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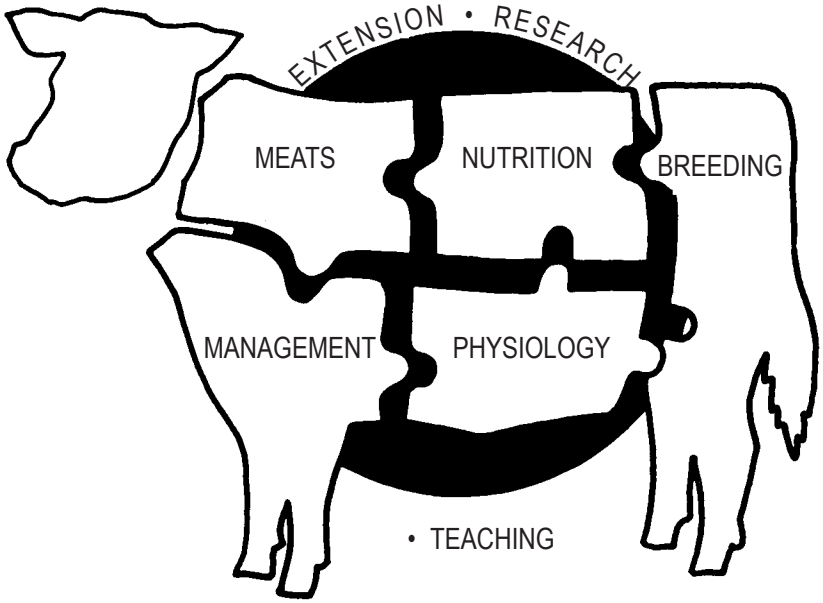

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2014 Beef Cattle Report

IANR

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Effect of Pubertal Status and Number of Estrous Cycles Prior to the Breeding Season on Pregnancy Rate in Beef Heifers

Rebecca A. Vraspir
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Rick N. Funston[1]

Summary

Three experiments were conducted to evaluate whether pubertal status and number of estrous cycles prior to breeding influences pregnancy rate in beef heifers. Pubertal heifers were heavier and older at the start of breeding and had greater AI and overall pregnancy rate than non-pubertal heifers. Second season pregnancy rate was greater for heifers reaching puberty prior to first breeding and for heifers having ≥ 2 estrous cycles prior to breeding compared with non-pubertal heifers. Pregnancy rate was greater for heifers achieving puberty prior to breeding; however, earlier onset of puberty did not significantly improve first pregnancy rates.

Introduction

Replacement heifer development can significantly impact the profitability of a beef cattle operation. Heifers that conceive early in the breeding season calve earlier and wean heavier calves, increasing longevity and productivity within the herd. Pregnancy rates have been correlated with the percentage of heifers that reach puberty before or early in the breeding season. It has been demonstrated that heifers inseminated on pubertal estrus had a decreased pregnancy rate compared with heifers inseminated on their third estrus. However, heifers inseminated on pubertal estrus were inseminated at an earlier date than heifers inseminated on the third estrus. Therefore, heifers inseminated on the pubertal estrus were younger and weighed less at breeding. Beef heifer reproductive performance has changed over time and is hypothesized to be due to genetic selection with the implementation of Expected Progeny Difference (EPD) for traits such as growth, milk, carcass characteristics, and scrotal circumference. Therefore, the objectives of this study were to determine the effect of pubertal status and the number of estrous cycles prior to breeding on pregnancy rates in beef heifers.

Procedure

All animal procedures and facilities were approved by the University of Nebraska–Lincoln Institutional Animal Care and Use Committee.

Data were collected at the West Central Research and Extension Center (WCREC), North Platte, Neb., from 2002 to 2011 (n = 1,005, Experiment 1) and Gudmundsen Sandhills Laboratory (GSL), Whitman, Neb., from 1997 to 2011 (n = 1,253, Experiment 2; n = 156, Experiment 3). Heifers at WCREC were Angus-based and synchronized with a melengestrol acetate-$PGF_{2\alpha}$ protocol (*2010 Nebraska Beef Cattle Report*, pp. 11-13) prior to AI. Approximately 10 days following AI, heifers were exposed to fertile bulls at a bull to heifer ratio of 1:50 for 60 days. Conception to AI was determined 45 days after AI by transrectal ultrasonography, and final pregnancy rate was determined via transrectal ultrasonography 45 days following removal of bulls.

Data from GSL were collected on a spring calving herd of composite Red Angus × Simmental females. Heifers were exposed to bulls for 45 days at a bull to heifer ratio of 1:25. A single injection of $PGF_{2\alpha}$ was administered i.m. to heifers 108 hours after placement with bulls. Pregnancy determination was performed via transrectal ultrasonography approximately 45 days after the breeding season.

Pubertal status was determined by evaluating progesterone concentration in two blood samples collected via coccygeal venipuncture 10 days apart prior to the breeding season for Experiments 1 and 2. The number of estrous cycles prior to the breeding season in Experiment 3 was determined via serial blood collection every 10 days beginning in early January of each year until the beginning of the breeding season (late May). Progesterone concentration >1 ng/mL was interpreted to indicate ovarian luteal activity. Heifers in Experiment 3 were further classified as non-pubertal or pubertal (0 vs. ≥ 1 estrous cycle) and as having exhibited 1 estrous cycle or greater than or equal to 2 estrous cycles, excluding heifers that had not reached puberty (1 vs. ≥ 2) prior to breeding to evaluate effects on pregnancy rate.

Statistical Analysis

The statistical model included pubertal status or number of estrous cycles prior to breeding as a fixed effect and random effects included year and treatment within year. Data were analyzed using PROC GLIMMIX of SAS (SAS Institute, Inc., Cary, N.C.). Means were separated using least significant difference (LSD). Effects of pubertal status or number of estrous cycles were considered to be significant when $P \leq 0.05$, a tendency when $P \leq 0.10$, or a trend when $P \leq 0.15$.

Results

Experiment 1

Date of birth, BW, pregnancy rate, and first calving characteristics of heifers classified by pubertal status prior to breeding are presented in Table 1. Julian birth date was similar ($P = 0.12$) for heifers that were pubertal or non-pubertal. Pubertal heifers had greater ($P < 0.01$) BW compared with non-pubertal heifers from weaning through final pregnancy diagnosis. Weaning to final pregnancy diagnosis ADG was similar

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for pubertal and non-pubertal heifers ($P = 0.62$; 1.19 vs. 1.17 ± 0.11 lb/day, respectively), providing evidence that differences in post-weaning BW were likely due to greater pre-weaning ADG for heifers that reached puberty prior to breeding. Heifers that were pubertal prior to breeding tended ($P = 0.08$) to have greater AI pregnancy rate (62 vs. 56 ± 4%) and greater ($P < 0.01$) overall pregnancy rate (94 vs. 88 ± 2%) compared with non-pubertal heifers. Days to calving was decreased ($P < 0.01$) for pubertal vs. non-pubertal heifers; however, calf birth BW did not differ ($P = 0.92$; 75 ± 1.5 lb).

Table 1. Birth date, BW, pregnancy rate, and first calf characteristics of heifers classified by pubertal status prior to breeding. (Experiment 1)[1]

	Pubertal	Non-Pubertal	SE	*P*-value
N	695	310		
Julian birth date[2], day	78.9	81.9	1.5	0.12
Weaning BW, lb	529	512	9.5	<0.01
AI BW, lb	786	768	26.6	<0.01
AI pregnancy rate, %	61.9	55.5	3.7	0.08
Overall pregnancy diagnosis BW, lb	932	916	18.2	<0.01
Overall pregnancy rate, %	94.2	87.7	1.9	<0.01
Days to calving[3], day	284	288	2.0	<0.01
Calve within first 21 days[4], %	77.8	66.2	5.1	<0.01

[1]Performed at the West Central Research and Extension Center (WCREC), North Platte, Neb.
[2]Birth date was known for only a subset of heifers (n = 360).
[3]Days from start of breeding season to calving.
[4]Calved within the first 21 days of the calving season; day 1 refers to the day the first calf is born.

Experiment 2

Date of birth, BW, ADG, pregnancy rate, and first calf characteristics of heifers classified by pubertal status prior to breeding are presented in Table 2. Heifers that were pubertal prior to breeding were born approximately four days earlier ($P < 0.01$) than non-pubertal heifers.

Heifer birth BW did not differ ($P = 0.28$) between groups. However, pubertal heifers had greater ($P < 0.01$) weaning and pre-breeding BW, and tended ($P = 0.08$) to be heavier at pregnancy diagnosis than non-pubertal heifers. Heifers that were pubertal prior to breeding had greater ($P < 0.01$) ADG from birth to weaning. Heifers that did not reach puberty prior to breeding tended ($P = 0.09$) to have greater ADG from weaning to pre-breeding and had greater ($P < 0.01$) ADG from breeding to pregnancy diagnosis. The greater ADG from weaning to pregnancy diagnosis by non-pubertal heifers resulted in a similar ($P = 0.41$) BW at pre-calving.

Pregnancy rate was greater ($P < 0.01$) for pubertal heifers vs. non-pubertal heifers (90 vs. 84 ± 2%, respectively). A greater ($P < 0.01$) proportion of pubertal heifers calved within the first 21 days of the calving season compared with heifers classified as non-pubertal prior to breeding. Date of calving was five days earlier for heifers that were pubertal prior to breeding, and their calves were heavier ($P < 0.01$) at birth and were heavier and older ($P < 0.05$) at weaning than calves from heifers that were not pubertal prior to breeding. At weaning, there was no difference (P > 0.90) in BW (699 ± 18.5 lb) and BCS (5.1 ± 0.1) between first-calf heifers classified as pubertal or non-pubertal before start of breeding as heifers. Second season pregnancy rate was also similar ($P = 0.65$) between groups.

Table 2. Birth date, BW, ADG, pregnancy rate, and first calf characteristics of heifers classified by pubertal status prior to breeding. (Experiment 2)[1]

	Pubertal	Non-Pubertal	SE	*P*-value
N	752	491		
Julian birth date, day	83.9	87.8	4.8	<0.01
Born first 21 days[2], %	63.8	49.7	5.9	<0.01
Birth BW, lb	77	78	1.4	0.28
Weaning BW, lb	461	445	6.7	<0.01
Birth to weaning ADG, lb	1.74	1.70	0.08	<0.01
Pre-breeding age, day	428	424	2.9	<0.01
Pre-breed BW, lb	665	649	9.6	<0.01
Pre-breed ADG, lb	0.99	1.01	0.07	0.09
Pregnancy diagnosis BW, lb	812	805	9.6	0.08
Breeding to pregnancy diagnosis ADG, lb	1.40	1.49	0.1	<0.01
Pregnancy rate, %	90.0	82.4	2.0	<0.01
Pre-calving BW, lb	933	928	15.7	0.41
Calve within first 21 days[3], %	79.1	67.0	4.3	<0.01
Calf Julian birth date, day	75	80	4.9	<0.01
Calf birth BW, lb	72	70	1.0	<0.01
Calf weaning BW, lb	413	391	12.0	<0.01
Calf weaning age, days	181	177	3.8	0.05
Cow BW at weaning, lb	920	920	18.6	0.99
Cow BCS at weaning	5.1	5.1	0.1	0.91
Second pregnancy rate, %	89.8	91.2	3.1	0.65

[1]Performed at Gudmundsen Sandhills Laboratory (GSL), Whitman, Neb.
[2]Born within the first 21 days of calving season, day 1 is the day the first calf is born.
[3]Calved within the first 21 days of the calving season; day 1 is the day the first calf is born.

Experiment 3

Date of birth, BW, ADG, pregnancy rate, and first calf characteristics are presented in Table 3 for heifers classified by number of estrous cycles prior to the breeding season. Heifers had similar ($P = 0.34$) birth BW regardless of number of estrous cycles prior to breeding. There was a trend ($P = 0.12$) for heifers that had three estrous cycles prior to the breeding season to be born earlier and a tendency ($P = 0.10$) to have greater

Table 3. Birth date, BW, ADG, pregnancy rate, and first calf characteristics of heifers classified by number of estrous cycles prior to breeding. (Experiment 3)[1]

	0	1	2	3	≥4	SE	*P*-value
N	25	16	22	27	66	156	
Julian birth date, day	85.3	85.9	85.8	78.2	84.0	3.1	0.12
Born first 21days[2], %	67.8	80.8	73.1	93.0	78.7	9.3	0.24
Birth BW, lb	79	75	75	80	78	2.9	0.34
Weaning BW, lb	489	494	507	524	504	16.9	0.10
Age at puberty, days	—	409[a]	394[ab]	379[b]	324[c]	6.3	<0.01
Puberty BW, lb	—	697[a]	713[a]	695[a]	573[b]	30.1	<0.01
Wean to puberty ADG, lb/day	—	1.08a	1.09[a]	1.09[a]	0.61[b]	0.1	<0.01
Pre-breed BW, lb	830	844	865	895	848	38.3	0.16
Pregnancy diagnosis BW, lb	797	804	807	837	802	29.1	0.27
Pregnancy rate, %	68.0	81.3	86.4	92.6	81.8	9.4	0.15
Wean to pregnancy diagnosis ADG, lb/day	1.06	1.07	1.05	1.09	1.04	0.09	0.79
Puberty to pregnancy diagnosis ADG, lb	—	1.14[a]	0.83[b]	1.09[ab]	1.26[a]	0.19	<0.01
Pre-calving BW, lb	939	939	972	1004	958	35.4	0.10
Calve within first 21days[3], %	65.3	83.6	87.6	82.7	75.1	14.2	0.47
Calf Julian birth date, day	72.5	66.9	63.4	67.8	68.8	4.5	0.20
Calf birth BW, lb	67.7	67.2	68.8	70.3	69.5	3.1	0.78
Second pregnancy rate, %	79.5[b]	87.2[ab]	100.0[a]	97.0[a]	97.9[a]	8.0	0.03

[a-c]Means without a common superscript differ (P ≤ 0.05).
[1]Performed at Gudmundsen Sandhills Laboratory (GSL), Whitman, Neb.
[2]Born within the first 21 days of calving season, day 1 is the day the first calf is born.
[3]Calved within the first 21 days of the calving season; day 1 is the day the first calf is born.

weaning BW compared with heifers that exhibited estrus ≤ 2 and ≥ 4 times.

Heifers exhibiting ≥ 4 estrous cycles were younger ($P < 0.01$; 409, 394, 379, 324 ± 6.3 days, for 1, 2, 3, and ≥ 4 estrous cycle groups, respectively) and had reduced ($P < 0.01$) BW at puberty than heifers exhibiting estrus ≤ 3 times. Heifers that exhibited ≤ 3 estrous cycles had similar ($P \geq 0.92$) BW at puberty.

There was a trend ($P = 0.15$) for pregnancy rate to increase with the number of estrous cycles exhibited prior to breeding. Heifers that were pubertal prior to breeding had greater ($P = 0.05$; 85 vs. 68 ± 8%) pregnancy rate than non-pubertal heifers. Pregnancy rate did not differ for heifers having one estrous cycle compared with heifers having ≥ 2 estrous cycles prior to breeding ($P = 0.68$; 81 vs. 85 ± 9% for 1 and ≥ 2, respectively). In contrast, Byerley et al. (*Journal of Animal Science*, 1987, 65:645-650) reported pregnancy rate was decreased 21 percentage points for heifers inseminated at pubertal estrus compared with third estrus. In the current study, heifers were placed with bulls or AI on a common date resulting in similar age at breeding, whereas date of insemination in Byerley et al. (*Journal of Animal Science*, 1987, 65:645-650) was earlier for heifers at pubertal estrus compared with heifers inseminated on third estrus, resulting in heifers inseminated on first estrus being approximately 50 days younger at breeding.

Heifers that were pubertal prior to the first breeding season had a greater ($P < 0.01$) second season pregnancy rate than heifers that were non-pubertal prior to the first breeding season (97 vs. 80 ± 7%). Second season pregnancy rate was greater ($P = 0.03$) for heifers having ≥ 2 estrous cycles prior to the first breeding season than heifers having ≤ 1 estrous cycle; however, heifers that had 0 or 1 estrous cycle had similar ($P = 0.81$) second season pregnancy rates (80, 87, 100, 97, and 98 ± 8% for 0, 1, 2, 3, and ≥ 4 estrous cycle groups, respectively). Heifers with ≥ 2 estrous cycles prior to the first breeding season also tended ($P = 0.08$) to have a greater second season pregnancy rate compared with heifers that had 1 estrous cycle (98 vs. 88 ± 6% for ≥ 2 and 1 estrous cycles, respectively). Therefore, it is recommended to develop heifers to reach puberty and allow for at least one estrous cycle prior to the breeding season to optimize heifer pregnancy rates; however, multiple estrous cycles prior to breeding did not significantly improve subsequent pregnancy rates.

[1]Rebecca A. Vraspir, graduate student; Adam F. Summer, post doctoral scientist, University of Nebraska–Lincoln (UNL) West Central Research and Extension Center, North Platte, Neb.; Andy J. Roberts, USDA-ARS, Miles City, Mont.; Rick N. Funston, professor, UNL West Central Research and Extension Center, North Platte, Neb.

Comparison of Long-term Progestin-Based Synchronization Protocols on Fixed-time AI Pregnancy Rate in Beef Heifers

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Summary

Yearling Angus heifers at a commercial ranch in the Nebraska Sandhills were randomly assigned to one of two progestin-based fixed-time AI protocols (MGA or 14-day CIDR) to compare pregnancy rates. Heifers had similar fixed-time AI pregnancy rates between MGA and 14-day CIDR. A similar proportion of MGA and 14-day CIDR heifers displayed a second estrus; however, heifers previously synchronized with MGA tended to have a greater second AI pregnancy rate. Overall pregnancy rate was similar between MGA and 14-day CIDR treatments. The MGA system was the more cost effective synchronization protocol in this study.

Introduction

Yearling beef heifers are the future of the cowherd and their lifetime reproductive success is dependent on conceiving early in the first and subsequent breeding seasons. Heifers that conceive early in the breeding season and calve within the first 21days of the calving season have increased lifetime reproductive performance and produce progeny with greater overall productivity than those born later in the calving season (*2012 Nebraska Beef Cattle Report*, pp. 18-19). Estrous synchronization and AI are reproductive procedures that can produce a greater proportion of heifers that reach puberty and achieve pregnancy early in the breeding season. Fixed-time AI (FTAI) protocols can reduce time and labor by eliminating estrus detection and minimizing the number of times heifers are handled. Progestin-based estrous synchronization, such as those utilizing melengestrol actetate (MGA) and controlled internal drug release (CIDR), have been documented to induce estrous cyclicity in heifers failing to reach puberty prior to administration. Therefore, the objectives of this study were to evaluate the pregnancy rates and compare monetary costs of MGA and 14-day CIDR FTAI protocols in beef heifers.

Procedure

The University of Nebraska–Lincoln Institutional Animal Care and Use Committee approved the procedures and facilities used in this experiment.

Heifers and Diet

Nulliparous, predominately Angus, yearling beef heifers (n = 1,385) purchased from livestock auctions in Nebraska and South Dakota were utilized in this study, which took place on a commercial ranch in the Nebraska Sandhills. Upon arrival, heifers were vaccinated with Express® 3 FP3 VL3 and de-wormed with SafeGuard. Pelvic area was measured and the presence of a significant ovarian structure (follicle and/or corpus luteum) was identified via rectal palpation by a single technician. Heifers with a small pelvic area or underdeveloped reproductive tract, and any freemartins were culled (n = 15). Heifer average BW was 725 lb at assignment to treatment. Prior to estrous synchronization treatment, heifers were placed in a drylot and offered 15.7 lb/day DM of a diet containing wet distillers grains plus solubles (26.9% DM), mixed hay (66.9% DM), and a supplement (6.2% DM) during a 14-day adaptation period. After heifers were assigned to treatment groups, they were offered 19 lb/day DM of the same diet (Table 1).

Table 1. Composition and nutrient analysis of drylot diet fed to heifers[1]

Item	% DM
Wet distillers grain	26.9
Mixed hay	66.9
Supplement[2]	6.2
Diet nutrient analysis, %	
CP	15.7
TDN	65.3
Fat	4.8

[1]Nutrient analysis performed by Cattlemen's Nutrition Services, LLC (Lincoln, Neb.).
[2]Supplement included 10.0% dried distillers grain plus solubles, 48.8% wheat middlings, 39.9% vitamins and minerals, 0.9% urea, 0.4 % trace mineral premix, and 200 mg·heifer^{-1}·d^{-1} Rumensin.

Treatments

Heifers from varying sources were randomly subdivided into four groups, and each group was randomly assigned to one of two treatments (Figure 1): MGA (n = 688) or 14-day CIDR (n = 697). Heifers assigned to MGA received melengestrol acetate (0.5 mg·heifer^{-1}·d^{-1}) from day 0 through 13, were administered $PGF_{2\alpha}$ (25 mg i.m.) 19 days after MGA withdrawal (day 32), and AI approximately 72 hours after $PGF_{2\alpha}$ (day 35). Heifers assigned to 14-days CIDR received an Eazi-Breed CIDR insert (1.38 g progesterone) from day 2 to 16, followed by administration of $PGF_{2\alpha}$ 16 days after CIDR removal (day 32) and AI approximately 66 hours after $PGF_{2\alpha}$ (day 35). Both treatment groups received GnRH (100 µg i.m.) at FTAI.

Artificial Insemination, Natural Service, and Pregnancy Diagnosis

Heifers were inseminated by 10 AI technicians using semen from a single

Table 2. Reproductive measurements prior to treatment and effect of controlled internal drug release (14-day CIDR) and melengestrol acetate (MGA) synchronization systems on pregnancy rates.

	Treatment			
Item	MGA[1]	14-day CIDR[2]	SEM	*P*-value
n	688	697		
Significant structure,[3] %	99	97	1	0.08
Pelvic area, cm^2	159	157	1	0.50
Fixed-time AI pregnancy rate,[4] %	62	61	2	0.56
Heifers receiving second AI, %	26	26	2	0.83
Second AI pregnancy rate,[5] %	66	56	4	0.06
Natural service pregnancy rate,[6] %	66	65	4	0.85
Final pregnancy rate,[6] %	93	90	1	0.27

[1]Received MGA day 0 to 13, followed by $PGF_{2\alpha}$ day 32, GnRH was administered at fixed time-AI, approximately 72 hours after $PGF_{2\alpha}$ (day 35).
[2]Received CIDR day 2 to 16, followed by $PGF_{2\alpha}$ day 32, GnRH was administered at fixed time-AI, approximately 66 hours after $PGF_{2\alpha}$ (day 35).
[3]Presence of a palpable follicle and/or corpus luteum.
[4]Determined via transrectal ultrasound 45 days following FTAI.
[5]Determined via transrectal ultrasound approximately 50 days following second AI.
[6]Determined via transrectal ultrasound 36 days following bull removal.

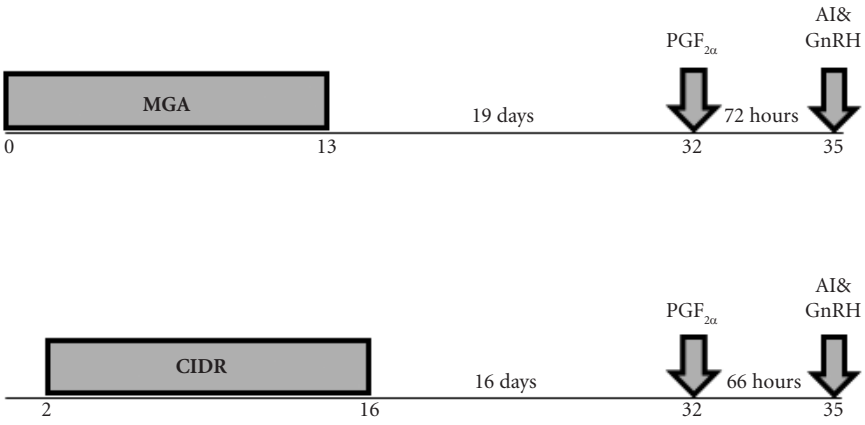

Figure 1. Treatment schedule for heifers assigned to MGA (n = 688) or 14-days CIDR (n = 697); MGA = melengestrol acetate, CIDR = controlled internal drug release, $PGF_{2\alpha}$ = prostaglandin, GnRH = gonadotropin releasing hormone.

bull to reduce variation in pregnancy rates due to semen quality. Following FTAI, heifers remained in the drylot and were observed twice daily for signs of estrus from day 15 to 25. Heifers observed in estrus were AI 12-18 hours later and placed on summer pasture. Heifers not observed in estrus remained in the drylot until pregnancy diagnosis 45 days after FTAI via transrectal ultrasonography. Bulls were placed with heifers approximately 32 days after FTAI for 50 days with a bull to heifer ratio of 1:25. Repeat AI heifers were examined for pregnancy approximately 50 days after second AI. Diagnosis of natural service pregnancy occurred approximately 36 days following removal of bulls.

Economic Analysis

A partial budget analysis was conducted using the procedure by Feuz (*Journal of the American Society of Farm Managers and Rural Appraisers*, 1992, 56(1): 61-66). The budget analysis was evaluated for the FTAI, second AI, and overall pregnancy. Costs associated with each treatment (MGA, CIDR, and additional pharmaceuticals) were derived from the Estrus Synchronization Planner (Beef Reproduction Task Force, 2011); semen and labor costs were based on actual costs. The value of the heifers at the beginning of the study (purchase value) and at pregnancy diagnosis (cull value) was calculated from the Nebraska and South Dakota average price reported by the USDA Agricultural Marketing Service (2012) for each corresponding date. Total breeding costs included progestin source, pharmaceuticals, semen, and labor cost per heifer. Total treatment cost per heifer was calculated by adding the purchase price and total breeding cost. The net cost of 1 pregnant heifer was calculated as the difference between total treatment cost per heifer and cull value, divided by pregnancy rate.

Statistical Analysis

The statistical model included estrous synchronization protocol as the fixed effect. Heifer origin and AI technician were included as random variables. Continuous and binomial data were analyzed using the MIXED and GLIMMIX procedure of SAS (SAS Institute, Inc., Cary, N.C.) 9.2, respectively. Means were separated by LSD, and declared different at $P \leq 0.05$.

Results

Pregnancy Rates

Fixed-time AI pregnancy rates did not differ ($P = 0.56$) between MGA and 14-day CIDR (62 vs. 61 ± 2%, respectively; Table 2). These FTAI pregnancy rates were similar to those reported by Busch et al. (*Journal of Animal Science*, 2007, 85:1933-1939) when comparing a 14-day CIDR to a 7-day CIDR (CIDR Select vs. CO-Synch + CIDR). The final pregnancy rates in this study ranged from 47 to 62% across three locations, with the 14-day CIDR consistently yielding greater pregnancy rates.

Second AI occurred 15 to 25 days following FTAI. Throughout this

(Continued on next page)

period a similar number of heifers from each treatment ($P = 0.83$) were observed in estrus and AI; however, heifers previously synchronized with MGA tended ($P = 0.06$) to have greater second AI conception rate (66 vs. 56% ± 2% for MGA and CIDR, respectively).

Natural service pregnancy rate (66 vs. 65 ± 4%) and overall pregnancy rate (93 vs. 90 ± 1%) were similar ($P > 0.27$) between the MGA and 14-day CIDR groups, respectively. Similar pregnancy rates have been reported in heifers when comparing 14-day progestin-based synchronization protocols (MGA and CIDR), with a period of estrus detection. Similar pregnancy rates were reported when comparing MGA and 14-day CIDR in heifers detected for estrus for 60 hours and AI 12 hours later, followed by a clean-up FTAI at 72 hours for heifers not detected in estrus (66% MGA vs. 62% CIDR; *Theriogenology*, 2007, 68:162-167) and when utilizing estrus detection for 144 hours and AI 12 hours later (43 to 54% MGA vs. 49 to 53% CIDR; *Journal of Animal Science*, 2010, 88: 3568-3578). From the present study it appears FTAI has the capability to yield similar pregnancy rates when compared with estrus detection and AI utilizing similar synchronization protocols.

Economic Analysis

When comparing MGA or 14-day CIDR utilizing strictly FTAI, the MGA estrous synchronization protocol resulted in approximately a $15 decrease in cost per pregnant heifer. This can be attributed mostly to the difference in breeding cost and partially to the number of cull heifers. Comparing overall costs for each synchronization method (FTAI and second AI), the MGA system cost approximately $19 less to produce a pregnant heifer compared with 14-day CIDR, primarily due to differences in breeding costs between treatments. Therefore, it was more cost effective to synchronize with MGA, which resulted in similar pregnancy rates compared with 14-day CIDR.

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Androgen Excess in Beef Cows Results in Altered Theca Cell Gene Expression and Fertility

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Summary

Within the University of Nebraska–Lincoln physiology herd, two sub-populations of cows with different concentrations of androstenedione have been identified. Androstenedione is a precursor for estradiol production, and androstenedione concentration is increased 24.5-fold in the high androstenedione cows. Our objective was to determine the cause of increased androstenedione production in high androstenedione cows and the effects on theca cell and oocyte gene expression. High androstenedione cows had increased steroidogenic enzyme abundance in theca cells and altered oocyte mRNA abundance. Increased androgen production in high androstenedione cows is associated with altered gene expression and/or mRNA stability during oocyte growth and maturation, which may reduce fertility.

Introduction

Profitability is directly related to the ability of a cow to maintain a 365-day calving interval and wean a marketable calf each year. Consequently, the main reason cows are removed from the production herd is the inability to maintain pregnancy. Early embryonic mortality results in loss of 20 to 44% of pregnancies in beef cattle. Thus, development of tools or markers to help predict fertility in beef cattle could decrease the number of low fertility heifers developed and placed in the herd. Many factors can impact fertility, including follicle quality and ovarian environment.

Steroidogenesis, or the conversion of cholesterol to estradiol (E2), occurs within the theca and granulosa cells of the ovarian follicle through actions mediated by specific steroidogenic enzymes. Previous studies have reported altered steroidogenic enzyme expression, which results in increased androgen hormone production, leads to increased androstenedione (A4) production and reduced fertility in women (polycystic ovary syndrome; PCOS). Differential production of A4 in sub-populations within the UNL physiology herd has been previously reported (*2012 Nebraska Beef Cattle Report*, pp. 28-29). The objective of this study was to identify differences in mRNA abundance of theca steroidogenic enzymes and oocyte maternal effect genes collected from these two cow sub-populations.

Procedure

All procedures were approved by the University of Nebraska–Lincoln Institutional Animal Care and Use Committee. Non-lactating, composite [25% MARC III (¼ Angus, ¼ Hereford, ¼ Pinzgauer, ¼ Red Poll) and 75% Red Angus] beef cows from the beef physiology herd at the University of Nebraska Agricultural Research and Development Center (ARDC), near Mead, Neb., were used in this study.

Estrus was synchronized in (n = 64) utilizing a Co-Synch + CIDR protocol for timed artificial insemination, with ovariectomy performed after. Cows received a single injection (100 μg/cow; i.m.) of GnRH (Cystorelin, Merial Limited, Duluth, Ga.) on treatment day 0 to induce ovulation and, thus, initiate a new follicular wave. Also on day 0, an intravaginal insert [controlled internal drug release device (CIDR), Zoetis, Florham Park, N.J.] containing 1.38 g of progesterone (P4) was inserted. Approximately 84 hours prior to ovariectomy, cows were transported to the UNL Animal Science building for holding and surgery. The CIDR was removed on day 7 and cows received a single injection (25 mg/cow; i.m.) of prostaglandin $F_{2\alpha}$ ($PGF_{2\alpha}$; ProstaMate, AgriLabs, St. Joseph, Mo.). Thirty-six hours after CIDR removal and $PGF_{2\alpha}$ administration, ovaries were removed via right flank laparotomy. Following removal, ovaries were measured and dominant follicles collected. Follicular fluid was aspirated from these follicles, the cumulus-oocyte complex (COC) was retrieved, and the theca cells were removed via microdissection.

Follicular fluid E2 and P4 concentrations were determined by radioimmunoassay (RIA). Follicular fluid A4 and dehydroepiandrosterone (DHEA) concentrations were determined utilizing a human A4 ELISA kit (Alpha Diagnostics International, San Antonio, Tex.) and DHEA ELISA kit (Fitzgerald Industries International, Acton, Mass.), respectively. Follicles determined to be E2 active (E2:P4 ratio > 1) were utilized for data analysis. Cows were classified as high A4 (HIGH A4) or low A4 (LOW A4) based on follicular fluid A4 concentration (HIGH A4 > 40 ng/mL; LOW A4 < 20 ng/mL). Total RNA was extracted from theca cells and COCs for quantitative RT-PCR to evaluate mRNA abundance for steroidogenic enzymes, vascular endothelial growth factor A (*VEGFA*) receptors and isoforms, and maternal effect genes.

Primers were also designed for the constitutively expressed mRNAs, glyceraldehyde-3-phosphate dehydrogenase (*GAPDH*), ribosomal protein L 15 (*RPL-15*), and ribosomal protein L 19 (*RPL-19*). The stability of the constitutively expressed mRNAs was

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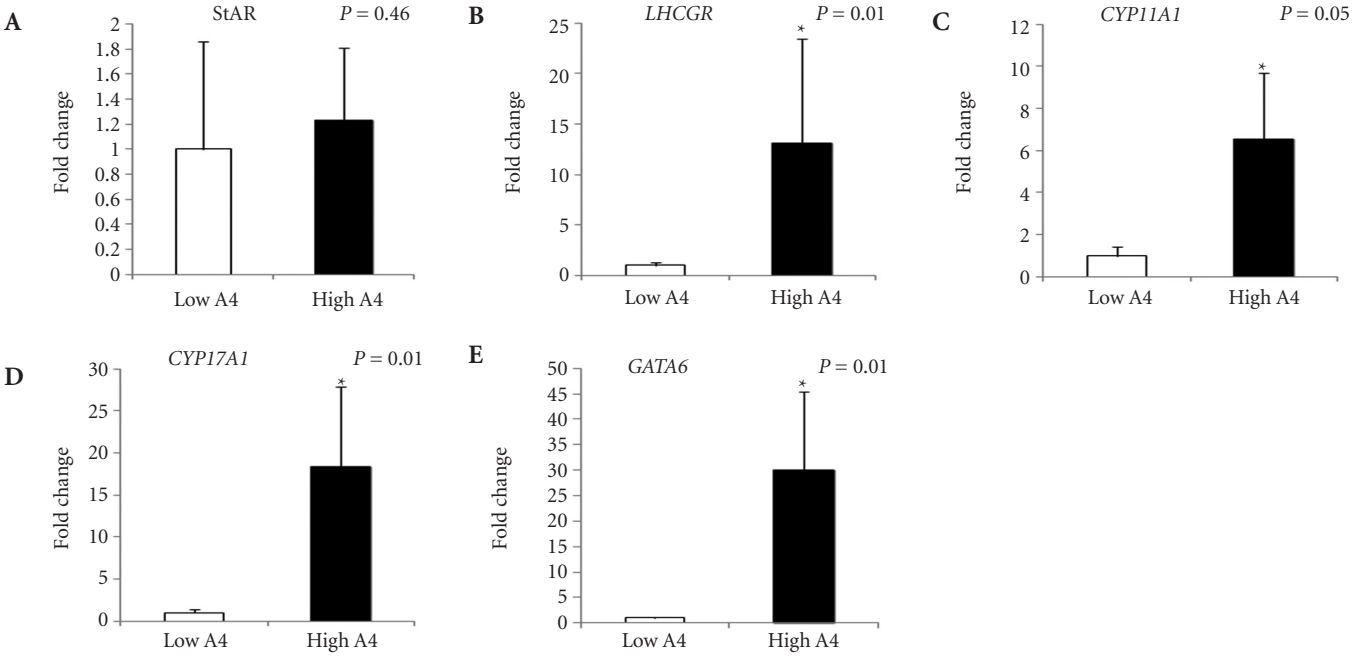

Figure 1. HIGH A4 Cows have increased steroidogenic gene expression. Quantitative RT-PCR results for steroid acute regulatory protein (*StAR*; A), luteinizing hormone/choriogonadotropin receptor (*LHCGR;* B), cholesterol side chain cleavage enzyme (*CYP11A1;* C), 17α-hydroxylase/17,20 lyase (*CYP17A1; D*), and transcription factor *GATA6* (E) in theca cells from dominant follicles of HIGH and LOW A4 cows. The geometric mean of *GAPDH* and *RPL-15* was used as an endogenous control to account for differences in starting material. Data for *CYP11A1*, *CYP17A1*, *LHCRG*, and *GATA6* were log transformed to meet normal distribution assumptions. Graphs were represented as a fold change with LOW A4 set as control (1). The mean ± SEM normalized values are presented from LOW A4 n ≥ 12 and HIGH A4 n ≥ 19. A $P \leq 0.05$ was considered significant.

calculated using Normfinder and based on this analysis, candidate gene mRNA abundance was normalized using the geometric mean of *GAPDH* and *RPL-15*. The resulting normalized data for each candidate mRNA was then compared to the mean normalized mRNA abundance in LOW A4 samples and expressed as a fold change.

Ovariectomies were performed over a 5-year period with approximately 10 to 14 cows ovariectomized during each replicate. Thus each surgery period was considered a replicate and animal was considered the experimental unit. Data were analyzed utilizing the MIXED procedure of SAS (SAS Institute, Inc., Cary, N.C.) with A4 classification considered the main effect and replicate a random effect. The original model included A4 classification and age as fixed effects with replicate as the random effect. Age was not significant, and thus was removed from the model. Data were log transformed where appropriate to meet normal distribution assumptions. A P-value ≤ 0.05 was considered significant.

Results

Concentrations of E2 in the follicular fluid tended ($P = 0.07$) to be greater for HIGH A4 compared with LOW A4 cows. However, there was no difference ($P = 0.15$) in P4 concentration based on A4 classification. Concentration of DHEA (a precursor of A4) was 2.7-times greater ($P < 0.0003$) in the follicular fluid of HIGH A4 cows compared with LOW A4 cows. Similarly, A4 concentration was approximately 19-times greater ($P < 0.01$) in the follicular fluid of HIGH A4 cows. Although the ratio of E2:A4 was 12.4 times greater ($P < 0.01$) for LOW A4 cows, the ratio of A4:P4 was greater ($P < 0.01$) in the HIGH A4 cows.

Theca cells are important in the regulation of steroidogenesis in the ovary. Steroidogenic enzyme gene expression, LH receptor (*LHCGR*), and growth factors regulating angiogenesis were analyzed. Binding of steroid acute regulatory protein (*StAR*) to the mitochondrial membrane resulting in cholesterol binding sites is the rate limiting step in steroidogenesis and is required to transport cholesterol into the mitochondria. There was no difference in *StAR* ($P = 0.46$, Figure 1A) mRNA expression between HIGH A4 cows and LOW A4. However, *LHCGR* ($P = 0.01$; Figure 1B) mRNA expression was increased 13.1-fold in theca cells of cows. *CYP11A1*, which is responsible for the conversion of cholesterol to pregnenolone, mRNA abundance was 6.5-fold greater

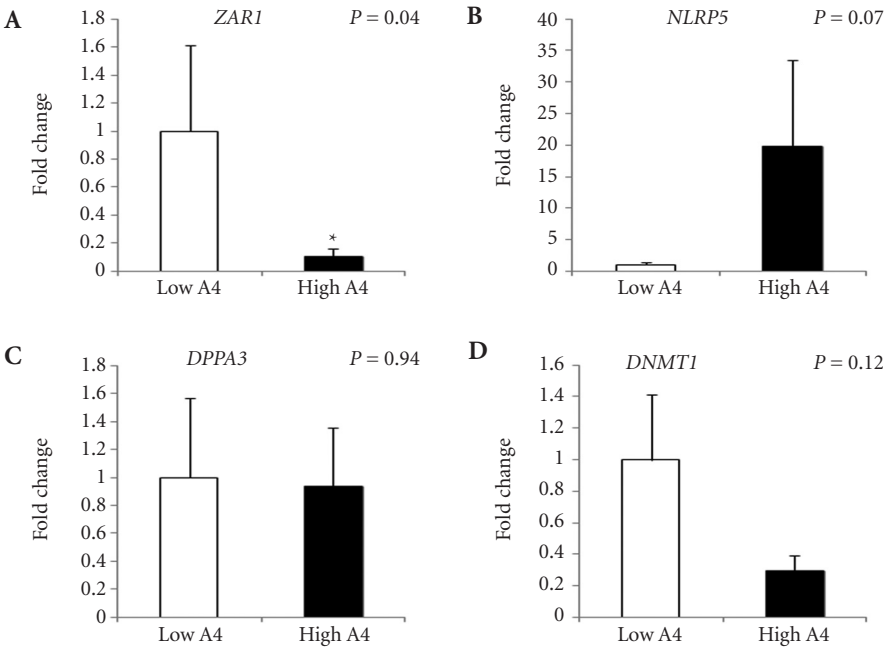

Figure 2. Maternal effect gene *ZAR1* mRNA abundance is reduced in HIGH A4 compared with LOW A4 cows. Quantitative RT-PCR results for zygote arrest-1 (*ZAR1*; A), NLR family, pyrin domain containing 5 (*NLRP5*; B), developmental pluripotency associated protein 3 (*DPPA3*; C), and DNA methyltransferases-I (*DNMT1*; D) in cumulus oocyte complexes from dominant follicles of HIGH and LOW A4. The geometric mean of *GAPDH* and *RPL-15* was used as an endogenous control to account for differences in starting material. Graphs were represented as a fold change with LOW A4 set as control (1). Data for *NLRP5, DPPA3,* and *WEE-1* were log transformed to meet normal distribution assumptions. The mean ± SEM normalized values are presented from LOW A4 n ≥ 5 and HIGH A4 n ≥ 3. $P \leq 0.05$ was considered significant.

($P = 0.05$, Figure 1C) in HIGH A4 cows compared with controls. Furthermore, *CYP17A1*, which is responsible for the conversion of pregnenolone to 17-OH pregnenolone and ultimately dehydroepiandrosterone (DHEA), mRNA abundance increased ($P = 0.01$, Figure 1D) 18.4-fold compared with LOW A4 cows. Expression of GATA-binding factor 6 (*GATA6*) has previously been reported to increase promoter activities of *CYP11A1* and *CYP17A1*. We report HIGH A4 cows have a 30-fold increase in expression of *GATA6* mRNA in theca cells compared with LOW A4 cows ($P = 0.01$, Figure 1E). Thus, it is likely the increased *GATA6* expression reported in the current study, although as a trend, increases regulation of the steroidogenic factors previously mentioned.

Maternal effect genes are important in promoting survival during early embryogenesis. Messenger RNA abundance of the maternal effect gene, *ZAR1*, was reduced 10-fold in HIGH A4 ($P = 0.04$, Figure 2A) compared with LOW A4 cows. There was no difference in *DNMT1* ($P = 0.12$, Figure 2D); however, *NLRP5* gene expression tended to be increased 19.8-fold in HIGH A4 cows ($P = 0.07$, Figure 2B). Whereas expression of *DPPA3* (Figure 2C, $P = 0.94$) mRNA was similar for HIGH and LOW A4 cows. The embryonic block coincides with the time that maternal genome activation is transferred to embryo genome activation; thus, alterations in maternal effect gene expression could be partially responsible for impaired fertility in the HIGH A4 cows.

Cows classified as HIGH A4, have altered steroidogenesis with increased expression of *CYP17A1* and *CYP11A1* steroidogenic enzyme mRNA abundance. Furthermore, these cows have increased concentrations of the E2 precursors, DHEA, and A4. These phenotypes are similar to a disorder in women with androgen excess and impaired fertility, PCOS. Theca cells from PCOS women have increased expression of the steroidogenic enzymes, *CYP11A1* and *CYP17A1*. Similarly, these patients also present increased expression of *GATA6*. Increasing our understanding of differential production of A4 in our subpopulations of cows will improve our knowledge regarding reduced fertility in beef cattle and potentially aid in developing improved synchronization protocols. Also, identifying specific genes associated with reduced fertility may aid in the development of genetic markers that will allow producers to cull potentially low fertility heifers at weaning.

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Follicular *Vascular Endothelial Growth Factor A* Expression Before and After the LH Surge

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Summary

Granulosa cell expression of VEGFA isoforms in dominant bovine follicles was evaluated. Collection of granulosa cells via follicle aspiration revealed altered expression of the proangiogenic VEGFA_164 isoform but not the antiangiogenic VEGFA_164B isoform prior to and after the LH surge. Expression of VEGFA_164 declines as both the LH surge and ovulation approaches. In addition, VEGFA_164 and VEGFA_164B expression prior to the LH surge was positively correlated with FSHR and CYP19A1 expression, suggesting that VEGFA expression may be regulated by FSH. These data indicate differential expression of VEGFA isoforms may be an important feature of bovine dominant follicle development.

Introduction

Follicle stimulating hormone (FSH) promotes ovarian follicle growth including oocyte maturation and E_2 (estrogen) production by the granulosa cells in these follicles while a surge in the release of luteinizing hormone (LH) midway through the reproductive cycle stimulates ovulation of the dominant follicle and transformation of this follicle into a P_4 (progesterone)-secreting corpus luteum. Although selection of the dominant follicle is primarily regulated through these anterior pituitary hormones, growth factors are also important for dominant follicle development. For example, inhibition of vascular endothelial growth factor (VEGFA) has been shown to impair follicle development and block ovulation. However, both proangiogenic and antiangiogenic VEGFA isoforms exist and the majority of prior studies evaluating the role of VEGFA in follicle development have not differentiated between these different isoforms. The antiangiogenic "B" isoforms were named based upon their ability to inhibit the new blood vessel formation which is stimulated by the proangiogenic VEGFA. The current study evaluated the expression of proangiogenic and antiangiogenic *VEGFA* isoforms in granulosa cells of dominant follicles prior to and after the LH surge.

Procedure

All procedures were approved by the University of Nebraska–Lincoln Institutional Animal Care and Use Committee. Crossbred, non-lactating beef cows that were 75% MARC III (¼ Angus, ¼ Hereford, ¼ Pinzgauer, ¼ Red Poll) and 25% Red Angus/European composite background crossbreds were used in this study. Average age was 5.2 ± 2.4 years, and the weight range for breeding-age heifers and cows in this herd is approximately 850-1,400 lb.

Cows in the first experiment (n = 70) received 2 i.m. injections of $PGF_{2\alpha}$ (Lutalyse; prostaglandin F2 alpha; hormone that stimulates the regression of the corpus luteum and, thus, initiation of a new reproductive cycle) 14 days apart to synchronize estrus. Follicular fluid and granulosa cells were collected from dominant follicles with a minimum diameter of 10 mm via transvaginal, ultrasound-guided aspiration 6, 12, 18, 24, 30, 36, 48, 56, and 72 hours after the second injection of $PGF_{2\alpha}$. Blood samples were collected from a subset of 12 cows to determine the timing of the subsequent LH surge. In these cows, LH surges were detected between 56 and 72 hours following the second $PGF_{2\alpha}$ injection. To evaluate follicles prior to the LH surge, only follicles aspirated between 6 and 48 hours post-$PGF_{2\alpha}$ were analyzed.

Cows in the second experiment (n = 55) also received GnRH (Cystorelin; gonadotropin releasing hormone; hormone produced in the hypothalamus that stimulates release of FSH and LH from the anterior pituitary gland) 48 hours after the second $PGF_{2\alpha}$ injection to stimulate an LH surge. Dominant follicles were then aspirated 0, 3, 6, 12, 18, and 24 hours following GnRH. The peak of LH secretion has been shown to occur 2 hours after GnRH administration, and ovulation is induced between 22 and 32 hours following GnRH; therefore, aspiration of follicles 3 to 24 hours post-GnRH should occur after the stimulated surge of LH and just prior to ovulation.

Follicles with a follicular fluid E_2 to P_4 ratio less than 1 have been shown to be destined for degeneration rather than ovulation; thus, only follicles with an E_2 to P_4 ratio greater than 1 were utilized for data analysis. Total RNA was extracted from aspirated granulosa cells for quantitative RT-PCR to evaluate mRNA abundance for *VEGFA_164* and *VEGFA_164B*. Messenger RNA abundance was also evaluated for *CYP19A1* (aromatase; enzyme which converts androgens to E_2), *FSHR* (receptor which binds and mediates the actions of FSH), and *LHCGR* (receptor which binds and mediates the actions of LH). The constitutively expressed gene, glyceraldehyde-3-phosphate dehydrogenase (*GAPDH*), was used as a control for RNA amplification. Data were analyzed by one-way ANOVA using JMP software and means for the different time points were compared using a Tukey-Kramer test. Differences in means were considered to be statistically significant at $P < 0.05$.

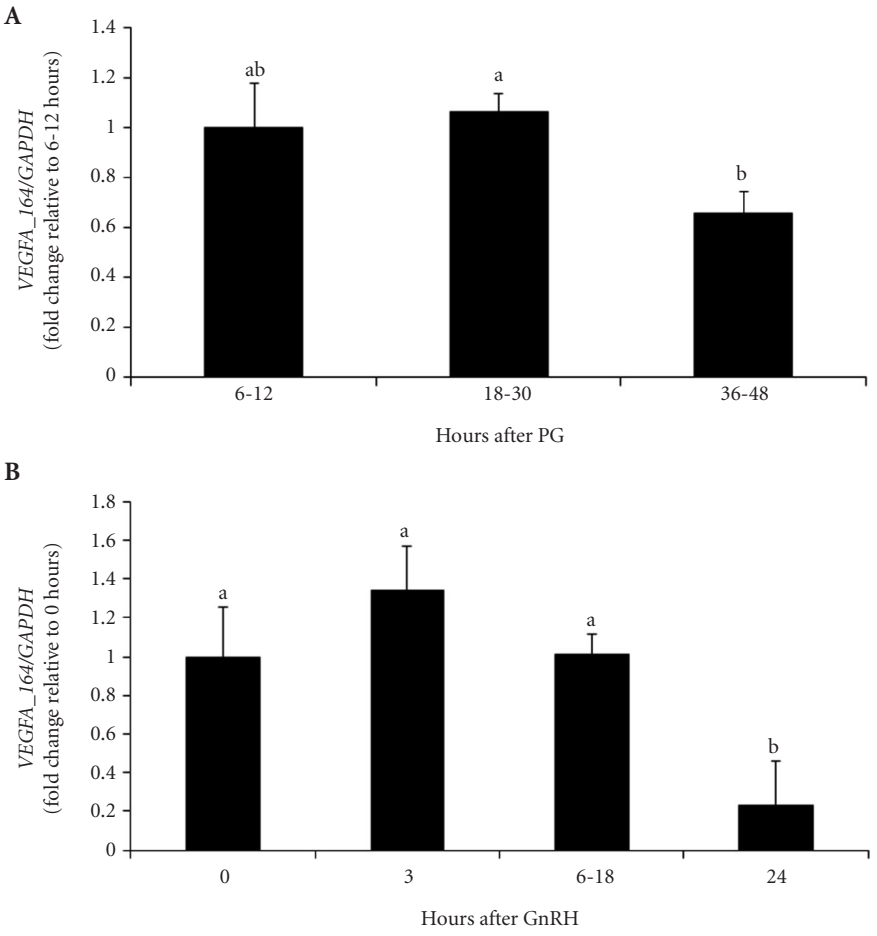

Figure 1. Quantitative RT-PCR was conducted to detect granulosa cell mRNA levels for *VEGFA_164* in dominant follicles 6 to 12 hours (n = 13), 18 to 30 hours (n = 40), 36 to 48 h ours (n = 11) after $PGF_{2\alpha}$ administration and prior to a LH surge (A) and 0 hours (n = 6), 3 hours (n = 9), 6 to 18 hours (n = 33), and 24 hours (n = 7) after GnRH administration (B). *GAPDH* was used as an endogenous control to account for differences in starting material. The mean normalized values obtained for granulosa cells aspirated 6 to 12 hours after $PGF_{2\alpha}$ (A) or 0 hours after GnRH (B) were set at 1 and the values for the other time points were calculated as a fold change. The subsequent means ± SEM are presented and different letters represent a statistically significant difference in LS Means ($P < 0.05$) between time points.

Table 1. Correlation coefficients for granulosa cell mRNA levels in dominant follicles following $PGF_{2\alpha}$ and GnRH administration.

Correlation Coefficients: Post-$PGF_{2\alpha}$

	FSHR	LHCGR	VEGFA_164	VEGFA_164B
CYP19A1	0.60[a]	0.47[c]	0.53[c]	0.35[d]
FSHR		0.77[a]	0.50[c]	0.46[d]
VEGFA_164				0.59[b]

n = 70

Correlation Coefficients: Post-GnRH

	VEGFA_164B
VEGFA_164	0.79[a]

n = 55

Letters represent correlation coefficients that are significant:
[a]$P < 0.0001$
[b]$P < 0.001$
[c]$P < 0.01$
[d]$P < 0.05$

Results

When granulosa cell gene expression was evaluated in dominant follicles not exposed to an LH surge (after PGF_2 administration), no differences were identified between early (6 and 12 hours), mid (18 to 30 hours) and late (36 and 48 hours) time points; therefore, data from these time points were combined for further analysis. This analysis revealed the relative abundance of *VEGFA_164* mRNA in granulosa cells was greater ($P = 0.0129$) in follicles aspirated 18 to 30 hours following PGF_2 administration compared to those aspirated 36 to 48 hours after PGF_2 (Figure 1). In addition, mRNA levels for *VEGFA_164* were strongly correlated ($P < 0.01$) with those for *VEGFA_164B* (0.59), *CYP19A1* (0.53), and *FSHR* (0.50). Positive correlations also were identified between the mRNA abundance of *VEGFA_164B* and mRNA levels for *CYP19A1* (0.35, $P = 0.0298$), and *FSHR* (0.46, $P = 0.0125$) (Table 1).

When gene expression was evaluated in dominant follicles following exposure to an LH surge (after GnRH administration), no differences were identified between the 6, 12, and 18 hour time points; therefore, data from these time points were combined for further analysis. This analysis determined the relative abundance of *VEGFA_164* mRNA in granulosa cells was lowest ($P = 0.0311$) 24 hours after GnRH (Figure 1). Likewise, the ratio of *VEGFA_164:164B* was lower in granulosa cells 24 hours post-GnRH compared to 3 ($P = 0.0155$) and 16 to 18 ($P = 0.0112$) hours post-GnRH (data not shown). Furthermore, a strong positive correlation (0.79, $P < 0.0001$) was identified between mRNA levels for *VEGFA_164* and *VEGFA_164B* (Table 1).

This study revealed altered expression of the proangiogenic *VEGFA_164* isoform but not the antiangiogenic *VEGFA_164B* isoform in bovine granulosa cells from dominant follicles prior to and after the LH surge. Before the LH surge, granulosa cell expression

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of *VEGFA_164* and *VEGFA_164B* mRNA was positively correlated with *FSHR* and *CYP19A1* expression in dominant follicles. Because FSH stimulates both *CYP19A1* expression and E_2 production in bovine granulosa cells, the correlation between *FSHR* and *CYP19A1* is not surprising. In addition, the reduction in *VEGFA_164* mRNA levels and the *VEGFA_164:164B* ratio 24 hours after administration of GnRH suggests the proangiogenic VEGFA isoforms may be initially important for the maintenance of preovulatory follicles but reduced proangiogenic *VEGFA* expression may be beneficial prior to ovulation. Increased vasculature will allow for the delivery of nutrients and hormones to developing follicles but blood vessel growth may need to be tempered to allow for rupture of the follicle wall and to limit ovulatory hemorrhage. Therefore, inappropriate VEGFA isoform expression may impair dominant follicle development and ovulation which would result in reduced reproductive efficiency.

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Evaluation of Genomic Predictors for Red Angus Cattle

Stephen D. Kachman
Matthew L. Spangler[1]

Summary

Purebred Red Angus genotypes, via the Ilumina BovineSNP50 assay, and expected progeny differences (EPD) were used to evaluate the accuracy of genomic predictors for traits that are currently reported through the American Red Angus Associations' National Cattle Evaluation. Two genomic predictors were evaluated, one derived using prediction equations from the National Beef Cattle Evaluation Consortium and the other from Zoetis.

Introduction

Several beef breed associations, including the American Angus Association, American Simmental Association, American Hereford Association, American Brahman Breeders Association (tenderness only), and the Red Angus Association of America, are currently augmenting their traditional expected progeny differences (EPD) with genomic information. In addition, many other breeds are nearing deployment of this technology. These genomic predictors, or molecular breeding values (MBV), are currently generated by multiple service providers including Zoetis (formally Pfizer) and GeneSeek, a Neogen Company. Many breeds utilize genomic prediction equations developed by the National Beef Cattle Evaluation Consortium (NBCEC) whereby they own the intellectual property arising from discovery of the genomic predictors. In either case, it has been clearly demonstrated that the inclusion of MBV into EPD can increases EPD accuracy particularly on unproven animals (i.e., yearling bulls). The magnitude of this change in accuracy is determined by the proportion of genetic variation explained by the MBV. Consequently, the objective of the current study was to evaluate the efficacy of two different MBV in Red Angus cattle.

Procedure

Red Angus specific genomic predictors were evaluated using EPD, Beef Improvement Federation accuracies, and MBV provided by the Red Angus Association of America for genotyped animals (n = 233) not used in training of the MBV. For each trait, there were two different prediction equations used to derive the MBV: one from Iowa State University and the National Beef Cattle Evaluation Consortium (NBCEC), and the other from Zoetis. The two training populations differed in the specific animals used, in the number of animals used, and the statistical model used. However, there was likely a considerable degree of overlap between the two training populations. Both MBV were evaluated if a MBV and corresponding EPD existed. The EPD were transformed by deregressing them and weighting them following the methods of Garrick and others (Genetics Selection Evolution, 2009). Beef Improvement Federation accuracies were transformed into the reliabilities used in the weighting of the deregressed EPD. The unweighted heritability of the deregressed EPD was set to an arbitrary value (0.4). To check that the final results were not sensitive to the choice of heritability, the analysis was rerun at different values of heritability and, as expected, the same results were obtained each time. A four-generation pedigree was constructed for the genotyped animals used in the evaluation. A two-trait linear mixed model was fitted using ASReml. The dependent variables were the MBV and weighted deregressed EPD. The model for the MBV included a fixed effect for the intercept, a random additive genetic effect, and a residual with variance fixed at 0.0001% of the unweighted phenotypic variance of the deregressed EPD. The model for the deregressed EPD included a fixed effect for the intercept, a random additive genetic effect, and a weighted random residual. The additive genetic and unweighted residual variances for the deregressed EPD were fixed at 0.4 and 0.6 of the deregressed unweighted phenotypic variance of the EPD, respectively. Any deregressed EPD with a reliability less than 0.1 was removed prior to analysis. The analysis was rerun without this edit and the results were very similar.

Results

In general, genetic correlations between the MBV and the trait of interest were moderate to high and would be expected to add accuracy to EPD for unproven animals. Genetic correlations and corresponding standard errors for continuous traits for the two MBV are detailed in Table 1. Differences between the two MBV (NBCEC and Zoetis) were small, although the NBCEC MBV had numerically higher genetic correlations with the trait of interest for all traits evaluated. This could be a function of the number of animals used in the training set or the relationship between the training data and the evaluation data or a function of both. Table 2 details the genetic correlations for threshold traits when the MBV were trained and evaluated using EPD either on the observed or underlying scale (NBCEC only). The genetic correlations for threshold traits were moderate to high, but differences did exist between estimates depending on the scale (observed or underlying) of the deregressed EPD used for training. The larger estimates of the genetic correlations may due to the nonlinear transformation of the EPD to the observed scale not being consistent with the assumptions of the model used to estimate the EPD. The moderate to high genetic correlations for threshold traits may be due to biases created by

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a combination of the relative low accuracies of EPD for threshold traits and the correlations in the prediction errors of the deregressed EPD.

Implications

Both MBV evaluated here have the potential to increase the EPD accuracy of unproven animals. Differences did exist between the two MBV, likely due to the animals used in training, both in terms of the number of animals and their relationship with the animals used in the evaluation data. The most critical differences existed for threshold traits. Differences did exist when genetic correlations between MBV and the trait of interest were estimated on the observed versus the underlying scale. For inclusion of MBV in national cattle evaluation, the theoretically sound method would include training MBV for threshold traits using deregressed EPD on the underlying scale.

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Table 1. Genetic correlations for continuous variation traits in Red Angus cattle with standard errors.

Trait	N	NBCEC Prediction Genetic Correlation	SE	Zoetis Prediction Genetic Correlation	SE
Birth Weight	197	0.644	0.053	0.586	0.058
Carcass Weight	199	0.661	0.065	0.528	0.075
Fat	166	0.488	0.098	0.429	0.099
Milk	192	0.399	0.085	0.319	0.087
Marbling	189	0.608	0.101	0.504	0.108
Ribeye Area	187	0.500	0.114	0.478	0.116
Weaning Weight	200	0.546	0.063	0.485	0.068
Yield Grade	190	0.382	0.114	—	—
Yearling Weight	200	0.579	0.061	0.449	0.071
Maintenance Energy	181	0.581	0.061	—	—

Table 2. Genetic correlations (standard errors) for threshold traits in Red Angus cattle.

Trait	N	NBCEC Prediction Observed Scale Genetic Correlation	NBCEC Prediction Underlying Scale Genetic Correlation
Calving Ease Maternal	170	0.458	0.679 (0.058)
Calving Ease Direct	176	0.479	0.588 (0.067)
Heifer Pregnancy	64	0.616	0.610 (0.124)
Stayability	104	0.801	0.787 (0.118)

Preconception Distillers Grains Supplementation Improves Mature Beef Cow Return to Estrous

Adam F. Summers
Daniel M. Larson
Andrea S. Cupp[1]

Summary

For three years, cows and first-calf heifers were supplemented two levels of RUP prior to breeding to determine the effect of RUP on reproductive efficiency and performance. Cows resumed estrous after being supplemented 30 days with distillers grains, but pregnancy rate was not different. First-calf heifer performance and reproductive efficiency was similar regardless of protein supplement offered. Protein supplements offered in this study did not impact cow BW, milk production, or progeny performance. More cows supplemented with distillers grains prior to the breeding season resumed luteal activity prior to breeding; however, pregnancy rates were similar.

Introduction

To maintain profitability and a 365 day calving interval, cows must return to estrous and become pregnant within 90 days after calving. Furthermore, protein intake and type have been reported to influence reproductive efficiency. Utilizing distillers grains during heifer development improved AI conception rate compared with heifers offered a dried corn gluten feed based supplement (*2007 Nebraska Beef Cattle Report*, pp. 5-6); however, final pregnancy rates were similar. Similarly, June-calving first-calf heifers supplemented 1.5 lb/day distillers grains for 60 days prior to the breeding season had similar final pregnancy rates as non-supplemented heifers (*2006 Nebraska Beef Cattle Report*, pp. 5-6). The objective of this study was to determine the effect of rumen undegradable intake protein level supplementation prior to the breeding season on first-calf heifer and cow reproductive efficiency.

Procedure

All procedures were approved by the University of Nebraska–Lincoln Institutional Animal Care and Use Committee. Non-lactating composite beef cows and first-calf heifers [25% MARC III (¼ Angus, ¼ Hereford, ¼ Pinzgauer, ¼ Red Poll) and 75% Red Angus] from the beef physiology herd located at the University of Nebraska Agricultural Research and Development Center (ARDC), Mead, Neb., were used in this study.

First-calf heifers (FCH; year 1= 49; year 2 = 51; year 3 = 43) and cows (year 1= 161; year 2= 170; year 3 = 160) were blocked by age, BW, and calving date and assigned to one of two treatment groups: receive a distillers based (DDGS) supplement or a dried corn gluten feed (CGF) based supplement (Table 1). Cows and FCH grazed predominately brome pastures during the supplement period and were offered 0.25% BW/day (cows) or 0.30% BW/day (FCH) of assigned supplement for 30 and 45 days, respectively, prior to the beginning of the breeding season. Supplement level was based on NRC calculations to allow FCH to gain a single BCS in 50 days. To determine the effect supplement treatment may have on milk production, a weigh-suckle-weigh procedure was conducted on all FCH, and a subset of mature cows (n = 50/year) approximately 14 days after initiation of supplementation.

Prior to supplementation, blood samples were collected 10 days apart to determine estrous status. Blood samples were then collected every 14 days during the supplementation period to determine resumption of estrus during the feeding period. Plasma progesterone concentration was determined via radioimmunoassay and samples with concentrations greater than 1 ng/mL were interpreted to indicate ovarian luteal activity, and resumption of estrus.

Table 1. Supplement composition and nutrient analysis.

	DM, %	
Item	CGF[1]	DDGS[2]
DDGS	—	91.5
Dried corn gluten feed	75.1	—
Corn germ	14.1	—
Urea	2.3	—
Supplement[3]	8.5	8.5
Nutrient analysis		
Crude fat, %	9.8	9.4
Crude protein, %	26.1	28.1
RUP, % CP	18.7	56.5
NEg, Mcal/lb	0.73	0.77

[1]CGF = dried corn gluten feed based supplement offered 30 (mature cows) or 45 (first-calf heifers) days prior to the breeding season.
[2]DDGS = dried distillers grains with solubles-based supplement offered 30 (mature cows) or 45 (first-calf heifers) days prior to the breeding season.
[3]Supplement = includes trace minerals, vitamins, molasses, and pellet binder.

Estrus was synchronized utilizing two injections of PG (Lutalyse, Zoetis, Madison, N.J.) 14 days apart. Estrus detection was performed for at least 1 hour in the early morning and late evening for 5 days after the second PG injection. First-calf heifers and cows in estrus received AI approximately 12 hours later. Artificial insemination was performed by one of four technicians used equally across treatments. Cows and FCH were exposed to bulls (1 bull to 25 cows) for approximately 45 days beginning 10 days after the final AI. Artificial insemination and final pregnancy rates were determined via transrectal ultrasonography approximately 45 days after AI and bull removal, respectively.

Data were analyzed using the MIXED and GLIMMIX procedures of SAS (SAS Institute, Inc., Cary,

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N.C.) for continuous and categorical data, respectively. Treatment group within year was the experimental unit (n = 3). Supplement was considered the main effect. Year and age were classified as random effects. A *P*-value ≤ 0.05 was considered significant.

Results

Performance and reproductive efficiency data are reported in Tables 2 and 3 for cows and FCH, respectively. Initial BW and final BW were similar between treatments for cows and FCH; however, BW change and ADG tended ($P = 0.12$) to be greater for FCH offered DDGS. First-calf heifers in early lactation have maintenance requirements as well as requirements for milk production and growth. Heifers offered DDGS, which is higher in RUP could have possibly utilized protein from the supplement for tissue growth, increasing BW.

Cows offered DDGS had greater ($P = 0.01$) estrous activity prior to the breeding season than CGF cows (91 vs. 78% ± 4%). However, AI and overall pregnancy rates were similar for DDGS- and CGF-supplemented cows (58 vs. 63% ± 5%; 76 vs. 81% ± 9%, respectively). There was no difference in the proportion of FCH in estrus prior to the breeding season based on supplement type, and similar to cow data, AI and final pregnancy rates were also similar (Table 3). Cows were placed on brome pastures during the prebreeding period (May through early June). This time period coincides with relatively high forage quality and it is likely protein supplementation was not needed to meet animal nutrient requirements.

In our study, maternal supplementation coincided with mid lactation. Increasing RUP during lactation may increase milk production and thus could increase calf weaning BW. Milk production was similar for FCH and cows regardless of protein supplement type. Similarly, calf weaning BW and 205-day adjusted weaning BW were similar for cows and FCH supplemented DDGS and CGF.

Table 2. Effect of protein source supplied 30 days prior to the breeding season on cow performance and reproduction.

	CGF[1]	DDGS[2]	SEM	*P*-value
n	3	3		
Weight, lb				
Initial	1,243	1,246	26	0.88
Final	1,327	1,355	19	0.35
Pregnancy diagnosis	1,317	1,341	22	0.39
BW change	76	101	31	0.20
ADG, lb/day	1.27	1.76	0.21	0.20
24 hour milk production, lb	24	22	6	0.73
DPP[3], day	74	74	1	1.00
Days to estrus[4], day	19	20	6	0.45
Resumed estrus by breeding, %	78	91	4	0.01
Estrus response, %	80	77	8	0.55
AI pregnancy rate, %	63	58	5	0.53
Final pregnancy rate, %	81	76	9	0.58
Calf weaning BW, lb	521	522	22	0.96
205-day adjusted weaning BW, lb	536	557	16	0.30

[1]CGF = dried corn gluten feed based supplement consisting of 75.1% dried corn gluten feed, 14.1% corn germ, 2.3% urea, and 8.5% supplement.
[2]DDGS = dried distillers grains with solubles based supplement consisting of 91.5% dried distillers grains with solubles and 8.5% supplement.
[3]DPP = days postpartum.
[4]Calculated as days from initiation of supplementation to resumption of estrus.

Table 3. Effect of protein source supplied 45 days prior to the breeding season on first-calf heifer performance and reproduction.

Item	CGF[1]	DDGS[2]	SEM	*P*-value
n	3	3		
Weight, lb				
Initial	1,114	1,119	65	0.65
Final	1,155	1,186	57	0.25
Pregnancy diagnosis	1,177	1,191	56	0.72
BW change	83	123	7	0.12
ADG, lb/day	1.12	1.77	0.44	0.12
24 hour milk production, lb	17	19	3	0.61
DPP[3], day	69	70	11	0.55
Days to estrus[4], day	28	24	8	0.13
Resumed estrus by breeding, %	82	84	7	0.83
Estrus response, %	53	60	12	0.41
AI pregnancy rate, %	61	59	5	0.79
Final pregnancy rate, %	89	88	3	0.85
Calf weaning BW, lb	511	504	10	0.41
205-day adjusted weaning BW, lb	557	558	9	0.93

[1]CGF = dried corn gluten feed based supplement consisting of 75.1% dried corn gluten feed, 14.1% corn germ, 2.3% urea, and 8.5% supplement.
[2]DDGS = dried distillers grains with solubles based supplement consisting of 91.5% dried distillers grains with solubles and 8.5% supplement.
[3]DPP = days postpartum.
[4]Calculated as days from initiation of supplementation to resumption of estrus.

Mature cows supplemented DDGS 30 days had greater resumption of estrus prior to the breeding season. However, AI and overall pregnancy rates were similar for DDGS- and CGF-supplemented cows and FCH.

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Impact of Supplemental Protein Source on Pregnant Beef Heifers

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Summary

Crossbred, *AI-pregnant heifers were fed in a Calan Broadbent individual feeding system for 110 days beginning at approximately day 142 of gestation. Heifers were offered ad libitum grass hay and no supplement, hay plus distillers based supplement, or hay plus dried corn gluten based supplement. Supplements were isocaloric, isonitrogenous, and equal in lipid content but differed in rumen undegradable protein. Protein supplementation increased DMI and ADG in pregnant heifers; however, calf birth BW and subsequent pregnancy rates were similar.*

Introduction

The relationship between prepartum nutrition and subsequent breeding season pregnancy rates is well established. This relationship is especially critical for primiparous heifers and young cows due to the added nutrient requirement of their own growth, resulting in a higher risk of reproductive failure compared with mature cows.

Providing supplemental protein to beef cattle grazing low quality forages has been reported to increase forage intake, improve cow BW gain, and may increase pregnancy rate (*Journal of Animal Science*, 2000, 77:1-16). However, results vary based on protein source, degradability, and physiological status of the female. Therefore, objectives of the current study were to determine the effect of supplemental protein source on ADG, feed intake, calf birth BW, and subsequent pregnancy rate in pregnant beef heifers.

Materials and Methods

The University of Nebraska–Lincoln Institutional Animal Care and Use Committee approved all procedures and facilities used in this experiment.

Pregnant Heifer Management

A 3-year study was conducted at the West Central Research and Extension Center (WCREC), North Platte, Neb. Crossbred, AI-pregnant heifers (year 1 n = 38, year 2 n = 40, year 3 n = 36) were stratified by BW (992 ± 22 lb) and placed in a Calan Broadbent individual feeding system at approximately day 142 of gestation. Heifers were allowed approximately 25 days to adapt to the individual feeding system followed by an 84 day feeding trial. Heifers were offered ad libitum grass hay (8 to 11% CP, DM basis) and either no supplement (CON), 1.8 lb/day (DM basis) distillers based supplement (HI), or 1.8 lb/day (DM basis) dried corn gluten feed based supplement (LO, Table 1). Supplements were formulated to be isocaloric and isonitrogenous and equal in lipid content but differ in rumen undegradable protein (RUP). Feed offered was recorded daily and refusals removed and weighed weekly. Residual feed intake (RFI) was calculated as the actual DMI minus predicted DMI, with DMI calculated based on net energy (NE) values of the feed to account for different energy levels of the supplement compared with the control diet.

Table 1. Composition of supplements offered to heifers during feeding trial.

	% DM	
Ingredient, %	High[1]	Low[2]
DDGS[3]	99.0	—
CGF[4]	—	72.4
Corn germ	—	24.5
Urea	—	2.1
Trace minerals and vitamins	1.0	1.0
Nutrient Analysis[5], %		
CP	28.2	28.1
RUP, % CP	59.0	34.0
TDN	79.4	77.3
Crude fat	11.9	11.9

[1]Heifers offered 1.8 lb/d (DM) distillers grain based supplement.
[2]Heifers offered 1.8 lb/d (DM) dried corn gluten feed based supplement.
[3]Dried distillers grains with solubles.
[4]Dried corn gluten feed.
[5]Wet chemistry, Ward Laboratories, Inc., Kearney, Neb.; RUP based on NRC (1996).

Post-Calving Management

After calving, cows and calves remained at WCREC through AI. Prior to the breeding season, blood samples were collected 10 days apart via coccygeal venipuncture to determine plasma progesterone concentration. Plasma progesterone concentration was determined through direct solid phase RIA (Coat-A-Count, Diagnostics Products Corp., Los Angeles, Calif.). Cows with plasma progesterone concentrations >1.0 ng/mL were considered to have resumed estrus.

Estrus was synchronized utilizing a controlled internal drug release (CIDR; Zoetis, Florham Park, N.J.) protocol, with cows receiving 100 µg i.m. GnRH (Fertagyl, Intervet Inc., Millsboro, Del.) and CIDR insert on day 0. Seven days later, the CIDR was removed and a single injection of $PGF_{2\alpha}$ (25 mg; i.m.; Lutalyse, Zoetis, Florham Park, N.J.) administered followed by GnRH administration and AI approximately 60 hours later. Following AI, cows and calves were transported 28 miles to a commercial ranch in the Nebraska Sandhills for summer grazing. A single bull was placed with heifers approximately 10 days after AI for 60 days. Cows and calves were returned to WCREC prior to weaning for final pregnancy diagnosis. Following weaning, all pregnant 2 year old cows grazed corn residue and received 1 lb/day (32% CP, DM basis) distillers based supplement.

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Statistical Analysis

Heifers were offered hay and supplement on an individual basis during the experimental period; therefore, heifer was the experimental unit and diet the treatment. The statistical model included treatment as the fixed effect with pen and year as random effects. Calf sire and gender were included in the model for calving data. Data were analyzed using PROC MIXED and PROC GLIMMIX of SAS (SAS Institute, Inc., Cary, N.C.) for categorical and binomial data, respectively. Regression analysis utilizing PROC REG of SAS was used to determine the relationship between DMI, diet, and week of gestation. There was no intake × diet interaction ($P = 0.62$); thus, regression was utilized to determine the relationship of DMI and week of gestation. Data were considered significant if $P \leq 0.05$.

Results and Discussion

Individual Feeding Results

Heifers not receiving supplement tended ($P = 0.09$) to consume less total DM than either supplement treatment (Table 2). Similarly, total energy intake was less ($P < 0.01$) for CON heifers (10.98 lb) compared with HI or LO heifers (11.97 and 11.79 lb, respectively). However, CON heifers consumed more ($P < 0.01$) forage (21.91 lb) compared with HI or LO heifers (18.74 and 18.39 lb, respectively).

Forage intake declines when diet CP values are below 7%. Providing supplemental protein when cattle are grazing or consuming low quality forage may increase forage DMI. In the present study, forage CP content was greater than 7% and subsequently protein supplement replaced forage intake in HI and LO heifers. These data agree with Loy et al. (*2004 Nebraska Beef Cattle Report*, pp. 22-24) who reported heifers provided chopped grass hay (8.2% CP) and 0.4% BW/day of either dry-rolled corn or dried distillers grain supplement had reduced ($P < 0.01$) hay DMI compared to nonsupplemented heifers.

Table 2. Impact of supplemental protein source on ADG, feed intake, and feed efficiency in pregnant beef heifers.

Item	No supplement[1]	High RUP[2]	Low RUP[3]	SEM	*P*-value
Initial BW, lb	996	994	988	22	0.74
Final BW, lb	1,105[a]	1,144[b]	1,131[a,b]	20	<0.01
DMI[4], lb	21.91	22.75	22.40	0.26	0.09
Forage DMI[5], lb	21.91[a]	18.74[b]	18.39[b]	0.26	<0.01
NE DMI[6], lb	10.98[a]	11.97[b]	11.79[b]	0.51	<0.01
ADG, lb	1.30[a]	1.81[b]	1.72[b]	0.31	<0.01
RFI, DMI, lb	-0.037	0.018	-0.042	0.377	0.98
RFI, NE, lb	-0.465[a]	0.183[b]	0.141[b]	0.650	<0.01
G:F lb gain/lb	0.061[a]	0.085[b]	0.073[c]	0.013	<0.01

[1]Offered ad libitum grass hay (8 to 11% CP, DM basis) and no supplement.
[2]Offered ad libitum grass hay (8 to 11% CP, DM basis) and 1.8 lb/day (DM; 28% CP) distillers grain based supplement.
[3]Offered ad libitum grass hay (8 to 11% CP, DM basis) and 1.8 lb/day (DM; 28% CP) dried corn gluten feed based supplement.
[4]Dry matter intake of total diet.
[5]Dry matter intake of ad libitum grass hay only.
[6]Dry matter intake based on net energy (NE) values of the feed to account for different energy levels of the supplement compared with the control diet.
[a,b]Within each row, means without common superscripts differ ($P < 0.05$).

Table 3. Impact of supplemental protein source on subsequent cow and calf characteristics.

Item	No supplement[1]	High RUP[2]	Low RUP[3]	SEM	*P*-value
Julian birth date, day	60	60	62	1	0.36
Gestation length, day	276	276	277	1	0.88
1st calf birth BW, lb	73	73	73	2	0.99
Calving ease[4]	1.40	1.39	1.53	0.13	0.70
Calf vigor[5]	1.41	1.46	1.89	0.19	0.14
Resumption of estrus, %	25	27	37	11	0.51
Prebreeding BW, lb	981[a]	1,010[b]	1,014[b]	29	0.03
Pregnancy diagnosis BW, lb	1,065	1,076	1,087	26	0.48
Retention rate, %[6]	92	90	82	5	0.35
AI pregnancy rate, %	59	56	64	10	0.80
Overall pregnancy rate, %	90	91	79	12	0.22
Second calf Julian birth date, day	68	72	64	4	0.19
AI to parturition, day	290	294	286	4	0.20
Calved first 21 days, %	73	65	87	9	0.20

[1]Offered ad libitum grass hay (8 to 11% CP, DM basis) and no supplement.
[2]Offered ad libitum grass hay (8 to 11% CP, DM basis) and 1.8 lb/day (DM; 28% CP) distillers grain based supplement.
[3]Offered ad libitum grass hay (8 to 11% CP, DM basis) and 1.8 lb/day (DM; 28% CP) dried corn gluten feed based supplement.
[4]Calving ease scoring system: 1 = no assistance, 2 = easy pull, 3 = mechanical pull, 4 = hard mechanical pull, 5 = Caesarean section.
[5]Calf vigor scoring system: 1 = nursed immediately; 2 = nursed on own, took some time; 3 = required some assistance to suckle; 4 = died shortly after birth; 5 = dead on arrival.
[6]Proportion of cows remaining at the beginning of the second breeding season.
[a,b]Within each row, means without common superscripts differ ($P < 0.05$).

Heifers receiving no supplement had less ($P < 0.01$) ADG (1.30 lb) than either HI (1.81 lb) or LO (1.72 lb) heifers, resulting in reduced ($P < 0.01$) BW (1,105 lb) compared with HI heifers (1,144 lb) at the end of the trial. The differences in diet nutrient density resulted in a greater ($P < 0.01$) NE intake for the HI and LO heifers compared with the CON heifers. Although DMI tended to be greater for HI compared with CON heifers, G:F was greater ($P < 0.01$) for HI compared with CON heifers. The increase in G:F can be attributed to improved ADG for HI heifers, which was approximately 1.4 times greater than CON heifers. However,

CON heifers had increased ($P < 0.01$) RFI based on diet energy compared with HI and LO heifers, whereas RFI between supplement groups was similar.

Dry matter intake was greatest at gestation week 28 (22.18 lb/day) and decreased ($P = 0.01$) as week of gestation increased throughout the remainder of the feeding period (week 38).

Calving and Subsequent Pregnancy Results

Julian birth date and gestation length were similar among treatments. Calf birth BW, calving ease, and calf vigor did not differ among treatments (Table 3). At pre-breeding, CON heifers weighed less ($P < 0.03$) compared with LO heifers. However, prepartum supplementation did not influence the proportion of heifers cycling prior to the breeding season. Cow BW was similar among treatments at pregnancy diagnosis. The proportion of cows pregnant to AI and final pregnancy rate was similar among treatments.

Cows were synchronized utilizing a CIDR estrus synchronization protocol. It has been reported (*Journal of Animal Science*, 2001, 79:982-995) CIDR increased the proportion of anestrous cows detected in estrous within the first three days of the breeding season compared with $PGF_{2\alpha}$-treated or control cows. It is possible the synchronization protocol used in the current study increased synchronization response and subsequent pregnancy rates to AI given the relatively low percentage of cows resuming estrus prior to synchronization. Regardless, prepartum supplement treatment did not affect resumption of estrus prior to CIDR insertion.

The impact of late gestation nutrition on subsequent pregnancy rate has been inconclusive (reviewed in *Journal of Animal Science*, 2000, 77:1-16). Patterson et al. (*2000 Nebraska Beef Cattle Report*, pp. 7-10.) reported increased pregnancy rates for heifers supplemented with RUP during late gestation to balance MP requirements compared to heifers supplemented to balance CP requirements. Also, it was reported (*Journal of Animal Science*, 2008, 86:1697-1708) providing heifers a diet of hay and distillers grains with solubles during late gestation improved pregnancy rate 10 percentage points compared with heifers offered hay and soybean hulls. In both studies, pregnancy rates were decreased in heifers offered diets deficient in MP during late gestation. In the present study, all diets supplied excess MP (CON, + 96 g/day; HI, + 247 g/d; LO, + 168 g/day), which may explain the lack of treatment effects on pregnancy rates.

In the current experiment, protein supplementation increased ADG in pregnant heifers; however, calf birth BW, resumption of estrus, and subsequent pregnancy rates were similar, regardless of supplementation or supplemental protein source. All diets in the current study were balanced for or exceeded MP requirements. Future studies restricting heifer MP intake during mid- to late gestation are warranted to determine the impact protein source and level may have on feed intake, ADG, and reproductive efficiency.

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Effects of Winter Supplementation on Cow Performance and Post-Weaning Management on Steer and Heifer Progeny in a Late Spring Calving System

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Summary

The objective of this experiment was to evaluate the effects of winter supplementation while grazing dormant Sandhills winter range or meadow on cow performance and the effects of post-weaning management on steer and heifer progeny. Winter treatment had no effect on cow BCS or BW at precalving, prebreeding, and weaning. Steers and heifers fed hay gained more BW during winter treatment compared to those grazing meadow, but post-weaning management had no subsequent effects on steer or heifer progeny.

Introduction

The amount of harvested and purchased feed required to sustain a Nebraska Sandhills cow herd can be reduced by calving late in the spring, better matching the cow's nutrient requirement with grazed forage resources. Altering the calving date may provide additional enterprise opportunities and timing when the calves are marketed, which may be economically advantageous, allowing producers the flexibility to sell calves at different ages and BW.

The nutritional requirements of a spring-calving beef cow grazing dormant Sandhills range during late gestation typically exceed the nutrient content of the grazed forage. Protein is commonly supplemented to maintain cow BCS during winter grazing. Supplementing protein also increases weaning BW and the proportion of live calves at weaning (2006 *Nebraska Beef Cattle Report*, pp. 7-9). Supplementing beef cows during late gestation has been shown to affect the lifelong productivity of the calf by altering post-weaning growth and carcass composition (2009 *Nebraska Beef Cattle Report*, pp. 5-8). The objectives of the current study were to evaluate the effects of winter supplementation while grazing dormant Sandhills winter range or meadow on cow performance and effects of post-weaning management on steer and heifer progeny in a late spring calving herd.

Procedure

All animal procedures and facilities were approved by the University of Nebraska–Lincoln Institutional Animal Care and Use Committee.

Cow-Calf Management

An ongoing trial is being conducted utilizing composite Red Angus × Simmental cows and their progeny at the Gudmundsen Sandhills Laboratory (**GSL**), Whitman, Neb., and the West Central Research and Extension Center (**WCREC**), North Platte, Neb. Cows grazed either dormant upland winter range or meadow from December 1 to March 29 and received 0 or 1 lb/day of a 28% CP (As-fed basis) supplement. Supplement was prorated and delivered three times/week on a pasture (88 acres) basis. Cows were managed as a common group the remainder of the year. Cows were estrous synchronized with a single injection of $PGF_{2\alpha}$ (Lutalyse®, Pfizer Animal Health, New York, N.Y.) five days after being placed with bulls (1:20 bull to cow ratio), approximately August 1, for 45 days. Pregnancy was determined via rectal palpation or ultrasonography at weaning in early January. Cows were removed from the study for reproductive failure, calf death, or injury. Approximately five days post-weaning, calves were placed on one of two winter treatments: graze winter meadow with 1 lb/day supplement (**MDW**), or offered meadow hay (ad libitum) and 4 lb/day supplement (**HAY**).

Heifer Management

After January weaning, heifers were blocked by dam treatment and BW. They were then assigned to either MDW or HAY treatment until May 15. Winter treatments were replicated twice. Following winter treatment, heifers were managed as a single group. Blood samples were collected 10 days apart prior to the breeding season to determine luteal activity. Heifers were considered pubertal if serum progesterone concentrations were >1 ng/mL. Heifers were moved to upland range pastures for the breeding season. Heifers were estrous synchronized with a single injection of $PGF_{2\alpha}$ (Lutalyse) five days after being placed with bulls (1:20 bull to heifer ratio) on approximately July 25 for 45 days. Pregnancy was determined via transrectal ultrasonography in late October. Data reported was collected in 2011 (n = 65) and 2012 (n = 65).

Steer Management

After January weaning, steers were blocked by dam treatment and BW. They were then assigned to either MDW or HAY treatment. Winter treatments were replicated twice. On May 15 one-half of the steers from each winter treatment were placed in a feedlot at WCREC (calf-fed system). The remaining steers were implanted with Revalor®-G (Merck Animal Health, Summit, N.J.) and subsequently grazed upland summer range until approximately August 30, and then placed in the feedlot (yearling-fed system). Upon feedlot

Table 1. Effects of winter grazing treatment[1] on cow BCS, BW, pregnancy rate, and calf BW.

Item	MNS	MS	RNS	RS	SE[2]	*P*-value
Cow BCS						
January	4.4	4.4	4.5	4.4	0.2	0.76
Winter change	-0.2	0.0	0.0	0.2	0.1	0.16
Pre-calving	4.5	4.6	4.8	4.8	0.2	0.31
Pre-breeding	5.3	5.4	5.4	5.4	0.1	0.81
Cow BW						
January BW, lb	988	999	992	985	9	0.97
Winter BW gain, lb	106[ab]	119[a]	75[b]	112[ab]	9	0.03
Pre-calving BW, lb	1,054	1,069	1,027	1,058	23	0.54
Pre-breeding BW, lb	1,080	1,101	1,100	1,102	15	0.87
Pregnancy rate, %	84	88	73	77	1	0.60
Calf BW						
Birth BW, lb	79	77	75	77	2	0.45
Pre-breeding BW, lb	223	214	213	225	7	0.47
Weaning BW, lb	437	434	423	439	9	0.58

[1]Treatments: MNS = grazed meadow without supplement, MS = grazed meadow and 1 lb 28% CP supplement, RNS = grazed winter range without supplement, RS = grazed winter range and 1 lb 28% CP supplement.
[a,b]Within a row, means without common superscript differ at $P < 0.05$.

entry, steers were limit-fed five days at 2.0% BW, weighed two consecutive days, and adapted (21 days) to a common finishing diet of 48% dry rolled corn, 40% wet corn gluten feed, 7% prairie hay, and 5% supplement. In the calf-fed system, Synovex Choice (Ft. Dodge Animal Health, Overland Park, Kan.) was administered at feedlot entry and Synovex Plus (Ft. Dodge Animal Health, Overland Park, Kan.) approximately 100 days later. In the yearling-fed system, Ralgro (Merck Animal Health, Summit, N.J.) was administered at feedlot entry, followed by Synovex Plus approximately 60 days later. Steers were slaughtered when estimated visually to have 0.5 in fat thickness over the 12th rib. Steers were slaughtered at a commercial abattoir, and carcass data were collected after a 24-hour chill. Final BW was calculated from HCW using a standard dressing percentage (63%). Data reported were collected in 2011 (n = 68) and 2012 (n = 54).

Statistical Analysis

Cow and progeny winter treatments and steer feedlot treatment were applied on a pasture or group basis. Pasture (n = 4/year) served as experimental unit for cow performance and reproductive data. Winter treatment (n = 4/year) served as experimental unit for heifers. Winter treatment × feedlot treatment served as the experimental unit for the steers. Data were analyzed with the GLIMMIX procedure of SAS (SAS Institute, Inc., Cary, N.C.). Model fixed effects for cow data included winter treatment and age. Winter treatment, feedlot system, and appropriate interactions ($P < 0.05$) were included in the progeny model. Year was considered a random effect for cow and calf variables.

Results

Cow-Calf Results

Cows that grazed meadow with supplement had greater ($P = 0.03$) BW gain over the treatment period compared with cows grazing range without supplement (Table 1). Winter treatment did not affect BCS over the treatment period. Winter treatment also did not affect cow BW or BCS at precalving, prebreeding, or weaning. Calf birth BW, calving difficulty, calf vigor, and subsequent pregnancy rates were not affected by supplementation or winter treatment. There was a difference of 21 percentage points (± 17 %) in pregnancy rates between the youngest (3-year-old) cows compared with older cows despite a lack of significance (67 vs. 88% for young and old cows, respectively; $P = 0.24$), which is likely a result of limited data at this point. Moving to a late-spring calving season results in a breeding season that begins in late summer, coinciding with declining forage nutrient quality, which may have a greater impact on pregnancy rates in young cows.

Heifer Progeny Results

The effects of winter management system on heifer progeny are presented in Table 2. Heifers on HAY treatment had greater ($P = 0.03$) winter ADG than MDW heifers and tended ($P = 0.10$) to have increased BW in May and July. Percent pubertal at the beginning of the breeding season and pregnancy rates were similar between treatments. Heifers on HAY treatment had a numerically greater proportion of heifers pubertal prior to breeding (78 vs. 69%) and numerically greater pregnancy rate (68 vs. 61%) compared with MDW heifers despite a lack of significance ($P \geq 0.39$). Again, this may be related to limited data. Pregnancy rates were approximately 20 percentage points lower than pregnancy rates in March-born heifers on the same ranch, which may be a function of declining nutrient quality during the later breeding season. Younger cows and heifers may require supplemental nutrition during the breeding season to achieve similar pregnancy rates as beef females in an earlier spring calving herd.

Steer Progeny Results

The interaction between winter treatment and feedlot system was not significant ($P > 0.10$). Therefore, only main effects of winter treatment and feedlot system will be presented (Table 3). Steers on HAY treatment had greater ($P = 0.03$) ADG compared with steers on MDW treatment during treatment period and tended ($P = 0.07$) to have increased BW at end of winter treatment in May. In the calf-fed system, steers on HAY treatment tended to have greater ($P = 0.06$) feedlot entry BW than steers on MDW

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treatment and tended ($P = 0.06$) to have greater BW at second implant in August. Winter treatment did not influence ($P > 0.10$) final BW or carcass characteristics in the calf-fed system (Table 3). In the yearling-fed system, steers on HAY treatment had greater ($P = 0.05$) BW entering the feedlot in September until time of second implant ($P = 0.02$) in November. Winter treatment had no effect on final BW or carcass characteristics in the yearling-fed system. At present, with 2-year data, steers from the calf-fed and yearling-fed systems have similar feedlot ADG and carcass characteristics.

Currently, winter management systems for cows or progeny have not had significant effects on subsequent dam or progeny performance. Additional data and economic analysis are required to make specific recommendations relating to management strategies for a late spring calving herd in the Nebraska Sandhills.

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Table 2. Effects of winter grazing treatment[1] on heifer progeny.

	HAY	MDW[1]	SE	P-Value
Winter ADG[2], lb	1.52	0.84	0.04	0.03
May BW, lb	615	525	7	0.07
June BW, lb	686	615	9	0.12
July BW, lb	719	650	9	0.10
Summer ADG[3], lb	1.76	2.07	0.06	0.18
October BW, lb	816	754	9	0.12
October BCS	5.7	5.5	0.05	0.22
Pubertal, %	78	69	7.7	0.47
Pregnancy rate, %	68	61	3.6	0.39

[1]Winter grazing treatments: HAY = meadow hay (ad libitum) and 4 lb 28% CP supplement; MDW = grazed winter meadow and 1 lb 28% CP supplement.
[2]Calculated from January weaning date to end of winter treatment on May 15 (126 days).
[3]Calculated from removal of winter treatment on May 15 to July 14 (60 days).

Table 3. Effects of winter treatment[1] and feedlot system[2] on steer performance.

	HAY		MDW			P-Value	
	Calf-fed	Yearling-fed	Calf-fed	Yearling-fed	SE	Winter treatment	Feedlot System
Winter ADG[3], lb	1.50	1.57	0.79	0.79	0.04	0.03	0.64
May BW, lb	637	650	556	547	11	0.07	0.86
Feedlot entry BW, lb	637	809	556	743	15	≤0.06	0.09
Feedlot ADG[4], lb	3.90	4.19	4.18	4.14	0.02	0.47	0.39
Final BW[5], lb	1,470	1,508	1,446	1,430	29	0.28	0.77
HCW, lb	926	950	911	902	15	0.28	0.77
Marbling score[6]	520	555	521	544	8.4	0.71	0.43
12th rib fat, in	0.56	0.59	0.56	0.58	0.03	0.90	0.65
LM area, in^2	14.7	14.8	14.4	14.3	3	0.41	0.94
Yield grade	3.17	3.36	3.25	3.35	0.12	0.83	0.43
USDA Choice, %	93	96	90	100.0	0.06	0.95	0.34
1,000 lb carcass, %	11	28	18	4	0.09	0.42	0.83

[1]Winter grazing treatments: HAY = meadow hay (ad libitum) and 4 lb 28% CP supplement; MDW = grazed winter meadow and 1 lb 28% CP supplement.
[2]Feedlot system: Calf-fed steers entered feedlot on May 15; Yearling-fed steers entered feedlot on August 30.
[3]Weaning (January) to end of winter treatment (May 15, 126 days).
[4]May 15 to December 11 (210 days) for calf-fed system and September 14 to February 28 (167 days) for yearling-fed system.
[5]Calculated from HCW, adjusted to a 63% dressing percentage.
[6]Small^{00} = 400.

Effects of Calf Age at Weaning on Cow and Calf Performance and Efficiency in a Drylot/Confinement Production System

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Summary

An ongoing study evaluated the effects of calf age at weaning on cow and calf performance and reproduction in a confinement production system. Early-weaning improved cow BW at normal weaning. Pregnancy rates were not impacted by calf age at weaning. Dry matter intake was not different between early-weaned cows and calves compared with normal-weaned pairs. Feed requirements and energy utilization were equal between early- and normal-weaned pairs when fed a distillers grains and crop residue based diet.

Introduction

Increases in grain prices and the subsequent impact on land values and lease rates have challenged the long-term availability of forage for summer grazing. Recent drought conditions have decreased forage production and diminished rangeland carrying capacity in certain areas. Maintaining cow-calf pairs in total or semi-confinement may be a viable alternative for producers when grass is limited or unavailable due to drought and other factors. Limit-feeding high energy diets to cows in confinement can be utilized to reduce feed costs without negatively impacting performance as compared to feeding forage *ad libitum* (*2009 Nebraska Beef Cattle Report*, pp. 11-12). Early-weaning of calves reduces cow maintenance requirements and may have beneficial effects on reproduction (*Journal of Animal Science*, 68:1438-1446). Additionally, early-weaned calves are very efficient at converting feed to gain (*Journal of Animal Science*, 78:1403-1413). Thus, early weaning may be logical when cow-calf pairs are maintained in confinement. Therefore, our objectives were to: 1) evaluate the impact of calf age at weaning on cow BW, BCS, reproduction, and calf performance when cow-calf pairs are limit-fed high energy diets in a drylot/confinement production system; and 2) compare the energy efficiency of producing a weaned calf to 205 days of age between early and normal weaning.

Procedure

Multiparous, crossbred (Red Angus x Red Poll x Tarentaise x South Devon x Devon), lactating beef cows (n = 84) with summer-born calves at side were utilized in a continual study (2012 - present) conducted at both the University of Nebraska–Lincoln Agricultural Research and Development Center (ARDC) feedlot located near Mead, Neb. and the Panhandle Research and Extension Center (PHREC) feedlot at Scottsbluff, Neb. The trial was a randomized complete block design with a 2 x 2 factorial arrangement of treatments. Cows were blocked by pre-breeding BW (heavy, medium, and light), stratified by calf age, and assigned randomly within strata to one of four treatments with three replications (pens) per treatment. Treatment factors included: 1) calf age at weaning; early weaned (EW) at 90 days of age or normal weaned (NW) at 205 days of age and 2) research location: eastern (ARDC) or western (PHREC) Nebraska. Data reported are for year 1 only.

Prior to the beginning of the experiment, cows at both locations were managed as a common group and calved in June and July in earthen feedlot pens without access to shade. Post-calving, cows were limit-fed approximately 19.0 lb DM/cow/day a diet of 50% wet or modified distillers grains plus solubles (WDGS; MDGS) and 50% ground cornstalks (ARDC) or wheat straw (PHREC), on a DM basis. Upon trial initiation (late-September), EW calves were weaned at 90 days of age, and fed separately from their dams within each location. Normal-weaned calves remained with their dams and were weaned in late January at 205 days of age. Two-day consecutive cow BW measurements were recorded to determine weight change from pre-breeding to normal-weaning. Body condition score was assessed visually at pre-breeding and normal weaning by the same experienced technician. Two-day consecutive calf BW measurements were collected to evaluate gain from early to normal weaning. Prior to collecting weights, all cattle were limit-fed (1.3% of BW for cows, 2.0% of BW for calves; DM basis) for 5 days prior to initiation and upon completion of the trial to minimize variation in gastrointestinal tract fill.

Table 1. Ingredient and nutrient composition of diets fed to all cows and calves from early to normal weaning by location[1].

	Location	
Ingredient, %	ARDC	PHREC
MDGS	56.5	
WDGS	—	58.0
Cornstalks	40.0	—
Wheat straw	—	40.0
Supplement[2]	3.5	2.0
Calculated Composition		
CP, %	19.0	18.8
TDN, %	80.0	80.0
Ca, %	0.75	0.77
P, %	0.50	0.49

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

From early to normal weaning, EW cows within each location were limit-fed 15.0 lb DM/cow daily a diet consisting of either WDGS or MDGS and cornstalks or wheat straw (Table 1). Concurrently, EW calves within each location were offered *ad libitum* access to the same diet as the cows. Normal-weaned cow-calf pairs were limit-fed the equivalent amount of DM by adding the DMI of the EW cows and calves. Intake was not partitioned between the NW cow and calf. Consequently, the total DMI between either the EW cows and calves or the NW pairs was intended to be equal and increased due to growth of the calf. All cattle were pen-fed once daily in concrete fence line feed bunks with the following bunk space allotments: 2 feet per EW cow, 1 foot per EW calf,

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Table 2. Daily DMI by weaning treatment.

	Weaning Treatment	
Item	EW[1]	NW[2]
Cow	15.0	—
Calf	8.5	—
Cow-calf pair	—	22.8
Total	23.5	22.8

[1]EW = early-weaned at 90 days of age.
[2]NW = normal weaned at 205 days of age.

and 3 feet per NW cow-calf pair.

Cows were exposed to fertile Simmental x Angus bulls at a bull:cow ratio of 1:10 for 60 days beginning September 26 (concurrent with early-weaning), and breeding occurred in the feedlot pens. Pregnancy was diagnosed via ultrasound 60 days after bull removal.

Data were analyzed as a randomized complete block design with pen as the experimental unit. Model fixed effects included calf age at weaning, location, and the weaning x location interaction. Block was included in the analysis as a random effect, and significance was declared at $P \leq 0.05$.

Results

Across locations, EW calves had a daily DMI of 8.5 lb from early to normal weaning (Table 2). This amount was adjusted weekly and added to the 15.0 lb DM fed to the EW cows to derive the total amount fed to the NW pairs. Therefore, the EW cows and calves consumed 23.5 lb total DM/day while the NW pairs consumed 22.8 lb DM/day, supplying 18.8 and 18.2 lb of TDN to EW and NW treatments, respectively.

The weaning age by location interaction was not significant for cow BW at normal weaning (Table 3). Cows at PHREC had greater BW than ARDC cows, and EW cows had greater BW than NW cows at normal weaning. Although there was a significant weaning age by location interaction for BW change, EW cows gained more BW than NW cows regardless of location. Body condition score was not different among treatments at either pre-breeding or normal weaning. However, regardless of weaning regimen, PHREC cows gained 0.2 BCS units while ARDC cows lost 0.2 BCS units between early and normal weaning. Pregnancy rates (88.2-90.5%) were not impacted by calf age at weaning, but additional years are needed to gain statistical power.

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

	ARDC		PHREC			*P*-value		
Item	EW[4]	NW[5]	EW[4]	NW[5]	SEM	Weaning[1]	Location[2]	W x L[3]
Cow BW, lb								
Pre-breeding	1115	1101	1150	1134	90	0.56	0.21	0.95
Normal-weaning	1129[b]	1109[b]	1266[a]	1165[b]	89	0.05	0.01	0.16
Cow BW change, lb	15[b]	7[b]	115[a]	32[b]	12	0.01	<0.01	0.02
Cow BCS[6]								
Pre-breeding	5.4	5.3	5.0	5.0	0.3	0.56	0.06	0.91
Normal-weaning	5.1	5.1	5.4	5.1	0.3	0.23	0.23	0.34
Cow BCS change[6]	-0.3[c]	-0.2[c]	0.3[a]	0.1[b]	0.1	0.23	<0.01	0.03

[1]Fixed effect of calf age at weaning.
[2]Fixed effect of location.
[3]Calf age at weaning x location interaction.
[4]EW = early weaned at 90 days of age.
[5]NW = normal weaned at 205 days of age.
[6]BCS on a 1 (emaciated) to 9 (obese) scale.
[a-c]Within a row, least squares means without common superscripts differ at $P \leq 0.05$.

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

	ARDC		PHREC			*P*-value		
Item	EW[4]	NW[5]	EW[4]	NW[5]	SEM	Weaning[1]	Location[2]	W x L[3]
Calf BW[6], lb								
Early-weaning	274	276	295	288	14	0.85	0.23	0.76
Normal-weaning	447[b]	501[a]	494[a]	479[a,b]	13	0.17	0.36	0.03
Calf ADG, lb	1.48[b]	1.93[a]	1.65[b]	1.58[b]	0.05	0.01	0.12	<0.01

[1]Fixed effect of calf age at weaning.
[2]Fixed effect of location.
[3]Calf age at weaning x location interaction.
[4]EW = early weaned at 90 days of age.
[5]NW = normal weaned at 205 days of age.
[6]Actual weights.
[a-b]Within a row, least squares means without common superscripts differ at $P \leq 0.05$.

Calf BW and gain data are presented in Table 4. Weight was similar among treatments at early-weaning. There was a significant weaning age by location interaction for ADG. Early weaned and NW calves at PHREC were not statistically different, while NW calves gained significantly more than EW calves at ARDC. As a result, EW and NW calves at PHREC had similar BW at normal weaning while NW calves were heavier than EW at ARDC.

Reasons for the weaning age by location interactions among cow and calf performance variables are unclear but may be related to lack of statistical power in one year of data. However, when evaluating only the main effect of weaning age for cow BCS change, both EW and NW cows on average maintained body condition (Table 3). Furthermore, such changes in BCS are small and likely have little biological relevance. Cow BW change from early to normal weaning was 45 lb greater on average for EW than NW cows. Likewise, EW calves gained 19 lb less than NW calves from early to normal weaning, indicating that the sum weight of the EW pair was similar to that of the NW pairs. Dry matter intake was also similar between EW and NW pairs implying energy utilization is comparable when pairs are fed distillers grains and crop residue based diets. Our preliminary data suggest early weaning has minimal impact on cow or calf performance or cow reproduction when pairs are limit-fed high energy diets in confinement. Furthermore, early-weaned cows and calves require the same amount of feed as normal weaned pairs together. Limit-feeding distillers grains and crop residue based diets to cow-calf pairs in confinement may be a viable alternative for producers when grass is limited or unavailable.

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Effects of Forage Quality, MDGS, and Monensin on Performance, Methane Concentration, and Ruminal Fermentation of Growing Cattle

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Summary

A growing study was conducted to evaluate a novel method for measuring methane concentration by feedlot cattle, and to determine the effects of forage quality, inclusion of modified distillers grains plus solubles (MDGS), and presence or absence of monensin on performance, methane concentration, and rumen fermentation characteristics. Performance was improved by use of high-quality forage and MDGS, while response to monensin was variable across basal diet type. Response of methane concentration and volatile fatty acid (VFA) profile due to diet was variable and subject to multiple interactions, reflecting the complexity of the microbial processes involved within the rumen.

Introduction

Methane emissions by ruminant livestock have recently garnered interest as a significant source of greenhouse gasses, although livestock account for only 3.6% of greenhouse gas emissions in the United States or about one-third of all agriculture sources. Methane is one gas that contributes to total greenhouse gas emissions, and cattle account for 20% of U.S. methane. Despite the relatively small contribution of methane from cattle to total emissions, methane emissions from cattle should be a concern to producers not only from an environmental standpoint, but also because the production of methane represents an energetic loss to the animal. Diet is one of the main determinants of methane production, thus prompting recent work evaluating nutritional mitigation strategies. However, much of this work has been conducted on a small scale using intensive techniques such as respiration chambers or head boxes. Therefore, a method of gas collection and analysis was developed to allow evaluation of methane emissions by a large number of growing cattle under conditions that more closely mimic a production setting. The objective of this study was to evaluate the effect of forage quality, level of MDGS inclusion, and presence or absence of monensin on performance, methane concentration emitted by cattle, and ruminal VFA profile in growing calves and to determine the degree to which methane concentration and rumen fermentation characteristics are correlated.

Procedure

An 84-day growing study was conducted using 120 crossbred steers (initial BW = 661 ± 55 lb) that were individually fed using the Calan gate system. Five days before trial initiation, cattle were limit-fed a common diet of 50% alfalfa hay and 50% *Sweet Bran*® at 2% of BW to reduce variation in gut fill and then weighed on three consecutive days, with the average used as initial BW. Steers were stratified by initial BW and assigned randomly to one of 10 treatments based on the first two-day weights, with 12 steers per treatment. Six of these treatments (Table 1) were designed as a 2×2+2 factorial and were used in the analysis of performance. These diets consisted of four high-quality forage (blend of alfalfa and sorghum silage) diets with 0 or 40% MDGS and with or without monensin, and two low-quality forage (ground corn stalks) diets with 40% MDGS with or without monensin. Performance of cattle on the remaining treatments is discussed in the *2014 Nebraska Beef Cattle Report* (pp. 32-33. Methane and VFA measurements were collected on all 120 steers and all 10 treatments were used in those analyses. Steers were implanted with Ralgro on day 21. At the end of the study, cattle were again limit-fed the common diet for five days and weighed on three consecutive days to obtain ending BW.

To facilitate the collection of respired air by the cattle to be analyzed for methane and carbon dioxide, the individual Calan gate bunks were partially enclosed and outfitted with a small air pump that was used to gradually fill a gas collection bag. Gas collection was conducted at feeding, and gas sample bags were filled at a constant rate over approximately 10 minutes. Samples were collected only while steers were in their bunks. The

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

	High-quality Forage				Low-quality Forage	
	0 MDGS[1]		40 MGDS		40 MGDS	
Monensin[2]	Y	N	Y	N	Y	N
Alfalfa	57	57	33	33	0	0
Sorghum silage	38	38	22	22	0	0
Corn stalks	0	0	0	0	55	55
MDGS	0	0	40	40	40	40
Supplement	5	5	5	5	5	5

[1]MDGS = modified distillers grains plus solubles.
[2]Diets with monensin were formulated to provide 200 mg/head/day.

collected gas consisted of a mixture of respired gasses and ambient air and was analyzed within 24 hours for concentration of methane and carbon dioxide in ppm using a gas chromatograph. Methane data are expressed as a ratio of methane to carbon dioxide (CH_4:CO_2) where CO_2 can be used as an internal marker since its production is relatively constant across cattle of similar size, type, and production level. Gas samples were collected from each steer a total of four times, about once every 21 days. Volatile fatty acid profile was evaluated using rumen fluid collected via esophageal tubing on day 21 and 63 prior to feeding. A portion of rumen fluid was also frozen and stored at -80° C for future microbial community analysis.

Additionally, VFA profile was used to estimate methane concentration in the theoretical fermentation balance equation proposed by Wolin, et al. 1960 (*Journal of Animal Science).* The predicted methane concentration was analyzed and compared to observed methane to carbon dioxide ratio. All data were analyzed using the Mixed procedure of SAS (SAS Institute, Inc., Cary, N.C.) with steer as the experimental unit. Methane and VFA data were analyzed using sampling point as the repeated measure.

Results

Steers fed diets based on high-quality forage were 134 lb heavier at the end of the growing period than those fed low-quality forage based diets ($P < 0.01$; Table 3). Cattle fed 40% MDGS in high-quality forage diets had heavier ending BW than those consuming no MDGS ($P < 0.01$; Table 2). This is not surprising considering cattle on high-quality forage diets also consumed 37% more DM, had greater ADG, and were more efficient than cattle consuming low-quality forage ($P < 0.01$). When comparing steers fed high-quality forage diets, those consuming 40% MDGS had greater DMI and ADG; and lower F:G than those not receiving MDGS ($P < 0.01$). A MDGS level by monensin interaction was observed for ADG ($P = 0.02$) and F:G ($P = 0.03$) in high-quality forage diets. Presence of monensin in the diet improved ADG and had no effect on F:G in diets containing 40% MDGS. However, in the absence of MDGS, monensin decreased ADG and resulted in poorer efficiency ($P < 0.05$). No effect due to monensin was observed when comparing only diets containing 40% MDGS (Table 3).

Methane to CO_2 ratio was not affected by inclusion level and oil content of MDGS or by presence of monensin in high-quality forage diets (Table 4). However, in diets with 40% MDGS, a forage quality x monensin interaction was observed ($P = 0.02$, Table 5). Monensin had no effect on CH_4:CO_2 in high-quality forage, but decreased CH_4:CO_2 by 16% in low-quality forage diets. Using actual VFA profile in the prediction equation of Wolin generates a theoretical production of methane in moles of CH_4 /100 mol of total VFA concentration. Measurement of total VFA production was not possible in the current study, but this estimated value may be of some value to compare with our observed CH_4:CO_2. In high-quality forage diets, presence of both MDGS and monensin decreased theoretical CH_4 ($P < 0.01$), whereas no effect was observed in CH_4:CO_2.

Table 2. Effect of level of MDGS and presence of monensin on cattle performance in diets containing high-quality forage.

	0 MDGS		40 MDGS			*P*-value[1]		
Monensin	Y	N	Y	N	SEM	Level	Mon	Level*Mon
Initial BW, lb	660	663	661	658	7.0	0.80	0.99	0.67
Ending BW, lb	822	836	959	931	11.6	<0.01	0.53	0.08
DMI, lb/day	19.6	19.5	22.8	21.9	0.75	<0.01	0.53	0.60
ADG, lb	1.93[d]	2.06[c]	3.55[a]	3.25[b]	0.09	<0.01	0.34	0.02
F:G	10.2[c]	9.5[b]	6.5[a]	6.8[a]	0.23	<0.01	0.47	0.03

[1]*P*-value: Level = main effect of MDGS inclusion level, Mon = main effect of presence of monensin, Level*Mon = effect of interaction between level and monensin.
[a,b,c,d]Means in a row with different superscripts are different ($P < 0.05$).

Table 3. Effect of forage quality and presence of monensin on cattle performance in diets containing 40% MDGS.

	High-quality forage		Low-quality forage			*P*-value[1]		
Monensin	Y	N	Y	N	SEM	Forage	Mon	Forage*Mon
Initial BW, lb	661	658	663	663	7.6	0.67	0.81	0.88
Ending BW, lb	959	931	809	814	12.2	<0.01	0.35	0.17
DMI, lb/day	22.8	21.9	13.7	14.5	0.45	<0.01	0.96	0.07
ADG, lb	3.64	3.34	1.83	1.91	0.19	<0.01	0.27	0.07
F:G	6.5	6.8	8.2	8.2	0.34	<0.01	0.58	0.65

[1]*P*-value: Forage = main effect of forage quality, Mon = main effect of presence of monensin, Forage*Mon = effect of interaction between forage quality and monensin.

Table 4. Effects of MDGS level and monensin in high-quality forage diets.

	0 MDGS		40 MDGS			*P*-value[1]		
Monensin	Y	N	Y	N	SEM	MDGS	Mon	MDGS*Mon
CH_4:CO_2	0.101	0.104	0.100	0.102	0.003	0.69	0.39	0.74
Total VFA, Mm	36.3	38.3	32.2	43.6	2.86	0.82	0.02	0.10
Acetate, mol/100 mol	71.3	72.8	66.8	67.2	0.48	<0.01	0.04	0.23
Propionate, mol/100 mol	15.2	14.5	17.7	17.0	0.42	<0.01	0.11	0.98
Butyrate, mol/100 mol	8.4[b]	7.9[b]	8.7[b]	9.7[a]	0.29	<0.01	0.33	<0.01
Acetate:Propionate	4.78	5.05	3.81	3.99	0.12	<0.01	0.06	0.70
Theoretical mol CH_4[2]	35.9	36.6	32.9	33.8	0.24	<0.01	<0.01	0.69

[1]*P*-value: MDGS = main effect of MDGS inclusion level, Mon = main effect of presence of monensin, MDGS*Mon = effect of interaction between level of MDGS and monensin
[2]Calculated mol of methane produced per 100 mol VFA
[a,b,c]Means in a row with different superscripts are different ($P < 0.05$).

Table 5. Effects of forage quality and monensin in diets containing 40% de-oiled MDGS.

	High-quality forage		Low-quality forage			*P*-value[1]		
Monensin	Y	N	Y	N	SEM	Forage	Mon	Forage*Mon
CH_4:CO_2	0.101	0.102	0.083	0.099	0.003	<0.01	<0.01	0.02
Total VFA, Mm	32.2[b]	43.5[a]	38.6[a,b]	38.7[a,b]	2.65	0.76	0.04	0.04
Acetate, mol/100 mol	66.9	67.3	70.8	70.8	0.56	<0.01	0.73	0.69
Propionate, mol/100 mol	17.7	17.1	17.8	17.9	0.34	0.20	0.51	0.24
Butyrate, mol/100 mol	8.6	9.7	5.8	6.6	0.24	<0.01	<0.01	0.54
Acetate:Propionate	3.81	3.97	4.01	3.96	0.093	0.30	0.54	0.24
Theoretical mol CH_4[2]	33.0	33.8	33.6	34.0	0.24	0.09	0.01	0.28

[1]*P*-value: Forage = main effect of forage quality, Mon = main effect of presence of monensin, Forage*Mon = effect of interaction between forage quality and monensin
[2]Calculated mol of methane produced per 100 mol VFA
[a,b,c]Means in a row with different superscripts are different ($P < 0.05$).

Table 6. Effects of type and level of MDGS in diets containing low-quality forage and monensin.

	De-oiled		Normal			*P*-value[1]		
	20 MDGS	40 MDGS	20 MDGS	40 MDGS	SEM	Type	Level	Type*Level
CH_4:CO_2	0.084	0.083	0.086	0.082	0.004	0.96	0.43	0.64
Total VFA, Mm	32.6	38.5	38.9	32.2	3.15	0.99	0.90	0.05
Acetate, mol/100 mol	71.8	71.0	71.7	72.1	0.62	0.41	0.70	0.35
Propionate, mol/100 mol	17.6[a]	17.8[a]	18.3[a]	15.7[b]	0.42	0.09	<0.01	<0.01
Butyrate, mol/100 mol	6.7	5.8	6.3	6.0	0.169	0.51	<0.01	0.12
Acetate:Propionate	4.10[b]	4.02[b]	3.95[b]	4.72[a]	0.160	0.09	0.03	0.01
Theoretical mol CH_4[2]	34.7[a]	33.7[b]	34.3[a,b]	34.9[a]	0.35	0.25	0.48	0.03

[1]*P*-value: Type = main effect of type of MDGS (De-oiled or Normal), Level = main effect of level of MDGS inclusion, Type*Level = effect of interaction between type and inclusion of MDGS.
[2]Calculated mol of methane produced per 100 mol VFA.
[a,b,c]Means in a row with different superscripts are different ($P < 0.05$).

The Wolin equation also predicted a decrease in CH_4 due to monensin in diets containing MDGS, which agrees with observed CH_4:CO_2. Future work is planned to improve use of prediction equations, and to estimate CO_2 production, which will be used to convert CH_4:CO_2 to a more useful methane production value.

Total Mm concentration of VFA in rumen fluid collected in this study is lower than may have been expected. This is likely due to time of sampling, as cattle were tubed in the morning prior to feeding and had relatively low DMI compared to VFA concentrations that would be seen in finishing cattle on full feed. In diets containing 40% MDGS, steers fed high-quality forage had decreased acetate and increased butyrate concentrations ($P < 0.01$). This is indicative of fermentation of more digestible fiber compared to low-quality forage. Forage quality did not affect acetate to propionate ratio ($P = 0.30$). In high-quality forage based diets, inclusion of 40% MDGS also decreased acetate, increased propionate, and decreased acetate to propionate ratio ($P < 0.01$), as would be expected with the addition of an increase in total diet digestibility. Monensin tended ($P = 0.06$) to decrease acetate to propionate ratio in these diets as well, while presence of MDGS negated the effect of monensin on acetate to propionate ratio. A type of MDGS (de-oiled or normal) x inclusion level interaction was observed for propionate concentration ($P < 0.01$) and acetate to propionate ratio ($P = 0.01$). Increasing de-oiled MDGS from 20 to 40% of diet DM had no effect, while increasing inclusion of normal-fat MDGS actually decreased propionate and increased acetate to propionate ratio. This unexpected result may be due to the high fiber nature of these diets, where added fat may inhibit digestibility.

These data represent the first effort into a new area of research for our group. Work is ongoing to refine both the methods used for collecting methane in this setting, and the calculations used to generate meaningful estimates of methane emissions. These data suggest that methane concentration by growing cattle can be manipulated by diet composition. Differences in forage type and the inclusion of MDGS and monensin did appear to influence ruminal fermentation, and as a result methane concentration.

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Energy Value of De-Oiled Modified Distillers Grains Plus Solubles in a Forage-Based Diet

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Summary

Sixty individually fed steers were used to determine the effects of feeding de-oiled modified distillers grains plus solubles (MDGS) on steer performance in an 84-day forage-based growing study. De-oiled MDGS did not significantly alter performance when compared to normal MDGS if fed at the same concentration in growing diets. Inclusion of either de-oiled or normal MDGS at 40% of the diet resulted in improved ending BW, DMI, ADG, and F:G as compared to inclusion of 20% MDGS in the diet.

Introduction

Recently, it has become increasingly common for ethanol plants to remove oil from the thin stillage component of the distillers grain product. Ethanol plants have been finding market value in the corn oil produced from the ethanol process, and thus have begun to remove the oil from the thin stillage constituent via centrifugation. Previous research suggests fat content of modified distillers grains plus solubles (MDGS), when fed at 40% of the diet, does not affect ADG, HCW, and F:G in a feedlot finishing trial (*2013 Nebraska Beef Cattle Report*, pp.64-65). The effects of feeding de-oiled condensed distillers solubles (CDS) in growing cattle diets has been previously evaluated. Feeding 20% normal CDS improved feed efficiency by 13.6% compared to de-oiled CDS, but only improved feed efficiency by 1% at 40% inclusion (*2013 Nebraska Beef Cattle Report,* pp. 25-26). We hypothesized that feeding normal MDGS would improve performance compared to de-oiled MDGS when fed at low inclusions, but would not be different at 40% inclusion because of negative associative effects of feeding fat with fiber. Thus, the objective of this study was to determine the energy value of de-oiled MDGS at two inclusions in a forage-based diet.

Procedure

An 84-day growing study utilized 60 crossbred steer calves (BW = 660 ± 56) that were individually fed using the Calan gate system at the University of Nebraska–Lincoln Agricultural Research and Development Center (ARDC) near Mead, Neb. Prior to the start of the trial, steers were limit-fed a diet consisting of 25% alfalfa, 25% grass hay, and 50% *Sweet Bran*® at 2.0% BW for five days to minimize differences in gut fill. Steers were then weighed on three consecutive days to determine initial BW. Based on initial BW, steers were blocked into six blocks and then assigned randomly to one of five treatments within block. Treatments were organized in a 2x2+1 factorial design, with five total treatments and 12 steers per treatment. The first treatment factor was concentration of distillers grains at 20% or 40% of the diet (Table 1). The second factor was either de-oiled (7.2% fat) or normal (12.0% fat) modified distillers grains plus solubles (MDGS). A 40% (DM basis) dry-rolled corn (DRC) diet was used as the control. Corn stover (ground through a 1-inch screen) and supplement comprised the remainder of all five diets. All diets were formulated to meet the metabolizable protein requirements using the 1996 NRC model. Cattle consuming the 40% DRC control or 20% distillers grains diets had urea supplemented at 1.65% of the diet to meet metabolizable protein requirements. Diets were also formulated to provide 200mg/steer of monensin daily. All steers received a Ralgro implant on day 21 of the study.

Feed refusals were collected weekly, weighed, and then dried in a 60°C forced air oven for 48 hours to calculate an accurate DMI for individual steers. Feed ingredient samples were

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

	Control[1]	De-Oiled MDGS[2]		Normal MDGS[2]	
Ingredient, % of DM	0	20	40	20	40
De-oiled MDGS	—	20.0	40.0	—	—
Normal MDGS	—	—	—	20.0	40.0
DRC	40.0	—	—	—	—
Corn Stover	55.0	75.0	55.0	75.0	55.0
Fine Ground Corn	1.68	1.68	3.41	1.68	3.41
Limestone	1.19	1.19	1.11	1.19	1.11
Salt	0.30	0.30	0.30	0.30	0.30
Tallow	0.10	0.10	0.10	0.10	0.10
Urea	1.65	1.65	0.00	1.65	0.00
Rumensin-90[3]	0.01	0.01	0.01	0.01	0.01
Trace Mineral premix	0.05	0.05	0.05	0.05	0.05
Vitamin ADE premix	0.02	0.02	0.02	0.02	0.02
Diet Composition (% diet DM)					
Fat	2.25	2.25	3.45	3.25	5.45
Sulfur	0.12	0.19	0.30	0.18	0.28
Protein	12.28	16.76	16.18	17.89	16.73
NDF	48.64	68.10	68.28	59.44	59.80

[1]Urea was added to supplements formulated for control and 20% distillers grain diets to meet metabolizable protein requirements.
[2]MDGS=modified distillers grains plus solubles.
[3]All diets formulated to provide 200 mg/steer daily of Rumensin.

Table 2. Effects of de-oiled and normal fat MDGS[1] fed at 20 and 40% inclusion in forage-based diets.

	20 % MDGS		40% MDGS		40% DRC			*P*-values[2]		
	De-oiled	Normal	De-oiled	Normal	Control	SEM	F-Test	Concentration	Type	Int
Initial BW, lb	659	663	663	661	660	5	0.98	0.83	0.90	0.58
Ending BW, lb	731[a]	728[a]	809[c]	797[b,c]	772[b]	10	<0.01	<0.01	0.39	0.64
DMI, lb/day	11.6[a]	10.9[a]	13.7[b]	12.9[b]	13.1[b]	0.4	<0.01	<0.01	0.05	0.95
ADG, lb	0.86[a]	0.77[a]	1.73[c]	1.61[c]	1.33[b]	0.10	<0.01	<0.01	0.26	0.85
Feed:Gain	13.89[a]	14.09[a]	7.94[c]	7.87[c]	9.80[b]	—	<0.01	<0.01	0.85	0.98

[1]Modified distillers grains plus solubles.
[2]Concentration = Main effect of MDGS concentration in the diet; Type = Main effect of de-oiled vs. normal MDGS; Int = Interaction of MDGS concentration and MDGS type.
[a,b,c]Means with unlike superscript letters differ ($P = 0.05$).

collected each week throughout the trial, and analyzed for fat, sulfur, protein, and fiber content. At the conclusion of the study, steers were limit-fed for five days the same diet fed prior to the start of the trial and then were weighed on three consecutive days and averaged to determine an accurate ending BW.

Data were analyzed as a 2X2 factorial arrangement of treatments to evaluate the interaction of MDGS concentration (20% vs. 40%) and fat content (de-oiled vs. normal). If no interaction was detected ($P < 0.05$), main effects were evaluated. Additionally, an F-test was used to determine the response to the 40% DRC control to other treatments. Treatment means were separated using a t-test ($P < 0.05$) when the F-test was significant ($P < 0.05$).

Using the 1996 NRC, the energy value of MDGS relative to DRC was calculated by using the observed ADG. First, the TDN of MDGS and cornstalks were set at 108% and 43%, respectively. Then the NE adjusters were set so that the observed ADG was achieved in the model for 20% and 40% MDGS inclusion. This resulted in NE adjusters of 131% and 106% for 20% and 40% MDGS, respectively. The change in NE adjuster per change in ADG was calculated to determine the NE adjuster required to achieve the ADG for the 40% DRC control (116%). Finally, the TDN of DRC was adjusted to achieve the observed gain for the 40% DRC control. The resulting TDN for DRC was estimated to be 87% which is similar to a previous estimated TDN of DRC in forage-based diets of 83% (*2003 Nebraska Beef Cattle Report,* pp. 8-10). The TDN of DRC was compared to the TDN of MDGS to provide a relative energy value of MDGS to DRC in a growing, forage-based diet.

Results

The fat content of the de-oiled and normal MDGS were 7.2% and 12.0%, respectively, and DRC and corn stover contained 4.0% and 1.0% fat, respectively. Sulfur content was 0.63% and 0.57% for de-oiled and normal MDGS, and 0.16% and 0.10% for DRC and corn stover, respectively. Protein content was 35.5% and 32.6% for de-oiled and normal MDGS, respectively, and 9.9% and 6.7% for DRC and corn stover, respectively. Fiber (i.e., NDF) content was 37.5% and 38.4% for de-oiled and normal MDGS, respectively, 10.5% for DRC, and 80.8% for corn stover. There was no inclusion by fat content interaction observed between de-oiled and normal MDGS at either 20% or 40% inclusion in this study (Table 2). Main effects of concentration and fat content of MDGS will be discussed.

Concentration of MDGS

As expected, feeding 40% MDGS resulted in greater ending BW, DMI, and ADG ($P < 0.01$) compared to 20% MDGS. Additionally, steers consuming 40% MDGS had improved F:G ($P < 0.01$) compared to steers consuming 20% MDGS.

Fat Content

Steers receiving diets with MDGS containing 7.2% fat had a greater DMI when compared to steers fed MDGS containing 12.0% fat ($P = 0.05$). Ending BW ($P = 0.39$) and ADG ($P = 0.26$) were not significantly different for steers fed de-oiled or normal MDGS diets, but steers fed diets containing 12.0% fat numerically gained less than those consuming 7.2% fat diets causing F:G to be unaffected ($P = 0.85$).

Energy Value

Cattle consuming the 40% DRC control diet tended to be lighter at the conclusion of the study compared to the those cattle receiving the 40% normal MDGS diet ($P = 0.08$). Their DMI was not different compared to cattle receiving either 40% de-oiled or normal MDGS ($P = 0.28$ and $P = 0.81$ respectively), and ADG and F:G were intermediate for steers fed the DRC control diet compared to steers fed 20% or 40% inclusion of either normal or de-oiled MDGS. The energy value of MDGS relative to corn was calculated to be 124% for these growing calves. The results of this study suggest that removing oil from thin stillage to create MDGS fat content of 7.2% vs. 12.0% does not alter cattle performance in forage-based diets. Further reduction of corn oil in MDGS may result in decreased performance, thus further research will be required if additional oil is removed from distillers grains.

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Replacement of Grazed Forage and Animal Performance when Distillers Grains are Fed in a Bunk or on the Ground on Summer Range

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Summary

Forage savings and supplement loss caused by feeding on the ground were estimated when spayed yearling heifers were fed modified distillers grains with solubles (MDGS) while grazing Sandhills summer range. Across two years, heifers fed 0.6% BW MDGS had 1.39 lb greater ADG and consumed approximately 17% less forage than non-supplemented heifers. Calculated loss of MDGS when fed on the ground was 5.6%. Supplementing MDGS decreased forage consumption approximately 17% and increased summer gains.

Introduction

Distillers grains, a byproduct of the corn milling industry, fits well into forage-based diets as it contains a highly fermentable fiber source which does not hinder forage digestion, and also supplies undegradable intake protein (UIP) to meet metabolizable protein deficiencies common in grazing situations (*2004 Nebraska Beef Cattle Report,* pp. 25-27).

Distillers grains supplementation has been shown to increase growing cattle ADG while reducing forage intake in a forage-based system *(2005 Nebraska Beef Cattle Report,* pp. 18-20). Forage intake was reduced 0.5 lb for each 1.0 lb of distillers grains fed, as summarized from six distillers grains supplementation studies (2007 *Nebraska Beef Cattle Report*, pp. 10-11). Distillers grains loss when fed on the ground appears to be affected by distillers grain form, animal type, and grazing situation. Wet distillers grains with solubles (WDGS) fed to yearling steers on Sandhills winter range resulted in a 13-20% loss (*2010 Nebraska Beef Cattle Report,* pp. 17-18), while dried distillers grains with solubles (DDGS) fed to calves on a subirrigated meadow resulted in a 36-41% loss (*2012 Nebraska Beef Cattle Report*, pp. 51-52). Thus, the objectives of this study were to determine forage replacement rate and performance of spayed yearling heifers when supplemented with MDGS at 0.6% BW while grazing native Sandhills summer range, and calculate MDGS loss that resulted from ground feeding.

Procedure

Each year for two years, 24 spayed yearling heifers were stratified by initial BW (620 ± 57 lb) and assigned randomly to treatment. Treatments were: 1) no supplementation (control), 2) MDGS supplementation fed at 0.6% of BW daily in a bunk, and 3) MDGS supplementation fed at 0.6% of BW daily on the ground. There were two replications per treatment, with four heifers per replication. Treatments were assigned randomly to an east and west grazing block to minimize potential differences in plant species and topography. Heifers grazed upland Sandhills summer range 120 days at the Gudmundsen Sandhills Laboratory near Whitman, Neb., beginning May 18, 2011 (year 1) or May 23, 2012 (year 2). Year 2 data were collected during a severe drought.

Heifers in each replication rotated through six, 2.47-acre paddocks twice throughout the grazing season. Paddocks were stocked at 0.8 AUM/acre. Grazing days per paddock were increased during the second grazing cycle to account for additional forage growth. Based on previous research that has shown distillers supplementation results in a 17% forage replacement rate, paddocks were stocked for equal grazing pressure between treatments by allowing control cattle to graze each of their paddocks for 17% less time than supplemented cattle. This was achieved by moving control cattle one day earlier than supplemented cattle during a six-day grazing cycle from their grazing paddock to a pasture of similar forage species composition and moving control cattle 2 ½ days earlier during the 14-day cycle. Therefore, control cattle were managed separately until rotating into their next paddock on the same day that supplemented cattle rotated.

Forage diet samples were collected using esophageally fistulated cows at the midpoint of each grazing rotation during the first, third, and fifth rotations of both grazing cycles, for 12 total collections. Forage quality (CP, NDF, and IVDMD) was analyzed from extrusa samples. *In vitro* organic matter digestibility was adjusted to *in vivo* values. Unlike year 1 diet collections, in year 2, solid bottom bags, rather than screen bottom bags, were used during diet collection and CP, NDF, and IVOMD analyses were calculated to account for solid and liquid proportion of sample in year 2 analyses.

Gains were estimated throughout the summer at 1.5 lb per day and MDGS feeding amounts were adjusted monthly to account for cattle gain. Samples of MDGS were collected twice per month to calculate DM and used to adjust feeding amount to target 0.6% BW on a DM basis. A MDGS composite sample was analyzed to determine supplement nutrient composition (31% CP, 12% fat, 25% NDF).

At the conclusion of grazing each paddock during the first, third, and

Table 1. Forage quality of diet samples from the experimental paddocks over grazing season.[1]

Sample dates	5/25-26	6/6-7	6/18-19	6/28-29	7/26-27	8/23-24
CP%	9.5	9.0	7.4	6.4	6.4	6.3
NDF%, on OM basis	63.1	64.0	62.4	67.0	60.9	58.4
IVOMD%	66.9	66.4	66.2	65.4	64.0	61.6

[1]Sequence of grazing paddocks over summer, from May 25 through Aug. 24, 2012 (year 2).

Table 2. Performance response of heifers to distillers grains.

	Treatment				
	Control[1]	Ground-fed[2]	Bunk-fed[3]	SEM	*P*-value
Initial BW (lb)	623	623	618	3.3	0.82
ADG (lb) Year 1	1.17[a]	2.51[b]	2.39[b]	0.08	< 0.01
ADG (lb) Year 2	0.73[a]	2.18[b]	2.31[b]	0.09	< 0.01
ADG (lb) Year 1 & 2	0.95[a]	2.27[b]	2.40[b]	0.15	< 0.01
Ending BW (lb)	741[a]	911[b]	922[b]	7.7	< 0.01

[1]Control = Cattle grazed with no MDGS supplement.
[2]Ground-fed = Cattle supplemented with MDGS daily at 0.6% BW, fed on the ground.
[3]Bunk-fed = Cattle supplemented with MDGS daily at 0.6% BW, fed in a bunk.
[ab]Means with different superscripts differ ($P < 0.05$).

Table 3. Residual forage post-grazing (lb/ac)[1] (Year 1 and 2).

	Treatment			
	Control[2]	Bunk-fed[3]	Ground-fed[4]	SEM
Total live[5]	737	920	844	421
Standing dead	562	531	572	94
Litter	1211	1062	1145	301

Means with different superscripts differ (*P*-value < 0.01).
[1]Average post-grazing values from six paddocks per treatment over three clipping dates (early July, late July, late August).
[2]Paddocks grazed by control cattle.
[3]Paddocks grazed by bunk-fed cattle.
[4]Paddocks grazed by ground-fed cattle.
[5]Total live represents live grass, forbs, and shrubs.

fifth rotation of the second grazing cycle, 10 quadrats (2.69 ft^2), were hand clipped at ground level. Forage was sorted into live material, standing dead, litter, forbs, shrubs, and cactus categories. Samples were dried in a forced-air oven for 48 hours at 140°F, weighed, and residual forage per acre was calculated to verify forage replacement and evaluate the equal grazing pressure hypothesis between treatments.

The 1996 NRC model was used to estimate range forage intake based on cattle performance and supplement intake. The model was also used to retrospectively calculate the MDGS intake difference between bunk and ground-fed treatments.

All data were analyzed using the GLIMMIX procedure of SAS (SAS Institute, Inc., Cary, N.C.)

Results

During the grazing season, diet samples averaged 10% CP, 63% NDF, and 61% IVDMD during year 1 (*2013 Nebraska Beef Cattle Report*, pp. 27-28). In year 2, during drought, diet samples averaged 7.5% CP, 69.4% NDF, and 65.1% IVOMD (Table 1). Across years, there was a general forage quality decline throughout the grazing season, as CP and IVDMD or IVOMD decreased, and there was a general increase in NDF as forages matured.

Supplemented cattle gained more per day (2.34 lb/day vs. 0.95 lb/day; $P < 0.05$) and had greater ending weights (917 lb vs. 741 lb; $P < 0.05$) than control cattle (Table 2). Heifers supplemented on the ground gained 0.13 lb/day less than those fed in bunks, a difference that was not statistically significant ($P = 0.16$). However, using the 0.13 lb/day difference, retrospective analysis estimated 5.6% of offered MDGS was lost when ground-fed.

Through use of the NRC model, a 15.9% forage replacement rate was calculated in year 1. In year 2, forage growing conditions were under severe drought which resulted in poor gains of non-supplemented controls. Thus, it was inappropriate to estimate forage intake using the NRC, so forage savings were only estimated from residual forage clip data in year 2.

There were no differences ($P = 0.31$) in residual forage among paddocks grazed by different treatment groups in either year (Table 3). This illustrates similar grazing pressure by supplemented and unsupplemented heifers, as grazing days had been adjusted based on a 17% forage savings hypothesis when supplementing MDGS at 0.6% BW to yearlings in a range situation. Numerically, supplemented cattle had more total live forage, so 17% forage savings estimate may be conservative.

Supplementing MDGS to spayed yearling heifers at 0.6% BW daily effectively increased summer gains and final BW and reduced forage needs approximately 17%. There was little performance advantage to bunk feeding over ground feeding but we speculate approximately 5% loss.

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Effect of Winter Supplementation Level on Yearling System Profit Across Economic Scenarios

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Summary

Calves backgrounded in a forage–based, yearling system at a greater ADG maintained a performance advantage through finishing. High-level supplemented cattle gained an additional 0.18 lb daily during finishing and produced an additional 81 lb of saleable live weight compared to cattle backgrounded at a low-supplementation level. Across four economic scenarios with varying corn and distillers prices, high-level supplemented cattle returned $55.54 more than cattle fed a low level of supplementation during the winter backgrounding phase. Corn price would have to exceed $11.70/bu for high supplementation level to no longer be profitable.

Introduction

Wintering programs are typically associated with high feed costs; thus, decades of research have focused on the effects of low nutritional inputs during the winter period as a means to lower costs but then attain increased summer grazing gains (compensatory growth) during a period of higher nutrient intake. However, this philosophy may not have considered the benefits of a high-supplementation level when cattle are retained through finishing, or when ethanol byproducts are available as a supplement.

In the last seven years, corn prices have nearly tripled. Previous economic analyses may no longer be relevant and increasing gain prior to feedlot entry through backgrounding may be of greater value than previously realized. The objective of this study was to compare a high and low winter supplementation level in a forage-based backgrounding system regarding animal performance, and supplementation level profit sensitivity concerning corn price and distillers grains price relationship to corn. The forage-based backgrounding system includes three phases (winter backgrounding, summer grazing, and finishing).

Procedure

Six studies, completed from 1987 through 2013, examined a high (HI) and low (LO) winter supplementation level within a forage-based backgrounding system, subsequent summer grazing performance, followed by feedlot finishing. Four studies utilized steers, and two studies used spayed heifers. Cattle were backgrounded on corn residue to achieve specific levels of gain during the winter, and grazed cool- and warm-season grass through the summer prior to being finished. Within studies, treatment groups had identical implant procedures, summer grazing management, and finishing diets. Performance data were adjusted to an equal fat thickness within study to equitably compare treatments.

Five studies used were outlined in an initial analysis *(2013 Nebraska Beef Cattle Report,* pp. 17-18). A sixth study (*2014 Nebraska Beef Cattle Report* pp. 39-42) was included in the present analysis which used 110 heifer calves (initial BW = 491 lb). Heifers grazed corn residue 149 days and were supplemented with 2 lb (LO) or 5 lb (HI) wet distillers grains with solubles (WDGS) on a DM basis. This added study was similar to study 5 (*2013 Nebraska Beef Cattle Report*, pp. 17-18), but was completed under drought conditions and was included in the analysis to increase statistical power.

Performance values from each of the six studies (Table 1) were adjusted to an equal fat thickness within study and an economic sensitivity analysis was applied to the two backgrounding gain levels using four scenarios. The economics are intended to represent the biology differences between treatments rather than absolute profit or

Table 1. Backgrounding and finishing average performance across six systems studies comparing winter supplement level.

	LO	HI	SEM	*P*-value
Winter backgrounding phase				
Initial BW, lb	500	497	1.2	0.36
ADG, lb	0.57	1.4	0.09	<0.01
Summer grazing phase				
ADG, lb	1.39	1.06	0.07	0.02
Compensation, %	35[1]			
Finishing phase				
DOF	114	110	3.72	0.51
ADG, lb	4.00	4.18	0.04	0.05
Total DMI, lb	3,210	3,168	95.0	0.77
Feed:Gain	6.85	6.80	9.6	0.63
Final BW, lb	1,230	1,311		<0.01

Means with different superscripts differ ($P < 0.05$).
LO = cattle supplemented during the winter phase for a low daily gain.
HI = cattle supplemented during the winter phase for a high daily gain.
[1]Percent compensation, calculated as difference in total lb of summer gain divided by difference in total lb of winter gain.

Table 2. Effect of corn and distillers price on profitability of low or high winter supplementation level.

	LO[1]	HI[2]	SEM	*P*-value[3]
Initial Cost, $/head	873.87	870.96	2.1	0.36
Revenue, $/head	1,545.90	1,646.74	12.10	<0.01
$5.50/bu corn, distillers priced at 85% corn price				
Winter cost, $/head	72.69	114.66	1.18	<0.01
Summer cost, $/head	110.00	110.	0	1.0
Finishing cost, $/head	420.66	414.26	12.49	0.73
Total cost, $/head	1,477.22	1,509.9	11.71	0.11
Profit, $/head	68.68	136.86	9.78	<0.01
$5.50/bu corn, distillers priced at 105% corn price				
Winter cost, $/head	79.26	131.13	2.19	<0.01
Summer cost, $/head	110.00	110.00	0	1.0
Finishing cost, $/head	420.66	414.26	12.49	0.73
Total cost, $/head	1,483.81	1,526.35	11.44	0.05
Profit, $/head	62.11	120.39	9.45	0.01
$7.50/bu corn, distillers priced at 85% corn price				
Winter cost, $/head	88.62	145.88	2.42	<0.01
Summer cost, $/head	123.75	123.75	0	1.0
Finishing cost, $/head	552.42	544.34	16.38	0.74
Total cost, $/head	1,638.67	1,684.92	14.81	0.07
Profit, $/head	-92.76	-38.19	11.55	0.02
$7.50/bu corn, distillers priced at 105% corn price				
Winter cost, $/head	97.61	168.33	2.99	<0.01
Summer cost, $/head	123.75	123.75	0	1.0
Finishing cost, $/head	552.42	544.34	16.38	0.74
Total cost, $/head	1,647.65	1,707.37	14.78	0.04
Profit, $/head	-101.75	-60.63	11.06	0.05

[1]LO = cattle supplemented during the winter phase for a low daily gain
[2]HI = cattle supplemented during the winter phase for a high daily gain
[3]Means with $P < 0.05$ differ.

loss. Economic scenarios included 1) corn priced at $5.50/bu with distillers grains priced at 85% corn price, **$5.50 and 85%**; 2) corn priced at $5.50/bu with distillers grains priced at 105% corn price, **$5.50 and 105%**; 3) corn priced at $7.50/bu with distillers grains priced at 85% corn price, **$7.50 and 85%,** 4) corn priced at $7.50/bu with distillers grains priced at 105% corn price, **$7.50 and 105%** (Table 2).

Initial feeder calf cost was assumed to be $174.95/cwt. For $5.50/bu corn scenario, stalk grazing cost was $0.31/day per head, summer grazing cost was $0.80/day per head, and feedlot diet cost was $0.115/lb of diet DM. At $7.50/bu corn scenario, stalk grazing cost was $0.35/day per head, summer grazing cost was $0.90/day per head, and feedlot diet cost was $0.156/lb of diet DM. Stalk grazing costs included supplement delivery cost regardless of level of supplement as calves need to be checked and supplemented anyway. Supplement cost varied with amount. Feedlot yardage was $0.45 daily per head. Sale price was $125.53/cwt on a liveweight basis.

Across scenarios, modified distillers grains (MDGS) was the winter supplement fed at 2.0 lb/head (DM) daily for the low supplementation level and 5.0 lb/head (DM) daily for the high supplementation level. Distillers supplement was charged at $0.097, $0.12, $0.132, and $0.164/lb DM for $5.50 and 85%, $5.50 and 105%, $7.50 and 85%, and $7.50 and 105% scenarios, respectively.

Given profitability results, corn price/bu was adjusted to determine the point at which HI and LO had equal profit. All economic assumptions were held constant for each scenario, with only corn price and MDGS price varied.

Data were analyzed using the GLIMMIX Procedure of SAS (SAS Institute, Inc., Cary, N.C.). Performance data and profitability comparisons were analyzed as a complete block design with treatment within study the experimental unit. Winter supplementation level was a fixed effect, and study a random effect.

Results

Calves supplemented at HI level gained 1.41 lb/day, compared to 0.57 lb/day for cattle at the LO level ($P < 0.01$) during winter backgrounding. Cattle supplemented at the LO winter level gained 0.33 lb/day ($P = 0.02$) more during the summer phase, (1.39 lb/day for LO compared to 1.06 lb/day for HI), which is a classic compensatory gain response. Numerically LO cattle required an additional 4 DOF (Table 1). Total DMI and feed efficiency were similar. Gain during finishing was greater ($P = 0.05$) by 0.18 lb/day for HI cattle. This greater ADG coupled with the maintained weight advantage from the winter phase, resulted in 81 lb greater final weight ($P < 0.01$) for HI at 1,311 lb, compared to 1,230 lb for LO.

Revenue was $100.84 greater ($P = 0.05$) for HI than LO (Table 2). Total costs between HI and LO tended ($P = 0.07$) to be greater when distillers grains were priced at 85% corn price, and were greater ($P < 0.05$) for HI than LO when distillers grains were priced at 105% corn price (Table 2), regardless of corn price. Profit was consistently greater for HI than LO ($P < 0.05$), with a $54.83 advantage for HI across the four scenarios (Table 2).

Profit advantage for HI compared to LO was greater at $5.50/bu corn compared to $7.50/bu corn, and greater when distillers grains were priced at 85% corn price compared to 105% corn price (Table 2). At $5.50/bu corn, profit advantage for HI was $68.18 and $58.28, when distillers grains were priced at 85% and 105%

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corn price, respectively. However, at $7.50/bu corn, profit advantage for HI was $54.47 and $41.12, when distillers grains were priced at 85% and 105%, respectively.

At both the low corn price ($5.50/bu) and the low distillers price (85% corn price), there was a greater profit response with high winter supplementation level than was observed with the high corn price and high distillers price. Because revenue was constant among studies, the greater winter cost due to supplement price is responsible for the various responses in profit difference across studies.

Given these results, corn price/bu was adjusted to determine the point where HI and LO had equal profit within each of the scenarios. That breakpoint was $14.50, $11.70, $14.65, and $11.90/bu, at $5.50 and 85%, $5.50 and 105%, $7.50 and 85%, and $7.50 and 105%, respectively (Table 3). As distillers grains price increases, the point at which HI supplementation no longer has a profit advantage decreases. If corn price would attain these breakpoint levels, assumptions in this analysis may no longer be true. However, corn price/bu would have to dramatically increase before increased winter gains from supplementation level would no longer be profitable.

Table 3. Economic sensitivity of corn price and distillers price relative to corn on profit/head advantage for High compared to Low winter supplemented cattle[1].

	Distillers grains price relative to corn	
Corn price/bu	85%	105%
$5.50	$68.18	$58.28
$7.50	$54.57	$41.12

[1]Profit/head difference = Profit advantage of supplementing at a high winter level over low winter level.

Profitability increased by $55.54 when supplementing 5 lb/head daily of MDGS compared to 2 lb/head. Regardless of corn price or distillers grains price, HI was more profitable than LO. When economic assumptions were held constant, corn price/bu would have to exceed at least $11.70/bu for HI supplementation to no longer have a profit advantage compared to LO.

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Distillers Grains Supplementation in a Forage System with Spayed Heifers

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Summary

Spayed heifers were developed into yearlings by grazing corn residue and bromegrass, followed by native range, and were finished on a common diet. Treatments were 2 lb or 5 lb of wet distillers grains with solubles (WDGS; DM basis) supplement on corn residue daily, and modified distillers grains with solubles (MDGS) fed at 0.6% BW daily or no MDGS during summer grazing. Feeding 5 lb increased winter ADG by 0.68 lb (year 1) or 0.40 lb (year 2) compared to 2 lb, and increased HCW after finishing. Summer supplementation increased summer ADG by 0.50 lb (year 1) or 0. 44 lb (year 2), but increased F:G during finishing. There were no differences in DMI, DOF, or marbling.

Introduction

In the last seven years, corn prices have increased nearly 250%. Rising grain prices have increased the incentive to add additional weight to cattle prior to finishing, which may be done with a forage-based backgrounding system. Backgrounding systems utilize readily available, grazed forages to develop yearlings for summer grazing, target different marketing windows, and create a year-round beef supply. In a yearling system, growing calves backgrounded on corn stalks through the winter are commonly supplemented to meet protein requirements, but summer supplementation is a relatively recent development that has arisen as a result of readily available, competitively priced distillers grains.

Distillers grains from the corn milling industry work well in forage-based systems as there is little interference with fiber digestion, unlike when grain is supplemented. Distillers grains are high in CP, energy, and phosphorus and have been shown to increase ADG and BW with increasing levels of supplementation. In addition to increasing ADG, supplementing distillers grains reduces forage intake approximately 17% on pasture. Cattle supplemented with distillers grains during the summer had increased summer ADG, greater final BW at finish, required fewer DOF, and were more profitable than non-supplemented cattle (*2011 Nebraska Beef Cattle Report,* pp. 24-25; *2012 Nebraska Beef Cattle Report,* pp. 112-114).

The objective of this experiment was to determine optimal winter and summer supplementation level and interaction of timing within a forage-based system using spayed yearling heifers. In addition, forage replacement when modified distillers grains plus solubles (MDGS) are fed at 0.6% BW on Sandhills range would be investigated.

Procedure

Treatments were arranged in a 2 x 2 factorial with level of winter supplement serving as one factor, and summer supplementation vs. no summer supplementation as the second factor.

Winter Phase

Each year of a two-year study, 229 crossbred heifers (initial BW = 473 ± 56 lb), were processed according to University of Nebraska–Lincoln protocol, limit-fed five days, and initial weight was the average of two-day weights. Heifers were backgrounded on corn residue over the winter and supplemented with 2 lb DM wet distillers grains with solubles (WDGS; **LO**) or 5 lb DM of WDGS (**HI**). After grazing corn residue approximately 145 days, heifers were surgically spayed, and grazed bromegrass pasture approximately 30 days.

Summer Phase

Upon removal from bromegrass pasture, heifers were weighed (same procedure as above) and the weight was used as heifers' ending BW from the winter phase and beginning BW of summer phase. Heifers were processed for summer grazing, implanted with a Revalor-G implant, and assigned to summer treatment.

Heifers were transported to the UNL Barta Brothers Ranch where heifers grazed native Sandhills range 120 days (year 1) or 111 days (year 2). Grazing days were shortened in year 2 due to drought. Summer treatments included daily supplementation of modified distillers grains at 0.6% BW (SUP) or no supplementation (NO SUP).

Pastures were stocked to test the forage savings hypothesis that when distillers grains is fed at 0.6% BW daily, there is approximately a 17% forage savings rate (*Professional Animal Scientist,* 28:443). This was tested by stocking pastures with an equal number of cattle, but due to the size of available pastures, supplemented cattle were provided 24% less animal unit months (AUMs). Pastures were stocked at 0.64 AUM/ac for unsupplemented cattle and 0.84 AUM/ac for supplemented cattle. It was hypothesized that there would be similar amounts of residual forage between pastures grazed by supplemented and unsupplemented cattle at the end of each grazing rotation. Forage residual height measurements

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Table 1. Winter, summer, and system performance of yearling spayed heifers supplemented distillers grains in a forage-based system

	LO[1]		HI[2]			*P*-value[3]		
Item	NO SUP[4]	SUP[5]	NO SUP[4]	SUP[5]	SEM	Winter	Summer	W x S
Winter								
Initial BW, lb — Year 1	453	451	453	451	4.4	0.96	—	—
Initial BW, lb — Year 2	495	495	486	499	4.4	0.24	—	—
ADG, lb — Year 1	0.70[b]	0.68[b]	1.41[a]	1.32[a]	0.02	<0.01	—	—
ADG, lb — Year 2	0.97[b]	0.97[b]	1.39[a]	1.32[a]	0.02	<0.01	—	—
Ending BW, lb[6] — Year 1	572	568	689	671	1.76	<0.01	<0.01	0.02
Ending BW, lb[6] — Year 2	671	673	741	750	4.4	<0.01	0.25	0.48
Summer								
ADG, lb — Year 1	1.43[c]	1.98[a]	1.19[d]	1.63[b]	0.02	<0.01	<0.01	0.07
ADG, lb — Year 2	1.01[c]	1.45[a]	0.84[d]	1.28[b]	0.04	0.01	<0.01	1.0
Growing System								
ADG, lb — Year 1	1.03	1.25	1.30	1.45	0.02	<0.01	<0.01	0.12
ADG, lb — Year 2	1.01	1.19	1.30	1.36	0.02	<0.01	<0.01	0.55
Ending BW, lb[7] — Year 1	755[d]	818[c]	840[b]	880[a]	2.8	<0.01	<0.01	0.02
Ending BW, lb[7] — Year 2	792	847	840	900	2.05	<0.01	<0.01	0.18

[1]LO = supplemented at 2 lb WDGS daily during winter backgrounding phase on corn residue.
[2]HI = supplemented at 5 lb WDGS daily during winter backgrounding phase on corn residue.
[3]*P*-Value: Winter = effect of winter supplementation treatment across year 1 and 2; Summer = effect of summer supplementation treatment across year 1 and 2; W x S = effect of winter x summer treatment interaction across year 1 and 2.
[4]NO SUP = not supplemented during summer grazing.
[5]SUP = supplemented at 0.6% BW daily with MDGS during summer grazing period.
[6]Winter ending BW = Summer phase initial BW.
[7]Growing System ending BW = Summer ending BW.
[a,b,c,d] = Within a row (year), values lacking common superscripts differ when year or year x treatment interaction was significant at $P \leq 0.10$.

were taken at the conclusion of each grazing rotation to test this hypothesis.

Finishing

In late September, heifers were transported to the University of Nebraska Agricultural Research and Development Center (ARDC) near Mead, Neb., re-implanted with Revalor®-200, weighed (same procedure as before), and adapted to a common finishing diet. Initial BW at finishing phase entry differed between treatments, thus DOF among treatment groups were varied to produce carcasses with a similar 12th rib fat thickness. This was achieved through use of serial slaughter, with half of each treatment group's cattle slaughtered at an earlier date, and half slaughtered at a later date to produce differences in 12th rib fat thickness. These differences then allowed carcass measurements to be adjusted to a common fat thickness for an equitable comparison.

There were interactions with year so the two years were statistically analyzed separately as 2 x 2 factorial arrangement of treatments. Feedlot pen (two per year) was the experimental unit.

Results

Winter

By design, there was no difference in initial BW ($P > 0.24$) between LO and HI treatment groups in either year (Table 1). Supplementation at HI level increased ADG 0.68 lb ($P < 0.01$) in year 1, and 0.40 lb ($P < 0.01$) in year 2, compared to LO. The additional ADG and 110 lb greater ($P < 0.01$) winter ending BW for HI in year 1 or 73 lb greater ($P < 0.01$) winter ending BW for HI than LO in year 2 is a response to the additional energy provided with HI level, whereas the LO treatment was only designed to meet protein requirements.

Summer

In year 1, there was a winter by summer interaction ($P = 0.07$) for summer ADG with LO, SUP having the greatest daily gain at 1.98 lb, followed by HI, SUP at 1.63 lb, LO, NO SUP at 1.43 lb, and HI, NO SUP gained 1.19 lb. In year 2, there was no interaction and winter treatment and summer treatment were both significant ($P = 0.01$). Winter supplementation at the HI level reduced summer ADG ($P < 0.01$) by 0.18 lb/day and summer supplementation of MDGS increased ADG 0.44 lb ($P < 0.01$). In both years, the greater summer gain by LO is a classic compensatory gain response, which illustrates gain following a period of restriction (winter backgrounding) are greatest for cattle which had the greatest nutritional restriction, which in this study was LO. Across all treatments, summer gains in year 2 averaged 0.19 kg less than year 1, illustrating potential differences in performance related to drought and forage availability.

Forage System

There were no winter by summer supplementation treatment inter-

Table 2. Finishing performance and carcass characteristics of yearling spayed heifers supplemented distillers grains in a forage-based system .

	LO[1]		HI[2]			*P*-value[3]		
Item	NO SUP[4]	SUP[5]	NO SUP[4]	SUP[5]	SEM	Winter	Summer	W x S
Days on feed — Year 1	125	126	126	120	3	0.53	0.45	0.39
Days on feed — Year 2	124	124	124	124	0	1.0	1.0	1.0
Final BW, lb — Year 1	1225[c]	1243[c]	1335[a]	1289[b]	13.2	<0.01	0.31	0.08
Final BW, lb — Year 2	1190	1221	1243	1280	15.4	0.03	0.10	0.85
DMI, lb — Year 1	27.9	27.1	27.5	27.06	.7	0.96	0.23	0.57
DMI, lb — Year 2	28.6	27.7	27.5	28.2	1.5	0.79	0.92	0.66
ADG, lb — Year 1	3.78	3.39	3.96	3.45	0.1	0.34	0.02	0.66
ADG, lb — Year 2	3.23	3.06	3.28	3.10	0.13	0.78	0.28	0.96
F:G, — Year 1	7.14	7.81	6.94	7.58	0.05	0.14	<0.01	0.93
F:G, — Year 2	8.85	9.09	8.40	9.01	0.10	0.25	0.07	0.34
HCW, lb — Year 1	772[c]	783[c]	843[a]	812[b]	8.9	<0.01	0.33	0.08
HCW, lb — Year 2	750	770	781	805	11	0.03	0.10	0.84
LM area, cm.^{2} — Year 1	12.6[b]	13.3[a,b]	14.0[a]	12.9[b]	0.02	0.21	0.82	0.03
LM area, cm.^{2} — Year 2	12.6	12.6	13.0	13.2	0.02	0.01	0.76	0.44
Marbling score[6] — Year 1	629	618	603	627	23	0.73	0.79	0.49
Marbling score[6] — Year 2	585	582	582	586	13	0.97	0.97	0.77
Calculated YG[7] — Year 1	3.22a	2.99[b]	3.06[a,b]	3.26[a]	0.08	0.51	0.85	0.05
Calculated YG[7] - Year 2	3.14	3.25	3.22	3.25	0.13	0.79	0.61	0.76

[1]LO = supplemented at 2 lb WDGS daily during winter backgrounding phase on corn residue.
[2]HI = supplemented at 5 lb WDGS daily during winter backgrounding phase on corn residue.
[3]*P*-Value: Winter = effect of winter supplementation treatment over two years; Summer = effect of summer supplementation treatment over two years; W x S = effect of winter x summer treatment interaction across year 1 and year 2.
[4]NO SUP = not supplemented during summer grazing.
[5]SUP = supplemented at 0.6% BW daily with MDGS during summer grazing period.
[6]Marbling: Small^{00} = 500, Small^{50} = 550, Modest^{00} = 600.
[7]Calculated YG = (2.5 + (5.51 x 12th rib fat thickness) – (0.70 x LM area) + (0.2 x KPH) + (0.0084 x HCW)).
[a,b,c] = Within a row (year), values lacking common superscripts differ when year or year x treatment interaction was significant at $P \leq 0.10$.

actions ($P > 0.12$) when examining the entire forage-based growing system for ADG (Table 1). With HI supplementation, ADG increased ($P < 0.01$) 0.24 lb in both year 1 and year 2. With summer supplementation, ADG increased 0.20 lb in year 1 ($P < 0.01$) and ADG increased 0.13 lb in year 2 ($P < 0.01$).

In year 1, there was a winter by summer treatment interaction ($P = 0.02$) for system ending BW with HI, SUP having greatest ending BW at 880 lb, followed by HI, NO SUP at 840 lb, LO, SUP at 818 lb, and finally LO, SUP at 755 lb. In year 2, HI winter supplementation increased system ending BW ($P < 0.01$) 51 lb, and SUP increased system ending BW ($P < 0.01$) 57 lb.

Finishing Phase

In both years, there were no statistical differences in DOF across treatments or DMI (Table 2). Feedlot ADG was not affected ($P > 0.78$) by winter supplement level in either year. This is in contrast to a six-study summary (*2014 Nebraska Beef Cattle Report*, pp. 36-38) using a similar systems approach, which showed cattle supplemented at a high winter level and then summered without supplementation, tended to gain more (0.20 lb) during finishing than cattle in the same system backgrounded at a low supplement level. Data from this study using HI, NO SUP and LO, NO SUP cattle was included in that analysis, so the lack of difference observed here suggests the inclusion of SUP cattle in these data diluted the effect seen in the *2014 Nebraska Beef Cattle Report* (pp. 36-38). Feedlot ADG was 0.46 lb less with summer MDGS supplementation ($P = 0.02$) in year 1. There were no differences in feedlot ADG observed in year 2. Feed efficiency was not impacted by winter treatment ($P > 0.14$) but decreased ($P < 0.07$) 0.54 lb with summer supplementation in year 1 and year 2.

In year 1, there was a winter by summer treatment interaction ($P = 0.08$) for final BW with HI, NO SUP finishing 46 lb heavier than HI, SUP, which was followed by LO, SUP and LO, NO SUP which were similar. In year 2, HI winter supplementation increased ($P = 0.03$) final BW 57 lb and summer supplementation increased ($P = 0.10$) final BW 35 lb.

Carcass Characteristics

Using serial slaughter data, carcass data were adjusted to 0.5 inches rib fat. In year 1, consistent with final BW data, there was a winter by summer treatment interaction for HCW with HI, NO SUP producing the heaviest carcasses, followed by HI, SUP 31 lb less, and then LO, SUP and LO, NO SUP were similar. Similar to year 2 final BW data, HCW in year 2 was increased ($P = 0.03$) with HI by 33 lb and decreased ($P = 0.10$) 22 lb with SUP.

In year 1, winter and summer treatments interacted ($P = 0.03$) to produce the largest LM area in HI, NO SUP and LO, SUP, followed by HI, SUP and LO, NO SUP. Year 2 data were clearer, with HI cattle having

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0.54 in^2 larger ($P = 0.01$) LM area than LO cattle, and no summer effect. Larger LM area are primarily due to heavier carcass weights. Treatments had no effect on marbling scores ($P > 0.49$). There was a treatment interaction for yield grade in year 1, with LO, SUP and HI, NO being most desirable, followed by LO, NO and HI, SUP. There were no yield grade differences in year 2. Finally, there were no overweight carcasses (greater than 1,000 lb) across treatments in either year, contrary to previous research using steers.

Forage Savings

There was no difference ($P = 0.50$) in residual forage height between pastures grazed by supplemented and unsupplemented cattle during the summer (Table 3). Numerically, pastures grazed by unsupplemented cattle had 0.6 in. greater residual forage. Because pastures were stocked assuming a 24% forage savings rate by SUP to utilize available acres and considering Watson et al., (*Professional Animal Scientist,* 2012. 28:443), this numerical difference suggests forage savings may be less than the 24% that pastures were stocked for.

Table 3. Season average forage residual height.

Item	Residual height, inches	SEM	*P*-value
NO SUP[1]	6.42	0.58	0.50
SUP[2]	5.84		

[1]NO SUP = Pastures grazed by non-supplemented cattle.
[2]SUP = Pastures grazed by supplemented cattle.

A similar, but more intensive study was conducted during the same years (*2014 Nebraska Beef Cattle Report,* pp. 34-35), which affirmed the 17% forage savings hypothesis through clipping quadrats in paddocks grazed by unsupplemented and supplemented cattle. However, heifers supplemented on the ground numerically left 107 lb/ac more live material at the conclusion of the grazing season, indicating forage savings was greater than the assumed 17% for that study. Therefore, these combined data indicate forage savings when supplementing MDGS at 0.6% BW/day on a native Sandhills range situation results in a 17% to 24% forage savings.

Heifers responded to more supplement in the winter when grazing stalks and produced 42 lb heavier carcasses after finishing. Because the heifers need to be supplemented at some level, the extra expense for feeding 5 lb WDGS vs 2 is essentially only for the WDGS. Supplementation in the summer is not common and has the expense of delivery of supplement. While ADG was increased by summer supplementation, F:G was increased in the feedlot and carcass weight was increased only 6 lb. This suggests that biologically, and perhaps from a management standpoint, the extra WDGS is better used in the winter period.

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Economics of Distillers Grains Supplementation in a Forage System with Spayed Heifers

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Summary

In a two-year study, spayed heifer calves were backgrounded on cornstalks with 2 lb or 5 lb wet distillers grains with solubles supplemented daily. During the summer, heifers grazed native range and received no summer supplementation or were supplemented with modified distillers grains with solubles at 0.6% BW daily. Heifers were finished on a common regimen, and an economic scenario was applied to each phase of production and overall. Supplementing more in winter increased profit, but summer supplementation did not impact overall profitability. Numerically, heifers not supplemented during the summer were more profitable than supplemented heifers.

Introduction

In a yearling system, growing calves backgrounded on corn residue through the winter are commonly supplemented to meet protein requirements, but summer supplementation is a relatively recent development that has arisen as a result of readily available, competitively priced distillers grains.

The historical backgrounding philosophy has centered on lowering winter feed input costs and then capitalizing on compensatory gain during summer grazing. However, recent research illustrated that backgrounding cattle at a higher supplement level during the winter phase resulted in increased feedlot gain, greater final BW, and increased profits (*2014 Nebraska Beef Cattle Report*, pp. 36-38). Further, heavier slaughter weights tend to be negatively correlated to slaughter breakeven and positively correlated to profitability *(2000 Nebraska Beef Cattle Report,* pp. 23-26). Previous research has shown summer supplementation of distillers grains to be profitable due to use of lower cost forages at the time, reduced finishing costs, and increased selling weight (*2011 Nebraska Beef Cattle Report*, pp. 24-25; *2012 Nebraska Beef Cattle Report,* pp. 112-114). The combination of winter and summer was recently completed (*2014 Nebraska Beef Cattle Report*, pp. 39-42) to determine if supplementing during one phase is better than the other or if it is additive.

The objective of this experiment was to determine profitability of winter and summer supplementation level and interaction of timing within a forage-based system using spayed yearling heifers.

Procedure

Each year of a two-year study, 229 crossbred heifers (initial BW = 473 ± 57 lb) were used in a completely randomized design with a 2 × 2 factorial treatment design. Factors were winter supplement level and summer supplement level. Winter supplementation level was: 1) 2 lb DM wet distillers grains with solubles (WDGS) (LO); or 2) 5 lb DM WDGS (HI) and summer supplementation level was: 1) modified distillers grains with solubles (MDGS) fed at 0.6% BW daily (SUP); or 2) no MDGS supplementation (NO SUP).

Economic assumptions were applied to the actual performance values and actual days in each production phase from year 1 and year 2 in this study (*2014 Nebraska Beef Cattle Report,* pp. 39-42). The economics are intended to represent the biology differences among treatments rather than absolute profit or loss. Initial purchase price was $170.00/cwt. Distillers grains price was calculated using a $5.50/bu corn price and pricing distillers grains at 85% of corn price on a DM basis, resulting in a cost of $197.59/ton of distillers grains (DM basis).

Daily stalk grazing was charged at $0.31 per heifer and WDGS charged at $0.097/lb fed (DM). Total winter cost was the sum of WDGS supplement cost and stalk grazing cost. Daily summer grazing costs were charged at $0.80 per head for non-supplemented heifers. Given supplemented heifers were provided 22% less acres due to MDGS supplementation and projected forage savings, daily grazing cost was reduced to $0.62 per head for supplemented heifers. Supplemented heifers were charged $0.20 daily to account for additional labor, fuel, and equipment to provide distillers supplementation. Non-supplemented heifers during the summer phase were charged $0.10 daily in yardage costs. Total summer costs included MDGS supplementation cost (if applicable), yardage, and summer grazing cost.

Yardage during finishing was assumed to be $0.45 daily. Feedlot diet was charged at $0.115/lb (DM) of DMI. Cattle were sold on a live weight basis at $124.38/cwt. Total finishing costs included finishing diet (DMI) cost and yardage during finishing.

Profitability was calculated as total revenue (selling price multiplied by final live weight determined on carcass adjusted basis) minus total costs (initial purchase cost, wintering costs, summer costs, and finishing costs). Interest was 6% and health and implant costs were $20/head.

(Continued on next page)

Results

There were interactions with year so years were analyzed separately as a 2 x 2 factorial treatment arrangement. Feedlot pen (two per year) was the experimental unit.

There were no winter by summer treatment interactions or summer effects during the winter phase, as summer treatment had not yet been applied (Table 1 and 2). Corn residue cost, including yardage to deliver WDGS supplement, was consistent across treatments at $42.78 per head (year 1) or $46.19 per head (year 2). Supplementation costs, and consequently total wintering costs were greater ($P < 0.01$) for HI than LO by $40.12 in year 1, and $43.31 in year 2. Total winter backgrounding costs averaged $69.52 (year 1) or $75.07 (year 2) per head for LO cattle, and $109.64 (year 1) or $113.38 (year 2) per head for HI cattle.

There were no winter by summer treatment interactions during summer grazing. Grazing cost was greater ($P < 0.01$) for NO SUP at $102.40 (year 1) or $95.20 (year 2), compared to SUP at $79.87 (year 1) or $74.26 (year 2). These differences reflect that supplemented cattle were provided 22% fewer acres. For SUP cattle, supplementation costs were $52.34 and $49.93 greater, year 1 and 2, respectively ($P < 0.01$) and yardage costs were $12.80 and $11.90 (year 2) greater ($P < 0.01$). Total summer grazing costs averaged $157.81 for SUP compared to $115.20 for NO SUP in year 1 ($P < 0.01$), and $147.99 for SUP and $107.10 for NO SUP in year 2 ($P < 0.01$).

There were no winter by summer treatment interactions affecting finishing costs in either year. In year 1, finishing diet cost tended ($P = 0.06$) to be $21.54 greater for NO SUP cattle, there were no differences in yardage cost, and overall finishing cost tended ($P = 0.07$) to be $22.95 greater for NO SUP cattle, with no differences observed from winter treatment. Numerically, NO SUP cattle had a greater DMI and DOF, which created

Table 1. Profitability of yearling spayed heifers supplemented distillers grains in a forage-based system, Year 1.

	LO[1]		HI[2]			*P*-value[3]		
Item	SUP[4]	NO SUP[5]	SUP	NO SUP	SEM	Winter	Summer	W x S
Winter backgrounding phase								
WDGS cost, $	26.74	26.74	66.86	66.86	6.62	<0.01	—[6]	—[6]
Stalk cost, $	42.78	42.78	42.78	42.78	0	—[6]	—[6]	—[6]
Total cost, $	69.52	69.52	109.64	109.64	0	<0.01	—[6]	—[6]
Summer grazing phase								
Grazing cost, $	79.87	102.40	79.87	102.40	0	—[6]	<0.01	—[6]
MDGS cost, $	52.34	0	52.34	0	0	1.0	<0.01	—[6]
Yardage, $	25.60	12.80	25.60	12.80	0	—[6]	<0.01	—[6]
Total cost, $	157.81	115.20	157.81	115.20	0	1.0	<0.01	—[6]
Finishing cost								
Diet cost, $	383.04	389.08	360.73	397.76	8.13	0.45	0.06	0.13
Yardage, $	56.28	56.23	53.69	56.56	1.68	0.54	0.45	0.43
Total cost, $	439.32	445.31	414.42	454.32	8.52	0.44	0.07	0.14
Profitability								
Initial cost, $	766.70	770.10	766.70	770.01	6.45	0.96	0.55	0.94
Total cost, $	1,519.92	$1,485.36	$1,537.18	1,536.76	13.15	0.07	0.62	0.25
Revenue, $	1,546.49	1526.62	1606.16	1664.17	17.97	<0.01	0.32	0.08
Profit, $	26.57[c]	41.26[c]	68.98[b]	127.39[a]	7.63	<0.01	0.19	0.05

[1]LO = supplemented at 2 lb WDGS daily during winter backgrounding phase on corn residue.
[2]HI = supplemented at 5 lb WDGS daily during winter backgrounding phase on corn residue.
[3]*P*-Value: Winter = effect of winter supplementation treatment; Summer = effect of summer supplementation treatment; W x S = effect of treatment interaction.
[4]SUP = supplemented at 0.6% BW daily with MDGS during summer grazing period.
[5]NO SUP = not supplemented during summer grazing.
[6]Did not vary within treatment combination.
[7]Includes interest and health.
[abc]Within a row, means with unlike superscripts differ ($P < 0.05$).

Table 2. Profitability of yearling spayed heifers supplemented distillers grains in a forage-based system, Year 2.

	LO[1]		HI[2]			*P*-value[3]		
Item	SUP[4]	NO SUP[5]	SUP	NO SUP	SEM	Winter	Summer	W x S
Winter backgrounding phase								
WDGS cost, $	28.88	28.88	72.19	72.19	6.62	<0.01	—[6]	—[6]
Stalk cost, $	46.19	46.19	46.19	46.19	0	—[6]	—[6]	—[6]
Total cost, $	75.07	75.07	118.38	118.38	0	<0.01	—[6]	—[6]
Summer grazing phase								
Grazing cost, $	74.26	95.20	74.26	95.2	0	—[6]	<0.01	—[6]
MDGS cost, $	49.93	0	49.93	0	0	1.0	<0.01	—[6]
Yardage, $	23.80	11.90	23.80	11.90	0	—[6]	<0.01	—[6]
Total cost, $	147.99	107.10	147.99	107.10	0	—[6]	<0.01	—[6]
Finishing phase								
Diet cost, $	396.00	409.25	400.40	391.8	23.10	0.79	0.92	0.66
Yardage, $	55.80	55.80	55.80	55.80	0	—[6]	—[6]	—[6]
Total cost, $	451.80	465.05	456.20	447.68	23.10	0.79	0.92	0.66
Profitability								
Initial cost, $	841.50	841.50	848.30	826.20	3.79	0.26	0.08	0.09
Total cost, $	1,606.78	1,557.61	1,663.61	1,590.72	22.54	0.23	0.31	0.44
Revenue, $	1,519.85	1,481.17	1,593.75	1,546.45	20.33	0.03	0.10	0.84
Profit, $	-86.93	-96.50	-69.86	-44.27	9.34	0.02	0.15	0.18

[1]LO = supplemented at 2 lb WDGS daily during winter backgrounding phase on corn residue
[2]HI = supplemented at 5 lb WDGS daily during winter backgrounding phase on corn residue
[3]*P*-value: Winter = effect of winter supplementation treatment; Summer = effect of summer supplementation treatment; W x S = effect of treatment interaction.
[4]SUP = supplemented at 0.6% BW daily with MDGS during summer grazing period
[5]NO SUP = not supplemented during summer grazing
[6]Did not vary within treatment combination.

these tendencies for differences in finishing cost.

In year 2, there were no winter or summer treatment effects on diet cost, yardage, or total finishing cost. There were minimal performance differences in year 2 across treatments, consequently there were minimal finishing cost differences.

In year 1, initial cost was similar ($P > 0.55$) as initial weights were also similar by design. Total costs were \$32.52 greater (P = 0.07) for HI, due to additional winter supplementation costs. Summer supplementation numerically increased total costs \$15.43 due to MDGS cost and additional summer yardage cost, but was not statistically significant ($P = 0.62$). Revenue was \$98.62 greater ($P < 0.01$) for HI than LO cattle, due to the additional 80 lb of saleable weight. There was a winter by summer treatment interaction ($P = 0.05$) on overall profitability with HI, NO SUP most profitable at \$127.39 per head, followed by HI, SUP at \$68.98, LO, NO SUP at \$41.26 and LO, SUP at \$26.57.

In year 2, initial cost was similar ($P > 0.08$) by design. Total costs were not impacted by winter treatment ($P = 0.23$) but were \$47.23 numerically greater ($P = 0.31$) with summer supplementation due to MDGS and additional yardage cost. Similar to year 1, revenue was greater ($P = 0.03$) by \$69.59 for HI, but summer supplementation increased ($P = 0.10$) revenue \$42.99 as well. Similar to year 1, profit (less loss) was greater for HI than LO ($P = 0.02$) by \$34.65, and NO SUP ($P = 0.15$) was more profitable (less loss) than SUP by \$8.01. Profit differences between year 1 and year 2 are due to lower year 2 performance, and consequently lower revenue.

High winter supplementation level increased profit, but summer supplementation did not impact overall profitability. Numerically, NO SUP were more profitable than SUP. Lack of profit response to summer supplementation may be due to the greater distillers grains price and lower cattle performance in this data set compared to previous analyses.

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Effect of Distillers Grains Plus Solubles Supplementation on Grazing Cattle Performance

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Summary

Yearlings rotationally grazing smooth bromegrass were individually supplemented modified distillers grains plus solubles (MDGS) at .05, 0.4, 0.6, and 0.8% BW. Gain increased quadratically as MDGS level increased. Maximal ADG (2.95 lb/d) was predicted when supplementing level of 0.48% of BW. Economic analysis compared 0, 2, and 5 lb (DM) MDGS supplementation. When cattle ownership was retained through the feeding period, MDGS supplementation was profitable. Supplementation at 2 lb (DM) was more profitable than 5 lb (DM) when MDGS is above $265.63/ton (DM) or 85% the price of $7.50 /bu corn.

Introduction

High grain prices and drought have increased the need to maximize the grazing resources. Supplementation of ethanol byproducts is an effective tool in managing forage supply without sacrificing cattle performance. Metabolizable protein (MP) is the first limiting factor for yearling steers grazing smooth bromegrass. Distiller grains plus solubles (DGS) meet MP requirements with 24% CP and 65% rumen undegradable protein (RUP). Supplementing DGS also provides energy. Previous research determined dried distiller grains (DDG) to be 127% the energy value of dry-rolled corn in forage diets (2003 NE Beef Report pp. 8-10). Research has shown DGS supplementation allows growers to increase stocking rate and ADG (*2010 Nebraska Beef Cattle Report* pp. 24-25). However, rising DGS prices may impact the optimum supplementation level. Likewise, the optimum levels may differ whether for performance or for economics.

Procedure

Experimental Design and Animal Performance

Crossbred yearling steers (n = 30, BW = 736 ± 71 lb) were utilized in a complete randomized design and assigned to one of four treatments. The treatments were based on increasing supplementation levels of modified distiller grain plus solubles (MDGS) at .05, 0.4, 0.6, and 0.8% of BW. Daily, each steer was individually supplemented MDGS in an individual feeding barn. The remainder of the day, cattle grazed smooth bromegrass pasture. Cattle were managed in an intensive rotational grazing system (117 days). Cattle were moved every 4 – 6 days from April 27, 2012, through July 20, 2012. The dry summer conditions forced the cattle to be moved to an extra pasture from July 20 to Aug. 24. The move to the extra pasture allowed the cattle adequate forage supply.

Prior to the trial, steers were limit-fed a common diet at 2% of BW for five days to minimize gut fill variation. Steers were weighed three consecutive days to determine initial BW. Interim, one-day weights were taken at the end of each 24- to 36-day cycle. Following the fifth cycle, steers were limit-fed a common diet for five days and weighed to establish ending BW. Animal ADG was calculated for the 117-day grazing season using initial and ending BW. Individual orts were recorded and actual MDGS intakes were calculated.

Performance of non-supplemented steers, from the same pool of cattle on a similar grazing rotation, were used to create a regression equation to estimate ADG in relation to the amount of MDGS supplemented. The regression equation was developed using actual MDGS DMI and ADG. Efficiency improvements due to daily MDGS supplementation at 0, 2, and 5 lb/steer (DM) were calculated.

Performance and actual MDGS intake were analyzed using the SAS MIXED procedure (SAS Institute, Inc., Cary, N.C.). Steer was the experimental unit and supplementation level is the fixed effect. Maximal gain was determined using a regression formula using actual MDGS intake and ADG.

Economic Analysis

Assuming retained ownership through the feeding period, profitability differences (partial budget) were calculated for supplementing MDGS to steers at 0, 2, and 5 lb (DM) during a 120-day summer grazing period. Calculations were established using corn at $5.50/bu and $7.50/bu, distillers priced at 85% and 100% the price of corn (DM basis), and finished steers priced at $120.00 cwt. The respective costs of MDGS, on DM basis were $194.79, $229.17, $265.63, and $312.50/ton. The as-is price of MDGS would depend on the DM content of the MDGS. Delivery cost of supplementation was assumed at $0.10/steer daily.

Performance from earlier research (*2005 Nebraska Beef Cattle Report*, pp. 18-20 and *2006 Nebraska Beef Cattle Report*, pp. 30-32) was included, resulting in ADG of 1.55, 2.10, and 2.37 lb. The expected efficiency of weight retained in the feedlot from cattle supplemented 2 lb and 5 lb (DM) MDGS is 100% and 96.1%, respectively (*2006 Nebraska Beef Cattle Report*, pp. 18-20 and *2011 Nebraska Beef Cattle Report*, pp. 31-32). Cattle consumed the same amount of feed in the feedlot; therefore, the cost is assumed to be equal.

The assumed pasture rent price

Table 1. Grazing steer ADG improvement with MDGS supplementation levels.

		Improvement	
MDGS, lb (DM)	ADG, lb (DM)	Comparison, lb (DM)	Change, %
0	1.55	—	—
2	2.10	0 v 2	26.3%
5	2.37	2 v 5	11.1%

2005 Nebraska Beef Cattle Report, pp. 18-20; *2006 Nebraska Beef Cattle Report*, pp. 30-32; and Current Study (176 head).

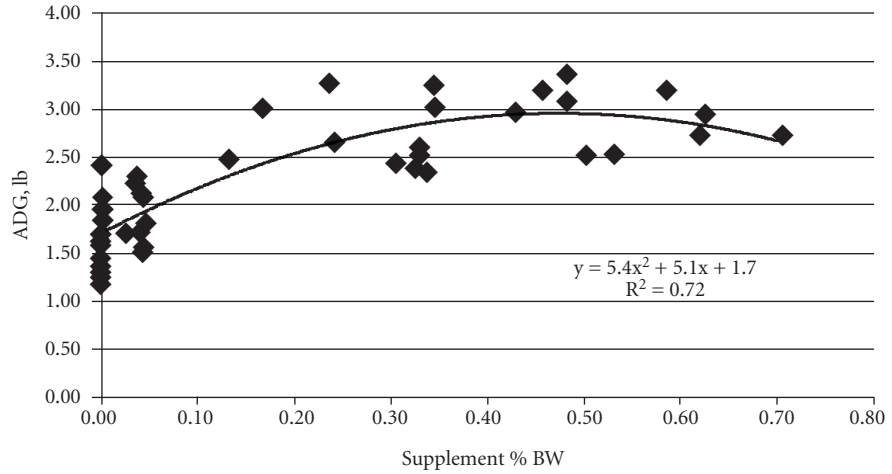

Figure 1. Effect of actual MDGS supplement intake on grazing steer ADG.

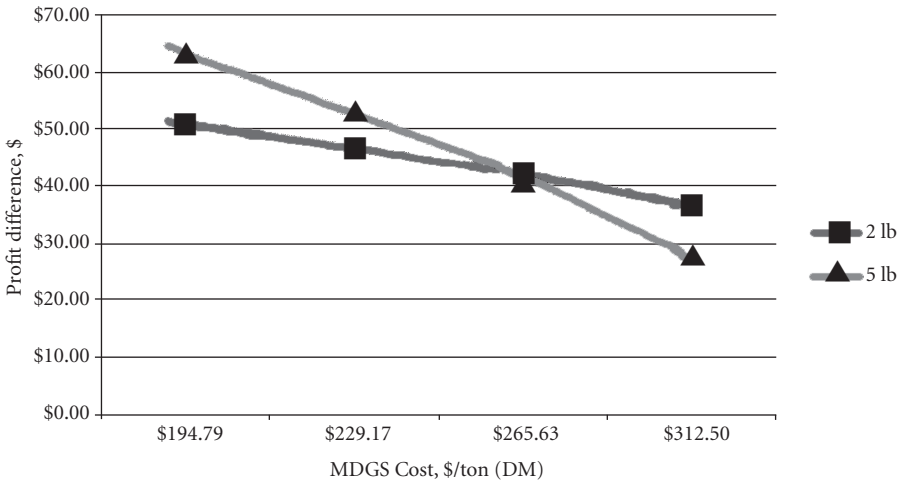

Figure 2. Effect of MDGS price and supplementation level on profitability.

is $.80/head/day. However, previous research suggests forage savings is 6.8 and 17%/head for 2 lb and 5 lb (DM) MDGS supplementation (*2010 Nebraska Beef Cattle Report*, pp. 44-43). Correspondingly, stocking rate and profitability/acre can be increased. Therefore, the assumed pasture rent for the 2 lband 5 lb (DM) MDGS supplementation is $.75 and $.66/head/day.

Results

Average Daily Gain and Efficiency

As actual supplement intake increased , ADG increased quadratically ($P < 0.01$ Figure1). The actual supplement intake regression equation ($y = -5.4146x^2 + 5.1705x + 1.7231$) predicts maximal ADG at the MDGS supplementation level of x = 0.48% BW with y = 2.95 lb ADG ($r^2 =. 72$).

As the MDGS supplementation increased from 0 lb to 2 lb to 5 lb (DM), the greatest gain response of 26.3% occurred between 0 lb and 2 lb (DM) supplementation (Table 1). The high gain response is due to the steer's MP requirements being met by the RUP of MDGS. The 11.1% increase in ADG from 2 lb to 5 lb MDGS (DM) is due to the additional energy consumed (Table 1). The added gain from the 5 lb MDGS (DM) supplementation may be advantageous when selling cattle at the end of the feeding period. However, feeding 2 lb (DM) may be more advantageous with high priced MDGS.

Economic Analysis

In general, steers supplemented MDGS and non-supplemented steers gained 2.24 and 1.55 lb, respectively. Supplemented steers generated $28.17 to $63.48 more profit compared to non-supplemented steers across all MDGS levels and prices (Figure 2). Increasing supplementation from 2 lb to 5 lb (DM) increased ADG .27 lb. Feeding 5 lb (DM) MDGS level was more profitable when MDGS price was below $265.63/ton (DM) (85% the price of 7.50/bu corn). Supplementing 2 lb MDGS (DM) became more profitable than supplementing 5 lb MDGS (DM) by $0.10 /lb as MDGS prices increased above $265.63/ton. This analysis suggests that supplementing MDGS for maximal ADG is not always the most economical. This is because DGS prices have recently increased more rapidly than both grass and cattle prices. In the current economic scenario, grazing yearlings would be more profitable when supplemented DGS, but the amount that should be supplemented depends on price relative to corn, grass, and cattle. When expensive, use as a protein source for grazing cattle is more logical (i.e., 2 lb/day (DM)) than feeding at higher levels.

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Effect of Distillers Grains Supplementation on Calves Grazing Irrigated or Non-Irrigated Corn Residue

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Summary

Steer calves grazing irrigated or non-irrigated corn residue received supplementation of dried or modified distillers grains plus solubles (DGS) at 0.3, 0.7, or 1.1% of BW . Steers were individually supplemented daily through Calan gates. Daily gain improved quadratically with increasing supplementation (1.55 lb/day to 2.12 lb/day) and for calves grazing non-irrigated (2.02 lb/day) compared to irrigated (1.77 lb/day) corn residue. Feeding dry instead of modified DGS did not significantly impact ADG. Supplementing DGS to calves grazing corn residue increased gain during the winter period.

Introduction

There is significant potential for grazing corn residues in Nebraska due to the acres of corn planted annually. Grazing residues increases the length of the grazing season, allowing producers to feed less harvested feeds, thereby reducing annual feed costs. However, residues are lower in CP and energy than what is required to meet the needs of growing calves gaining more than 1 lb per day. Providing protein supplementation in the form of rumen undegradable protein (RUP) allows producers to increase winter gain of growing calves on corn residue. A feed that acts as an excellent source of RUP and energy in forage-based diets is distillers grains plus solubles (DGS). A quadratic effect has previously been demonstrated for calves grazing irrigated corn residue and receiving dried DGS at increasing levels, with optimal supplementation being at 1.1% of body weight (*2006 Nebraska Beef Cattle Report*, pp. 36-37). Research in finishing cattle has shown improvements in ADG for wet DGS over partially dried (i.e., modified) DGS or dried DGS (2009 Nebraska Beef Cattle Report, pp. 28-29). However, a significant difference has not been observed in growing calves grazing forages.

For grazing cattle, stocking rates are traditionally based on available forage and not the quality of the forage. Non-irrigated corn residue has a greater nutritional value, although a lower quantity of total residue, compared to irrigated fields. Therefore, the increased energy observed for non-irrigated fields should result in an increase in ADG for the calves when stocked at similar grazing pressures. The objective of this trial was to compare two types of DGS at three levels of supplementation for calves grazing an irrigated or non-irrigated corn residue field.

Procedure

One hundred twenty crossbred steers (435 ± 16 lb) were backgrounded on corn residue from Nov. 1, 2012, to Dec. 22, 2012 at the University of Nebraska–Lincoln Agricultural Research and Development Center (ARDC) near Mead, Neb. The trial was terminated early due to substantial snowfall. Treatments were arranged in a 2 x 3 x 2 factorial design, with two types of DGS, three levels of inclusion, and two different field types of corn residue. Steers were assigned randomly to treatment to evaluate the effects of supplementing modified or dried DGS on calves grazing either irrigated or non-irrigated corn residue on ADG. Each type of DGS was fed at an inclusion level of 0.3, 0.7 or 1.1% of BW. Steers were offered daily supplementation through the Calan Gate System for approximately two hours each morning and were then turned out to graze residue for the remainder of the day. Calves were gathered early each morning at sunrise prior to grazing, penned up for supplement consumption, and then turned out for grazing the remainder of the day. All calves were implanted with Ralgro on day one of the trial and received monensin at 200mg/steer and limestone at 60g/steer daily as part of supplementation.

Stocking rate was calculated based on yield of the field at harvest and previous research quantifying the amount of residue consumed per acre. The yield (bu/acre), estimated forage availability (8 lb/bu), grazing efficiency factor (100% for non-irrigated, 85% for irrigated) and number of acres were multiplied together to estimate the total available forage for each field. Total available forage was then divided by estimated DMI of all steers allotted to graze each respective field in order to get days of available grazing. Using this calculation, the 32-acre irrigated field would allow 66 steers to graze for 70 days based on a yield of 214 bushels of grain/acre. The non-irrigated fields totaled 42 acres and had a yield of 100 bushels of grain/acre, allowing for 60 steers to graze 70 days. Due to the limited number of Calan gates, only 60 steers could be used on the irrigated field. The six ruminally fistulated steers utilized for diet sampling were able to graze irrigated corn residue and received daily supplementation in a feed bunk outside the barn.

Diet samples were collected four times throughout the trial by emptying the rumen of solid and liquid particulate matter. Prior to turn out, steers were assigned randomly to graze either the irrigated or non-irrigated field (three per field type). Once steers had a chance to graze for 30 minutes they were brought back in and the grazed forage was collected from the rumen, sealed in a labeled bag, and stored on ice for later analysis of *in-vitro* organic matter disappearance (IVOMD). The original rumen contents prior to diet sampling were replaced in the rumen of the respective steer prior to turning them out with the herd. Total grazed contents were frozen and subsequently freeze dried. Samples were ground through a 1 mm screen prior to analysis. The IVOMD calculation was determined by incubating each sample for 48 hours in a solution of MacDougall's buffer and rumen fluid. Samples were then filtered, dried,and ashed to obtain DM and OM amounts for the IVOMD calculation. Feed refusals were collected each week and analyzed for DM. Samples were dried in a forced air oven at 60°C for 48 hours, weighed and then

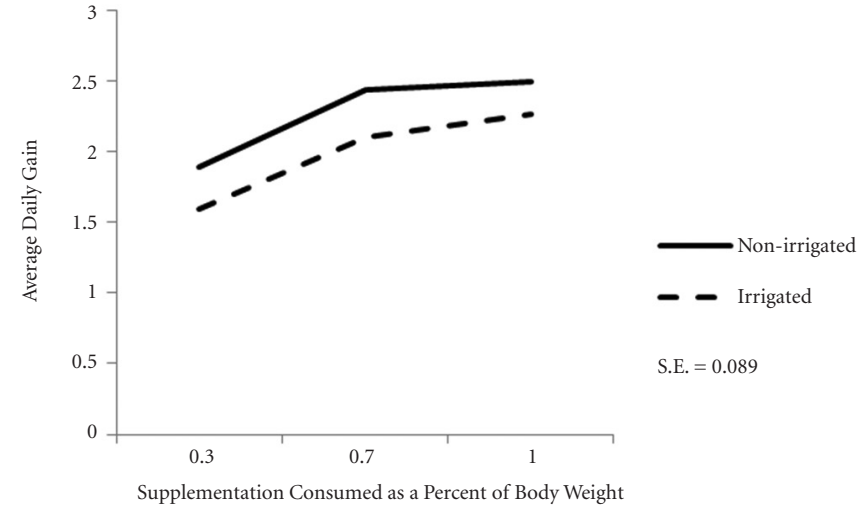

Figure 1. Relationship of distillers grains level and type of corn residue field on average daily gain.

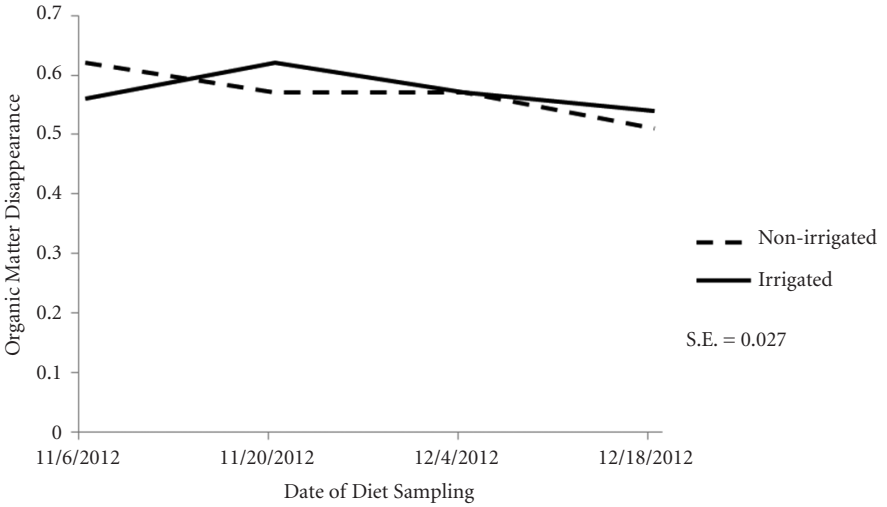

Figure 2. *In vitro* **organic matter disappearance of diet samples over time.**

dried in a 100ºC oven for 12 hours to get a lab corrected DM. Refusals for each individual animal were subtracted from the total amount of supplement offered to calculate actual supplement intake as a percentage of BW.

Results

No interactions were present for the 2 x 3 x 2 factorial design ($P = 0.12$). Therefore, the main effects of DGS type, level of inclusion and field type are presented.

Average daily gain increased quadratically ($P = 0.01$) with increasing level of supplementation for calves grazing irrigated and non-irrigated corn residue. Calves supplemented at 0.3, 0.7, and 1.1% of BW gained an average of 1.55, 2.02, and 2.12 lb/day ($P < 0.0001$). Some feed refusals were observed for steers supplemented at 0.7 and 1.1% of BW. The gain response to increasing levels of DGS supplementation is shown in Figure 1. The quadratic effect suggests that minimal improvements in gain occurred when calves grazing corn residue are offered supplementation at more than 1.1% of body weight. Based on supplement intake and ADG, the optimal supplementation level was 1% for calves grazing irrigated corn residue and 0.9% of BW for calves grazing a non-irrigated field.

Calves receiving modified DGS gained 1.92 lb/day compared to 1.88 lb/day for calves on the dried DGS treatment. Gains were not different ($P = 0.51$), which is similar to previous work in forage-based diets. Therefore, the type of DGS utilized may be based on amount that can be used/stored, location, availability, and pricing on a DM basis.

Steers grazing the non-irrigated corn residue gained more ($P = 0.0002$; 2.02 lb/day) in comparison to steers grazing irrigated residue (1.77 lb/day). While non-irrigated corn residue is lower in quantity and requires a lower stocking rate per acre, previous research has shown that the nutritional quality is higher than with irrigated corn residue. The improvement in ADG of steers grazing the non-irrigated field supports previously observed differences in nutritional quality.

Differences were not present for diet samples collected and analyzed by sampling period ($P = 0.07$) or field type ($P = 0.76$). Figure 2 shows the changes in IVOMD over time. The IVOMD calculation shows the linear decline in quality of the diet samples throughout the sampling period for both the irrigated and non-irrigated fields. Grazing corn residue is unique in that all of the available forage is accessible to the animal on the first day of grazing. Animal selectivity occurs with the steer consuming the grain, husk, leaf, cob, and then stalk. Residue parts are selected for in order of highest to lowest nutrient quality, supporting the decline in IVOMD over the grazing period. Based on previous research and the performance data from this trial, non-irrigated residue was expected to be different in nutritive quality when compared to irrigated corn residue. The ruminally fistulated steers grazed the irrigated corn residue field unless being utilized for diet sampling. Those assigned to graze the non-irrigated field may have had the disadvantage of not knowing the best grazing areas in the unfamiliar field, forcing them to consume lower quality plant parts.

This experiment suggests ADG is greater for calves grazing non-irrigated residue in comparison to irrigated corn residue and a quadratic effect occurs with increasing levels of supplementation, with no difference between types of supplementation.

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Effects of Grazing on Nebraska Sandhills Meadow Forage Nutrient Content

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Summary

Nebraska Sandhills subirrigated meadow pastures were utilized to measure the effects of grazing on forage nutrient content in summer pastures. Pre-grazed pastures had greater protein and in vitro dry matter digestibility levels and lower neutral detergent fiber levels compared with post-grazed pastures early in the grazing season. By late July, post-grazed vs. pre-grazed pastures did not differ in in vitro dry matter digestibility and neutral detergent fiber levels. Observed results indicate the greatest differences in nutrient content between post-grazed and pre-grazed pastures occur early in the grazing season.

Introduction

Nebraska Sandhills subirrigated meadows are an excellent resource for grazing cattle. Most are dominated by cool-season grass species which have greater growth during early spring. However, as temperatures increase by mid-summer, forage quality decreases (*1997 Nebraska Beef Cattle Report*, p. 3-5). Previous research has shown the changes in forage nutrient composition throughout the year, but it is unclear how grazing affects the nutrient composition of Sandhills subirrigated meadows. Therefore, the objective of this research was to determine the difference in forage quality between post-grazed pastures vs. pre-grazed pastures in the Nebraska Sandhills subirrigated meadows.

Procedure

A total of eight subirrigated meadow pastures (161 ac ± 47 ac) in the Nebraska Sandhills were used. The meadow was divided into multiple pastures to allow rotational grazing. Of the eight sampled pastures, two adjacent pastures were sampled on one of four dates: early June, late June, early July, or late July. Of the two adjacent pastures sampled each date, one pasture was not previously grazed (pre-grazed), while the other pasture had been grazed (post-grazed) the previous four days, with the exception of the late July pasture which was grazed for three days. On each sampling date the pre-grazed pasture was sampled prior to introduction of cattle to the pasture and the post-grazed pasture was sampled after the allotted grazing had occurred. Stocking rates consisted of 15, 15, 30, and 19 animal unit days per acre for early June, late June, early July, and late July, respectively. Because of severe drought, stocking rate was reduced in late July. Three esophageally fistulated cows were used to sample each pasture on each date to determine forage quality. Prior to each diet sample collection, cows were withheld from feed, but not water, for 12 hours, then transported to pastures where diets were to be collected. Cows were fitted with solid bottom bags after removal of the esophageal plug and introduced to the pasture then allowed to graze for about 20 minutes.

Samples were separated into a liquid and fibrous portion for lab analysis. Immediately after separation, diet samples were frozen and stored at -20° C. Fibrous samples were lyophilized, ground to pass a 1-mm screen in a Wiley mill and analyzed for nitrogen. Neutral detergent fiber content was determined using the Van Soest et al. method, and IVDMD using the Tilley and Terry method with the modification of adding 1 g of urea to the buffer and adjusted to *in vivo* values. Results were analyzed using the PROC MIXED procedure of SAS (SAS Institute, Inc., Cary, N.C.).

Results

In early June, CP ($P < 0.001$) and IVDMD ($P = 0.03$) content were greater and NDF ($P = 0.07$) content was lower in pre-grazed compared with post-grazed pastures (Table 1). Late June pastures exhibited similar patterns such that pre-grazed pastures were greater in CP ($P = 0.03$) and IVDMD ($P = 0.09$) than post-grazed pastures. Late June NDF was numerically lower ($P = 0.11$) for pre-grazed compared with post-grazed pastures. The CP content of pastures in early July did not differ (P = 0.30) between pre-grazed vs. post-grazed treatments. Neutral detergent fiber ($P = 0.08$) was lower and IVDMD ($P = 0.09$) was greater for pre-grazed compared with post-grazed pastures in early July. With the higher stocking rate during this sampling period, it seems logical that this is when the greatest nutrient differences would have occurred. However, the results from this study could be due to the nature of the cool-season grass species being lower quality during July. Late July pre-grazed pastures had greater ($P = 0.05$) CP levels than post-grazed pastures. However, there were no differences between pre-grazed vs. post-grazed pastures for NDF ($P = 0.56$) or IVDMD ($P = 0.78$) in late July. These data suggest the greatest impact of grazing cool season grass meadows on forage quality occurs early in the grazing season in multi-pasture grazing systems.

Table 1. Crude protein, NDF, and IVDMD values of masticate samples.

Item	Pre-Grazed[1]	Post-Grazed[2]	SE	*P*-value
Early June[3]				
CP %	12.0	7.1	0.3	<0.001
NDF %	66.8	75.7	4.8	0.07
IVDMD %	66.7	58.1	2.3	0.03
Late June[3]				
CP %	9.8	7.2	0.3	0.03
NDF %	70.4	78.7	2.5	0.11
IVDMD %	63.5	57.0	1.4	0.09
Early July[3]				
CP %	8.7	8.3	0.2	0.30
NDF %	61.8	67.8	1.3	0.08
IVDMD %	58.2	54.1	1.4	0.09
Late July[3]				
CP %	10.0	8.0	0.5	0.05
NDF %	66.1	63.0	3.5	0.56
IVDMD %	54.6	54.0	1.4	0.78

*Significant differences (*P*-value ≤ 0.1).
[1] Pastures sampled prior to grazing.
[2] Pastures sampled after grazing.
[3] Date pasture was sampled using esophageally fistulated cows.

Severe drought during 2012 may have affected the quality of the July pastures. It also may be a possibility that as the season progressed and less water was present in the meadow the cattle would have been able to reach forage that was previously unavailable on an average precipitation year.

Cattle are selective grazers. When first introduced to a pasture, cattle eat the higher quality plants and plant parts, leaving lower quality plants and plant parts for later consumption. This creates a change in diet quality over time independent of change in nutrient content of the forage. With the decline in diet quality, it might be assumed the cow's requirements would not be met during the entire time she grazes a particular pasture. However, this is not always the case. A 1,200 lb cow consuming 2.5% of her body weight would eat 30 lb (DM) of forage, of which, about 18 lb would be TDN in early June. This exceeds the TDN requirements for a lactating cow. Even though a spring calving cow's nutrient requirements are highest early in the grazing season due to lactation, on average, the cow's TDN requirements would be met this entire time she grazes a pasture. However, her protein requirements may not be met. This is especially true for animals with relatively high requirements such as heifers and cattle at peak lactation. In this study, CP content of early June forage went from 12% before cattle were introduced to the pasture to 7.1% on the day they were removed from the pasture. Initially, the diet contained a relatively high amount of CP, but at the time cattle were removed from the pasture, CP content of the diet was much lower. This change in CP in the diet may be a result of the fact that when cattle are introduced into a pasture early in the grazing season, plants have not had sufficient time to accumulate sufficient current year's growth resulting in last year's growth becoming a major component of the diet toward the end of the time cattle are in the pasture. These data suggest strategic supplementation or more frequent rotation among pastures early in the grazing season could be beneficial. In July, after the plants had had more time to grow, the availability of current year's forage allowed the cattle to consume higher quality, current year's growth the entire time they grazed a pasture. Close management is key to success in multi-pasture rotation systems to manage the quality of the forage and ensure the cattle's requirements to be met.

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Effect of Irrigation Allocation on Perennial Grass Production and Quality

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Summary

Cool-season grass mixtures and warm-season grass mixtures were evaluated in 2010, 2011, and 2012 under varying irrigation levels to determine dry matter yield, CP, and TDN for beef cattle in the Nebraska Panhandle. As a generalization, when seasonal precipitation was average, irrigation levels over 10 inches resulted in no significant increase in either grass production or quality. Cool-season grasses produced more dry matter yield and maintained greater CP and TDN than warm-season grasses. In all three years, a mixture of wheatgrasses had greater forage yield than an orchardgrass monoculture or a mixture dominated by bromegrasses. In 2010 and 2011, treatments containing switchgrass yielded more DM than a big bluestem/indiangrass mixture.

Introduction

The Nebraska Panhandle is a low rainfall area (14-16 inches annually). Many producers in western Nebraska face reduced irrigation amounts because of drought (reservoir water) and NRD groundwater allocations. This makes it difficult for producers to grow crops with high water needs such as corn. Additionally, there are many years when rainfall is below the long-term average, limiting native grass production and forages grown on dryland acres. These drought conditions often force beef cattle producers to locate and purchase additional feed resources. Therefore, irrigated pastures can be an important resource; however, there is very little data for the Panhandle on the production potential of cool- and warm-season perennial grasses under different irrigation levels. The objectives of this research were to determine the production and forage quality of perennial cool- and warm-season grasses (monoculture and mixtures) from dryland to fully irrigated conditions in a semi-arid climate.

Procedure

Plots were established in 2009 on a Tripp fine sandy loam soil at Scottsbluff, Neb. Cool-season grasses included: orchardgrass (OG); a bromegrass-based mixture (meadow and smooth bromegrass, orchardgrass, and creeping foxtail) (BM); and a wheatgrass mixture (western, intermediate, and pubescent wheatgrass) (WM). Warm-season grasses included: switchgrass (SG), big bluestem plus indiangrass (BBI), and switchgrass plus big bluestem and indiangrass (SBBI). Nitrogen fertilizer rates for limited irrigation treatments were developed from dry matter and N relationships from published dryland and full-ET research. Weed control was required for both cool- and warm-season grasses. Data were collected in 2010, 2011, and 2012. In 2010, irrigation levels included 5, 10, 15, and 20 inches. In 2011 and 2012, irrigation levels were 0, 5, 10, and 15 inches. Plots were harvested with a tractor-mounted, flail-type chopper. Samples were weighed with the chopper's scale, subsampled, and dried in a 100° F forced air oven for 48 hours. Dry matter production was calculated based on the size of the harvested area. The dried subsamples were ground and sent to a commercial laboratory for crude protein and TDN (calculated from wet chemistry ADF analysis.) Harvest dates were early July and again in September for cool season grasses and October for warm-season grasses with the exception of 2012 when cool season grasses were only harvested in July and warm-season grasses were harvested in late August. Data were analyzed using the GLM procedure of SAS.

Results

In 2010, dry matter yields of BM and OG were not significantly higher ($P < 0.05$) with 20 inches of irrigation than with 10 inches (Table 1). However, there was an apparent trend that confirms increased dry matter production of BM and OG from 5 to 15 inches and a slight decreased trend thereafter from 15- to 20-inch irrigation. Meaning, under given experimental conditions, the optimum irrigation level for maximum dry matter production for these two grass species was 15 inches. The trend was not consistent with WM. The WM had similar yields with 15 or 20 inches of irrigation but both resulted in greater yields than at 10 inches ($P < 0.05$). Regardless of irrigation level, WM produced more DM yield than BM or OG ($P < 0.05$). Providing 20 inches irrigation did not increase DM yield ($P > 0.05$) compared to the 15 inch irrigation for SG, BBI, or SBBI (Table 2). All irrigation levels resulted in similar DM yields for SBBI. DM yield was less for BBI than for SG or SBBI which were similar ($P < 0.05$). Unlike cool-season grasses, the trend of DM production for warm-season grasses was increased linearly with the increased irrigation levels. The CP and TDN values were not significantly impacted ($P > 0.05$) by irrigation level in either the cool- or warm-season grasses (Table 3). However, both CP and TDN were higher for cool-season grasses than warm-season grasses

Table 1. 2010 growing season yield of cool-season grasses at Scottsbluff, Neb., harvested in June and September.

Irrigation Level[1]	Brome Mix	Orchardgrass	Wheatgrass Mix	Irrigation Mean
	---------- tons of dry matter per acre----------			
5 inches	2.70[b]	1.58[b]	4.20[b]	2.83
10 inches	3.63[ab]	3.12[ab]	3.76[b]	3.50
15 inches	4.76[a]	4.38[a]	5.27[a]	4.80
20 inches	4.33[a]	3.93[a]	5.55[a]	4.60
Grass production average[2]	3.86[b]	3.29[b]	4.69[a]	

[1]Means with superscripts in a column that differ are different ($P < 0.05$).
[2] Means with superscripts in a row that differ are different ($P < 0.05$).

Table 2. 2010 fall (Oct. 20, 2010) yield of warm-season grasses at Scottsbluff, Neb.

Irrigation Level[1]	Switchgrass	Big Blue/ Indian Mix	Sw + Big Blue + Indian	Irrigation Mean
	---------- tons of dry matter per acre----------			
5 inches	1.94[b]	1.09[b]	1.85	1.63
10 inches	2.28[ab]	1.35[b]	1.96	1.86
15 inches	2.79[a]	1.61[a]	2.37	2.26
20 inches	2.79[a]	2.19[a]	2.93	2.64
Grass production average[2]	2.44[a]	1.56[b]	2.28[a]	

[1]Means with superscripts in a column that differ are different ($P < 0.05$).
[2] Means with superscripts in a row that differ are different ($P < 0.05$).

Table 3. 2010 crude protein and TDN of cool- and warm-season grasses at Scottsbluff, Neb.

	Brome Mix		Orchardgrass		Wheatgrass Mix		Irrigation Mean	
Irrigation Level[1]	CP	TDN	CP	TDN	CP	TDN	CP	TDN
5 inches	10.4	60.8	10.5[a]	57.7[a]	10.7[a]	59.3	10.5	59.3
10 inches	12.5	61.0	12.8[bc]	60.7[ab]	13.0[b]	60.5	12.8	60.7
15 inches	12.5	60.2	14.2[b]	62.1[b]	13.0[b]	61.3	13.2	61.2
20 inches	11.9	58.6	12.2[ac]	59.0[ab]	11.5[ab]	59.8	11.9	59.1
Grass production mean[2]	11.8	60.1	12.4	59.9	12.1	60.2		
	Switchgrass		BB /Indian Mix		Switch/BB/ Indian Mix		Irrigation Mean	
Irrigation Level[1]	CP	TDN	CP	TDN	CP	TDN	CP	TDN
5 inches	4.0	55.3	5.3	54.0	4.4	57.0[a]	4.6	55.4
10 inches	4.0	53.8	7.5	53.2	5.8	51.6[b]	5.8	52.9
15 inches	3.3	54.6	5.1	52.3	3.8	54.9[ab]	4.1	53.9
20 inches	3.5	52.5	6.4	53.5	3.8	52.7[ab]	4.6	52.9
Grass production mean[2]	3.7[a]	54.1	6.1[b]	53.2	4.4[a]	54.0		

[1]Means with superscripts in a column that differ are different ($P < 0.05$).
[2]Means with superscripts in a row that differ are different ($P < 0.05$).

Table 4. 2011 growing season yield of cool-season grasses Scottsbluff, Neb., harvested in July.

Irrigation Level[1]	Brome Mix	Orchardgrass	Wheatgrass Mix	Irrigation Mean
	---------- tons of dry matter per acre----------			
0 inches	2.94[c]	2.48[d]	4.38[c]	3.27
5 inches	5.81[b]	4.29[c]	6.06[b]	5.39
10 inches	6.24[ab]	5.53[b]	7.40[a]	6.39
15 inches	7.24[a]	6.62[a]	7.91[a]	7.26
Grass production mean[2]	5.55[b]	4.73[c]	6.44[a]	

[1]Means with superscripts in a column that differ are different ($P < 0.05$).
[2]Means with superscripts in a row that differ are different ($P < 0.05$).

($P < 0.05$). Had the warm-season grass been harvested earlier, quality may have been improved.

Due to consistent lack of significant improvement in DM production and quality for 20-inch irrigation across all grass species in 2010, the irrigation treatments were limited to 15 inches in 2011 and 2012. In 2011, all irrigation levels significantly increased DM yield of the cool-season grasses over the 0 irrigation treatment ($P < 0.05$). The 15 inch level did not increase DM yield for BM and WM over the 10 inch level, but did for OG (Table 4). Regardless of irrigation level, WM had the greatest DM yield. DM yield was also greater for BM compared to OG ($P < 0.05$). There were no significant differences in DM yield for SG regardless of irrigation level ($P > 0.05$). There were no differences in DM yield of BBI for 5, 10, or 15 inches, but DM yield was greater for 5, 10, and 15 inches compared to 0 inches. The DM yield was greater for 10 and 15 inches in SBBI than 0 inches (Table 5). Overall yield was similar for SG and SBBI (4.37 and 4.46 ton/ac, respectively) which was significantly greater than BBI (3.35 ton/ac) ($P < 0.05$). Crude protein and TDN were unaffected by irrigation level in BM (Table 6) ($P > 0.05$). The TDN was greater for the 5, 10, and 15 inch levels compared to the 0 level for OG and WM while CP was unaffected by irrigation ($P < 0.05$). When irrigation treatments were combined, CP and TDN were similar for BM, OG, and WM. Irrigation level had no significant effect on CP or TDN for SG, BBI, or SBBI.

A severe drought coupled with extreme heat plagued the Nebraska Panhandle in 2012, reducing forage growth substantially. Each level of irrigation increased DM yield for BM, OG, and WM ($P < 0.05$) (Table 7). The greatest DM yield across all irrigation levels was WM (2.61 ton/ac) followed by BM (2.06 ton/ac), which was greater ($P < 0.05$) than OG (1.70 ton/ac). Similarly, the irrigation level increased DM yield for the warm-season grasses ($P < 05$) (Table 8). However, no significant difference in yield was detected

(Continued on next page)

among SG, BBI, or SBBI when irrigation level was combined. Crude protein was not affected by irrigation level in BM, OG, or WM ($P > 0.05$) (Table 9). However, TDN was decreased at the 10 and 15 inch levels in OG and WM and at the 15 inch level in BM ($P < 0.05$). When averaged over irrigation level, BM had the greatest CP (13.8%) and WM (11.8%) was greater than OG (10.2%). BM also had greater TDN (62.4%) than OG (59.7%), while the TDN of WM was similar to BM and OG (61.1%) ($P < 0.05$). The TDN of the warm-season grasses was lowest for the 15 inch level ($P < 0.05$), but similar for the other levels. The 10 and 15 inch levels were lower in CP than the 0 and 5 inch levels, most likely due to increased DM yield. The greater CP and TDN values for SG, BBI, and SBBI in 2012 compared to 2010 and 2011 was most likely due to the earlier harvest date (August vs. October). The warm-season grasses were fertilized with a nitrogen rate that was 70% of that for cool season. Further research with N rates on warm seasons may be required.

Grass yields in 2010 for cool-season grasses were over 5 tons per acre. Yields of warm-season grasses were generally less than 55% of cool-season grasses (Table 10). The cool-season grass yields were excellent during 2011 maximizing at over 7 dry tons per acre which was a 40% increase over 2010. Warm-season grass production in 2011 increased significantly and was over 60% higher compared to 2010 levels and maximum yield was near 5 dry tons per acre. Warm-season grass productivity versus cool season improved in 2011, but still did not match cool season productivity. At the 0 irrigation level in 2011, warm season yield equaled cool season. With even the lowest irrigation level, cool-season grasses outperformed warm-season grasses. More weed control was needed for warm season than cool season due to the lack of competitiveness of the

Table 5. 2011 yield of warm-season grasses harvested Oct. 14, 2011, Scottsbluff, Neb.

Irrigation Level[1]	Switchgrass	Big Blue/Indian Mix	Sw + Big Blue + Indian	Irrigation Mean
	tons of dry matter per acre			
0 inches	3.61	2.42^{b}	3.64^{b}	3.22
5 inches	4.52	3.97^{a}	4.59^{ab}	4.36
10 inches	4.70	3.72^{a}	4.72^{a}	4.38
15 inches	4.64	3.71^{a}	4.94^{a}	4.43
Grass production mean[2]	4.37^{a}	3.35^{b}	4.46^{a}	

[1]Means with superscripts in a column that differ are different ($P < 0.05$).
[2]Means with superscripts in a row that differ are different ($P < 0.05$).

Table 6. 2011 crude protein and TDN of cool- and warm-season grasses at Scottsbluff, Neb.

	Brome Mix		Orchardgrass		Wheatgrass Mix		Irrigation Mean	
Irrigation Level[1]	CP	TDN	CP	TDN	CP	TDN	CP	TDN
0 inches	9.4	54.3	7.5^{a}	49.8^{a}	7.7^{a}	51.4^{a}	8.2	51.8
5 inches	12.0	59.0	11.3^{ac}	57.8^{b}	11.3^{a}	57.7^{b}	11.5	58.2
10 inches	11.9	58.7	11.5^{bc}	58.2^{b}	11.0^{ab}	57.0^{ab}	11.5	58.0
15 inches	11.8	55.4	10.8^{ab}	56.8^{b}	12.9^{b}	58.5^{b}	11.8	56.9
Grass production mean[2]	11.3	56.8	10.3	55.6	10.8	56.1		

	Switchgrass		BB /Indian Mix		Switch/BB/ Indian Mix		Irrigation Mean	
Irrigation Level[1]	CP	TDN	CP	TDN	CP	TDN	CP	TDN
0 inches	5.3	51.4	5.5	49.4	5.5	52.3	5.4	51.0
5 inches	3.8	48.4	7.2	51.1	4.5	50.1	5.2	49.9
10 inches	3.3	49.0	4.9	49.1	4.0	49.9	4.1	49.3
15 inches	4.4	49.2	6.0	48.0	3.7	49.5	4.7	48.9
Grass production mean[2]	4.2	49.5	5.9	49.4	4.4	50.4		

[1]Means with superscripts in a column that differ are different ($P < 0.05$).
[2]Means with superscripts in a row that differ are different ($P < 0.05$).

Table 7. 2012 growing season yield of cool-season grasses Scottsbluff, Neb.

Irrigation Level[1]	Brome Mix	Orchardgrass	Wheatgrass Mix	Irrigation Mean
	tons of dry matter per acre			
0 inches	0.12^{d}	0.12^{d}	0.30^{d}	0.18
5 inches	1.06^{c}	0.66^{c}	0.96^{c}	0.89
10 inches	2.25^{b}	1.31^{b}	3.06^{b}	2.21
15 inches	4.81^{a}	4.51^{a}	6.28^{a}	5.20
Grass production mean[2]	2.06^{b}	1.70^{c}	2.61^{a}	

[1]Means with superscripts in a column that differ are different ($P < 0.05$).
[2]Means with superscripts in a row that differ are different ($P < 0.05$).

Table 8. 2012 yield of warm-season grasses harvested Aug. 30, 2012, Scottsbluff, Neb.

Irrigation Level[1]	Switchgrass	Big Blue/Indian Mix	Sw + Big Blue + Indian	Irrigation Mean
	tons of dry matter per acre			
0 inches	0.26^{d}	0.19^{d}	0.27^{d}	0.24
5 inches	1.63^{c}	1.31^{c}	2.08^{c}	1.67
10 inches	4.01^{b}	3.12^{b}	3.91^{b}	3.68
15 inches	5.64^{a}	5.44^{a}	6.09^{a}	5.72
Grass production mean [2]	2.89	3.04	3.15	

[1]Means with superscripts in a column that differ are different ($P < 0.05$).
[2]Means with superscripts in a row that differ are different ($P < 0.05$).

Table 9. 2012 crude protein and TDN of cool- and warm-season grasses at Scottsbluff, Neb.

	Brome Mix		Orchardgrass		Wheatgrass Mix		Irrigation Mean	
Irrigation Level[1]	CP	TDN	CP	TDN	CP	TDN	CP	TDN
0 inches	14.3	63.7[a]	11.1	61.6[a]	13.7[a]	64.1[a]	13.0	63.1
5 inches	13.3	63.6[a]	11.3	62.6[a]	11.2[ab]	63.4[a]	11.9	63.2
10 inches	14.1	62.2[ab]	9.1	57.8[b]	10.5[b]	59.1[b]	11.2	59.7
15 inches	13.6	60.2[b]	9.3	56.7[b]	11.6[ab]	57.8[b]	11.5	58.2
Grass production mean[2]	13.8[a]	62.4[d]	10.2[b]	59.7[e]	11.8[c]	61.1[de]		

	Switchgrass		BB /Indian Mix		Switch/BB/ Indian Mix		Irrigation Mean	
Irrigation Level[1]	CP	TDN	CP	TDN	CP	TDN	CP	TDN
0 inches	12.1[a]	65.7[a]	9.8[a]	62.1[a]	12.4[a]	65.2[a]	11.4	64.3
5 inches	9.7[b]	65.7[a]	8.6[ab]	61.8[ac]	10.4[a]	67.0[a]	9.6	64.8
10 inches	7.7[c]	62.8[a]	7.1[b]	60.8[a]	7.7[b]	63.0[a]	7.5	62.2
15 inches	7.1[c]	55.6[b]	7.1[b]	56.3[bc]	6.7[b]	57.2[b]	7.0	56.4
Grass production mean[2]	9.2[ac]	62.4[ab]	8.1[bc]	60.2[a]	9.3[a]	63.1[b]		

[1]Means with superscripts in a column that differ are different ($P < 0.05$).
[2]Means with superscripts in a row that differ are different ($P < 0.05$).

Table 10. Ratio of warm-season to cool-season grass yields at Scottsbluff, Neb.

Irrigation Level	2009 WS/CS	2010 WS/CS	2011 WS/CS	2012 WS/CS
0 inches	—	—	99%	133%
5 inches	30%	57%	81%	187%
10 inches	27%	53%	69%	167%
15 inches	27%	43%	61%	110%
20 inches	37%	53%	—	—

different warm-season grasses with the weed spectrum in the Nebraska Panhandle. These data suggest irrigated cool season perennial grasses have an advantage over irrigated perennial warm-season grasses in the Nebraska Panhandle. However, in extreme drought and heat, the warm-season grasses out yielded the cool-season grasses. Additionally, unless the season's precipitation is drastically below normal, irrigation levels over 10 inches do not provide significant improvements in DM yield, CP, or TDN.

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Dryland Cover Crops as a Grazing Option for Beef Cattle

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Summary

A two-year grazing study was conducted to evaluate forage quality and utilization of cover crops (CC) in dryland cropping systems compared to crested wheatgrass pastures (CWP). The CC mixture consisted of oats, peas and turnips planted in March with a no-till drill. Both CC and CWP were grazed during the month of June. Total tract dry matter digestibility and CP were greater for CC compared to CWP while NDF and ADF of CC were less. The CC was observed to have greater forage quality over both years and may produce similar amounts of forage as crested wheatgrass pastures allowing deferred grazing on native pasture.

Introduction

Many producers in dryland wheat farming regions have made a shift from the typical winter wheat fallow rotation to a no-till system paired with crop rotations which may include forage crops. Combinations of cereals and legumes provide biomass to inhibit water loss due to evaporation as well as provide organic matter for the soil from their decomposing residues. The legumes provide nitrogen through fixation which can then be available for the next crop, while brassicas, as another component, have the ability to loosen compacted soils with their roots reducing the requirement for tillage.

The biomass from cover crops could potentially be used as a source of forage for cattle producers and return most of the nutrients to the cropping system when grazed. Cover crops may decrease pressure on pasture grasses or allow for deferred grazing when pastures need rest. The objective of this experiment was to determine the differences in forage quality of cover crops in a dryland no-till farming system compared to crested wheatgrass pastures grazed by yearling cattle.

Materials and Methods

A two-year study (June 2011 and June 2012) was conducted at the University of Nebraska High Plains Agricultural Lab located near Sidney, Neb. Treatments were cover crops (CC) and crested wheatgrass pasture (CWP). Oats, peas, and turnips utilized in the CC treatment were planted with a no-till drill in March. Seeding rates for CC were 40, 40, and 2 lb/ac for oats, peas, and turnips, respectively. In 2011, no fertilizer was applied prior to planting. In 2012, 30 lb/ac nitrogen was applied according to soil test results. The field was replicated into three 6-acre paddocks in year 1 and three 10-acre paddocks in year 2. A 30-acre pasture was utilized for the CWP treatment and divided into three 10- acre paddocks both years. The CWP treatment pasture predominantly consisted of crested wheatgrass but also included buffalo grass and blue grama. All paddocks were sampled for forage production the first, third, and fifth week of grazing. Samples from CC treatment were sorted by each plant species and weighed individually to determine DM yields at each sampling date. Cattle were allowed to graze paddocks for five weeks. Ungrazed samples were clipped to determine DM tonnage. The forage in the CC treatment was chemically killed at the end of five weeks, after cattle were removed, to preserve moisture for fall wheat planting. Five steers were used in each paddock, which resulted in stocking densities of 3.6 steers/ac for CC in year 1, and two steers/ac for CWP both years, as well as CC in year 2. Stocking density was held constant over the entire grazing period.

Hand clipped forage samples (5.4 ft^2, n = 4/paddock) and diet samples collected using three esophageally fistulated cows were analyzed for IVDMD (similar to TDN), CP, NDF, and ADF in both years. In year 2, diet samples were also analyzed for undegradable intake protein (UIP) as a percent of CP.

Samples were analyzed with time (week) as a repeated measure using the MIXED procedure of SAS (SAS Institute, Inc., Cary, N.C.). Additionally, linear and quadratic contrasts were used to determine effects of nutrient composition over the grazing season.

Results and Discussion

Hand-clipped Forage Samples

Hand-clipped forage samples were analyzed for IVDMD and nutrient composition (CP, NDF, and ADF) each year (Table 1). Values "for IVDMD and CP were greater ($P \leq 0.05$) and NDF was lower ($P = 0.02$) for CC compared to CWP over the grazing season for both years. In 2011, ADF content tended ($P = 0.08$) to be lower for CC compared to CWP. Conversely, in 2012 ADF content was lower ($P < 0.01$) for CC compared to CWP. In 2011, IVDMD percentages decreased linearly ($P < 0.01$) across weeks for CC and CWP (Table 2). The CP concentration for CC responded quadratically ($P < 0.01$), with weeks 1 and 5 having the greatest CP content and week 3 having the lowest, while CP content of CWP tended ($P < 0.06$) to decrease linearly. Additionally, a linear ($P \leq 0.03$) increase in NDF and ADF content was observed for CC. The NDF content increased in CWP ($P < 0.01$) while ADF content was not different ($P \geq 0.17$). In 2012, IVDMD decreased linearly ($P< 0.01$) for CC and CWP. The CP content decreased

Table 1. *In-vitro* **digestibility and nutrient composition in clipped quality samples for cover crops (CC) and crested wheatgrass pasture (CWP).**[1]

Item	CC	CWP	SEM	*P*-Value
2011				
IVDMD[2]	71.5	58.3	2.2	0.05
CP	10.5	7.8	0.4	0.05
NDF	46.5	67.5	1.5	0.02
ADF	34.3	41.5	1.1	0.08
2012				
IVDMD	60.1	46.3	1.1	0.02
CP	9.4	5.9	0.2	0.01
NDF	55.2	69.7	1.5	0.04
ADF	38.9	54.5	0.8	< 0.01

[1]% DM.
[2]*In vitro* DM digestibility.

Table 2. Clip sample forage quality for cover crops (CC) and crested wheatgrass pasture (CWP) over time.

Item	Week 1	Week 3	Week 5	SEM	Linear[1]	Quad[2]
2011 CC						
IVDMD[3]	77.1	73.9	63.6	2.2	< 0.01	0.32
CP	11.3	8.7	12.5	0.6	0.19	< 0.01
NDF	34.5	44.8	52.3	1.1	< 0.01	0.31
ADF	31.0	30.2	39.6	2.6	0.03	0.13
2011 CWP						
IVDMD	63.1	58.1	53.9	2.2	< 0.01	0.85
CP	9.1	7.4	7.3	0.6	0.06	0.32
NDF	62.1	68.3	70.8	1.1	< 0.01	0.18
ADF	37.7	44.6	42.3	2.6	0.24	0.17
2012 CC						
IVDMD	70.3	60.4	53.5	0.7	< 0.01	0.11
CP	11.2	9.6	8.2	0.3	< 0.01	0.72
NDF	41.3	54.2	61.6	1.0	< 0.01	0.04
ADF	32.5	40.7	42.4	1.1	< 0.01	0.03
2012 CWP						
IVDMD	49.2	46.2	46.0	0.7	< 0.01	0.13
CP	6.0	5.8	5.8	0.3	0.50	0.77
NDF	68.4	68.9	67.8	1.0	0.70	0.53
ADF	53.8	54.7	54.9	1.1	0.47	0.77

[1]Linear effect of week.
[2]Quadratic effect of date.
[3]*In vitro* DM digestibility.

Table 3. ***In-vitro*** **digestibility and nutrient composition of samples collected using esophageally fistulated cows in 2011 and 2012 for cover crops (CC) and crested wheatgrass pasture (CWP)[1].**

Item	CC	CWP	SEM	*P*-Value
2011				
IVDMD[2]	69.4	58.9	1.47	< 0.01
CP	9.5	7.3	0.60	0.04
NDF	50.2	69.9	0.02	< 0.01
ADF	31.6	40.9	0.02	< 0.01
2012				
IVDMD[2]	62.7	51.4	3.9	< 0.01
CP	9.3	7.4	0.7	0.01
NDF	54.2	64.4	3.5	< 0.01
ADF	39.2	47.9	3.2	0.02
UIP[3]	29.5	32	2.9	0.41

[1]%DM.
[2]*In vitro* DM digestibility.
[3]Undegradable intake protein as a % of CP.

linearly ($P < 0.01$) for CC but was not significantly different for CWP. Both NDF and ADF content of the CC increased linearly ($P < 0.01$) and quadratically ($P \leq 0.04$; respectively), while NDF and ADF were not significantly different across weeks for CWP. The relatively small decrease in IVDMD and no differences in CP, NDF, and ADF content during the 2012 grazing period, suggests that the CWP may have been dormant during the grazing period due to a combination of reduced precipitation and warm temperatures observed during that year. The high temperatures for April, May, and June in 2012 were 10 degrees higher than for 2011. Additionally, cumulative rainfall for those three months in 2012 was only 3.6 inches compared to 12.1 inches in 2011.

Diet Samples

The diet sample quality for 2011 and 2012 followed similar tends as the clipped sample (Table 3). In both years CC was greater ($P \leq 0.04$) in IVDMD and CP content than CWP while the NDF and ADF content was less ($P \leq 0.02$) for CC compared to CWP. These data suggest the diet selected when grazing CC was of greater quality than the CWP. The undegradable intake protein was not different ($P = 0.41$) for CC compared with CWP.

Yields of Cover Crop Species

The yields of oats, peas, and turnips within the CC were analyzed to determine DM contribution of each species (Table 4). No differences ($P \geq 0.73$) were observed for the yield (as a % of total yield) of oats or peas across the grazing season in 2011. In 2011, the dry matter contribution of turnips decreased each week. However, the small amount of turnips available (approximately 2.5% of total yield) would likely have little effect on the selectivity of the cattle. In 2012, by week five, the yield of oats increased ($P = 0.03$) and the yield of peas decreased ($P = 0.03$). In 2012, turnips did not establish and grow in

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the CC treatment. Oats dominated the available forage in both years at 85% of the total yield with peas contributing most of the remaining yield. There was a trend for oats to increase and peas to decrease over the grazing period in 2012. A possible explanation of this could be a greater selection preference for peas compared to oats. The lack of precipitation and elevated temperatures observed in 2012 may have caused the oats to mature and earlier and likely made the peas more desirable for grazing. As mentioned previously, in 2011, cumulative rainfall for April, May, and June was 12.1 inches, and the CC was not fertilized that year. As a result the CC dry matter tonnage produced was considerably less than that of the CWP and consequently, the AUM's available for the month of June were less as well (Table 5). In 2012, the total rainfall for April, May, and June was only 3.6 inches, the average high temperature was 10 degrees higher for each of those months compared to 2011, and the CC was fertilized. These factors may have contributed largely to the tonnage and therefore AUM's available for CC and CWP being very similar.

Table 4. Yields of each crop within cover crops (CC) treatment[1].

Item	Week 1	Week 3	Week 5	SEM	*P*-value
2011					
Oats	80.0	84.0	80.6	3.7	0.73
Peas	16.1	13.9	17.8	3.8	0.77
Turnips	3.9[a]	2.1[ab]	1.6[b]	0.5	0.06
2012					
Oats	87.9[a]	87.9[a]	94.3[b]	1.4	0.03
Peas	12.1[a]	12.1[a]	5.7[b]	1.4	0.03
Turnips	0	0	0	—	—

[1]Values are a % of the total mass measured in each clip.
[a,b]Means within a row with unlike superscripts differ ($P < 0.05$).

Table 5. Total dry matter production and Animal Unit Months available for cover crops and crested wheatgrass pasture.

	2011 Total production measured June 28		2012 Total production measured July 11	
	Cover Crops	Crested Wheatgrass	Cover Crops	Crested Wheatgrass
DM ton/acre	0.55	0.97	0.73	0.76
Digestible DM ton/acre[1]	0.38	0.57	0.46	0.44
AUM/acre	0.40	0.69	0.53	0.54

[1]Digestible DM calculated from tons DM*IVDMD.

Predicted Cattle Performance

Obtaining accurate cattle weights after only one month of grazing is difficult because of changes in gut fill. With no accurate way to account for differences in gut fill, the authors chose to calculate daily gain based on NEg adjustments from diet quality data and historic gain data. Previous research (*1996 Nebraska Beef Cattle Report*, p. 51) indicated yearlings grazing crested wheatgrass for 62 days gained 2.0 lb/day. The average weight of the cattle over both years was used as the BW (750 lb) in NRC calculations which resulted in forage intake of 18.4 lb for both treatments. The predicted gain of cattle grazing CC and CWP in 2011 was 2.7 and 2 lb/day, respectively. In 2012, the predicted gain for cattle grazing CC and CWP was 2.2 and 1.1 lb/day, respectively. Greater cattle performance is expected when grazing CC based on NEg adjustments and diet quality data. The predicted ADG of CC may be supportive of stocker cattle or early weaned calves due to the quality of this forage source.

Cover crops had greater forage quality compared to crested wheatgrass pastures. Greater digestibility improved predicted performance at similar intakes compared to crested wheatgrass. Depending on the year and environmental factors, cover crops may be able to produce similar amounts of forage as native pastures. Cover crops planted on acres used for no-till wheat production offer a source of high-quality forage in addition to traditional grazing and haying acres. This integration of crops and livestock increased productivity per unit of land compared to fallow. This integration may offer a more sustainable approach utilizing acres for both grain and cattle production, but effects of grazing cover crops on wheat production need to be evaluated.

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Using Enspira™ to Improve Fiber Digestion

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Summary

Two experiments evaluated the effect of treating various feedstuffs with an enzyme (Enspira) on digestibility. Twelve feeds commonly fed to beef cattle were treated with four levels of the enzyme (0, 0.25, 0.50, or 0.75 lb of enzyme per ton of DM). Enzyme treatment increased in vitro DMD of high moisture corn (HMC), wet distillers grains plus solubles (WDGS), corn bran, and husks. There was a quadratic increase in gas production for corn leaves, as well as a linear increase in gas production for corn bran treated with increasing levels of Enspira. Treating feeds with the commercial enzyme Enspira improved in vitro digestibility of feeds high in hemicellulose, but not all feeds.

Introduction

About one-third of corn production in the United States is used for ethanol production today. The utilization of corn in the production of ethanol, in addition to the current drought, has forced cattle producers to feed less corn. Non-traditional feeds like corn milling byproducts and low-quality forages are being used to replace corn in beef cattle diets. However, these feed alternatives are higher in fiber content compared to the corn they are replacing, thus resulting in more fiber-based diets. Therefore, if the digestibility of these fibrous components of cattle diets could be improved, cattle efficiencies could be increased. Enspira is a direct-fed enzyme designed to increase fiber (i.e., hemicellulose) digestion. It has been fed in pork and poultry diets and resulted in improved feed efficiency. However, it has not been tested in ruminant diets. Therefore, the objective of these two experiments was to investigate the use of Enspira on common feeds in beef cattle diets *in vitro* and determine the optimal dosage in cattle diets.

Procedure

Experiment 1

The first experiment was designed as a 4 x 11 x 2 factorial with threee replications per treatment. Factors were four levels of Enspira (0, 0.25, 0.50, 0.75 lb per ton of DM) and 11 commonly used feeds (Table 1) incubated for 24 or 48 hours. All samples were freeze-dried and ground through a 1-mm screen. Feeds were analyzed for IVDMD. The procedure involved weighing 0.5 g of sample into a 100 mL tube, treating the sample with one of the four levels of enzyme, and adding 50 mL of inoculum. Inoculum was obtained by collecting a mixture of rumen fluid, strained through cheesecloth, from two steers consuming a 30% concentrate/70% roughage diet. The strained ruminal fluid was then mixed with McDougall's buffer (1:1 ratio) containing 1 g urea/L. Test tubes were placed in a water bath at 101°F. Tubes were incubated for 24 or 48 hour. Fermentation was ended by adding 6 mL of 20% HCl and 2 mL of 5% pepsin solution per tube. Tubes were then placed in the water bath for another 24 hours. Residue was filtered, dried, and weighed to determine IVDMD. Data were analyzed using the mixed procedures of SAS (SAS Institute, Inc., Cary, N.C.). The response variable was IVDMD. Tube was the experimental unit and there were three tubes per treatment per incubation time.

Experiment 2

Experiment 2 was similar to that as described in Experunebt 1; however, gas production was measured using the ANKOM gas production system instead of IVDMD. Gas production bottles were limited to 12 bottles per run; therefore, 12 feeds were used (Table 1) and divided into four runs. The same 11 feeds were used as in Experiment 1 with the addition of beef pulp. Feeds were grouped within run as follows: low-, medium-,

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Table 1. Substrates utilized in Experiment 1 and Experiment 2.

Experiment 1	Experiment 2
Low-quality forage[1]	Low-quality forage[1]
Medium-quality forage[2]	Medium-quality forage[2]
High-quality forage[3]	High-quality forage[3]
Corn cobs	Corn cobs
Corn husks	Corn husks
Corn leaves	Corn leaves
Wheat straw	Wheat straw
Corn bran	Corn bran
Wet distillers grains plus solubles	Wet distillers grains plus solubles
Dry-rolled corn	Dry-rolled corn
High-moisture corn	High-moisture corn
—	Beet pulp

[1]50-55% TDN.
[2]55-50% TDN.
[3]60-65% TDN.

and high-quality forage; corn cobs, corn husks, and corn leaves; wheat straw, beet pulp, and wet distillers grains plus solubles; dry-rolled corn, corn bran, and high-moisture corn. Within each run, feeds were treated with 0, 0.25, and 0.50 lb/ton of DM of Enspira. The procedure involved weighing 1 g of sample into a 250 mL gas production bottle, treating the sample with one of the three levels of enzyme, and adding 100 mL of inoculum. Inoculum was prepared as described in Experiment 1. Gas production was measured continuously for 36 hours. Each group of feeds was run four times to ensure adequate experimental power. Data were analyzed using the mixed procedures of SAS. The response variables were total gas produced and the rate of gas produced. Bottle was the experimental unit.

Results

Experiment 1

There was a feed*enzyme level interaction ($P < 0.01$). Digestibilities varied between feeds, which was to be expected. There was also a feed*enzyme*time interaction ($P < 0.01$), which was anticipated since different feeds digest at different rates. There was a linear increase in IVDMD at 24 hours of incubation, when corn bran was treated with increasing levels of Enspira (Table 2). However, a linear decrease (90% to 86.8% DMD) in digestibility was observed when increasing levels of enzyme were added to HMC ($P < 0.01$). Similarly, husk digestibilities ranged from 49.6% with no enzyme added to 39.5% at the highest level of enzyme added. Conversely, enzyme treatment improved IVDMD linearly ($P < 0.05$) for WDGS when incubated at 48 hours (Table 3). There was an improvement in digestibility at 48 hours of incubation when the enzyme was added to the husks; however, all levels of the enzyme responded the same. These results suggest that the enzyme is improving digestion of feeds that are higher in hemicellulose. It does not appear to improve digestibilities of feeds that are more cellulosic fiber. This response would be expected since Enspira contains a minimum of 350 U/g xylanase, which is the enzyme responsible for degrading hemicellulose.

Table 2. Effects of Enspira on *in vitro* DM digestion of various feedstuffs (24 hour; SE = 1.7).

	Enzyme Level				*P*-value		
Item	0.00	0.25	0.50	0.75	F-Test	Linear	Quad
HMC	90.0[ab]	91.6[a]	85.6[b]	86.8[b]	0.05	<0.01	0.66
DRC	89.9	90.7	89.2	87.5	0.57	0.07	0.16
WDGS	67.1	68.0	70.9	67.7	0.36	0.87	0.42
Bran	60.1[a]	59.9[a]	66.7[b]	66.4[b]	<0.01	0.01	1.0
Husks	49.6[a]	44.5[b]	39.6[c]	39.5[c]	<0.01	0.08	0.51
Leaves	32.1	32.7	30.0	28.8	0.31	0.01	0.23
Cobs	29.1[a]	28.0[a]	25.1[ab]	23.5[b]	0.07	<0.01	0.75
Low quality	41.8	41.0	41.5	39.2	0.68	0.04	0.36
Medium quality	44.3	42.8	42.5	43.1	0.89	0.54	0.46
High quality	52.5	52.5	51.8	52.3	0.99	0.94	0.87
Wheat straw	30.8	27.4	26.7	28.1	0.31	0.05	0.02

Table 3. Effects of Enspira on *in vitro* dry matter digestion of various feedstuffs (48 hour; SE = 1.7).

	Enzyme Level				*P*-value		
Item	0.00	0.25	0.50	0.75	F-Test	Linear	Quad
HMC	94.9	94.1	90.1	91.1	0.12	0.02	0.36
DRC	95.9	97.2	94.4	92.9	0.31	0.07	0.20
WDGS	72.5[a]	81.3[b]	75.2[a]	79.8[b]	<0.01	0.03	0.32
Bran	81.3[a]	85.9[b]	79.1[a]	80.8[a]	0.03	0.84	0.41
Husks	53.1[a]	62.9[b]	60.7[b]	62.0[b]	<0.01	0.17	0.34
Leaves	46.8[a]	46.8[a]	41.4[b]	42.8[ab]	0.05	<0.01	0.23
Cobs	43.3	45.3	41.1	42.3	0.34	0.36	0.61
Low quality	52.1	47.9	50.9	50.8	0.32	0.54	0.18
Medium quality	55.5	57.4	53.3	53.2	0.22	0.12	0.33
High quality	67.2	67.6	68.1	68.7	0.92	0.33	0.93
Wheat straw	41.6	42.7	40.9	40.2	0.74	0.29	0.33

Table 4. Effects of Enspira on total gas produced (mL/g of DM) on various feedstuffs.

	Enzyme Level				*P*-value		
Sample	0	0.25	0.50	SEM	F-Test	Linear	Quad
HMC	293.6[a]	310.1[b]	307.0[b]	2.42	0.01	0.01	0.02
DRC	301.2	295.7	291.7	8.42	0.74	0.46	0.94
Wheat straw	111.3	113.0	103.9	6.48	0.61	0.46	0.53
Poor brome	104.8	101.3	98.4	5.32	0.71	0.43	0.97
Good brome	133.6	134.0	133.8	12.44	1.0	0.99	0.98
High brome	158.9	163.4	156.9	20.25	0.97	0.95	0.83
Cob	115.70	115.01	122.03	13.67	0.92	0.75	0.83
Husk	198.53	197.12	201.73	6.51	0.88	0.74	0.72
Leaves	125.63	132.79	125.30	6.36	0.67	0.97	0.39
Beet pulp	198.05	189.12	197.90	4.84	0.41	0.98	0.21
WDGS	121.57	121.05	119.59	2.13	0.80	0.55	0.87
Corn bran	113.01	121.32	122.72	2.18	0.07	0.03	0.27

Experiment 2

There was no feed*enzyme interaction ($P > 0.45$). Similar to Experiment 1 there was a significant difference between feeds for digestion; however, this was by design as digestibilities of the selected feeds ranged widely. Enzyme treatment improved the amount of total gas

Table 5. Effect of Enspira on gas production rate (mL/hour) on various feedstuffs in Experiment 2.

	Enzyme Level				*P*-value		
Sample	0	0.25	0.50	SEM	F-Test	Linear	Quad
HMC	8.15[a]	8.61[b]	8.53[b]	0.076	0.03	0.03	0.04
DRC	4.92	4.78	4.40	0.124	0.09	0.04	0.49
Wheat straw	6.53	6.57	6.58	0.138	0.96	0.81	0.93
Poor brome	3.22	3.05	1.91	0.687	0.42	0.25	0.60
Good brome	4.14	4.13	4.14	0.078	1.0	1.0	0.95
High brome	4.96	5.07	4.89	0.810	0.57	0.68	0.36
Cob	3.22	3.19	3.39	0.211	0.78	0.59	0.68
Husk	5.51	5.48	5.60	0.072	0.51	0.43	0.42
Leaves	3.49	3.69	3.48	0.053	0.08	0.93	0.04
Beet pulp	5.50	5.26	5.50	0.134	0.41	1.0	0.21
WDGS	3.38	3.36	3.32	0.057	0.79	0.52	0.91
Corn bran	3.14	3.37	3.41	0.062	0.07	0.04	0.28

produced when applied to HMC (Table 4). This improvement was a quadratic response as gas production increased to 0.25 lb per ton of DM application rate and was constant as enzyme increased to 0.50 lb per ton of DM ($P < 0.05$). Similarly, rate of gas production linearly increased as the enzyme treatment was applied to the HMC ($P < 0.05$). Rate of gas production also linearly increased (Table 5) when the enzyme was applied to corn bran ($P < 0.05$). Conversely, there was a linear decrease ($P < 0.05$) in rate of gas production when the commercial enzyme was added to DRC. There was a quadratic response when treating corn leaves with the enzyme ($P < 0.05$). The effect of the enzyme on the digestion of feeds is variable between Experiment 1 and 2. In Experiment 1, the enzyme had a negative impact on the IVDMD of HMC; however, the enzyme treatment caused an improvement in gas production when applied to HMC in Experiment 2.

Implications

In conclusion, the impact of the enzyme on various feedstuffs is highly variable. Data from these two studies suggest the optimum level of enzyme is 0.25 lb per T of DM. Enspira has the potential to be used to improve digestibility of high hemicellulose feeds in beef cattle diets. This could improve efficiency of the cattle consuming the higher fiber based diets that are being fed today.

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Use of Treated Corn Residues in Growing Diets

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Summary

A growing study compared the effects of pelleting corn residue and treating with calcium oxide or calcium hydroxide. All diets contained 60% corn residue, 36% distillers products, and 4% supplement (DM basis). Steers consuming pelleted diets had increased DMI, greater ending BW, but poorer F:G compared to non-pelleted treatments. Diets containing the chemically treated corn stover had increased ADG and lower F:G compared to the non-treated diets. While both pelleting and chemical treatment with CaO increased DMI, and ADG, only the use of CaO improved feed efficiency.

Introduction

Treatment of corn stover with 5% calcium oxide (*CaO)* increases forage digestibility and can result in acceptable finishing performance when fed in combination with distillers grains (*2012 Nebraska Beef Cattle Report*, pp.106-107). Additionally, reducing particle size prior to calcium oxide addition may further increase the benefits of this type of treatment (*2012 Nebraska Beef Cattle Report,* pp. 108-109). A recent receiving study (*2014 Nebraska Beef Cattle Report*, pp. 64-66*)* evaluated a complete pelleted feed compared to a standard control diet and determined that pelleted rations may be a viable way to feed newly received cattle. Little work has been done evaluating calcium oxide treatment of corn residue in combination with distillers grains in growing diets; therefore, the objective of this study was to evaluate the effects of calcium oxide treatment of corn residue and pelleting in growing diets containing distillers grains.

Procedure

Experiment

An 80 day growing study was conducted using 480 yearling crossbred steers (BW = 688 ± 17 lb). Steers were limit-fed a diet of 50% forage and 50% byproduct for five days prior to the study at an estimated 2% of BW in order to minimize gut fill differences. Initial weights were collected on individuals two consecutive days. Steers were sorted into four weight blocks, stratified by BW within block, and assigned randomly to pens. Pens were assigned randomly to one of four treatments, with seven pens per treatment and 16 or 24 steers per pen. Pen served as the experimental unit. During processing, steers were implanted with Ralgro®. Ending BW were collected similar to initial BW, where steers were limit-fed for five days the same diet at an estimated 2% of BW and weighed two consecutive days prior to feeding.

Treatments were arranged in a 2 x 2 factorial with factors including corn residue with and without calcium oxide treatment, and diets that were either mixed or pelleted (pellets processed and provided by Iowa Agricultural Bio Fiber, Harlan, Iowa). Unpelleted diets contained modified distillers grains plus solubles, whereas the pelleted diets contained dry distillers grains plus solubles. Corn residue used in all diets originated from the same source (i.e., same fields and split two ways). All diets contained 60% baled corn residue, 36% distillers grains, and 4% supplement, which was formulated to provide 200 mg/steer daily of Rumensin.

Chemical treatment of non-pelleted residue consisted of CaO (Standard Quicklime, Mississippi Lime Co., Kansas City, Mo.), ground residue (3-inch screen), and water weighed and mixed into Roto-Mix® feed trucks. The mixture was calculated to be 50% DM with calcium oxide added at 5% of the forage DM. Feed trucks dispensed treated residue into a bunker and was subsequently covered with plastic. This process was completed every two weeks continuously throughout the trial so that residue treatment occurred for at least seven days prior to feeding. The pelleted residue was treated with 6.6% calcium hydroxide [$Ca(OH)_2$] in place of CaO which provided the same hydroxide units as 5% CaO. Approximately 50% of this residue was treated with a moisture content of 35% before being blended with the remainder of the residue and pelleted.

Statistical Analysis

Performance data (BW, DMI, ADG, G:F) were analyzed using the MIXED procedure of SAS (SAS Institute, Inc., Cary, N.C.) as a generalized randomized block design with pen as the experimental unit. The model included block, effects of pelleting, chemical treatment, and interaction of pellet and chemical treatment.

Results

There were no pellet x treatment interactions observed for this trial. Ending BW, DMI, and ADG were increased due to pelleting ($P < 0.01$, Table 1). However, the relative increase in ADG was smaller than the increase in DMI resulting in poorer F:G for the pelleted diets. The large increase in DMI due to pelleting may be related to increased passage rate from reduced particle size in the pellet. In this situation, steers are consuming feed to gut fill; therefore, reducing particle size by pelleting likely increased passage rate. This, in turn, allowed for increased DMI. The

Table 1. Effects of pelleting and chemical treatment on cattle performance.

	Pelleted		Not Pelleted			*P*-values		
Item	Untreated	$Ca(OH)_2$	Untreated	CaO	SEM	Pellet[1]	T[2]	PxT[3]
Initial BW, lb	688	689	688	688	1	0.49	0.49	0.82
Ending BW, lb	926	954	907	927	5	<0.01	<0.01	0.47
ADG, lb	2.97	3.31	2.74	2.99	0.06	<0.01	<0.01	0.44
DMI, lb/day	26.1	27.4	20.7	22.2	0.2	<0.01	<0.01	0.58
Feed:Gain[4]	8.80	8.29	7.55	7.46	—	<0.01	0.05	0.18

[1]Fixed effect of pelleting.
[2]Fixed effect of CaO or $Ca(OH)_2$ treatment.
[3]Pellet x CaO/$Ca(OH)_2$ treatment interaction.
[4]Statistics calculated on Gain:Feed.

increased passage rate and DMI presumably decreased digestibility.

Chemical treatment of residue with CaO or $Ca(OH)_2$ increased ending BW, DMI, and ADG ($P < 0.01$) and improved feed conversions ($P < 0.05$). While there was no interaction between pelleting and chemical treatment ($P = 0.18$), the improvement in feed conversion due to chemical treatment was 6% in pelleted diets and 1% in unpelleted diets.

Chemically treated forages are known to have increased digestibility compared to untreated forages (*2011 Nebraska Beef Report*, pp.35-36). In finishing diets, treatment of residues with CaO is profitable when they replace corn (*2012 Nebraska Beef Report*, pp.106-107). However, in growing diets the expense of chemical treatment may increase the cost per unit of energy of the corn residue compared to untreated corn residue because the improvement in feed conversion was small. Chemical treatment appeared to have a larger numeric impact on F:G in the pelleted diet, although the interaction was not significant ($P = 0.18$) . Additionally, while the pelleted diets showed a desirable increase in ending BW, ADG, and DMI, pelleting did not positively impact feed conversion compared to the unpelleted diets. Using a pelleted ration for growing calves could be a feasible option to achieve additional gain if the diet is favorably priced.

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Use of a Pelleted Corn Residue Complete Feed in Receiving Diets

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Summary

The effects of feeding a complete pelleted feed to newly received steer calves (585 ± 4 lb; n = 1318) was compared to a control ration consisting of 32% (DM basis) wet or modified distillers grains, 32% alfalfa hay, 32% dry-rolled corn, and 4% supplement. The pelleted complete feed consisted of 35% corn residue and a blend of grain byproducts and minerals. Feeding the complete pelleted feed increased DMI but decreased ADG, thereby reducing feed efficiency. The pelleted feed numerically reduced morbidity. Feeding a complete pellet consisting of corn residue appears to be a viable option for receiving calves if it is priced appropriately.

Introduction

A proprietary complete pelleted feed consisting primarily of corn residue (Iowa Agriculture Bio Fiber, Harlan, Iowa) is designed to replace a conventional grain and forage receiving diet, therefore eliminating the need to mix a starter diet. Due to the increased cost and limited availability of forages, alternative sources must be considered. Because of improved corn yields, there is an abundance of available corn residue making it a practical source to incorporate into feedlot diets. Pelleting allows for transport from areas with abundant residue to areas with greater cattle numbers. This pelleted forage source reduces the amount of traditional forages sources typically needed in feedlots. The objective of this study was to compare animal performance and treatment for bovine respiratory disease (BRD) of feeding a complete pelleted feed to a high quality receiving diet consisting of distillers grains, corn, and alfalfa hay.

Procedure

Experiment

The experiment was replicated at the University of Nebraska–Lincoln Agricultural Research and Development Center (ARDC) near Mead, Neb., and the Panhandle Research Extension Center (PREC) in Scottsbluff, Neb. Crossbred steers (ARDC: n=818; BW=582±49 lb, PREC: n=500; BW=581±50 lb) were purchased from sale barns through order buyers in Nebraska. Steers were received over four consecutive days at the ARDC, and two consecutive days at the PREC. Within location, steers were blocked by source within date received, resulting in eight blocks for ARDC and three blocks for PREC. Within blocks, cattle were assigned randomly to 48 pens at ARDC and 60 pens at PREC. There were 11-23 steers per pen at ARDC and 8-11 steers per pen at PREC. The number of steers/pen was balanced by treatment within block. Upon arrival, steers were allowed access to water and were processed, weighed, and allocated to treatment within 12 hours. During processing in both locations, steers were identified with an individual ear tag, individually weighed, vaccinated with Vista® Once and Cydectin® Injectable, and were orally drenched with Safe-Guard®. Initial BW was a single day weight collected at the time of processing.

Treatments included a control receiving diet consisting of 32% wet or modified distillers grains (wet at PREC and modified at ARDC), 32% alfalfa hay, 32% dry-rolled corn, and 4% supplement (DM basis; CON) and a complete pelleted feed (proprietary formulation; provided by Iowa Agricultural Bio Fiber; PelCR) consisting of 35% corn residue and a blend of grain byproducts and minerals. The PelCR contained a combination of plant extracts (RumeNext®, ADM, Quincy, Ill.), whereas CON contained 150 mg/head/day of monensin. Both diets were formulated to contain 125 mg/steer daily of decoquinate. Steers were offered *ad libitum* access to treatment diets for 23, 24, or 25 days at ARDC and 25 days at PREC. Similar bunk-calling protocols were used at both locations. Free-choice hay was not offered in the bunk. Steers were evaluated daily using the DART system (depression, appetite loss, respiratory character change, and temperature elevation). Steers meeting one or more of these criteria were treated with an antibiotic and returned to their pen. At the end of the experiment, steers were limit-fed a diet (50% forage, 50% byproduct) in both locations at 2% of BW for 5-7 days before weighing for ending BW to minimize gut fill variation. Ending BW was an average of 2-day weights collected after limit-feeding.

Statistical Analysis

Performance data (BW, DMI, ADG, G:F) were analyzed using the MIXED procedure of SAS (SAS Institute, Inc., Cary, N.C.) with pen as the experimental unit. Steers that died during the experiment were removed from the analysis. The model included treatment, location, treatment x location interaction, and block nested within location. Morbidity incidence was evaluated as the number of first treatments (number of steers treated in the pen divided by the total number of steers in the pen). Additionally,

Table 1. Performance and health by location for calves fed a complete pelleted feed on performance and morbidity.

	ARDC		PREC			*P*-values		
Item	Control	Pellet	Control	Pellet	SEM	Trt	Location	Interaction
Initial BW, lb	582	580	588	589	4	0.82	0.05	0.66
Ending BW, lb	670	652	665	655	4	<0.01	0.88	0.20
DMI, lb/day	14.8[b]	15.5[a]	12.8[c]	13.0[c]	0.15	<0.01	<0.01	0.03
ADG, lb	3.68	3.03	3.11	2.64	0.07	<0.01	<0.01	0.18
Feed:Gain[1]	4.05	5.19	4.15	5.01	0.11	<0.01	0.75	0.17
NEm, Mcal/lb	0.941	0.802	0.971	0.880	—	—	—	—
NEg, Mcal/lb	0.636	0.516	0.656	0.577	—	—	—	—
Morbidity								
First pull, %[2]	20.6	17.4	42.2	38.2	0.02	0.13	<0.01	0.85
Second pull, %[3]	9.5[a]	11.3[a]	9.5[a]	1.0[b]	0.03	0.07	0.03	0.03
Dead, n	1[d]	2[e,f]	0	1[g]	—	—	—	—

[1]Statistics calculated on Gain:Feed.
[2]Percentage of calves treated one or more times.
[3]Percentage of calves treated two or more times expressed as a % of cattle pulled one more times.
[a,b,c]Means within a row without a common superscript are different, ($P < 0.05$).
[d]Death due to Bovine Respiratory Disease (BRD).
[e]Death was non-health related.
[f]Death due to Acute or Atypical Interstitial Pneumonia (AIP).
[g]Death due to congested heart.

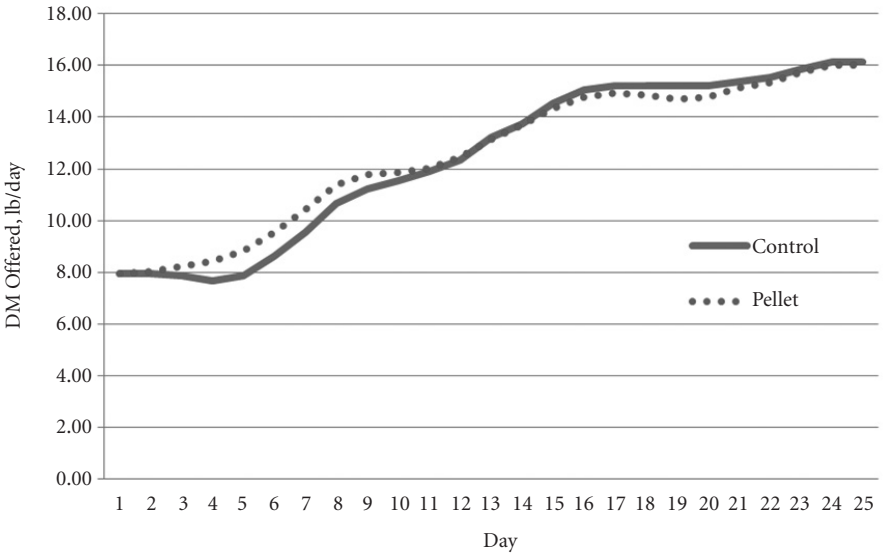

Figure 1. Daily DM offered to steer calves consuming a control diet or a completely pelleted ration at the UNL Agricultural Research and Development Center near Mead, Neb.

the 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.

The net energy equations in the NRC (1996) were used to determine the energy concentration of the CON and PelCR. Dietary TDN of CON was estimated by applying known TDN values (alfalfa, 50%; dry-rolled corn, 90%; MDGS, 108%) to the dietary components. Then, the energy adjusters were manipulated so that calculated animal performance of CON matched observed animal performance. Subsequently, the energy adjusters used for CON were held constant, and the TDN of PelCR was adjusted until calculated animal performance matched observed animal performance. Therefore, the NEm and NEg values for PelCR are relative to CON.

Results

A treatment x location interaction was observed for DMI ($P = 0.03$; Table 1). At PREC, no difference ($P = 0.45$) in DMI was observed. However, DMI was increased ($P < 0.05$) by feeding PelCR compared to CON at ARDC. The use of PelCR resulted in decreased ADG ($P < 0.01$) when compared to the control diet at both locations. Therefore, F:G was increased with PelCR ($P < 0.01$) compared to CON. An increase in F:G resulted in reduced estimates of NEm and NEg for PelCR.

The interaction between treatment and location was evaluated by graphing the amount of DM offered daily at each location. Figures 1 and 2 show daily DM offered to CON and PelCR at ARDC and PREC, respectively.

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At ARDC, DMI remained the same over the first 14 days, then PelCR intakes continued to increase while CON remained constant (Figure 1). However, at PREC (Figure 2), DMI for both treatments remained comparable throughout the trial.

The number of calves pulled and treated for BRD one time tended to be less ($P = 0.13$) for PelCR compared to CON. A treatment x location interaction was observed for the percentage of steers pulled two or more times ($P = 0.03$; Table 1). There were no differences ($P = 0.72$) in the percentage of calves treated two or more times at ARDC. However, a decrease ($P < 0.05$) in second pulls at PREC was observed where calves experienced a higher morbidity rate, although the number of steers requiring a second treatment was low. The greater incidence of morbidity at PREC may have influenced DMI.

Receiving calves on PelCR may have a positive effect on DMI, but a negative effect on ADG and F:G compared to a high-quality receiving diet similar to CON. The energy value of PelCR averaged 86% of CON based on estimates of dietary NEm and NEg. Use of PelCR may result in reduced morbidity for high-risk calves. While steer performance was less desirable compared to the high quality CON fed in this experiment, steers fed PelCR gained over 2.5 lb/day with a F:G of approximately 5.0-5.2. Therefore, receiving calves on a complete feed consisting of pelleted corn residue may be a viable option for producers if it is appropriately priced.

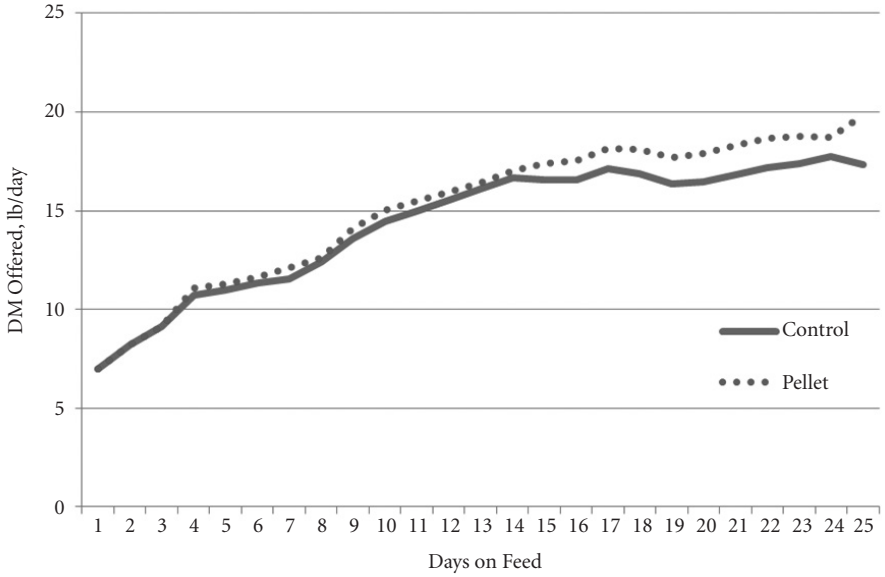

Figure 2. Daily DM offered to steer calves consuming a control diet or a completely pelleted ration at the UNL Panhandle Research and Extension Center, Scottsbluff, Neb.

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Alkaline Treated Wheat Straw or Corn Stover Fed to Growing Calves

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Summary

Four hundred sixty steer calves were fed CaO treated (5% of DM) or untreated wheat straw and corn stover with wet distillers grains plus solubles (WDGS) during a 69-day growing study. An interaction between crop residue and alkaline treatment was observed for ending BW and ADG. The relative response in ADG and ending BW due to alkaline treatment was greater for wheat straw compared to corn stover. Steers fed wheat straw diets had greater DMI and improved F:G compared to corn stover diets. Alkaline treatment increased DMI and improved F:G, although the F:G response was small. Growing calves on untreated residue diets may be more economical.

Introduction

Utilizing crop residues for growing calves has the potential to be economical when fed with distillers grains. Previous research with wheat straw (*2009 Nebraska Beef Cattle Report*, pp. 35-36) and corn stover (*2009 Nebraska Beef Cattle Report*, pp. 30-32) found increased ADG and improved F:G when inclusion levels of WDGS increased in growing calf diets. Another option to increase ADG and improve F:G may be growing cattle on alkaline treated residue. The objective of this trial was to evaluate treated wheat straw or corn stover in growing calf diets.

Procedure

This experiment utilized 460 steers (initial BW: 729 ± 44 lb). Steers were received during the fall of 2011 and grazed corn stalks from late November until start of the experiment (Feb. 23, 2012). Corn stover was treated using CaO (standard quicklime; Mississippi Lime Company, Kansas City, Mo) and carried out using a patented process with successive tub grinders (Performance Plus Liquids, Inc., Palmer, Neb). Wheat straw was treated with CaO every two weeks similar to as described in previous reports (*2012 Nebraska Beef Cattle Report*, pp. 106-107; pp. 108-109). In both corn stover and wheat straw treatments, the mixture was calculated to be 50% DM with calcium oxide added at 5% of the total DM. Treated corn stover and treated wheat straw DM averaged 57.6 and 49.6%, respectively. Treated corn stover and wheat straw were stored anaerobically in silage bags throughout the trial. The authors recognize that methodology to apply alkaline treatment is a critical factor to be considered. Correspondingly, since two types of processes were used to treat corn stover and wheat straw, this could potentially influence the response to treatment and results. Steers were limit-fed a mix of 47.5% alfalfa hay, 47.5% wet corn gluten feed, and 5.0% supplement at 2% of BW for five days prior to trial initiation and five days following to equalize gut fill. Steers were weighed two consecutive days following five days of limit-feeding at initiation and at the end of the trial. This trial was designed as 2 x 2 factorial with factors consisting of alkaline treatment (CaO+ H_2O vs. none) and residue (corn stover vs. wheat straw). There were three initial weight blocks, six replications per treatment, and 19 steers per pen. Diets (Table 1) were offered *ad libitum* to steers once daily. Treated diets contained sufficient Ca (3.35% from CaO treatment) and supplement was included at 1.0%. Untreated diets had supplement inclusion of 3.0% and limestone was added (1.58% of diet DM) to maintain a Ca:P of 1.2:1. Monensin was included in both supplements and formulated to supply 200 mg/steer daily. Monthly composite samples were assayed for

(Continued on next page)

Table 1. Dry matter and nutrient composition of diets fed to growing steers.

	Corn Stover		Wheat Straw	
Ingredient, % of DM	Treated	Untreated	Treated	Untreated
Treated stover/straw				
Untreated stover/straw	69.0	—	69.0	—
WDGS	—	67.0	—	67.0
Supplement	30.0	30.0	30.0	30.0
Fine ground corn	0.8228	1.2388	0.8228	1.2388
Limestone	—	1.5840	—	1.5840
Tallow	0.1000	0.1000	0.1000	0.1000
Trace mineral	0.0500	0.0500	0.0500	0.0500
Vitamin A-D-E	0.0150	0.0150	0.0150	0.0150
Rumensin[1]	0.0122	0.0122	0.0122	0.0122
Crop Residue				
DM, %	57.6	86.8	49.6	86.7
IVDMD, %[2]	39.6	38.6	43.1	36.1

[1]Formulated to provide 200 mg per steer/daily.
[2]*in vitro* DM disappearance of crop residue, 48 hour incubation time.

Table 2. Effect of crop residue and alkaline treatment on growing steer performance.

	Corn stover		Wheat straw					
Item	Treated	Untreated	Treated	Untreated	SEM	CaO[1]	Residue[2]	CaO x Residue
Initial BW, lb	729	729	728	727	0.64	0.59	0.43	0.19
Ending BW, lb	844[b]	834[c]	868[a]	841[b]	2.60	<0.01	<0.01	<0.01
DMI, lb/day	16.7	15.7	18.7	16.4	0.43	<0.01	<0.01	0.15
ADG, lb	1.67[b]	1.52[c]	2.02[a]	1.63[bc]	0.04	<0.01	<0.01	<0.01
F:G	10.00	10.32	9.25	10.06	—	0.06	0.07	0.18
$/head[3]	-15.01	0.00	-6.80	0.00	—	—	—	—

[1]Main effect of CaO + water or none.
[2]Main effect of residue type (corn stover or wheat straw).
[3]Average profit/head relative to untreated crop residue.
[abc]Within a row, means lacking common superscripts differ, when interaction $P < 0.05$.

in vitro DM disappearance (IVDMD). Inoculum for IVDMD was obtained by collecting a mixture of rumen fluid (strained through four layers of cheesecloth) from two steers consuming a 30% concentrate-70% roughage diet. Inoculum was mixed with McDougall's buffer at a 1:1 ratio along with 1 gram of urea/L of rumen fluid. A 0.5 gram sample was added to a 200 mL test tube and 50 mL of inoculum was added. Test tubes were placed in a water bath at 39°C for 48 hours. Fermentation was ended by adding 6 mL of 20% HCl per test tube. Residue was filtered, dried at 100°C, and weighed to determine IVDMD. A partial budget analysis was constructed to estimate profitability of steers fed diets in this study. Assumptions included: untreated ground wheat straw or corn stover cost at $100/DM ton, alkaline treatment cost of $50/DM ton, WDGS priced 95% of corn ($6.50/bu), initial purchase price of $1.50/lb and $0.042 slide. Data were analyzed using the MIXED procedure of SAS (SAS Institute, Inc., Cary, N.C.) with block as a fixed effect. Main effects of chemical treatment and residue, as well the interaction were tested. If an interaction was significant ($P \leq 0.05$), simple effect means were separated with a t-test using the pDiff option.

Results

An interaction ($P < 0.01$) between crop residue and alkaline treatment (Table 2) was observed for ending BW and ADG; therefore, simple effects are presented. The magnitude of response on ADG and ending BW due to alkaline treatment was greater in wheat straw diets compared to corn stover diets. Steers fed treated corn stover had increases of 1.9% for ADG and 3.2% for ending BW compared to untreated corn stover. However, steers fed treated wheat straw diets had increases of 23.9% for ADG and 9.8% for ending BW compared to untreated wheat straw. The observed ADG and ending BW differences of steers fed treated and untreated crop residues are also supported by IVDMD of treated and untreated corn stover (39.6% vs. 38.6%) and wheat straw (43.1 vs. 36.1%). No interaction was observed for F:G ($P = 0.18$) or DMI ($P = 0.15$) between crop residue and alkaline treatment. Steers fed treated wheat straw diets had greater DMI ($P < 0.01$) and tended ($P = 0.07$) to have improved F:G compared to corn stover diets. Alkaline treatment tended ($P = 0.06$) to improve F:G and increased DMI ($P < 0.01$) compared to untreated. Given the economic assumptions applied to this study, feeding steers treated corn stover and wheat straw diets resulted in lower net return ($/head) compared untreated residue diets. This estimated lost in profitability is related to the increase in diet cost from alkaline treatment, increased DMI of steers fed alkaline treated diets compared to untreated, and the small improvement in BW gain of steers fed alkaline treated diets compared to untreated. The results of this study indicate that response to CaO treatment on growing calf performance is dependent on crop residue source. Calcium oxide treated crop residues fed with distillers grains did improve growing calf ADG and F:G. However, the response to alkaline treatment in growing calf diets is much lower than observed in finishing cattle work when used as a corn replacement. Given the small improvement in performance identified in this study, growing calves with untreated crop residues maybe just as economical.

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Impact of Feeding Alkaline-Treated Corn Stover at Elevated Amounts in Commercial Feedlot Cattle

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Summary

*A commercial trial was conducted to compare feeding 20% alkaline treated corn stalks (**TRT**) in place of 14% dry-rolled corn and 6% native stalks (**CON**). Both diets contained dry-rolled corn (40 or 54%), 35% wet distillers grains plus solubles, and 5.17% supplement. Alkaline treatment was performed by adding 5% calcium oxide to 95% ground corn stalks (DM basis) and water to equal 50% DM. Cattle fed TRT had lower ADG and poorer F:G with equal DMI. The changes in gain were due to lower live and carcass weights. Carcass quality was impacted subtly, and reflects the lower gain with equal days fed between the two treatments.*

Introduction

Alkaline treatment of forages improves fiber digestibility by disrupting bonds. Treating crop residues was researched heavily in the 1970s to improve forage quality and cost effectiveness. With recent increases in commodity prices, there is renewed interest in applying this to feedlot diets today that include wet distillers grains plus solubles. In four of five controlled UNL feedlot trials, performance was similar between feeding 20% treated stalks and 5 to 10% untreated roughage in diets with 40% distillers grains (*2013 Nebraska Beef Cattle Report*, pp. 70-73; *2012 Nebraska Beef Cattle Report*, pp. 106-107; *2012 Nebraska Beef Cattle Report*, pp. 108-109; *2014 Nebraska Beef Cattle Report*, pp. 72-74). However, in one yearling study, a significant 6.7% increase in F:G was observed when compared to a 5% untreated stalk control (*2013 Nebraska Beef Cattle Report*, pp. 70-73). Treatment process in all of these university trials included 5% CaO (Mississippi Lime, StoverCalO, granulated quicklime) with 95% corn stalks (DM basis) and then mixed with enough water to produce a final mix that was 50% DM. No data are available using commercial treatment technologies and mixing and storing for seven days prior to feeding. Likewise, no data are available on commercial feedlot performance using alkaline treated stalks in place of a portion of corn. Therefore, the objective was to evaluate feedlot performance and carcass characteristics when 20% treated stalks were fed compared to a conventional control ration.

Procedure

This study was completed at a commercial feedlot in Northeast Colorado (Timmerman Feeding Co., Sterling, Colo.). Steers were received and processed in two separate groups and blocked by source. Block 1 consisted of 513 yearling steers originating from the Northern Plains, weighing 805 lb across eight pens. Block 1 steers were started on June 6, 2012, and fed 141 days to Oct. 24, 2012. Block 2 steers were yearling steers of Mexican origin weighing 750 lb across eight pens. Block 2 steers were started on June 13, 2012, and fed 153 days to Nov. 11, 2012. Steers in both blocks were fed a common distillers grains-based grower ration until the respective day of treatment initiation, upon which steers were removed from pens and alley-sorted two steers each way until pen replicates were filled. Steers were then uniquely identified with numbered tags, vaccinated with Pyramid® 5 (Zoetis Animal Health) and treated for internal and external parasites with an injection of Cydectin® (Zoetis Animal Health) and an oral dose of Safe-Guard® (Merck Animal Health). Steers were also given a Revalor-XS implant (Merck Animal Health). Following processing, steers were pen weighed and these weights served as initial weight for each pen replicate. Initial weights were assumed to be shrunk, so no pencil shrink was assigned to initial pen weights.

Two treatments were evaluated in this study with eight pen replicates per treatment, four within each block. The study design was a randomized block design with 16 total pens, two blocks with four replications per block, and eight total replications per treatment. Diets included a control (CON) with 6% stalks, 35% wet distillers grains plus solubles, dry-rolled corn and supplement compared to a diet with 20% alkaline treated corn stalks, 35% wet distillers grains plus solubles, dry-rolled corn and supplement (TRT; Table 1). Treated stalks replaced untreated stalks and dry-rolled corn. The only other difference between the two diets was that limestone was not included in the supplement for TRT, as calcium was provided by the alkaline-treated corn stalks.

Alkaline-treated stalks were provided by a nearby commercial feedlot that was treating stalks on a weekly basis. The treatment process utilized a Roto Grind (Burrows Enterprises, Greeley, Colo.) where ground corn stalks (4 inch tub ground) were added to the Roto Grind. During grinding, water and calcium oxide (Stover CalO, Mississippi Lime, St. Louis, Mo.) were added using a continuous flow system developed by Performance Plus Liquids (Palmer, Neb.). This system targets adding water to reach a final DM of 50% in the treated stalks and 5% calcium oxide on a DM basis. The calcium oxide product, Stover CalO, is granular, pure, reactive calcium oxide or quicklime that has particles

(Continued on next page)

less than ¼ inch. Following treatment and grinding, stalks were stored in a loosely packed pile for 7 to 14 days prior to feeding.

Both finishing diets included similar feed additives added via a micro nutrient machine. Targeted consumptions for Rumensin® (340 mg/steer), Tylan® (80 mg/steer), vitamin A (30,000 IU/steer), vitamin D (3,000 IU/steer), and vitamin E (100 IU/steer) were equal across treatments.

After initial BW were collected, steers were adapted to finishing diets. Grain adaption was slightly different between the two treatments due to a greater amount of stalks included in TRT. For the CON treatment, steers were fed three grain adaptation diets prior to the finishing diet, containing 45 and 33% alfalfa hay for steps 1 and 2, respectively. Step 3 contained 14% alfalfa hay and 5% untreated stalks, whereas the CON finishing ration contained 6% untreated stalks, all on a DM basis. The TRT fed cattle were adapted using two adaptation diets prior to the finishing ration. Alfalfa hay was fed at 25, 13, and 0% while treated stalks were kept constant at 20% inclusion in all steps. For both treatments, each adaptation diet was fed five full days followed by 1-3 days of transition between steps. As a result, cattle fed TRT were adapted to their final diet eight days faster than CON and using less alfalfa hay.

When visually appraised as being finished across treatments within a block, steers were removed from pens, weighed live at the pen scale and shrunk 4%, and shipped by entire blocks for slaughter (Cargill Meat Solutions, Fort Morgan, Colo.). On day of slaughter, hot carcass weights were collected. Following a 24-hour chill, fat depth, *Longissimus* muscle area, called USDA Quality Grade, and called USDA Yield Grade were collected on a pen basis.

Table 1. Diets fed to finishing steers comparing 6% stover (CON) to 20% alkaline-treated stover (TRT).

Ingredient	CON	TRT
Dry-rolled corn	53.83	39.83
Wet distillers grains plus solubles	35.0	35.0
Corn stalks, ground	6	—
Treated stalks, ground	—	20.0
Liquid supplement	5.17	5.17
Nutrient composition, formulated (actual)		
DM	50.88 (49.5)	47.03 (47.9)
CP	16.3 (18.5)	15.8 (18.0)
Ca	0.67 (0.72)	0.87 (1.08)
P	0.44 (0.53)	0.41 (0.50)
K	0.79 (1.00)	0.96 (1.15)
S	0.37 (0.37)	0.38 (0.36)

Table 2. Performance and carcass characteristics of commercial feedlot steers fed either alkaline treated corn stover at 20% of diet DM (TRT) or a conventional control with 6% stover (CON) blocked by two different types of steers and arrival date.

				P-values[1]		
	CON	**TRT**	SEM	Diet	Block	Int.
Performance						
Initial no., n	593	595	—	—	—	—
Slaughter no., n	592	594	—	—	—	—
Pens, n	6	6	—	—	—	—
Days of Feed	147	147	—	—	—	—
Initial BW, lb	780	775	8	0.70	<0.01	0.98
DMI, lb/day	23.36	23.58	0.23	0.53	<0.01	0.44
Live						
Final BW, lb	1372	1353	10	0.19	<0.01	0.52
ADG, lb	4.04	3.94	0.03	0.06	<0.01	0.24
F:G	5.79	5.99	0.05	0.01	<0.01	0.97
Carcass-adjusted						
Final BW, lb	1401	1370	10	0.04	<0.01	0.25
ADG, lb	4.25	4.05	0.04	<0.01	<0.01	0.05
block 1	*4.68*	*4.36*	*0.06*			
block 2	*3.81*	*3.75*				
F:G	5.53	5.83	0.05	<0.01	<0.01	0.37
Total Gain, lb	622	594	6	<0.01	<0.01	0.07
block 1	*660*	*616*	*8*			
block 2	*584*	*573*				
Carcass Characteristics						
Hot Carcass Weight	882.8	862.9	6.3	0.04	<0.01	0.25
Dressing %	64.35	63.78	0.09	<0.01	0.05	0.03
block 1	*64.65*	*63.75*	*0.13*			
block 2	*64.05*	*63.80*				
Fat Depth	0.513	0.488	0.009	0.07	<0.01	0.19
Ribeye Area	13.33	13.08	0.10	0.11	0.32	0.73
Yield Grade	3.29	3.21	0.05	0.29	<0.01	0.29
Quality Grade Distribution						
% Prime	0.45	0.30	0.16	0.53	<0.01	0.53
% Choice	57.94	51.74	1.70	0.02	0.03	0.17
% Select	38.66	42.64	1.53	0.09	<0.01	0.64
% < Standard	2.95	5.33	1.07	0.14	0.04	0.15

[1]*P*-values for effect of diet (CON vs TRT), block, and interaction (Int.) between block and diet.

Results

Cattle performance and carcass characteristics are provided in Table 2. Steers had similar (P =0.98) initial BW as expected when assigned in sorting alleys. Steers had similar DMI between treatments (P = 0.23) and consumed approximately 2.14% of BW for CON steers and 2.20% of BW for TRT using average of initial and carcass-adjusted final BW. On a live basis, steers fed TRT were 19 lb numerically lighter (P = 0.19) in shrunk live BW at the end of the feeding period compared to CON. As a result, ADG was decreased by feeding TRT compared to CON (P = 0.06) and cattle were less efficient (P = 0.01), with a 0.20 increase in F:G.

Carcass weights were 20 lb lighter (P = 0.04) for TRT fed steers compared to CON. Therefore, when performance was adjusted for 63% dress final BW, ADG was decreased (P < 0.01) by 0.20 lb/day for TRT compared to CON. Less gain resulted in poorer F:G for TRT steers compared to CON (P < 0.01). There was a significant block by treatment interaction for carcass-adjusted ADG, which was tested due to four replications per block. Feeding TRT decreased ADG by 0.32 lb/day in block 1 (northern cattle) whereas ADG only decreased by 0.06 lb/day in block 2 (Mexican cattle) compared to CON.

Similar to carcass-adjusted ADG, there was a decrease in dressing percentage caused by feeding TRT; however, there was an interaction between block and dietary treatment. Dressing percentage for steers in block 1 were impacted by dietary treatment more than steers in block 2, with a 0.9 percentage unit decrease by feeding TRT compared to CON for block 1 and only a 0.25 percentage unit decrease in dressing percentage for block 2. Other carcass characteristics reflect the performance results. In general, feeding TRT tended to decrease fat depth (P = 0.07) and LM area (P = 0.11), and decreased percent USDA Choice grade (P = 0.02) compared to CON. These data likely reflect the lower ADG observed with feeding TRT as all cattle were slaughtered at one time point within blocks and were equal across dietary treatment.

As a general rule, feeding TRT resulted in lighter carcasses, and lower dressing percentage. With no change in intake, the decrease in ADG resulted in poorer feed conversions and some subtle impacts on carcass quality, which reflect poorer ADG.

It is unclear the cause of the depression in ADG observed in this commercial study relative to previous research. One of the five experiments conducted at UNL matches these results where feeding 20% treated stalks did not result in similar performance. Interestingly, similar to the current study, that particular study (*2013 Nebraska Beef Cattle Report*, pp. 70-73) was conducted with yearlings fed in the summer and resulted in a 6.7% increase in F:G for steers fed 20% treated stalks. For comparison, in the current study we observed a 5.4% increase in F:G when steers were fed TRT compared to CON. It is unclear if cattle type, season, or some other variable impacts cattle performance when replacing corn with alkaline treated stalks.

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Optimum Inclusion of Alkaline-Treated Cornstalks and Distillers Grains Fed to Calf-fed Steers

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Summary

A finishing study evaluated the effects of adding 10, 20 or 30% CaO treated cornstalks to diets containing either 20 or 40% (DM basis) modified distillers grains (MDGS). Steers fed a diet containing 40% MDGS responded quadratically with 10 and 20% (DM basis) treated residue having equal and better F:G than feeding 30% treated stalks. However, cattle fed 20% MDGS did not respond as well to treated cornstalks with 10% treated stalks having the lowest F:G, but poorer than the control diet with 5% stalks and 20% MDGS.

Introduction

A previous study determined that a 3:1 ratio of distillers to treated stalks along with a maximum of 20% treated residue and at least 25% corn (DM basis) are required to maintain feed efficiency when compared to a 56% corn, 5% roughage control diet (*2013 Nebraska Beef Cattle Report,* pp. 56-57). Numerous studies have illustrated that cattle perform similarly when fed 20% alkaline treated stalks compared to a control diet with 5% stalks, thus allowing for 15% corn to be replaced (*2012 Nebraska Beef Cattle Report*, pp.108-109*; 2012 Nebraska Beef Cattle Report*, pp. 106-107*; 2013 Nebraska Beef Cattle Report,* pp. 70-73). However, all of these studies provided 40% wet or modified distillers grains plus solubles along with treated residue. With variable inclusions of wet or modified distillers grains possible under different economic scenarios, producers need to know whether inclusion of distillers grains plus solubles impact how alkaline treated stalks perform in finishing diets. Therefore, the objective was to identify the maximum amount of treated forage in combination with varying levels of MDGS on cattle performance and carcass characteristics.

Procedure

Experiment

A 180-day finishing study was conducted using crossbred steer calves (n = 378; BW = 705±15 lb) to evaluate inclusion levels of treated stalks in combination with MDGS. Calves were received for approximately 30 days prior to the study. Following receiving, steers were limit-fed at an estimated 2% of BW a 50% forage, 50% byproduct diet for five days prior to weighing. Initial weights were collected on two consecutive days to reduce gut fill effects. Based on first day weights, steers were separated into two weight blocks, stratified by BW within block, and assigned randomly to pens. Pens were assigned randomly to one of seven treatments, with six pens per treatment and nine steers per pen.

The seven treatments were set up in a 2x3 plus 1 factorial design including a dry-rolled corn (DRC), modified distillers grains with solubles (MDGS) and 5% untreated stalks control (CON). The 2x3 factorial diets contained either 20 or 40% MDGS with 10, 20, or 30% alkaline treated stalks (Table 1). All diets on the study contained 4% dry meal supplement, which was formulated to provide 330 mg/steer daily Rumensin® and 90 mg/steer daily of Tylan®.

Chemical treatment consisted of adding 5% CaO (standard quicklime; Mississippi Lime, Co., Kansas City, Mo.), ground cornstalks (1-inch screen), and water weighed and mixed into Roto-Mix feed trucks. The mixture was targeted to be 50% DM with calcium oxide added at 5% of the forage DM. Feed trucks dispensed treated residue into a bunker and were covered with plastic. This treatment process was completed every two weeks continuously throughout the trial, allowing for residue to be exposed for at least one week prior to feeding, at a minimum.

During initial processing, steers were vaccinated with Vision 7® and Vista 5®, and were implanted with Revalor®-XS. One day prior to slaughter, steers were weighed using a pen scale in the afternoon after being fed 50% of the previous day's intake that morning. Following weighing, steers

Table 1. Diet composition for diets containing 20% or 40% MDGS and 10%, 20%, or 30% treated stalks.[1,2]

	20 MDGS				40 MDGS		
Item	CON	10	20	30	10	20	30
Ingredient							
DRC	71	66	56	46	46	36	26
MDGS	20	20	20	20	40	40	40
Treated stalks[3]	—	10	20	30	10	20	30
Stalks	5	—	—	—	—	—	—
Supplement[4]	4	4	4	4	4	4	4

[1]Values presented on a DM basis.
[2]MDGS = modified distillers grain with solubles; DRC = dry-rolled corn.
[3]Treated with 5% CaO and water added to 50% DM.
[4]Supplements formulated to provide: 330 mg/steer daily Rumensin and 90 mg/steer daily Tylan.

Table 2. Performance of finishing cattle comparing the simple effects of 10, 20, or 30% alkaline treated stalks with either 20 or 40% MDGS along with the control diet that included 5% untreated stalks and 20% MDGS.

		20 MDGS					40 MDGS						*P*-values	
Item	Control	10	20	30	Lin[1]	Quad[2]	10	20	30	Lin[3]	Quad[4]	SEM	F-Test[5]	DxT[6]
Performance														
Initial BW, lb	704	704	706	707	0.12	0.84	705	705	705	1.00	0.92	1	0.74	0.45
Final BW, lb[7]	1440^{ab}	1409^{bc}	1377^{cd}	1308^{e}	<0.01	0.24	1437^{ab}	1452^{a}	1361^{d}	<0.01	<0.01	14	<0.01	0.26
DMI, lb/d	23.5	23.5	23.8	23.1	0.51	0.25	23.8	24.2	24.3	0.34	0.70	0.32	0.18	0.47
ADG, lb[8]	4.07^{ab}	3.90^{bc}	3.71^{cd}	3.32^{e}	<0.01	0.23	4.05^{ab}	4.13^{a}	3.63^{d}	<0.01	<0.01	0.07	<0.01	0.21
F:G[8]	5.79^{a}	6.02^{b}	6.40^{c}	6.98^{d}	<0.01	0.54	5.89^{ab}	5.88^{ab}	6.70^{d}	<0.01	<0.01	—	<0.01	0.07
Live BW, lb[9]	1407^{abc}	1394^{bcd}	1376^{cde}	1347^{e}	0.01	0.69	1413^{ab}	1433^{a}	1372de	0.02	0.01	12.64	<0.01	0.29
Carcass Characteristics														
HCW, lb	907^{ab}	888^{bc}	868^{cd}	824^{e}	<0.01	0.24	905^{ab}	915^{a}	858^{d}	<0.01	<0.01	9	<0.01	0.26
Dressing, %	64.4^{a}	63.7^{bc}	63.1^{cd}	61.2^{e}	<0.01	0.05	64.1^{ab}	63.8^{ab}	62.5^{d}	<0.01	0.11	0.3	<0.01	0.21
LM area, in^2	14.4	14.0	14.2	13.8	0.54	0.23	14.1	14.5	14.0	0.67	0.10	0.18	0.18	0.93
12th Rib fat, in	0.58^{a}	0.53^{a}	0.46^{b}	0.39^{c}	<0.01	0.98	0.59^{a}	0.53^{a}	0.43^{bc}	<0.01	0.45	0.02	<0.01	0.74
Marbling[10]	459	488	488	470	0.30	0.53	476	462	463	0.44	0.62	13	0.42	0.31

^{abcde}From the F-test, means lacking common superscripts, differ $P < 0.05$.
[1] Linear contrast for treated stalks within 20% MDGS inclusion.
[2] Quadratic contrast for treated stalks within 20% MDGS inclusion.
[3] Linear contrast for treated stalks within 40% MDGS inclusion.
[4] Quadratic contrast for treated stalks within 40% MDGS inclusion.
[5] Overall F-test statistic comparing the Control to all other treatments.
[6] DxT is the distillers inclusion by alkaline treated stalks inclusion interaction.
[7] Calculated as HCW/common dress (63%).
[8] Calculated from carcass-adjusted final BW and statistics performed on G:F, the reciprocal of F:G.
[9] Pen weight before slaughter shrunk 4%.
[10] Marbling score where 400 = Small^0.

were loaded and shipped to the abattoir. The following morning (day 182), steers were slaughtered at Greater Omaha Pack (Omaha, Neb.), at which time hot carcass weights (HCW) and liver scores were recorded. Following a 48-hour chill, fat thickness, rib eye area (REA), USDA marbling score were measured. Final BW, ADG, and F:G were calculated using HCW adjusted to a common (63%) dressing percentage. However, live final BW and dressing percentages were analyzed assuming a 4% shrink on final live BW collected the day of shipping.

Performance and carcass data were analyzed as a 2 x 3 plus 1 factorial using the Mixed procedures of SAS (SAS Institute, Inc., Cary, N.C.) as a randomized block design with pen as the experimental unit. Weight block was included as a fixed effect. Orthogonal linear and quadratic contrasts were used to determine the response curve for alkaline treated forage within MDGS inclusion.

Results

Performance

Intakes were not impacted by treatment ($P > 0.18$) and no differences were observed across different treated stalks inclusion (Table 2). For the factorial design, no significant interaction ($P = 0.21$) was observed between treated stalks and distillers inclusion on ADG. However, the simple effect responses were different depending on whether treated stalks were fed with 20 or 40% MDGS. As treated stalks increased in diets with 20% MDGS, ADG decreased linearly. However, ADG decreased quadratically when treated stalks were added to 40% MDGS diets with ADG equivalent between 10 and 20% treated stalks and decreasing at 30% inclusion. There was a distillers inclusion by treated stalks interaction for both carcass adjusted F:G ($P < 0.10$) and F:G based on final live BW ($P < 0.05$; data not shown). Similar to ADG, F:G increased linearly when treated stalks were increased from 10 to 30% in diets with 20% MDGS, but increased quadratically when treated stalks increased in diets with 40% MDGS (Table 2). No difference was observed between 10 or 20% treated stalks with 40% MDGS but increased at 30% which caused the quadratic response. The control diet contained 20% MDGS with 5% untreated stalks which resulted in better ADG and F:G compared to 10% treated stalks with 20% MDGS suggesting that with only 20% MDGS in the diet, even feeding 10% treated stalks will not result in equal performance to cattle fed 5% untreated stalks as a roughage source. Unfortunately, a control diet with 40% MDGS and 5% untreated stalks was not included in the treatment design. These data suggest that the impact of increasing treated stalks in feedlot diets on F:G (and likely ADG) depends on inclusion of distillers grains.

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For performance variables besides F:G, no interaction was observed between MDGS inclusion and treated stalks. Table 3 presents the main effects of increasing treated stalks in finishing diets across both inclusions of MDGS. Final BW, ADG, and live BW all decreased quadratically as treated stalks increased in the diet from 10 to 30%. These data suggest that feeding 10 or 20% treated stalks gives comparable performance whereas increasing to 30% inclusion decreases BW and ADG.

Table 3. Main effect of alkaline treated stalks inclusion at 10, 20, or 30% of diet DM on performance and carcass characteristics

	Stalks inclusion					
Item	10	20	30	SEM	Linear	Quadratic
Performance						
Initial BW, lb	704	705	706	0.82	0.21	0.81
Final BW, lb[1]	1423	1415	1335	10	<0.01	0.01
DMI, lb/day	23.7	24.0	23.7	0.23	0.84	0.29
ADG, lb[2]	3.97	3.92	3.47	0.05	<0.01	<0.01
F:G[8]	5.95	6.13	6.80	—	<0.01	<0.01
Live BW, lb[3]	1403	1404	1359	9	<0.01	0.04
Live F:G, lb[8]	6.13	6.21	6.58	—	<0.01	0.08
Carcass Characteristics						
HCW	897	891	841	6	<0.01	0.01
Dressing, %[4]	63.9	63.4	61.9	0.2	<0.01	0.02
REA, in	14.0	14.3	13.9	0.1	0.43	0.04
12th Rib fat, in	0.56	0.49	0.41	0.02	<0.01	0.60
Marbling[5]	482	475	467	9	0.23	0.93

[1]Calculated as HCW/common dress (63%).
[2]Calculated from carcass-adjusted final BW.
[3]Pen weight before slaughter.
[4]Calculated as HCW/Live BW.
[5]400 = Small.
[6]Main effects of 20 vs. 40 MDGS.
[7]Interaction of distillers x chemical treatment.
[8]Statistics calculated on G:F.

Carcass Characteristics

Cattle fed elevated amounts of roughage tend to maintain live BW, but have decreased dressing percentage. Thus, evaluating treatments on a carcass-adjusted basis is critical for accurate conclusions. Dressing percentage decreased linearly when treated stalks were included in the 40% MDGS and decreased quadratically when fed with 20% MDGS (Table 2). The greatest dressing percentage was for the control and 40% MDGS with 10% treated residue suggesting increased fill for the other treatments. Fat thickness generally reflected changes in ADG with cattle that gained less being leaner at slaughter with linear decreases in fat depth as treated stalks increased in both 20 and 40% MDGS based diets (Table 2). The fattest cattle were on the control, as well as the 10% and 20% treated stalks with 40% MDGS diets. These data suggest that if 10 or 20% alkaline treated stalks are fed, then 40% distillers included in the diet in addition to the treated residue is important to maintain F:G, carcass finish, and likely ADG.

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Transitioning Cattle from RAMP® to a Finishing Diet on Feed Intake and Ruminal pH

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Summary

A metabolism trial was conducted where steers were adapted to high grain diets using a traditional approach or one of two RAMP® adaptation programs. RAMP programs adapted cattle to a finishing diet either gradually over 28 days in four steps or switched to a finishing ration without steps. Feed intake and ruminal pH were monitored continuously throughout the trial. Cattle on the 4-STEP treatment spent more time eating compared to other treatments but total feed consumption was similar among treatments. Ruminal pH was greater for cattle on RAMP adaptation programs when compared to traditional grain adaptation. Cattle fed RAMP for 10 days can be transitioned directly to a finishing diet containing 47.5% Sweet Bran®.

Introduction

RAMP is a complete starter ration that contains a high level of *Sweet Bran* and a minimal amount of forage. Previous research suggests starting cattle on RAMP may eliminate the need for an adaptation period (*2013 Nebraska Beef Cattle Report,* pp.78, 80). However, a metabolism trial reported that a system of transitioning cattle from RAMP to a finishing diet without an adaptation period had decreased ruminal pH and increased time below a pH of 5.6 compared to cattle adapted using a 4-step system (*2013 Nebraska Beef Cattle Report,* pp. 82-83), which suggests that eliminating the adaptation period may have increased acidosis. Therefore, the objective of this experiment was to determine effects of transitioning cattle from RAMP to a finishing diet with or without an adaptation period on ruminal pH, DMI, and eating behavior.

Procedure

A metabolism trial was conducted using 12 ruminally fistulated steers (BW = 877 ± 66 lb) to evaluate the effects of transitioning cattle from RAMP directly to a finishing diet on ruminal pH and DMI characteristics during grain adaptation. The experiment was conducted in two blocks, with each block utilizing six steers for 42 days. Before the trial was initiated, steers in the first block were grazing smooth bromegrass pastures throughout the summer and steers in the second block were used on growing trials to measure digestibility of grass hay.

Treatments consisted of three grain adaptation systems imposed during the first 28 days of the feeding period. Steers on traditional adaptation treatment (TRD; Table 1) were adapted to a finishing diet by feeding 4-step diets for 4, 6, 6, and 6 daus. Alfalfa hay inclusion was gradually decreased from 45 to 7.5% while inclusion of a corn blend (60% high-moisture corn (HMC) and 40% dry-rolled corn) was increased from 25 to 62.5% (DM Basis). The RAMP adaptation treatments (Table 2) involved transitioning cattle from RAMP to a finishing diet containing 47.5% *Sweet Bran* in either four steps or one step. The four-step system (4-STEP) gradually decreased dietary RAMP inclusion (100 to 0%) while increasing finishing ration (0 to 100%) equally over four periods (4, 6, 6, and 6 days) by mixing RAMP with finishing ration 1 (F1, 47.5% Sweet Bran, 40% HMC, 7.5% alfalfa hay and 5% supplement, DM basis) with the blend fed as a single diet. The 1 step adaptation system (1-STEP) involved feeding RAMP for 10 days and switching directly to F1 on day 11. Following the 28-day adaptation period, a second finishing diet (F2) was fed for 14 days (Table 2). All diets contained 25 g/ton Rumensin® and 12 mg/lb thiamine (DM basis).

Steers were individually housed in box stalls and were offered *ad libitum* access to feed and water and fed once daily at 0800 hour. Feed intake was continuously monitored using feed bunks suspended on load cells. Data for feed intake were collected every 10 seconds and six readings were averaged for each minute. Data obtained from continuously monitored DMI included meals consumed per day, time spent eating, and intake rate.

Wireless, submersible pH probes were placed into the rumen of each steer to monitor ruminal pH for the

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Table 1. Traditional (TRD) adaptation diets fed in this trial. Ingredient inclusions and chemical compositions are listed on a DM basis.

Item	Step 1	Step 2	Step 3	Step 4	Finisher
Ingredient, %					
Alfalfa hay	45.0	35.0	25.0	15.0	7.5
High-moisture corn	25.0	35.0	45.0	55.0	62.5
Sweet Bran[1]	25.0	25.0	25.0	25.0	25.0
Dry supplement[2]	5.0	5.0	5.0	5.0	5.0
Chemical composition, %					
DM	75.9	74.3	72.7	71.2	70.1
CP	14.7	14.1	13.5	12.8	12.4
NDF	35.4	30.9	26.5	22.0	18.6

[1]Sweet Bran, Cargill Corn Milling, Blair, Neb.
[2]Supplement formulated to contain 25 g/ton Rumensin and 12 mg/lb thiamine (DM basis).

duration of the trial. Each probe was attached to a weighted enclosure designed to ensure the electrode remained in the ventral sac of the rumen. On day 14 and 28, each probe was removed for approximately 2 hours in order to download pH data and recalibrate probes. Ruminal pH measurements from each period were adjusted using beginning and ending calibration values to ensure accurate pH measurements.

Because treatment was an adaptation system, data from two time periods were analyzed to compare the three adaptation systems. Time periods included the entire adaptation system (day 1 to 28) and all days cattle were fed a common finishing diet (day 29 to 42). Ruminal pH and DMI characteristics for each of the two time periods were analyzed as separate variables using the GLIMMIX procedure of SAS (SAS Institute, Inc., Cary, N.C.). All data were analyzed using a repeated measures analysis. The model included d and treatment as a fixed effects and steer nested within treatment was considered a random effect.

Table 2. Adaptation diets for the 4-STEP treatment[1] where RAMP[2] was blended with a finishing diet 1(F1) to adapt cattle to high grain diets. Following the adaptation system a common finishing ration (F2) was fed.

	Ratio of RAMP:F1					
Item	100:0	75:0	50:50	25:75	0:100	F2
Ingredient, %						
RAMP	100.0	75.0	50.0	25.0	—	—
High-moisture corn	—	10.0	20.0	30.0	40.0	42.5
Sweet Bran	—	11.9	23.8	35.6	47.5	25.0
MDGS	—	—	—	—	—	22.5
Alfalfa hay	—	1.9	3.7	5.6	7.5	—
Wheat straw	—	—	—	—	—	5.0
Dry supplement[3]	—	1.2	2.5	3.8	5.0	5.0
Nutrient composition, %						
DM	65.7	66.1	66.6	67.0	67.5	66.0
CP	24.5	22.3	20.2	18.0	15.8	16.6
NDF	35.8	33.0	20.1	27.3	24.4	24.4

[1]Treatment were as follows: 4-STEP blends 100:0, 75:0, 50:50, 25:75, and 0:100 were fed for 4, 6, 6, 6, and 6 days, respectively; 1-STEP fed 100:0 for 10 days and 0:100 day 11 to 28.
[2]RAMP is a complete starter feed (Cargill Corn Milling, Blair, Neb.) consisting of wet corn gluten feed, alfalfa hay, minerals, and vitamins.
[3]Supplement formulated to contain 25 g/ton Rumensin and 12 mg/lb thiamine (DM basis).

Table 3. Dry matter intake and ruminal pH characteristics during the 28 day adaptation system.

	Adaptation treatment[1]				
Item	TRD	4-STEP	1-STEP	SEM	*P*-value
DMI, lb/day	25.1	24.7	22.4	1.74	0.53
Intake rate, %/hour	17.8	19.9	21.5	1.18	0.17
Eating time, minute	246[a]	336[b]	276[a]	14.8	0.01
Meals/d, n	8.93	9.44	9.71	0.74	0.76
Ruminal pH					
Average	5.81[a]	5.94[b]	5.98[b]	0.06	0.09
Minimum	5.26[a]	5.36[a]	5.52[b]	0.06	< 0.01
pH variance	0.099	0.084	0.092	0.010	0.44
Time < 5.6, minute	316[a]	252[ab]	219[b]	39.7	0.08
Area < 5.6[2]	100	31	49	29.1	0.27

[a,b]Within a row, means with different superscripts are different ($P \leq 0.10$).
[1]Treatments were a traditional adaptation system (TRD), or two RAMP treatments where cattle were adapted in 4-step diets (4-STEP) or transitioned directly to a finishing diet (1-STEP).
[2]Area < 5.6 = area under the curve (magnitude of pH < 5.6 by minute).

Results

Intakes were similar for treatments during the 28-day adaptation period ($P = 0.53$; Table 3) and during the 14-day period when cattle were fed a common finishing diet. ($P = 0.77$; Table 4; Figure 1). Time spent eating during the adaptation period was affected by treatment ($P = 0.01$) with 4-STEP cattle spending more time eating compared to 1-STEP ($P = 0.02$) or TRD ($P < 0.01$). While cattle were on a common finishing diet, treatment tended to effect eating time ($P = 0.12$; Table 4) with 4-STEP cattle spending more time eating compared with TRD ($P = 0.04$). No differences among treatments were observed for meals per day during the adaptation period ($P = 0.76$; Table 3) or while cattle were fed a common diet ($P = 0.82$; Table 4). Intake rate was similar for all treatments during adaptation ($P = 0.17$; Table 3) and while on a common diet ($P = 0.38$; Table 4). The percentage of feed consumed after 2100 hour was not different as a result of adaptation treatment ($P = 0.49$; Table 4) once cattle were on a common finishing diet.

During the 28-day adaptation system, average ruminal pH was affected by treatment ($P = 0.09$) and was higher for 1-STEP ($P = 0.04$) and 4-STEP ($P = 0.10$) compared to TRD (Table 3). Minimum pH was different among treatments ($P < 0.01$) during the adaptation period. Surprisingly, minimum ruminal pH was higher for 1-STEP when compared to 4-STEP ($P = 0.04$) or TRD ($P < 0.01$) and time below pH of 5.6 was lower for 1-STEP compared to TRD ($P = 0.03$) during the adaptation period. Treatment had no effect on area below pH of 5.6 ($P = 0.27$) or pH variance ($P = 0.44$) during the first 28 days of the experiment. These findings are contrary to previous research where adapting cattle with *Sweet Bran* increased pH variance and decreased average, and minimum pH values (*2009 Nebraska Beef Cattle Report*, pp. 56-57). The previous trial also reported time and area below pH 5.6 was approximately three times greater for cattle adapted to

Table 4. Dry matter intake and ruminal pH characteristics during the 14-day period when cattle were on a common diet

	Adaptation treatment[1]				
Item	TRD	4-STEP	1-STEP	SEM	*P*-value
DMI, lb/day	28.6	27.1	26.5	2.1	0.77
Intake Rate, %/hour	18.6	16.9	21.0	1.99	0.38
Eating time, minute	259[a]	299[b]	276[ab]	11.9	0.12
Meals/day, n	9.50	8.95	9.52	0.74	0.82
Night intake,[2]%	24.3	28.9	23.1	3.45	0.49
Ruminal pH					
Average	5.65	5.87	5.96	0.12	0.21
Minimum	5.10	5.28	5.44	0.11	0.17
pH variance	0.083	0.086	0.068	0.014	0.65
Time < 5.6, min	611	323	236	138.2	0.19
Area < 5.6[3]	196	60	39	56.0	0.16

[a,b]Within a row, means with different superscripts are different ($P < 0.05$).
[1]Treatments were a traditional adaptation system (TRD), or two RAMP treatments where cattle were adapted in 4-step diets (4-STEP) or transitioned directly to a finishing diet (1-STEP).
[2]Night intake = percentage of total DMI consumed after 2100 hour.
[3]Area < 5.6 = area under the curve (magnitude of pH < 5.6 by minute).

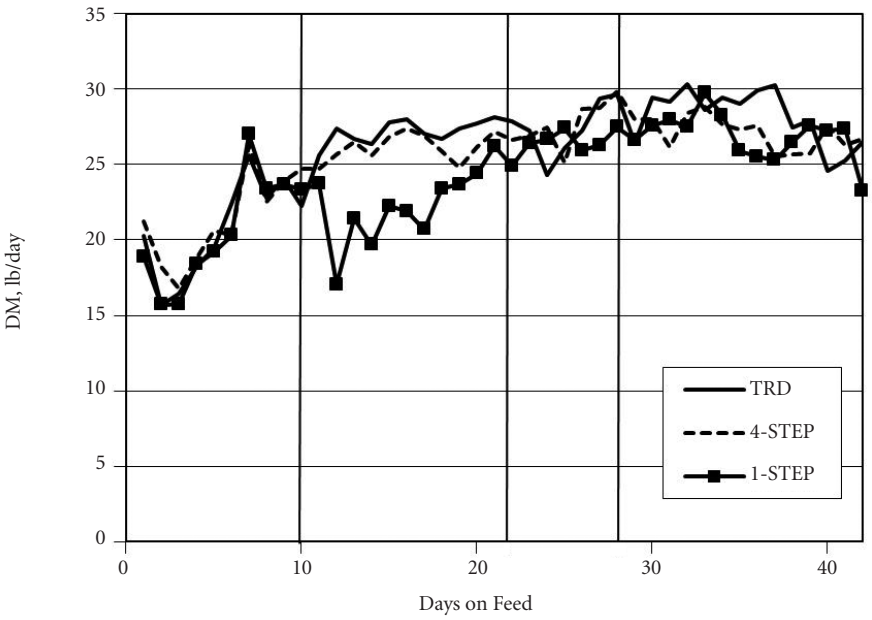

Figure 1. Daily DMI for steers adapted to a finishing diet using a traditional program (TRD), transitioned from RAMP to a finishing diet using four steps (4-STEP), or transitioned directly (1-STEP). Solid vertical bars indicate from left to right: 1-STEP starting on a finishing ration on d 10, 4-STEP and TRD starting on a finishing ration on day 21, and all cattle starting on a common finishing ration on day 28.

finishing diets with *Sweet Bran* than for cattle adapted with a traditional grain adaptation program using alfalfa hay. The authors attributed low pH to differences in DMI. It is unclear why there are differences among trials in the effects of grain adaptation on ruminal pH but they may be due differences in DMI among trials. Transitioning cattle directly from RAMP to a finishing diet did not reduce average ruminal pH and actually resulted in a higher minimum pH when compared to the 4-STEP program suggesting less acidosis. These findings are contrary to the observations of previous work which observed transitioning cattle from RAMP directly to a high-grain finishing diet decreased average ruminal pH while increasing time below pH 5.3 and pH variation when compared to a 4-STEP system suggesting more acidosis (*2013 Nebraska Beef Cattle Report*, pp. 82-83). It is unclear why acidosis was more apparent in the previous trial, other than susceptibility to acidosis among animals is highly variable.

While cattle were fed a common finishing diet (Table 4), no differences in average ruminal pH ($P = 0.21$) or minimum pH ($P = 0.17$) were observed as a result of previous adaptation treatment but numerical differences were still apparent. Ruminal pH variance was similar for all treatments once cattle were fed a common diet ($P > 0.43$). Adaptation treatment did not affect time or area below pH 5.6 when cattle were fed a common finishing diet ($P > 0.16$). These findings are contrary to the results of previous trial where greater ruminal pH variance was observed once cattle that had been transitioned directly from RAMP to a finishing diet were fed a common diet when compared to cattle adapted using a 4-step system (*2013 Nebraska Beef Cattle Report,* pp. 82-83).

The findings of this research suggest that feeding RAMP to adapt cattle to high grain diets may allow feedlots to eliminate the adaptation period. Regardless of adaptation period length, RAMP treatments increased eating time and average ruminal pH during the adaptation period, suggesting less risk of acidosis when using RAMP to start cattle on feed. Cattle fed RAMP for 10 days can be transitioned directly to a finishing diet containing 47.5% Sweet Bran and may actually have higher ruminal pH and less intake variation over the first 28 days of the feeding period.

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Transitioning Cattle from RAMP® to a Finishing Diet on Feedlot Performance and Feed Intake Variance

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Summary

Individually fed cattle were adapted to high grain diets with a traditional grain adaptation program or one of two RAMP® adaptation programs. RAMP programs adapted cattle to a finishing diet gradually over 28 days in four steps or directly without an adaptation. Feed intake variance among d was greater for traditionally adapted cattle compared to either RAMP program, but DMI was not different during the adaptation period. Over the 138-day period, feedlot performance and carcass traits were not affected by adaptation treatment. Cattle fed RAMP for 10 days can be transitioned to a finishing ration containing 47.5% Sweet Bran® abruptly without affecting performance.

Introduction

RAMP is a complete starter ration which contains a high level of Sweet Bran and a minimal amount of forage. Adapting cattle to high grain diets with RAMP increased ADG and improved F:G over the entire finishing period compared to traditional grain adaptation (*2012 Nebraska Beef Cattle Report*, pp. 85-86). Previous work has suggested starting cattle on RAMP may eliminate the need for an adaptation period (*2013 Nebraska Beef Cattle Report,* pp.80-81). However, a metabolism trial showed that a system of transitioning cattle from RAMP to a finishing diet without an adaptation period decreased ruminal pH and increased time below a pH of 5.6 compared to cattle adapted using a four-step system (*2013 Nebraska Beef Cattle Report,* pp. 82-83). The lower pH suggests that eliminating the adaptation period may have increased acidosis. Therefore, the objective of this experiment was to determine the effect of transitioning cattle from RAMP to a finishing diet with or without an adaptation period on DMI variation and feedlot performance compared to a traditional grain adaptation program with alfalfa hay.

Procedure

Sixty yearling steers (BW=844 ± 33 lb) were used in a completely randomized design study. Steers were trained to the Calan gate system and adapted to the facilities for a 28-day period. Eight days before trial initiation, steers were limit-fed (at a targeted 2% of BW daily) a diet containing 47.5% Sweet Bran, 47.5% alfalfa hay, and 5% supplement (DM basis) to minimize variation in gut fill before collecting BW. Steers were consecutively weighed over three days and the average of three weights was used as initial BW. Using the average of BW collected over the first two days, steers were stratified by BW, and assigned randomly within strata to one of three treatments.

Treatments consisted of three grain adaptation systems imposed during the first 28 days of the feeding period. Steers on traditional adaptation treatment (TRD; Table 1) were adapted to a finishing diet by feeding 4-step diets for 4, 6, 6, and 6 days. Alfalfa hay inclusion was gradually decreased from 45 to 7.5% while inclusion of a blend of 60% high-moisture corn (HMC) and 40% dry-rolled corn was increased from 25 to 62.5% (DM Basis). The RAMP adaptation treatments (Table 2) involved transitioning cattle from RAMP to a finishing diet containing 47.5% Sweet Bran in either four steps or one step. The four-step system (4-STEP) gradually decreased dietary RAMP inclusion (100 to 0%) while increasing finishing ration inclusion (0 to 100%) equally over four periods (4, 6, 6, and 6 days) by mixing RAMP with finishing ration 1 (F1, 47.5% Sweet Bran, 40% HMC, 7.5% alfalfa hay and 5% supplement, DM basis) with the blend fed as a single diet. The one step adaptation system (1-STEP) involved feeding RAMP for 10 days and switching directly to F1 on day 11. All step rations, RAMP, and the first finishing ration contained 25 g/ton Rumensin® and 12 mg/lb thiamine (DM basis).

On day 29 and through the remainder of the finishing period, cattle were fed a common diet which contained 40% HMC, 25% Sweet Bran, 22.5% modified distillers grains with solubles, 5% wheat straw, and 5% dry supplement on a DM basis (F2; Table 2). The second finishing diet was formulated to contain 30 g/ton monensin and provide 90 mg per steer daily of Tylan® (DM basis). After cattle were on a common finishing diet for two weeks (day 42), BW were collected to evaluate performance over the adaptation period, and steers were

Table 1. Adaptation diets for the traditional (TRD) adaptation program (DM basis).

Item	Step 1	Step 2	Step 3	Step 4	Finisher
Ingredient, %					
Alfalfa hay	45.0	35.0	25.0	15.0	7.5
High-moisture corn	25.0	35.0	45.0	55.0	62.5
Sweet Bran[1]	25.0	25.0	25.0	25.0	25.0
Dry supplement[2]	5.0	5.0	5.0	5.0	5.0
Chemical composition, %					
DM	74.7	72.8	70.9	69.1	67.9
CP	15.2	14.5	13.9	13.2	12.7
NDF	38.9	33.7	28.5	23.4	19.5

[1]Sweet Bran, Cargill Corn Milling, Blair, Neb.
[2]Supplement formulated to contain 25 g/ton Rumensin and 12 mg/lb thiamine (DM basis).

Table 2. Adaptation diets for the 4-STEP treatment[1] where RAMP[2] was blended with a finishing diet 1(F1) to create 4 step diets or the 1-STEP treatment.[1]Following the adaptation system a common finishing ration (F2) was fed.

	Ratio of RAMP:F1					
Item	100:0	75:0	50:50	25:75	0:100	F2
Ingredient, %						
RAMP	100.0	75.0	50.0	25.0	—	—
High-moisture corn	—	10.0	20.0	30.0	40.0	42.5
Sweet Bran	—	11.9	23.8	35.6	47.5	25.0
MDGS	—	—	—	—	—	22.5
Alfalfa hay	—	1.9	3.7	5.6	7.5	—
Wheat straw	—	—	—	—	—	5.0
Dry supplement[3]	—	1.2	2.5	3.8	5.0	5.0
Nutrient composition, %						
DM	65.6	65.8	65.9	66.1	66.2	65.2
CP	22.5	20.9	19.2	17.5	15.9	16.4
NDF	36.9	34.1	31.3	28.4	25.6	24.9

[1]Treatment were as follows: 4-STEP blends 100:0, 75:0, 50:50, 25:75, and 0:100 were fed for 4, 6, 6, 6, and 6 days, respectively; 1-STEP fed 100:0 for 10 days and 0:100 day 11 to 28.
[2]RAMP is a complete starter feed (Cargill Corn Milling, Blair, Neb.) consisting of wet corn gluten feed, alfalfa hay, minerals, and vitamins.
[3]Supplement formulated to contain 25 g/ton Rumensin and 12 mg/lb thiamine (DM basis). The supplement for F2 was the same but was formulated to contain 30 g/ton Rumensin and provide 90 mg of Tylan per animal daily.

Table 3. Feedlot performance and carcass characteristics of steers adapted to a finishing diet using a traditional grain adaptation program or RAMP.

	Treatment[1]				
Item	TRD	4-STEP	1-STEP	SEM	*P*-value
Performance					
Initial BW, lb	842	842	843	7.6	0.99
Final BW, lb[2]	1404	1382	1419	17.2	0.31
DMI, lb/day					
42 days	25.9	26.3	26.7	0.45	0.50
Final	24.1	23.5	24.5	0.50	0.39
Night intake[3], %	13.6	16.8	15.8	1.21	0.18
ADG, lb					
42 days	3.60[a]	3.75[ab]	4.07[b]	0.13	0.05
Final	4.07	3.91	4.17	0.09	0.14
F:G[4]	5.88	5.99	5.85	—	0.59
Carcass traits					
LM area, in[2]	14.6	14.0	14.9	0.33	0.88
12 rib fat, in	0.48	0.51	0.51	0.03	0.77
Yield Grade[5]	2.90	3.10	2.90	0.17	0.63
Marbling[6]	456	445	445	14.7	0.82

[a,b]Within a row, means with different superscripts are different ($P < 0.05$).
[1]Treatments were a traditional adaptation system (TRD), or two RAMP treatments where cattle were adapted in 4 step diets (4-STEP) or transitioned directly to a finishing diet (1-STEP).
[2]Final BW was calculated from HCW using a common dressing percentage of 63%.
[3]Night intake = percentage of total DMI consumed after 2100 h.
[4]Statistics performed on G:F, inverse of G:F presented.
[5]Calculated as 2.5+ (2.5 x 12th rib fat) + (0.2 x 2.5[KPH]) + (0.0038 x HCW)-(0.32 x LM area).
[6]300 = Slight, 400 = Small, 500 = Modest.

implanted with Revalor®-S. Among day DMI variance (DIV) and DMI for each steer were calculated for three time periods (day 1-28 before feeding a common finishing diet, the first six days of finishing diet 1, and the first six days on the common finishing diet) to assess DMI variation.

On the first day of feeding, steers were fed at 2.3% of BW (DM basis). Ration was increased by 2 lb DM each day until feed remained the following day. Throughout the feeding period, cattle were offered ad libitum access to feed and water and fed once daily at approximately 0900 hour. Feed consumption at night was estimated during two time periods (day 35 to 49 and day 61 to 74) during the trial. These estimates were conducted by evaluating feed bunks at 2100 hour and again at 0600 hour the following day. The amount of feed consumed overnight divided by DMI were used to calculate the percentage of feed consumed at night for each steer over the two periods.

All cattle were fed Zilmax® at a level of 7.56 g/ton DM for 20 days followed by a three-day withdrawal before harvesting the animals. On day 138, cattle were individually weighed and transported to a commercial abattoir (Greater Omaha Packing, Omaha, Neb.) to be slaughtered. Hot carcass weight (HCW) and liver abscess scores were obtained on the day of slaughter. Following a 48-hour chill, USDA marbling score, 12th rib fat thickness, and LM area were recorded. Yield grade was calculated using HCW, 12th rib fat thickness, LM area, and an assumed 2.5% KPH. Carcass adjusted performance was calculated using a common dressing percentage (63%) to determine final BW, ADG, and F:G. Final live BW were shrunk 4% and used to calculate dressing percentage.

Performance and carcass characteristics were analyzed using the MIXED procedure of SAS (SAS Institute, Inc., Cary, N.C.). Pair-wise comparisons for treatments were determined by Fisher's LSD method when the F-test statistic was significant at $P \leq 0.10$. Among day DMI variance (DIV) and DMI for each animal were analyzed for three time periods. Period was analyzed as a repeated measure using the GLIMMIX procedure of SAS using first order autoregressive.

Results

During the 28-day adaptation period, steers on both RAMP treatments consumed more feed ($P < 0.03$) compared to cattle on the TRD treatment (data not shown). No treatment differences were observed for DMI over the first six days F1 was fed ($P = 0.84$), the first six days F2 was fed ($P = 0.31$; data not shown), or over first 42 days of the experiment ($P = 0.50$; Table 3). Feed intake variance among days for steers was greater

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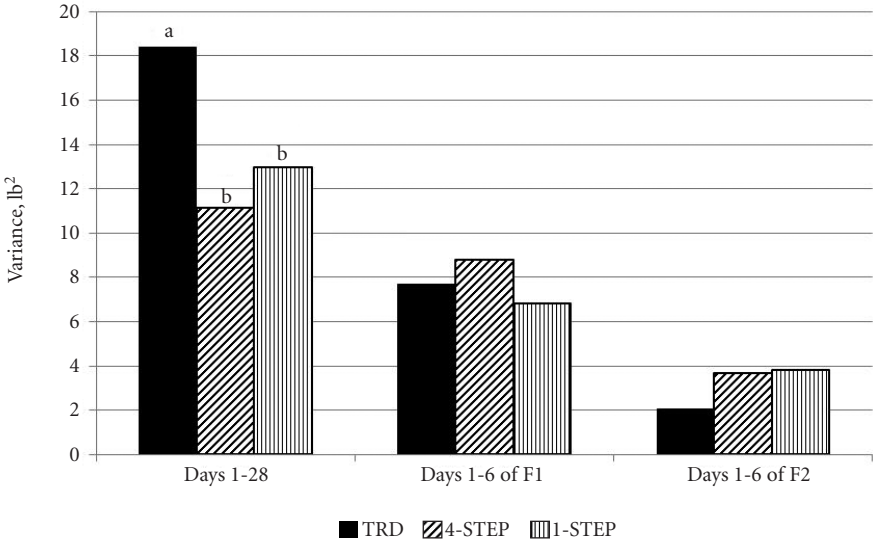
for TRD compared to 4-STEP ($P < 0.01$) and 1-STEP ($P = 0.04$) during the 28 d adaptation period (Figure 1). No differences in DIV were observed among treatments for the first six days F1 was fed ($P = 0.69$) or for the first six days F2 was fed ($P = 0.39$). Although not significant ($P = 0.18$), there was a numeric trend for cattle fed RAMP to consume a higher percentage of feed at night compared to TRD over the two time periods (Table 3). High variation associated with subjective visual estimates of feed remaining may have limited detection of treatment differences.

Gain during the first 42 days was affected by treatment ($P = 0.05$; Table 3) as 1-STEP cattle had greater (P=0.02) ADG compared to TRD and tended to have greater (P=0.10) ADG compared to 4-STEP. Improvements in ADG resulted in a tendency for treatment differences ($P = 0.09$) in F:G. Over the entire 138-day feeding period, no differences were observed among treatments for carcass adjusted ADG ($P = 0.14$) or F:G (P=0.59; Table 3). In contrast a previous trial reported improvements in ADG as a result of grain adaptation programs using RAMP when compared to traditional grain adaptation programs (2012 *Nebraska Beef Cattle Report*, pp. 85-86). Similarly, another trial reported improvements in ADG and F:G as a result of using Sweet Bran for grain adaptation (2009 *Nebraska Beef Cattle Report*, pp. 53-54).

Carcass characteristics were not affected by adaptation treatment (Table 3) as there were no differences among treatments for LM area ($P = 0.19$) or 12th rib fat thickness ($P = 0.78$). Calculated yield grade and marbling score were similar among treatments ($P > 0.64$). The incidence of liver abscesses was low in this trial (5%) and was not analyzed.

Transitioning cattle directly to a finishing diet from RAMP did not affect feedlot performance or alter carcass characteristics. Similarly, another trial showed no differences in performance over the entire feeding period between cattle that were transitioned from RAMP to a finishing diet either directly or gradually using a four-step system (*2013 Nebraska Beef Cattle Report*, pp.80-81). Cattle fed RAMP for 10 days can be transitioned to a finishing ration containing 47.5% Sweet Bran abruptly without affecting performance.



[ab]Means with different superscripts differ ($P < 0.05$).
[1]For period SEM = 0.367; *F*-test *P*-value = 0.02.
[2]For period SEM = 0.335; *F*-test *P*-value = 0.69.
[3]For period SEM = 0.210; *F*-test *P*-value = 0.39.

Figure 1. DMI variance for three time periods: all days before feeding a common finishing diet[1] (day 1-28), the first six days of finishing diet 1[2] (F1), and the first six days on the common finishing diet[3] (F2). Treatments shown left to right in chart: TRD, 4-STEP, and 1-STEP.

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Effects of Increasing Inclusion of Wet Distillers Grains Plus Solubles With and Without Oil Extraction on Finishing Performance

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Summary

A finishing study was conducted to assess the effects of feeding increasing amounts of wet distillers grains plus solubles (WDGS) with and without corn oil removal. Oil removal and WDGS inclusion did not interact. Compared to normal oil, de-oiled WDGS did not impact ADG, F:G, or carcass characteristics. Increasing inclusion of WDGS decreased DMI and F:G linearly, with no change in ADG. Regardless of inclusion, oil removal via centrifugation had little impact on finishing cattle performance.

Introduction

The ethanol industry has the ability to remove a portion of corn oil, via centrifugation, from thin stillage to produce de-oiled distillers byproducts that are lower in fat content. A recent study concluded that removal of corn oil via this centrifugation process had no effect on ADG and F:G when 27% inclusion of condensed distillers solubles or 40% inclusion of modified distillers grains plus solubles were fed in finishing diets (*2013 Nebraska Beef Cattle Report*, pp. 64-65). Therefore, the objective of this study was to determine the effects of feeding de-oiled wet distillers grains plus solubles (WDGS) on finishing performance and carcass characteristics when included at greater inclusions in finishing diets. It is plausible that at low inclusions, the oil would have benefits for performance, and at greater inclusions, the de-oiled distillers may actually be better for finishing cattle due to oil inhibiting rumen digestion. This was observed in a previous growing study (*2013 Nebraska Beef Cattle Report*, pp. 25-26).

Procedure

A 147-day finishing experiment was conducted using 336 crossbred, yearling steers (initial BW = 774 ± 42 lb) in a randomized block design, with a 2x3+1 factorial arrangement of treatments. Steers were limit-fed for five days at 2% of BW prior to the initiation of the trial and weighed on two consecutive days (0 and 1) to determine initial BW. Steers were implanted on day1 with Revalor-XS. Steers were blocked by BW, stratified by BW within each block, and assigned randomly to pen. Pens were then assigned randomly to one of seven treatments with six pens per treatment and eight steers per pen.

The control diet contained a 1:1 blend of dry-rolled and high-moisture corn with 12% corn silage (Table 1). The remaining diets contained WDGS with inclusions of 35% de-oiled or normal oil WDGS, 50% de-oiled or normal oil WDGS, and 65% de-oiled or normal WDGS (DM basis). Wet distillers grains plus solubles was sourced from the same plant (KAAPA Ethanol, Minden, Neb.) and received approximately every three weeks throughout the experiment. Samples of WDGS were collected at each delivery as well as monthly composites of weekly feed ingredients and analyzed for DM, fat, CP, and S. Fat concentration was analyzed using the biphasic lipid extraction procedure. All diets contained 5% supplement, which was formulated for 30 g/ton of DM and provided approximately 380 mg/steer daily of Rumensin® as well as formulated to provide 90 mg/steer daily of Tylan®.

All animals were harvested on day 148 at a commercial abattoir (Greater Omaha Packing, Omaha, Neb.) with hot carcass weights (HCW) and liver scores recorded at slaughter. Carcass 12th rib fat, LM area, and USDA marbling score were recorded after a 48-hour carcass chill. Yield grade was calculated using the USDA YG equation [YG = 2.5 + 2.5 (fat thickness, in) – 0.32 (LM area, in^2) + 0.2 (KPH fat, %) + 0.0038 (HCW, lb)]. Final BW, ADG, and F:G were calculated using HCW adjusted to a common dressing percentage of 63%.

Data were analyzed using the GLIMMIX procedure of SAS (SAS Institute, Inc., Cary, N.C.) as a randomized block design with pen as the experimental unit. The PROC IML was used to determine coefficients due to unequal spacing of inclusion level of WDGS. The 2x3 factorial design was analyzed for an oil (de-oiled,

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

		35% WDGS		50% WDGS		65% WDGS	
	Control	De-Oiled	Normal	De-Oiled	Normal	De-Oiled	Normal
Ingredient, % of DM							
DRC[1]	41.5	24	24	16.5	16.5	9	9
HMC[1]	41.5	24	24	16.5	16.5	9	9
WDGS: De-Oiled[1]	—	35	—	50	—	65	—
WDGS: Normal Fat[1]	—	—	35	—	50	—	65
Corn Silage	12	12	12	12	12	12	12
Supplement [2]	5	5	5	5	5	5	5
Analyzed Composition, %							
Fat	4.5	5.5	7.1	6.0	8.2	6.4	9.3
CP	12.8	16.2	15.8	19.4	18.8	22.6	21.9
Sulfur	0.09	0.32	0.31	0.42	0.41	0.52	0.51
NDF	13.5	26.6	27.8	32.3	34.0	38.0	40.2

[1]DRC = Dry rolled corn; HMC = High moisture corn; WDGS = Wet distillers grains plus solubles.
[2]Formulated to contain 380 mg/head/day of Rumensin and 90 mg/head/day of Tylan.

Table 2. Nutrient Composition of WDGS.

	De-oiled	Normal
Fat, %	7.9	12.4
CP, %	30.5	29.3
S, %	0.76	0.73
NDF, %	48.0	51.5

[1]All values expressed on a DM basis.

normal) by inclusion level (35%, 50%, 65%) interaction. Using the control as the common intercept, linear and quadratic interactions were evaluated.

Results

The fat concentrations (Table 2) of de-oiled and normal WDGS were 7.9% ± 0.71% and 12.4% ± 0.60%, respectively. Crude protein and sulfur concentration were slightly greater for de-oiled WDGS compared to normal fat WDGS likely due to being more concentrated when a portion of oil is removed. Dietary fat concentrations are included in Table 1.

No linear or quadratic interactions were observed for final BW, ADG, or F:G ($P > 0.31$; Table 3). There was a linear interaction ($P < 0.01$) for DMI producing different slopes for de-oiled and normal oil WDGS (Table 3) suggesting that DMI was different between de-oiled and normal WDGS at different inclusions. For the main effect of oil content, there were no statistical differences ($P > 0.19$) for final BW, ADG, or F:G between de-oiled and normal oil WDGS (Table 4). The effect of oil content was significant ($P < 0.01$) for DMI with cattle fed de-oiled diets having greater DMI than normal fat. There is a numerical difference ($P = 0.19$) between de-oiled and normal oil for F:G with cattle fed normal fat having a 2.6% improvement compared with de-oiled. For the main effect of inclusion, DMI decreased quadratically ($P < 0.01$) and F:G decreased linearly ($P < 0.01$) as the inclusion of WDGS increased in the diet with no response for ADG ($P > 0.17$; Table 5).

There was no linear or quadratic interactions observed for all carcass characteristics ($P > 0.19$). There were no statistical differences for the main effect of oil content ($P > 0.34$) for carcass characteristics (Table 4). For the main effect of level of WDGS, there were no statistical differences ($P > 0.17$) except calculated yield grade tended to increase linearly with increased inclusion of WDGS ($P = 0.08$; Table 5).

Feed conversion decreased linearly which suggests that either de-oiled or normal WDGS could be fed up to 65% of the diet which contradicts our hypothesis of an interaction. We would not recommend feeding WDGS at 65% inclusion, due to availability and economics as well as risk of sulfur toxicity. Regardless of inclusion, the oil content of WDGS had no significant effect on ADG or F:G suggesting that oil removed via centrifugation will have minimal impact on finishing performance.

Table 3. Linear and quadratic interactions for increasing levels of de-oiled and normal oil WDGS on finishing performance.

		35%		50%		65%			*P*-value	
	Control	DO[1]	N[1]	DO[1]	N[1]	DO[1]	N[1]	SEM	Lin Int[2]	Quad Int[2]
Performance										
DMI, lb/day	25.1	25.4	25.3	25.6	24.1	24.2	22.9	0.8	< 0.01	0.48
ADG, lb	3.88	3.99	4.14	4.15	3.92	4.12	4.06	0.12	0.31	0.64
F:G[3]	6.44	6.33	6.09	6.13	6.10	5.83	5.63		0.38	0.89

[1]DO = De-Oiled, N = Normal fat.
[2]Linear and quadratic interaction term.
[3]Analyzed as G:F, the reciprocal of F:G.

Table 4. Main effect of oil concentration on performance and carcass characteristics.

	De-Oiled	Normal	SEM	*P*-value
Performance				
Final BW, lb	1384	1375	9	
DMI, lb/day	25.1	24.1	0.2	0.52
ADG, lb	4.09	4.04	0.07	<0.01
F:G[1]	6.12	5.96	0.19	0.58
Carcass Characteristics				
HCW, lb	870	867	6	0.68
LM area, in	13.1	13.2	0.12	0.58
12th rib fat, in	0.56	0.56	0.01	0.93
Calculated YG	3.46	3.47	0.06	0.91
Marbling score[2]	465	476	8	0.34

[1]Analyzed as G:F, the reciprocal of F:G.
[2]Marbling score: 400 = Small00.

Table 5. Main effect of level of WDGS on performance and carcass characteristics.

	Control	35%	50%	65%	SEM	Linear	Quadratic
Performance							
Final BW, lb	1354	1382	1377	1382	36	0.23	0.46
DMI, lb/day	25.1	25.4	24.8	23.6	0.8	<0.01	<0.01
ADG, lb	3.88	4.07	4.04	4.09	0.12	0.17	0.60
F:G[1]	6.44	6.21	6.12	5.73		<0.01	0.13
Carcass Characteristics							
HCW, lb	850	871	867	867	22	0.25	0.27
LM area, in	13.4	13.2	13.3	13.2	0.20	0.53	0.97
12th rib fat, in	0.52	0.57	0.54	0.56	0.03	0.17	0.37
Calculated YG	3.24	3.49	3.38	3.49	0.12	0.08	0.42
Marbling score[2]	447	473	455	475	19	0.25	0.79

[1]Analyzed as G:F, the reciprocal of F:G
[2]Marbling score: 400 = Small00

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Effects of a Terminal Sorting System with Zilpaterol Hydrochloride on Feedlot Steers

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Summary

Crossbred yearling steers were utilized to evaluate the effects of Zilpaterol hydrochloride (Zilmax®) and terminal sorting 50 days prior to harvest on feedlot performance and carcass characteristics. Four treatments were used: an unsorted group not fed Zilmax (–CON), an unsorted group fed Zilmax, sorting by weight into two market groups and fed Zilmax, or sorting by weight into four market groups and fed Zilmax (4-Sort). Carcass weight was increased in cattle fed Zilmax by 33 lb and was further increased by 9 lb by 4-SORT. Yield grade and marbling score were lower for all cattle fed Zilmax compared to the –CON. Sorting four ways (4-Sort) increased HCW, reduced HCW variation, and decreased the percentage of overweight carcasses compared to not sorting.

Introduction

Zilpaterol hydrochloride (Zilmax) is a ß-adrenergic receptor agonist that increases skeletal muscle mass and reduces body fat content. Studies conducted using feedlot steers fed corn-based diets in the United States have demonstrated feeding Zilmax for the last 20 days prior to slaughter resulted in increased ADG, improved F:G, increased carcass weight, and increased carcass leanness compared to cattle not fed Zilmax. Feeding Zilmax has reduced USDA quality grades compared to cattle not fed Zilmax. However, little research has been conducted on the use of a weight sort in combination with feeding Zilmax for the last 20 days prior to slaughter. Previous research indicates that sorting cattle allows pens of cattle to be fed longer without increasing overweight discounts (*1999 Nebraska Beef Cattle Report*, pp.57-59). Another study showed sorting in combination with feeding Zilmax in the finishing period allowed for an increase in carcass weight without increasing variation in carcass weight, and allowed for cattle to reach an optimum fat endpoint (*2012 Nebraska Beef Cattle Report,* pp.115-118). Therefore, the objectives of this study were to determine the effects of 1) identifying heavy cattle within a pen with one sort or sorting a large group four ways and 2) feeding Zilmax to steers on feedlot performance and carcass traits.

Procedure

Crossbred yearling steers (n = 1,400; 829±64 lb initial BW) were used to evaluate the effects of Zilpaterol hydrochloride (Zilmax) and terminal sorting 50 days prior to harvest on feedlot performance and carcass characteristics. Steers were blocked by arrival group (25 steers/pen, 56 pens) and assigned randomly to pen which received one of four treatments. The four treatments included: 1) an unsorted non- Zilmax fed negative control (-CON); 2) unsorted Zilmax fed positive control (+CON); 3) early weight sort fed Zilmax (1-Sort) with the heaviest 20% identified at day 1 and sorted 50 days from harvest and marketed 14 days prior to –CON and +CON, with the remaining 80% of the pen fed seven das longer than the –CON and +CON; and 4) four-way sort 50 days from harvest fed Zilmax (4-Sort) with steers sorted into a heavy, mid-heavy, mid-light, and light group, marketed -14 days, 0 days, +7 days, and +28 days from the –CON and +CON, respectively (Figure 1). Because the heaviest steers were sorted early, the remaining steers in the sorted treatments were fed longer than the –CON and +CON treatments (Figure 1).

Steers fed Zilmax were fed Zilmax (Zilmax, Merck Animal Health, De Soto, Kan.) at 7.56 g/ton DM for 20 days followed by a three-day withdrawal. Basal diets and supplement

(Continued on next page)

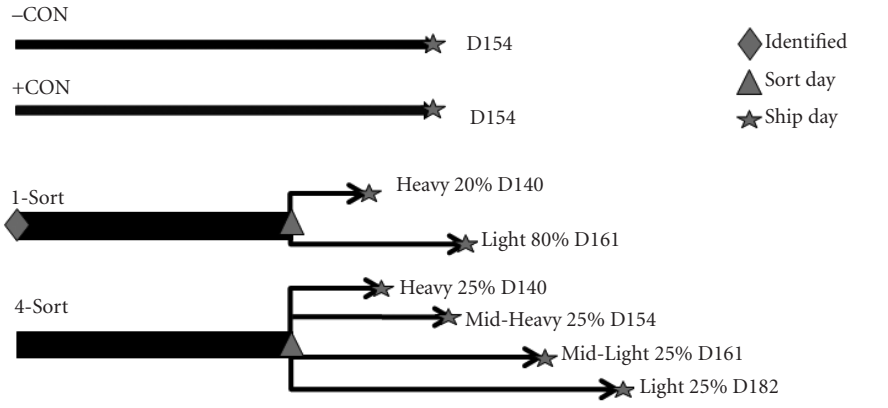

Figure 1. -CON and +CON were randomized into pen and removed on day 154 for harvest. 1-Sort the heaviest 20% were identified on day 1 and sorted 50 days before harvest with the heavy 20% being harvested on day 140 and the light 80% being harvested on day 161. Fifty days before harvest 4-Sort was sorted into a heavy, mid-heavy, mid-light, and light group marketed -14, 0, +7, and +28 days from the –CON and +CON.

Table 1. Basal diet and supplement (finishing ration).

Ingredient	% of diet DM
Basal Diet	
DRC	33.0
HMC	8.0
MDGS	25.0
Sweet Bran®	20.0
Silage	6.0
Wheat straw	3.0
Supplement	5.0
Supplement	
Fine ground corn	2.72
Limestone	1.75
Salt	0.30
Tallow	0.13
Trace mineral	0.05
Rumensin-90	0.02
Tylan-40	0.01
Vitamin A,D,E	0.02

Two supplements were manufactured and fed during the study. One supplement contained Zilmax, and one supplement did not contain any Zilmax. In supplement containing Zilmax, Zilmax replaced find ground corn.

ingredients are presented in Table 1. Steers used in this experiment were sourced from multiple locations in the fall of 2011 and backgrounded during the winter, while some were sourced from auction barns in May of 2012.

On the day of allocation to treatment, all steers were implanted with Revalor-XS®. Prior to the start of the experiment, steers were limit-fed a common diet at 2.0% of BW for five consecutive days and weighed two consecutive days to eliminate variation in body weight due to gut fill. Following the limit-feeding period, steers were assigned randomly to pen and pens were assigned randomly to treatment. The heaviest 20% of steers in each pen in the 1-Sort treatment were identified during weighing and processing on day 0. Cattle were fed *ad libitum* twice daily at 7 and 11 a.m.

Fifty days prior to the target marketing date, the heaviest 20% (five steers/pen) identified on day 0 in the 1-Sort treatment were sorted and moved to a separate pen, and the remaining light 80% were returned to the original pen. Likewise, steers from four pens (100 steers) in the 4-Sort group within a block were individually weighed and sorted with the heaviest 25% (25 steers) sorted into the

Table 2. Performance data for steers fed Zilmax (+CON) or not (-CON) and sorted wo ways (1-SORT) or four ways (4-SORT) and fed Zilmax.

	Treatments					
		Zilmax Fed				
Variable	-CON	+CON	1-SORT	4-SORT	SEM	*P*-value
Pens, n	8	8	8	8		
Steers, n	200	200	200	800		
Average days, n	154	154	157	159		
Live Performance						
Initial BW, lb	824	822	822	824	17.10	0.99
Final BW, lb	1479	1492	1503	1503	18.01	0.11
DMI, lb/day	26.7[a]	26.4[a,b]	26.2[b,c]	26.1[c]	0.4	<0.01
ADG, lb	4.25	4.34	4.34	4.30	0.10	0.78
F:G	6.29	6.09	6.03	6.07	—	0.33

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

Table 3. Carcass characteristic data for steers fed Zilmax (+CON) or not (-CON) and sorted two ways (1-SORT) or four ways (4-SORT) and fed Zilmax.

	Treatment					
		Zilmax Fed				
Variable	-CON	+CON	1-SORT	4-SORT	SEM	*P*-value
HCW, lb	915[c]	948[b]	954[a]	957[a]	10.69	<0.01
Change in HCW, lb[2]	—	33.0	39	42	—	—
HCW C.V[1]	7.0[a]	6.7[a]	6.2[a]	4.1[b]	—	<0.01
HCW Std. Dev, lb	64.0[a]	63.6[a]	58.5[a]	39.5[b]	—	<0.01
HCW Over 1000 lb, %	9.79[a]	17.61[b,c]	22.34[c]	13.64[a,b]	5.70	<0.01
HCW Over 1050 lb, %	1.97[a,b]	4.42[a]	1.99[a,b]	1.38[b]	2.68	0.05
Dressing Percent	61.8[a]	63.5[b]	63.5[b]	63.6[b]	0.2	<0.01
12th Rib Fat, in.	0.63	0.60	0.60	0.59	0.02	0.10
LM Area, in.[2]	13.5[a]	14.7[b]	14.8[b,c]	14.9[c]	0.2	<0.01
Calculated Yield Grade	3.6[a]	3.3[b]	3.2[b]	3.2[b]	0.1	<0.01
Marbling Score[3]	515	494	491	487	16	0.06

[1]HCW = hot carcass weight; C.V. = coefficient of variation and is calculated by dividing the standard deviation by the mean and is expressed as a percentage.
[2]Change in HCW is the difference between the HCW in each treatment and -CON.
[3]Marbling Score 500 = Modest, 400 = Small, 300 = Slight.
[a,b,c]Means within a row with different superscripts differ (P < 0.05).

Table 4. Yield and quality grade for steers fed Zilmax (+CON) or not (-CON) and sorted two ways (1-SORT) or four ways (4-SORT) and fed Zilmax.

	Treatment[2]					
		Zilmax Fed				
Variable	-CON	+CON	1-SORT	4-SORT	SEM	*P*-value
USDA Yield Grade[1]						
1	0.43[a]	2.17[a,b]	5.37[b]	4.20[b]	1.42	0.05
2	15.08[a]	30.73[b]	31.64[b]	31.96[b]	5.02	<0.01
3	58.22	54.77	50.11	49.52	5.28	0.13
4	22.58[a]	10.94[b]	11.03[b]	12.94[b]	2.59	<0.01
5	2.66[a]	0.44[a,b]	0.44[a,b]	0.11[b]	0.67	0.01
USDA Quality Grade[2]						
Prime	4.19	2.75	2.31	3.12	1.40	0.71
High Choice	50.08[a]	40.92[a,b]	41.34[a,b]	37.30[b]	5.65	0.02
Low Choice	38.22	41.15	44.11	40.86	4.23	0.69
Select	6.71[a]	14.06[b,c]	11.23[a,b]	17.32[c]	3.08	<0.01

[1]The Yield Grade (YG) and Quality Grade (QG) values represent the proportion of carcasses within each group that received each YG or QG.
[2]All numbers are expressed as percentages.
[a,b,c] Means within a row with different superscripts differ (P < 0.05).

heavy group, the next heaviest 25% (25 steers) into the mid-heavy group, the next heaviest 25% (25 steers) into the mid-light group, and the lightest 25% (25 steers) into the light group. All replicates within block were managed the same and weighed and sorted on the same day. Intake was determined by using the pen average before sort and pen average after sort for individual animals. Within a block, the heaviest 20% of steers in the 1-Sort and heavy group in 4-Sort sorted treatments were weighed by pen and harvested 14 days before the –CON and +CON. The mid-heavy 4-Sort group, the –CON, and the +CON were weighed by pen and shipped for harvest on day 154. The remaining 80% of the 1-Sort treatment and the mid-light 4-Sort group were weighed by pen and shipped for harvest seven days after the –CON and +CON. Lastly, the light 4-Sort group were weighed by pen and shipped for harvest 28 days after the –CON and +CON. On the day of shipping cattle were pen weighed to determine final body weight before shipping. Steers were harvested at a commercial abattoir the following morning. Liver scores and HCW were collected on the day of slaughter. After a 48-hour chill, marbling score, 12th rib fat depth, KPH fat, and LM area were recorded. Yield grade was calculated using the yield grade equation (Boggs and Merkel, 1993) where yield grade = 2.50 + (2.5 x fat thickness, in) – (0.32 x LM area, in^2) + (0.2 x KPH, %) + (0.0038 x HCW, lb). Dressing percentage was calculated using the HCW and final BW shrunk 4%.

Data were analyzed as a randomized block design using the Glimmix procedure of SAS (SAS Institute, Inc., Cary, N.C.). Steers were blocked by arrival group and pen was the experimental unit. The model included the fixed effect of treatment, with block as a random effect. For the –CON, +CON and 1-SORT, replication consisted of a pen of 25 steers. However, for the 4-Sort, replication consisted of four pens or 100 steers each. To account for this difference in treatment size, standard deviation and coefficient of variation were calculated on each pen and a log transformation was done to test variability of the standard deviation and coefficient of variation.

Results

Due to the weight sort, steers in the 1-Sort and 4-Sort treatments were fed an average of three days and five days longer than the control treatments, respectively (Table 2). Steers in the 4-Sort treatment had lower DMI ($P < 0.01$) compared to the unsorted treatments, but were not different compared to 1-Sort treatments. Although not different ($P = 0.11$), Zilmax fed treatments tended to have heavier final BW when compared to the –CON. Similarly, there were increases in ADG and numerical improvements in the F:G ratio.

Carcasses from +CON steers were 33 lb heavier ($P < 0.01$) than –CON (Table 3). Carcasses from steers in 1-Sort and 4-Sort were 39 and 42 lb heavier ($P < 0.01$) than -CON. Carcass weight standard deviation (SD) were not different ($P > 0.95$) between +CON and –CON, while carcass weight SD of 4-Sort was reduced ($P<0.01$) compared to the unsorted controls. All steers fed Zilmax had a greater percentage of carcasses over 1,000 lb than –CON ($P < 0.01$). Although not different ($P = 0.16$), the percentage of carcasses over 1,000 lb was reduced by 22% for 4-Sort compared to +CON. The percentage of carcasses over 1,050 lb was significantly lower ($P < 0.01$) for 4-Sort compared to +CON. Thus, sorting four ways was effective at reducing the percentage of overweight carcasses at 1,000 lb and 1,050 lb compared to an unsorted Zilmax fed control. Fat depth was lower ($P < 0.05$) in +CON than –CON, but did not differ between Zilmax fed treatments. *Longissimus* muscle area was greater ($P < 0.01$) in +CON than -CON, and 4-Sort had increased ($P = 0.05$) LM area compared to +CON. Marbling score was lower numerically for +CON, 1-Sort, and 4-Sort compared to –CON.

The percentage of USDA Yield Grade 1 and 2 carcasses was greater ($P < 0.01$) for 4-Sort compared to the –CON. Because of this shift, the percentage of USDA Yield Grade 4 and 5 carcasses was reduced ($P < 0.01$) for 4-Sort cattle compared to the –CON (Table 4). There was a reduction ($P < 0.01$) in USDA High Choice for 4-Sort compared to –CON. There was an increase ($P < 0.01$) in the percent of 4-Sort carcasses that graded USDA Select compared to –CON. Zilpaterol hydrochloride increased hot carcass weight, and when used in combination with a 4 way weight sort to identify heavy carcasses, there was an increase in HCW while decreasing HCW variation. This allowed for cattle to reach an optimum market endpoint, which in turn allows for a potential increase in profits by increasing total saleable weight while avoiding overweight discounts.

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Evaluating Corn Condensed Distillers Solubles Concentration in Steam-Flaked Corn Finishing Diets on Cattle Performance and Carcass Characteristics

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Summary

Performance and carcass characteristics were evaluated using five concentrations of corn condensed distillers solubles (CCDS) replacing steam-flaked corn (SFC) in feedlot finishing diets using crossbred steers. As CCDS replaced SFC at concentrations of 0, 9, 18, 27, or 36% of the diet DM, DMI decreased quadratically. Average daily gain increased quadratically with greatest gains observed at 27% CCDS inclusion. A quadratic improvement was observed in F:G with optimum concentrations similar to what was observed for ADG at 27% CCDS inclusion. These results suggest corn condensed distillers solubles can effectively be used to replace SFC in feedlot finishing diets while improving ADG and F:G.

Introduction

Byproducts from the dry-milling ethanol process can be used in cattle diets to replace corn. Wet distillers grains with solubles (WDGS) interacts with corn processing methods (*2007 Nebraska Beef Cattle Report*, pp. 33-35). When replacing corn with WDGS, there is a greater improvement in F:G when DRC diets are fed compared to SFC diets. However, with distillers solubles (CCDS), the same interaction has not been observed. In fact, including 30% CCDS in SFC-based diets improved F:G to a greater extent compared with DRC-based diets (*2013 Nebraska Beef Cattle Report*, pp. 51-52), but 30% was the maximum inclusion evaluated. Previous work has shown that up to 36% of the diet (DM basis) of CCDS can be fed with a 50:50 blend of DRC and HMC (DRC:HMC) while improving gain and feed efficiency (*2012 Nebraska Beef Cattle Report*, pp. 64-65). Therefore, the objective of this study was to determine if greater concentrations of CCDS could be fed in SFC-based diets without reducing performance.

Materials and Methods

Four hundred forty crossbred steers (initial BW = 878 ± 49 lb) were utilized in a feedlot finishing trial at the University of Nebraska–Lincoln Panhandle Research Feedlot near Scottsbluff, Neb. Cattle were limit-fed a diet at 2% BW consisting of 40% wet distillers grains with solubles, 30% alfalfa hay, 20% corn silage, and 10% wheat straw (DM basis) for five days prior to the start of the experiment. Two-day initial weights were recorded on day 0 and 1 and were averaged and used as the initial BW. The steers were blocked by BW into light, medium, and heavy BW blocks, stratified by BW and assigned randomly to one of 40 pens with pen assigned randomly to one of five dietary treatments. There were 11 head per pen and eight replications per treatment. Dietary treatments included 0, 9, 18, 27, or 36% CCDS replacing SFC and urea (Table 1). The corn was flaked at a target density of 28 lb/bushel at a commercial feedlot (Panhandle Feeders, Morrill, Neb.).

The composition of the CCDS used in this trial (Colorado Agri Products, Bridgeport, Neb.) contained 24.3% DM, 16.0% CP, 20.1% Fat, and 0.41% S (DM basis). Soybean meal (SBM) and urea were added to the diets to meet or exceed MP requirements of the animal. All diets contained 16% corn silage, 3.5% SBM, and 4.0% pelleted supplement (DM basis).

Steers were implanted with Component T-200 (Elanco Animal Health) on day 1. Animals in the heavy BW block were harvested on day 89 and the medium/light BW blocks were harvested on day 104 (Cargill Meat Solutions, Fort Morgan, Colo.). Hot carcass weight and liver scores were recorded on the slaughter date. Fat thickness, LM area, and marbling score were recorded after a 48-hour chill. Final BW, ADG, and F:G were calculated using HCW adjusted to a common 63% dressing percentage.

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

Results

Dry matter intake decreased quadratically ($P = 0.02$) as the concentration of CCDS increased in the diet (Table 2). Average daily gain increased quadratically ($P < 0.01$) as CCDS increased with greatest gains observed at 27% and slightly decreased at 36%. There was a quadratic improvement ($P < 0.01$) in F:G as CCDS concentration increased in the diet. Less feed was consumed per pound of gain from 0% CCDS up to the 27% CCDS diet, but F:G increased at 36% CCDS. Even though a small increase in F:G was observed for cattle fed 36% CCDS compared with the optimum at 27%, the F:G was improved compared with the control diet. Hot carcass weight increased quadratically ($P < 0.01$) as CCDS increased, also peaking at 27% CCDS. Marbling score and calculated YG increased quadratically ($P = 0.08$ and 0.06, respectively). Fat thickness and LM area also tended to increase quadratically ($P = 0.13$ and 0.07, respectively) as CCDS increased in the diet. There was a trend ($P = 0.10$) for an increasing linear response for dressing percentage as CCDS increased in the diet. These results were similar to

Table 1. Dietary treatments and nutrient analysis for steers fed CCDS[1] (DM basis).

	CCDS, % Diet DM				
	0	9	18	27	36
Ingredient, %					
SFC[2]	75.6	66.8	57.9	49.2	40.4
Silage	16.0	16.0	16.0	16.0	16.0
CCDS	0.0	9.0	18.0	27.0	36.0
SBM	3.5	3.5	3.5	3.5	3.5
Urea	0.9	0.7	0.6	0.3	0.1
Supplement[3]	4.0	4.0	4.0	4.0	4.0
Analyzed Composition, %					
Crude Fat	2.8	4.4	5.9	7.5	9.0
Crude Protein	13.5	13.7	14.1	14.0	14.1
Calcium	0.55	0.56	0.57	0.58	0.59
Phosphorus	0.25	0.36	0.46	0.57	0.68
Sulfur	0.11	0.12	0.14	0.15	0.17

[1]CCDS = corn condensed distillers solubles, SFC = steam-flaked corn, SBM = soybean meal.
[2]Flake density was 28 lb/bu.
[3]The same pelleted supplement was used for all diets, providing 0.687% urea. 360 mg Rumensin® and 90 mg Tylan® per head/day was added using a micro machine.

Table 2. Effect of corn condensed distillers solubles in steam-flaked corn-based diets on performance and carcass characteristics.

	CCDS[1], % Diet DM						*P*-value	
Item	0	9	18	27	36	SEM[2]	Linear[3]	Quad.[4]
Performance								
Initial BW, lb	879	876	877	878	879	1.382	0.58	0.11
Final BW, lb[5]	1293	1323	1320	1332	1293	8.997	0.63	<0.01
DMI, lb/day	26.0	26.0	25.3	25.1	23.8	0.377	<0.01	0.02
ADG, lb[5]	4.18	4.50	4.47	4.57	4.17	0.095	0.83	<0.01
F:G[5,6]	6.21	5.79	5.68	5.49	5.71	0.004	<0.01	<0.01
Carcass Characteristics								
HCW, lb	815	834	832	839	815	5.650	0.65	<0.01
Marbling Score[7]	525	532	534	533	512	12.231	0.37	0.08
Calculated YG[8]	3.37	3.46	3.52	3.52	3.45	0.074	0.21	0.06
12th rib fat, in	0.56	0.58	0.59	0.60	0.58	0.019	0.11	0.13
LM area, in. sq.	12.5	12.7	12.6	12.7	12.3	0.165	0.24	0.07
Dressing, %	61.6	61.9	62.0	62.2	62.0	0.291	0.10	0.22
Liver abscess[9],[10] %	10.98	8.43	14.46	9.76	9.52	—	0.83	—
A, %	4.88	4.82	9.64	6.10	5.95	—	0.71	—
A+, %	6.10	3.61	4.82	3.66	3.57	—	0.93	—

[1]CCDS = concentration of condensed distillers solubles in diet.
[2]SEM = standard error of the mean for the interaction.
[3]Linear effect for the concentration of CCDS included ($P < 0.05$).
[4]Quad. = quadratic effect for the concentration of CCDS included ($P < 0.05$).
[5]Final BW calculated from hot carcass weight adjusted to a common dressing percentage of 63%.
[6]Analyzed as G:F, reciprocal of F:G.
[7]Marbling score: 400 = Slight 0, 500 = Small 0.
[8]Calculated YG = 2.5 + 2.5 (fat thickness, in) – 0.32 (LM area in. sq.) + 0.2 (2.5 KPH fat, %) + 0.0038 (hot carcass weight, lb).
[9]Liver score: A = 3 or 4 abscesses; A+ = 4 or more abscesses.
[10]*P*-value listed is Protected F-test value.

previous data when CCDS was fed in DRC:HMC based diets (*2012 Nebraska Beef Cattle Report*, pp. 64-65).

These data with CCDS in SFC-based diets disagree with previous data evaluating SFC and distillers grains. Previous data with distillers grains suggest that increasing concentrations of WDGS in SFC-based diets slightly decreases ADG and has no effect on F:G. However, in HMC or DRC-based diets, ADG and F:G are improved with WDGS (*2007 Nebraska Beef Cattle Report*, pp. 33-35). In our hypothesis, we expected a similar result would occur with CCDS and SFC, but ADG and F:G were actually improved with increasing concentrations of CCDS in SFC-based diets in this study as well as a previous study (*2013 Nebraska Beef Cattle Report*, pp. 51-52).

Feeding distillers byproducts with greater concentrations of sulfur (S) increases the incidence of S toxicity (Polioencephalomalacia). During the experiment, a load of CCDS was delivered after the plant flushed their system with sulfuric acid. Six steers were treated for S toxicity. Three steers were on the 18% CCDS diet and one each from the 9%, 27%, and 36% CCDS diets. Two steers became chronic and were subsequently removed from the trial (one each from 18% and 27% CCDS diets). An analysis of the S content of the CCDS was 2.59% S on a DM basis. A bunk sample from the 36% CCDS treatment was 0.92% S (DM basis). These concentrations of S exceed toxic amounts of 0.46% S of the total diet DM (*2009 Nebraska Beef Cattle Report*, pp. 79-80). Logically, it was thought more toxicity would have been observed from steers fed the 36% CCDS concentration diet, but it is believed those concentrations were greater than the threshold and steers decreased DMI similar to previous studies (*2011 Nebraska Beef Cattle Report*, pp. 62-64). However, the steers on the 18% CCDS diet may have continued to consume feed and subsequently had a greater incidence of adverse reactions.

This study suggests feeding condensed distillers solubles can effectively be used to replace SFC in feedlot finishing diets up to 36% of the total diet DM. The lowest observed F:G was at 27% CCDS, at which the steers were 13% more efficient than those fed 0% CCDS. This was not the same interaction observed with SFC and WDGS. The optimum CCDS concentration for ADG was calculated at 17.5% and 25% for optimum F:G. The decision to feed CCDS to replace corn would depend on price relative to corn on a DM basis. Markets will dictate whether elevated concentrations of CCDS will be economical in finishing diets with SFC.

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Feeding Elevated Levels of Corn Silage and MDGS in Finishing Diets

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Summary

A finishing experiment evaluated substitution of corn silage and modified distillers grains with solubles (MDGS) in place of corn. The treatment arrangement was a 2 X 2 + 1 factorial with 15 or 45% corn silage and 20 or 40% MDGS plus a control containing 5% cornstalks and 40% MDGS. There were interactions between corn silage and MDGS for carcass adjusted performance. As corn silage inclusion was increased in the diet, F:G increased when fed with 20% MDGS, however there was no difference when fed with 40% MDGS.

Introduction

Corn silage in beef finishing diets has been shown to be economical especially in times of high priced corn. We previously reported (*2013 Nebraska Beef Cattle Report*, pp. 74-77) that when corn silage partially replaced corn in finishing diets containing distillers grains, ADG and feed efficiency were poorer as corn silage inclusion increased in calf-fed steers. However, despite poorer F:G, feeding elevated corn silage was economical. The objectives of this experiment were to 1) determine the performance effects and carcass characteristics of feeding elevated levels of corn silage and the impact of dietary inclusion of MDGS and 2) assess the feeding values of corn silage and MDGS relative to corn.

Procedure

Crossbred yearling steers (n = 295; BW = 1,030 ± 114 lb) were sorted into six weight blocks and assigned randomly to 30 pens (9 or 10 steers/pen). Treatments were designed as a 2 X 2 + 1 factorial arrangement consisting of 15% or 45% corn silage and 20% or 40% MDGS (15:20 - 15% corn silage, 20% MDGS; 15:40 - 15% corn silage, 40% MDGS; 45:20 - 45% corn silage, 20% MDGS; and 45:40 - 45% corn silage, 40% MDGS) and a control diet consisting of 5% cornstalks and 40% MDGS (Table 1). Elevated levels of corn silage and MDGS replaced a 1:1 blend of dry-rolled corn:high-moisture corn. All steers were fed a supplement formulated for 30 g/ton Rumensin® (DM basis) and a targeted intake of 90 mg/steer daily of Tylan®. Steers were implanted with Revalor®-200 on day 1. One block of steers were harvested after 91 days on feed. Five blocks were harvested after 98 days on feed. Prior to being transported to a commercial abattoir (Greater Omaha Packing Co., Inc., Omaha, Neb.), pens of steers were weighed on a platform scale. A 4% pencil shrink was applied to this weight for final live BW and calculation of dressing percentage. Steers were weighed in the afternoon prior to evening shipping, with slaughter the following morning. On the last day of feeding, pens were fed 50% of the previous day's intake at the normal morning feeding time. Hot carcass weight was obtained the day of harvest. Carcass adjusted final BW, used in calculation of ADG and F:G, was calculated from HCW and a common dressing percentage (62%). Marbling score, 12th rib fat thickness, and LM area were recorded after a 48 hour (one block) or 144 hour (five blocks) carcass chill. The longer chill was equal across treatments and was due to scheduling at the plant.

Performance and carcass data were analyzed as a 2 X 2 + 1 factorial in a randomized block design using the mixed procedure of SAS (SAS Institute, Inc., Cary, N.C.). Pen was the experimental unit, and BW block was included as a fixed effect. Main effects of corn silage and MDGS inclusion were tested as well as the interaction of corn silage and MDGS. The control was included for the analysis of an overall F-test across all treatments. Treatment differences were considered significant at $P < 0.10$.

Results

There was no difference in DMI across treatments ($P = 0.48$; Table 2). There was a corn silage by MDGS interaction for final BW, ADG, and F:G ($P < 0.10$). For cattle fed 15% corn silage diets, ADG was 0.31 lb greater for cattle fed 20% MDGS in comparison to 40% MDGS ($P = 0.11$). There was no statistical difference in final BW ($P = 0.11$) or F:G ($P = 0.13$) for cattle fed 15% corn silage diets with

Table 1. Diet composition (DM basis).

	Treatment[1]				
	Control	15:20	15:40	45:20	45:40
DRC[2]	25.0	30.0	20.0	15.0	5.0
HMC[3]	25.0	30.0	20.0	15.0	5.0
Corn Silage	0.0	15.0	15.0	45.0	45.0
Cornstalks	5.0	0.0	0.0	0.0	0.0
MDGS[4]	40.0	20.0	40.0	20.0	40.0
Supplement[5]	5.0	5.0	5.0	5.0	5.0

[1]15:20 = 15% Corn Silage, 20% MDGS; 15:40 = 15% Corn Silage, 40% MDGS; 45:20 = 45% Corn Silage, 20% MDGS; 45:40 = 45% Corn Silage, 40% MDGS
[2]DRC = Dry-rolled corn.
[3]HMC = High-moisture corn.
[4]MDGS = Modified distillers grains with solubles.
[5]Formulated for 30 g/ton of DM for Rumensin and to provide 90 mg/steer daily for Tylan®.

Table 2. Effect of corn silage and MDGS inclusion on cattle performance and carcass characteristics.

	Treatment[1]						*P*-value[2]			
	Control	15:20	15:40	45:20	45:40	SEM	F-test	Int.	Silage	MDGS
Performance										
Initial BW, lb	1036	1032	1032	1034	1034	2.2	0.17	0.30	0.09	0.72
Final BW, lb[3]	1393	1415	1385	1367	1385	11.0	0.12	0.09	0.08	0.58
DMI, lb/day	29.1	29.5	28.7	29.5	29.8	0.4	0.48	0.24	0.34	0.47
ADG, lb[3]	3.70^{ab}	3.95^{a}	3.64^{b}	3.44^{b}	3.62^{b}	0.11	0.09	0.08	0.06	0.59
Feed:Gain[3]	7.87^{ab}	7.46^{a}	7.87^{ab}	8.55^{c}	8.20^{bc}		0.01	0.08	<0.01	0.71
Live final BW, lb	1433	1455	1422	1433	1440	13.2	0.48	0.18	0.84	0.34
Carcass Characteristics										
HCW, lb	864	877	858	849	858	6.6	0.12	0.09	0.08	0.57
Dressing percentage, %	60.3^{a}	60.3^{a}	60.3^{a}	59.1^{b}	59.6^{b}	0.3	0.01	0.37	<0.01	0.40
LM area, in^2	13.9^{a}	14.0^{a}	13.4^{b}	13.5^{b}	13.5^{b}	0.1	0.04	0.09	0.27	0.11
12th-rib fat, in	0.47	0.47	0.50	0.47	0.48	0.02	0.65	0.82	0.65	0.20
Calculated YG	3.01	3.03	3.20	3.06	3.14	0.08	0.38	0.58	0.84	0.15
Marbling Score[4]	540^{b}	583^{a}	548^{b}	554^{b}	532^{b}	11.0	0.03	0.54	0.05	0.02

[1]15:20 = 15% Corn Silage, 20% MDGS; 15:40 = 15% Corn Silage, 40% MDGS; 45:20 = 45% Corn Silage, 20% MDGS; 45:40 = 45% Corn Silage, 40% MDGS

[2]F-test= *P*-value for the overall F-test of all diets. Int. = *P*-value for the interaction of corn silage X MDGS. Silage = *P*-value for the main effect of corn silage inclusion. MDGS = *P*-value for the main effect of MDGS inclusion.

[3]Calculated from hot carcass weight, adjusted to a common 62% dressing percentage.

[4]Marbling Score: 400 = Slight00, 500 = Small00.

[abcd]Within a row, values lacking common superscripts differ ($P < 0.10$).

20 or 40% MDGS; however cattle fed 20% MDGS had numerically greater final BW and improved F:G. For diets containing 45% corn silage, there were numerical improvements for final BW, ADG, and F:G ($P \geq 0.31$) for cattle fed 40% MDGS compared to 20% MDGS. When cattle were fed 20% MDGS diets with 15% corn silage in contrast to 45% corn silage, there was an improvement in ADG (0.51 lbs; $P = 0.01$), F:G (13% more efficient; $P < 0.01$), and an increase of 48 lb of final BW ($P = 0.02$). For cattle fed 40% MDGS diets, there was no difference in final BW, ADG, or F:G ($P \geq 0.33$) across corn silage inclusions; however, numerically the cattle fed 15% corn silage were 4% more efficient. The overall F-test including the control indicated cattle on 15:20 had greater ADG than cattle on 15:40, 45:20, and 45:40 ($P \leq 0.08$). Cattle fed the control diet were not different in regards to ADG compared with all other treatments ($P \geq 0.14$). Control, 15:20, and 15:40 cattle had the most favorable F:G ($P \leq 0.04$). Feed:gain ($P \geq 0.24$) were not different between cattle on control, 15:40, and 45:40 treatments. Feed:gain did not differ between cattle on 45:20 or 45:40 treatments ($P = 0.27$); however, cattle fed 45% corn silage with 20% MDGS had poorer F:G than control, 15:20, and 15:40 ($P \leq 0.04$). Feeding values relative to corn were calculated from G:F (the inverse of F:G). For the 30% replacement of corn by corn silage, the feeding value of corn silage was 58% in 20% MDGS diets and 70% in 40% MDGS diets.

There was an interaction for HCW ($P = 0.09$), which parallels previously mentioned carcass adjusted performance. There was no difference in live final BW across treatments ($P = 0.48$). These cattle were fed during a wet winter and consequently went to slaughter with a high degree of mud and tag on the cattle, but these should be equal across all treatments. Cattle fed 45% corn silage had a 0.97 percentage unit lower dressing percent than cattle fed 15% corn silage (59.32% vs. 60.29%; $P < 0.01$). Cattle fed the control diet had a dressing percentage that was not different from cattle fed 15% corn silage diets ($P \geq 0.97$). These differences in dressing percentage illustrate the need to make conclusions for ADG and F:G based on carcass-adjusted performance. When forage is increased in the diet, live final BW is inflated due to gut fill. There was no difference in 12th-rib fat thickness or calculated yield grade ($P \geq 0.15$). Replacement of corn with either corn silage or MDGS decreased marbling scores ($P \leq 0.05$). Cattle on the 15:20 treatment had higher marbling scores ($P = 0.07$) than all other treatments.

Data from this experiment suggest that feeding higher levels of corn silage (45% instead of 15%) results in poorer ADG and F:G when fed in combination with 20% MDGS; however, when the elevated level of corn silage is fed with 40% MDGS, there is not as much depression in ADG and F:G. Cattle on higher levels of corn silage (or any roughage) will have lower dressing percentages due to gut fill.

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Effects of Feeding Next Enhance® in Finishing Diets on Performance and Carcass Characteristics

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Summary

Increasing NEXT ENHANCE (NEXT) essential oils in finishing diets containing Rumensin® and Tylan® were evaluated on performance and carcass characteristics. Treatments consisted of 0, 75, 150, 225, or 300 mg per steer daily of NEXT. Increasing NEXT linearly decreased DMI and F:G, but ADG was not different among treatments. Feed conversion (F:G) was improved by 4.0% and 3.8% when feeding NEXT at 225 and 300, respectively, compared to steers fed 0 NEXT. Therefore, results suggest that feeding NEXT at rates of 225 and 300 improves feed conversions in feedlot finishing diets containing Rumensin and Tylan.

Introduction

Feed additives, such as Rumensin and Tylan, are commonly fed in feedlot diets today because of the favorable response observed in feed efficiency. As new feed additives become commercially available, it is critical to evaluate the response in animal performance to ensure positive attributes for the feedlot industry. NEXT ENHANCE (NEXT) is a natural plant extract composed of garlic oil and cinnamaldehyde that may alter rumen fermentation and improve feed efficiency; however, the optimum rate of NEXT in feedlot diets has not been well established. Therefore, the objective of this study was to evaluate the optimum rate of NEXT with Rumensin and Tylan on performance and carcass characteristics of finishing cattle.

Procedure

Three hundred and sixty calf-fed steers (BW = 664 ± 61 lb) were utilized in a randomized block design experiment at the University of Nebraska–Lincoln Panhandle Research and Extension Center feedlot. Prior to the start of the experiment, calves were vaccinated with Express 5®, and given an electronic and visual identification tag. Calves were limit-fed a 32% alfalfa, 32% wet distillers grains plus solubles (WDGS), 32% dry-rolled corn (DRC) diet (DM basis) at 2% BW for seven days to minimize gut fill variation. Steers were weighed two consecutive days (day 0 and 1) to establish initial BW. Calves were blocked by day 0 BW, stratified by BW within blocks (light, medium, heavy), and assigned randomly to 45 pens. Pens were assigned randomly to one of five treatments with nine replications (i.e., pen) per treatment and eight steers per pen. Light, medium, and heavy blocks consisted of 2, 4, and 3 replications, respectively. On day 80, all steers were re-vaccinated with Bovi-Shield® Gold 5 and poured with Ivomec®.

A common basal diet was used for all five treatments (Table 1) consisting of 65% DRC, 25% WDGS, 5% wheat straw, and 5% supplement (DM basis). Only one basal supplement was used and feed additives were included via micro-machine. Treatments consisted of NEXT feeding rates of 0, 75, 150, 225, and 300 mg per steer daily. The liquid supplement contained vitamins and minerals to meet or exceed animal requirements. Rumensin and Tylan were provided via micromachine at 360 and 90 mg per steer daily, respectively.

Steers were implanted on day 0 with Revalor®-XS. After 141, 169, or 174 days on feed, depending on BW block, cattle were weighed and transported to a commercial abattoir (Cargill Meat Solutions, Fort Morgan, Colo.). Hot carcass weight and liver scores were recorded on day of harvest. After a 48-hour chill, LM area, marbling score, and 12th rib fat thickness were recorded. Yield grade was calculated from the following formula: 2.5 + (2.5 x 12th rib fat) – (0.32 x LM area) + (0.2 x 2.5 [KPH]) + (0.0038 x HCW). With the use of a common dressing percentage (63%), final BW, ADG, and F:G were calculated.

Performance and carcass characteristics were analyzed using the MIXED procedure of SAS (SAS Institute, Inc., Cary, N.C.) with dead or chronic animals removed from analysis. Animals removed from the experiment were removed due to common maladies and not treatment related. Pen was the experimental unit and block was treated as a fixed effect. Orthogonal contrasts were constructed to determine the response curve (linear, quadratic, and cubic) for NEXT in the diet. Occurrences of liver abscesses were analyzed using the GLIMMIX procedure of SAS.

Table 1. Composition of dietary treatments.

Ingredient	% of diet DM
DRC[1]	65
WDGS[1]	25
Wheat Straw	5
Supplement	5
Nutrient Composition, %	
CP	13.6
Ca	0.41
P	0.39
K	0.78
Ether Extract	4.97
NDF	20.3
Starch	46.4

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

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

	NEXT ENHANCE, mg per steer daily						*P*-value	
Item	0	75	150	225	300	SEM	Lin.[1]	Quad.[2]
Performance								
Initial BW, lb	655	656	655	655	656	1	1.00	0.55
Final BW, lb[3]	1263	1270	1267	1261	1271	8	0.75	0.94
DMI, lb/day	23.8	23.4	23.3	22.8	23.1	0.3	0.04	0.38
ADG, lb[3]	3.78	3.82	3.81	3.77	3.82	0.05	0.77	0.90
Feed:Gain[3,4]	6.29	6.13	6.11	6.04	6.05	—	0.02	0.34
Carcass Characteristics								
HCW, lb	796	800	799	795	801	5	0.76	0.96
Dressing,%	63.0	63.3	62.9	63.1	62.7	0.002	0.31	0.32
Marbling[5]	455	461	457	443	480	10	0.34	0.19
LM area, in^2	12.07	12.05	12.09	12.35	12.07	0.12	0.42	0.50
Calculated YG	3.57	3.69	3.60	3.44	3.55	0.06	0.11	0.75
12th rib fat, in	0.57	0.59	0.57	0.55	0.55	0.01	0.02	0.32
Liver abscess, %	5.5	5.9	11.3	11.3	11.4	—	0.11	0.62

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

Results

As rate of NEXT in the diet increased, DMI decreased linearly ($P = 0.04$; Table 2). Steers fed NEXT at 225 and 300 resulted in a 4.2% and 2.9% reduction in DMI compared to cattle fed 0 NEXT. Feeding increasing rates of NEXT had no effect on ADG ($P = 0.77$; linear) or final BW ($P = 0.75$; linear). Feed conversion (F:G) decreased linearly ($P < 0.02$) as rate of NEXT in the diet increased. Compared to the 0 treatment, feeding NEXT at 225 and 300 mg resulted in 4.0% and 3.8% improvement in F:G, respectively. Hot carcass weight, dressing percent, marbling score, and LM area were not different ($P > 0.18$; linear or quadratic) among treatments. However, calculated yield grade tended to decrease linearly ($P = 0.11$) as rate of NEXT increased. As rate of NEXT increased, 12th rib fat thickness decreased linearly ($P = 0.02$), but numerically steers in all treatments were finished to a similar endpoint. The occurrence of liver abscesses tended to increase linearly ($P = 0.11$) with increasing rates of NEXT, yet poorer feed conversions were not observed due to the higher prevalence of liver abscesses.

These data suggest that increasing rates of NEXT doesn't affect gain; however, DMI decreased, resulting in a favorable improvement in feed conversion. Including NEXT at 225 and 300 suggest an improvement in animal performance (i.e., feed conversion) in feedlot finishing diets containing Rumensin and Tylan.

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Optimal Marketing Date of Steers Depends on Marketing Strategy

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Summary

Seven research trials conducted over five years at the University of Nebraska–Lincoln were summarized to determine how animal performance changes through the finishing period on a live and carcass weight basis. Live weight, carcass weight, carcass ADG, and carcass feed efficiency all changed quadratically throughout the feeding period; live ADG and live feed efficiency declined linearly. During times of negative profit margins, optimal profitability for steers marketed on a live-basis occurred by selling early, whereas optimal profitability was achieved by feeding steers marketed on a carcass-basis longer.

Introduction

Optimal marketing date is defined as marketing when the cost of additional gain equals the price received for the additional gain. Continuing to feed cattle when the cost of gain surpasses the price received for the gain is not profitable. It is well recognized that feed efficiency is an important contributor to cost of gain and is especially important during times of high feed costs. Intuition is that feed efficiency declines throughout the feeding period, so steers should be marketed early when costs of gain are high. However, cattle may be marketed either on a live-weight basis or carcass-weight basis, so it is important to understand how cost of gains change both in the live animal and the carcass. A previous report (*2007 Nebraska Beef Cattle Report*, pp.55-57) evaluated the changes in animal performance throughout the feeding period. The purpose of this report is to expand on the previous data set and to apply an economic evaluation to demonstrate if optimal marketing date differs when selling on a live-basis vs. selling on a carcass-basis.

Procedure

Five years of data were compiled to evaluate the change in animal performance and carcass performance throughout the feeding period. The data set included 298 pens (2,380 head) of steers from seven research experiments conducted at the University of Nebraska–Lincoln. This analysis expands upon a data set previously described (*2007 Nebraska Beef Cattle Report*, pp.55-57). Experiments were selected where steers were on similar diets, or where dietary treatment had no effect on animal performance. Additionally, the data set was limited to experiments where individual animal weights were collected at approximately 30-day intervals. The experiments selected provided four or five interim weights for each steer. Initial BW was collected on two or three consecutive days following a period of limit-feeding. However, interim weights were single day full weights which were pencil-shrunk 4%. Interim carcass weights were calculated using a changing dressing percentage throughout the feeding period as previously described (*2007 Nebraska Beef Cattle Report*, pp.55-57). Average initial BW was 769 lb (SD = 47 lb) and steers were on feed from 117 to 159 days from May to October. The target marketing endpoint for all cattle was 0.50 inch backfat and the average backfat was 0.51 inch.

Changes in weight, weight gain, dry matter intake, feed efficiency, and transfer of live weight gain to carcass weight gain were calculated for each interim period and expressed on a shrunk BW and carcass weight basis. Linear and quadratic regression coefficients were calculated for each pen of cattle using the mixed

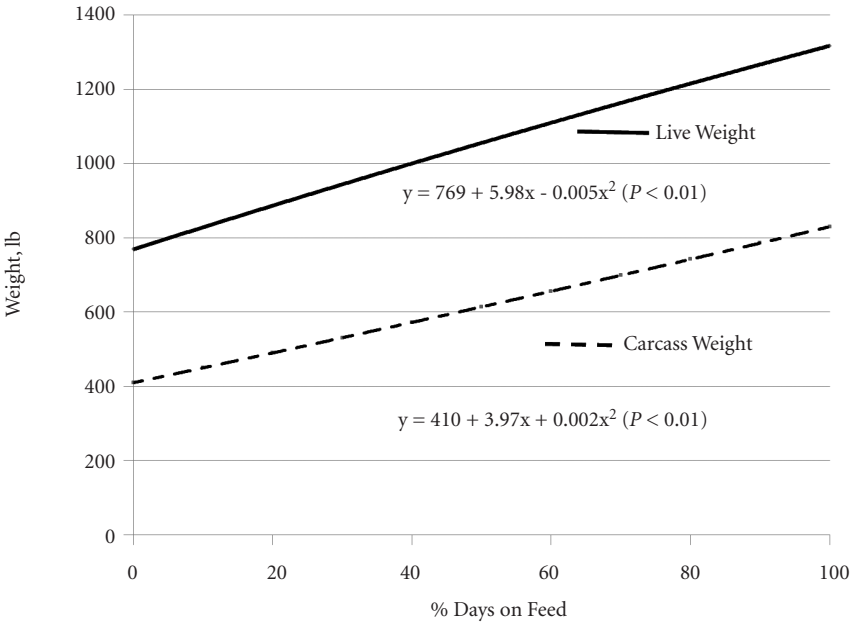

Figure 1. Change in BW and carcass weight throughout the feeding period.

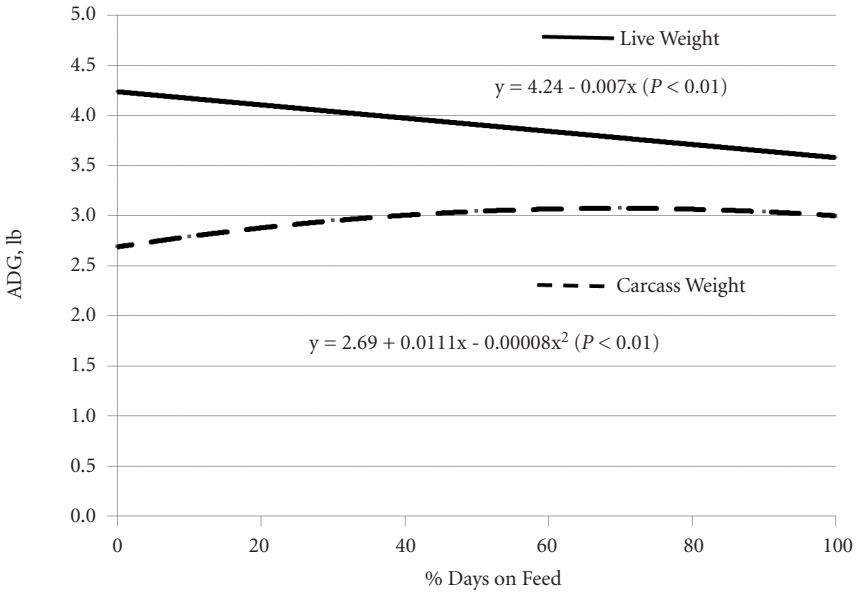

Figure 2. Change in ADG on a live weight and carcass weight-basis throughout the feeding period.

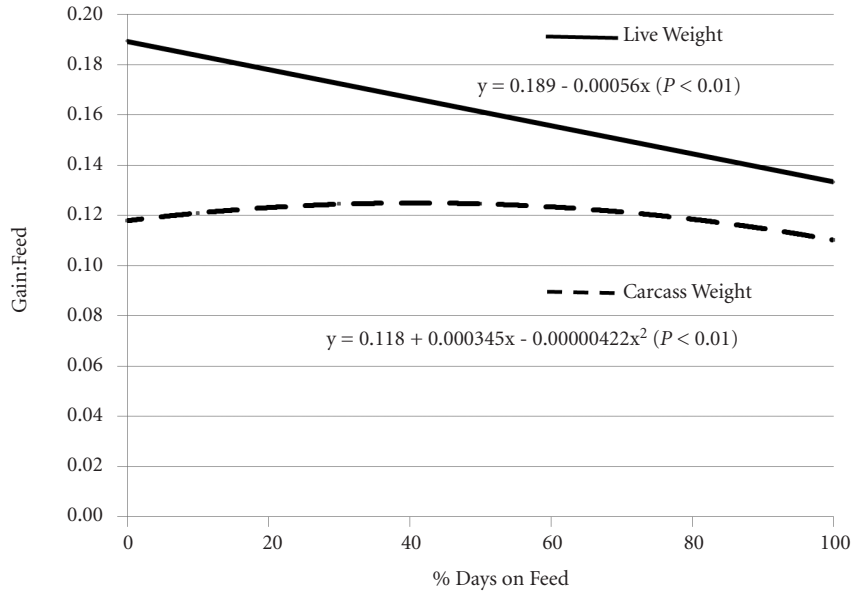

Figure 3. Change in feed efficiency on a live weight and carcass weight-basis throughout the feeding period.

procedures of SAS (SAS Institute, Inc., Cary, N.C.). The significance of the linear and quadratic coefficients were tested for each response variable using the mixed procedures of SAS. Experiment was considered a fixed effect.

Changes in cost of gain were estimated for three different diet cost scenarios. Cost of gain was calculated by dividing feed efficiency by sum of the diet cost plus yardage and interest. Change in feed efficiency was estimated by the regression equations from the analysis of seven experiments. Diet costs were assumed to be equivalent to $4.00, $6.00, and $8.00 per bushel corn. Yardage and interest charges were assumed to be $0.45 per head per day calculated on a live and carcass-basis.

A profitability analysis was generated for three corn price scenarios to illustrate how ideal marketing time may differ depending on marketing strategy and corn price. The three corn prices were $4.00, $6.00, and $8.00 per bushel equivalent to DM diet costs of $165.15, $247.73, and $330.31/ton DM, respectively. Assumptions for the profitability analysis were: feeder price = $1.50/lb; yardage + interest = $0.45/head/day; miscellaneous charges = $12/head. Live cattle price was assumed to be $1.25/lb and carcass price was $1.98 which assumes a 63% dressing percentage. Profit/loss was calculated on a live and carcass-basis from the difference between total costs per steer and the revenue received per steer. Marketing date was altered to be 75% of normal (105 days on feed) to illustrate the effects of selling early, 100% of normal (140 days on feed), and 125% of normal (175 days on feed) to illustrate the effects of feeding longer. Estimates of feeding 125% of normal are an extrapolation of the seven-trial analysis from which performance was estimated.

Results

Live weight and carcass weight both increased in a quadratic manner ($P < 0.01$; Figure 1). The quadratic term for live weight was slightly negative whereas the quadratic term for carcass weight was slightly positive. This suggests that live weight increases at a decreasing rate whereas carcass weight increases at an increasing rate. Live weight ADG decreased linearly throughout the feeding period ($P < 0.01$; Figure 2) while carcass ADG changed quadratically ($P < 0.01$). Carcass ADG increased early in the feeding period before slightly declining late in the feeding period. It was previously reported that both live weight and carcass weight increased linearly and carcass ADG remained constant throughout the feeding period (*2007 Nebraska Beef Cattle Report*, pp. 55-57). The additional observations in the current data set provided a more

(Continued on next page)

robust analysis which allowed for the detection of quadratic changes in these variables. Live weight ADG linearly declined in both analyses. Similarly, live weight feed efficiency declined linearly ($P < 0.01$; Figure 3) and carcass weight feed efficiency changed in a quadratic manner ($P < 0.01$). Dry matter intake increased quadratically ($P < 0.01$; Figure 4) with a positive quadratic term. This suggests DMI increased at an increasing rate. The increase in DMI at the end of the feeding period could be related to the fact that the data set consisted entirely of summer-fed yearlings finished in the fall so that temperatures were cooling at the end of the feeding period. Temperature changes may have allowed DMI to increase at the end of the feeding period which may be a function of environment and not biology.

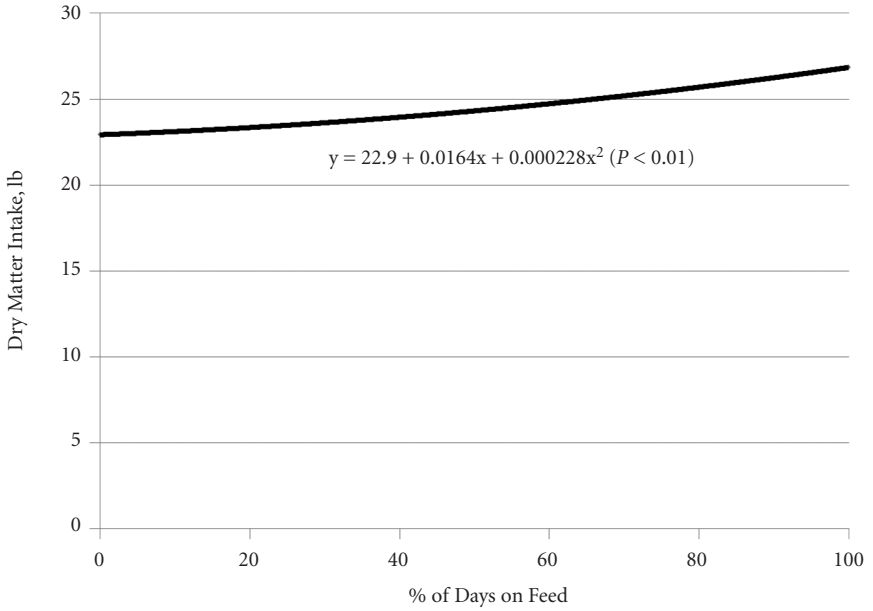

Figure 4. Dry matter intake throughout the feeding period.

Transfer of live weight gain to the carcass increased linearly ($P < 0.01$; Figure 5) and was approximately 90% at the end of the feeding period. This suggests that 90% of every additional pound of gain is added to the carcass at the end of the feeding period. The high percentage of weight transfer is economically meaningful since the price difference between live and carcass weight is based on dressing percentage (typically 63%). To put this in perspective, 1 lb of additional live weight gain would equate to 0.90 lb of additional carcass weight gain. If market steers were valued at $125/cwt on a live basis and $198/cwt on a carcass basis (63% dress), the additional revenue generated by adding a pound of live gain would be $1.25 if selling live and $1.78 (0.9 lb at $198/cwt) if selling in the beef. Therefore, each additional pound would generate $0.53 more revenue by marketing on a carcass-basis.

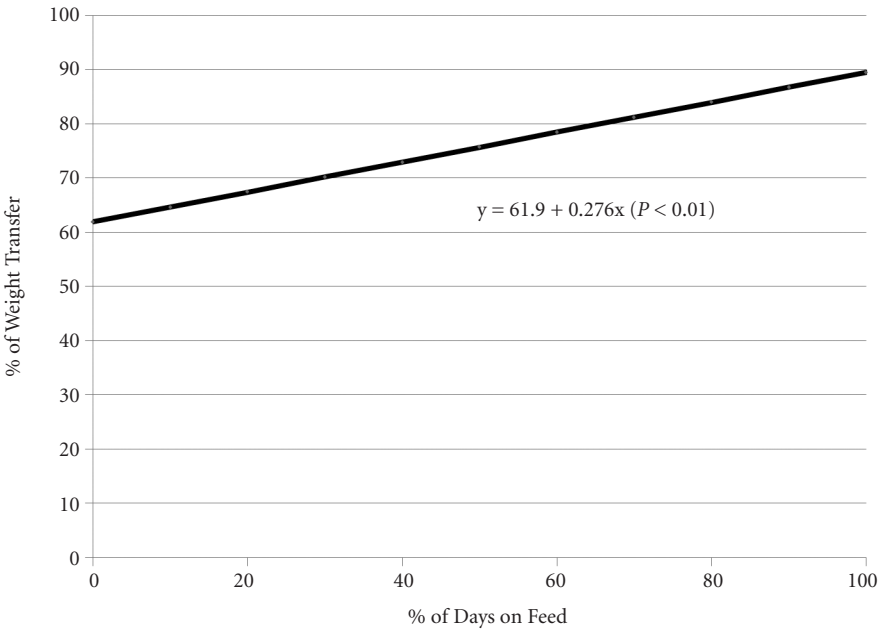

Figure 5. Percentage of live weight gain transferred to carcass weight gain throughout the feeding period.

Figures 6 and 7 show the change in cost of gain at $4.00, $6.00, and $8.00/bu corn on a live and carcass-basis, respectively. It is not surprising that the cost of gain increases with increasing corn price, nor is it surprising that cost of gain increases throughout the feeding period. However, it is interesting to note that both the linear and quadratic terms are positive for cost of gain on a live weight-basis ($P < 0.01$; Figure 6) whereas the linear term is negative and the quadratic term is slightly positive for cost of gain on a carcass weight-basis ($P < 0.01$; Figure 7). This illustrates that while cost of gain is increasing both on a live and carcass-basis, the incremental increase is greater on a live-basis.

The projected close-out performance for steers marketed at 75%, 100%, or 125% of the normal market-

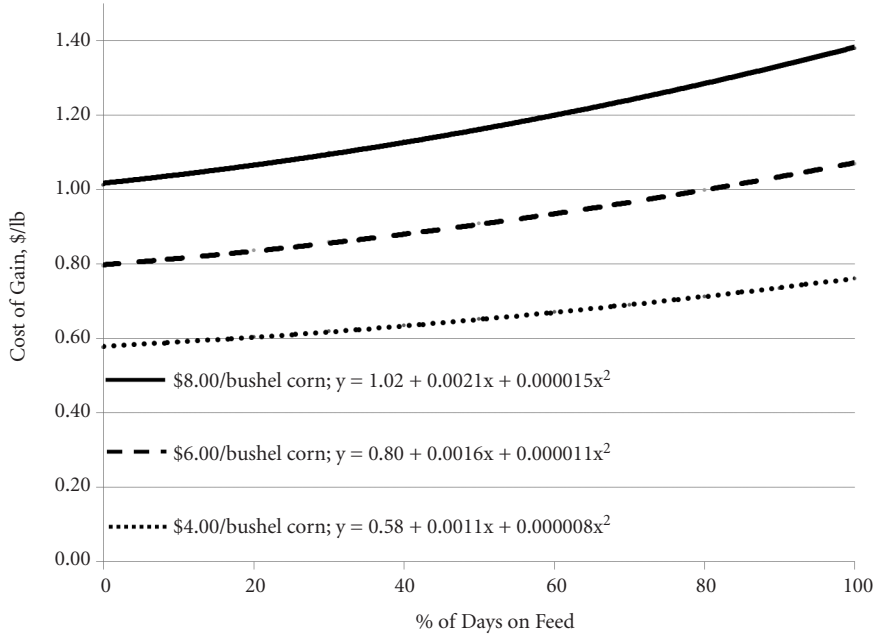

Figure 6. Change live weight cost of gain at three different corn prices throughout the feeding period.

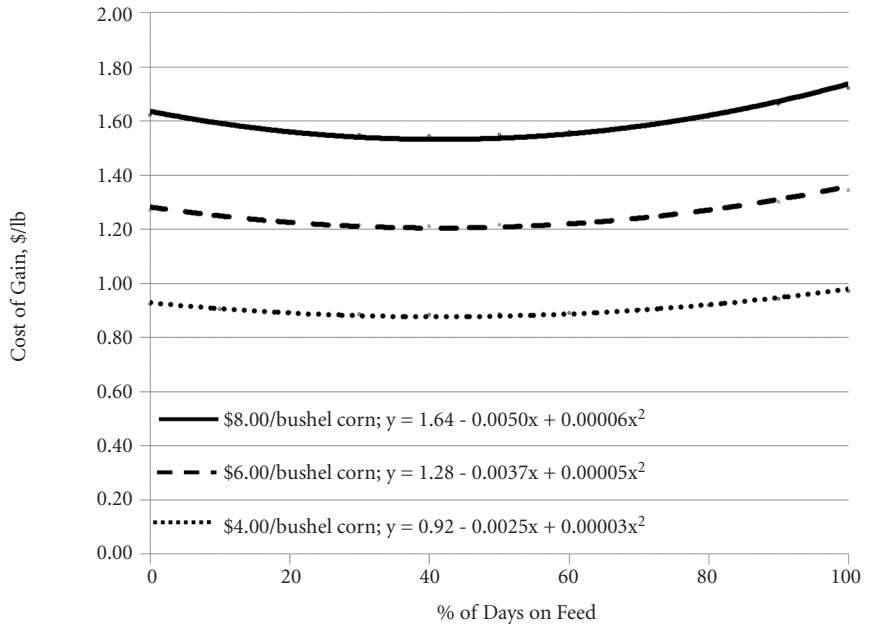

Figure 7. Change in carcass weight cost of gain at three different corn prices throughout the feeding period.

ing date (days to achieve 0.50 inch back fat) using the analysis from the seven experiments is provided in Table 1. The profit/loss analysis is provided in Tables 2, 3, and 4 for diet prices equivalent to $4.00, $6.00, and $8.00/bu corn, respectively. When the diet cost was equivalent to $4.00/bu corn, all marketing scenarios resulted in positive profitability and profit was improved by feeding longer regardless of marketing strategy. Similarly, at a diet cost equivalent to $6.00 corn, profit improved by feeding longer, regardless of marketing strategy. However, when the diet cost was greatest (equivalent to $8.00/bu corn), the optimal marketing date for steers sold on a live-basis was achieved by selling at the earliest time, 75% of normal, to minimize losses. However, the optimal marketing date for steers sold on a carcass-basis was achieved by feeding to 125% of normal. Additionally, the best case scenario for a live marketing strategy was $141.48/head loss whereas the best scenario for a carcass marketing strategy was $107.20/head loss. Profitability of steers marketed on a carcass-basis appear to benefit from additional days on feed during times of expensive feed and negative profitability compared to steers marketed on a live-basis. Across all market scenarios, cost of gain increased on a live-basis and decreased on a carcass-basis.

A central principal in feeding steers longer is the distribution of costs over more weight. The reason cost of gains decreased in the carcass marketing scenarios is related to the relative gain in live weight and carcass weight with increasing days on feed. The carcass weight gain (final carcass weight minus initial carcass weight) was 64, 69, and 73% of the live weight gain (final live weight minus initial live weight) for 75, 100, and 125% of days on feed, respectively. The cost of gain decreases on a carcass basis because the weight gain that the costs are distributed over is increasing in the carcass relative to the live steer weight. The same principal can be applied to initial purchase price of the steer. The purchase price was $150/cwt and the live market price was $125/cwt. Therefore, $25/cwt of the purchase weight must be made up by a cost of gain lower than $125/cwt. For a 769 lb steer, the negative margin that must be overcome is $192.25/steer (769 lb x $25/cwt). At 0.50 inch of rib fat, the live gain is 548 lb and the negative margin would equate to $35/cwt of gain. If the same steers were fed 25% longer, the live gain is 669 lb and the negative margin from purchase price

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is $29/cwt because it is spread over more weight.

Feeding longer than 0.50 to 0.55 inch of rib fat is an extrapolation of the data set. Feed efficiency may decline more rapidly beyond 0.50 inch rib fat than the equations in this data set predict. Therefore, we cannot ensure that feeding 25% longer will improve profit when selling on a carcass-basis. Feeding beyond 0.50 inch rib fat is clearly more profitable, but the optimum additional time on feed cannot be established with this data set.

Feeding steers longer than 0.50 inch rib fat increases yield grades, quality grades, and carcass weight. Few discounts are currently given for overweight carcasses. Premiums for improved quality grade may compensate for discounts given for greater yield grades. Finally, more carcass weight results in more beef on the market and potentially lower prices in the short-term. However, if we expect consumers to purchase more beef, we need to produce it; they consume what is produced.

Optimal marketing date is dependent on the marketing strategy used. During times of high feed costs and negative profits, it may be beneficial to market steers early if selling on a live-basis. However, for producers who market on a carcass-basis, feeding steers longer than the industry average 0.50 inch rib fat may improve profit.

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Table 1. Predicted average performance of steers marketed at 75, 100, or 125% of expected days on feed.

	Marketing Date, % of normal to achieve 0.50 inch back fat		
Item	75%	100%	125%
Days on Feed	105	140	175
Initial BW, lb	769	769	769
Final BW, lb	1189	1317	1438
Initial Carcass Weight, lb	450	450	450
Final Carcass Weight, lb	720	830	939
DMI, lb	23.97	24.51	25.14
Live ADG, lb	3.99	3.91	3.83
Live F:G, lb/lb	5.94	6.20	6.48
Carcass ADG, lb	2.95	2.98	2.96
Carcass F:G, lb/lb	8.14	8.26	8.52

Table 2. Predicted profit/loss and cost of gain of steers fed corn priced at $4.00/bu and marketed at 75, 100, or 125% of expected days on feed.

	Marketing Date, % of normal to achieve 0.50 inch back fat		
Item	75%	100%	125%
Days on Feed	105	140	175
Costs			
Steer cost, $	1153.52	1153.52	1153.52
Diet cost, $	207.84	283.35	363.35
Yardage, $	47.25	63.00	78.75
Miscellaneous, $	12.00	12.00	12.00
Total Costs, $	1420.61	1511.87	1607.62
Live Marketing			
Revenue, $	1486.58	1646.00	1797.58
Cost of Gain, $/lb	0.64	0.65	0.68
Profit, $	65.97	134.13	189.96
Carcass Marketing			
Revenue, $	1429.09	1646.03	1868.75
Cost of Gain $/lb	0.99	0.94	0.93
Profit, $	8.48	134.16	255.48

Table 3. Predicted profit/loss and cost of gain of steers fed corn priced at $6.00/bu and marketed at 75, 100, or 125% of expected days on feed.

	Marketing Date, % of normal to achieve 0.50 inch backfat		
Item	75%	100%	125%
Days on Feed	105	140	175
Costs			
Steer cost, $	1153.52	1153.52	1153.52
Diet cost, $	311.76	425.03	545.03
Yardage, $	47.25	63.00	78.75
Miscellaneous, $	12.00	12.00	12.00
Total Costs, $	1524.53	1653.54	1789.29
Live Marketing			
Revenue, $	1486.58	1646.00	1797.58
Cost of Gain, $/lb	0.88	0.91	0.95
Profit, $	(-37.95)	(-7.54)	8.28
Carcass Marketing			
Revenue, $	1429.09	1646.03	1868.75
Cost of Gain $/lb	1.37	1.32	1.30
Profit, $	(-95.44)	(-7.51)	73.81

Table 4. Predicted profit/loss and cost of gain of steers fed corn priced at $8.00/bu and marketed at 75, 100, or 125% of expected days on feed.

	Marketing Date, % of normal to achieve 0.50 inch back fat		
Item	75%	100%	125%
Days on Feed	105	140	175
Costs			
Steer cost, $	1153.52	1153.52	1153.52
Diet cost, $	415.69	566.71	726.70
Yardage, $	47.25	63.00	78.75
Miscellaneous, $	12.00	12.00	12.00
Total Costs, $	1628.45	1794.22	1970.97
Live Marketing			
Revenue, $	1486.58	1646.00	1797.58
Cost of Gain, $/lb	1.13	1.17	1.22
Profit, $	(-141.87)	(-149.22)	(-173.39)
Carcass Marketing			
Revenue, $	1429.09	1646.03	1868.75
Cost of Gain $/lb	1.76	1.69	1.66
Profit, $	(-199.36)	(-149.19)	(-107.87)

Effect of Micro-Aid® Supplementation on Nitrogen Losses from Manure

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Terry J. Klopfenstein
Mike J. Rincker[1]

Summary

A 2x2 factorial designed experiment was used to study the effects of Micro-Aid and time on OM and N losses from manure, in a simulated feedlot pen setting. Manure was collected from cattle on a common diet, except for the addition of 1 g Micro-Aid /steer daily. Losses of OM were greater at 60 d than 30 d, and greater for control than Micro-Aid. Nitrogen losses at d 30 were similar between treatments but control pans had greater N losses at d 60. Feeding Micro-Aid to cattle may inhibit N volatilization from manure, enhancing the fertilizer value of manure.

Introduction

Measuring N and OM losses from manure in a feedlot pen setting is very challenging. Several factors, such as environmental conditions, cattle movement, and precision in removing manure all affect losses and are difficult to control. Feedlot pen surfaces can be simulated in a laboratory setting under controlled conditions in order to better understand differences due to treatment without confounding effects of environment. An aluminum pan can serve as a simulated pen with the hard pan surface representing the hard interface on a feedlot pen, on top of which is 3-6 inches of a loose soil and manure mixture. Mixing manure and soil together simulates the hoof action of cattle on the pen surface. Treatments, such as time, precipitation, or temperature can then be imposed on these pans to study each factor individually.

The objective of this trial was to determine the impact of Micro-Aid supplementation and time on OM and N losses from manure. Micro-Aid is an all-natural plant extract that has been used as a feed ingredient to reduce manure odors and volatilization of ammonia, which contributes to decreased N losses from manure. Previous research evaluated the effect of Micro-Aid on N losses in a feedlot setting (*2012 Nebraska Beef Cattle Report*, p. 98; *2013 Nebraska Beef Cattle Report*, p. 70). Results were conflicting but overall found minimal benefit due to Micro-Aid. In recent years, commercial fertilizer prices have increased dramatically which has renewed interest in manure as a fertilizer and enhanced the value of manure nutrients, especially N.

Procedure

A 2x2 factorial designed experiment was used to study the effects of Micro-Aid and time on OM and N losses from manure, in a simulated feedlot pen setting. The first factor compared losses after 30 vs. 60 days, and the second factor compared manure with or without Micro-Aid. Sixty aluminum pans (13x9x2 inches) were used to simulate feedlot pen surface, which included the four treatments, resulting in 15 replications. Complete manure (urine and feces) was collected from six ruminally fistulated steers for five days. All cattle were fed a common diet, (Table 1) with three of the steers ruminally dosed with 1 g Micro-Aid/steer daily for 10 days prior to the start of manure collection and throughout manure collection. For manure collection, cattle were tied in stanchions for five days with manure collected in a cement pit behind the cattle. Manure was collected from three Micro-Aid (MA) treated steers and from three control (CON) steers. Soil was collected from the University Research Feedlot near Mead, Neb., in an area used for rebuilding pens after cleaning. Representative samples of manure and soil were taken and analyzed for OM and N in order to calculate OM and N losses over time.

Table 1. Composition of diet fed to cattle during manure collection.

Ingredients, % of diet DM	
High-moisture corn	41.5
Modified distillers grains plus solubles	22.5
Sweet Bran®	25.0
Wheat straw	6.0
Supplement[1]	5.0

[1]Cattle on the Micro-Aid treatment were ruminally dosed with 1 g Micro-Aid per steer daily for 10 days prior to the start of manure collection and throughout manure collection.

On day 1, soil and manure were weighed into each pan in order to equal 60% soil and 40% manure, on a DM basis. Manure and soil were completely mixed together to simulate the hoof action of cattle; the mixture was approximately 1½ inches deep within the pan. Pans were kept in a temperature controlled room (65°F) for either 30 or 60 days to determine N and OM losses over time. At the end of either 30 or 60 days, material from the pans was ground through a 1 mm screen and subsampled. These samples were then analyzed for DM, OM, and N. Data were analyzed as a 2x2 factorial and differences were considered significant at $P < 0.05$.

Results

Samples of initial manure and soil were analyzed for OM and N. Soil was essentially devoid of N, less than 0.001%, thus all N in the pans is assumed to be coming from the manure, which was 2.7% N, regardless of treatment. Soil OM was 2% and both MA and CON manure averaged 84% OM.

Initial OM averaged 142.0 g across all pans and was not different between treatments ($P \geq 0.19$; Table 2). Initial

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Table 2. Effect of Micro-Aid supplementation to cattle on OM and N losses from manure over time.

	30 Day		60 Day			*P*-value[1]		
Variable	Control	Micro-Aid	Control	Micro-Aid	SEM	Int	Time	Trt
Initial OM, g	142.5	141.5	142.4	141.6	0.67	0.87	0.92	0.19
Ending OM, g	98.6[b]	115.7[a]	76.8[c]	104.4[b]	2.28	0.03	< 0.01	< 0.01
OM loss, g	43.9[b]	25.8[d]	65.5[a]	37.2[c]	2.30	0.03	< 0.01	< 0.01
OM loss, %	30.9[b]	18.2[d]	46.0[a]	26.3[c]	1.60	0.03	< 0.01	< 0.01
Initial N, g	4.37[a]	4.31[b]	4.37[a,b]	4.31[a,b]	0.022	0.83	0.90	0.01
Ending N, g	3.31[a]	2.91[a]	2.26[b]	2.86[a]	0.203	0.02	< 0.01	0.62
N loss, g	1.06[b]	1.40[b]	2.10[a]	1.45[b]	0.198	0.02	< 0.01	0.43
N loss, %	24.5[b]	32.4[b]	48.1[a]	33.7[b]	4.62	0.02	< 0.01	0.49

[a,b,c] Within a row, means without a common superscript differ ($P < 0.05$).
[1] Int = *P*-value for the time x trt interaction; Time = main effect of 30 or 60 days; Trt = main effect of Micro-Aid inclusion in cattle diet.

N was approximately 3.1% of initial OM. Initial N for the 30 days MA pans was 4.31 g, slightly less than initial N for 30 days CON pans, 4.37 g ($P = 0.05$). This was due to less manure DM being weighed into these pans, not due to MA manure having less N as a % of DM.

Losses of OM and N are presented as both g lost and as a % of the initial OM or N present in the pan. Losses of OM, measured as both g lost and as % lost, were greater at 60 days than 30 days ($P < 0.01$) and greater for CON than MA ($P < 0.01$). Of total OM losses at day 60, approximately 68% occurred by day 30 for both treatments. At both time points, MA pans lost approximately 42% less OM than CON pans. Nitrogen losses were greater at day 60 than day 30 ($P < 0.01$) for CON pans but MA pans had similar N losses at day 30 and day 60 ($P = 0.84$). Both MA and CON pans had similar N losses at day 30 ($P = 0.23$), but CON pans had greater N losses at day 60 ($P = 0.03$). Of total N losses at day 60, MA pans lost approximately 97% by day 30 while CON pans lost only 50% by day 30. At day 60, MA pans had lost approximately 30% less N than CON pans.

Measuring N losses from manure can be quite challenging, especially in a feedlot setting with many environmental factors influencing N volatilization. Past research on the effects of Micro-Aid on N volatilization in a feedlot pen setting has had mixed results. By controlling these environmental factors we were able to decrease variation and better estimate the impact Micro-Aid has on reducing average N losses. In this pan study, variation in N measures, measured as CV, were greater than variation in measurements of OM.

[1]Andrea K. Watson, research technician; Galen E. Erickson, professor; Terry J. Klopfenstein, professor, University of Nebraska–Lincoln Department of Animal Science, Lincoln, Neb.; Mike J. Rincker, DPI Global, Porterville, Calif.

Effects of Dietary Change on Viral-Bacterial Interactions in the Rumen of Cattle

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Samodha C. Fernando[1]

Summary

This ongoing study investigates the impact of diet and bacteriophage activity on the structuring of rumen microbial community composition and diversity. Fistulated cattle were acclimated to a given diet for 21 days before samples were collected and subsequently enriched for viral particles with tangential flow filtration. Taxonomic identification, abundance, and functional attributes were assigned to both bacterial and viral communities. Principle coordinate analysis of the bacterial communities revealed significant clustering based on diet. While diet drives the structuring of rumen bacterial communities, bacteriophages may maintain high, constant bacterial diversity.

Introduction

Cattle, like other animals (including humans), are a complex supra-organism composed of not only their own gene collection, but also those of their associated microbes living on and within the host. The majority of these microbes are found in the gastrointestinal tract, playing an important role in shaping the immune system, gut function and development, nutrition acquisition, and host metabolism. This is especially true in ruminants such as bovine where microbial fermentation in the rumen aids in feed degradation, digestion, and later absorbance. Disruption of the "normal" microbiota may have dramatic consequences for health of the animal. Factors believed to influence rumen bacterial composition include other microbial life such as viruses, stress, colonization history, diet, and host genotype interactions.

Bacteriophages are a subset of viruses that infect and potentially lyse microbial cells, exerting significant influence on bacterial community structure. It is proposed bacteriophages help to maintain bacterial diversity by keeping bacterial species in check, allowing for diverse biological activity in the rumen. Through culture independent methods, this study aims to investigate the impact of dietary change on viral and bacterial composition and diversity while beginning to elicit the impact of bacteriophage-bacteria interactions on rumen function and animal performance traits such as feed efficiency.

Procedure

Five ruminally fistulated bovine cattle rotated through a series of four diets: 55% corn silage, 27% corn distillers solubles (27% CDS), 40% modified distillers grains plus solubles (40%MDGS), and a corn-based diet (Table 1). After 21 days of acclimation to a given diet, a total rumen evacuation was performed and contents were mixed, providing a homogenous sample. Bacterial DNA was extracted using MagMAX™ Pathogen RNA/DNA Kit (Life Technologies, Corp., Carlsbad, Calif.). Bacterial metagenomes (total rumen bacterial DNA) and V1-V3 variable regions of amplified 16s rRNA genes were sequenced with 454-pyrosequencing technology. Information regarding bacterial community composition and abundance are gleaned from 16s rRNA sequences through bioinformatic software packages mothur and QIIME. Dietary and host effects on community structure were analyzed using multivariate analysis (Wilk's Lambda) within JMP statistical software. Bacterial metagenome sequences were compared to curated databases to assign functional attributes to the microbial community.

Viruses were enriched from rumen contents via tangential flow-filtration on a 0.2 micron filter and subsequently concentrated on a 100-kilodalton filter. Concentrated viral particles were pelleted with ultracentrifugation at 100,000 X g and DNA was extracted (MagMAX Pathogen RNA/DNA Kit, Life Technologies) then amplified using multiple displacement amplification with phi29 DNA polymerase (New England BioLabs). Viral metagenomes were prepped and sequenced with 454-pyrosequencing. Sequences were searched against databases to assign taxonomic and functional characteristics to the viral community.

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Table 1. Dietary composition (%) on DM basis.

Ingredient, % DM	Control	27% CDS	40% MDGS	55% Corn Silage
High-Moisture Corn	51.25	36.3	28.5	—
Dry-Rolled Corn	36.25	24.2	19	—
CDS[1]	—	27	—	—
MDGS[1]	—	—	40	40
Corn Silage	—	—	—	55
Brome Hay	7.5	7.5	7.5	—
Supplement[2]	5	5	5	5

[1]CDS = Condensed distillers solubles; MDGS = Modified distillers grains plus solubles.
[2]Provided to contain 336 mg/head/day Rumensin® and 90 mg/head/day Tylan®.

Results

Numerous factors influence the structuring of the rumen bacterial community, but diet is the main driving factor. A change in dietary substrate allows different microbes to flourish, causing a shift in the bacterial community composition and diversity (Figure 1). Steers on the 55% corn silage diet consistently had the highest bacterial community diversity, while those on the corn-based diet the lowest. Principle coordinate analysis taking into account taxonomic differences and phylogenetic relationships demonstrates that bacterial communities of steers on the same diet cluster together (Figure 2), indicating these communities are more similar to each other than to samples from other diets. Multivariant analysis confirmed the principle coordinate analysis; there is a significant difference between bacterial communities based on diet (Wilk's Lambda, $P < 0.05$), but not by individual animal (Wilk's Lambda $P > 0.05$).

Viruses in the rumen outside of a bacterial host were enriched by tangential flow filtration. Enriched viral communities were nearly completely free of bacterial and eukaryotic contamination. Bacterial and viral metagenomic analysis is ongoing. This data will give us an indication of potential bacterial metabolic functions and contains signals of bacteriophages that have embedded themselves into the bacterial genome of a host (prophages). Preliminary work suggests prophages are highly abundant, but their influence on community structure is incomplete at this point. Continued work in this area will aid in understanding the role of bacteriophages on bacterial communities and identify bacteriophages that can be used to control microbes in hopes of improving the health, performance, and feed efficiency of cattle.

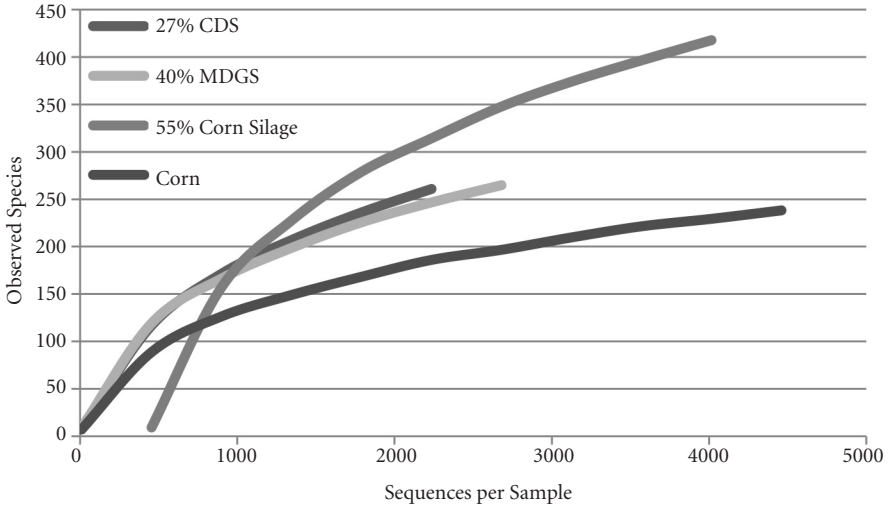

Figure 1. Average species richness of bacterial communities from four experimental diets.

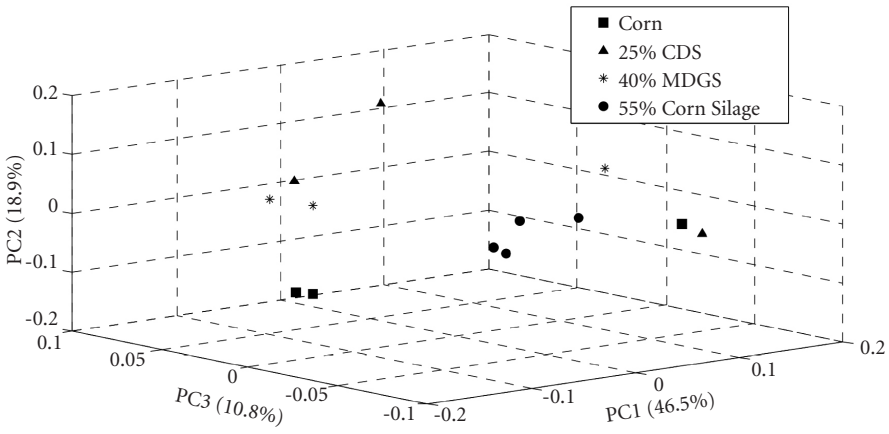

Figure 2. Principle Coordinate Analysis of the bacterial communities from each diet.

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Differences in Fecal Bacterial Community Composition Between Beef Steers which are High-Shedders and Low-Shedders of Shiga Toxin-Producing *Escherichia coli* (STEC)

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Summary

The community composition of the fecal microbiota was compared between beef steers which were high-shedders and low-shedders of Shiga toxin-producing Escherichia coli. Based on Shannon and Chao 1 diversity indices, the high-shedders had a more diverse fecal bacterial community than the low-shedding steers. Members of the genus Prevotella were observed as being more abundant in the low-shedders compared to the high-shedders, while Succinivibrio were more abundant in the high-shedders. Isolation of specific bacteria which are significantly more abundant in low-shedders may pave the way to developing direct-fed microbials which are effective in reducing STEC shedding among high-shedding beef steers.

Introduction

Shiga toxin-producing *E. coli* (STEC) are important foodborne pathogens whose natural reservoir happens to be the gastrointestinal tract of ruminants. Of particular relevance to the beef industry is the fact that seven major STEC serogroups, namely O157, O111, O145, O45, O26, O103, and O121, are considered adulterants in beef and beef products. Therefore, intervention strategies need to be developed to minimize contamination of beef by these pathogens. A better understanding of the factors which play a part in the shedding of STEC by beef animals is an important prerequisite to the development of such intervention strategies.

The purpose of this study was to understand the role played by the commensal gut microbiota of beef steers in relation to STEC shedding, through characterization and comparison of the fecal microbiotas of STEC high-shedders and low-shedders.

Procedure

Fecal samples were collected from 170 beef steers during August 2011, and animals that were high-shedders and low-shedders of STEC were identified as described previously (*2013 Nebraska Beef Cattle Report*, pp. 92-93). DNA was extracted and purified from 48 of the highest shedders and 48 low-shedders using the MagMAX™ Pathogen RNA/DNA Kit (Life Technologies Corp., Carlsbad, Calif.) according to manufacturer's instructions. The V1-V3 regions of the 16S rRNA genes from the fecal bacterial community of each fecal sample were amplified using the polymerase chain reaction (PCR) technique. The resulting amplicons were multiplexed and were subsequently sequenced at the Genome Center, University of Oklahoma, using 454 pyrosequencing (*www.454.com/*). The resulting sequence data were analyzed using the published bioinformatic pipelines of MOTHUR (*www.mothur.org/*) and QIIME (*qiime.org/*).

Results

The taxonomic composition of the most abundant phyla and genera in the two shedding phenotypes is compared in Figures 1 and 2, respectively.

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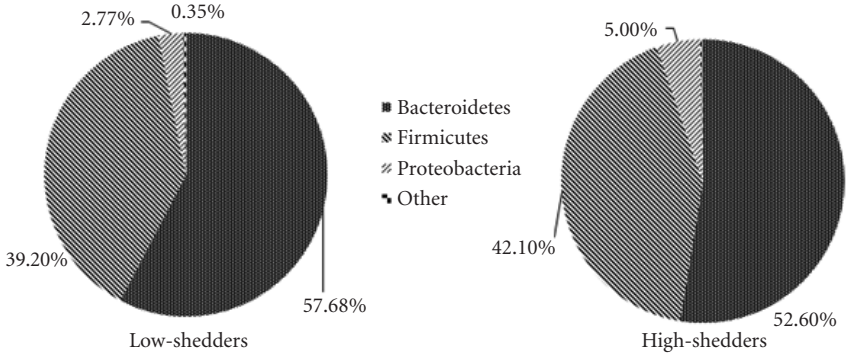

Figure 1. Phylum level taxonomic distribution of bacteria in high- and low-shedder fecal samples.

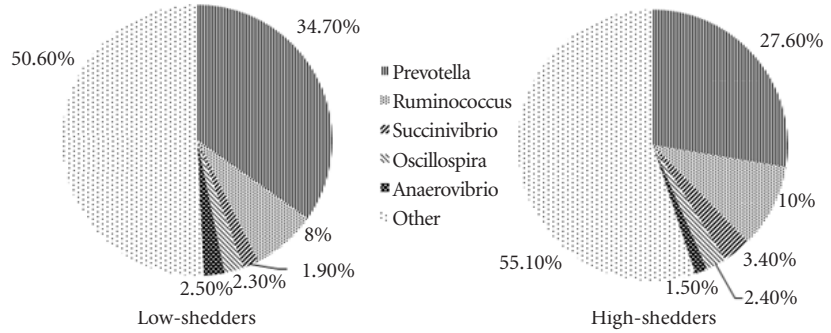

Figure 2. Genus level taxonomic distribution of bacteria in high- and low-shedder fecal samples.

The phyla Bacteroidetes and Firmicutes were the most abundantly represented phyla of both the high-shedder and low-shedder fecal bacterial communities. The phylum Proteobacteria, however, was represented more in the high-shedders. At the genus level, members of the genus *Prevotella* were more abundant in the low-shedders, while members of the genus *Succinivibrio* were more represented in the high-shedders.

The abundance of several operational taxonomic units (OTUs — which are roughly equivalent to bacterial species), were significantly different ($P < 0.05$) between the two shedding phenotypes as shown in Figures 3 and 4.

The 170 animals from which the fecal samples were collected were on three different diets: a corn-based control diet (CON), DDGS, and WDGS. The distribution of these three diets among each of the two shedding phenotypes is represented in Figure 5.

The results presented above show that 45.83% of the high-shedders were on the WDGS diet while only 10.42% of the low-shedders were on the same diet. Conversely, a majority of the low-shedders were on the corn-based control diet, while the DDGS diet appeared similarly represented among both high- and low-shedding animals. This apparent impact of the diet on shedding phenotype suggests diet may also influence STEC shedding in cattle, which has been described (*2010 Nebraska Beef Cattle Report*, pp. 86-87), but was unclear if related to microbial community.

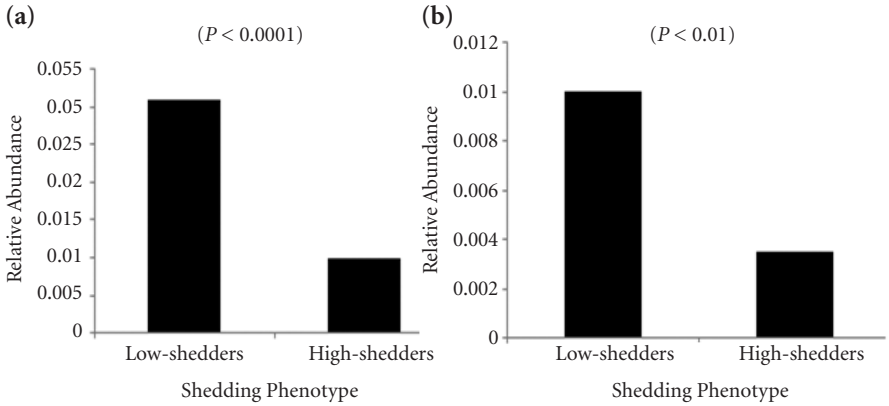

Figure 3. OTUs which were significantly more abundant in the low-shedders compared to the high-shedders. (a) OTU 13 and (b) OTU 37, both corresponding to the genus *Prevotella* (exact species unknown)

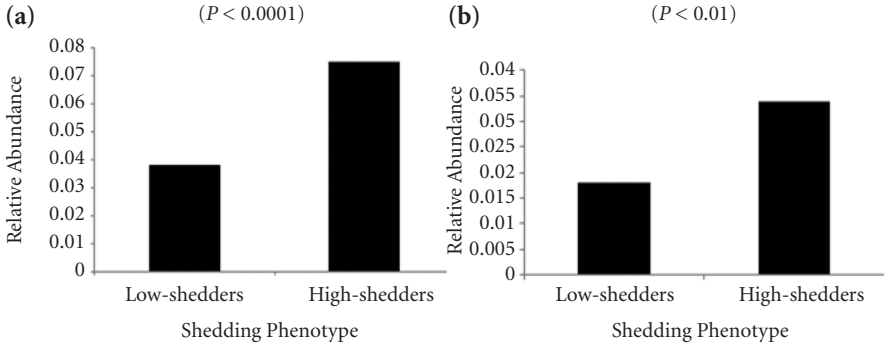

Figure 4. OTUs, which were significantly more abundant in the high-shedders compared to the low-shedders. (a) OTU 4, a member of the genus *Ruminococcus* and (b) OTU 12, a member of the *Succinivibrio* genus

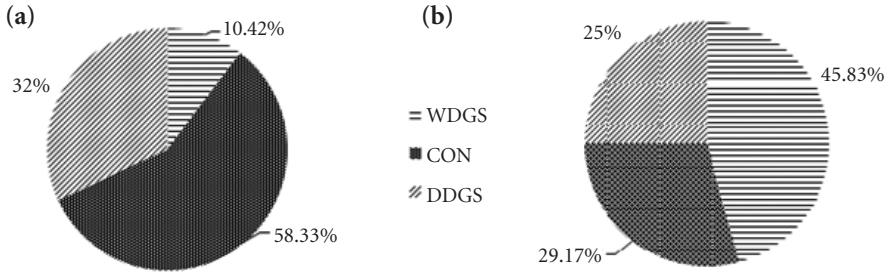

Figure 5. Distribution of the three diets among the shedding phenotypes: (a) Low-shedders (b) high-shedders

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Shelf Life of Cooked Ground Beef Patties From Cattle Fed Wet Distillers Grains with Solubles

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Kimberly A. Varnold
Derek J. Schroeder
Amy L. Redfield
Gary A. Sullivan[1]

Summary

Cattle were grazed without or with energy supplementation of wet distillers grains with solubles (WDGS) during backgrounding, and were finished on a corn-based diet with or without 35% WDGS. Ground beef patties were made from shoulder clods, cooked, and stored in a refrigerated or frozen state. Cattle supplemented with WDGS had greater lipid oxidation in cooked ground beef patties regardless of finishing diet or storage type.

Introduction

Animal fat is associated with each species' meat flavor. Within each species, the fat content of each animal varies depending on the diet each animal consumed during growth and development. Feeding WDGS to cattle causes increases in polyunsaturated fatty acids and oxidation rates in the meat (*2009 Nebraska Beef Cattle Report*, pp. 110-112; *2009 Nebraska Beef Cattle Report*, pp. 113-115), resulting in rancid flavors and aroma.

Oxidation in meat products is a major concern of meat processors and impacts the product quality and shelf life. Moreover, feeding WDGS during backgrounding and finishing has continued to increase along with growth in the ethanol industry. While much work has been conducted on the impact of feeding WDGS on raw steaks, little research has been conducted in the area of cooked, ready-to-eat meat products. This study investigated the impact of feeding WDGS during different stages of production on lipid oxidation in ready-to-eat beef products.

Procedure

Cattle (n = 64) were assigned to a diet in a 2 x 2 factorial design. During backgrounding (177 days), cattle either received energy supplementation in the form of WDGS (0.6% BW/day) or no supplementation. Cattle were then finished on a corn-based diet with or without 35% WDGS for 119 days. Cattle were harvested at the Greater Omaha Packing plant in Omaha, Neb.

The shoulder clod of four different carcasses from each of the four treatment groups were collected, totaling 16 clods. Day 7 post-mortem, the clods were coarse ground (fat content was not formulated,), mixed with ingredients (1.5% salt and 0.25% sodium phosphate), and fine ground. The same day, ¼ lb patties were formed, covered with plastic wrap, and stored overnight in the refrigerator. The next day each patty was cooked on a belt grill to an internal temperature 158°F. Half of the patties from each treatment were placed in a zip top bag and stored in a dark 38°F cooler for an assigned number of days. The remaining patties were placed on a plastic tray, overwrapped with PVC oxygen-permeable plastic film, and placed in a -4°F freezer. When the patties were crust frozen, they were placed in a zip top bag and stored in a dark -4°F freezer for an assigned number of days

Samples were collected on the day of cooking (day 8 postmortem) and every two days for the next 14 days for refrigerated samples and every 28 days for the next 252 days for frozen samples. Samples were ground, weighed, and stored at -112°F freezer until evaluation for lipid oxidation using the thiobarbituric acid reactive substances (TBARS) measure.

Proximate composition (fat, moisture, protein, and ash) of the cooked patties was also measured. Moisture and ash were measured using a LECO thermogravimetric analyzer, and fat was measured using ether extraction. Protein was calculated by difference.

Data were analyzed using the PROC GLIMMIX procedure of SAS (SAS Institute, Inc., Cary, N.C.) for treatment, day and treatment*day effects.

Results

For both frozen and refrigerated patties, there were no significant three-way interactions between supplementation, finishing diet, and day ($P > 0.05$). For frozen patties there was a significant ($P < 0.01$) interaction between supplementation and finishing diet (Figure 1). When supplementation was provided, TBARS values were the greatest regardless of finishing diet. This suggests that cooked beef patties in frozen storage from animals that were supplemented with WDGS during backgrounding will have more oxidation and, therefore, will be more rancid than patties from animals that did not receive supplementation. Noticeable rancid flavors are associated with TBARS values greater than 1.0 mg/kg. All four treatment combinations from patties held under freezer conditions had TBARS values well over 1.0 mg/kg by the end of the study. However, patties from cattle that were not supplemented during grazing and were finished on WDGS did not have oxidation values over 1.0 mg/kg until day 140 of frozen storage while all other treatment

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Table 1. The effect of supplementation and finishing diet on meat quality characteristics of cooked beef patties.

	Supplementation[1]				Finishing Diet			
	No	Yes	SEM	*P*-value	Corn	WDGS[2]	SEM	*P*-value
Moisture, %	59.1	58.95	0.81	0.90	59.06	58.99	0.81	0.95
Fat, %	19.81	19.61	1.21	0.91	19.53	19.89	1.21	0.84
Ash, %	2.98	3.09	0.04	0.06	3.02	3.05	0.04	0.54
Protein, %	18.12	18.36	0.59	0.78	18.39	18.08	0.59	0.72

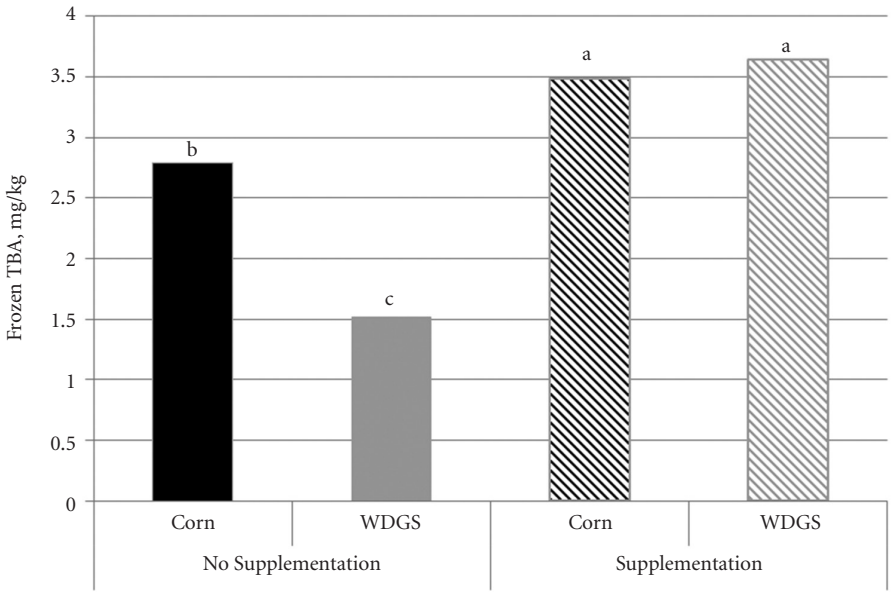
[1]Energy supplementation with WDGS during backgrounding phase.
[2]WDGS = Wet distillers grains with solubles.
[a,b]Means within the same row sharing a common superscript are similar ($P \geq 0.05$).

combinations exceeded 1.0 mg/kg by day 28.

For refrigerated patties, providing supplementation caused significantly higher ($P < 0.01$) TBARS values than not supplementing, and finishing on corn without WDGS had a tendency ($P = 0.07$) to also cause higher TBARS values (Figure 2). Numerically, patties from the non-supplemented cattle that were finished on WDGS had the lowest scores for both refrigerated and frozen storage. For all proximate composition measures (% moisture, fat, ash, and protein) neither the main effects of supplementation or finishing diet nor their interactions had any significant effects ($P > 0.05$, Table 1).

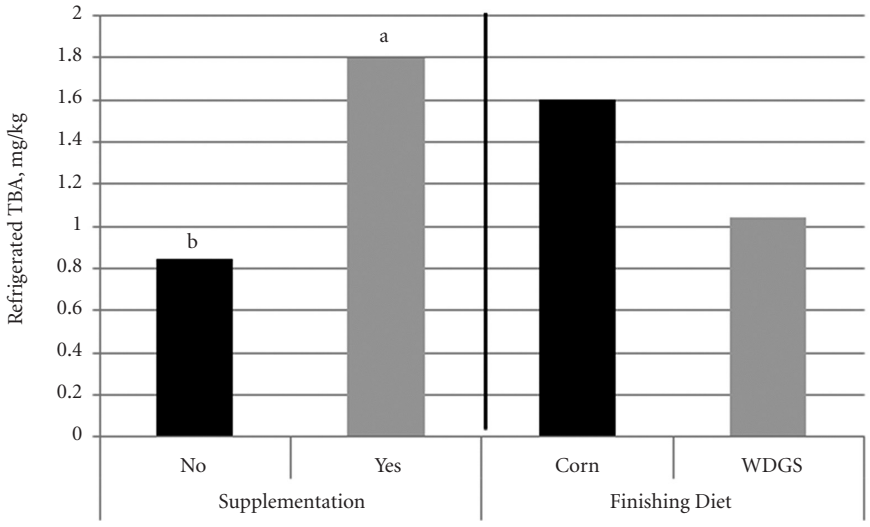
In conclusion, feeding WDGS as an energy supplementation during backgrounding caused higher amounts of oxidation in both refrigerated and frozen cooked beef patties regardless of finishing diet. The levels of oxidation were greater in frozen patties. These data suggest that the time WDGS is fed during production impacts lipid oxidation in cooked beef products.

[1]Nathan T. Dierks, veterinary medicine student; Tommi F. Jones, laboratory technician; Kimberly A. Varnold, graduate student; Derek J. Schroeder, graduate student; Amy L. Redfield, graduate student; Gary A. Sullivan, professor, University of Nebraska–Lincoln Department of Animal Science, Lincoln, Neb.



[a,b,c]Means within the same treatment sharing a common superscript are similar ($P \geq 0.05$)

Figure 1. The effect of the interaction between supplementation and finishing diet on cooked beef patties under frozen storage ($P < 0.01$)



[a,b]Means within the same treatment sharing a common superscript are similar ($P \geq 0.05$)

Figure 2. The effect of supplementation ($P < 0.01$) and finishing diet ($P = 0.07$) on cooked beef patties under refrigerated storage

Effect of Feeding Different Types of Byproducts and Concentrations Throughout a Beef Growing System on Ground Beef Color and Lipid Oxidation

Joe O. Buntyn
Brandy D. Cleveland
Amy L. Redfield
Jim C. MacDonald
Galen E. Erickson
Tommi F. Jones
Ty B. Schmidt
Gary A. Sullivan[1]

Summary

The objective of this trial was to evaluate the effect of feeding different concentrations of wet distillers grains during winter backgrounding and either modified wet distillers grains or Sweet Bran® during the finishing phase on ground beef color and lipid oxidation. After a 14 day aging period, ground beef patties were made and placed in a simulated retail display for seven days. There were no overall differences in lipid oxidation between treatments but was a treatment by day interaction for discoloration. Ground beef from heifers finished with modified wet distillers grains discolored at a greater extent when compared to ground beef from heifers finished with Sweet Bran.

Introduction

Cattle fed distillers grain have an increase in polyunsaturated fatty acids, which may decrease oxidative stability (*2009 Nebraska Beef Cattle Report,* pp. 97-98). Higher levels of PUFA contribute to greater lipid oxidation, reduced retail shelf life, and off flavor development in fresh beef products (*2009 Nebraska Beef Cattle Report,* pp. -107-109 and 110-112*; 2011 Nebraska Beef Cattle Report,* pp. 96-99). Furthermore, the formation of metmyoglobin, the brown pigment state in meat, and lipid oxidation are related and can reduce the retail display life in fresh beef products. The objective of this project was to evaluate the effect of amount and types of byproducts fed during different production phases on the shelf life and rancidity in fresh ground beef patties.

Procedure

Sixty-four heifers were randomly assigned to dietary treatments in a 2 x 2 factorial design that included 2 or 5 lb/head/day DM basis supplementation of wet distillers grain during the winter backgrounding phase and either 40% Sweet Bran or MDGS during the finishing phase. During summer grazing, all cattle were supplemented with modified wet distillers grains at a rate of 0.6% of BW. At the conclusion of the finishing phase, cattle were harvested at a commercial abattoir. Forty-eight hours post-harvest, four clods were collected from USDA Choice carcasses from each of the dietary treatment group with similar fat content, vacuum packaged and wet aged for 14 days. On day 14, each clod was independently ground and 12, ¼ lb patties were formed (hand hamburger press).

Patties were placed on Styrofoam trays (two per tray), overwrapped with permeable oxygen wrap, and placed under simulated retail display for seven days. Objective color measurements were collected each day for seven days with a Minolta Chromameter CR-400 (Minolta Camera Company, Osaka, Japan) with an 8 mm diameter illumination area, illuminant D65 and 2° standard observer, L* (brightness), a* (redness) and b* (blue to yellow) values were recorded. Three readings were taken from each patty and averaged together for each individual tray; the same patties were used to evaluate objective color through the entire display period. Subjective color was also evaluated by a five-person panel of graduate students on days 0, 1, 2, 3, 5, and 6 using a score from 0% to 100% discoloration (%DIS) on a randomly selected predetermined package of patties. Also, during retail display, patties were removed from light and frozen at -20°F until thiobarbituric acid reactive substance (TBARS) were analyzed.

For TBARS, patties were removed from freezer storage and half a patty was cut into small pieces while partially frozen. The pieces were then flash frozen in liquid nitrogen and then powdered in a blender. Powdered samples were then analyzed using the TBARS standard protocol. Data were analyzed as a 2 x 2 factorial with repeated measures (day) utilizing the PROC GLIMMIX procedures of SAS (SAS Institute, Inc., Cary, N.C.).

Results

There was a linear increase ($P < 0.001$) over time for TBARS concentrations, however, the main effects of WDGS during backgrounding or finishing diet did not impact ($P \geq 0.53$) TBARS concentration (Figure 1). There was a finishing diet by day interaction ($P < 0.001$) for percent discoloration (%DIS); patties from heifers fed MDGS on days 3, 5, and 6 were observed to have a greater ($P \leq 0.02$) %DIS when compared to patties from heifers fed SB (days 0, 1, 2, and 7 were similar; $P \geq 0.19$) (Figure 2). For objective color, a* and b*

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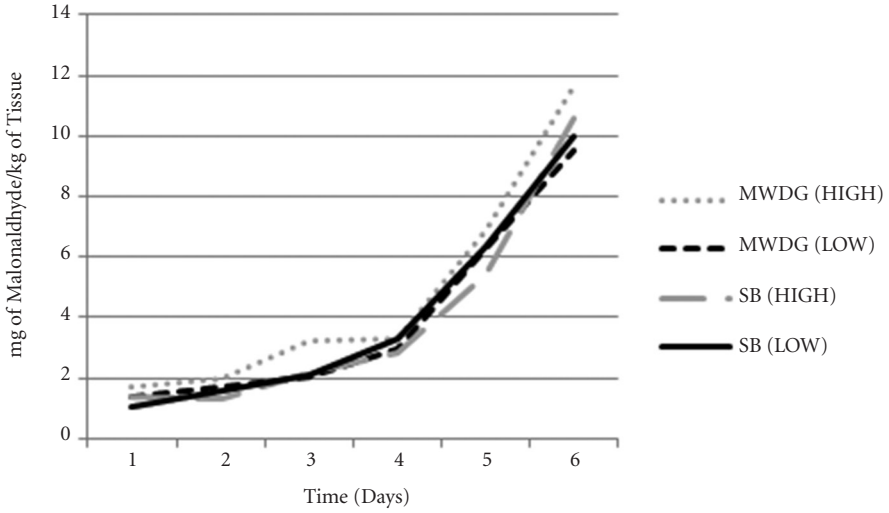
values linearly decreased ($P < 0.001$) over time regardless of treatment. The main effects of backgrounding and finishing diet did not have an impact ($P > 0.65$) on %DIS. Both finishing diet and day had an impact ($P \leq 0.03$) on L* values. Dietary effect was observed ($P = 0.03$) for L* measurements with patties from heifers finished with Sweet Bran having greater L* values compared to heifers finished with MWDG (53.01 vs. 51.73). The L* (lightness) values increased ($P < 0.001$) linearly as days of simulated retail display increased. Ground beef from heifers finished with MDGS discolored to a greater degree compared to ground beef from heifers finished with SB which would likely result in one extra day of acceptable retail shelf life of the product.

[1]Joe O. Buntyn, graduate student; Brandy D. Cleveland, graduate student; Amy L. Redfield, graduate student; Jim C. MacDonald, associate professor; Galen E. Erickson, professor; Tommi F. Jones, research technician; Ty B. Schmidt, assistant professor; Gary A. Sullivan, assistant professor, University of Nebraska–Lincoln Department of Animal Science, Lincoln, Neb.



Low and High indicate amount of supplementation, 2 or 5 lb/head/day, of WDGS during backgrounding. Finishing diet included either 40% MWDG or 40% Sweet Bran (SB).

Figure 1. Lipid oxidation (mg of Malonaldhyde/kg of tissue) over time based on cattle diets.

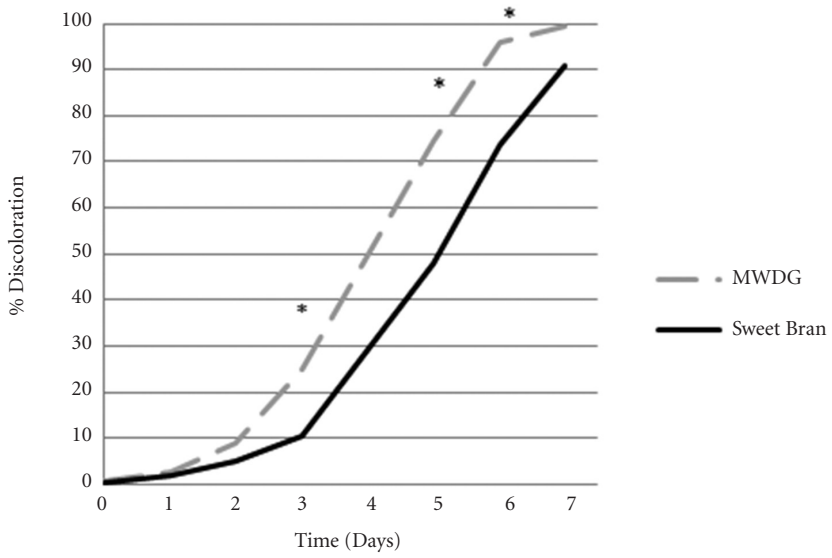


Figure 2. Percent discoloration of ground beef patties over time based on finishing diet.

Lipid Oxidation in Cooked Ground Beef Links from Cattle Fed Distillers Grains in Different Phases of Production

Brandy D. Cleveland
Joe O. Buntyn
Amy L. Redfield
Jim C. MacDonald
Galen E. Erickson
Tommi F. Jones
Ty B. Schmidt
Gary A. Sullivan[1]

Summary

Ground beef links from cattle fed high or low levels of distillers grains during backgrounding and Sweet Bran® or modified wet distillers grains in finishing diets were compared to analyze oxidation over time. Ready-to-eat beef links from cattle fed 5 lb/head/day (DM basis) of wet distillers grains during backgrounding had greater oxidative rancidity with extended storage than those from cattle fed 2 lb/head/day (DM basis). Beef links from cattle finished with wet distillers grains oxidized more rapidly than those fed Sweet Bran. Therefore, cooked beef from cattle fed distillers grains during either phase of production (backgrounding or finishing) showed greater oxidative rancidity as well as an increase rate of oxidation.

Introduction

As a result of the rapid growth of the ethanol industry, many cattle producers include ethanol byproducts in cattle diets. Previous research has shown that cattle fed wet distillers grains (WDGS) have an increase in polyunsaturated fatty acids, which may decrease oxidative stability (*2009 Nebraska Beef Cattle Report*, pp. 107-109 and 110-112). The polyunsaturated fatty acids will readily undergo free-radical chain reactions resulting in deterioration of the lipid. Lipid oxidation and off-flavor development after cooking is accelerated due to the release of free and heme-iron from myoglobin during cooking. While much research has been conducted on fresh beef characteristics from cattle fed ethanol co-products, the impact on cooked beef products has not been studied. Therefore, the objective of this trial was to evaluate the impact of feeding modified wet distillers grains during two production phases on lipid oxidation in ready-to-eat beef.

Procedure

Heifers were randomly assigned to a dietary treatment in a 2 X 2 design factorial that included 2 or 5 lb/head/day (DM basis) supplementation of wet distillers grains during the winter backgrounding phase and finished on a corn based diet with 40% dietary inclusion (DM basis) of either Sweet Bran or modified wet distillers grains. During the summer months, all cattle were supplemented with modified wet distillers grains at a rate of 0.6% of BW. A total of 16 USDA Choice clods, four carcasses from each dietary treatment group, were collected. Each clod was independently ground 14 days post-harvest. Beef (with no fat content formulation) and non-meat ingredients, 0.75% sodium chloride and 0.25% sodium phosphate, were mixed for one minute and the mixture was stuffed into skinless links using a piston stuffer. Links were placed in individual foil trays for each clod and cooked in a smokehouse to an internal temperature of 160°F. The links were placed in zip-top bags with the presence of oxygen and placed in refrigerated dark storage. Lipid oxidation was evaluated on days 0, 3, 6, 9, 12, 15, and 18 using the thiobarbituric acid reactive substances (TBARS) analysis. Data were analyzed as a 2 X 2 factorial with repeated measures (day) using the PROC GLIMMIX procedure of SAS (SAS Institute, Inc., Cary, N.C.).

Results

Significant winter backgrounding diet × day ($P = 0.008$) and finishing diet × day ($P = 0.02$) interactions were identified. During winter backgrounding, there was no difference ($P > 0.05$) in lipid oxidation between cattle fed 2 lb/head/day or 5 lb/head/day (DM basis) of modified wet distillers grains on days 0, 3, and 6 of refrigerated storage ($P = 0.99$, 0.88, and 0.58, respectively; Figure 1).

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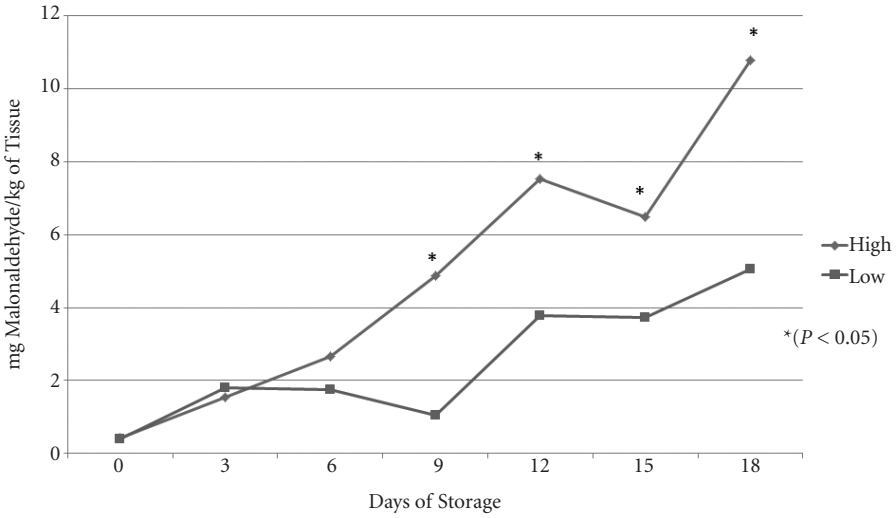

Figure 1. Effect of supplementation level of wet distillers grains (2 or 5 lb/head/day DM basis) during backgrounding on lipid oxidation (mg of malonaldehyde/kg of tissue) in cooked ground beef links.

However, cattle fed 5 lb of wet distillers grains during backgrounding had greater lipid oxidation than cattle fed 2 lb of wet distillers grains for days 9, 12, 15, and 18 ($P = 0.02$, 0.02, 0.09, and 0.001, respectively). In finishing, there was a linear increase in lipid oxidation for days 0, 3, 6, 9, and 12 for cattle fed modified wet distillers grains (Figure 2) and had great lipid oxidation than cattle fed Sweet Bran on days 6 and 9 ($P = 0.05$ and 0.02, respectively). There was little increase in lipid oxidation for cattle fed Sweet Bran during finishing for days 0, 3, 6, and 9. On days 12, 15, and 18, the oxidation of cattle fed distillers grains and cattle fed sweet bran were similar ($P = 0.55$, 0.62, and 0.09, respectively). These findings suggest that feeding distillers grains during either production phase (backgrounding or finishing) increases lipid oxidation and decreases shelf life of ready-to-eat beef products.

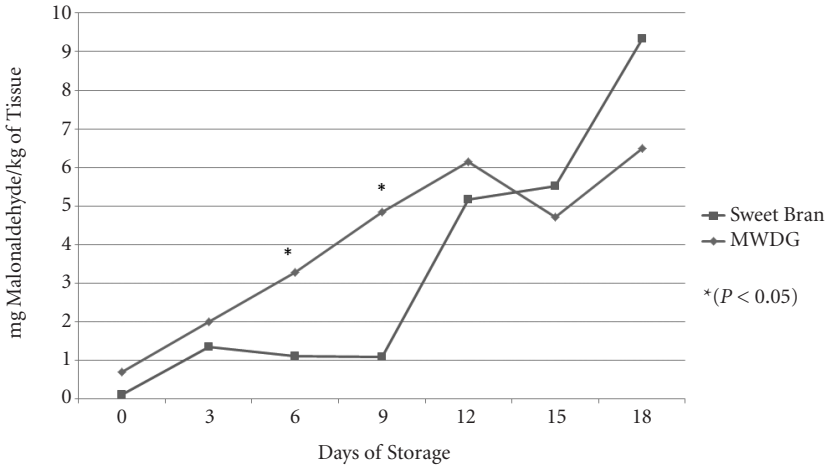

Figure 2. Effect of feeding Sweet Bran or modified wet distillers grains during finishing on lipid oxidation (mg of malonaldehyde/kg of tissue) in cooked ground beef links.

[1]Brandy D. Cleveland, graduate student; Joe O. Buntyn, graduate student; Amy L. Redfield, graduate student; Jim C. MacDonald, associate professor; Galen E. Erickson, professor; Tommi F. Jones, research technician; Ty B. Schmidt, assistant professor; Gary A. Sullivan, assistant professor, University of Nebraska–Lincoln Department of Animal Science, Lincoln, Neb.

[2] This project was funded in part by the Nebraska Beef Council and the Beef Checkoff.

Effect of Natural Antioxidant Concentration on Lipid Oxidation of Ready-to-Eat Ground Beef Links from Cattle Fed Distillers Grains in Different Phases of Production

Brandy D. Cleveland
Joe O. Buntyn
Amy L. Redfield
Jim C. MacDonald
Galen E. Erickson
Tommi F. Jones
Ty B. Schmidt
Gary A. Sullivan[1]

Summary

Shelf life of cooked ground beef links with no, low, or high concentrations of a blend of natural plant extract antioxidant were compared to evaluate lipid oxidation over time. When no antioxidants were added, samples stored nine days or beyond were more oxidized than the samples with the addition of an antioxidant. No differences in lipid oxidation were observed between 0.13% and 0.20% antioxidant concentrations during similar days of refrigerated storage days. Therefore, the addition of natural antioxidants were effective at reducing oxidative rancidity, regardless the concentration of antioxidant.

Introduction

Lipid oxidation occurs most commonly in phospholipids and polyunsaturated fatty acids that will readily undergo free-radical chain reactions resulting in deterioration of the lipid. Lipid oxidation reduces shelf life and decreases overall desirability of the product by increasing the evidence of "warmed over" or "rancid" flavors. The use of plant extracts, such as rosemary or green tea, is becoming increasingly popular in meat processing as a natural antioxidant to increase shelf life of cooked meat products. This becomes particularly beneficial for companies seeking to clean up labels or use "natural" labeling claims for their product. Therefore, the objective of this study was to evaluate the effectiveness of natural rosemary and green tea extract in cooked beef from cattle fed distillers grains.

Procedure

Cattle were randomly assigned to a dietary treatment in a 2 x 2 factorial that included 2 or 5 lb/head/day (DM basis) of wet distillers grains during the winter backgrounding phase and either Sweet Bran® or modified wet distillers grains during the finishing phase (40% dietary inclusion, DM basis). All cattle were supplemented with modified wet distillers grains at a rate of 0.6% of BW during the summer months. A total of 16 USDA Choice clods from four carcasses from each dietary treatment group were collected. Each clod was independently ground and divided into three 5 lb batches. All treatments contained 0.75% salt, 0.25% phosphate and either 0, 0.13% or 0.20% rosemary plus green tea extract (FORTIUM RGT12 Plus Dry Natural Plant Extract; Kemin, Des Moines, Iowa). Beef and non-meat ingredients were mixed for one minute and the mixture was stuffed into skinless

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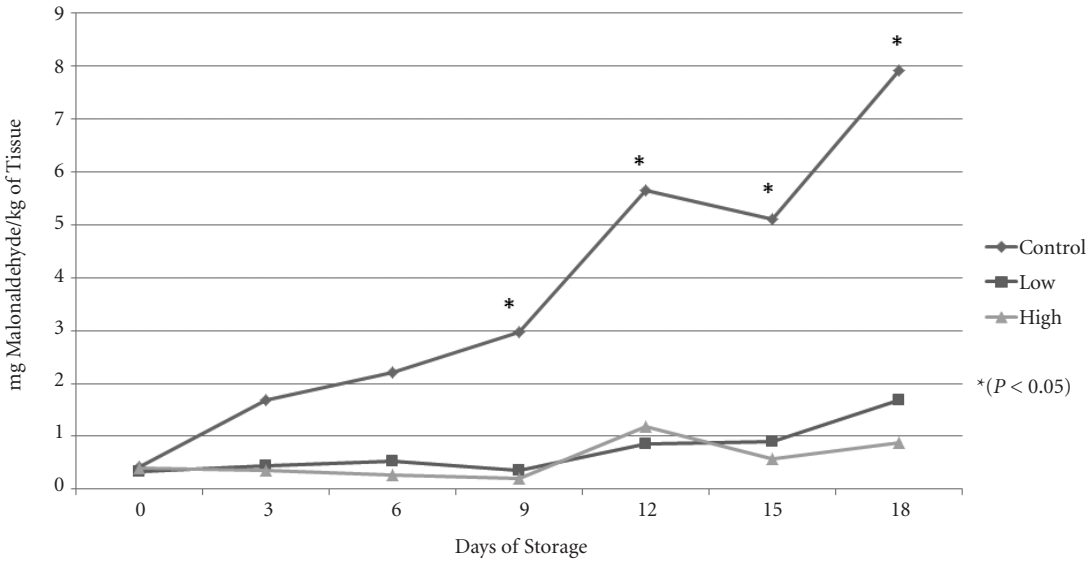

Figure 1. Effect of adding no, low, or high concentrations (0%, 0.13%, 0.2%) natural plant extract on the lipid oxidation (mg of malonalydehyde/ kg or product) in ready-to-eat beef links.

links using a piston stuffer. Links were placed in individual foil trays for each clod and cooked in a smokehouse to an internal temperature of 160°F. Links were placed in zip-top bags with the presence of oxygen and placed in dark refrigerated storage. Lipid oxidation was evaluated on days 0, 3, 6, 9, 12, 15, and 18 using the thiobarbituric acid reactive substances (TBARS) analysis. Data were analyzed as a 2 X 2 factorial with repeated measures (day) using the PROC GLIMMIX procedure of SAS (SAS Institute, Inc., Cary, N.C.).

Results

An antioxidant concentration × day interaction ($P < 0.05$) was observed (Figure 1), whereas no significant dietary treatment interactions or main effects were observed. A study was done viewing the same dietary treatments independent from antioxidant treatment, where cattle fed higher levels of modified wet distillers grains during backgrounding had greater oxidative rancidity with extended storage and beef links from cattle finished with wet distillers grains oxidized more rapidly than those finished on Sweet Bran (*2014 Nebraska Beef Cattle Report*, pp. 107-108). The lack of dietary effects ($P > 0.16$) in this study is likely due to the effectiveness of antioxidants masking the effects of diet on lipid oxidation.

On days 6, 9, 12, 15, and 18 of storage, cooked links with no added antioxidants were more oxidized ($P > 0.05$) than all treatments with either concentration of antioxidant on any day. On day 3 for the control, there was a trend for increased oxidation when compared to high levels of antioxidant ($P = 0.10$). The threshold for when lipid oxidation becomes evident to consumers is 1 mg of melonaldehyde/kg of product. The control surpassed this threshold on day 3, whereas samples with any level of added antioxidant did not surpass it until day 18. There were no ($P > 0.05$) differences in lipid oxidation between samples with 0.13 or 0.20% added antioxidants on any day of evaluation. These findings suggest that the addition of rosemary and green tea extract can suppress lipid oxidation in cooked beef products.

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[2]This project was funded in part by the Beef Checkoff.

Effects of Feeding Distillers Grains in a Yearling Beef System on Meat Quality

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Summary

Distillers grains use while wintering on cornstalks during summer grazing and during the finishing period was evaluated to determine the effects of lifetime exposure to distillers grains on meat characteristics. Finishing diets with distillers grains increased discoloration in steaks following six days of retail display for steaks aged seven days, and after four days of retail display for steaks aged 21 days. Supplementation during summer grazing increased discoloration when cattle were not finished using distillers grains. There were no differences in oxidative rancidity among dietary treatments. Supplementing with distillers grains prior to finishing was not additive in impacting the color stability and overall shelf life of retail beef when cattle were finished using distillers grains. However, polyunsaturated fatty acids fed during the backgrounding phase can affect beef quality.

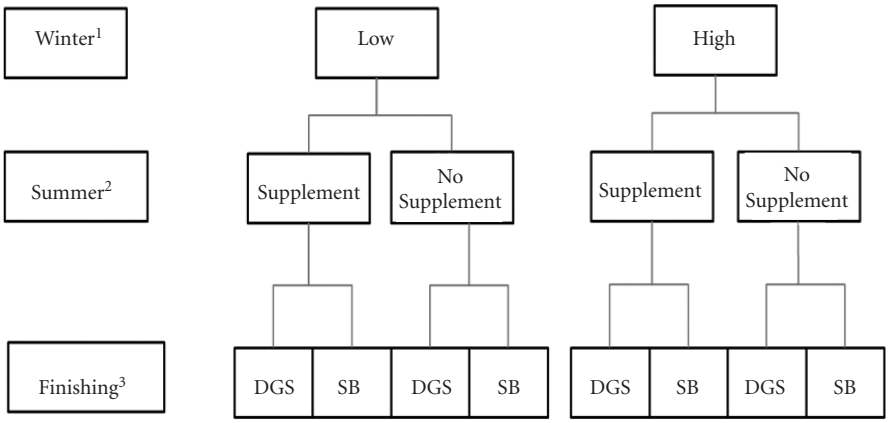
Introduction

Distillers grains plus solubles (DGS) are commonly fed as an energy source replacing corn in beef diets. Previous research has shown that a portion of the corn oil is protected from rumen biohydrogenation (*2007 Nebraska Beef Cattle Report,* pp. 39-42), and there is a linear increase in polyunsaturated fatty acids (PUFA) in the meat as the level of DGS inclusion in finishing diets increased (*2009 Nebraska Beef Cattle Report,* pp.118-119). Increased PUFA resulted in higher oxidation and decreased color stability of the retail beef in as little as three days after being placed in the retail case. (*2008 Nebraska Beef Cattle Report*, pp. 122-123). Decreased color stability is caused by the PUFA being more readily oxidized than the monounsaturated or saturated fatty acids. The increased oxidation results in a decreased retail shelf-life and a potential loss of retail value. Supplementing DGS to cattle backgrounded on cornstalks or grazing pasture throughout a yearling beef production system is economically beneficial (*2014 Nebraska Beef Cattle Report,* pp. 39-42). However, supplementing DGS would increase the total amount of dietary PUFA to which the animal is exposed and there is little research evaluating this effect on the quality of retail beef. The objective of this study was to determine if the feeding of DGS during the backgrounding and grazing periods was cumulative towards increasing discoloration and reducing shelf-life of beef.

Procedure

Heifers (n = 228) were allocated to one of eight dietary treatments in a current study (*2014 Nebraska Beef Cattle Report,* pp. 39-42). Heifers grazed cornstalks during the winter while being supplemented either a high (5 lb DM) or low (2 lb) amount of DGS daily. During the summer grazing period, half of the heifers from each previous treatment either received a DGS supplement at 0.6% of body weight or no DGS supplement. During the finishing phase of the yearling system, the heifers were fed either a 40% DGS (DM basis) or 40% Sweet Bran® based finishing diet (Figure 1). Feeding these two different finishing diets would change the amount of unsaturated fatty acids capable of reaching the small intestine. Strip loins, (11-13 per treatment), were collected and aged for 7 or 21 days. After aging, loins were cut into three 1-inch thick and two ½-inch thick steaks. The same loins were utilized for both the 7 and 21 day aging by vacuum packaging the remainder of the loin following cutting the 7 day aging period steaks. The first 1-inch steak was trimmed of all external fat and frozen at -112°F to avoid oxidation for laboratory analyses of 0 day oxidative rancidity (TBARS). The second and third 1-inch steaks were trimmed to

(Continued on next page)



[1]Received 2 lb DM (Low) or 5 lb (High) level of distillers grains supplementation during winter corn stalk grazing period.
[2]Received no supplement (No Suppl) or a distillers grains supplement (Suppl) at 0.6% of body weight during summer grazing period.
[3]Received a finishing diet consisting of either 40% Sweet Bran (SB) or 40% distillers grains (DGS).

Figure 1. Treatments for heifers fed distillers grains throughout a yearling beef production system

Table 1. Effects of summer supplementation and finishing diet on average percent discoloration across 7 days of retail display for strip steaks aged 7 and 21 days from heifers fed distillers grains throughout a yearling beef production system.

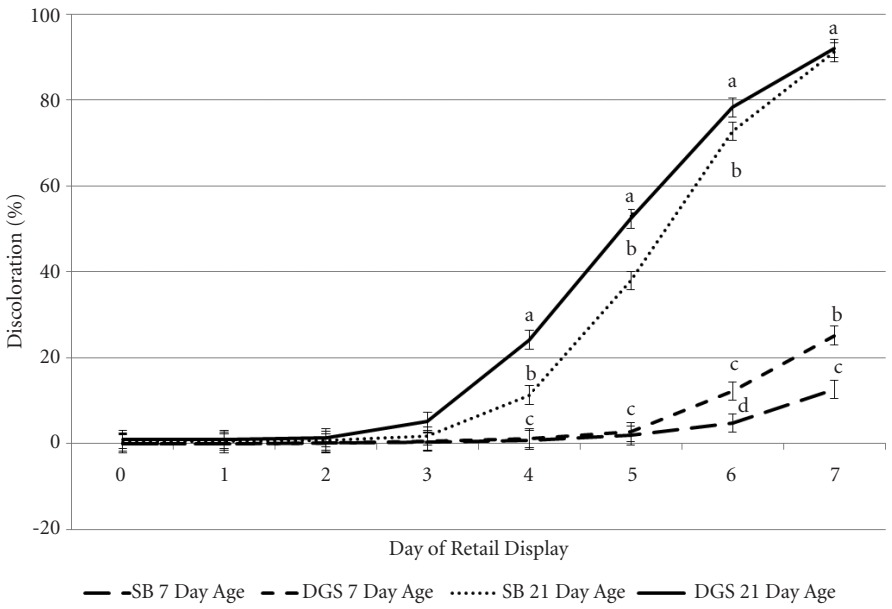
	Sweet Bran[1]		DGS			*P*-value		
	No-Suppl[2]	Suppl	No-Suppl	Suppl	SEM	Summer	Finishing	S x F[3]
Discoloration (%)	12.88[a]	16.73[b]	18.61[c]	18.55[bc]	0.77	0.014	< 0.001	0.014

[a,b,c]Means in the same row having different superscripts are significantly different at $P \leq 0.10$.
[1]Received a finishing diet consisting of either 40% Sweet Bran or 40% distillers grains.
[2]Received no supplement or a distillers grains supplement at 0.6% of body weight during summer grazing period.
[3]Interaction between summer supplementation level and composition of finishing diet.

¼- inch of fat with the second steak being packaged and stored at -4°F for 0 day Warner Bratzler Shear Force (WBSF). The third 1-inch steak and the two ½-inch steaks were then packaged on Styrofoam trays and covered with oxygen-permeable film and placed on table in a cooler maintained at 32-36°F under artificial lighting to simulate retail case display. Visual color evaluations were made by five individuals daily and based on the percent discoloration of the steak from 0% (not discolored) to 100% (completely discolored). Following the fourth day of retail display, one of the ½-inch steaks was vacuum packaged and stored at -4°F for TBARS laboratory analysis. At the conclusion of the seven day retail display simulation, the remaining 1-inch steak was vacuum packaged and stored at -4°F for WBSF and the ½-inch steak for TBARS laboratory analysis. For WBSF analysis, steaks were grilled to 95°F then turned and grilled until they reached 160°F at their center. After cooking, steaks were cooled overnight at 39°F at which point cores (½-inch in diameter) were removed with a drill press parallel to the orientation of the muscle fibers. Then, six cores from each steak were sheared on an Instron Universal Testing Machine with a Warner-Bratzler blade. Laboratory analysis of oxidative rancidity was measured by thiobarbituric acid reactive substances (TBARS) as described by Senaratne et al. (*2009 Nebraska Beef Cattle Report*, pp. 113-115).

Results

Visual color evaluations showed the expected increased rate of discoloration that is associated with aging steaks 21 days versus 7 days ($P < 0.01$) and with retail display days ($P < 0.01$). Within aging period, there was no effect ($P > 0.10$) of finishing diet for the retail days 1-5 for those steaks aged 7 days and days 1-3 for those aged 21 days. However, there was an increased rate of percent discoloration for those feed the DGS ($P < 0.01$) during the finishing phase on days 4, 5, and 6 for the 21-day aged steaks and days 6 and 7 for the 7-day aged steaks (Figure 2). The effect of the finishing diet carries over into the interaction between summer supplementation and the finishing diet (Table 1) where there was a difference in the average steak discoloration between the supplemented and non-supplemented cattle when finished on a Sweet Bran based diet ($P = 0.01$), but no difference between either supplementation strategy when DGS was used in the



[a,b,c]Means in the same day of retail display having different superscripts are significantly different at $P \leq 0.10$.

Figure 2. Effects of finishing diet, retail display, and aging on discoloration of strip steaks from heifers fed distillers grains throughout a yearling beef production system.

Table 2. Effects of retail display and aging on amount of malondialdehyde ppm (mg/kg) (oxidative rancidity) of strip steaks from heifers fed distillers grains throughout a yearling beef production system.

Day of retail display	7-day age	21-day age
0	1.45[a]	2.02[a]
4	3.22[b]	5.33[b]
7	5.96[c]	7.72[c]

[a,b,c]Means in the same column having different superscripts are significantly different at $P \leq 0.10$.

Table 3. Tenderness of steaks from heifers fed distillers grains throughout a yearling beef production system.

	DGS[1]				Sweet Bran								
	Low[2]		High		Low		High			*P*-Value			
	No-Suppl[3]	Suppl	No-Suppl	Suppl	No-Suppl	Suppl	No-Suppl	Suppl	SEM	Winter	Summer	Finish	Int[4]
WBSF, kg	3.09[c]	3.46[a]	3.24[bc]	3.24[bc]	3.38[ab]	3.44[ab]	3.18[bc]	3.36[bc]	0.09	0.167	0.016	0.168	0.052

[a,bc]Means in the same row having different superscripts are significantly different at $P \leq 0.10$. Lower score indicates more tender.
[1]Received a finishing diet consisting of either 40% Sweet Bran or 40% distillers grains.
[2]Received Low (2 lb) or High (5 lb) level of distillers grains supplementation during winter corn stalk grazing period.
[3]Received no supplement or a distillers grains supplement at 0.6% of body weight during summer grazing period.
[4]Winter, summer, and finishing phases interaction.

finishing diet ($P = 0.95$). Thus, feeding DGS prior to the finishing phase was not cumulative in impacting the color stability and overall shelf life of the retail beef when cattle were finished using DGS. When they were finished on Sweet Bran, however, supplementing with DGS during the summer was detrimental to color stability. There was no interaction between winter supplementation and finishing diet for discoloration ($P = 0.39$). The effects of aging ($P < 0.01$), days of retail display ($P < 0.01$), and the interaction of aging and retail display ($P < 0.01$; Table 2) on TBARS correspond to the percent discoloration data; however, there were no significant differences ($P > 0.15$) for oxidation due to any of the dietary treatments. Generally while all samples were relatively tender, cattle supplemented with DGS during the summer were slightly, but significantly, less tender (Table 3) than cattle that were not supplemented ($P = .016$). This effect was most noticeable when cattle were finished on DGS. Although significant, the magnitude of the tenderness is not likely to be meaningful to consumers.

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[2]This project was funded in part by the Beef Checkoff.

Effect of Feeding De-oiled Wet Distillers Grains Plus Solubles on Beef Oxidation and Tenderness

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Summary

Cattle fed a de-oiled wet distiller's grains plus solubles (WDGS) diet were compared to cattle fed corn or traditional (full-fat) WDGS diets to determine effects on discoloration, oxidation, and tenderness of beef aged for seven and 21 days. At seven days of aging, dietary treatment had no effect on discoloration. At 21 days of aging, beef from cattle fed de-oiled WDGS had less oxidation than the corn control and several of the full-fat WDGS treatments. Although tenderness increased with aging and retail display, dietary treatment had no effect on tenderness. These findings suggest that these dietary treatments, followed by a short aging period, don't have a large impact on shelf life stability and oxidation, but with prolonged aging periods and retail display, feeding de-oiled WDGS can reduce oxidation.

Introduction

Research done at the University of Nebraska–Lincoln has found that feeding wet distillers grains plus solubles (WDGS) increases the polyunsaturated fatty acid (PUFA) content in beef, which results in higher oxidation (2011 *Nebraska Beef Cattle Report*, pp. 96-99). Oxidation in beef is evidenced by visual discoloration and development of off-flavors and, consequently, has a negative effect on consumer purchasing decisions. Greater oxidation is seen with prolonged aging periods. With recent trends in the removal of the soluble oil fraction from WDGS used for ethanol production, de-oiled WDGS is more accessible than normal or full-fat WDGS. Therefore, this research was conducted to determine the effect of feeding de-oiled WDGS on retail shelf life, oxidation, and tenderness after aging compared to corn or full-fat WDGS diets.

Procedure

A total of 336 steers were fed one of seven dietary treatments: an all-corn control, and 35%, 50%, or 65% dietary inclusion of WDGS, either full-fat or de-oiled. After harvest, 15 low Choice carcasses were selected within each dietary treatment (n = 105) and strip loins were obtained. Vacuum sealed loins were aged seven and 21 days (33°F). At seven days of aging part of the loins were fabricated into 1-inch steaks for visual discoloration and tenderness and ½-inch steaks for Thiobarbituric acid reactive substances (TBARS), a measure of oxidation. The remaining portions of the loins were vacuum sealed and aged up to 21 days at which point the fabrication process was repeated. At both aging periods the steaks were placed in Styrofoam trays and overwrapped with oxygen-permeable film and placed in retail display conditions (37°F) for four and seven days. Steaks at day 0 of retail display were immediately vacuum packed and stored in an ultra-freezer (-112°F) until needed.

Visual Discoloration (discoloration score)

Visual discoloration was assessed daily for all samples placed in retail display. The steaks were evaluated on a percent scale where 0% meant no discoloration and 100% meant complete discoloration.

Oxidation (TBARS)

Frozen samples were diced into small pieces, with no subcutaneous fat, and flash frozen in liquid nitrogen. The nitrogen-frozen pieces were powdered in a metal cup blender and 5 g of powdered sample was weighed to conduct the TBARS protocol.

Tenderness (Warner-Bratzler Shear Force – WBSF)

The 1-inch frozen steaks were thawed for 24 hours (33°F) and a thermocouple was placed in the geometric center of each steak. The steaks were grilled on Hamilton Beach grills until they reached an internal temperature of 160°F (cooked on one side until 95°F and flipped to finish cooking). The cooked steaks were placed on trays and covered with plastic film and kept in a cooler for 24 hours (33°F). Six cores were taken parallel to the muscle fiber of each steak and sheared to determine tenderness. The Proc Glimmix procedure in SAS (SAS Institute, Inc., Cary, N.C.) was used to test the effects of dietary treatment, aging period, and retail display and their interactions. Repeated measures were used to analyze the discoloration data and all means were separated with the LS MEANS statement and the TUKEY adjustment with an alpha level of 0.05.

Results

Treatment had no effect on discoloration in samples aged for seven days ($P > 0.05$). After 21 days of aging, discoloration was significant at five days of retail display ($P < 0.0001$; Table 1) and all treatments surpassed 50% discoloration by day seven. At day five, meat from the corn control had the most discoloration and was as equally discolored as 50% de-oiled WDGS

Table 1. Discoloration (%) of strip loin steaks (*L. dorsi*) aged 21 days.

	Days on retail display							
Treatment	0	1	2	3	4	5	6	7
35% De-oiled WDGS	0.12	0.32	0.33	0.88	1.53	4.35^{c}	17.75^{d}	52.98^{d}
50% De-oiled WDGS	0.50	0.88	1.07	1.73	3.10	15.42^{ab}	39.50^{b}	67.75^{b}
65% De-oiled WDGS	0.28	0.60	0.75	1.00	3.43	9.38^{bc}	40.20^{b}	69.88^{ab}
35% Full-fat WDGS	0.38	0.80	1.02	1.73	2.50	4.48^{c}	25.83^{c}	67.67^{b}
50% Full-fat WDGS	0.17	1.05	0.33	0.55	1.87	11.95^{bc}	31.30^{c}	57.30^{cd}
65% Full-fat WDGS	0.50	1.50	1.15	1.67	3.75	14.98^{ab}	50.30^{a}	76.72^{a}
Corn control	0.38	1.56	1.17	2.22	6.87	20.03^{a}	31.77^{c}	60.60^{c}

$^{a\text{-}d}$Means in the same column with different superscripts are significantly different ($P \leq 0.05$).

Table 2. TBA means according to dietary treatment.

Treatment	Mean
35% De-oiled WDGS	1.12^{c}
50% De-oiled WDGS	1.13^{c}
65% De-oiled WDGS	1.21^{bc}
35% Full-fat WDGS	1.78^{ab}
50% Full-fat WDGS	1.18^{c}
65% Full-fat WDGS	1.78^{ab}
Corn control	1.98^{a}
SEM	0.14
P-value	<0.0001

$^{a\text{-}c}$Means with different superscripts are significantly different ($P \leq 0.05$).

and 65% full-fat WDGS. Some of the corn control cattle had been exposed to WDGS prior to this finishing diet study, which could explain the higher-than-anticipated results for the corn control. At day six of retail display, 65% full-fat WDGS had the most discoloration followed by 65% and 50% de-oiled WDGS. By day seven, 65% full-fat and 65% de-oiled WDGS showed the most discoloration, while 35% de-oiled WDGS presented the least discoloration.

Treatment had a significant effect on oxidation ($P < 0.0001$; Table 2), as measured by the amount of thiobarbituric acid reactive substances. The corn control was found to have the highest amount of oxidation and was not statistically different from 35% full-fat WDGS and 65% full-fat WDGS. The oxidation measures suggest that beef from cattle finished on de-oiled WDGS and 50% full-fat WDGS had less oxidation, yet these data were not in full agreement with the discoloration data.

There was an increase in tenderness with aging from seven to 21 days ($P < 0.0001$) and as retail display progressed ($P < 0.0001$), where at seven days of aging the WBSF was 3.4 kg, at 21 day aging the WBSF was 2.9 kg, and at 0 day retail display the WBSF was 3.3 kg, and at seven day retail display the WBSF was 3.1 kg. Dietary treatment had no effect on WBSF ($P = 0.57$). At seven days of aging, dietary treatment had no effect on discoloration and all samples had an increase in oxidation regardless of the treatment. However, at 21 days of aging, feeding de-oiled WDGS resulted in less oxidation compared to the corn control and several of the full-fat WDGS treatments. These findings suggest that feeding WDGS doesn't have a large impact on shelf life stability and oxidation when the meat is aged for short periods, but with prolonged aging periods and retail display, feeding de-oiled WDGS can reduce oxidation.

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[2]This project was funded in part by The Beef Checkoff.

Effect of Feeding De-oiled Wet Distillers Grains Plus Solubles on Beef Fatty Acid Profiles

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Summary

A total of 336 steers were fed one of seven finishing diets: a corn-based control, 35%, 50%, or 65% inclusion of wet distillers grains plus solubles (WDGS), either traditional (full-fat) or de-oiled. At harvest, 15 low USDA Choice carcasses within each dietary treatment (n = 105) were selected to evaluate the effect of diet on the fatty acid profile of strip loin steaks aged seven days. Feeding WDGS increased the amount of polyunsaturated fatty acids (PUFA) in comparison to a corn based diet. Feeding de-oiled WDGS resulted in less PUFA's than the full-fat WDGS diets. It seems that the removal of the soluble fat portion of WDGS is effective at reducing the PUFA content and thus has the potential to reduce lipid oxidation in beef.

Introduction

Feeding cattle wet distillers grain plus solubles (WDGS) is a common practice in Nebraska as it is a corn by-product that lowers cost of production yet has a high nutritional value. The use of WDGS does present a challenge as it increases the polyunsaturated fatty acids (PUFA) content in beef, which results in higher lipid oxidation (2008 *Nebraska Beef Cattle Report*, pp. 120-121). More recently, ethanol plants have been extracting soluble fats found in WDGS by centrifugation for other uses (2011 *Nebraska Beef Cattle Report*, pp. 96-99). It is unclear if the decreased fat content in the WDGS will potentially reduce the amount of PUFA's in the fatty acid profile of beef and subsequently reduce lipid oxidation. Thus, this research was conducted to evaluate the effect of feeding de-oiled WDGS at three levels of inclusion compared to full-fat WDGS diets and a corn control diet on the fatty acid profile of beef.

Procedure

A total of 336 steers were fed one of seven dietary treatments: a corn-based control, 35%, 50%, or 65% inclusion of either traditional (full-fat) or de-oiled WDGS. The steers were subjected to these finishing diets for 147 days and after harvest, 15 low USDA Choice carcasses were selected within each treatment (n = 105) and strip loins were obtained. Vacuum sealed loins were aged for seven days (33°F) and ½-inch steaks we fabricated and immediately vacuum packed and stored in an ultralow-freezer (-112°F) for fatty acid determination and proximate analysis.

Fatty Acid Profile

Frozen samples were diced into small pieces, with no subcutaneous fat, and flash frozen in liquid nitrogen. The nitrogen frozen pieces were powdered in a metal cup blender and 1 g of powdered sample was weighed out to conduct fatty acid determination by gas chromatography. The chromatography was done using a Chromopack CP-Sil (0.25 mm x 100 m) column with an injector temperature of 518°F and a detector temperature of 572°F. The head pressure was set at 40 psi with a flow rate of 1.0 mL/min and a temperature programing system was used. The fatty acids were identified by their retention times in relation to known standards and the percent of fatty acid was determined by the peak areas in the chromatograph.

Proximate Analysis

Fat was extracted with ether following the Soxhlet extraction procedure. Moisture and ash were determined by using the LECO thermogravimetric analyzer. Fat, moisture, and ash percentages were added and subtracted from 100% to determine the amount of protein by difference.

Statistical Analysis

The experimental design was a 2x3+1 factorial that was analyzed with the GLIMMIX procedure in SAS (SAS Institute, Inc., Cary, N.C.). Dietary treatments were separated by the LS MEANS statement with the LINES option and TUKEY adjustment with an alpha level of 0.05. Additional comparisons were made between type of feed with estimates and contrasts statements.

Results

The proximate analysis data reflected that there were no differences in moisture ($P = 0.44$), fat ($P = 0.36$), protein ($P = 0.11$), or ash ($P = 0.89$) content in the beef from the seven dietary treatment. The overall averages for the nutritional constituents were: 71.70% moisture, 6.48% fat, 20.26% protein, and 1.56% ash.

Table 1 provides the fatty acid profiles of all the dietary treatments. Significant differences were found in the C16:1 fatty acid ($P < 0.0001$). The C16:1 fatty acid was prevalent in the corn control along with the 35% de-oiled WDGS diets. This fatty acid

Table 1. Amount[1] of fatty acids from steers feed different inclusion levels of de-oiled or full-fat WDGS (*L. dorsi*)

	Treatment								
	De-oiled WDGS			Full-Fat WDGS			Corn		
Fatty Acid	35%	50%	65%	35%	50%	65%	Control	SEM	*P*-value
C14:0	156.49	139.36	150.35	171.89	155.00	162.89	180.61	12.98	0.3583
C14:1	33.03	29.98	28.01	33.35	27.36	30.37	40.66	3.37	0.1017
C15:0	32.17	26.78	29.08	32.30	31.71	30.59	31.90	2.57	0.7120
C15:1	35.15	28.32	30.45	30.27	29.01	30.73	33.55	2.26	0.3346
C16:0	1588.06	1364.32	1501.57	1706.01	1543.98	1609.64	1679.52	102.47	0.2779
C16:1	149.67^{ab}	132.58^{b}	115.32^{b}	145.11^{b}	120.71^{b}	128.23^{b}	194.26^{a}	10.68	< 0.0001
C17:0	103.35	86.42	93.81	103.89	104.32	98.18	98.83	7.78	0.6498
C17:1	73.43	64.38	59.95	66.60	65.26	61.78	80.07	5.51	0.1441
C18:0	1017.22	874.61	1029.27	1126.37	1109.31	1119.00	927.89	71.84	0.0917
C18:1T[2]	156.98^{ab}	170.91^{ab}	227.49^{ab}	248.40^{a}	248.03^{a}	256.20^{a}	120.12^{b}	26.89	0.0011
C18:1	2514.37	2180.72	2243.01	2697.93	2383.59	2514.37	2590.88	164.98	0.2807
C18:1V[3]	252.13	245.10	256.12	268.89	255.38	288.60	318.34	19.13	0.1003
C18:2	227.16^{b}	231.08^{ab}	287.89^{a}	294.87^{a}	279.78^{a}	301.36^{a}	177.70^{b}	19.49	< 0.0001
C18:3	0.00	5.59	8.63	10.06	12.03	8.94	0.00	2.28	0.5162
C20:1	31.94	26.69	28.58	38.48	30.85	33.51	30.89	3.24	0.2089
C20:4	47.62	42.39	45.41	45.33	42.77	45.83	46.29	2.13	0.5880
C22:0	18.31	14.51	14.83	16.10	14.39	16.09	12.04	1.48	0.2383
Total	6414.15	5637.85	6134.96	7005.20	6427.48	6692.61	6545.69	406.10	0.3469
SFA	2901.25	2494.55	2811.00	3151.19	2947.00	3024.60	2947.00	189.54	0.3260
UFA	3512.90	3143.30	3323.96	3854.01	3480.48	3668.00	3624.53	220.86	0.3595
SFA:UFA	0.82	0.79	0.85	0.82	0.85	0.83	0.81	0.02	0.1640
MUFA	3238.13	2869.46	2988.93	3512.47	3156.32	3320.22	3400.54	206.62	0.3107
PUFA	273.77^{ab}	273.84^{ab}	335.03^{a}	341.54^{a}	324.15^{a}	347.79^{a}	223.98^{b}	20.75	0.0002

[1]Amount (mg/100g tissue) of fatty acid in powdered loin sample determined by gas chromatography.
[2]C18:1T is the trans elaidic acid.
[3]C18:1V is the cis vaccinic acid.
[a,b]Means in the same row with different superscripts are significantly different ($P < 0.05$).

was found in significantly less amount in the 50% and 65% de-oiled and all full-fat WDGS diets.

Differences were observed in two of the 18 carbon fatty acids: C18:1T and C18:2. The C18:1T fatty acid showed a higher concentration in the de-oiled and full-fat WDGS ($P = 0.0011$). This indicates that WDGS, regardless of the fat content in the feed, will increase the C18:1T fatty acid concentrations in relation to a corn control diet. The C18:2 fatty acid was found in higher amount in the three full-fat WDGS and was not statistically different than the amount found in the 50% and 65% de-oiled WDGS. The 35% de-oiled WDGS and the corn control had significantly less C18:2 ($P < 0.0001$).

No differences were seen in the amounts of monounsaturated fatty acids (MUFA), saturated fatty acids (SFA), unsaturated fatty acids (UFA), the SFA:UFA relation, or the total amount of fatty acids.

Significant difference was seen with the PUFA content ($P = 0.0002$). The corn control had the least amount of PUFA's (223.98 mg/100g). The 35% and 50% de-oiled WDGS diets (273.77 and 273.84 mg/100g, respectively) had intermediate PUFA values that were not statistically different than the corn control or the remaining diets. This indicates that 65% de-oiled WDGS and the three full-fat WDGS had the most elevated PUFA contents but were not statistically different than the 35% and 50% de-oiled dietary treatments. Therefore, the lowest PUFA content was obtained with the corn control diet and the lower inclusion levels of the de-oiled feeds, confirming the increase in PUFA's typically associated with the feeding of WDGS.

Table 2 summarizes the fatty acid profiles of the de-oiled WDGS, full-fat WDGS, and corn control diets averaged across dietary inclusion of WDGS. The corn control had significantly higher concentrations of C14:1 and C16:1 fatty acids in relation to the de-oiled and full-fat WDGS. The C17:1 fatty acid was found in higher amounts in the corn control and in least amount in the full-fat WDGS, while the de-oiled WDGS had an intermediate amount that was not statistically different from the corn control or the full-fat WDGS. The de-oiled WDGS had the least amount of C18:0. The full-fat WDGS had the most C18:1T and had an intermediate amount of C18:1V where the corn control was the highest and the de-oiled WDGS were the lowest. The C18:2 fatty acid was most abundant in the full-fat WDGS, followed by the de-oiled WDGS and lastly the corn control. This same trend was seen in the PUFA content, where, the highest amount was obtained with the full-fat WDGS (337.83 mg/100g), followed by

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the de-oiled WDGS (294.55 mg/100g), and lastly the corn control (223.98 mg/100g) was the lowest; and they were all significantly different from each other (P <0.0001).

These findings confirm that feeding WDGS increases the amount of PUFA's in comparison to a corn based diet. Feeding de-oiled WDGS resulted in less PUFA's than all full-fat diets. It seems that the removal of the soluble fat portion of WDGS is effective at reducing the PUFA content and thus has the potential to reduce lipid oxidation in beef.

[1] Katherine I. Domenech, graduate student; Kim A. Varnold, graduate student; Michelle E. Semler, graduate student; Michael D. Chao, graduate student; Tommi F. Jones, laboratory technician; Galen E. Erickson, professor; Chris R. Calkins, professor, University of Nebraska–Lincoln Department of Animal Science.

[2] This project was funded in part by The Beef Checkoff.

Table 2. Amount[1] of fatty acids from steers feed de-oiled or full-fat WDGS and a corn control (*L. dorsi*).

	Dietary Treatment			
Fatty Acid	De-oiled	Full-fat	Corn Control	*P*-value
C14:0	148.73	163.26	180.61	0.0842
C14:1	30.29[b]	30.43[b]	40.66[a]	0.0179
C15:0	29.34	31.53	31.90	0.5012
C15:1	31.38	30.00	33.55	0.3861
C16:0	1484.65	1619.88	1679.52	0.1443
C16:1	132.53[b]	131.35[b]	194.26[a]	< 0.0001
C17:0	94.53	102.13	98.83	0.4858
C17:1	65.92[ab]	64.55[b]	80.07[a]	0.0460
C18:0	973.70[b]	1118.23[a]	927.89[a]	0.0170
C18:1T	185.13[b]	250.93[a]	120.12[b]	< 0.0001
C18:1	2312.70	2524.11	2590.88	0.1884
C18:1V	251.12[b]	270.96[ab]	318.34[a]	0.0106
C18:2	248.71[b]	292.00[a]	177.70[c]	< 0.0001
C18:3	7.87	10.62	0.00	0.1563
C20:1	29.03	34.36	30.89	0.1249
C20:4	45.14	44.64	46.29	0.7992
C22:0	15.76	15.65	12.04	0.2099
Total	6062.32	6708.43	6545.69	0.1424
SFA	2735.60	3040.93	2921.16	0.1439
UFA	3326.72	3667.50	3624.53	0.1475
SFA:UFA	0.82	0.83	0.81	0.3533
MUFA	3032.18	3329.67	3400.54	0.1332
PUFA	294.55[b]	337.83[a]	223.98[c]	< 0.0001

[1]Amount (mg/100g tissue) of fatty acid in powdered loin sample determined by gas chromatography
[a,b,c]Means in the same row with different superscripts are significantly different ($P < 0.05$)

Nutrient and Tenderness Differences of Beef from Heifers Due to Mutation of the Myostatin Gene

Michelle E. Semler
Chris R. Calkins
Galen E. Erickson[1]

Summary

Strip loins and eye of rounds were obtained from heifers genotyped with variations of the myostatin gene; 19 homozygous dominant (Angus), 20 heterozygous dominant (Angus x Piedmontese), and 20 homozygous recessive (Piedmontese). Steaks were aged for 14 days, cooked fresh (never frozen), and nutrient steaks were frozen three days postmortem. Meat from homozygous recessive heifers was equal in tenderness to homozygous dominant and heterozygous dominant heifers. Fat content of meat from homozygous recessive heifers decreased while moisture and protein increased compared to homozygous dominant and heterozygous dominant. Calorie content decreased with increasing copies of the recessive gene. Thus, meat from the homozygous recessive cattle was leaner, yet equal in tenderness, to the meat from homozygous dominant cattle.

Introduction

Piedmontese cattle possess a genetic mutation of the myostatin gene, commonly known as double muscling, that results in a dramatic increase in overall muscle mass due to myostatin being unable to regulate/control myogenesis (muscle growth). The increase in muscle mass is due to increase muscle fiber number and, in turn, results in cattle yielding heavier muscled carcasses that are also leaner compared to conventionally raised cattle that do not possess a myostatin mutation. A question within the beef industry is the impact of the mutated myostatin gene on beef tenderness due to increased muscle mass and decreased overall fat content. It was hypothesized that meat from homozygous recessive heifers would be equal in tenderness to homozygous dominant and heterozygous dominant. Thus, the study was conducted to compare tenderness, nutritional, and compositional differences of meat from heifers due to mutation of the myostatin gene.

Procedure

The current study included 59 yearling heifers genotyped and placed into categories based of the myostatin gene that each possessed. Genotypes were confirmed using DNA testing as homozygous dominant (normal myostatin gene; Angus), heterozygous dominant (partially recessive gene; Angus x Piedmontese), and homozygous recessive (mutated myostatin gene; Piedmontese), (n = 19, 20, and 20, respectively). Animals were individually fed a common finishing diet for 191 days using Calan electronic gates at the University of Nebraska–Lincoln Agricultural Research and Development Center (ARDC) Research Feedlot. Heifers received no implants or feed additives to fulfill their requirement in an all-natural feeding program.

At three days postmortem strip loin and eye of round samples were collected from the left side of each carcass. Steaks for nutrient analysis (proximate, lipid, and mineral content) were cut to 0.5-inch thick from each eye of round and strip loin, trimmed to .125-inch subcutaneous fat, and frozen. In most instances, homozygous recessive animals had less than 0.125-inch of subcutaneous fat and did not require trimming. Steaks for Warner-Bratzler Shear Force (WBSF) were cut to 1-inch thickness, vacuum packaged, and after 14 days of aging were cooked fresh/never frozen. Shear force steaks were cooked on a Hamilton Beach Indoor-Outdoor Grill and initial temperature and weight were recorded for each steak. Steaks were cooked to an internal temperature of 95°F and were then turned over and allowed to finish cooking on the other side until the internal temperature reached 160°F. After completion of cooking, steaks were weighed once more for final weight so that cook loss could be calculated. Steaks were wrapped in oxygen-permeable film and placed in a 39°F cooler overnight. The following morning steaks were removed from the cooler and six cores (0.5 inch in diameter) were taken from each steak parallel to the muscle fiber using a Delta Drill Press followed by shearing on a tabletop Warner-Bratzler Shear Force Machine.

Data were analyzed using ANOVA in PROC GLM in SAS (Version 9.2) (SAS Institute, Inc., Cary, N.C.). Fixed effects were the inactive myostatin mutation and random effects were the animal used. Separation of means was determined using LS MEANS and DIFF LINES option of SAS with significance determined at $P \leq 0.05$.

Results

With increasing copies of the recessive myostatin gene, overall fat content decreased ($P < 0$ .001) and percent protein increased ($P < 0.001$) (Tables 1 and 2), which is expected as Piedmontese cattle yield heavier muscled carcasses compared to cattle that do not possess a myostatin mutation. Fat contains little to no moisture and thus with increasing copies of the recessive myostatin gene moisture content increased ($P < 0.001$) while caloric content decreased ($P < 0.001$) with increasing copies. Steaks from homozygous recessive heifers had greater cholesterol content ($P \leq 0.001$) than homozygous dominant. Cholesterol helps stabilize the cell membrane

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and with Piedmontese cattle having an increase in muscle mass due to increase muscle cell numbers (hyperplasia) an increase in cholesterol concentration is needed to stabilize the increase in cells. Saturated fatty acids and monounsaturated fatty acids decreased ($P < 0.001$) with increasing copies of the recessive gene for myostatin, while strip loin steaks from homozygous recessive heifers had a lower ($P < 0.001$) trans fatty acid concentration compared to heterozygous dominant and homozygous dominant. Polyunsaturated fatty acid concentration decreased ($P < 0.001$) in eye of round samples with increasing copies of the recessive myostatin gene, while strip loin samples from homozygous dominant heifers had a greater ($P < 0.001$) polyunsaturated fatty acid concentration than heterozygous dominant and homozygous recessive samples. Mineral analysis showed increased potassium levels ($P < 0.001$) and increased calcium ($P < 0.001$) for homozygous recessive compared to homozygous dominant and heterozygous dominant. There were no differences in WBSF values (Table 3) detected for strip loin ($P = 0.16$) and eye of round ($P = 0.19$) samples. This indicates that meat from homozygous recessive heifers is leaner, yet equivalent in tenderness, to homozygous dominant and heterozygous dominant heifers.

In conclusion, steaks from homozygous recessive cattle had a decreased fat content, greater cholesterol, and decreased concentration of saturated, monounsaturated, polyunsaturated, and trans fatty acid, and greater protein levels when compared to homozygous normal cattle. As hypothesized, beef from homozygous recessive heifers is equivalent in tenderness when compared to homozygous dominant and heterozygous dominant recessive cattle even though the product is leaner.

[1]Michelle E. Semler, graduate student; Chris R. Calkins, professor; Galen E. Erickson, professor, University of Nebraska–Lincoln Department of Animal Science, Lincoln, Neb.

Table 1. Proximate, lipid, and mineral analysis of strip loin.

		Genotype				
	Unit	MM	Mm	mm	SEM	*P*-value
Number of Loins Analyzed		19	20	20		
Proximate Analysis						
Moisture	%	57.00[c]	62.29[b]	67.27[a]	0.603	< 0.001
Protein	%	19.65[c]	20.88[b]	22.32[a]	0.257	< 0.001
Fat	%	21.48[a]	15.96[b]	9.46[c]	0.728	< 0.001
Ash	%	0.50[b]	0.74[a]	0.81[a]	0.046	< 0.001
Carbohydrates	%	0.66	0.48	0.59	0.135	0.69
Calories	kCal	306.58[a]	255.90[b]	197.30[c]	6.627	< 0.001
Lipid Analysis						
Cholesterol	mg/100g	42.26[c]	46.65[b]	49.70[a]	1.100	< 0.001
Saturated Fatty Acids	mg/100g	9.64[a]	7.19[b]	4.37[c]	0.458	< 0.001
Monounsaturated Fatty Acids	mg/100g	10.85[a]	7.92[b]	4.36[c]	0.539	< 0.001
Polyunsaturated Fatty Acids	mg/100g	0.75[a]	0.64[b]	0.59[b]	0.038	< 0.001
Trans Fatty Acids	mg/100g	0.23[a]	0.21[a]	0.14[b]	0.018	< 0.001
Mineral Analysis						
Sodium	mg/kg	381.82[b]	401.68[a]	404.39[a]	5.915	0.02
Potassium	mg/kg	2597.21[c]	2939.90[b]	3134.65[a]	37.978	< 0.001
Calcium	mg/kg	69.77[c]	85.96[b]	94.23[a]	2.714	< 0.001
Iron	mg/kg	13.26	14.76	14.10	0.511	0.125

[abc]Means with different superscripts within the same row are considered different $P \leq 0.05$.
[1]Myostatin: homozygous active (MM), heterozygous partially recessive (Mm), and homozygous recessive inactive (mm).

Table 2. Proximate, lipid, and mineral analysis of eye of round.

		Genotype				
	Unit	MM	Mm	mm	SEM	*P*-value
Number of Eyes Analyzed		19	20	20		
Proximate Analysis						
Moisture	%	65.21[c]	69.38[b]	72.78[a]	0.449	< 0.001
Protein	%	20.79[c]	22.73[b]	23.68[a]	0.218	< 0.001
Fat	%	12.85[a]	6.91[b]	2.08[c]	0.590	< 0.001
Ash	%	0.91[b]	0.67[c]	1.04[a]	0.044	< 0.001
Carbohydrates	%	0.45	0.57	0.80	0.144	0.22
Calories	kCal	224.16[a]	173.30[b]	129.20[c]	5.258	< 0.001
Lipid Analysis						
Cholesterol	mg/100g	41.47[c]	43.70[b]	48.55[a]	0.724	< 0.001
Saturated Fatty Acids	mg/100g	5.52[a]	3.00[b]	0.88[c]	0.362	< 0.001
Monounsaturated Fatty Acids	mg/100g	6.71[a]	3.44[b]	0.94[c]	0.435	< 0.001
Polyunsaturated Fatty Acids	mg/100g	0.49[a]	0.40[b]	0.23[c]	0.034	< 0.001
Trans Fatty Acids	mg/100g	0.13[a]	0.08[b]	0.03[c]	0.010	< 0.001
Mineral Analysis						
Sodium	mg/kg	368.94	373.89	373.31	5.280	0.77
Potassium	mg/kg	3091.16[c]	3398.40[b]	3529.20[a]	35.151	< 0.001
Calcium	mg/kg	61.80[b]	61.48[b]	67.01[a]	1.912	0.007
Iron	mg/kg	15.35[a]	14.60[a]	12.49[b]	0.315	< 0.001

[abc]Means with different superscripts within the same row are considered different $P \leq 0.05$.
[1]Myostatin: homozygous active (MM), heterozygous partially recessive (Mm), and homozygous recessive inactive (mm).

Table 3. Tenderness (shear force) and cooking loss of strip and eye of round steaks.

	Genotype				
	MM	Mm	mm	SEM	*P*-value
Strip Steak Cooking Loss (%)	14.35[b]	21.19[a]	15.96[b]	1.254	< 0.001
Strip Steak Shear Force (kg)	2.62	3.08	2.82	0.097	0.16
Eye of Round Cooking Loss (%)	23.16	26.14	27.00	1.551	0.19
Eye of Round Shear Force (kg)	3.60	3.70	3.45	0.117	0.29

[abc]Means with different superscripts within the same row are considered different $P \leq 0.05$.
[1]Myostatin: homozygous active (MM), heterozygous partially recessive (Mm), and homozygous recessive inactive (mm).

Vein Steak Differences in Strip Loins of Heifers Due to Mutation of the Myostatin Gene

Michelle E. Semler
Chris R. Calkins
Galen E. Erickson[1]

Summary

Strip loins from heifers with variations of the myostatin gene; 19 homozygous dominant (Angus), 20 heterozygous dominant (Angus x Piedmontese), and 20 homozygous recessive (Piedmontese) were studied. Strip loins were cut into 1-inch thick steaks and total number of steaks and number of steaks with Gluteus medius *(often called vein steaks) were recorded. Strip loins from heterozygous dominant heifers had a greater number of non-vein steaks and decreased percentage of vein steaks compared to homozygous dominant and homozygous recessive samples. Differences in percentage of vein steaks were inconsistent and showed no meaningful pattern.*

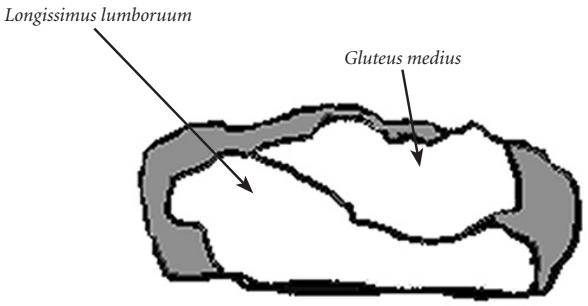

Figure 1. Illustration showing vein steak from posterior end of strip loin.

Introduction

Piedmontese cattle possess a recessive myostatin gene mutation that is a regulator of myogensis (muscle growth) and leads to an increase in muscle mass due to increase muscle fiber number (hyperplasia). Cattle that are homozygous recessive for the myostatin gene have approximately twice the number of muscle fibers when compared to conventionally produced cattle (Kambadur, et al., *Genome Research,* 1997). Within heterozygous dominant cattle the myostatin allele is known as "partially recessive" and some noticeable differences in muscularity are observed (Kambadur, et al., *Genome Research,* 1997).

Toward the posterior end of the strip loin the *Gluteus medius* increases in size while the *Longissimus lumborum* decreases in size and narrows. Strip loin steaks that contain the *Gluteus medius* also include a piece of connective tissue separating the *Glutues medius* from the *Longissumus lumborum.* These steaks, known as vein steaks (Figure 1), are lower in value and have decreased tenderness compared to strip steaks without the *Glutues medius.* Therefore, this study was conducted to compare amount and musculature differences within the strip loin of heifers due to the inactive myostatin mutation.

Procedure

Yearling heifers were divided into categories based on the myostatin gene that each animal possessed. Fifty-nine heifers were studied with 19 identified as homozygous dominant (Angus) for the myostatin allele (active myostatin gene), 20 were carriers (Angus x Piedmontese) of heterozygous allele (partially recessive myostatin gene), and 20 homozygous recessive (mutated myostatin gene; Piedmontese). Genotypes of heifers were confirmed using DNA testing. Heifers were delivered to the University of Nebraska–Lincoln Agricultural Research and Development Center (ARDC) Research Feedlot and individually fed a common finishing diet for 191 days using Calan electronic gates. Cattle received no implants or feed additives to fulfill the requirements of an all-natural feeding program. Cattle were harvested and at three days postmortem strip loins were collected from the left side of carcasses. Strip loins were measured for loin weight, loin length, sirloin face width, rib face width, sirloin tail length, rib tail length, and fat thickness at the rib face prior to loins being fabricated. Strip loins were then cut into 1-inch thick steaks where total number of steaks, total number of vein steaks (those containing the *Gluteus medius*), total number of non-vein steaks, and weight of each steak were recorded.

Data were analyzed within a completely randomized design using ANOVA in PROC GLM in SAS (Version 9.2) (SAS Institute, Inc., Cary, N.C.) with the fixed effects being the different myotatin mutations and random effects was animal used. Separation of means was determined using LS MEANS and DIFF LINES options of SAS, with significance determined at $P \leq 0.05$.

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Results

With increasing copies of the recessive gene for myostatin, fat thickness (Table 1) decreased ($P < 0.001$). Homozygous recessive heifers yielded shorter loins ($P < 0.001$) and possessed a wider rib face ($P < 0.001$) compared to strip loins genotyped as homozygous dominant and heterozygous dominant. There were no differences for overall loin weight, sirloin face width, sirloin tail length, and rib tail length.

When total number of steaks were compared (Table 2) strip loins from homozygous recessive heifers yielded fewer total steaks ($P < 0.001$) compared to heterozygous dominant, which was expected as they were shorter in length. The strip loins from heterozygous dominant heifers had a greater number of non-vein steaks ($P = 0.002$), and a lower percentage of vein steaks ($P = 0.01$) compared to homozygous dominant and homozygous recessive. The differences observed in percent vein steaks was inconsistent across genotypes and showed no meaningful patters. Overall mean steak weight, total weight of vein steaks, average steak weight, and percent weight of vein steaks did not differ among the genotypes.

Table 1. Heifer dimensional measurements of strip loin from cattle MM, Mm, or mm genotype of the myostatin gene.

	Number of Inactive Myostatin Alleles				
Measurements	MM	Mm	mm	SEM	*P*-value
Fat Thickness (in)	0.55[a]	0.32[b]	0.19[c]	0.033	< 0.001
LoinWeight (kg)	6.62	6.77	6.59	0.188	0.77
Loin Length (in)	15.81[a]	15.80[a]	14.74[b]	0.193	< 0 .001
Sirloin Face Width (in)	9.97	9.68	9.96	0.116	0.13
Rib Face Width (in)	7.46[b]	7.75[b]	8.41[a]	0.123	< 0 .001
Sirloin Tail Length (in)	2.95	3.08	1.86	0.400	0.06
Rib Tail Length (in)	1.18	1.25	1.17	0.046	0.39

[abc]Means with different superscripts within the same row are considered different $P \leq 0.05$.
[1]Myostatin: homozygous active (MM), heterozygous partially recessive (Mm), and homozygous recessive inactive (mm).

Table 2. Heifer number, weight, and proportion of vein steaks from strip loins of cattle MM, Mm, or mm genotype of the myostatin gene.

	Number of Inactive Myostatin Alleles				
Steak Trait	MM	Mm	mm	SEM	*P*-value
Number of Loins Analyzed	19	20	20		
Total Steaks	12.63[ab]	13.05[a]	12.40[b]	0.177	0.03
Number Vein Steaks	4.10	3.70	3.85	0.132	0.09
Non-Vein Steaks	8.53[b]	9.35[a]	8.85[b]	0.179	0.002
Average Steak Weight (g)	514.91	497.77	506.09	11.233	0.55
% of Vein Steaks in Loin	32.47[a]	28.32[b]	31.17[a]	1.011	0.01
Combined Weight of Steaks (g)	6490.16	6513.00	6284.40	157.350	0.52
Total Weight of Vein Steaks (g)	2123.68	1996.00	1888.80	79.789	0.12
% Weight of Vein Steaks	32.55	30.73	30.32	1.089	0.31

[abc]Means with different superscripts within the same row are considered different $P \leq 0.05$.
[1]Myostatin: homozygous active (MM), heterozygous partially recessive (Mm), and homozygous recessive inactive (mm).

[1]Michelle E. Semler, graduate student; Chris R. Calkins, professor; Galen E. Erickson, professor, University of Nebraska-Lincoln Department of Animal Science, Lincoln, Neb.

The Effects of Diet and Cooler Aging on Specific Flavor Notes in Beef

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Summary

Crossbred steers (n = 64) were grazed on warm- or cool-season grass-dominated pastures, without or with energy supplementation of wet distillers grains with solubles (WDGS), and were finished on a corn-based diet with or without 35% WDGS. Finishing on corn increased desirable flavor notes and decreased undesirable flavor notes in both L. dorsi *and* B. femoris *steaks. In addition, grazing on warm-season grasses increased the prevalence of undesirable flavors but was often dissipated by the addition WDGS supplementation. Longer aging periods tended to increase the prevalence of undesirable flavors, especially in* B. femoris *steaks. It is recommended producers provide WDGS supplementation, especially when grazing on warm-season grasses, and finish on an all corn diet in order to create a favorable flavor palate.*

Introduction

Flavor is an important attribute when describing beef desirability. Beef flavor is not made up of just one element but of many different flavor notes combined. Specific flavor notes in beef can be changed by the diet fed to cattle and by the amount of time the meat is aged.

Jenschke et al. (*Journal of Animal Science*, 2008, 86:949-959) found that when low levels of alfalfa are fed, the prevalence of a bloody flavor becomes stronger. Senaratne et al. (*2010 Nebraska Beef Cattle Report*, pp. 101-103) showed a higher degree of liver and/or off-flavor in meat from cattle fed wet distillers grains with solubles as opposed to corn. These differences were only found after the meat had been aged in a retail display for seven days, showing that aging periods also may play a role in flavor development.

The objective of this study was to evaluate how beef flavor notes are affected in two different muscles from cattle grazing different forages post-weaning, with or without supplement, finished on either corn or 35% wet distillers grains plus solubles (WDGS) diet, and aged for 7 or 28 days.

Procedure

Crossbred steers (n = 64) were allowed to graze from April 17, 2012, until Oct. 10, 2012, (177 days) on warm-season grasses at the Barta Brothers Ranch in the Eastern Sandhills of Nebraska or on cool-season pastures near Ithaca, Neb., without or with energy supplementation of WDGS (0.6% BW/ day). After the grazing period, cattle were finished on a corn-based diet with or without 35% WDGS for 119 days to an average live weight of 1,427 lb. Cattle were harvested at Greater Omaha Packing, Co. in Omaha, Neb.

Six carcasses from each treatment (n = 48) that graded USDA Choice or Select were identified and *Longissimus dorsi (L. dorsi)* and *Biceps femoris* (*B. femoris*) muscles from each side of each carcass were collected and aged under vacuum for 7 and 28 days. Upon fabrication, one steak was cut from each subprimal, placed on a Styrofoam tray, wrapped with oxygen-permeable overwrap film, and placed under simulated retail display for seven days. At the end of retail display, steaks were vacuumed packaged and frozen until further use in flavor lexicon taste panels at Texas A&M University.

All lexicon panels were approved by the Institutional Review Board. An expert, trained descriptive attribute sensory panel with over 23 cumulative years of experience in evaluating beef flavor and aromas was used. The panel underwent ballot development, training, and validation sessions to assure consistent rating and identification of individual aroma and flavor attributes.

During training and testing, steaks were cooked on a Hamilton Beach Health Smart® grill (model 31605A, Hamilton Beach/Proctor-Silex, Inc., Southern Pines, N.C.) to an internal temperature of 70°F. Aromas and flavor aromatics were evaluated using the Spectrum® Universal 16-point scale where 0 = none and 15 = extremely intense. Traits evaluated were browned, bloody, fat, metal, liver, green hay, umami, overly sweet, sweet, sour, salty, bitter, sour aroma, barnyard, burnt, heated oil, chemical, apricot, asparagus, cumin, floral, beet, chocolate, green grass, musty, medicinal, petroleum, smoked/charred, smoked wood, spoiled, dairy, buttery, cooked milk, sour milk, refrigerator stale, warmed over, soapy, painty, fishy, and cardboardy. Browned, fat, umami, sweet, salty, chocolate, smoked wood, and buttery were considered desirable flavors and the others were considered undesirable.

Data were analyzed using the Mixed procedure in SAS (SAS Institute, Inc., Cary, N.C.) with differences determined at $P \leq 0.05$. Whenever there was a three- or four-way interaction, the LSmeans were reanalyzed using the GLIMMIX procedure with the slicediff option in order to more accurately study differences.

Results

Lexicon scores for *L. dorsi* steaks had two significant ($P \leq 0.04$) three-way interactions — grass type, finishing diet, and aging period — for fat scores and supplementation, diet, and aging period for bloody scores.

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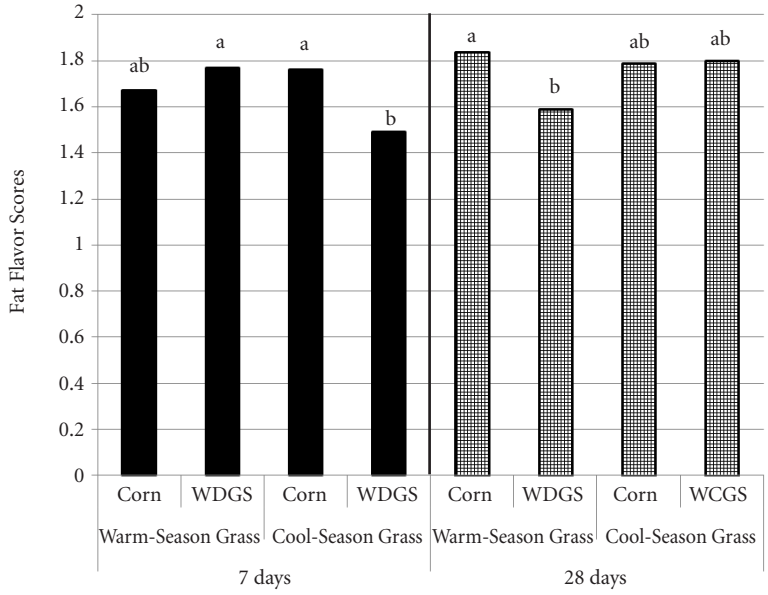
At seven days aging, the prevalence of fat flavor was weaker ($P = 0.02$) when cattle were grazed on cool-season grasses and finished on WDGS than when they were grazed on cool-season grasses and finished on corn or grazed on warm-season grasses and finished on WDGS (Figure 1). Conversely, when the meat was aged for 28 days, meat from cattle grazed on warm-season grasses had a stronger fat flavor when finished on corn instead of WDGS, with no differences within cool-season grass grazing.

For bloody flavor, of seven-day aged *L. dorsi* steaks, not supplementing and finishing on WDGS caused the highest scores ($P = 0.04$) compared to all other supplementation and finishing diet combinations (Figure 2). Following the 28 day aging periods, there were no differences in bloody flavor scores between any supplementation and finishing diet combinations. It would appear that the longer aging allows flavor differences caused by supplementation and finishing diet to dissipate. In addition, following the seven day aging period, beef from cattle finished on WDGS had low scores for fat flavor and high scores for bloody flavor. This suggests that desirable flavors are weaker at a shorter aging period while undesirable flavor are more intense. After a longer aging period it would appear that these differences are reduced.

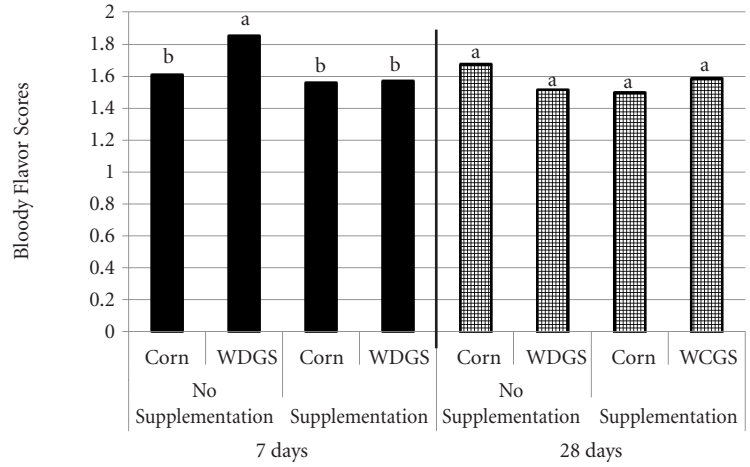
Not supplementing while grazing on warm-season grasses caused the highest liver flavor scores in *L. dorsi* steaks ($P = 0.03$) compared to all other grass type and supplementation combinations (Figure 3). Grazing on warm-season grass and aging to 28 days also caused higher liver scores (Figure 4). Clearly, grass type is a key factor in the development of liver flavor, an undesirable flavor, in beef.

Finishing on corn significantly increased ($P = 0.04$) the sweet flavor intensity and decreased ($P = 0.002$) warmed over flavor (Table 1). Thus, corn tended to promote desirable flavors while dissipating undesirable flavors. Liver flavor was not influenced by finishing diet ($P = 0.56$).



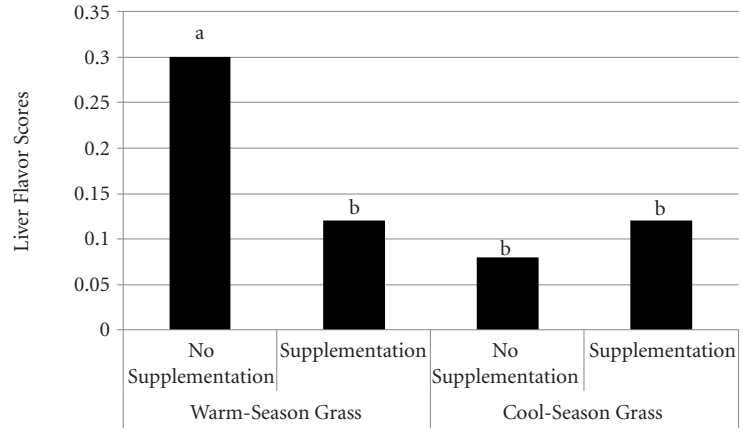
[ab]Means within the same aging period with the different superscripts are significantly ($P \leq 0.05$) different

Figure 1. The effect of grass type, finishing diet, and aging period on the LS means of fat flavor scores when separated by aging period in *L. dorsi* steaks ($P = 0.02$).



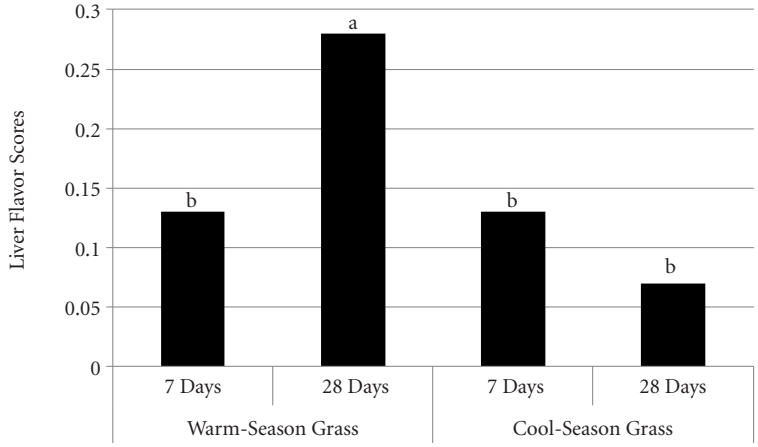
[ab]Means within the same aging period with the different superscripts are significantly ($P \leq 0.05$) different

Figure 2. The effect of supplementation, finishing diet, and aging period on the LS means of bloody flavor scores when separated by aging period in *L. dorsi* steaks ($P = 0.04$).



[ab]Means with different superscripts are significantly ($P \leq 0.05$) different

Figure 3. The effect of grass type and supplementation on the LS means of liver flavor scores in *L. dorsi* steaks ($P = 0.03$).



[ab]Means with different superscripts are significantly ($P \leq 0.05$) different

Figure 4. The effect of grass type and aging period on the LS means of liver flavor scores in *L. dorsi* steaks ($P = 0.04$).

Table 1. The effect of finishing diet on the LS means for select beef lexicon scores for *L. dorsi* steaks.

	Finishing Diet			
Trait	Corn	WDGS[1]	SEM	*P*-value
Brown	1.88	1.76	0.07	0.20
Bloody	1.59	1.63	0.04	0.43
Fat	1.77	1.66	0.05	0.10
Metal	1.70	1.73	0.04	0.59
Liver	0.14	0.17	0.04	0.56
Sweet	1.07[a]	0.94[b]	0.04	0.04
Sour	1.33	1.39	0.04	0.25
Salty	1.40	1.36	0.03	0.37
Bitter	1.12	1.11	0.03	0.99
Burnt	0.12	0.09	0.02	0.52
Smoked Wood	0.01	0.01	0.01	0.98
Buttery	0.08	0.09	0.02	0.91
Sour Milk	0.07	0.03	0.02	0.28
Warmed Over	0.06[b]	0.24[a]	0.04	0.002
Painty	0.004	0.000	0.003	0.32
Fishy	0.01	0.03	0.01	0.13

[1]WDGS = Wet distillers grains with solubles.
[ab]Means within the same treatment and the same row with different superscripts are different ($P \leq 0.05$).

For *B. femoris* steaks, the least desirable flavor notes were associated with warm-season grasses (liver, bloody, metallic, and sour), most of which were improved with supplementation. Aging increased painty, sour milk, and bitter flavors (Table 2). For this muscle, it appears that longer aging periods actually promote undesirable flavors, which is different from what was seen in *L. dorsi* steaks. Muscles from the round, such as the *B. femoris*, contain less marbling. The marbling in the *L. dorsi* steaks could be masking any off-flavors that are present, even after aging. Since there is less marbling in *B. femoris*, any undesirable flavors that are magnified due to aging would be even stronger because there is nothing there to hide them.

These data suggest that beef flavor is best established with cool season grasses, feeding WDGS as an energy supplement during grazing, and finishing on corn. Shorter aging periods appear to reduce off-flavor development.

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Table 2. The effect of grass type and aging period on LS means for select beef lexicon scores for *B. femoris* steaks

	Grass Type				Aging Periods			
Trait	Warm-season	Cool-season	SEM	*P*-value	7 Days	28 Days	SEM	*P*-value
Brown	1.67[b]	1.83[a]	0.06	0.04	1.70	1.80	0.06	0.19
Bloody	1.77[a]	1.62[b]	0.05	0.02	1.70	1.68	0.05	0.80
Fat	1.72	1.72	0.05	1.00	1.70	1.74	0.05	0.55
Metal	2.01	1.91	0.04	0.09	1.95	1.98	0.04	0.57
Liver	0.38[a]	0.17[b]	0.05	0.0004	0.23	0.32	0.04	0.16
Sweet	0.83	0.90	0.04	0.23	0.90	0.83	0.04	0.23
Sour	1.53[a]	1.37[b]	0.04	0.01	1.40	1.50	0.04	0.09
Salty	1.37	1.41	0.03	0.34	1.43	1.35	0.03	0.10
Bitter	1.41	1.41	0.04	0.94	1.30[b]	1.52[a]	0.04	<0.0001
Burnt	0.15	0.20	0.03	0.27	0.14	0.22	0.03	0.10
Smoked Wood	0.008	0.000	0.004	0.16	0.008	0.000	0.004	0.16
Buttery	0.05	0.04	0.01	0.84	0.04	0.05	0.01	0.84
Sour Milk	0.09	0.09	0.03	1.00	0.05[b]	0.13[a]	0.03	0.05
Warmed Over	0.54	0.59	0.06	0.53	0.51	0.62	0.06	0.23
Painty	0.02	0.06	0.02	0.07	0.01[b]	0.07[a]	0.02	0.01
Fishy	0.05	0.04	0.02	0.50	0.03	0.07	0.02	0.09

[ab]Means within the same treatment and the same row with different superscripts are different ($P \leq 0.05$).

Grass Type, Grazing Supplementation, and Finishing Diets Affect Beef Fatty Acids

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Summary

Crossbred steers (n = 64) were grazed on warm- or cool-season grasses, without or with energy supplementation of wet distillers grains with solubles (WDGS), and were finished on a corn-based diet with or without 35% WDGS. Grass type was the major contributor in determining the fatty acid profile, especially in the neutral lipid layer. Warm-season grasses decreased concentrations of most fatty acids compared to cool-season grasses. The provision of WDGS as an energy supplement while grazing dissipated any differences caused by grass type.

Introduction

The diet of beef cattle has a large effect on the fatty acid (FA) profile of beef. Due to the use of corn for ethanol production, finishing cattle on wet distillers grains with solubles (WDGS), a byproduct of ethanol production, has increased in use. Several studies have shown that finishing cattle on WDGS drastically increases the content of polyunsaturated FA (PUFA) when compared to an all-corn finishing diet (*2011 Nebraska Beef Report*, pp. 96-99 and *2009 Nebraska Beef Report*, pp. 110-111).

Type of grass grazed also can have an effect on ultimate FA profiles. Jenschke et al. (*Journal of Animal Science*, 2008, 86:949-959) grazed cattle on different types of forages and found the FA profile to be drastically different. In addition, providing supplementation while grazing also has been found to cause changes in FA profiles (*Animal Industry Report*, 2011, 657:16; *Journal of Animal Science*, 1997, 75:910-919). Little research has been conducted examining the effects on diet from weaning to finish on the FA profile. The objective of this study was to investigate how fatty acids are affected in two different muscles from cattle fed two types of forages post-weaning, with or without supplemental energy, and finished on either a corn or WDGS diet.

Procedure

Crossbred steers (n = 64) were allowed to graze from April 17, 2012, until Oct. 10, 2012, (177 days) on warm-season grasses at the Barta Brothers Ranch in the Eastern Sandhills of Nebraska or on cool-season pastures near Ithaca, Neb., without or with energy supplementation of wet distillers grains with solubles WDGS (0.6% BW/ day). After the grazing period, cattle were finished on a corn-based diet with or without 35% WDGS for 119 days to an average live weight of 1,427 lb. Cattle were harvested at Greater Omaha Packing Co. in Omaha, Neb.

Six carcasses from each treatment (n = 48) that graded USDA Choice or Select were identified and *Longissimus dorsi (L. dorsi)* and *Biceps femoris* (*B. femoris*) muscles from each side of each carcass were collected and aged under vacuum for seven days. After aging, one steak was cut from each muscle and analyzed for fatty acids in the neutral and phospholipid layers.

Steaks were cut into cubes, flash frozen using liquid nitrogen, and powdered in a grinder to create a homogenous sample. Powdered meat samples were then analyzed for fatty acid analysis. Lipid layers were separated using thin layer chromatography. The neutral and phospholipid layers were identified, isolated, and the fatty acids were extracted. Gas chromatography was used to determine the fatty acid profile in each lipid layer. A Chrompack CP-Sil 88 (0.25 mm x 100 m) was used. Injector temperature was set at 518°F and the detector temperature was set at 572°F. The carrier gas was Helium with a flow rate of 1.1 mL/min.

Data were analyzed using the Mixed procedure in SAS (SAS Institute, Inc., Cary, N.C.) with differences determined at $P \leq 0.05$. Whenever there was a three- or four-way interaction, the LSmeans were reanalyzed using the GLIMMIX procedure with the slicediff option in order to more accurately study differences.

Results

In the neutral lipid layer of *L. dorsi* steaks, warm-season grass grazing without supplementation lowered total unsaturated FA(UFA) and total monounsaturated FA (MUFA) concentrations ($P = 0.04$) compared to cool-season grasses (Table 1). When supplementation was provided, there were no differences in UFA or MUFA between grass types. Within warm-season grasses, providing supplementation caused higher concentrations of total UFA and MUFA than when supplementation was not provided. A higher level of UFA and MUFA could lead to increased oxidation and decreased shelf-life. Clearly, warm-season grasses caused a shift to occur in FA profiles that can be altered by supplementation with WDGS.

For total PUFA, grazing warm-season grasses lowered concentrations ($P = 0.006$) compared to cool-season grasses while finishing on WDGS caused higher concentrations of PUFA ($P = 0.002$) compared to diets without WDGS (Table 2). It is well known that WDGS causes increased concentrations of total PUFA due to the composition of the grains. Increased concentrations of PUFA are also commonly associated with changes in oxidation, discoloration, and flavor.

Table 1. The effects of the interaction between grass type and supplementation on the LS means of fatty acids in the neutral lipid layers in *L. dorsi* steaks.

	Warm-Season Grass		Cool-Season Grass			
	No Supplementation	Supplementation	No Supplementation	Supplementation	SEM	*P*-value
Neutral Lipids, mg/100 g of meat						
Total SFA[1]	854.90	1250.75	1304.72	1281.18	138.88	0.13
Total UFA	1045.30[b]	1584.17[a]	1607.48[a]	1489.49[a]	159.18	0.04
Total MUFA	1013.53[b]	1531.32[a]	1545.75[a]	1428.78[ab]	153.35	0.04
Total PUFA	31.78	52.85	61.73	60.71	6.73	0.10

[1]SFA = saturated fatty acids, UFA = unsaturated fatty acids, MUFA = monounsaturated fatty acids, and PUFA = polyunsaturated fatty acids.
[ab]Means within the same row with different superscripts are different ($P \leq 0.05$).

Table 2. The effect of grass type and finishing diet on the LS means scores of fatty acids in the neutral and phospholipid layers of *L. dorsi* and *B. femoris* steaks.

	Grass Type				Finishing Diet			
	Warm-Season	Cool-Season	SEM	*P*-value	Corn	WDGS[1]	SEM	*P*-value
L. dorsi Neutral Lipids, mg/100 g of meat								
Total SFA[2]	1052.82	1292.95	95.95	0.08	1141.14	1204.63	95.95	0.64
Total UFA	1314.74	1548.48	109.97	0.14	1389.51	1473.72	109.97	0.59
Total MUFA	1272.43	1487.27	105.95	0.15	1348.84	1410.85	105.95	0.68
Total PUFA	42.31[b]	61.22[a]	4.65	0.006	40.67[b]	62.86[a]	4.65	0.002
L. dorsi Phospholipids, mg/100 g of meat								
Total SFA	308.84	348.42	24.85	0.26	336.44	320.82	24.85	0.66
Total UFA	551.33	614.09	38.12	0.25	584.18	581.24	38.12	0.96
Total MUFA	202.20	215.91	19.41	0.62	229.80	188.32	19.41	0.13
Total PUFA	349.13	398.18	22.76	0.13	354.38	392.93	22.76	0.23
B. femoris Neutral Lipids, mg/100 g of meat								
Total SFA	1089.11	1047.88	63.00	0.65	1126.86	1010.13	63.00	0.20
Total UFA	1587.68	1486.36	87.15	0.42	1602.98	1471.07	87.15	0.29
Total MUFA	1540.56	1433.86	84.17	0.38	1557.17	1417.24	84.17	0.25
Total PUFA	47.13	52.50	3.64	0.30	45.81	53.82	3.64	0.62
B. femoris Phospholipids, mg/100 g of meat								
Total SFA	324.44	340.03	15.03	0.47	332.94	331.53	15.03	0.95
Total UFA	630.04	664.00	30.14	0.43	644.39	649.65	30.14	0.90
Total MUFA	208.51	209.69	13.40	0.95	233.07[a]	185.12[b]	13.40	0.02
Total PUFA	421.53	454.32	21.62	0.29	411.31	464.54	21.62	0.09

[1]WDGS = Wet distillers grains with solubles.
[2]SFA = saturated fatty acids, UFA = unsaturated fatty acids, MUFA = monounsaturated fatty acids, and PUFA = polyunsaturated fatty acids.
[ab]Means within the same treatment and the same row with different superscripts are different ($P \leq 0.05$)

The FA profile of the phospholipid layer was unaffected by diet. The lack of differences could be due to the fact that phospholipids have a faster turnover rate than the neutral lipid layer. Since the phospholipids have a faster turnover rate, any changes in composition due to diet, especially grass type and supplementation, which were fed at a young age, could have been negated by the end of the finishing period.

The fatty acids in the neutral lipids layer of *B. femoris* steaks were affected by a three-way interaction between grass-type, supplementation, and finishing diet (Table 3). Grazing on warm-season grasses without supplementation and finishing on corn without WDGS decreased concentrations ($P \leq 0.03$) of total saturated FA (SFA), total UFA, and total MUFA compared to not supplementing and finishing on WDGS. When supplementation was provided, there were no differences in concentrations of total SFA, total UFA, or total MUFA among finishing diets. The lack of differences could be because WDGS were used for supplementation.

In contrast, when cattle were grazed on cool-season grasses there were no differences in concentrations of total SFA, total UFA, or total MUFA regardless of supplementation or finishing diet. The differences in FA composition when cattle are grazed on warm-season grasses compared to the lack of differences seen with cool-season grass grazing indicates that grass type causes the FA changes. The amount of time the cattle were in the finishing lot was not enough to overcome the effects of the grass type, but supplementing while grazing helped to prevent the change in FA composition of the phospholipid layer due to grass type.

Similar to *L. dorsi* steaks, few dietary components had an effect on FA in the phospholipid layer. Finishing diet had the greatest effect with an all-corn diet causing an increased ($P \leq 0.02$) concentration of

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total MUFA over finishing on WDGS. There was also a tendency ($P = 0.09$) for WDGS to cause higher concentration of total PUFA compared to finishing on corn (464.54 vs. 411.31).

In conclusion, FA in neutral lipids are more easily altered by diet than those in the phospholipid layer. Grass type had the biggest effect on the fatty acid profile with warm-season grasses causing decreased concentrations in a majority of the FA, especially in the neutral lipid layer. Even though grass type had such a major effect, the provision of WDGS as a supplemental energy source was able to minimize, if not deter, a majority of the changes. This would mean that if a producer concerned about the effect of grass type on their cattle, they could provide an energy supplementation to their cattle and effectively negate any effects.

Table 3. The effect of grass type, supplementation, and finishing diet on the LS means of fatty acid concentrations in the neutral lipid layer when separated by grass type for *B. femoris* steaks

	No Supplementation		Supplementation			
	Corn	WDGS[1]	Corn	WDGS	SEM	*P*-value
Warm-season Grass, mg/100 g of meat						
Total SFA[2]	1375.10[a]	857.17[b]	1026.02[ab]	1098.15[ab]	125.99	0.02
Total UFA	1952.46[a]	1330.93[b]	1496.66[ab]	1570.67[ab]	174.30	0.03
Total MUFA	1905.19[a]	1285.39[b]	1455.10[ab]	1516.54[ab]	168.35	0.03
Total PUFA	47.27	45.55	41.56	54.13	7.27	0.20
Cool-season Grass, mg/100 g of meat						
Total SFA	947.37[a]	1073.76[a]	1158.95[a]	1011.42[a]	125.99	0.02
Total UFA	1375.74[a]	1584.63[a]	1587.05[a]	1398.04[a]	174.30	0.03
Total MUFA	1334.67[a]	1526.77[a]	1533.73[a]	1340.28[a]	168.35	0.03
Total PUFA	41.07	57.85	53.32	57.76	7.27	0.20

[1]WDGS = Wet distillers grains with solubles.
[2]SFA = saturated fatty acids, UFA = unsaturated fatty acids, MUFA = monounsaturated fatty acids, and PUFA = polyunsaturated fatty acids.
[ab]Means within the same treatment and the same row with different superscripts are different ($P \leq 0.05$).

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The Effects of Diet on the Biochemical Constituents of Beef

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Summary

Crossbred steers (n = 64) were grazed on warm- or cool-season grasses, without or with energy supplementation of wet distillers grains with solubles (WDGS), and were finished on a corn-based diet with or without 35% WDGS. Grass-type was the major contributor in determining the biochemical composition of L. dorsi steaks, with warm-season grasses causing increased concentrations of moisture and zinc and decreased concentrations of magnesium. Aging 28 days instead of 7 days increased pH and caused an increased concentration of carbohydrates, and non-heme and heme iron in B. femoris steaks. Diet, especially grass type, during grazing, can alter the end composition of beef.

Introduction

The diet of beef cattle can influence many of the biochemical constituents in meat. Research has shown that grass type grazed post-weaning can alter the composition of beef (*Journal of Food Science,* 1987, 52:245-251). It is also very common to supplement energy while grazing by feeding wet distillers grains plus solubles (WDGS). Providing supplementation alters growth traits (*2013 Nebraska Beef Cattle Report*, pp. 31-32 and *2011 Nebraska Beef Cattle Report*, pp. 24-25) and the biochemical composition of the beef (*Food Chemistry*, 1998, 63:543-547). Finishing cattle on WDGS also causes changes in the biochemical composition of beef (*2011 Nebraska Beef Cattle Report*, pp. 96-99). Biochemical changes in the meat could lead to changes in flavor and consumer acceptability. The objective of this study was to identify changes in beef composition in two different muscles from cattle fed two different forages post-weaning, with or without supplemental energy, finished on either a corn or WDGS diet, and aged for 7 or 28 days.

Procedure

Crossbred steers (n = 64) were allowed to graze for from April 17, 2012, until Oct. 10, 2012, (177 days) on warm-season grasses at the Barta Brothers Ranch in the Eastern Sandhills of Nebraska or on cool-season pastures near Ithaca, Neb., without or with energy supplementation of wet distillers grains with solubles WDGS (0.6% BW/ day). After the grazing period, cattle were finished on a corn based diet with or without 35% WDGS for 119 days to an average live weight of 1,427 lbs. Cattle were harvested at the Greater Omaha Packing Co. in Omaha, Neb.

Six carcasses from each treatment (n = 48) that graded USDA Choice or Select were identified and *Longissimus dorsi (L. dorsi)* and *Biceps femoris* (*B. femoris*) muscles from each side of each carcass were collected and aged under vacuum for 7 and 28 days. After aging, one steak was cut from each muscle and analyzed for proximate composition, pH, cooking loss, and heme and non-heme iron content, amino acid composition, and mineral content.

Ultimate pH was determined for 7 and 28 day aged samples using an Orion 4 STAR pH ISE Bench-top meter (Thermo Electron Corporation, Waltham, Mass.). Fat, protein, and ash content were analyzed for seven-day aged samples while moisture content was analyzed for both 7- and 28-day samples. Moisture and ash were measured using a LECO thermogravimetric analyzer and fat was measured using an ether extraction procedure. Protein was determined by difference (100% - % fat, % moisture and % ash).

For total carbohydrates, samples were extracted using an 80% ethanol solution. The extract was then mixed with 80% phenol and sulfuric acid and the optical density was read on a Cary 100 Varian UV/Visual Spectrophotometer (Varian Instruments, Sugarland, Tex.) at 490 nm. All results were compared to a standard curve for total concentration.

To measure non-heme iron, samples were mixed with a NaNO2 solution (0.39% w/v) and 40% (1:1) trichloroacetic acid:hydrochloric acid acid solution, vortexed, and placed in a water shaker bath set at 149°F for 20 hours. A 1 mL aliquot of the aqueous phase was mixed with a color reagent and read on a spectrophotometer, against a blank, at 540 nm. Readings were compared against a standard curve created using an iron stock standard. Similarly, heme iron samples were mixed with acetone and hydrochloric acid, homogenized, filtered into a new tube, and read on a spectrophotometer at 640 nm.

Mineral composition of seven-day samples was determined with an atomic absorption spectrophotometer (Ward Laboratories, Inc. in Kearney, Neb). Amino acid composition of seven-day samples was determined by AAA Service Laboratory, Inc. in Damascus, Ore. Samples were weighed, dried, and hydrolyzed in HCl/2% phenol at 230°F for 22 hours. Next, the hydrolysate was dried and a sample was injected onto a Hitachi L8900 Amino Acid Analyzer with post-column-ninhydrin derivatization. Norleucine was added to the samples to act as an internal control.

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Table 1. The effect of grass type, supplementation, and aging period on the LS means scores of select characteristics of *L. dorsi* and *B. femoris* steaks.

	Grass Type				Supplementation				Age			
	Warm-Season	Cool-Season	SEM	*P*-value	No	Yes	SEM	*P*-Value	7 Days	28 Days	SEM	*P*-value
L. dorsi												
pH	5.46	5.39	0.03	0.06	5.45	5.40	0.03	0.24	5.28[b]	5.57[a]	0.03	<0.0001
Moisture, %	71.62[a]	70.67[b]	0.23	0.04	71.34	70.95	0.23	0.38	71.14[a]	70.39[b]	0.23	0.02
Protein, %	20.91	21.07	0.15	0.46	21.24[a]	20.75[b]	0.15	0.03	NA[1]	NA	NA	NA
Magnesium, mg/kg	291.67[b]	326.67[a]	11.37	0.03	300.00	318.33	11.37	0.26	NA	NA	NA	NA
Zinc, mg/kg	42.29[a]	37.46[b]	1.01	0.002	39.00	40.75	1.01	0.22	NA	NA	NA	NA
Sulfur, mg/kg	2012.50	2060.00	17.52	0.06	2041.67	2030.83	17.52	0.66	NA	NA	NA	NA
B. femoris												
pH	5.52	5.52	0.03	0.99	5.53	5.52	0.03	0.69	5.39[b]	5.65[a]	0.03	<0.0001
Moisture, %	71.90	71.66	0.19	0.46	71.87	71.69	0.19	0.58	71.78	71.29	0.19	0.08
Total Carbohydrates, mg/mL	0.91	0.91	0.04	0.99	0.91	0.90	0.04	0.84	0.81[b]	1.00[a]	0.04	0.0003
Non-Heme Iron, µg/g meat	2.81	2.50	0.20	0.28	2.62	2.70	0.20	0.77	2.29[b]	3.02[a]	0.20	0.01
Heme Iron, mg/kg	10.09	10.03	0.19	0.83	10.00	10.11	0.19	0.68	9.54[b]	10.58[a]	0.19	0.0001

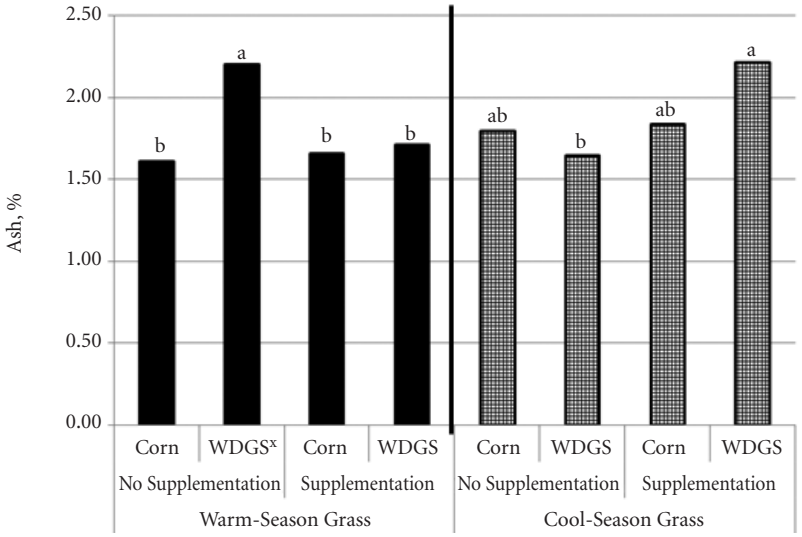
[1]NA = Not applicable, aging period was not tested for these factors.
[ab]Means within the same treatment and the same row with different superscripts are different ($P \leq 0.05$).

Data were analyzed using the Mixed procedure in SAS (SAS Institute, Inc., Cary, N.C.) with differences determined at $P \leq 0.05$. Whenever there was a three- or four-way interaction, the LSmeans were reanalyzed using the GLIMMIX procedure with the slicediff option in order to more accurately study differences.

Results

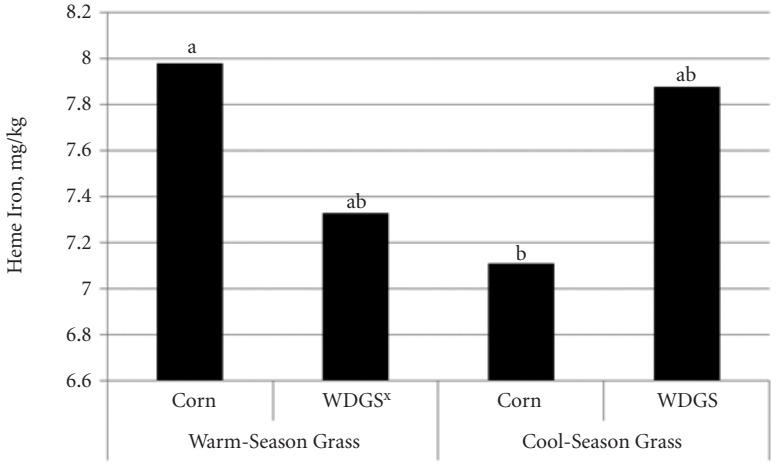
For both *L. dorsi* and *B. femoris* steaks, aging 28 days increased pH values ($P < 0.0001$) as compared to seven day aged beef (Table 1). A change in pH will have an effect on flavor as well as shelf life. Warm-season grass increased ($P = 0.04$) moisture content, decreased magnesium, and increased zinc concentration in *L. dorsi* steaks ($P \leq 0.03$) as compared to cool-season grasses (Table 1). In addition, grazing on a warm-season grass had the tendency ($P = 0.06$) to decrease sulfur content. Beef from cattle grazing warm-season grasses tended to have higher zinc and lower sulfur concentrations than beef from cattle grazing cool-season grasses.

Also, in *L. dorsi* steaks, supplementation decreased ($P = 0.03$) protein content (Table 1). There was a three-way interaction between grass type, supplementation, and finishing diet ($P = 0.04$) for ash content (Figure 1). Within warm-season grass grazing, not supplementing and finishing on WDGS caused ash content to be the



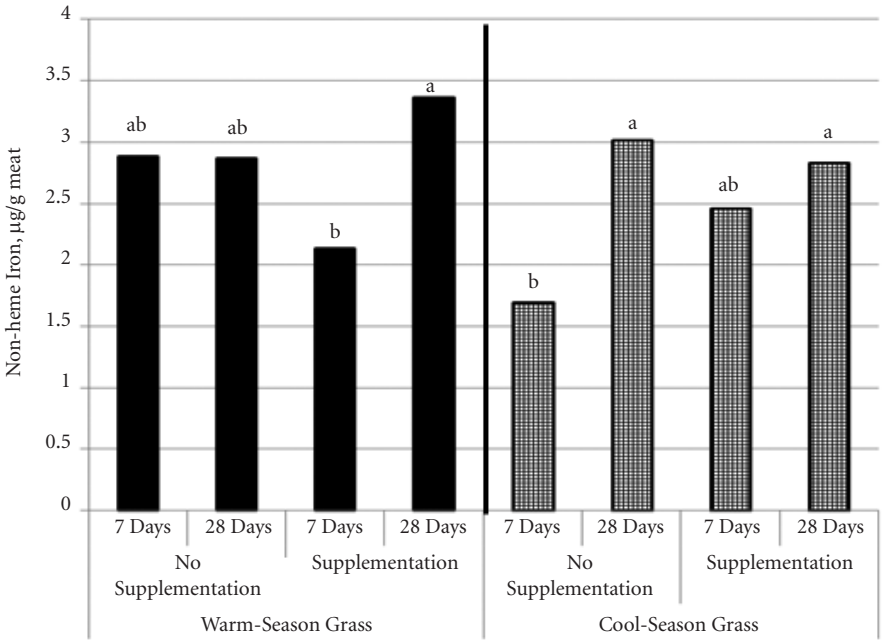
[x]WDGS = Wet distillers grains with solubles.
[ab]Means within the same grass type with the different superscripts are significantly ($P \leq 0.05$) different.

Figure 1. The interaction between grass type, supplementation, and finishing diet on the LS means of ash content when separated by grass type for *L. dorsi* steaks ($P = 0.04$).



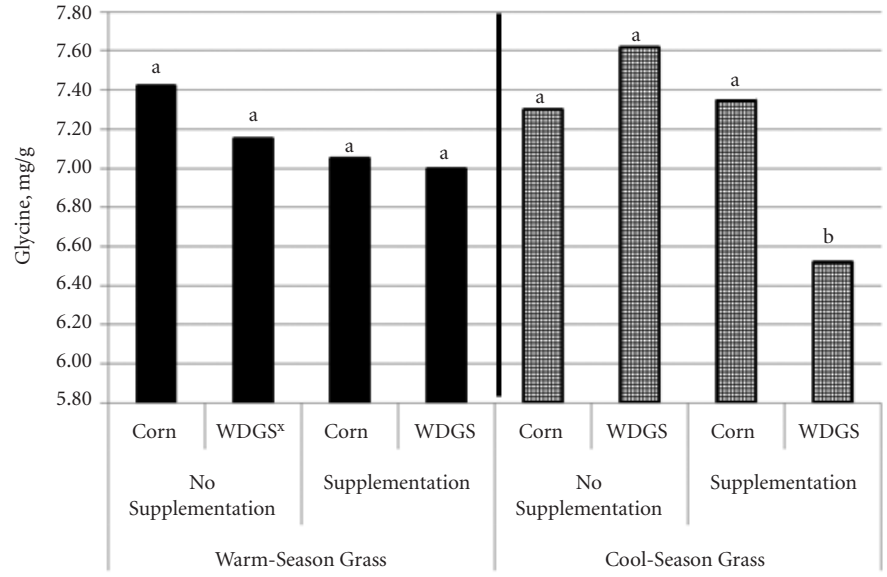
[x]WDGS = Wet distillers grains with solubles.
[ab]Means within the same grass type with the different superscripts are significantly ($P \leq 0.05$) different.

Figure 2. The interaction between grass type and finishing diet on the LS means of heme iron content for *L. dorsi* steaks ($P = 0.003$).



[ab]Means within the same grass type with the different superscripts are significantly ($P \leq 0.05$) different.

Figure 3. The interaction between grass type, supplementation, and aging period on LS means of non-heme iron content when separated by grass type for *B. femoris* steaks ($P = 0.05$).



[x]WDGS = Wet distillers grains with solubles.
[ab]Means within the same grass type with the different superscripts are significantly ($P \leq 0.05$) different.

Figure 4. The interaction between grass type, supplementation, and finishing diet on the LS means of glycine content when separated by grass type for *B. femoris* steaks ($P = 0.05$).

highest (2.20%) compared to any other supplementation and finishing diet combination ($P = 0.04$). Within cool-season grass grazing, supplementing and finishing on WDGS caused the ash content to be higher than if they weren't supplemented and finished on WDGS. Beef from corn-finished cattle had a higher heme iron content ($P = 0.003$) when grazed on warm-season versus cool-season grasses in *L. dorsi* steaks (Figure 2). The location of the ranches and the changes in both soil type and geography could have played a role in the differences seen with heme iron content.

Carbohydrates increased ($P = 0.0003$) in *B. femoris* steaks when aged 28 days as compared to seven days. As meat ages, moisture content decreases, as can be seen in Table 1 for the *L. dorsi* steaks ($P = 0.02$) with a similar tendency in the *B. femoris* steaks ($P = 0.08$). When the moisture content decreases due to aging, other components, such as carbohydrates, become more concentrated.

A three-way interaction ($P = 0.05$) between grass type, supplementation, and aging period influenced non-heme iron content in *B. femoris* steaks. Within warm-season grass grazing, when the animals were supplemented, 28-day aged product had a higher non-heme iron concentration ($P = 0.05$) than seven-day aged beef (Figure 3). Within cool-season grass grazing, 28 day-aged beef, from both not supplemented and supplemented cattle, had higher non-heme iron concentrations than seven-day aged beef from cattle that were not supplemented. Aging steaks 28 days caused the concentration of heme iron to be significantly ($P = 0.0001$) higher than seven-day aged steaks (Table 1), likely due to water being exuded from the meat and other components become more concentrated.

Glycine content was influenced ($P = 0.05$) by grass type, supplementation, and finishing diet interaction in *B. femoris* steaks (Figure 4). Within

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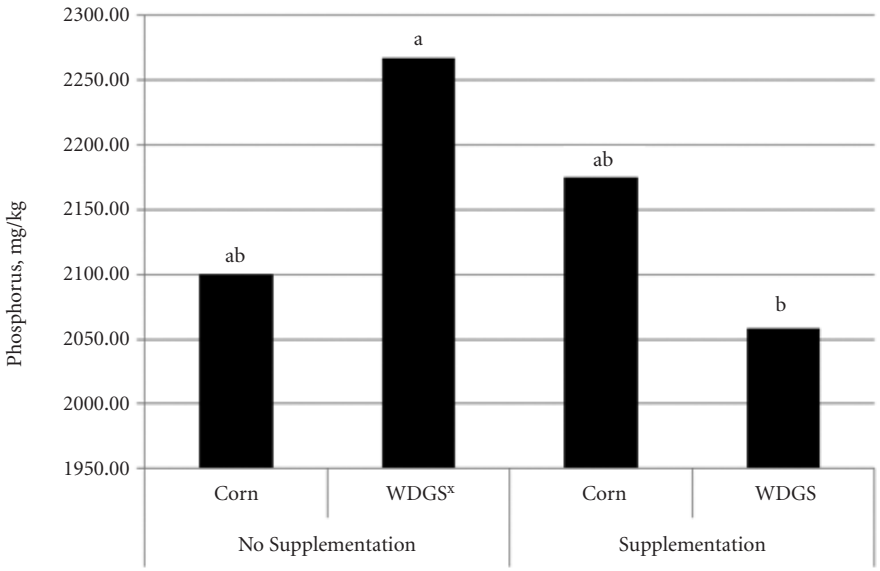
warm-season grass grazing there were no differences ($P > 0.05$) among dietary treatments. When cattle were grazed on cool-season grasses, providing supplementation and finishing on a WDGS diet caused the lowest glycine concentration compared to all other supplementation and finishing diet combinations. When finished on WDGS, *B. femoris* steaks from cattle that were not supplemented had higher phosphorus levels than when they were supplemented (Figure 5). The remaining components were unaffected by diet and aging period.

Overall, grass type and aging were found to have the most effect on the biochemical constituents of meat. This shows that the grass type cattle grazed after weaning can still cause a residual effect on the meat composition even after finishing on a high concentrate diet. In most cases, the addition of supplementation to the dietary regimen was able to even out the effects and remove any differences due to grass type.



[x]WDGS = Wet distillers grains with solubles.
[ab]Means within the same grass type with the different superscripts are significantly ($P \leq 0.05$) different.

Figure 5. The effect of supplementation and finishing diet on the LS means of phosphorous content in *B. femoris* steaks ($P = 0.04$).

[1]Kimberly A. Varnold, graduate student; Chris R. Calkins, professor; Brandon L. Nuttelman, graduate student; Lasika S. Senaratne, former graduate student; Justine J. Stevenson, former graduate student; Michelle E. Semler, graduate student; Michael D. Chao, graduate student; Tommi F. Jones, laboratory technician; Galen E. Erickson, professor, University of Nebraska–Lincoln Department of Animal Science, Lincoln, Neb.

The Effects of Diet and Cooler Aging on Consumer Panel Scores for Beef

Kimberly A. Varnold
Chris R. Calkins
Rhonda K. Miller
Galen E. Erickson[1]

Summary

Crossbred steers (n = 64) grazed warm- or cool-season grasses, without or with energy supplementation of wet distillers grains with solubles (WDGS), and were finished on a corn-based diet with or without 35% WDGS. Finishing cattle on WDGS, especially after being supplemented with WDGS, caused declines in flavor desirability scores of L. dorsi *steaks. Conversely, grass type was more influential in B. femoris steaks with warm-season grasses generating lower consumer panel scores. Scores were not different from each other when supplementation was provided. It is recommended that producers provide WDGS supplementation and finish on an all-corn diet in order to create the most pleasurable eating experience for consumers.*

Introduction

When describing a pleasurable beef eating experience, flavor is often one of the most important attributes for consumers. If a product has great flavor, consumers will not only purchase it again but will also pay more for it. The diet fed to cattle can significantly affect beef flavor. When cattle are finished on wet distillers grains with solubles (WDGS) instead of an all-corn diet, off-flavors are more prevalent (*2011 Nebraska Beef Cattle Report*, pp. 96-99).

As meat ages, lipid oxidation creates unique flavors. When Smith et al. (*Journal of Food Science*, 1978, 43:823-826) dry aged meat up to 11 days, flavor desirability was significantly increased. Campo et al. (*Meat Science*, 1999, 51:383-390) also found that flavor intensity increased as the length of wet aging increased up to 10 days.

This research was conducted to evaluate how consumer preferences are affected in two different muscles from cattle grazing different forages post-weaning, with or without supplemental energy, finished on either a corn or corn-with-WDGS diet, and aged for 7 or 28 days.

Procedure

Crossbred steers (n = 64) were allowed to graze for from April 17, 2012, until Oct. 10, 2012, (177 days) on warm-season grasses at the Barta Brothers Ranch in the Eastern Sandhills of Nebraska or on cool-season pastures near Ithaca, Neb., without or with energy supplementation of wet distillers grains with solubles WDGS (0.6% BW/ day). After the grazing period, cattle were finished on a corn- based diet with or without 35% WDGS for 119 days to an average live weight of 1,427 lbs. Cattle were harvested at Greater Omaha Packing Co., Omaha, Neb..

Six carcasses from each treatment (n = 48) that graded USDA Choice or Select were identified and *Longissimus dorsi (L. dorsi)* and *Biceps femoris* (*B. femoris*) muscles from each side of each carcass were collected and aged under vacuum for 7 or 28 days. Upon fabrication after aging, two steaks were cut from each subprimal, placed on Styrofoam trays, wrapped with oxygen-permeable overwrap film, and placed under simulated retail display for seven days. At the end of retail display, steaks were vacuumed packaged and frozen until further use in consumer panels.

All consumer panels were approved by the Institutional Review Board and all panelists signed a consent form. Consumer panels were conducted in Houston, Tex., and Olathe, Kan., (n = 120 per location). Consumers were recruited using existing consumer data banks and random phone solicitation. Consumers were selected who eat beef at least three times per week, range in age from 21 to 65, with an approximately equal balance of males and females, and a range in income.

In each city, consumer panels were conducted over two days, with the first day evaluating *L. dorsi* steaks and the second day evaluating *B. femoris* steaks. Different consumers evaluated each muscle type. Steaks from each animal were evaluated at both locations. Panels were conducted with three sessions per day and 20 consumers per session. Five consumers evaluated each steak. Treatment order was randomized and allocated to consumers using an incomplete block design. Each consumer evaluated eight steaks in a session.

Steaks were cooked on a Hamilton Beach Health Smart® grill (model 31605A, Hamilton Beach/ Proctor-Silex, Inc., Southern Pines, N.C.) to an internal temperature of 158°F. Consumers evaluated each sample using nine-point hedonic (1 = dislike extremely, 9=like extremely) and intensity scales (1 = none or extremely bland, 9 = extremely intense) for overall like, overall flavor like, beefy flavor like and intensity, and grilled flavor like and intensity.

Data were analyzed using the Mixed procedure in SAS (SAS Institute, Inc., Cary, N.C.) with differences determined at $P \leq 0.05$. Whenever there was a three- or four-

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way interaction, the LSmeans were reanalyzed using the GLIMMIX procedure with the slicediff option in order to more accurately study differences.

Results

When supplementing on pasture with WDGS, finishing on corn without WDGS caused higher ($P \leq 0.04$) scores for overall like, overall flavor like, and beefy flavor like of *L. dorsi* steaks than finishing on WDGS (Table 1). There were no differences in *L. dorsi* steak scores between finishing diets when no supplementation was given. The cattle finished on corn after being supplemented with WDGS received no WDGS during the finishing phase. In contrast, the cattle supplemented and finished on corn with WDGS had essentially been fed WDGS since weaning. The differences in consumer panel scores in the *L. dorsi* steaks are likely due to those cattle being fed WDGS for a longer length of time.

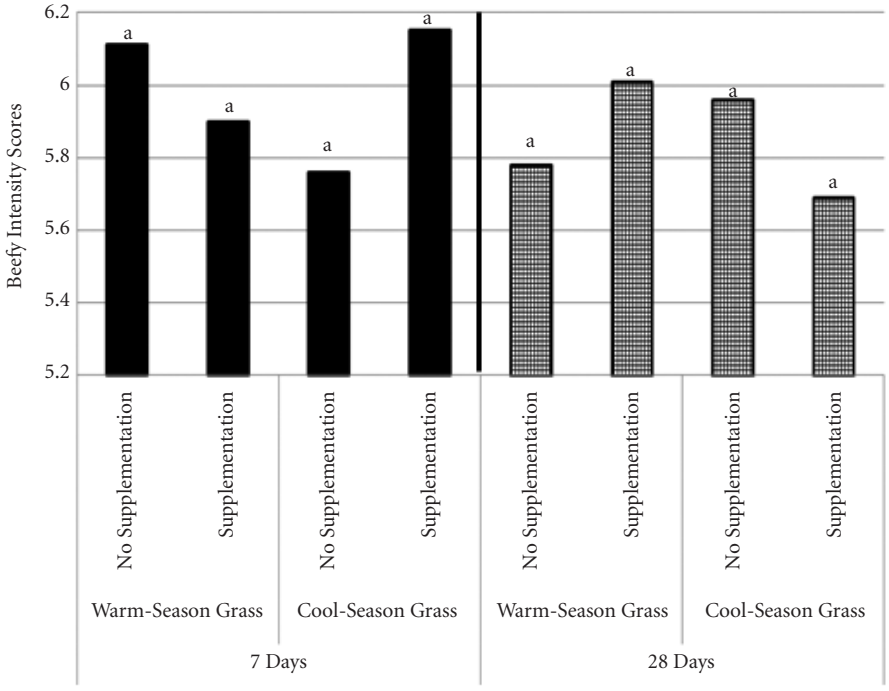
Beefy flavor intensity was significantly ($P = 0.04$) affected by a three-way interaction between grass-type, supplementation, and aging period. When the means were separated out by aging period (Figure 1) there were no differences between the means within the same aging period. This would demonstrate the aging period is causing the interaction to be significant. Neither grill flavor like nor grill flavor intensity scores were affected by any combinations of feeding regimens and aging.

For *B. femoris* steaks overall like, overall flavor like, beefy flavor like, and beefy flavor intensity scores were significantly ($P \leq 0.05$) influenced by the four-way interaction of grass type, supplementation, finishing diet, and aging (Table 2). Within the seven day aging period, grazing on warm-season grasses without supplementation and

Table 1. The effects of supplementation and finishing diet on the LS means of consumer panel scores for *L. dorsi* and *B. femoris* steaks.

	No Supplementation		Supplementation			
	Corn	WDGS[1]	Corn	WDGS	SEM	*P*-value
L. dorsi						
Overall Like[2]	6.14[b]	6.18[ab]	6.52[a]	5.98[b]	0.13	0.03
Overall Flavor Like	6.06[ab]	6.10[ab]	6.34[a]	5.84[b]	0.14	0.04
Beefy Flavor Like	6.15[ab]	6.24[ab]	6.43[a]	5.91[b]	0.13	0.02
Beefy Flavor Intensity	5.85	5.96	6.10	5.77	0.14	0.11
Grill Flavor Like	5.78	5.87	5.93	5.64	0.13	0.13
Grill Flavor Intensity	5.33	5.30	5.49	5.27	0.14	0.50
B. femoris						
Overall Like	5.77	5.64	5.97	5.72	0.14	0.66
Overall Flavor Like	5.65	5.65	6.08	5.69	0.14	0.16
Beefy Flavor Like	5.85	5.87	6.15	5.90	0.14	0.31
Beefy Flavor Intensity	5.63	5.84	6.00	5.77	0.14	0.12
Grill Flavor Like	5.51	5.54	5.95	5.48	0.14	0.06
Grill Flavor Intensity	5.16	4.97	5.46	5.10	0.15	0.55

[1]WDGS = Wet distillers grains with solubles.
[2]1=dislike extremely, none, or extremely bland, 9=like extremely or extremely intense.
[ab]Means within the same row with different superscripts are different ($P \leq 0.05$).



[a]Means within the same aging period with the same superscript are not significantly ($P > 0.05$) different.

Figure 1. The effect of grass type, supplementation, and aging period on the LS means of beefy flavor intensity consumer panel scores when separated by aging period in *L. dorsi* steaks ($P = 0.04$).

Table 2. The effect of grass type, supplementation, finishing diet, and aging period on the LS means of consumer panel scores when separated by aging period for *B. femoris* steaks.

	Warm-season Grass				Cool-season Grass					
	No Supplementation		Supplementation		No Supplementation		Supplementation			
	Corn	WDGS[1]	Corn	WDGS	Corn	WDGS	Corn	WDGS	SEM	*P*-value
7 Days										
Overall Like[2]	6.12^{a}	5.02^{b}	5.89^{a}	5.78^{ab}	5.92^{a}	6.25^{a}	6.02^{a}	6.17^{a}	0.29	<0.01
Overall Flavor Like	6.06^{a}	5.13^{b}	6.04^{a}	5.64^{ab}	5.83^{ab}	6.19^{a}	6.24^{a}	5.96^{a}	0.31	0.01
Beefy Flavor Like	6.08^{ab}	5.44^{b}	6.02^{ab}	6.05^{ab}	6.08^{ab}	6.41^{a}	6.43^{a}	6.17^{ab}	0.29	0.01
Beefy Flavor Intensity	6.11^{a}	5.55^{a}	5.88^{a}	5.72^{a}	6.11^{a}	6.10^{a}	6.24^{a}	5.98^{a}	0.32	0.05
Grill Flavor Like	5.85	5.22	5.81	5.59	5.59	5.71	6.12	5.55	0.28	0.23
Grill Flavor Intensity	5.38	4.65	5.60	5.16	5.03	5.02	5.41	4.91	0.31	0.06
28 Days										
Overall Like	5.18^{cd}	5.48^{bcd}	6.28^{a}	4.91^{d}	5.85^{abc}	5.80^{abc}	5.71^{abc}	6.02^{ab}	0.29	0.005
Overall Flavor Like	5.08^{c}	5.48^{bc}	6.38^{a}	5.19^{c}	5.64^{abc}	5.81^{abc}	5.66^{abc}	5.95^{ab}	0.31	0.01
Beefy Flavor Like	5.39^{b}	5.65^{b}	6.50^{a}	5.47^{b}	5.84^{ab}	6.00^{ab}	5.66^{b}	5.92^{ab}	0.29	0.01
Beefy Flavor Intensity	4.88^{c}	5.73^{ab}	6.36^{a}	5.49^{bc}	5.41^{bc}	5.96^{ab}	5.52^{bc}	5.90^{ab}	0.32	0.05
Grill Flavor Like	5.14	5.28	6.03	5.21	5.47	5.96	5.85	5.56	0.28	0.23
Grill Flavor Intensity	4.73	4.87	5.77	4.96	5.49	5.35	5.06	5.37	0.31	0.06

[1]WDGS = Wet distillers grains with solubles.
[2]1 = dislike extremely, none or extremely bland; 9 = like extremely or extremely intense.
[abcd]Means within the same treatment and the same row with different superscripts are different ($P \leq 0.05$).

finishing on WDGS caused the greatest number of differences with the lowest numerical, and sometimes significant ($P \leq 0.05$), scores for overall like, overall flavor like, beefy flavor like, beefy flavor intensity, grill flavor like, and grill flavor intensity scores than all other dietary combinations. When supplementation was given, finishing diets were not different from each other or other dietary treatment combinations, including cool-season grasses. This implies that supplementing cattle while grazing will prevent any differences in consumer scores caused by grass type. This is in contrast to *L. dorsi* scores which showed feeding WDGS for the lifespan of the animal decreased consumer scores.

For beef aged 28 days, supplementation and finishing on corn caused higher ($P < 0.05$) overall like, overall flavor like, beefy flavor like, and beefy flavor intensity (6.36) scores than all other supplementation and finishing diet combinations within warm-season grass grazing. For most traits, consumer scores were not different between warm- and cool-season grass grazing. The lack of differences between grass types could be due to the fact that samples were aged for 28 days. The longer aging period could have caused any negative flavor influences present in warm-season grasses to dissipate, as seen in the seven-day samples. Any differences present were only seen within warm-season grasses between supplementation and finishing diet, so aging effects are not completely dismissed.

None of the diet regimen and aging combinations influenced grill flavor like or grill flavor intensity scores ($P > 0.05$). There was a tendency ($P = 0.06$) for the interaction between supplementation and finishing diet to influence grill flavor like scores and for an interaction between grass type, supplementation, finishing diet, and aging period to influence grill flavor intensity scores ($P = 0.06$).

These data suggest that desirable beef flavor is best established with cool season grasses, feeding WDGS as an energy supplement during grazing and finishing on corn. However, for a majority of the scores, finishing on corn with WDGS was not very different from finishing on corn without WDGS. Aging also plays a key role in flavor development. For the most part, longer aging periods tend to dissipate any differences in consumer panel scores that previously existed. Due to these facts, a longer aging period of beef is recommended.

[1]Kimberly A. Varnold, graduate student; Chris R. Calkins, professor, University of Nebraska–Lincoln (UNL) Department of Animal Science, Lincoln, Neb.; Rhonda K. Miller, professor, animal science, Texas A&M University, College Station, Tex; Galen E. Erickson, professor, UNL Department of Animal Science, Lincoln, Neb.

Statistics Used in the Nebraska Beef Report and Their Purpose

The purpose of beef cattle and beef product research at University of Nebraska–Lincoln is to provide reference information that represents the various populations (cows, calves, heifers, feeders, carcasses, retail products, etc.) of beef production. Obviously, the researcher cannot apply treatments to every member of a population; therefore, he/she must sample the population. The use of statistics allows the researcher and readers of the *Nebraska Beef Report* the opportunity to evaluate separation of random (chance) occurrences and real biological effects of a treatment. Following is a brief description of the major statistics used in the beef report. For a more detailed description of the expectations of authors and parameters used in animal science see *Journal of Animal Science Style and Form* at: *http://jas.fass.org/misc/ifora.shtml*.

— **Mean** — Data for individual experimental units (cows, steers, steaks) exposed to the same treatment are generally averaged and reported in the text, tables and figures. The statistical term representing the average of a group of data points is mean.

— **Variability** — The inconsistency among the individual experimental units used to calculate a mean for the item measured is the variance. For example, if the ADG for *all* the steers used to calculate the mean for a treatment is 3.5 lb then the variance is zero. But, this situation never happens! However, if ADG for individual steers used to calculate the mean for a treatment range from 1.0 lb to 5.0 lb, then the variance is large. The variance may be reported as standard deviation (square root of the variance) or as standard error of the mean. The standard error is the standard deviation of the mean as if we had done repeated samplings of data to calculate multiple means for a given treatment. In most cases treatment means and their measure of variability will be expressed as follows: 3.5 ± 0.15. This would be a mean of 3.5 followed by the standard error of the mean of 0.15. A helpful step combining both the mean and the variability from an experiment to conclude whether the treatment results in a real biological effect is to calculate a 95% confidence interval. This interval would be twice the standard error added to and subtracted from the mean. In the example above, this interval is 3.2-3.8 lb. If in an experiment, these intervals calculated for treatments of interest overlap, the experiment does not provide satisfactory evidence to conclude that treatments effects are different.

— ***P* Value** — Probability (*P* Value) refers to the likelihood the observed differences among treatment means are due to chance. For example, if the author reports $P \leq 0.05$ as the significance level for a test of the differences between treatments as they affect ADG, the reader may conclude there is less than a 5% chance the differences observed between the means are a random occurrence and the treatments do not affect ADG. Hence we conclude that, because this probability of chance occurrence is small, there must be difference between the treatments in their effect on ADG. It is generally accepted among researchers when *P* values are less than or equal to 0.05, observed differences are deemed due to important treatment effects. Authors occasionally conclude that an effect is significant, hence real, if P values are between 0.05 and 0.10. Further, some authors may include a statement indicating there was a "tendency" or "trend" in the data. Authors often use these statements when *P* values are between 0.10 and 0.15, because they are not confident the differences among treatment means are real treatment effects. With *P* values of 0.10 and 0.15 the chance random sampling caused the observed differences is 1 in 10 and 1 in 6.7, respectively.

— **Linear & Quadratic Contrasts —** Some articles contain linear (L) and quadratic (Q) responses to treatments. These parameters are used when the research involves increasing amounts of a factor as treatments. Examples are increasing amounts of a ration ingredient (corn, by-product, or feed additive) or increasing amounts of a nutrient (protein, calcium, or vitamin E). The L and Q contrasts provide information regarding the shape of the response. Linear indicates a straight line response and quadratic indicates a curved response. P-values for these contrasts have the same interpretation as described above.

— **Correlation (r) —** Correlation indicates amount of linear relationship of two measurements. The correlation coefficient can range from B1 to 1. Values near zero indicate a weak relationship, values near 1 indicate a strong positive relationship, and a value of B1 indicates a strong negative relationship.

Animal Science

http://animalscience.unl.edu

Curriculum: The curriculum of the Animal Science Department at the University of Nebraska–Lincoln is designed so that each student can select from a variety of options oriented to specific career goals in professions ranging from animal production to veterinary medicine. With unique opportunities to double major in ***Grazing Livestock Systems*** (*http://gls.unl.edu*) or complete the ***Feedlot Management Internship Program*** (*http://feedlot.unl.edu/intern*)

Careers:

Animal Health
Banking and Finance
Animal Management
Consultant
Education
Marketing
Technical Service
Meat Processing
Meat Safety
Quality Assurance
Research and Development
Veterinary Medicine

Scholarships: The Animal Science Department also offers scholarships to incoming freshmen and upperclassmen. The department awards over $30,000 each year to Animal Science students.

ABS Global Scholarship
Baltzell-Agri-Products, Inc. Scholarship
Maurice E. Boeckenhauer Memorial Scholarship
Mike Cull Judging and Activities Scholarship
Don Geweke Memorial Award
Parr Young Senior Merit Award
Nebraska Pork Producers Association Scholarship
Waldo Family Farms Scholarship
Frank and Mary Bruning Scholarship
Art and Ruth Raun Scholarship
Animal Science Department Freshman Scholarship
Feedlot Management Scholarship
Robert Boeckenhauer Memorial Scholarship
Burnell Scholarship Fund
Doane Scholarship
Lincoln Coca-Cola Bottling Company Scholarship.
William J. and Hazel J. Loeffel Scholarship
Nutrition Service Associates Scholarship
Parr Family Student Support Fund
Chris and Sarah Raun Memorial Scholarship
Walter A. and Alice V. Rockwell Scholarship
Standard Manufacturing Co. Scholarship
Max and Ora Mae Stark Scholarship
D.V. and Ernestine Stephens Memorial Scholarship
Dwight F. Stephens Scholarship
Arthur W. and Viola Thompson Scholarship
Thomas H. Wake, III Scholarship
Frank E. Card Scholarship
Derrick Family Scholarship
G. H. Francke Livestock Judging Scholarship
Eric Peterson Memorial Award
Winkler Memorial Livestock Judging Scholarship