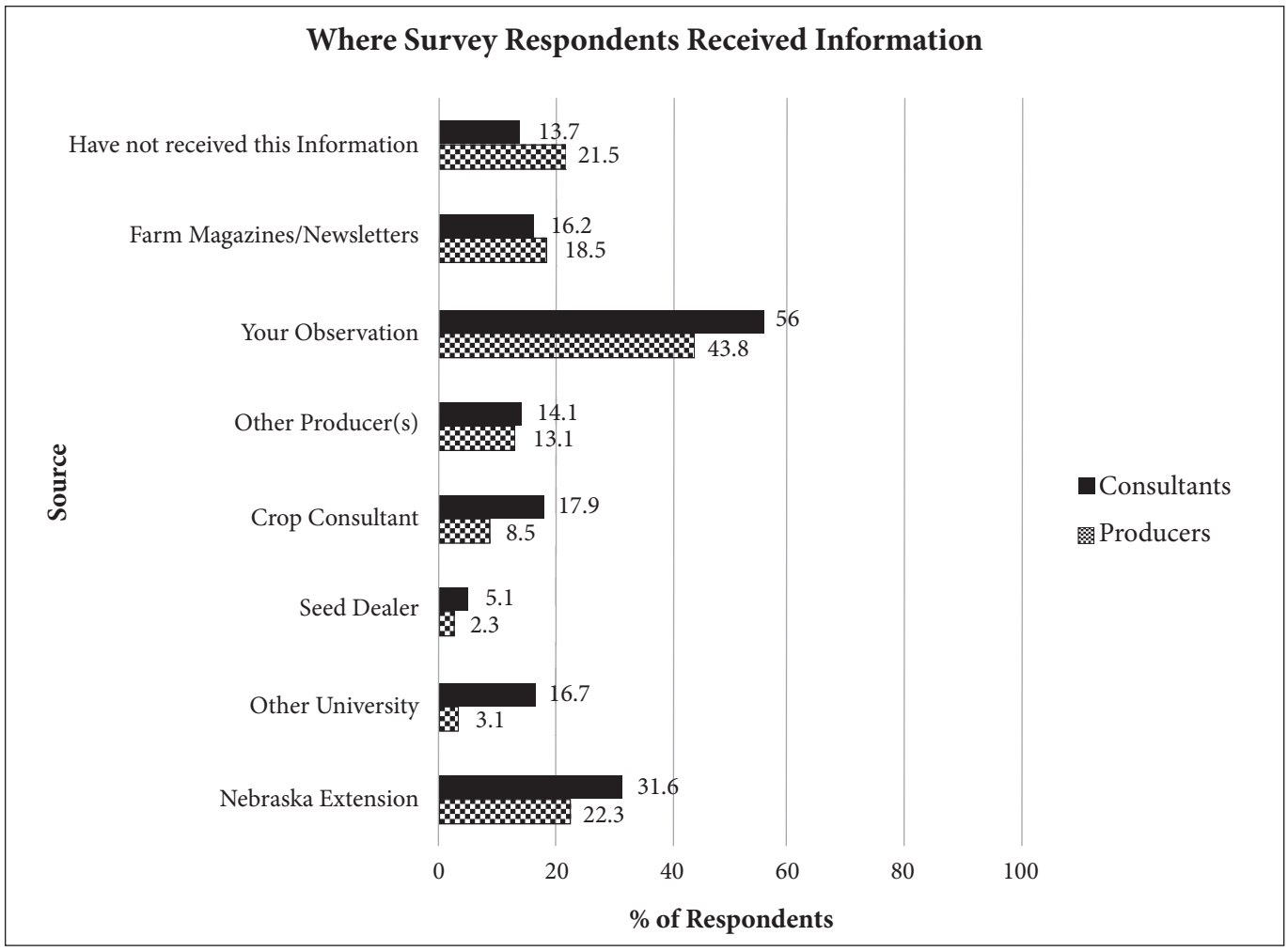

Figure 4. Where Survey Respondents Received Information.

Nebraska Extension remained the first and second choice regardless of whether they recommended/allowed grazing or did not recommend/allow grazing.

Conclusions

The purpose of the survey was to gain a better understanding of factors that influenced perceptions, attitudes, and behaviors of crop consultants and producers relative to grazing corn residue. The results indicated that the majority of consultants and producers had a neutral perception toward grazing impact on subsequent crop yields and that a large portion of consultants recommend grazing. The results also indicated that producers who did not allow grazing did so mostly because of concerns related to soil compaction, inconvenience (lack of water, fencing, and land/equipment damage), and lack of access to livestock. To our knowledge, this survey was the first to investigate factors influencing corn residue grazing recommendations of crop consultants and practices of producers.

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Statistics Used in the Nebraska Beef Report and Their Purpose

The purpose of beef cattle and beef product research at UNL 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* 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 1 to 1. Values near zero indicate a weak relationship, values near 1 indicate a strong positive relationship, and a value of 1 indicates a strong negative relationship.

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