2009 Beef Cattle Report

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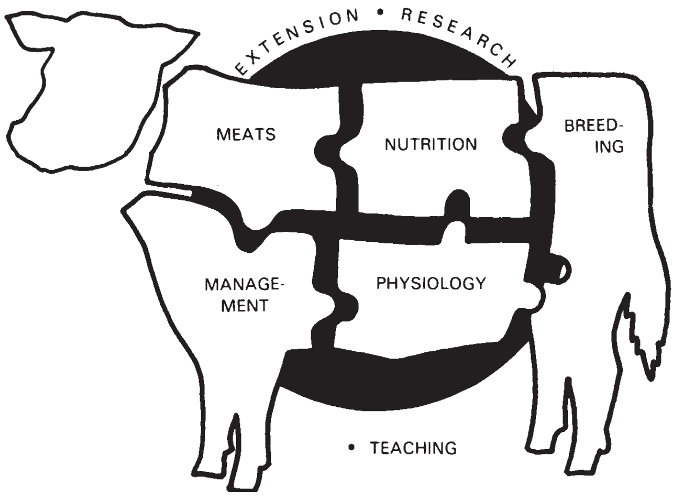

Agricultural Research Division
University of Nebraska Extension
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NEBRASKA

2009 Beef Cattle Report

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Thanks Ivan

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Effect of Winter Grazing System and Supplementation on Beef Cow and Progeny Performance

Rick N. Funston
Jeremy L. Martin
Don C. Adams
Daniel M. Larson[1]

Summary

Cows grazed winter range (WR) or corn residue (CR) during late gestation and received protein supplement (PS) of 1 lb/day 28% CP cubes or no supplement (NS). Pre-calving and pre-breeding body weight (BW) and body condition score (BCS) were greater for PS and CR cows. Pregnancy rate was not affected by treatments. Calf weaning BW was greater for PS cows that grazed WR. Final BW and 12th rib fat tended to be greater for steers from cows on CR. Steers from PS cows graded a higher proportion USDA Choice or greater. More heifers were pubertal before breeding from dams receiving PS on WR. Dam treatment did not affect heifer pregnancy rate.

Introduction

Protein supplementation of spring calving beef cows grazing dormant Sandhills range during late gestation does not improve cow reproductive performance (*2006 Nebraska Beef Report*, pp. 7-9), despite the fact nutrient requirements are greater than nutrient content of the grazed forage. Supplementation does increase progeny weaning weight and fertility of heifer progeny (*2006 Nebraska Beef Report*, pp. 7-9; *2006 Nebraska Beef Report*, pp. 10-12). Corn crop residue provides a winter grazing alternative more economical than harvested forage. Decreasing harvested forage needs can reduce breakeven costs of weaned calves or finished steers.

The fetal programming hypothesis states postnatal growth and physiology can be influenced by stimulus experienced *in utero*. Previous research (*2006 Nebraska Beef Report*, pp. 7-9; *2006 Nebraska Beef Report*, pp. 10-12) provides evidence for fetal programming of reproductive tissue and endocrine metabolism of progeny from cows grazing dormant winter range without supplementation. The objectives of the current study were to determine effects of grazing dormant Sandhills range or corn crop residue with or without supplementation on performance of cows and their progeny.

Procedure

A three-year study utilized composite Red Angus x Simmental cows and their progeny at Gudmundsen Sandhills Laboratory (GSL), Whitman, Neb., and West Central Research and Extension Center (WCREC), North Platte, Neb. Cows were used in a 2 x 2 factorial treatment arrangement to determine effects on cow and progeny performance of grazing dormant Sandhills winter range (WR) or corn crop residue (CR) and receiving protein supplement (PS) or no supplement (NS). Pregnant, spring-calving cows (n = 109) between 3 and 5 years of age were stratified by age and weaning weight of their previous calf and assigned randomly to treatment in year 1. Cows remained on the same treatment for the length of the study unless removed due to reproductive failure or injury. Pregnant 3-year-old cows were stratified by age and weaning weight of their previous calf and assigned randomly to treatment, to replace cows removed from the study and to increase cows as forage availability allowed. Data are reported for 2005 (n = 109), 2006 (n = 114) and 2007 (n = 116). Current results include three years of data through weaning, three years of feedlot and carcass data for steers, and three years of data through pregnancy diagnosis for heifers.

Cows grazing winter range were divided into four, 79-acre upland pastures; two pastures received protein supplement, two did not. Cows grazing cornstalks were maintained in four fields; two fields received protein supplement.

On a pasture or field basis, cows received the equivalent of 1 lb/day of 28% CP supplement three times/week or no protein supplement from Dec. 1 until Feb. 28. The supplement contained 62.0% dried distillers grains plus solubles, 10.6% wheat middlings, 9.0% cottonseed meal, 5.0% dried corn gluten feed, 5.0% molasses, 3.0% calcium carbonate and 2.0% urea on a DM basis. Additionally, the supplement was formulated to meet vitamin and trace mineral requirements of the heifers and to supply 80 mg/animal/day monensin (Rumensin, Elanco Animal Health, Indianapolis, Ind.).

After winter grazing, cows were managed in a common group and fed hay harvested from subirrigated meadows and protein supplement. Cows returned to upland range in late May and remained in a common group throughout the breeding season until the subsequent winter grazing period. Cows were exposed to fertile bulls at a ratio of approximately one bull to 25 cows for 60 days each year.

Pre-calving, pre-breeding and weaning BW and BCS (1-9; 1 = emaciated, 9 = obese) were recorded each year. Cows were not limit fed prior to weighing. A subset of cows (n = 12-15 per treatment) was assigned randomly to one of four weigh-suckle-weigh groups. Milk production data were collected each year in late May, prior to the grazing season and at weaning. Pregnancy was diagnosed via rectal palpation and/or transrectal ultrasonography 60 or more days following the end of the breeding season.

Treatments included only dam winter grazing system and late gestation protein supplementation; no further treatments were applied to calves. Approximately 14 days following

(Continued on next page)

Table 1. Effects of grazing WR or CR and PS during the last trimester of gestation on cow performance and reproduction.

Trait	Treatment[1]				SEM	Treatment *P*-value[2]		
	PS/WR	NS/WR	PS/CR	NS/CR		Sys	Supp	S*S
Pre-calving BW, lb	1105[a]	1032[b]	1169[c]	1144d	44	< 0.001	< 0.001	0.02
Pre-calving BCS	5.11[a]	4.75[b]	5.34[c]	5.20a	0.05	< 0.001	< 0.001	0.03
Calf birth date, day	83[a]	89[b]	82[a]	84[a]	2	0.24	0.02	0.03
Calf birth BW, lb	79	77	81	80	0.99	0.01	0.10	0.46
Calved in first 21 days, %	83[a]	62[b]	78[a]	78[a]		0.31	0.06	0.02
Pre-breeding BW, lb	996	974	1054	1041	27	< 0.001	0.06	0.67
Pre-breeding BCS	5.22	4.99	5.36	5.22	0.05	< 0.001	< 0.001	0.32
Pre-breeding calf BW, lb	198[a]	187[b]	203[a]	203[a]	2	< 0.001	0.01	0.01
May 24-hour milk, lb	11.9	11.7	13.2	12.6	2.2	0.11	0.41	0.69
Nov. 24-hour milk, lb	5.5	6.2	8.4	8.4	0.9	< 0.01	0.69	0.55
Calf weaning BW, lb	518[a]	485[b]	518[a]	518[a]	7	0.01	0.03	< 0.01
Calf adj. 205 day BW, lb	485[a]	465[b]	489[a]	487[a]	13	0.01	0.03	0.07
Cow weaning BW, lb	1056	1043	1094	1100	18	< 0.001	0.80	0.30
Cow weaning BCS	5.13	5.07	5.08	5.14	0.07	0.83	0.06	0.20
Pregnancy rate, %	96.4	92.6	97.7	95.3	—	0.46	0.20	0.96

[1]PS = dams supplemented with 1 lb/day 28% CP during gestation; NS = dams not supplemented; CR = dams grazed winter corn residue; WR = dams grazed winter range.
[2]Sys = winter system; Supp = supplementation treatment; S*S = winter system by supplementation treatment interaction.
[abc]Within a row, means without a common superscript differ at $P < 0.05$.

weaning, calves were transported to WCREC, North Platte, Neb. After arrival, steers were limit fed a starter diet containing 35% ground alfalfa hay, 40% wet corn gluten feed, 7.5% supplement and 17.5% dry-rolled corn at 2.0% of BW (DM basis) for five days, prior to being weighed on two consecutive days. At this time, an initial implant containing 20 mg estradiol benzoate and 200 mg progesterone (Synovex S, Ft. Dodge Animal Health) and moxidectin (Cydectin, Ft. Dodge Animal Health) were administered. Approximately 100 days prior to estimated harvest date, steers were implanted with 24 mg estradiol and 120 mg trenbolone acetate (Revelor S, Intervet). Steer calves were penned by dam treatment and replication and were adapted over 21 days to a finishing diet including 48% dry-rolled corn, 40% wet corn gluten feed, 7% ground alfalfa hay and 5% supplement (DM basis).

Steers were harvested when estimated visually to have 0.5 inches fat thickness over the 12th rib when fed for an average of 222 days. Steers were harvested at a commercial abattoir, and carcass data were collected.

Heifers remained in a single group for approximately 50 days following transport to WCREC. They were acclimated to a diet consisting of corn gluten feed and low quality forage. In year 1, heifers were fed 25% WCGF and 75% prairie hay (DM basis) *ad libitum*. In year 2, heifers were allowed *ad libitum* intake of 20% wet corn gluten feed and 80% (DM basis) of a forage mix including wheat straw and alfalfa hay ground together. In year 3, heifers were allowed *ad libitum* intake of 20% wet corn gluten feed and 80% meadow hay (DM basis). Interim BW and blood samples were collected every 14 days to determine approximate age at puberty. Subsequently, heifers from WR cows in year 1 and a subset of heifers from each treatment in years 2 and 3 were assigned randomly to one of four pens containing Calan gates to evaluate individual feed efficiency.

Following completion of the individual feeding period (minimum 84 days) in early May each year, heifers returned to GSL. Heifers were exposed to bulls (1:25 bull:heifer) for a 45-day breeding season. Pregnancy diagnosis was performed via transrectal ultrasonography approximately 45 days following completion of the breeding season.

Continuous data were evaluated using PROC MIXED of SAS (SAS Inst., Inc., Cary, N.C.). The statistical model included winter grazing system, protein supplementation and the interaction. Cow age was included as a covariate for cow performance traits. Year was included as a random variable in all analyses, and pen-within-year for individually fed heifer data. Binomial data, including reproductive performance and quality grade, were analyzed using Chi-square procedures in PROC GENMOD of SAS.

Results

Cow BW and BCS after the winter grazing period and prior to calving were affected by the winter grazing system and protein supplementation (Table 1). Heavier BW and greater BCS were recorded for PS and cows grazing CR. These results are similar to those of Stalker et al. (*2006 Nebraska Beef Report*, pp. 7-9), who reported cows grazing winter range lost 64 lb and 0.6 BCS if not supplemented, but maintained both if they received 1 lb/day of 42% CP supplement during this period. Calving date also was later with fewer cows calving the first 21 days of the season for NS cows grazing WR but not CR.

Calf birth BW was greater if their dams grazed corn residue rather than winter range and tended ($P = 0.10$) to increase with protein supplementation. This is somewhat surprising because previous research using the

Table 2. Effects of dam grazing system and PS during the last trimester of gestation on gain and carcass merit of steers.

	Treatment[1]					Treatment *P*-value[2]		
Trait	PS/WR	NS/WR	PS/CR	NS/CR	SEM	Sys	Supp	S*S
Beginning feedlot BW, lb	528[a]	483[b]	516[a]	533[a]	24	0.01	0.06	< 0.001
ADG, lb/day	3.74	3.66	3.74	3.66	0.14	0.98	0.19	0.99
Final live BW, lb	1364	1304	1355	1353	28	0.22	0.06	0.08
HCW, lb	825[a]	789[b]	820[a]	819[a]	17	0.22	0.06	0.08
12th rib fat, in	0.50	0.46	0.49	0.47	0.03	0.93	0.14	0.56
REA, in^2	13.7	13.7	13.9	13.9	.30	0.29	1.00	0.56
Yield grade	2.92	2.68	2.82	2.77	0.18	0.93	0.10	0.28
Quality grade, % Choice	82.5	77.8	86.8	64.4	—	0.71	0.05	0.30

[1]PS = dams supplemented with 1 lb/day 28% CP during gestation; NS = dams not supplemented; CR = dams grazed winter corn residue; WR = dams grazed winter range.
[2]Sys = winter system; Supp = supplementation treatment; S*S = winter system by supplementation treatment interaction.
[abc]Within a row, means without a common superscript differ at $P < 0.05$.

same cow herd did not find differences in calf birth BW due to supplementation of dams grazing winter range (*2006 Nebraska Beef Report*, pp. 7-9; *2006 Nebraska Beef Report*, pp. 10-12). Despite a relatively small magnitude of difference, winter grazing system and protein supplementation did affect birth BW of calves in the current study.

Pre-breeding cow BW and BCS were increased by winter grazing of corn residue and protein supplementation (Table 1). The interaction of grazing system and supplementation was no longer significant, but groups ranked nearly the same as they had before calving. Milk production did not differ by treatment in May but was greater in November for cows that previously grazed CR. Calf BW was increased in May by protein supplementation when cows grazed WR but not CR.

At weaning, actual and adjusted calf BWs were greater for calves from PS cows grazing winter range. Similar effects of dam supplementation during winter grazing on calf weaning BW were reported in previous studies (*2006 Nebraska Beef Report*, pp. 7-9; *2006 Nebraska Beef Report*, pp. 10-12). Cow BW and BCS at weaning were not affected by supplementation, but cows that grazed corn residue the previous winter were heavier at weaning than those that grazed winter range, despite similar BCS. Pregnancy rate was not affected by PS or winter system. Stalker et al. (*2006 Nebraska Beef Report*, pp. 7-9) also reported no benefit of PS on winter range on subsequent pregnancy rates.

Effects of dam treatment on steer progeny feedlot performance are shown in Table 2. Feedlot initial BW differed due to the interaction of dam grazing system and supplementation. However, feedlot average daily gain (ADG) was similar between treatments. Steers from cows that were supplemented tended to have heavier final live BW and hot carcass weight. External fat thickness measured over the 12th rib was not affected by winter treatment or supplementation of the dam. A greater proportion of steers born to PS cows achieved USDA quality grades of Choice or greater. However, dam grazing system did not affect quality grade. These data suggest a potential fetal programming effect of late gestation cow supplementation on subsequent steer progeny intramuscular fat deposition. Using only cows that grazed winter range, Stalker et al. (*2006 Nebraska Beef Report*, pp. 7-9) were unable to identify any significant differences in steer progeny feedlot or carcass data. However, they did note a tendency for increased proportions of steers grading Choice or higher if their dams were supplemented with protein during late gestation, with a comparable magnitude of difference as observed in the current study.

Heifer progeny from cows in the current study achieved similar ADG from weaning until breeding regardless of dam treatment (Table 3). Heifers born to cows that grazed WR with NS were lighter at breeding and pregnancy diagnosis compared to heifers from all other treatments. Heifers born to PS cows were younger at puberty than progeny of NS cows; weight at puberty was not affected by dam treatment. More heifers were cyclic before breeding from dams receiving PS on WR than from dams on CR. It is important to note heifers from WR cows were individually fed in year 1, while heifers from CR cows were not. In years 2 and 3, heifers from both systems were individually fed. The difference in environment in year 1 may have contributed to apparent differences in age at puberty. Final pregnancy rate was not affected by dam treatment. Previous research indicated a fetal programming effect of late gestation maternal nutrition on heifer progeny fertility, independent of age at puberty and percent cycling before the breeding season (*2006 Nebraska Beef Report*, pp. 10-12).

There were no differences in dry matter intake (DMI) or ADG due to dam protein supplementation. However, heifers from unsupplemented cows gained more efficiently, both in terms of residual feed intake (RFI) and gain-to-feed ratio (G:F), than heifers from supplemented cows. Average daily gain was greater for heifers born to cows that grazed WR than cows that grazed CR, but DMI was similar between grazing systems.

(Continued on next page)

Table 3. Effects of dam grazing system and PS during the last trimester of gestation on growth and reproduction of heifers.

	Treatment[1]					Treatment P-value[2]		
Trait	PS/WR	NS/WR	PS/CR	NS/CR	SEM	Sys	Supp	S*S
Act. weaning BW, lb	509	480	513	505	13	0.05	0.02	0.17
Adj. 205 day BW, lb	478[a]	454[b]	479[a]	480[a]	10	0.04	0.08	0.04
Gain while on test, lb/day	1.85[a]	1.80[a]	1.54[b]	1.78[a]	0.15	0.02	0.11	0.02
Gain, weaning to breeding, lb/day	1.11	1.07	1.04	1.12	0.12	0.80	0.58	0.20
DMI, lb/day	16.4	16.9	15.8	16.2	0.6	0.74	0.95	0.16
F:G, lb feed/lb gain	8.88[a]	8.90[a]	10.71[b]	9.24[a]	10	0.002	0.03	0.02
RFI	-0.01[a]	-1.03[b]	0.03[a]	0.04[a]	0.33	0.02	0.02	0.02
Pre-breeding BW, lb	712	677	712	716	2	0.14	0.22	0.10
Pubertal prior to breeding, %	91	72	77	81	—	0.47	0.20	0.06
Age at puberty, day	352	372	347	360	8	0.27	0.03	0.65
Pregnancy diagnosis BW, lb	811[ab]	785[a]	817[a]	826[b]	16	0.13	0.58	0.26
Pregnancy diagnosis BCS	5.80	5.82	5.75	5.89	0.04	0.33	0.27	0.06
Pregnancy rate, %	90.5	77.1	87.8	83.3	0.07	0.76	0.12	0.45

[1]PS = dams supplemented with 1 lb/day 28% CP during gestation; NS = dams not supplemented; CR = dams grazed winter corn residue; WR = dams grazed winter range.
[2]Sys = winter system; Supp = supplementation treatment; S*S = winter system by supplementation treatment interaction.
[abc]Within a row, means without a common superscript differ at $P < 0.05$.

Heifers born to cows that grazed WR were more efficient in terms of G:F and RFI than counterparts from CR cows. Specifically, heifers born to cows that grazed CR with PS had a lower G:F than those whose dams received other treatments. Furthermore, RFI was lowest for heifers born to cows that grazed WR and did not receive PS compared to all other treatments. Previously, RFI and DMI appeared to be affected by late gestation supplementation dependent upon postpartum dam treatment *(2006 Nebraska Beef Report*, pp. 10-12).

Grazing corn residue resulted in greater cow BW and BCS throughout the production year and increased steer final BW; PS reduced heifer age at puberty versus NS. Calf weaning BW and percentage of heifers pubertal before breeding increased with PS of WR cows, while PS improved steer quality grade in both systems.

[1]Rick N. Funston, associate professor of animal science, West Central Research and Extension Center; Jeremy L. Martin, former graduate student; Don C. Adams, director, West Central Research and Extension Center; and Daniel M. Larson, graduate student, Animal Science, Lincoln, Neb.

Effect of Estrus Synchronization with a Single Injection of Prostaglandin During Natural Service Mating

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Rick N. Funston[1]

Summary

Records from unsynchronized cows (n = 2073; 60-day breeding season) were compared with records from synchronized cows (n = 517; 45-day breeding season) collected between 2000 and 2006. A single injection of prostaglandin $F_{2\alpha}$ was administered approximately 108 hours after bull turn-in to synchronize estrus in spring calving mature beef cows. Estrus synchronization increased the percentage of cows calving in the first 21 days without affecting pregnancy rates. However, weaning BW of calves was not significantly different. Estrus synchronization improves synchrony of calving in a shorter breeding season with similar overall pregnancy rates.

Introduction

Estrus synchronization is primarily utilized in conjunction with artificial insemination. However, estrus synchronization is potentially beneficial to cattle producers using natural mating. A primary obstacle to increased usage of estrus synchronization is the labor associated with applying a synchronization protocol. Thus, a successful system will be easy to implement as well as cost effective. Prostaglandin $F_{2\alpha}$ (PGF) causes lysis of the corpus luteum when administered at least 96 hours after ovulation; however, the corpus luteum is not responsive to PGF prior to this time. Standing estrus will occur between 48 and 96 hours after PGF in cyclic females. Whittier et al. (1991, *Journal of Animal Science, 69*:4670-4677) found a single injection of PGF administered 96 hours after bull turn-in increased the percentage of cows calving in the first 50 days of the calving season.

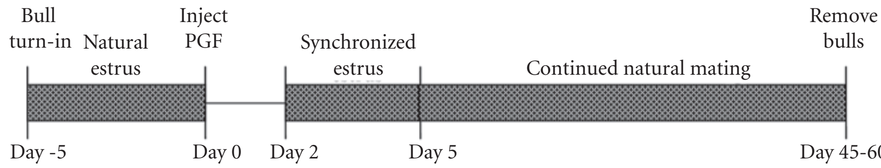

Figure 1. Breeding season protocol.

However, they did not detect a difference in the percentage calving in the first 21 days, nor did they measure weaning BW of the resulting calf crop. Data from our group (Larson et al., 2008 *Proceedings of the Western Section of the American Society of Animal Science*, abstract no. 74) indicate more heifers given PGF 96 hours after bull turn-in calved in the first 21 days of the breeding season. Further research is needed to evaluate the effect of this system in mature, lactating cows.

Procedure

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

Breeding, calving and weaning data were collected from the research herd at the Gudmundsen Sandhills Laboratory (GSL) near Whitman, Neb. The data for the spring calving herd, collected between 2000 and 2008, were used for the purposes of this analysis. The breeding season begins on approximately June 15 for the spring calving herd. Natural service mating was used for all cows greater than or equal to three years of age. Bulls remained with the cows for 60 days in years where no estrus synchronization was used and for 45 days in years where estrus synchronization was used. The exception was a subset of cows used in a current nutritional experiment, which were exposed to bulls for 60 days during the synchronized spring breeding season in 2007 (118 cows). The bull-to-cow ratio was at least 1:25 in all years. Pregnancy was diagnosed via rectal palpation approximately 45 days following bull removal. As varying nutritional and breeding treatments are applied to the yearling heifers during breeding, two-year-old cows were removed from this analysis to avoid confounding the results.

Estrus was synchronized using a single injection of PGF administered 108 hours after fertile bulls were turned in with each respective cowherd (Figure 1). Estrus was synchronized during the 2006 and 2007 breeding seasons (517 individual records), resulting in synchronized calving seasons in 2007 and 2008. These results were compared to the data collected between the 2000 and 2006 calving seasons resulting from unsynchronized breeding between 1999 and 2005 (2073 individual records). Weaning data also were analyzed for the 2007 weaned calves (208 individual records) and compared to those weaned between 2000 and 2006 (1790 individual records). The continuous data were analyzed using the MIXED procedure of SAS and binomial data with the GLIMMIX procedure of SAS. The model included the fixed effect of synchronization, the random effects of year and any treatments imposed on each particular herd within each year.

Results

The data for the spring calving herd are displayed in Table 1. The synchronized subset of data was generated for the 2007 and 2008 calving seasons and the unsynchronized

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subset was generated for the years between 2000 and 2006.

Calf birth date was similar ($P = 0.60$) for synchronized and unsynchronized cows, as was calf birth weight ($P = 0.48$). Average calving difficulty score was defined, where 1 = no assistance and 3 = difficult assist. Calving difficulty score was similar ($P = 0.16$) for unsynchronized and synchronized cows. The percentage of male calves was unaffected ($P = 0.93$) by synchronization scheme. Perhaps most interesting, synchronization increased the percentage calving in the first 21 days ($P = 0.002$) by 11% (74.9% vs. 63.2%, synchronized vs. unsynchronized, respectively). The mechanism underlying this synchronization system relies on the observation that the corpus luteum (CL) is unresponsive to PGF within 96 hours after ovulation. Thus, bulls are allowed to inseminate cows at natural estrus for approximately five days; cows inseminated during this period will not respond to PGF. On day 5, PGF is administered to all cows and the bulls inseminate cows at synchronized estrus following PGF, as described in Figure 1. It is imperative to administer PGF at the correct interval to avoid destroying the CL in cows inseminated on the day of bull turn-in. These data agree with previously published research on both mature cows and replacement heifers. However, calf birth date was unaffected, which may seem counterintuitive. Most likely, those cows failing to conceive at synchronized estrus were inseminated 21 days later; thus, average calving date was unaffected. Still, more calves were born early in the season with estrus synchronization. As more calves are born earlier in the season, one may expect weaning weight to be increased. However, while there was a numerical increase in calf weaning weight, the difference was not significant (P = 0.58). Finally, pregnancy rate of the dam was unaffected (P = 0.72) by previous synchronization scheme.

Estrus synchronization increased the percentage of cows calving in the first 21 days of the season (Table 1). This indicates more cows were mated by natural service early in the breeding season. In addition, the breeding season was shortened from 60 to 45 days for unsynchronized and synchronized seasons, respectively. The average calving date was unaffected by estrus synchronization, as were pregnancy rates. These data indicate that the majority of cows failing to conceive became pregnant at the subsequent mating. In summary, estrus synchronization using a single injection of prostaglandin improves synchrony of calving without sacrificing pregnancy rate in a 45-day breeding season.

Table 1. Effect of estrus synchronization using PGF in a spring calving herd.

	Non-synchronized	Synchronized	SEM	*P*-value
n	2073	518		
Calf birth date, julian day	86	85	2	0.60
Calf birth weight, lb	83	82	2	0.48
Calving ease score[1]	1.1	1.0	0.1	0.16
Calved in the first 21 days, %	63	75	3	0.002
Sex, % male	52	52	2	0.93
Pregnant, %	95	94	2	0.72
n	1597	414		
Weaning weight, lb	488	506	30	0.58
Cow weight at weaning, lb	1116	1113	31	0.92
Cow BCS at weaning	5.2	5.2	0.1	0.78

[1]1 = No assistance, 2 = easy assist, 3 = difficult assist.

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Limit Feeding Beef Cows with Bunkered Wet Distillers Grains plus Solubles or Distillers Solubles

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Summary

An experiment was conducted using 70 cows to evaluate performance when limit limit-fed grain byproducts. Cows in the wet distillers grains plus solubles (WDGS) treatment group and those in the distillers solubles (DS) treatment group were limit fed a diet containing 41% byproduct and 59% cornstalks. The control (CON) treatment consisted of ad libitum *intake of 43% brome hay, 34% cornstalks and 23% alfalfa haylage. Cows fed WDGS were heavier compared to those in the DS and CON treatment groups. Average daily gain (ADG) tended to be greater for WDGS treatment compared to the CON treatment. These data suggest that performance of cows limit-fed either WDGS or DS stored in a bunker is similar to that of cows fed an* ad libitum *forage diet.*

Introduction

Corn-based diets fed at a restricted intake can be used to meet nutrient needs for beef cows in gestation and early lactation without adverse effects on production. Grain byproducts from the ethanol industry are a viable source of nutrients for cows and could be used with low quality forages to provide a limit-fed ration that meets maintenance requirements. The objective of this experiment was to evaluate the performance of non-lactating, non-pregnant beef cows limit limit-fed grain byproducts compared with an *ad libitum* forage diet.

Procedure

Seventy non-lactating, non-pregnant beef cows (1,303 ± 139 lb) were stratified by age, BW and body condition (1 = emaciated, 9 = obese), then assigned randomly to one of three treatments and fed to maintain BW. Cows were fed at the UNL ARDC feedlot near Mead, Neb. Treatment diets were formulated to be isocaloric and isonitrogenous for the 76-day experiment. Cows (three pens/treatment) were limit fed a 41:59 ratio of bunkered wet distillers grains plus solubles (WDGS; n = 24) and cornstalks limited to 17 lb/head/day (1.3% of BW); bunkered distillers solubles (DS; n = 22) and cornstalks at a 41:59 ratio offered at 17 lb/head/day (1.3% of BW); or a control diet (CON; n = 24) containing 43% bromegrass, 34% cornstalks and 23% alfalfa haylage to provide *ad libitum* intake.

The WDGS and DS diets were mixed and stored 30 days prior to the start of the trial. To prepare the material to be bunkered, cornstalks were ground through a 7-in screen. Distillers solubles or WDGS and cornstalks were weighed into a Roto-mix truck and mixed for five minutes, then packed into a concrete bunker using a skid steer loader.

The targeted byproduct to cornstalks (DM basis) ratio for storage in the bunker was 65:35. However, the mixed material in the DS bunker would not pack at this ratio, so cornstalks were added until the material would pack. The optimal distillers solubles to cornstalks ratio was 41:59. The WDGS:corn stalks mix was adjusted to a storable bunker ratio of 70:30 of wet distillers grains plus solubles and cornstalks, respectively. Wet distillers grains plus solubles and DS bunkered material were covered with plastic.

WDGS was mixed at feed delivery with cornstalks to attain the 41:59 WDGS:cornstalks treatment ratio. The DS:cornstalks mixture was fed directly from the bunker. Prior to trial initiation and at trial conclusion, cows were limit-fed for five days using a diet that was 40% brome hay, 10% alfalfa hay and 50% wet corn gluten feed to minimize error due to gut fill (1.9% BW).

Two-day consecutive initial and final BW were recorded to determine performance characteristics. Limestone was added to limit-fed diets to achieve a minimum Ca:P ratio of 1.5:1. Salt and trace mineral blocks were offered free choice in the bunks. Data were analyzed using the PROC MIXED procedure of SAS with pen as the experimental unit.

Results

Initial and final body condition scores did not differ among treatments and averaged 5.9 (Table 1). Initial BW across treatments was similar among treatment groups. Final BW

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Table 1. Effects of limit feeding non-lactating, non-pregnant beef cows.

	Treatment[1]				
Performance Characteristics	WDGS	DS	CON	SEM	*P*-value
Initial BW, lb	1315	1295	1311	10	0.20
Final BW, lb	1379[a]	1348[b]	1346[b]	7	0.01
Initial BCS	5.7	5.8	5.7	0.08	0.49
Final BCS	6.0	6.0	5.9	0.11	0.48
Change in BW, lb	64	52	34	8	0.09
ADG, lb	0.82	0.68	0.44	0.20	0.09
DMI, lb/d	17.00[a]	17.00[a]	22.80[b]	0.32	0.01

[1]Dietary treatments: WDGS = wet distillers grains plus solubles mixed with corn stalks; DS = distillers solubles mixed with corn stalks; CON = corn stalks, alfalfa haylage and brome hay.
[a,b]Within a row, means without a common superscript differ ($P < 0.01$).

was greater ($P = 0.01$) for the WDGS (1,379 lb) treatment compared to DS (1,348 lb) and CON treatments (1,346 lb). Change in BW did not differ between WDGS (63 lb) and DS (52 lb) treatments but tended ($P = 0.09$) to differ between WDGS (63 lb) and CON (34 lb) treatments.

Dry matter intake (DMI) was 22.8 lbs for cows fed the CON diet compared with 17 lbs for the limit-fed WDGS and DS treatments. Performance differences were not observed between cows limit-fed WDGS or DS treatments.

Previous data suggest that corn oil supplementation decreases neutral detergent fiber (NDF) digestibility by 6% and 12% when corn oil is supplemented at 0.75 g/kg of BW and 1.5 g/kg of BW, respectively. As fat level in the diet increased, we hypothesized that ADG would be negatively impacted, thus anticipating a lower ADG when comparing WDGS and DS treatments to CON. Fat levels of the diets were 9.2% and 4.9% for DS and WDGS treatments, respectively, when using ether extract fat analysis. However, a new laboratory procedure for determining fat content of DS determined fat content of DS was 13.6% (observed) versus 22.7% (formulated; determined using ether extract analysis). Using the new fat values, the dietary fat level of DS cows calculated to be 5.6%. The CON treatment effects were likely due to lower DMI (1.8% of BW) than predicted by the National Research Council. In addition cows in the CON treatment visually sorted their diet. Cows on the WDGS and DS treatments did not sort their diets and consumed 100%.

With the increasing availability of grain byproducts, producers may consider using bunkered WDGS and DS in limit-fed rations. Although fat level showed no negative effect on animal performance in our experiment, dietary fat should be closely monitored because of its possible negative effect on forage digestion. Nonlactating, non-pregnant mature beef cows can be maintained on a limit-fed diet of WDGS or DS similar to feeding forage diets *ad libitum*.

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Estimating Livestock Forage Demand: Defining the Animal Unit

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Summary

Animals were housed in individual pens and fed high quality (11% CP) meadow hay ad libitum *daily to evaluate the effect of a beef animal's physiological state (cow-calf pair vs. dry cow vs. yearling steer) on forage intake. Daily diet samples were composited by week and analyzed. Refusals were collected, composited by week per pen and analyzed. Dry matter intake (DMI) was different among treatments. The results indicate different physiological states or classes of cattle should be considered when calculating forage demand for stocking rate or feeding purposes.*

Introduction

The term animal unit (AU) is utilized widely in grazing management strategies. Various definitions for the terms AU, animal unit day (AUD), animal unit month (AUM) and animal unit year (AUY) exist, but they all have one common theme — to define forage intake on the basis of a standard animal. The general consensus is a standard animal consumes about 2.6% of its BW on a DM basis. The factor accounted for in many animal unit definitions is body size, with physiological status being the most erratic factor in defining an animal unit. Therefore, the objective of the current experiment was to evaluate the effect of a beef animal's physiological state on forage intake.

Procedure

This project was replicated over two years, with year 1 located at the Gudmundsen Sandhills Laboratory (GSL) near Whitman, Neb., and year 2 at the West Central Research and Extension Center, North Platte, Neb. All animal procedures were approved by the University of Nebraska Institutional Animal Care and Use Committee.

Each year six replications of three treatments were evaluated: cow-calf pair (CC; BW = 1,307 lb); dry cow (DC; BW = 1,119 lb); and yearling steer (S; BW = 602 lb). The cow and calf were treated as one unit, with calves averaging 42 days and 161 lb at the start of the experiment each year. In year 1, the trial was 13 weeks and in year 2, the trial was nine weeks. Yearling and calf BW change during each trial is shown in Table 1.

Cattle were offered hay harvested from sub-irrigated meadows at GSL. Tables 2 and 3 provide the analysis of the hay supplied. Hay was weighed and offered daily in amounts to allow *ad libitum* intake. DM was determined from samples collected daily and composited within the week. Refusals from each pen were collected weekly in year 1 and collected daily in year 2.

At the beginning, middle and end of each trial, all animals were weighed for three consecutive days and their weights averaged. Average BW during the trial was used to determine intake relative to BW. Diet and refusal samples were dried in a forced air oven for 48 hours at 60°C. Daily diet and refusal samples were composited by week. All samples were ground to pass through a 2-mm screen, with a subsample ground to pass through a 1-mm screen.

Diet and refusal samples were analyzed for dry matter (DM), organic matter (OM), *in vitro* drymatter digestibility (IVDMD), neutral detergent fiber (NDF) and

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Table 1. Average BW change of yearling steers and calves for year 1 and year 2.

	Year 1			Year 2		
	Start BW	End BW	ADG	Start BW	End BW	ADG
Yearling steers, lb	582	746	1.74	631	733	1.46
Calves, lb	151	368	2.31	171	330	2.27

Table 2. Characteristics of hay fed to treatment animals during year 1.

	Hay offered	Hay refused	Actual diet
DM, %	84.1	76.4	—
OM, %	90.5	85.5	91.3
NDF, % DM	64.3	70.0	63.8
CP, % DM	11.6	10.5	—
IVDMD, % DM	52.6	48.4	53.2
UIP, % of CP	40.8	46.4	—

Table 3. Characteristics of hay fed to treatment animals during year 2.

	Hay offered	Hay refused	Actual diet
DM, %	79.7	85.8	—
OM, %	89.9	89.8	89.9
NDF, % DM	67.2	76.5	66.2
CP, % DM	10.7	10.2	—
IVDMD, % DM	51.8	46.5	52.9
UIP, % of CP	44.9	53.2	—

undegradable intake protein (UIP). Ruminally fistulated cows fed a basal diet of meadow hay provided inoculant for IVDMD, as well as *in situ* incubation.

Average daily intake during each week of the experiment was analyzed as a repeated measure using the MIXED procedure of SAS with a first order autoregressive (AR1) covariance structure. The model included the effects of treatment as a fixed effect and year, week, and treatment by week interaction as random effects. Individual animal or cow/calf pair was used as the experimental unit.

Table 4. Average intake in lbs, % BW and % MBW.[1]

	Cow-calf pair	Dry cow	Steer	SE	*P*-value
BW, lb	1431.4	1118.5	683.6	43.11	< 0.0001
MBW, lb	232.4	193.0	133.6	5.52	< 0.0001
DMI, lb	36.2	25.8	14.5	0.84	< 0.0001
DMI, % of BW	2.5	2.3	2.1	0.0006	< 0.0001
DMI, % of MBW	15.6	13.5	10.8	0.003	< 0.0001
OMI, lb	32.8	23.4	13.2	0.77	< 0.0001
OMI, % of BW	2.3	2.1	1.9	0.0005	< 0.0001
OMI, % of MBW	14.1	12.2	9.8	0.003	< 0.0001
IVDMD, lb	19.1	13.6	7.7	0.54	< 0.0001
IVDMD, % of BW	1.3	1.2	1.1	0.0004	0.0013
IVDMD, % of MBW	8.3	7.1	5.8	0.001	< 0.0001
NDF, lb	23.4	16.7	9.4	0.52	< 0.0001
NDF, % of BW	1.7	1.5	1.4	0.0004	< 0.0001
NDF, % of MBW	10.1	8.7	7.0	0.002	< 0.0001

[1]MBW (Metabolic body weight) = $BW^{0.75}$.

Results

Differences occurred among treatments for the variables analyzed as shown in Table 4. Actual daily DMI was over 28% higher for CC when compared to DC and almost 60% higher when compared to S. When DMI is compared as %BW, CC still had an 8% greater intake than DC and 16% greater intake than S. Maintenance requirements of lactating cows are approximately 20% higher than those of nonlactating cows (*Nutrient Requirements of Beef Cattle*, 2000 update.*)*. While calves were observed to eat the hay, no attempt was made to partition hay intake between the cow and calf. Some of the increased intake by CC compared to DC can be attributed to calf intake.

Voluntary intake in beef cows is similar to intake in growing cattle when adjusted for effect of milk production (NRC, 1987, *Predicting Feed Intake of Food-Producing Animals*). However, in this experiment, dry cows consumed 2.3% and yearling steers consumed 2.1% of their BW, compared to cow-calf pairs consuming 2.5% of their BW.

Actual daily organic matter intake (OMI) was over 28% higher for CC when compared to DC and almost 60% higher when compared to S. Previous research measured intake of calves approximately the same age as those in the present study, and found they consumed 1.1% to 1.5% of their BW on an OM basis (*1995 Nebraska Beef Report*, pp. 3-4). Lactating cows in the same study consumed 2.0% to 2.6% of their BW on an OM basis. In the present experiment, the cow and calf were treated as one unit, with the intakes for the lactating cows in the previous study being similar to intakes for the cow-calf pair (2.3% BW, OM basis).

Conclusion

In addition to BW, these results indicate DMI differences among cattle of different physiological state or class should be considered when calculating forage demand. This would further increase accuracy of forage demand estimates for stocking rate or feeding purposes.

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Moving Beyond Weight as the Only Predictor of Breeding Readiness: Using a Breeding Maturity Index

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Summary

A maturity index (MI) was developed using data from Gudmundsen Sandhills Laboratory to predict a heifer's optimal size for breeding. It was developed from observable information such as age, feeding regime, pre-breeding, birth and dam weights. The MI was the most precise predictor of actual percentage of mature weight versus using estimates developed from the herd's estimated average weight or the dam's mature weight. The MI also was a more accurate predictor of first pregnancy than the typically applied measure.

Introduction

Recommendations provided to producers with respect to the size beef cattle replacement females should attain prior to first breeding is generally given as a percentage of their mature body weight. What is not often mentioned is that the heifer's actual measure of percent mature body weight requires knowledge of her mature weight, which is not available until she reaches an age of 4 to 5 years. Animal scientists routinely substitute the herd's estimated average weight as a proxy for an individual animal's mature weight. This measure can accurately be described as percentage of average herd weight (PAHW).

Two assumptions are made when using the PAHW as a proxy measurement of maturity: 1) animals in a herd are of a homogeneous weight, and 2) the herd's average weight is representative of the average mature weights of cows from that herd. These two assumptions are problematic in application, since most commercial herds contain animals of various sizes and ages, where the ages and sizes are not likely to be uniformly distributed. It would be expected that a greater percentage of younger animals would be present in a herd versus older animals and that many factors could influence the size variation within the herd. Both of these facts introduce variation error in measuring maturity.

Despite these shortcomings, this method of determining mature body weight has been widely adopted and accepted, most likely because it is convenient and provides a rough measure of heifer maturity and breeding readiness. However with the amount of information available to animal scientists and producers, it is logical to explore other means of predicting maturity. Given current technology and information, a new method of measuring maturity was developed based on a series of observable individual animal characteristics, much like an index, and thus was titled the maturity index (MI).

Procedure

Data from two experiments performed on young heifers at the Gudmundsen Sandhills Laboratory (GSL) were analyzed to determine the MI. Each of these two experiments has been published in previous Nebraska Beef Cattle Reports (*2002 Beef Cattle Report*, pp. 4-7 and *2005 Beef Cattle Report*, pp. 3-6). These studies were initiated to determine the effect of reducing the PAHW. The first experiment consisted of a study of two groups of animals fed to an average PAHW of approximately 60% and 56%. The more recent study (2005) targeted even lower maturity levels to a PAHW of 58% and 53%. The primary objective in these two trials was to compare pregnancy rates. In both of these studies feed was varied to control the pre-breeding weights of the heifers. As with most groups, individual animals deviated from the group averages. In this work, the treatment effect was considered, but variation within groups also was an important part of the result. The within-group variation made possible the use of statistical techniques to estimate differences in individual maturities. The combined data for these two studies contained information about 500 heifers.

As the studies progressed, animals that died, did not conceive or lost their calves were culled and sold, leaving only 302 at the time of maturity. The actual percentage of mature body weight (APMBW) at the time of first breeding was calculated by dividing a heifer's pre-breeding weight by her actual mature weight at the time her third calf was weaned.

A series of ordinary least squares regressions was estimated using APMBW as the dependent variable and all possible combinations of five commonly observed variables: pre-breeding weight, birth weight, dam mature body weight, pre-breeding age and nutrition level, as measured by a set of indicator variables for the four ration treatments that were part of the original experiments. The selected model was chosen on the following two criteria. First, each of the coefficient estimates had to be statistically significant at the 95% level using a student t test; and second, the selected model had to have the lowest Akaike information criterion (AIC) score. The AIC, as described in *Basic Econometrerics* by Damodar Gujarati (2003), is used to balance the explanatory power obtained from the number of coefficients included in the estimation process versus the cost of increased model complexity, and is commonly applied as a model selection criterion.

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Results

Equation 1 shows the MI model meeting the two conditions of coefficient significance and minimum AIC score. Three indicator or "dummy" variables were included to account for the four feed treatment groups. The fourth group's T4 was the baseline and required no indicator variable.

Equation 1.

$$MI = 30.508 + 0.032\ PbWt - 0.146\ BirthWt + 0.078\ Age - 0.013\ DamWt + 4.839\ T1 + 2.658\ T2 + 2.499\ T3$$

Where:

MI = Maturity index

PbWt = Pre-breeding weight

BirthWt = Birth weight

Age = Age in days for first bull exposure

DamWt = Weight of the heifer's dam at weaning when four years of age

T1 = Dummy variable for feeding treatment group resulting in a group average pre-breeding weight of 58% of mature body weight

T2 = Dummy variable for feeding treatment group resulting in a group average pre-breeding weight of 53% of mature body weight

T3 = Dummy variable for feeding treatment group resulting in a group average pre-breeding weight of 56% of mature body weight

The relationship between MI and the variables that predict it provide clues about the factors that affect maturity and breeding readiness. From Equation 1, the right side coefficients represent the magnitude and nature of the relationship that each has to the MI. For example, the coefficient for pre-breeding weight shows there is a positive 0.032 increase in MI for every pound of weight, indicating that the heavier the heifer the greater her MI, relative to other heifers with identical birth weight, dam weight, age and nutrition level. The dam's weight has a negative effect on the MI, indicating animals of equal age, birth weight, pre-breeding weight and nutrition level have a 0.013 reduction in their MI for every pound larger their dam was relative to the dams of other heifers. The same effect holds for birth weight as for dam weight: the larger the birth weight the smaller the MI would be relative to contemporaries that differ only by birth weight. Age has the opposite effect of birth weight and dam weight. For each day of age, the heifer's MI would increase by .078, holding all other variables constant, *ceteris paribus*. Nutrition level also has an effect; as the level of nutrition increases, the MI increases, given the *ceteris paribus* condition.

From a statistical perspective, this model is ideal, but the important question is how well it performs. The true test for this model would be to compare its performance to that of the PAHW in predicting the actual percentage mature body weight and — most importantly — ability to successfully breed and become pregnant. Unfortunately, in creating the MI, all of the observations were used to construct the model, making it impossible to perform an out-of-sample test. A second option, which was used in this case, was to compare the two methods using the current data in an in-sample test. In addition, an *ad hoc* method of describing a heifer's maturity was included to provide breadth. This measure, referred to as the percent of mature dam weight (PMDW), was obtained by dividing a heifer's pre-breeding weight by her dam's mature body weight. The mature weight of the dam is expected to have a large influence on the mature weight of the heifer. It would be expected that the dam's weight would be a better predictor of a heifer's mature weight than the herd's average weight, but not as good a predictor as the MI. The Mean Absolute Percent Error (MAPE) method was used to compare the three methods.

Table 1. Comparing MI, PAHW and PMDW as predictors of APMBW using a MAPE.

Forecaster	MAPE
MI	5.7%
PAHW	12.3%
PMDW	8.9%

The MAPE is a weighted measure of the average amount of error observed over the sample space. The method with the smallest calculated MAPE is the method with the least amount of error and is therefore the most accurate predictor over the sample space. Table 1 shows the calculated MAPE values for MI, PAHW and PMDW when used to predict APMBW. These results indicate that over the sample space, the MI is the best predictor of percent of mature body weight. MI out-performs both other prediction methods, with more than 3% less error than PMDW and more than 5% less error than PAHW.

The next step in evaluating the usefulness of the MI was to determine how accurately it predicted pregnancy. The MI was compared to two other methods of expressing a heifer's maturity at breeding. The first of these methods was the APMBW, the individual animal's pre-breeding weight as a percentage of her actual mature weight. As discussed earlier, the heifer's actual mature weight is not available at the time of the breeding decision, thus making the APMBW unavailable for practical use, but it does serve as a base point of comparison, being an individually calculated measure of maturity. The second measure is the commonly used PAHW, the heifer's weight relative to the herd's average weight.

Each of the three measures was used as the independent variable in a Probit regression on pregnancy rate. Pregnancy is measured as occurring, 1, or not occurring, 0. This type of information, where the dependent variable is limited, is best handled by a limited dependent variable regression such as the Probit. A model of this type is estimated by maximum

Table 2. **Comparison of student t tests for the PAHW, APMBW and MI as predictors of the rate of first pregnancy using a Probit regression.**

Independent Variables Used	Constant	X	X^2
PAHW	-1.612	1.779	-1.663
APMBW	0.861	-0.788	0.863
MI	-1.880	1.923	-1.871

likelihood. The coefficient estimate is the part of the normal distribution equation that represents the mean and standard deviation, assuring that the Probits' results are translated into probabilities, regardless of the value of the coefficient estimates. The Probit regression equations were modified to reflect the diminishing returns of pregnancy rate to maturity, by including the quadratic term.

Table 2 shows the results of these Probit regressions. The greater the absolute value of the student t tests, the greater the chance that the coefficient is statistically significant. These findings indicate that MI is a statistically superior predictor of first pregnancy as compared to the PAHW and the APMBW.

Discussion

MI is a more accurate and statistically superior predictor of first time pregnancy in replacement beef heifers studied at GSL than the currently used PAHW, the commonly accepted method of stating heifer size at pre-breeding. Logically these results are not unexpected, since the MI is derived entirely from individual animal information, while the PAHW is based partially on herd information. The MI is also superior to the true measure of mature stature, APMBW. While at first this seems counter-intuitive, careful thought reveals why this is so. The MI contains information in addition to the heifer's mature stature including age, nutrition and birth weight.

It is possible to use the relationships found from estimating the MI to increase the probability of a higher pregnancy rate among replacement females. Relatively older calves with a smaller birth weight, smaller dam weight, and of a higher pre-breeding weight fed at a higher level of nutrition would have a relatively higher MI than herd mates and would thereby have a greater probability of becoming pregnant.

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The Effects of Breeding Maturity on Dystocia and Rebreeding of the Primiparous Beef Female

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Summary

Maturity Index (MI) was used in a Probit regression as an explanatory variable of dystocia, where dystocia was used in a Probit regression as an explanatory variable of rebreeding rates of primiparous cows from data collected on replacement heifers from the Gudmundsen Sandhills Laboratory. Dystocia was found to decrease from about 40% to 13% for heifers when the MI increased from 53 to 70, supporting the notion that maturity reduces the incidence of dystocia, resulting in an increase in the second pregnancy rate.

Introduction

The optimal size to breed the replacement female is a major concern of the cow-calf operator. An important consideration is the dystocia rate of the replacement female. Dystocia is a time-consuming and costly event. Producers have long included dystocia rates in their evaluation of bull genetics and relate this directly to their replacement heifer breeding regimes. Key to determining the optimal pre-breeding size of the replacement heifer is an understanding of the effects that size and maturity have on dystocia and, in turn, understanding dystocia's effect on second pregnancy.

The maturity index (MI) is used to predict breeding readiness of replacement beef females. For a complete explanation of how and why this index was developed, please refer to the article entitled "Moving Beyond Weight as the Only Predictor of Breeding Readiness: Using a Breeding Maturity Index" (pp. 19-21) in the current beef report.

Procedures

Data used to relate dystocia to MI and second pregnancy rates were taken from two experiments used to identify breeding readiness of several groups of beef heifers fed to four different pre-breeding weights at the Gudmundsen Sandhills Laboratory (GSL). The results from these studies were published in the *2002 and 2005 Beef Cattle Reports*, pp. 4-7 and pp. 3-6, respectively. These studies included 500 heifers, but only those heifers that calved (n = 448) were included in the analysis relating MI to dystocia, and only cows that were retained to the determination of their second pregnancy (n = 422) were included in the analysis of dystocia on pregnancy rates of primiparous cows.

Probit regression, a type of limited dependent variable regression technique, was used for both analyses. In the first analysis, the dependent variable was dystocia, limited to a value of one if the heifer required assistance at the time of parturition, or a zero if no intervention occurred. It was expected that MI would have an inverse relationship with dystocia. Three different functional relationships were compared: linear, quadratic and cubic forms. The models were evaluated using the Normalized Success Index (NSI) as described on page 294 of the *Shazam Econometrics Software User's Reference Manual*. Briefly, NSI is the proportion of predictions that were correct. The cubic form of the Probit was selected as the best model.

In the second analysis, the dependent variable was pregnancy of the primiparous animal and was assigned a value of one if the cow was diagnosed as pregnant and zero if otherwise.

Table 1. Normalized Success Index for three formulations of MI.

Form of MI	Normalized Success Index
Linear	0.034
Quadratic	0.086
Cubic	0.099

Table 2. Marginal changes in dystocia rates at selected MIs.

MI	Marginal Change of Dystocia
50	-3.74%
55	-2.69%
60	-1.57%
65	-0.71%
70	-0.06%

Results

Equation 1 shows the results of the cubic Probit estimation.

Equation 1

$$z = 6.185 - 0.104\, MI - 0.00145\, MI^2 + 0.0000207\, MI^3$$

Where:

z = Distance from zero in a normal distribution in terms of standard deviations and MI = Maturity Index

The coefficients were significantly different from zero, with all *P*-values less than or equal to 2%. The NSI results of all three equations are shown in Table 1. It should be noted that these results are only valid over the range of the data and that predictions outside of the data range might be nonsensical.

The probabilities of dystocia for all three models over the range of MIs of heifers in the study are illustrated in Figure 1. The linear and quadratic forms show that the probability of dystocia continues to decline as MI increases over the range of the data. The quadratic form of the model

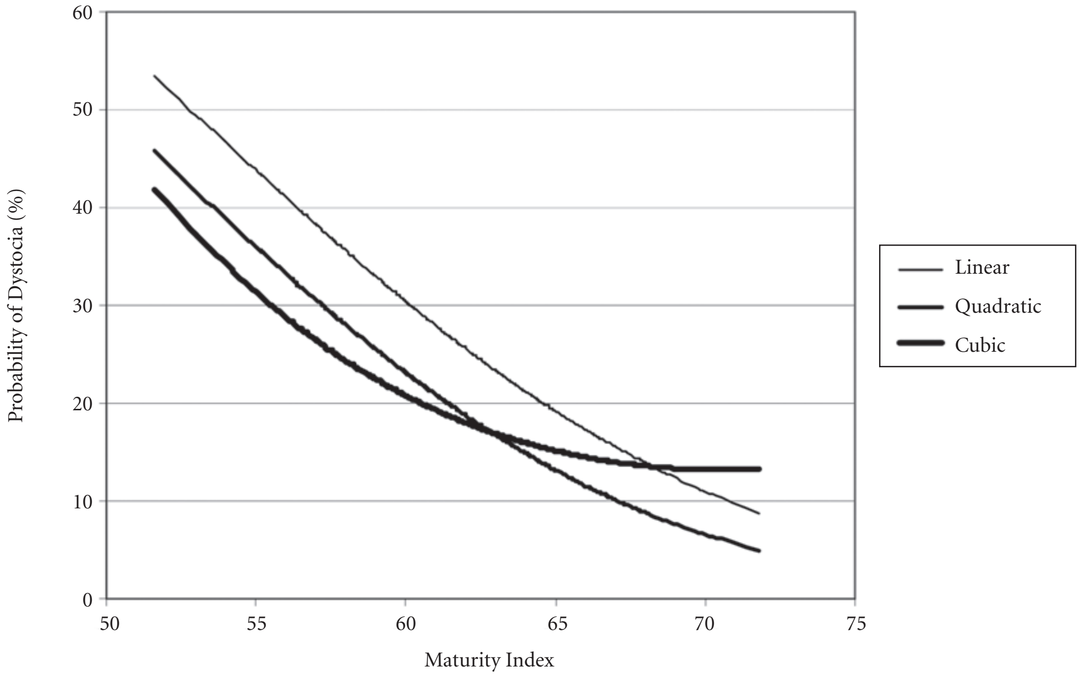

Figure 1. Dystocia rates as a function of Maturity Index as determined by a linear, quadratic and cubic probit.

reaches a minimum level of dystocia at a larger MI than does the cubic form. Results from the cubic regression show the probability of dystocia continues to decline until it reaches about 13%, where it then levels off.

While Figure 1 indicates the physical optimal MI is close to 70, the economic optimum will likely occur at a lower MI, since it includes costs. Economic theory suggests that the economic optimum occurs when marginal revenue equals marginal cost (MR=MC). In this case, marginal revenue is in the form of saved expenses from the reduction of one additional dystocia unit and includes the value of the added production from not having that unit of dystocia. Marginal revenue also has the added value of lower culling rates attributed to the decrease in the next unit of dystocia, and any other quantifiable effects of reducing dystocia. Marginal cost is the expense of either purchasing or developing a heifer to a one unit larger MI. These calculations are beyond the scope of this paper but are currently being studied and are left for future publication.

The physical marginal effects on second pregnancy for a one-unit change in MI was estimated using the first derivative of the normal distribution function at the z calculated for that MI. Table 2 shows these marginal changes in dystocia for MIs of 50, 55, 60, 65 and 70.

The Probit regression relating second pregnancy to dystocia indicates there was a statistically significant negative relationship between dystocia and rebreeding. The effect of dystocia on second pregnancy was estimated using the predicted values from the dystocia equation. Results indicated that primiparous cows that had experienced dystocia had an 86% chance of becoming pregnant during the year, while those primiparous cows that had not experienced dystocia had a 95% pregnancy rate.

Conclusion

MI can be used to predict the probability that dystocia will occur in first calf heifers and may potentially provide producers a method of quantifying this relationship to make better decisions on retaining or purchasing replacement heifers.

Also, this research demonstrates that dystocia of the primiparous beef female leads to reduced second pregnancy rates and increased costs. This reduction in pregnancy indicates that breeding smaller MI heifers comes at some additional cost to future production as well as added labor and veterinarian expenses and leads to the conclusion that an economic analysis needs to be completed to illustrate the degree to which the physical relationships affect profitability.

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An Economic Budget for Determining Co-Product Storage Costs

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Summary

Co-Product STORE — Storage To Optimize Ration Expenses — is a spreadsheet designed to quantify the costs of co-product storage. It allows producers to analyze and evaluate specific storage scenarios in response to changing market conditions using different storage methods. Two storage examples (bunker and silo bag) are evaluated to illustrate how the spreadsheet estimates storage costs. Co-Product STORE can be found online at http://beef.unl.edu *under the byproduct feeds tab.*

Introduction

Ethanol co-product contracting and storage opportunities may be available for cattle feeders and cow/calf operations based on co-product seasonal price trends (*2009 Nebraska Beef Report,* pp. 50-52). The typical decrease in co-product price during the late summer months provides incentive for producers to purchase co-product during this period and then place it in storage. Storage of ethanol co-products involves several costs that vary depending on the storage method used. Our objective was to use Co-Product STORE (Storage To Optimize Ration Expenses), an electronic budget designed to analyze the costs associated with different co-product storage methods for the purpose of co-product inclusion in cattle rations, to evaluate storage decisions. Co-Product STORE and accompanying user manual are available at *http://beef.unl.edu*.

Procedure

Co-Product STORE is organized into four steps (parameters, feed costs, equipment and structure costs, and other costs), and users need to provide several inputs for their operations in each of the four steps (Table 1). Using these inputs, the budget generates a results summary (Table 1). It is important to note that the co-product cost per ton is estimated using the co-product cost per ton, transportation cost per ton and a proportion of the remaining total costs based on the percentage of co-product in the total mixture. This value is used to compare co-product cost per ton across storage methods, because each storage method requires a different inclusion level of mixing material. Additionally, it allows the co-product cost per ton to be directly compared to contracted or spot prices if storage is foregone and the co-product is purchased at a later date. Users also can evaluate storage costs per pound of crude protein (CP) and/or per pound of total digestible nutrients (TDN) by providing appropriate CP and TDN values (DM basis) in the spreadsheet.

Although individuals using Co-Product STORE should define costs and include parameters that are representative of their own operation, general assumptions were utilized in this evaluation of two storage methods (bunker and silo bag) based on 2008 prices and conditions. Both examples assumed that 250 tons (as-is) of wet distillers grain plus solubles (WDGS) were mixed and stored with grass hay at the appropriate inclusion levels (34.2% and 15.3% inclusion DM basis for bunker and bag storage, respectively; Erickson et al., 2008, *Storage of Wet Corn Co-Products*). For the bunker method of storage, the mixture is assumed to be stored on the ground using large round bales for bunker walls. Because the large round bales will be usable after storage in this example, they are not included as a cost. The ownership cost of the owned tractor for both methods is calculated using an 8% interest rate and a useful life of 10 years. The salvage value, repairs, taxes, and insurance costs for the tractor are the average annual costs for each respective item expressed as a percentage of the original investment cost and are assumed to be 30%, 3%, 1.5% and 5%, respectively, for both storage methods. Additionally, the original purchase price of the tractor is assumed to be $75,000, and the proportion of time that the tractor is used for each storage project (expressed as a percentage of its annual total use) is 5% and 1.25% for bunker and bag storage, respectively. These values combine to generate the tractor ownership costs associated with each storage method

Table 1. Inputs required and outputs derived from Co-Product STORE.

Inputs Required	Outputs Generated
Step 1: Parameters	**Results Summary**
• Interest rate on feed and supplies	• Total mixture cost
• Shrink	• Mixture cost per ton without shrink
• Tons of co-product per loaded truck	• Mixture cost per ton with shrink
• Date co-product placed in storage	• Shrink cost per ton
• Date start feeding stored co-product	• Co-product cost per ton without shrink
• Date finish feeding stored co-product	• Co-product cost per ton with shrink
Step 2: Feed Costs	• Mixture cost per pound of CP without shrink
• Ethanol co-product % DM, % CP (DM basis), % TDN (DM basis), as-is quantity, as-is price (FOB plant)	• Mixture cost per pound of CP with shrink
• Forage % DM, % CP (DM basis), % TDN (DM basis), as-is quantity, as-is price	• Mixture cost per pound of TDN without shrink
Step 3: Equipment and Structure Costs	• Mixture cost per pound of TDN with shrink
• Rented equipment/structure quantity, price	• Tons of mixture before shrink
• Ownership costs on equipment/structures (proportion of time/space used, interest rate, useful life, salvage value, repairs, taxes, insurance)	• Tons of mixture remaining after shrink
• Other supplies quantity, price	• Tons of co-product before shrink
Step 4: Other Costs	• Tons of co-product remaining after shrink
• Transportation quantity, price	
• Labor quantity, price	

Table 2. Assumptions for bunker and silo bag storage examples.

	Bunker	Bag
Parameters		
Interest rate on feed and supplies	8.5%	8.5%
Shrink[1]	15%	6%
Tons of co-product per loaded truck	25	25
Date co-product placed in storage	8/1/2008	8/1/2008
Date start feeding stored co-product	12/1/2008	12/1/2008
Date finish feeding stored co-product	4/23/2009	4/23/2009
Feed		
WDGS	250 tons, 35% DM, 30% CP[2], 112% TDN[2,3], $65/ton	250 tons, 35% DM, 30% CP[2], 112% TDN[2,3], $65/ton
Grass hay	52 tons, 87.6% DM, 14.4% CP, 56% TDN, $85/ton	18 tons, 87.6% DM, 14.4% CP, 56% TDN, $85/ton
Rented Equipment		
Mixer	10 hrs, $15/hr	5 hrs, $15/hr
Hay grinder	6 hrs, $20/hr	3 hrs, $20/hr
Bagger		268 tons, $8/ton
Owned Equipment		
Tractor	$813.75 ownership cost	$203.44 ownership cost
Other Supplies and Costs		
Bunker plastic	600 sq ft, $0.13/sq ft	
Fuel	120 gal, $3.50/gal	30 gal, $3.50/gal
Transportation	30 miles, $3.50/loaded mile	30 miles, $3.50/loaded mile
Labor	21 hrs, $10/hr	6 hrs, $10/hr

[1]Percentage difference of quantity of material bunkered or bagged compared to quantity of material weighed out and fed. Shrink may range from 8% to 15% for bunker storage and 3% to 6% for bagging.
[2]Percentages are averages based on UNL feeding performance data and are expressed on a DM basis.
[3]TDN value changes depending on co-product inclusion level; percentages are calculated assuming corn is 90% TDN (DM basis).

Table 3. Bunker and silo bag storage costs estimated using Co-Product STORE.

	Bunker (As-is Basis)	Bunker (DM Basis)	Bag (As-is Basis)	Bag (DM Basis)
Total mixture cost	$24,465.61	$24,465.61	$22,283.37	$22,283.37
Mixture cost per ton without shrink	$81.01	$183.88	$83.15	$215.78
Mixture cost per ton with shrink	$95.31	$216.33	$88.45	$229.56
Shrink cost per ton	$14.30	$32.45	$5.31	$13.77
Co-product cost per ton without shrink	$88.84	$225.33	$86.55	$230.80
Co-product cost per ton with shrink	$104.52	$265.10	$92.07	$245.53
Mixture cost per pound of CP without shrink	$0.373	$0.373	$0.391	$0.391
Mixture cost per pound of CP with shrink	$0.439	$0.439	$0.416	$0.416
Mixture cost per pound of TDN without shrink	$0.099	$0.099	$0.104	$0.104
Mixture cost per pound of TDN with shrink	$0.117	$0.117	$0.111	$0.111

and are important to include for every piece of machinery used, regardless of whether it was purchased for the storage project or not. All other assumptions are outlined in Table 2.

Results

Table 3 presents the mixture and co-product costs for the bunker and silo bag storage examples previously described. As the table suggests, it is important to analyze the costs on a DM basis. Although the as-is mixture cost per ton with shrink is less for bag storage than bunker storage in this example, the DM mixture cost per ton with shrink is actually greater for the silo bag storage method compared to the bunker method. This is due to the lower total tonnage associated with bagging (lower forage inclusion level) and the resulting relative DM differences associated with the mixtures (bunker mixture was 44.1% DM and bag mixture was 38.5% DM).

Assuming that both storage methods are equal regarding physical feasibility, either method of storage could be cheapest depending upon an operation's individual costs. Whether the total mixture cost per ton or co-product cost per ton is most appropriate for comparison to other prices depends on the operation's needs. For example, if a cow/calf producer is analyzing co-product and forage storage during the summer versus purchasing co-product later in the year to feed as a supplement, it would be more appropriate to compare the mixture cost per ton with shrink to the cost of the co-product purchased at a later date. On the other hand, it may be appropriate for feedlots (or any operation storing only co-product with no other feedstuff) to evaluate the co-product cost per ton with shrink, as most of the co-product purchased by feedlots will be included in a ration regardless of whether it is stored alone, mixed with another feedstuff and stored, or purchased later in the year. It is important to remember that all costs and tonnage values will change from operation to operation, and the numbers in Table 3 simply represent the costs and parameters assumed for these two particular scenarios.

Many operations may use Co-Product STORE to compare storage costs to co-product purchased at a later date without storage (using a forecasted co-product price). In order to make this comparison, a spot market or contracted price for deferred co-product delivery (for a date similar to the date the stored co-product would start being fed) should be obtained from an ethanol plant. If the ethanol plant does not offer forward contracts, standardized relationships between co-products and corn or other feeds could be used to formulate a forecasted co-product price. If the forecasted or contracted co-product price without storage exceeds the total per-ton cost of the stored co-product, then it would likely be more beneficial for the producer to store the co-product.

In summary, ethanol co-product contracting and storage opportunities are available for cattle feeders and cow/calf operations as suggested by the co-product seasonal price trend. Although several methods are available for the storage of co-products, producers must recognize and define the type of storage method that is optimal for their own operation, while ensuring that the benefits of actually storing the co-product exceed the costs to do so. Co-Product STORE quantifies the costs of co-product storage and allows producers to analyze and address these issues.

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Replacing Fertilizer Nitrogen with Dried Distillers Grains Supplement to Yearling Steers Grazing Bromegrass Pastures: Daily Gain and Nitrogen Use Efficiency

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Summary

In a three-year study, corn-dried distillers grains plus solubles (DDGS) were evaluated as a substitute for forage and nitrogen (N) fertilizer in yearling steers grazing smooth bromegrass in eastern Nebraska. Stocking rate increased with N fertilization and DDGS, and average daily gain (ADG) increased with DDGS. Total gain per acre increased by 53% with N fertilization and 105% with DDGS supplementation. N use efficiency was 139% greater per acre with DDGS supplementation compared to fertilizing with N alone. Feedlot ADG was similar among treatments with steers maintaining their BW advantage through the finishing phase.

Introduction

Historically, nitrogen (N) fertilizer has been used to increase forage production and subsequent stocking rate relative to the cost of application. In growing animals, weight gain is the primary determinant of N retention by cattle, and DDGS supplementation is very effective in increasing weight gain on high quality forages (*2007 Nebraska Beef Report*, pp. 10-11). Supplementing with DDGS and removing N fertilizer may improve N use efficiency by decreasing N inputs and capturing more N in the form of additional weight gain. Additionally, recent increases in energy and N costs may reduce the associated economic benefits of N fertilization, creating economic and environmental opportunities to enhance production through better management of N within grazing systems.

Procedure

Treatments

Predominantly British breed crossbred steers (726 ± 22 lb) were used in a randomized complete block design to evaluate supplementation and management strategies for steers grazing smooth bromegrass pastures. Data were collected in the summer during three consecutive years (2005, 2006 and 2007) to measure treatment effects on yearling steer performance, N use efficiency, subsequent feedlot performance, and impact on forage production and forage quality throughout the duration of the experiment. The treatments included yearling steers stocked at four AUM/acre on smooth bromegrass pastures fertilized with 80 lb N/acre (FERT); non-fertilized smooth bromegrass pastures stocked at 2.8 AUM/acre (CON); and non-fertilized smooth bromegrass pastures stocked at the same rate as the FERT with five lb DM of corn DDGS supplemented daily (SUPP).

Paddock Management

Within each of three blocks, treatments were assigned randomly to one of three paddocks in the first year of the experiment. Paddocks maintained their treatment during subsequent years and paddock was the experimental unit. Paddocks were approximately 5.0 acres for FERT and SUPP and 7.2 acres for CON, and were grazed from late April through September. Previous studies at this site suggested equal animal performance could be obtained by reducing the stocking rate of nonfertilized pastures to 69% of the fertilized pastures. Each paddock was further divided equally into six strips to utilize a management-intensive rotational grazing system. The cattle were rotated through all six strips in each paddock for all five grazing cycles. The grazing period length was four days per strip in cycles 1 and 5, and six days per strip in cycles 2, 3 and 4. Urea was applied at 80 lb N/acre to the designated paddocks 14 to 21 days prior to the initiation of grazing.

In each of the three years of the experiment, 45 crossbred steers were blocked by weight and assigned randomly to the nine paddocks. The five steers per paddock were the tester animals. A variable stocking rate was used to maintain comparable grazing pressure among treatments and years. This was achieved with the addition and subtraction of put-and-take cattle. The number of put-and-take cattle varied between and within years based on the measured forage yield and visual observations.

Animal Management

Steers were limit fed a common diet at approximately 1.75% BW for five days at the beginning and end of the trial. Limit-fed BWs were measured for three consecutive days to minimize the impact of variation in gut fill.

Following completion of the study, steers were finished on high concentrate diets containing high-moisture corn, dry-rolled corn, corn milling byproducts, alfalfa hay and supplement. The finishing diet was the same for all steers within a year but changed across the three years. On average, steers were fed for 109 days. Steers were not maintained in their original treatment groups within finishing pens. Therefore, effects of pasture treatment on finishing dry matter intake (DMI) and gain-to-feed ratio (G:F) are not available; only

ADG is available.

Diet Sample Collection and Analysis

Diet samples were collected at the mid-point of a grazing period with two ruminally fistulated steers. Pre-grazing standing crop dry matter amount was measured the day prior to each diet collection period using the drop disc method. During each sampling period, 50 disc measurements (2.8 ft^2) were taken at randomly selected locations and correlated to actual clipped data from quadrats (4.1 ft^2) placed immediately below every eighth disc location.

Nitrogen Balance

System N balance inputs included N from DDGS, fertilizer and atmospheric deposition. Outputs for the system N balance included N retention by the steers. Nitrogen excretion was calculated by subtracting N retention from total N consumption. The National Research Council (1996) model predicts protein deposition in the animal (N retention) from ADG. Nitrogen use efficiency of the system was calculated by dividing the system outputs (N retention) by the system inputs (N from DDGS and fertilizer).

Statistical Analysis

Data were analyzed using the MIXED procedures of SAS (SAS Inst., Inc., Cary, N.C.) as a randomized complete block design, with block considered to be a random effect. Model effects were year, treatment, year x treatment interaction, cycle and cycle x treatment interaction. Repeated measures were used to test the effects of time (cycle). Paddock was the experimental unit.

Results

Fertilization had an effect on crude protein (CP) content ($P < 0.01$); however, the treatments did not affect dry matter digestibility of the forage diets (Table 1). CP content was higher for FERT ($P < 0.05$), but not different for SUPP compared with CON. Standing crop per acre for FERT was 18%

Table 1. Main effects of dried distillers grains (DDGS) supplementation and N fertilization on diet sample characteristics and standing crop measurements of smooth bromegrass pastures grazed by yearling steers.

	Treatment[1]				F-Test	
Item	CON	FERT	SUPP	SEM	TRT	YR
Total tract DMD[2]	60.45	59.66	60.52	0.85	0.72	< 0.01
Protein	15.21[a]	17.25[b]	16.19[a]	0.49	< 0.01	< 0.01
Standing crop lb/acre	2051[a]	2425[b]	2208[a]	102	< 0.01	< 0.01
AUM/acre	3.52d	5.42[e]	5.65[e]	0.19	< 0.01	< 0.01

[1]Pastures were either non-fertilized (CON), fertilized with N at 80 lb/acre of N (FERT), or non-fertilized and steers were supplemented with 5 lb (DM) of DDGS (30.4% CP) daily for the entire grazing period (SUPP).
[2]Total tract DM digestibility (TTDMD) was determined by including five hay samples of varying qualities with known total tract *in vivo* digestibilities. The IVDMD values for these standards were regressed on their known digestibilities to develop an equation to calculate TTDMD within each *in vitro* run.
[a,b,c]Means in a row without a common superscript differ ($P < 0.05$).
[d,e]Means in a row without a common superscript differ ($P < 0.01$).

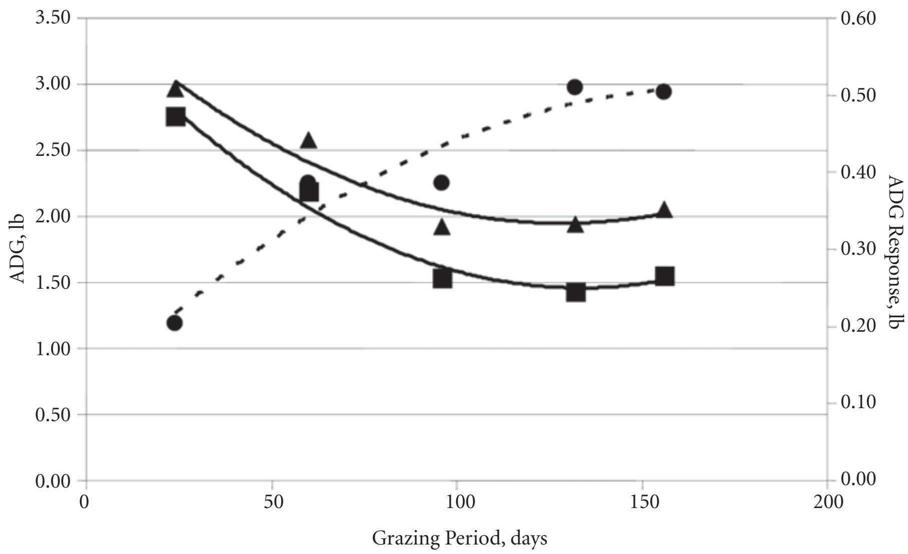

Figure 1. Growth profile for steers grazing smooth bromegrass and supplemented with dried distillers grains. The quadratic decrease in cumulative ADG ($P < 0.01$) for both the supplemented (▲; $y = 0.0001x^2 – 0.0254x + 3.5743$; $R^2 = 0.94$) and nonsupplemented (■ ; $y = 0.0001x^2 – 0.03x + 3.4617$; $R^2 = 0.98$) cattle is expressed over the entire grazing period. The ADG response (-------●) of the supplemented cattle over the controls increases as grazing days increase. The quadratic ($y = -0.00005x^2 + 0.0046x + 0.1138$; $R^2 = 0.9235$) response is inversely related to diet quality.

greater than for CON ($P < 0.01$) and 10% greater than for SUPP ($P < 0.01$). Stocking rates were greater ($P < 0.01$) for FERT and SUPP (5.42 and 5.65 AUM/acre, respectively), compared with CON (3.52 AUM/acre). The fertilized paddocks had a 54% increase in stocking rate compared with the CON. Therefore, total gain (lb/acre; Table 2) was greater for FERT and SUPP compared with CON. Supplementation of DDGS increased stocking rate to the same level as FERT and increased steer performance. Clearly, this is an indication DDGS supplementation was an effective method to increase efficiency of land use for livestock production.

The SUPP steers gained more ($P < 0.01$) than CON and FERT steers (Table 2). Total gain per acre increased ($P < 0.01$) by 53% for FERT and more than doubled for SUPP (105%) compared with CON. This dramatic effect on gain/acre for the SUPP steers was due to the increase in both stocking rate and animal performance. The large increase in gain/acre for the FERT steers was solely due to the increase in stocking rate because animal performance

(Continued on next page)

Table 2. **Main effects of grazing management and supplementation strategies on pasture performance for steers grazing smooth bromegrass.**

	Treatment[1]				F-test	
Item	CON	FERT	SUPP	SEM	TRT	YR
Head days[2]	834	897	884	—	—	—
Area, acre	7.16	4.96	4.96	—	—	—
Initial BW, lb[3]	726	724	726	7	0.95	< 0.01
Final BW, lb[3]	968[a]	961[a]	1049[b]	9	< 0.01	< 0.01
BW gain, lb	242[a]	238[a]	323[b]	7	< 0.01	< 0.01
Gain per acre, lb[4]	176[a]	269[b]	360[c]	7	< 0.01	< 0.01
ADG, lb	1.50[a]	1.47[a]	2.02[b]	0.04	< 0.01	< 0.01

[1]Pastures were either non-fertilized (CON), fertilized with N at 80 lb/acre of N (FERT), or non-fertilized and steers were supplemented with 5 lb (DM) of DDGS (30.4% CP) daily for the grazing period (SUPP).
[2]Head days calculated as the number of steers multiplied by the number of days in the grazing period, plus the number of put and take cattle multiplied by the number of days the put and take cattle grazed within the grazing period.
[3]Shrunk weight; steers were limit fed 5 days immediately prior to measuring initial and final weights.
[4]Calculated by multiplying ADG by the total number of head days, then dividing by the number of acres.
[a,b,c]Means in a row without a common superscript differ ($P < 0.01$).

Table 3. **Main effects of grazing management and supplementation strategies on feedlot performance and carcass characteristics for steers grazing smooth bromegrass.**

	Treatment[1]				F-test	
Item	CON	FERT	SUPP	SEM	TRT	YR
Days	109	109	109	—	—	—
Initial BW, lb[3]	1005[a]	1003[a]	1087[b]	3	< 0.01	< 0.01
Final BW, lb[4]	1426[a]	1426[a]	1516[b]	15	< 0.01	< 0.01
ADG, lb	3.85	3.89	3.93	0.1	0.88	< 0.01
HCW, lb	904[a]	906[a]	961[b]	9	< 0.01	< 0.01
Fat, in	0.49	0.49	0.57	0.07	0.12	0.06
Marbling score[5]	545[c]	530[c]	603[d]	18	< 0.01	0.18

[1]Pastures were either non-fertilized (CON), fertilized with N at 80 lb/acre of N (FERT), or non-fertilized and steers were supplemented with 5 lb (DM) of DDGS (30.4% CP) daily for the grazing period (SUPP).
[2]Individual intakes not available during the feedlot phase.
[3]Limit-fed weights were the average of two consecutive days following a 5-day limit-fed period.
[4]Carcass adjusted final weight, calculated from HCW, adjusted by a common dressing percentage of 63.5%.
[5]Where 400 = Slight 0; 500 = Small 0.
[a,b]Means without a common superscript differ ($P < 0.01$).
[c,d]Means without a common superscript differ ($P < 0.05$).

Table 4. **Main effects of pasture nitrogen (N) balance for grazing management and supplementation strategies of smooth bromegrass pastures grazed by yearling steers.**

	Treatment[2]				*P*-value		
Item[1]	CON	FERT	SUPP	SEM	INT	YR	TRT
N inputs							
N from DDGS	0	0	43	—	—	—	—
N fertilizer	0	80	0	—	—	—	—
N atmospheric deposition[3]	5.8	5.8	5.8	—	—	—	—
Total N inputs	5.8	85.80	48.8	1.4	< 0.01	< 0.01	< 0.01
N consumption							
N from DDGS	0	0	43.6	—	—	—	—
N from forage	43.2	74.8	69.1	2.1	0.06	< 0.01	0.14
Total N consumption	43.2	74.8	112.7	2.1	< 0.01	< 0.01	< 0.01
N retention[4]	4.7[a]	7.2[b]	9.3[c]	0.15	0.20	< 0.01	< 0.01
N excretion	38.5	67.6	103.4	2.0	< 0.01	< 0.01	< 0.01
N balance (surplus)[5]	1.1[a]	78.8[b]	40.10[c]	0.15	< 0.01	< 0.01	< 0.01
Apparent N recovery rate, %[6]	81.18[a]	8.33[b]	19.12[c]	1.65	< 0.01	< 0.01	< 0.01
N use efficiency, %[7]	—	8.93[a]	21.77[b]	0.26	< 0.01	< 0.01	< 0.01

[1]Items are expressed as total lb of N per acre for the entire grazing period, unless otherwise noted.
[2]Pastures were either non-fertilized (CON), fertilized with dry urea at 80 lb/acre of N (FERT), or non-fertilized and steers were supplemented with 5 lb (DM) of DDGS (30.4% CP) daily for the entire gazing period (SUPP).
[3]Data from the National Atmospheric Deposition Program. 2008. Available at *http://nadp.sws.uiuc.edu/isopleths/maps2006/ndep.gif*. Accessed on Jan. 7, 2008.
[4]N retention calculated from NRC (1996) equations.
[5]Difference between total N inputs and N retention.
[6]Calculated by dividing N retention by total N inputs, multiplied by 100.
[7]Calculated by dividing system outputs (N retention) by system inputs (N from DDGS and N fertilizer), multiplied by 100.
[a,b,c]Means within a row without a common superscript differ ($P < 0.01$).

between the CON and FERT steers was similar and stocking rate was increased by 54%. Average daily gain, measured from interim weights, decreased quadratically ($P < 0.01$) over the entire grazing season for supplemented and non-supplemented steers (Figure 1). The response, or difference between the supplemented and non-supplemented steers, increased quadratically ($P < 0.01$) over the grazing period, suggesting that the performance advantage increased with decreasing forage quality and then began to level off once re-growth occurred toward the end of the grazing period.

Finishing performance from steers in years 1 and 2 is shown in Table 3. Daily gain was similar among treatments, indicating that no compensatory response from the grazing phase was carried over into the finishing phase. Therefore, the weight advantage of SUPP from the grazing phase was maintained throughout the feedlot.

System-based N use efficiency (N retention per acre ÷ N input of fertilizer and DDGS per acre × 100) improved ($P < 0.01$; Table 4) by 139% for SUPP (21.37%) compared to FERT (8.93%). This ultimately indicates that N from DDGS is better converted into saleable product than N from fertilizer in these management and pasture conditions.

In combination with intensively managed pastures and better urine distribution, DDGS supplementation has the potential to increase N content and cycling of N in the pasture. Nitrogen use efficiency was improved by decreasing N inputs and capturing more N in the form of additional weight gain and in the cycling of N in the pasture. Dried distillers grains can be used as a substitute for forage and N fertilizer by improving performance and N use efficiency in smooth bromegrass pastures in eastern Nebraska.

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Replacing Fertilizer Nitrogen with Dried Distillers Grains Supplement to Yearling Steers Grazing Bromegrass Pastures: Economics and Modeling

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Summary

*An economic analysis of a three-year study evaluated use of N fertilizer and dried distillers grains plus solubles (DDGS) supplementation to yearling steers grazing smooth bromegrass in eastern Nebraska (*Nebraska Beef Report, 2009*, pp. 26-28). Costs of gain tended to be lower for cattle on fertilized pastures. Grazing profitability was lowest for cattle on non-fertilized pastures, intermediate for cattle supplemented with DDGS, and highest for cattle on fertilized pastures. The weight advantage (9%) of steers supplemented with DDGS during the grazing period was maintained through the finishing period, leading to greater profitability. Profitability for steers supplemented with DDGS at the end of the grazing period was significantly reduced due to the price slide on heavier cattle. Therefore, to maximize profits from DDGS supplementation in the grazing period, ownership of the steers through the finishing period is necessary.*

Introduction

Nitrogen fertilizer costs have increased because fossil fuel is used to produce ammonia and urea. Growth of the ethanol industry has produced byproducts at a reasonable cost. A three-year study was conducted to determine the feasibility of using distillers grains as a substitute for N fertilizer on brome pastures grazed by yearlings. The treatments included yearling steers stocked at 4 AUM/acre on smooth bromegrass pastures fertilized with 80 lb N/acre (FERT); stocked at 2.8 AUM/acre on non-fertilized smooth bromegrass pastures (CON); and stocked at 4 AUM/acre on non-fertilized smooth bromegrass pastures with 5 lb DM of corn DDGS supplemented daily (SUPP). Our objective in this study was to determine the economic feasibility of substituting distillers grains for N fertilizer.

Procedure

Biological data were collected over a three-year period (Greenquist et al., *2009 Nebraska Beef Report*, pp. 26-28).

Grazing Economics

All costs were based on three-year (2005 to 2007) average pricing (unless otherwise noted) and expressed on a dollars per head basis for the entire grazing period. The initial steer weight was multiplied by the USDA Nebraska auction market average for April steer (450 to 750 lb) prices. A regression equation was generated to account for the weight price slide. A similar approach was used to calculate final steer live values in September to adjust for weight differences. Simple interest (6.6%) was charged on initial steer cost for the entire ownership period. Cash rent costs were based on the cost per acre of the control (CON; $84.09/acre, calculated by multiplying the number of AUMs from the CON by the Nebraska average AUM value of $26.65) multiplied by the number of acres, divided by the total head days, then multiplied by the average number of grazing days. Costs per acre were then multiplied by the number of acres, divided by the total head days, and then multiplied by the average number of grazing days.

Animal unit equivalents of the steers used in this study were determined by taking the average weight of the steers during the grazing period divided by 1,000 lb. Simple interest (6.6%) was charged on the entire cash rent amount for one half of the grazing period. Yardage ($0.10 head/day) was charged while steers were grazing to cover labor for electrical cross fencing and for the daily checking of animal health, fresh water and minerals.

An additional $20/ton was added to the price of DDGS to account for handling and delivery. Dried distillers grains were priced based on the weekly DTN spot prices for the Midwest region during the grazing months of April through September. The average price during this time period was $110.54/ton in 2006 and 2007. Fertilizer costs were based on dry urea (46-0-0) prices from the National Agricultural Statistics Service (USDA, 2008). Urea prices for the period averaged $363/ton with the addition of $4.00/acre for cost of application. Steers were charged $8.33/head for health and processing costs during the grazing period, with a death loss of 0.5% assessed to an initial value of the animal.

Finishing Economics

Finishing costs were calculated from performance data following a 109-day finishing period. The final live values from the grazing period were used as the initial live values for the finishing period. Simple interest on initial steer cost (April), plus all expenses incurred during the grazing period were charged for the duration of the feeding period plus one half of the total feed costs. Feed costs for the yearling steers were based on the average prices of feed ingredients during the feeding period, assuming a corn and corn byproduct based diet. Wet distillers grains were priced at 85% the value of corn DM. Daily dry matter intakes were not available for individual treatments and were cal-

(Continued on next page)

Table 1. **Economic evaluation of grazing management and supplementation strategies for steers grazing smooth bromegrass and subsequent finishing performance.[1]**

Item	Treatment[2]				SEM	*P*-value
	CON	FERT	SUPP	F+S		
Initial BW, lb	726	724	726	726	7	0.95
Final BW, lb	968[a]	961[a]	1049[b]	1049[b]	42	< 0.01
Steer cost, $	805.10	804.30	805.10	805.10	11.58	0.99
Grazing						
Steer interest, $	23.28	23.25	23.28	23.28	0.57	0.99
Total cost, $	150.47[a]	139.65[b]	160.99[c]	154.27[d]	6.50	< 0.01
COG, $/lb[3]	0.63[a]	0.60[a]	0.50[b]	0.48[b]	0.03	< 0.01
Breakeven, $/lb[4]	1.01[a]	1.01[a]	0.95[b]	0.94[b]	0.02	< 0.01
Live value, $[5]	992.64[a]	991.50[a]	1009.12[b]	1009.12[b]	9.34	< 0.01
Profitability, $	13.79[a]	24.30[b]	19.75[ab]	26.47[b]	8.35	0.01
Finishing						
Steer interest, $	20.63	20.52	20.89	20.82	0.67	0.99
Total costs, $	248.25[a]	248.15[a]	262.40[b]	262.39[b]	6.10	< 0.01
COG, $/lb [3]	0.60	0.60	0.61	0.61	0.02	0.66
Total						
Breakeven, $/lb[4]	0.88[a]	0.88[a]	0.85[b]	0.85[b]	0.04	0.01
Live value, $[6]	1274.88[a]	1275.46[a]	1355.48[b]	1355.48[b]	41.44	< 0.01
Profitability, $	13.93[a]	20.05[a]	67.51[b]	71.28[b]	28.72	< 0.01

[1]Least square means are expressed per steer for the grazing analysis in years 2005, 2006 and 2007, and for the finishing analysis in years 2005 and 2006.
[2]Pastures were either non-fertilized (CON), fertilized with dry urea at 80 lb/acre of N (FERT); non-fertilized and steers were supplemented with 5 lb (DM) of DDGS (30.4% CP) daily for the entire gazing period (SUPP); or fertilized with dry urea at 80 lb/acre^{-1} of N and steers were supplemented with 5 lb (DM) of DDGS (30.4% CP) daily for the entire gazing period (F+S: hypothetical treatment based on equal steer performance of SUPP and equal pasture performance of FERT).
[3]Total costs divided by weight gain.
[4]Total costs plus initial steer cost and its interest for each period divided by sale weight.
[5]USDA Nebraska 3-year average auction market price (slide adjusted) multiplied by the live weight.
[6]Final weight multiplied by the 3-year average fed cattle prices.
[a,b,c,d]Means within a row with unlike superscripts differ *(P* < 0.01).

culated based on percent body weight (2.5%). Yardage was charged at $0.35 per head daily.

Increased volatility in inputs such as commercial fertilizer, DDGS and cash rent prices make it difficult to accurately predict cost of gain and profitability in livestock production systems. Therefore, evaluating inputs over a wide range of costs can be useful to project costs of gain for different management decisions. All costs were held constant at their respective three-year averages as described previously, and incremental price increases and decreases were evaluated separately for cash rent, urea and DDGS. Cost of gain breakpoints were established at varying prices for comparing treatments. A separate model was used based on the hypothetical treatment that included both N fertilizer and DDGS supplementation. This treatment was included so that varying prices of both urea and DDGS could be evaluated simultaneously for their effects on costs of gain.

Results

Fertilizer costs ($/head) were $0 for CON and SUPP, $28.15 for FERT and $18.58 for F+S (a hypothetical treatment based on equal steer performance of SUPP and equal pasture performance of FERT; Table 1). Fertilizer and fertilizer application costs were lower for F+S compared to FERT because of the increase in total head days, spreading the costs over a greater number of steers. Total head days were increased with supplementation and fertilization, partially due to forage replacement and/or an increase in pasture productivity. Dried distillers grain cost was $52.22/steer for both SUPP and F+S supplementation at a level of 5 lb/head daily. Total costs per steer for the grazing period were higher with DDGS supplementation (*P* < 0.01) and lower with N fertilization *(P* < 0.01) compared to CON. The sum of the total costs during the grazing period (minus interest on the steers) was $139.65 for FERT, $150.47 for CON, $160.99 for SUPP and $154.28 for F+S. The additional weight gain from DDGS was large enough to offset costs and decreased *(P* < 0.01) costs of gain for the SUPP and F+S compared to CON and FERT. Costs of gain were not different *(P* > 0.05) between SUPP and F+S or between CON and FERT.

Profitability at the end of grazing was lowest for CON ($13.79), intermediate for SUPP ($19.75) and highest for FERT ($24.30) and F+S ($26.48). During the grazing period, increasing the stocking rate by fertilizing pastures and spreading out cash rent costs over a greater number of steers appears to be more economical than increasing steer performance by supplementing. This phenomenon is largely due to the negative price slide associated with heavier steers. If steers were sold at the same price per pound, performance advantage and added weight from DDGS supplementation would have greater profitability than increasing stocking rate or fertilizing. Increasing stocking rate and performance at these prices would be the most profitable option. Full value of supplementing DDGS to grazing steers can be obtained by retaining ownership through the finishing period, assuming the finishing period is breakeven or better.

Finishing data were not yet available for year 3, so only final mean weights and prices from years 1 and 2 are presented in Table 1. The weight advantage (9%) of steers supplemented with DDGS during the grazing period was maintained through the finishing period (9%). Finishing performance was similar *(P* = 0.88) among treatments. Supplemented and F+S steers had higher *(P* < 0.01) feed costs than CON and FERT, but costs of gain did not differ *(P* = 0.66). Feed costs were based on the average cost of the ration and DMI for the feeding period. Dry matter intakes were not measured individually by treatment, though cattle were fed a common finishing diet across treatments. Dry matter intakes for economic purposes were determined by multiplying the average weight during the feeding period by 2.5%. Therefore, the heavier cattle from SUPP and F+S had greater feed costs. Costs of gain were not statistically different, but were about $0.02/lb greater for SUPP and F+S because of the added feed costs. Even though performance did not differ, finished live values were greater *(P* < 0.01) for SUPP ($1,356) and F+S ($1,356) compared to CON ($1,275) and FERT ($1,275) because of the additional weight maintained throughout the feeding period. No compensatory gain was observed during the finishing period in this experiment, a result consistent with other reports (*2006 Nebraska Beef Report*, pp. 30-32; *2007 Nebraska Beef Report*, pp. 10-11).

Total production system breakevens were lower *(P* < 0.01) for SUPP and F+S compared to CON and FERT. Profits were greater *(P* < 0.01) for SUPP ($67.51) and F+S ($71.28) for the total production system compared to CON ($13.93) and FERT ($20.05).

Effects on costs of gain were evaluated for a wide range of input costs. Cost of gain breakpoints were established at varying prices for comparing treatments with a separate model designed to evaluate the effects of input costs of DDGS and N fertilizer. All other inputs were held constant at their three-year average values. The cost of gain breakpoint for cash rent was $21.2/AUM (data not shown). Average three-year cash rent prices ($26.65/AUM) currently are well above this breakpoint, indicating a strong economic incentive to use N fertilizer and DDGS supplementation, based on cost-of-gain values. As land values increase, the advantage for fertilization and DDGS supplementation over the control increases as well.

The cost of gain breakpoint for N fertilizer was $0.51/lb N. Average three-year N fertilizer costs ($0.40/lb) were below this breakpoint, indicating an economic incentive to keep using N fertilizer until this point is reached. However, current prices and those in the future may be above this breakpoint. The costs of gain breakpoints for DDGS were $205/ton and $233/ton for SUPP compared to FERT and CON, respectively. The last two years of prices for DDGS ($130/ton), including handling, also are still below this breakpoint and indicate a strong economic incentive to supplement DDGS to grazing steers.

Evaluating the interaction of both DDGS supplementation and N fertilization on cost of gain is more complex and the simultaneous price movement of both inputs is likely. Table 2 shows the effect of price movement in either direction compared to the three-year average pricing. Current three-year average pricing shows a cost of gain of $0.48/lb.

Table 2. Effects of varying N fertilizer and DDGS prices on costs of gain for steers grazing smooth bromegrass in eastern Nebraska.[1]

DDGS prices, $•ton^{-1}	Fertilizer prices, $/lb N							
	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60
80	0.39	0.40	0.41	0.41	0.42	0.43	0.44	0.44
90	0.40	0.41	0.42	0.43	0.43	0.44	0.45	0.45
100	0.42	0.42	0.43	0.44	0.45	0.45	0.46	0.47
110	0.43	0.44	0.44	0.45	0.46	0.46	0.47	0.48
120	0.44	0.45	0.46	0.46	0.47	0.48	0.48	0.49
130	0.45	0.46	0.47	0.48	0.48	0.49	0.50	0.50
140	0.47	0.47	0.48	0.49	0.49	0.50	0.51	0.52
150	0.48	0.49	0.49	0.50	0.51	0.51	0.52	0.53
160	0.49	0.50	0.50	0.51	0.52	0.53	0.53	0.54
170	0.50	0.51	0.52	0.52	0.53	0.54	0.55	0.55
180	0.52	0.52	0.53	0.54	0.54	0.55	0.56	0.57
190	0.53	0.53	0.54	0.55	0.56	0.56	0.57	0.58
200	0.54	0.55	0.55	0.56	0.57	0.58	0.58	0.59
210	0.55	0.56	0.57	0.57	0.58	0.59	0.60	0.60

[1]Pastures were fertilized with 80 lb/acre and steers were supplemented with 5 lb of DDGS daily. The average 3-year value of N fertilizer and 2-year value of DDGS were $.40/lb N and $130/ton, respectively. Values expressed as $/lb of gain.

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Energy Value of Wet Distillers Grains in High Forage Diets

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Summary

One hundred sixty crossbred steers were used to determine the energy value of wet distillers grains in high forage diets. By design, steers had similar intakes and gains across treatments. Diets included either wet distillers grains (WDGS) or dry rolled corn, sorghum silage, grass hay and supplement (DRC). Diets were formulated to meet degradable intake protein and metabolizable protein requirements. The energy value of wet distillers grains was calculated using the National Research Council model (1996). In this study, wet distillers grains contained 130% of the energy of dry rolled corn when fed in forage-based diets.

Introduction

In forage-based diets, feeding starch as an energy source can suppress forage digestion. In the dry milling process, starch is removed from corn to produce ethanol. Therefore, replacing corn with WDGS can reduce the negative associative affects that the energy from starch can have on fiber digestion. In feedlot rations, the energy value of WDGS ranges from 100% to 140% of the value of corn. In forage-based diets, dried distillers grains have been shown to contain 118% to 130% of the energy value of DRC depending upon level fed (*2003 Nebraska Beef Report*, pp. 8-10). However, research evaluating the energy value of WDGS in forage-based diets is limited. Therefore, the objective of this study was to determine the energy value of WDGS relative to dry rolled corn (DRC) in forage-based diets.

Procedure

One hundred sixty crossbred steers (630 $\pm$ 41 lb) were used in a 67-day growing trial to compare the energy value of WDGS to DRC in a forage-based diet. Calves were blocked into two weight groups, stratified within block and then randomly assigned to one of ten pens (16 steers/pen). Pens were assigned randomly to one of two treatment diets: either 1) WDGS or 2) DRC. Five days prior to collecting initial and final BW, steers were limit fed a common diet to reduce variation in gut fill. The limit-fed diet contained 47.5% alfalfa hay, 47.5% wet corn gluten feed and 5.0% supplement. Weights were collected two consecutive days following each limit-feeding period.

Diets were formulated using the NRC (1996) model and were formulated to meet energy and metabolizable protein (MP) requirements for a targeted gain of 2.25 lb/day. For diet formulation, WDGS was assumed to contain 127% the energy value of DRC (*2003 Nebraska Beef Report*, pp. 8-10). Bunks were evaluated daily and managed so that intakes were equal across both treatments. Feed refusals were collected weekly and DM of the feed refused was determined using a 60°C forced air oven. Dry matter refused was subtracted from DM offered to determine DMI.

For both treatments, sorghum silage was fixed at 35% of the diet and grass hay was adjusted according to WDGS and DRC levels (Table 1). Analysis for fat content, % neutral detergent fiber (NDF), and % crude protein (CP) were conducted on individual feed ingredients (Table 2). Supplement for both diets included urea to meet degradable intake protein requirements. To prevent a performance response due to protein, Soypass® was included in the DRC supplement to provide undegradable intake protein to meet the metabolizable protein requirement.

Table 1. Diet composition.

	Composition, %DM	
Ingredient	WDGS	DRC
WDGS	25.00	—
DRC	—	33.60
Grass hay	39.05	26.41
Sorghum silage	35.00	35.00
Soypass®	—	3.35
Selenium	—	0.010
Limestone	0.24	0.24
Urea	0.30	0.90
Tallow	0.02	0.12
Salt	0.30	0.30
Trace mineral premix	0.05	0.05
Vitamin premix	0.015	0.015

The NRC (1996) model predicts animal performance using feed intake and dietary energy content. Therefore, energy content of the feed can be predicted if animal performance and daily feed intake are known. Intake, diet composition, weights and weight gain were used to calculate the energy value of WDGS in the treatment diet. The energy value of DRC was calculated similarly so that results for WDGS could be expressed relative to those for corn.

Data were analyzed using the MIXED procedure of SAS. The model included block and dietary treatment. Pen was the experimental unit (5 pens/treatment). Differences were considered significant when $P \leq 0.05$.

Results

Initial BW was not different ($P = 0.48$, Table 2). By design, DM intake was similar between treatments. Although not different ($P > 0.11$), ADG and feed-to-gain ratio (F:G) were numerically improved for

WDGS (0.17 and 0.46, respectively). Using the NRC (1996) model, animal performance was used to determine energy values for the DRC diet.

The total digestible nutrients (TDN) value for corn was set at 83%, for hay at 52% and for sorghum silage at 65%. Net energy (NE) adjusters were set at 100%. The NE adjusters were reduced to 98.96% for calculating the energy value of the WDGS because of the 0.17 lb/day greater gain. The resulting TDN value of the WDGS was 108%. Therefore, the estimated energy value of WDGS was 130% that of corn (108 ÷ 83).

The energy values for DDGS determined previously were 130% when DDGS was fed at 10% of diet dry matter and 118% when fed at 33% of ration dry matter. The value in this study is higher than would be predicted at the 25% level in the diet. Without a direct comparison, we cannot conclude that WDGS has more energy in forage diets than DDGS. This trial confirms that distillers grains (wet or dry) have a high energy value relative to corn. This is likely due to the low level of starch and energy density of fat, undegraded protein and corn fiber.

Table 2. Animal performance.

Item	DRC	WDGS	SEM	*P*-Value
Initial BW, lb	629	630	1	0.48
Final BW, lb	811	824	6	0.07
DMI, lb/day	17.9	17.7	0.7	0.72
ADG, lb	2.72	2.89	0.09	0.11
F:G	6.61	6.15	0.37	0.25

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Feeding Corn Distillers Solubles or Wet Distillers Grains plus Solubles and Cornstalks to Growing Calves

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Summary

A growing study compared the effects of a diet consisting of corn distillers solubles (SOL) to the effects of a diet containing corn wet distillers grains plus solubles (WDGS) when ensiled with cornstalks (stalks). Four levels of SOL and WDGS were fed at 15%, 20%, 25% and 30% of diet DM. The effect of feeding ensiled WDGS and stalks was compared to feeding WDGS and stalks mixed fresh daily at 30% inclusion. WDGS-fed steers were more efficient than those fed solubles. Steer performance also improved with increased levels of byproducts. However, no interaction between byproduct and level was observed, except for DMI.

Introduction

Previous research shows that these byproducts can be utilized as a supplement in backgrounding operations or cow/calf situations. Producers may face the challenge of storing the product to feed later. The objective of the current study was to evaluate stored WDGS or SOL with cornstalks when fed to growing calves and determine the impact of level of WDGS and SOL mixed and stored with low quality forage on calf performance.

Procedure

Storage

Over four consecutive days, ground cornstalks were mixed with WDGS or SOL in a 50:50 ratio (DM basis) and bagged at the University of Nebraska Research Feedlot near Mead, Neb. Dry matter was assumed to be 31% for SOL, 32% for WDGS and 85% for stalks. The as-fed percentage of cornstalks was 27.3% or 26.7% when mixed with WDGS or SOL, respectively. WDGS and cornstalks (WDGS:stalks) mixture and SOL and stalks (SOL:stalks) mixture were stored for 20 days prior to trial initiation of block 1.

Treatments

One-hundred twenty individually fed growing steers (BW = 694 ± 21 lb) 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 to minimize gut fill. Steers were weighed three consecutive days, and the average of the three-day weights was used as the initial BW. Weights obtained on the first two days were averaged and used to assign steers to one of nine treatments with 11 steers per treatment. Eight treatments were designed as a 2 x 4 factorial, WDGS or SOL, and level (15%, 20%, 25% and 30% of diet DM). The 30 WDGS:30 stalks mixture was utilized to compare feeding a stored diet to feeding a non-ensiled diet mixed fresh daily. The ensiled versus non-ensiled comparison consisted of 22 steers in the ensiled group and 21 in the non-ensiled group to increase replication. Levels of 15%, 20%, 25% and 30% of byproduct inclusion with an equal amount of stalks replaced mid-bloom bromegrass hay in the diet on a DM basis (Table 1). Block 1 steers were individually fed for 106 days and block 2 steers for 71 days using Calan electronic gates. Feed refusals were collected weekly and DM measured using a 60°C forced air oven. Bunks were evaluated and adjusted daily according to individual intake. Steers were limit fed for five days at trial completion and weighed for three consecutive days for ending BW.

Data were analyzed using MIXED procedures of SAS as a completely randomized design with animal as experimental unit. The 2 x 4 factorial design was analyzed for a type (SOL or WDGS) by level (15, 20, 25, 30) interaction. If the interaction was significant, simple effects were analyzed and presented. If no significant interaction was observed, main effects are presented. Orthogonal contrasts of linear and quadratic responses also were analyzed for level of byproduct. The ensiled versus non-ensiled comparison was analyzed separately using PROC MIXED and a simple means comparison.

Table 1. Diet composition on DM basis.

Ingredient	Level[1]			
	15	20	25	30[2]
Byproduct[3]	15	20	25	30
Stalks[4]	15	20	25	30
Grass hay	68	58	48	38
Supplement	2	2	2	2

[1]Byproduct inclusion on DM basis.
[2]30 WDGS:stalks the same for both ensiled and non-ensiled.
[3]SOL (distillers solubles) or WDGS (wet distillers grains plus solubles) included in diet on DM basis.
[4]Cornstalks mixed with byproduct and stored at a 50:50 ratio (DM basis).

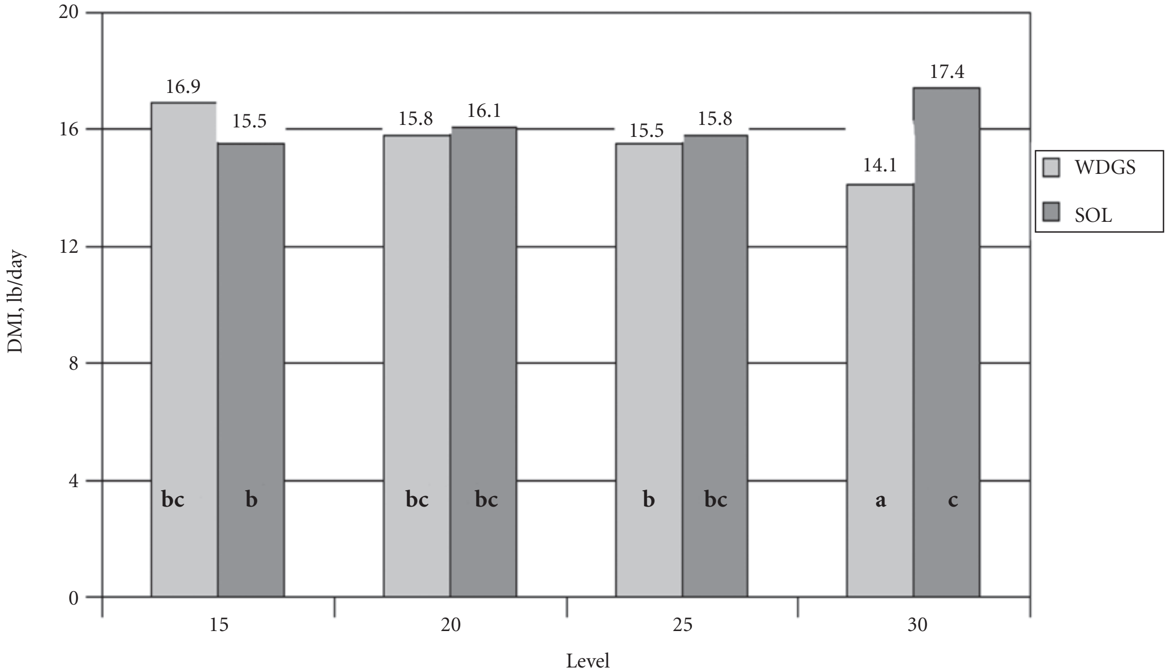

Figure 1. Dry matter intake interaction between byproduct of SOL or WDGS and level of 15, 20, 25 or 30 (as percent of byproduct included).

[a,b,c]Means without common superscript differ $P < 0.05$.

Lab Analysis

Feed ingredients were analyzed to determine DM, CP, fat and NDF values (Table 2). Dry matter determination was conducted using the 60°C forced air oven for 48 hours. Organic matter was calculated from six hours ash at 600°C oven. The combustion method was conducted for CP analysis. Fat was analyzed using the Gravimetric Fat Procedure modified by University of Nebraska. Percentage NDF was analyzed using Van Soest (1964) NDF procedure.

Results

The only type-by-level interaction observed was for DMI, as shown in Figure 1. Steers fed 30 WDGS:30 stalks consumed the least amount and were significantly different from all other treatments ($P < 0.01$). Steers fed 30 SOL:30 stalks consumed the most and were statistically similar to steers fed 20 SOL:20 stalks, 25 SOL:25 stalks, 15 WDGS:15 stalks and 20 WDGS:20 stalks ($P > 0.05$).

Table 2. Ingredient nutrient analysis.

Ingredient	DM	CP	Fat	NDF
SOL[1]	36.4	17.1	12.6	3.4
WDGS[2]	33.0	30.8	11.2	35.5
SOL:stalks[3]	46.4	13.4	11.0	35.4
WDGS:stalks[4]	46.1	19.2	6.2	58.0
Stalks	83.3	5.2	0.7	86.0
Grass hay	87.3	9.6	2.0	77.3

[1]Corn distillers solubles.
[2]Corn wet distillers grains plus solubles.
[3]Solubles and cornstalks mixed and stored in 50:50 ratio (DM basis).
[4]Wet distillers grains plus solubles and cornstalks mixed and stored in 50:50 ratio (DM basis).

Table 3. Main effects of feeding distillers solubles or wet distillers grains plus solubles to growing calves on performance.

Item	SOL[1]	WDGS[2]	SEM	*P*-value
Initial BW, lb	695	693	10	0.81
Ending BW, lb	806	825	10	0.06
ADG, lb	1.04	1.25	0.07	< 0.01
F:G	15.54	12.49	2.15	< 0.01

[1]Corn distillers solubles.
[2]Corn wet distillers grains plus solubles.

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Table 4. Main effects of feeding increasing levels[1] of byproducts to growing calves on performance.

Item	15	20	25	30	SEM	*P*-value
Initial BW, lb	693	696	696	691	14	0.98
Ending BW, lb[2]	788	804	834	835	14	< 0.01
ADG, lb[3]	0.90	1.02	1.30	1.35	0.09	< 0.01
F:G[4]	18.00	15.62	12.02	11.62	3.05	< 0.01

[1]15, 20, 25, 30 = % byproduct (solubles or WDGS) included in diet on DM basis.
[2]Linear response of $P < 0.01$; Quadratic response of $P = 0.47$.
[3]Linear response of $P < 0.01$; Quadratic response of $P = 0.60$.
[4]Linear response of $P < 0.01$; Quadratic response of $P = 0.58$.

Table 5. Effects of feeding a stored diet versus a diet mixed fresh daily to growing calves on performance.

Item	Ensiled[1]	Non-Ensiled[2]	SEM	*P*-value
Initial BW, lb	686	690	16	0.86
Ending BW, lb	838	798	20	0.05
DMI, lb/day	14.1	12.2	1.9	< 0.01
ADG, lb	1.43	1.02	0.41	< 0.01
F:G	9.83	11.95	1.05	0.07

[1]30 WDGS:stalks fed from stored product bagged in 50:50 ratio (DM basis).
[2]30 WDGS:stalks mixed fresh daily and fed.

Main effects of type of byproduct fed (Table 3) were analyzed by comparing performance of steers fed the SOL and stalks combinations to those fed WDGS and stalks combinations. Steers fed WDGS:stalks had higher ending BW ($P = 0.06$) than the steers fed the SOL:stalks mixtures. Average daily gain and F:G also were greater ($P < 0.05$) for steers fed WDGS:stalks than for those fed SOL:stalks.

Main effects of level of byproduct fed are presented in Table 4. Ending BW increased linearly as byproduct level increased in the diet ($P < 0.01$). Average daily gain increased linearly with byproduct level ($P < 0.01$), which led to a linear decrease in F:G ($P < 0.01$).

The performance results of steers fed a stored diet (ensiled) compared to a diet mixed fresh daily (non-ensiled) were analyzed separately and are shown in Table 5. The steers fed the ensiled mixture of WDGS and stalks weighed more at trial completion ($P = 0.05$) than steers consuming the same diet mixed fresh daily. Dry matter intake was greater ($P < 0.01$) for steers fed the ensiled treatment compared to those fed the non-ensiled diet. The steers fed the ensiled diet also had greater ADG ($P < 0.01$) than steers fed the diet mixed fresh daily. Interestingly, a trend was observed in F:G ($P = 0.07$) for steers fed the stored mixture to be more efficient than those fed the non-ensiled diet.

After the bagging process, DM analysis was performed using the 60°C forced air oven. Analysis suggested the DM of SOL and WDGS were greater (36% and 33%, respectively) than formulated at the time of ensiling. Likewise, the stalks had a lower DM (83%) than values used for mixing. Therefore, the actual ratio of SOL:stalks was 53:47 and the ratio of WDGS:stalks was 51:49. This demonstrates the value of accurate DM determination.

Even with the small differences in mixes, SOL and WDGS can be utilized as supplementation for growing calves when stored with cornstalks. Performance results showed that WDGS stored with stalks provided a higher quality diet in this study. However, more SOL could be fed as a mixture to produce the same performance. By comparing steers fed 30 SOL:30 stalks versus 20 WDGS:20 stalks, performance was statistically similar. Steers fed 30 SOL:30 stalks were as efficient as steers fed 20 WDGS:20 stalks, and both had similar DMI. Steers fed WDGS mixed with stalks did have lower F:G compared to steers fed SOL at the same level, but if a producer can purchase the SOL for less than the WDGS, it could be economically beneficial to use as a supplement even if they have to feed more.

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Comparison of Dry Distillers or Modified Wet Distillers Grains Plus Solubles in Wet or Dry Forage-Based Diets

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Summary

Modified wet distillers grains plus solubles (MDGS) or dry distiller grains plus solubles (DDGS) in combination with wet or dry forages were fed to growing steer calves (n =192). They were fed one of four treatments in a 2 x 2 factorial arrangement with factors as wet or dry forage and MDGS or DDGS for 105 days. Gain and feed-to-gain ratio (F:G) of steers fed MDGS were similar to those fed DDGS. Feeding wet forage significantly improved average daily gain (ADG) and F:G compared to feeding dry forage, which likely reflects forage quality in this study.

Introduction

Dry distillers grains plus solubles (DDGS) are completely dried from wet distillers grains plus solubles (WDGS) to 90% DM. Modified wet distillers grains plus solubles (MDGS), a modified wet product, are partially dried down from the traditional wet product (30-35% DM) to 46-48% DM.

These byproducts are often mixed with low quality forage and fed as a supplement in backgrounding operations. Our objective was to determine effects of feeding wet or dry distillers grains in a diet of wet or dry forage on growing calf performance.

Procedure

A 114-day growing trial utilizing 192 crossbred steer calves (642 ± 53 lb) in a randomized complete block design was conducted at the University of Nebraska–Lincoln Haskell Agricultural Laboratory near Concord, Neb. Steers were weighed on two consecutive days (day 0 and day 1) to obtain initial BW. Steers were assigned randomly to pen following stratification and blocking (by BW). Pen was assigned randomly to one of four dietary treatments with six pens per treatment and eight steers per pen. Steers were also implanted on day 1 with Ralgro® (Schering-Plough Animal Health). Steers were fed *ad libitum* once daily, with bunks read daily for intakes and adjusted accordingly. Steers were weighed on two consecutive days at the end of the trial for ending BW. From day 105 to day 114 all steers were fed a common ration to account for any differences in gut fill among treatments. Performance data were based on 105 days, assuming equal ADG of 1.5 for the last nine days on trial while consuming the common ration. Weekly feed samples were taken for 60°C forced-air oven DM analysis.

Dietary treatments (Table 1) consisted of DDGS or MDGS included at 32% of the diet on a DM basis. Corn silage constituted 59% of the diet DM for the wet forage diets. An oat hay and oat straw combination was used for the dry forage diets and constituted 16% and 13% of the diet DM, respectively. Dry rolled corn (DRC) was added at 35% of diet DM to the dry forage diets to account for the corn in the wet forage diets from corn silage. Liquid supplement was included at 4% of the diet DM. Diets were balanced to meet nutritional requirements for metabolizable protein, degradable intake protein and calcium-phosphorus ratio (Ca:P).

Lab analysis was conducted on all feedstuffs. Dry matter, organic matter (OM), crude protein (CP), fat, dry matter digestibility (DMD) and neutral detergent fiber digestibility (NDFD) were determined. Dry matter was determined in a 60°C forced-air oven for 48 hours. Organic matter was calculated from 6-hour ash at 600°C oven after lab-corrected DM (DM feed) was determined in 105°C oven for 24 hours. CP analysis was conducted by the combustion method. Fat was analyzed using the gravimetric fat procedure modified by University of Nebraska. Dry matter digestibility and NDFD were determined utilizing a 28-hour *in situ* rumen incubation. Samples were weighed (1.5 g) into small (5 x 10 cm) *in situ* bags. Two bags of each ingredient were placed in the rumen of a steer being fed 75% grass hay, 20% DRC and 5% supplement. Two steers were used and bags were incubated for 28 hours. After rinsing the bags, DM was determined using 60°C forced air oven (DM residue), and DMD was calculated as [100 * (DM feed - DM residue)/feed DM]. Ankom analysis was conducted after the 28-hour *in situ* incubation to analyze NDF in the remaining residue. The sample NDF was determined using beaker NDF analysis. These two NDF values were used to calculate the NDFD values for each foodstuff.

Data were analyzed using MIXED procedures of SAS (SAS Inst. Inc.) as a randomized complete block design. Block was a fixed effect and pen was the experimental unit. Block, byproduct type and forage type were included in the model statement. Interactions for type of byproduct and type of forage were analyzed. If the interaction was significant, simple effects were analyzed using Differences of LS Means. If no significant interaction was observed, main effects are presented.

Results

No interactions were observed between byproduct type and type of forage. Likewise, type of byproduct was not significant. These results suggest there is no difference in feeding values of dry or modified wet byproduct in forage-based diets, agreeing with Nuttelmen et al. (*2008 Nebraska Beef Report,* pp. 29-30) who reported wet distillers grains plus solubles and DDGS had similar values.

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

	Dry Forage		Wet Forage	
Ingredient	DDGS	MDGS	DDGS	MDGS
DDGS[1]	32.0	—	32.0	—
MDGS[2]	—	32.0	—	32.0
Corn silage	—	—	59.0	59.0
Oat hay	16.0	16.0	5.0	5.0
Oat straw	13.0	13.0	—	—
DRC	35.0	35.0	—	—
Supplement	4.0	4.0	4.0	4.0

[1]Dry distillers grains plus solubles.
[2]Modified wet distiller grains plus solubles (partially dried).

Table 2. Ingredient nutrient analysis on DM basis.

	DM	OM	CP	Fat	DMD[1]	NDFD[2]
DDGS[3]	89.8	97.9	31.2	13.0	69.6	56.5
MDGS[4]	46.9	95.9	28.2	12.8	62.8	54.6
Corn silage	41.4	94.9	8.3	2.8	65.0	37.1
Oat hay	78.4	93.1	11.3	2.3	52.1	39.5
Oat straw	75.4	94.3	5.1	1.0	34.8	32.3
DRC	87.8	98.3	9.5	6.5	82.4	43.0

[1]Dry matter (DM) digestibility calculated from 28-hour rumen incubation.
[2]Neutral detergent fiber (NDF) digestibility calculated from NDF analysis and 28-hour rumen incubation.
[3]Dry distillers grains plus solubles.
[4]Modified wet distiller grains plus solubles (partially dried).

Table 3. Performance results of feeding DDGS[1] or MDGS[2] in combination with wet or dry forage.

	Dry Forage		Wet Forage					
Item[3]	DDGS	MDGS	DDGS	MDGS	SEM	Interaction[4] *P*-Value	DGS[5] *P*-value	Forage[6] *P*-value
IW, lb	646	643	640	643	3	0.20	1.00	0.27
FW, lb	945	942	967	972	8	0.56	0.94	<0.01
DMI, lb/d	21.9	22.2	20.4	20.5	0.4	0.75	0.69	<0.01
ADG, lb	2.74	2.74	3.01	3.02	0.07	0.92	0.94	<0.01
F:G	8.07	8.15	6.82	6.80	0.87	0.76	0.83	<0.01

[1]DDGS = dry distillers grains plus solubles.
[2]MDGS= modified wet distillers grains plus solubles (partially dried wet product).
[3]IW = initial weight; FW = final weight; DMI = dry matter intake; ADG = average daily gain; F:G = lb of feed consumed per lb of weight gained (calculated from total gain over total DMI, which is reciprocal of F:G).
[4]Interaction between type of byproduct and type of forage fed.
[5]Effect of type of byproduct (DGS) fed.
[6]Effect of type of forage fed.

Forage type was statistically significant ($P < 0.05$) for all items except for initial BW (Table 2). Dry matter intake was lower for steers fed wet forage diets (20.4 lb/day, $P < 0.05$) compared to those fed dry forage diets (22.0 lb/day). Gain for steers fed wet forage diets was more at 3.01 lb/day and was statistically different than gain for steers consuming the dry forage diets (2.74 lb/day, $P < 0.05$). The wet forage fed steers had lower intakes and higher gains; therefore feed-to-gain ratio (F:G) was less (6.81; $P < 0.05$) for these steers compared to the dry forage fed steers (8.11).

Digestibility values helped explain the lack of difference in performance of steers fed DDGS versus those fed MDGS (Table 3). Byproducts had numerically similar DMD and NDFD values which would suggest similar utilization and performance. Forage feedstuffs varied in DMD and NDFD. The DMD of corn silage was higher than that of oat hay, which was higher than that of oat straw. Diet DMD showed that the dry forage diets (62.9% diet DMD) were slightly more digestible than the wet forage diets (62.1% diet DMD), although the difference was minimal. Even with the increased values contributed from the added DRC in the dry forage diets, oat hay and oat straw still did not result in steer performance comparable to that of the corn silage fed steers.

This study showed that when feeding growing calves, type of distillers grains (dry or modified wet) does not impact performance as much as the quality of forages.

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Level of Wet Distillers Grains Plus Solubles and Solubles Ensiled with Wheat Straw for Growing Steers

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Summary

A growing study compared wet distillers grains plus solubles (WDGS) and solubles ensiled with wheat straw individually fed to crossbred steers. Four blends of ensiled distillers grain and solubles were used to compare performance on growing calves versus feeding ensiled byproducts alone. Increasing the level of distillers grains in the diet increased average daily gain (ADG) and dry matter intake (DMI). The nonensiled distillers grain treatments had at least equal ADG and feed-to-gain ratio (F:G) compared to the ensiled treatments.

Introduction

Previous research has shown WDGS can be mixed with dry forages and stored in silo bags (Adams et al., *2008 Nebraska Beef Report*, pp. 23-25). The objectives of this study were to: 1) evaluate ensiled solubles and ensiled and nonensiled WDGS with wheat straw and their impact on performance of growing calves; and 2) compare blends of ensiled WDGS and solubles on performance of growing calves versus feeding ensiled byproducts alone.

Procedure

In November, four silo bags were filled using wheat straw, WDGS and solubles. Wheat straw was ground through a 5-in screen. Five hundred pounds of wheat straw were loaded into a feed truck, and 444 lb of WDGS were added to obtain a mix of 25% WDGS and 75% wheat straw (DM basis). Water was added to obtain a moisture content of 50%. The blend was mixed in the roto-mix feed truck for five minutes and then placed into a silo bag using 300 psi to exclude oxygen. Three additional bags were made using combinations of 55% WDGS + 45% wheat straw, 25% solubles + 75% wheat straw and 45% solubles + 55% wheat straw. Only the 55% WDGS silo bag did not have additional water added to the mixture to bring the mix to 50% moisture. The bags were sealed, and the ensiled byproducts were stored for 50 days before being fed.

Crossbred steers (n = 120) were individually fed for 80 days using the Calan gate system. Prior to initiation of the trial, steers were trained to use the Calan gate system for 21 days. Steers were limit-fed for five days at the beginning of the trial to minimize gut fill differences. Steers were weighed on three consecutive days to determine initial body weight. Based on body weight, steers were stratified and blocked into light, medium and heavy weight blocks. Steers were randomly assigned to treatment within each weight block (eight steers per treatment). Cattle were fed daily at 0600, and feed refusals were weighed and sampled weekly. Samples were dried in a 60°C forced air oven for 48 hours to calculate dry matter intake (DMI). At the conclusion of the trial, steers were limit-fed for five days, and consecutive weights were recorded daily for three days and averaged for final weights.

There were a total of 15 treatments. The first seven treatments included: 25% solubles; 35% solubles and 45% solubles ensiled with ground wheat straw; and 25% WDGS, 35% WDGS, 45% WDGS and 55% WDGS combined with wheat straw. The 25% solubles treatment was taken from the 25% solubles silo bag. Using a combination of the 25% and 45% ensiled material, the 35% treatment was produced. The 45% solubles treatment was taken from the 45% solubles silo bag. Similarly, the 25% WDGS was acquired from the 25% WDGS silo bag. The 35% and 45% WDGS treatments were combinations of the 25% and 55% silo bags.

The next four treatments consisted of a 35% and 45% WDGS ensiled and nonensiled group. The nonensiled treatments were made from mixing fresh WDGS and ground wheat straw daily. The ensiled treatments came from the combinations of the 25% WDGS and 55% WDGS silo bags. Two calves of similar weight were assigned either to ensiled 35% WDGS or fresh 35% WDGS treatment. The steer on the 35% WDGS treatments intake was limited to the intake of the nonensiled WDGS 35% treatment. Similarly, an ensiled 45% WDGS treatment had intake defined by a nonensiled 45% WDGS companion animal.

The last four treatments were blends of solubles. WDGS and wheat straw blends included: 17.5% solubles + 17.5% WDGS; 25% solubles + 10% WDGS; 25% solubles + 20% WDGS; and 26.25% solubles + 8.75% WDGS.

Each treatment was fed with a 2% supplement consisting of limestone, salt, tallow, vitamins A, D, and E and a beef trace mineral mix fed with a fine ground corn carrier.

Results

The sulfur contents (Table 1) of 35% solubles; 45% solubles; 25% solubles + 10% WDGS; 25% solubles + 20% WDGS; 26.25% solubles + 8.75% WDGS; and 55% WDGS were all calculated to be over 0.5%, which is greater than the National Research Council's recommended level of 0.4%. However, in this trial, we did not observe any signs of polioencephalomalacia. The percentage fat in diet was highest (8.7%) for the 45% solubles treatment. However, intake was not reduced and this treatment had the second highest intake of all the treatments.

Data from the treatments involving WDGS and solubles level were analyzed for effects of level and type of byproduct (Table 2). Treatments of 25% and 35% solubles were similar for ADG, but ADG increased for the 45%

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Table 1. Sulfur % and fat % of WDGS and soluble treatments.

Treatment	Sulfur[1] %	Fat [2] %
Ensiled WDGS 35 (limited)	.35	4.96
Ensiled WDGS 45(limited)	.45	6.14
Nonensiled WDGS 35	.35	4.96
Nonensiled WDGS 45	.45	6.14
Sol 25	.40	5.17
Sol 35	.56	6.92
Sol 45	.72	8.69
Sol 17.5 + WDGS 17.5	.46	6.07
Sol 25 + WDGS 10	.50	6.44
Sol 25 + WDGS 20	.60	7.69
Sol 26.25 + WDGS 8.75	.51	6.50
WDGS 25	.25	3.59
WDGS 35	.35	4.96
WDGS 45	.45	6.14
WDGS 55	.55	7.73

[1]Calculated daily sulfur intake when WDGS =1.0% S and solubles = 1.6%.
[2]Calculated percent fat in the diet due to grain byproduct when WDGS = 13.3% and solubles = 18.3%.

Table 2. Performance characteristics related to inclusion level of solubles or WDGS.

Item	25 % Solubles	35% Solubles	45% Solubles	25% WDGS	35% WDGS	45% WDGS	55% WDGS	SEM	*P*-value
Int BW, lb	555	554	555	562	557	554	555	11.49	0.99
Final BW, lb	639^{b}	634^{b}	654^{bc}	600^{a}	632^{b}	652^{bc}	681^{c}	14.87	< 0.01
DMI, lb/day	10.47^{bc}	11.15^{c}	11.25^{c}	9.04^{a}	9.73^{ab}	10.84^{c}	11.17^{c}	0.533	< 0.01
ADG, lb	1.05^{bc}	1.00^{bc}	1.24^{cd}	0.47^{a}	0.94^{b}	1.23^{c}	1.60^{d}	0.128	< 0.01
F:G	10.14^{bc}	11.49^{b}	8.8^{bc}	21.0^{a}	10.52^{bc}	9.20^{c}	6.86^{d}	1.757	< 0.01

[a,b,c] Within a row, means without a common superscript differ ($P < 0.05$).

Table 3. Performance characteristics of four blends of solubles and WDGS.

Item	17.5% Sol + 17.5% WDGS	25% Sol + 10% WDGS	25% Sol + 20% WDGS	26.25% Sol + 8.75% WDGS	SEM	*P*-value
Int BW, lb	551	549	557	559	13.95	0.87
Final BW, lb	630	632	666	650	16.80	0.14
DMI, lb/day	9.54^{a}	10.26^{ab}	11.52^{c}	9.71^{ab}	0.57	< 0.01
ADG, lb	0.99	1.03	1.36	1.10	0.15	0.08
F:G	10.06	10.20	8.80	9.33	1.01	0.49

[a,b,c]Within a row, means without a common superscript differ ($P < 0.05$).

Table 4. Performance characteristics on level and type of WDGS.

	Level		Type		SEM	*P*-value Type	*P*-value Level
	35	45	Ensiled	Nonensiled			
Int BW, lb	556	559	558	557	11.07	0.94	0.64
Final BW, lb	635	648	636	647	12.68	0.19	0.17
DMI, lb/day	9.87	9.01	9.37	9.50	0.53	0.74	0.03
ADG, lb	0.99	1.1	0.97	1.13	0.12	0.08	0.22
F:G	10.85	8.35	10.56	8.64	1.52	0.09	0.03

solubles level. There was a quadratic trend ($P = .069$) for F:G to decrease as inclusion of solubles increased. The 35% solubles treatment had the highest F:G, with 45% solubles being the most efficient and 25% solubles in the middle of the other two treatments.

The DMI and ADG increased linearly ($P < .01$) as the WDGS inclusion increased from 25% to 55%. Additionally, F:G of WDGS treatment decreased linearly ($P < 0.01$) as the level of inclusion increased. ADG of steers fed solubles and WDGS at the same inclusion rates were not different except for the 25% level of inclusion. Intake was greater for the 25% solubles compared to the 25% WDGS treatment.

Four blends were made using different inclusion levels of solubles and WDGS (Table 3). Differences in DMI ($P < 0.01$) were found between treatments. Steers on the 17.5% solubles + 17.5% WDGS treatment had a lower ($P < 0.01$) intake (9.54 lb) compared to steers on the 25% solubles + 20% WDGS treatment (11.52 lb). Additionally, ADG tended ($P = .08$) to be different among groups. However, F:G was not different ($P > .10$) among the four treatment blends. The blends totaling 35% byproduct resulted in gains of 0.99 to 1.1 lb/day, similar to gains achieved with either of the byproducts fed alone. There appears to be no associative effect of feeding the combinations. The 25% solubles + 20% WDGS blend also resulted in similar ADG to either of the byproducts fed alone.

Using a 2 x 2 factorial, the level (35% vs. 45%) and type (ensiled vs. nonensiled) of WDGS were compared (Table 4). The type x level interaction was not significant. There were no differences in type for initial and final BW or DMI. For type there was a trend for ADG ($P = 0.08$) and F:G ($P = 0.09$) to be different. There were no differences between the two levels for ADG and initial and final body weights. However, DMI and F:G differed ($P = 0.08$) between the 35% and 45% WDGS levels. Steers fed the 45% diet have lower F:G and DMI compared to steers fed the 35% diet.

In summary, both solubles and WDGS ensiled with wheat straw stored successfully in the silo bags. Calves responded positively to increasing levels of either solubles or WDGS, and the feeding values of solubles were at least equal to those of WDGS. Blends of solubles and WDGS resulted in performances similar to those of either solubles or WDGS fed alone. There were no associative effects. The WDGS mixed with wheat straw at feeding time gave comparable performance to similar levels of WDGS that had been ensiled for more than 50 days.

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Summary of Grazing Trials Using Dried Distillers Grains Supplementation

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Summary

A meta-analysis of grazing trials in which cattle were supplemented with dried distillers grains with solubles (DDGS) was conducted to determine effects of supplementation on average daily gain (ADG) and final BW in pasture grazing situations. Additionally, pen studies were evaluated to determine the effects of DDGS supplementation on cattle intake, forage replacement, ADG and final BW. In both the pasture and the pen studies, ADG and final BW increased quadratically with increased level of DDGS supplementation. Feeding DDGS decreased forage intake quadratically; however, total intake for cattle supplemented DDGS increased quadratically with increased level of supplementation.

Introduction

The increase in ethanol production has led to increased corn prices and increased costs of finishing cattle. This increase in finishing cost has caused producers to search for opportunities to increase cattle BW prior to feedlot entry using forage and feed resources other than corn grain. In growing studies comparing growing rations containing corn and growing rations containing DDGS, DDGS has been shown to have 125% the energy value of corn (*2003 Nebraska Beef Report*, pg. 8-10). Additionally, DDGS is typically priced lower than corn grain (approximately 70-90% the price of corn on a DM basis). The increased supply and competitive price of DDGS relative to corn make DDGS a viable resource for supplementing growing cattle consuming forage-based diets.

Meta-analysis procedures are used to account for individual trial variation when combining results from multiple studies. The objective of this meta-analysis was to evaluate the effect of increasing DDGS supplementation in forage-based production systems on cattle performance and forage replacement.

Procedure

Treatment means were compiled from 14 trials in which cattle were allowed to graze pasture and supplemented DDGS (treatment means = 35) and seven trials in which cattle were pen fed a forage-based growing ration and supplemented DDGS (treatment means = 28). Studies in which DDGS was supplemented to cattle grazing pasture (*2004 Nebraska Beef Report*, pp. 25-27; *2006 Nebraska Beef Report*, pp. 27-29; *2006 Nebraska Beef Report*, pp. 31-32; *2008 Nebraska Beef Report*, pp. 28-30; *2008 Nebraska Beef Report*, pp. 31-32; Lomas and Moyer [unpublished] and Griffin et al. [unpublished]) included 394 cattle that were allowed to graze either cool or warm season grasses for 60 to 196 days (average, 119 days). Pastures included smooth bromegrass and bermudagrass in Kansas, and smooth bromegrass and Sandhills range in Nebraska. Within each pasture grazing experiment, cattle were stratified by initial BW and assigned randomly to supplementation treatment. Additionally, cattle in each treatment were allowed to graze the same number of days. Supplementation of DDGS ranged from 0.0 to 8.0 lb/head daily, with an average supplementation of 2.8 lb/head daily.

Studies in which cattle were pen fed and supplemented DDGS (*2003 Nebraska Beef Report*, pp. 8-10; *2005 Nebraska Beef Report*, pp. 18-20; *2006 Nebraska Beef Report*, pp. 36-37; *2007 Nebraska Beef Report*, pp. 15-16; *2007 Nebraska Beef Report*, pp. 17-18; and *2008 Nebraska Beef Report*, pp. 33-34) included 348 cattle that were fed either hay or a forage mixture containing 60% sorghum silage and 40% alfalfa hay. The mixture was used to simulate the diet that cattle would consume if grazing green forage. Within each pen study, cattle were stratified by initial BW, assigned randomly to treatment and fed the same number of days. In the pen studies, supplementation with DDGS ranged from 0.0 to 7.6 lb/head daily (average, 3.7 lb/head daily). Pen study duration ranged from 82 to 95 days, with an average study length of 86 days.

In all pasture and pen studies, initial BW and final BW were determined by averaging multiple day weights at trial initiation and conclusion. For the pen studies, forage intake was measured to determine the amount of forage that DDGS would replace in the diet. Data from pen and pasture studies were analyzed separately using an iterative meta-analysis methodology that integrated quantitative findings from multiple studies using the MIXED procedure of SAS.

Results

Pasture Studies

Effect of DDGS supplementation on final BW and ADG are presented in Table 1. For gain and final BW performance, supplemented DDGS is represented as % of BW because of differences in BW across pasture and pen-fed studies. Supplementing DDGS to cattle grazing pasture linearly increased final BW ($P < 0.01$) and ADG ($P < 0.01$) with increased supplementation. However, final BW ($P = 0.07$) and ADG ($P = 0.21$; Figure 1) tended to be quadratic.

Pen Studies

Supplementing DDGS in growing rations and hay-fed situations consistently increased final BW ($P = 0.01$) and ADG ($P < 0.01$; Figure 1) quadratically as level of DDGS supplementation increased.

(Continued on next page)

Table 1. Effect of supplemental level of dried distillers grains plus solubles (DDGS) on final BW and gain of growing cattle.

DDGS supplementation[1]	0.0	0.2	0.4	0.6	0.8	1.0	1.2	Lin[2]	Quad[2]
Pasture studies: (Treatment means = 35)									
Final BW, lb	827	859	884	900	908	908	900	< 0.01	0.07
ADG, lb/day	1.47	1.71	1.90	2.05	2.16	2.23	2.26	< 0.01	0.21
Pen studies: (Treatment means = 28)									
Final BW, lb	685	720	749	772	790	803	811	< 0.01	< 0.01
ADG, lb/day	1.18	1.60	1.94	2.20	2.38	2.48	2.51	< 0.01	< 0.01

[1]Supplemented level of DDGS (DM-basis) as % of BW.
[2]Estimation equation linear and quadratic term t-statistic for variable of interest.

Table 2. Effect of supplemental level of dried distillers grains plus solubles (DDGS) on intake of growing cattle in pen-fed studies.

DDGS supplementation[1]	0.0	1.5	3.0	4.5	6.0	7.5	Lin[2]	Quad[2]
Total intake, lb/day	12.7	13.9	14.9	15.7	16.3	16.6	< 0.01	< 0.01
Forage intake, lb/day	12.7	12.4	11.9	11.2	10.3	9.1	0.31	< 0.01
Forage replacement[3], lb/day	0.0	0.3	0.8	1.5	2.4	3.6	—	—
Forage replaced/ DDGS[4], lb/lb	0.00	0.20	0.27	0.33	0.40	0.48	—	—

[1]Supplemented level of DDGS (DM-basis) in lb/head daily.
[2]Estimation equation linear and quadratic term t-statistic for variable of interest.
[3]Forage replacement calculated using forage intake at 0.0 lb/day supplementation and subtracting forage intake value for respective level of supplementation.
[4]The amount of forage replaced per lb of DDGS supplemented.

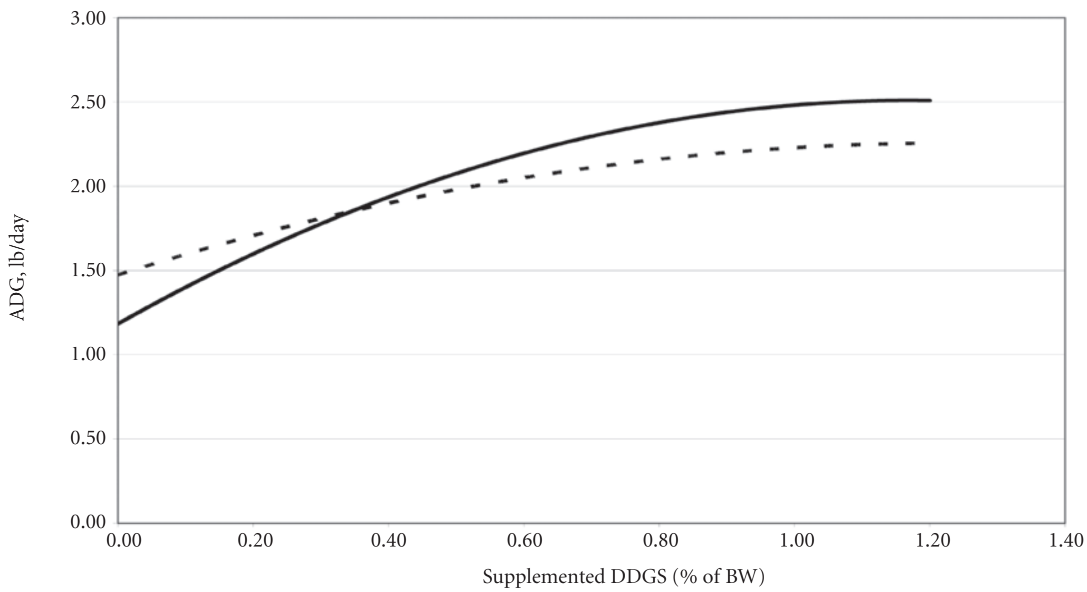

Figure 1. Effect of DDGS supplementation on ADG for growing cattle supplemented DDGS. Pasture ADG (- - - -) = $1.4736 + 1.2705x - 0.5156x^2$. Pen ADG (——) = $1.1828 + 2.2703x - 0.9715x^2$.

Intake data are presented as lb/day fed (Table 2). Total intake response to increasing levels of DDGS supplementation was quadratic ($P < 0.01$). However, as DDGS supplementation increased, forage intake decreased quadratically ($P < 0.01$). Additionally, forage replacement per pound of DDGS supplementation increased with increasing level of DDGS supplementation.

Final BW and ADG exhibited a significant linear response in the pasture studies; however, in the pen-fed studies, final BW and ADG were quadratically impacted by DDGS level. This difference in pasture and pen-fed studies is likely due to higher variation in the pasture studies when compared to the pen-fed studies. In the pen-fed studies feeding conditions are more tightly controlled. We conclude performance responses in the pasture studies are in fact quadratic; however, due to the increased variation we were able to detect only a trend in the pasture studies. Additionally, when comparing ADG across pasture and pen studies, pen studies showed a greater response to DDGS supplementation than pasture studies. The greater response may be due to differences in metabolizable protein

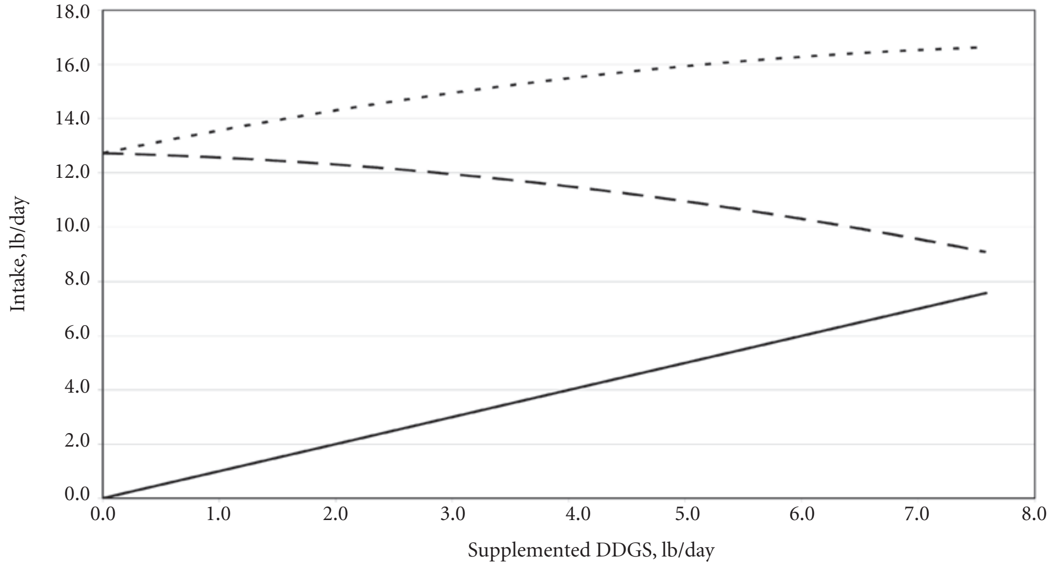

Figure 2. Effect of DDGS supplementation on intake for cattle fed in pen studies. DDG Supplementation (——) = x. Forage intake (– – – –) = 12.718 -0.1103x – 0.0490x^2). Total Intake (- - - -) = 12.719 + 0.8899x – 0.0494x^2.

(MP) requirements for the cattle. In the pen studies, cattle were lighter and younger at trial initiation, leading to greater requirement for MP in terms of grams of MP required per pound of BW. Also, energy response for lighter animals is greater per pound of BW when compared to heavier cattle. Because the ADG response was greater for pen-fed than for grazing cattle, forage replacement could have been greater in pasture-fed animals than in pen-fed calves. Since DDGS supplementation was at the same level, this leaves the forage intake as the variable input. In pasture and pen studies, forage quality was similar; therefore, the amount of forage replaced could be a logical explanation for the increased ADG response in the pen studies compared to the pasture studies.

Data were collected on cattle from 10 of the grazing trials during feedlot finishing subsequent to grazing. On average the supplemented cattle gained 81 lb more weight on grass than unsupplemented controls. The supplemented cattle were 69 lb heavier than control cattle at slaughter, indicating greater than 84% of the weight was maintained. In six of the 10 studies, dry matter intake (DMI) was measured in the feedlot. In general DMI was not increased in cattle fed DDGS on grass. The economics of feeding DDGS on grass are dependent upon the selling prices of cattle at the end of grazing and the pasture saved by supplementation. If ownership is retained, DMI in the feedlot and amount of weight retained through finishing are important considerations. It is very difficult to measure intake of cattle on pasture. Therefore, we attempted to estimate intake indirectly using National Research Council (1996) net energy equations and the pen-fed performance. Several assumptions on total digestible nutrient (TDN) values of the forages and net energy adjusters must be made. The most conservative estimate (lowest forage replacement) showed 0.76 lb reduced forage intake per pound of DDGS dry matter supplemented. Assuming 16 lb dry matter intake of controls, that gives a savings of 24% of grass with supplementation of 5 lb dry matter from DDGS. Greenquist et al. (*2009 Nebraska Beef Report* pp. 25-27) showed 60% increase in carrying capacity of brome pasture by supplementing with 5 lb DDGS DM. Some of that response may have resulted from N in the DDGS increasing growth of grass. However, it supports a savings in grass consumption of at least 24% as calculated above.

Given the assumptions on grass replacement by DDGS, we can estimate the economics of supplementing DDGS on pasture. The cost of grass for yearlings is about $.60/day. Twenty-four percent savings in grass would be $.14/day. Five pounds DDGS DM would be about $.50 at current prices. The net cost would be $.36/day. The yearlings should have 0.6 lb increased gain from 5 lb DDGS supplement and 0.5 lb should be retained through the feedlot. That 0.5 lb should be worth $.50. The net profit would then be $.14/day ($.50 minus $.36).

In conclusion, supplementing DDGS increased final BW and ADG quadratically for cattle in forage based production systems. Additionally, feeding DDGS decreased forage intake quadratically; however, total intake for cattle supplemented DDGS increased quadratically with increased level of supplementation.

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Profit Variability for Calf-Fed and Yearling Production Systems

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Summary

Profitability of calf-fed and backgrounding yearling systems was determined based on actual production data and prices from 1996 to 2007, and variability across years was compared. The two systems exhibited similar profits, on average, but the calf-fed system showed less profit variability, suggesting there is more risk inherent in a yearling backgrounding and finishing system. Also, profitable years were more apt to have less variable corn prices.

Introduction

Lightweight calves are more valuable relative to heavyweight calves when corn prices are low, suggesting it is more profitable to feed calf-feds in years with low corn prices (Dhuyvetter, Schroeder and Prevatt, "Managing for Today's Cattle Market and Beyond," March 2002). Therefore, due to the current high corn prices, it may be more beneficial to background calves on cornstalks and/or pasture and place feeder cattle in the feedlot as yearlings. It is important for producers to consider which beef production system is most appropriate for their operation and which offers less profit risk during times of high market price variability.

A previous study evaluating the differences in carcass characteristics, performance and profitability between calf-fed production systems and yearling production systems from 1996 to 2005 concluded that yearlings, although less efficient in the feedlot, were more profitable, on average, compared to calf-feds (Griffin et al., *2007 Nebraska Beef Report*, pp. 58-60). That analysis used seven-year averages of economic variables that affect cattle feeding profitability, which masked the yearly variation in returns and potential risks to producers. This study identifies the magnitude of year-to-year variability in profits within each system and examines the determinants of profit variation.

Procedure

Production data from Griffin et al. (*2007 Nebraska Beef Report*, pp. 58-60) were used to create calf-fed and yearling system budgets for 1996-2005, and the data in Adams et al. (*2008 Nebraska Beef Report*, pp. 70-71) were used to develop budgets for 2006-2007. All years included both a calf-fed system and a long yearling system, with the exception of 1997, for which only calf-fed production data were available, and 2005, for which only yearling production data were available. Calf-fed systems had heavier steers entering the feedlot after fall weaning. Yearling systems were comprised of lighter steers backgrounded on cornstalks and summer pasture and then placed in the feedlot the following fall (Griffin et al., *2007 Nebraska Beef Report*, pp. 58-60).

The rations for all production systems were held constant through the 12 budgeted years in order to compare the cost of a common diet, given varying feed costs from November 1995 until January 2008. All other production variables (i.e., days on feed, average daily gain, dry matter intake, etc.) and most input costs (i.e., ration costs, cornstalk and summer pasture rental rates, finishing death loss, finishing veterinary and medical expense, interest rates, etc.) varied according to actual prices for each respective year.

The finishing diet (DM basis) included 47.5% dry rolled corn, 40% wet corn gluten feed (WCGF), 7.5% alfalfa hay and 5% supplement. Dry-rolled corn was priced using weekly Omaha cash corn prices averaged over the feeding period. A processing charge of $1.44/ton (DM basis) was added to the corn price to cover processing costs (Macken, Erickson and Klopfenstein, 2006, *The Professional Animal Scientist*, 22:23-32). The delivered price of WCGF was 95% of the weekly Omaha cash corn price (DM basis) averaged across the feeding period. The budgets reflected an average alfalfa hay price for the feeding period as reported by Mark and Malchow (2007, *Crop and Livestock Prices for Nebraska Producers*, EC883), plus an assumed processing and shrink fee from Jose (1996-2008, *Nebraska Farm Custom Rates — Part II).* A yardage cost of $0.35/head/day, for the finishing period was indexed across years using Northern Plains feedlot data provided by Professional Cattle Consultants (1995-2008). Calf-feds were fed an average of 170 days from approximately mid-November to late April or mid-May, while yearlings were fed in the feedlot for an average of 98 days from approximately mid-September to December or January.

In addition to grazing cornstalks, the winter diet for the yearling system included WCGF (5 lb/head/day DM basis), which was priced as described previously, and supplement. Average cornstalk rental rates from surveys of producers in Dawson, Custer and Buffalo counties were used (Treffer, 1996-2007; Plugge, 2005-2007; Walz, 2003-2008), and $0.20/head/day, which was also indexed across years as described above, was assumed as the winter grazing yardage charge to cover management, labor, feeding, watering and other costs.

Summer grazing costs on an animal unit month (AUM) basis were determined using annual data from Johnson (*1996-2007, Nebraska Farm Real Estate Market Developments*). Yearlings grazed brome pasture an average of 21 days from late April until the middle of May before being moved to Sandhills pasture, where they grazed native range until they entered the feedlot in September. Similar to methods used by Griffin et al. (*2007 Nebraska Beef Report*, pp. 58-60), the total cost of summer grazing included determining an AUM steer equivalent (dividing average summer grazing BW of steers by 1,000 lb) and multiplying that by the average AUM rental rates for 1996 through 2007. Additionally, this analysis accounted for differences in AUM rental rates in the two regions where the cattle grazed. Note also that transportation costs were based on a hauling distance of 60 miles (Jose, 1996-2008, *Nebraska Farm Custom Rates—Part II*).

Dressed cattle sales prices ($/cwt) were determined using a grid price with the base grid using a USDA yield grade 3, low Choice carcass. Premiums and discounts were based on weekly average premiums and discounts reported by USDA. The feeder cattle purchase price was calculated using a price slide based on weekly USDA Agricultural Marketing Service (AMS) reported Nebraska cash prices for feeder steers placed in the fall of 1999 to 2006. Because the AMS Nebraska feeder steer price series goes back only to 1999, the study used estimated Nebraska prices for the fall of 1995 to 1998 based on AMS reported prices for Torrington, Wyo.

Similar to Griffin et al. (*2007 Nebraska Beef Report*, pp. 58-60), yearly veterinary and medical expenses for the calf-fed and yearling production systems were assumed to average $16.66/head. To reflect the variability in these prices across years, veterinary and medical expenses were also indexed to actual veterinary and medical expense data from Northern Plains feedlots (Professional Cattle Consultants, 1995-2007). Death loss in the winter and summer grazing periods for the yearling system averaged 1.8%. The average death loss in the finishing phase was 2.0% and 0.2% for the calf-fed and yearling systems, respectively. Death loss variability across years was also indexed using Professional Cattle Consultants data. The average marketing cost was $15.89/head and $17.28/head, respectively for calf-feds and yearlings and was indexed to USDA's National Agricultural Statistics Service (NASS) data. Quarterly farm operating loan interest rates reported in the Survey of Agricultural Credit Conditions were used to calculate interest costs (Federal Reserve Bank of Kansas City, 1995-2007; available at *http://www.kc.frb.org*). Full interest was charged on the feeder cattle purchase price. Interest also was charged on half the feed and variable costs incurred by both production systems during ownership. The calf-fed system averaged 170 days of ownership, consisting of the finishing period only, while the yearling system averaged 388 days of ownership, which includes the period from purchase in the fall until the cattle were marketed the next winter.

(Continued on next page)

Table 1. Profit/loss for calf-fed and yearling production systems from 1996 to 2007.[a]

Year	System	Profit/Loss ($/hd)	Fed Cattle Price ($/dressed cwt)	Feeder Cattle Price[b] ($/cwt)	Corn Price[c] ($/bu)
1996	Calf-fed	-101.82	92.17	69.49	3.68
	Yearling	146.78	119.81	71.18	2.96
1997	Calf-fed	68.58	111.49	72.05	2.68
	Yearling	NA	NA	NA	NA
1998	Calf-fed	-107.66	103.86	86.99	2.46
	Yearling	-162.61	93.85	92.38	1.91
1999	Calf-fed	13.73	99.94	78.00	1.97
	Yearling	34.26	99.43	85.74	1.72
2000	Calf-fed	48.81	111.45	90.86	1.95
	Yearling	-26.28	112.92	99.18	1.77
2001	Calf-fed	36.37	121.23	97.41	1.91
	Yearling	-111.74	100.89	106.70	1.84
2002	Calf-fed	-28.28	103.34	89.21	1.88
	Yearling	-110.07	105.16	98.37	2.49
2003	Calf-fed	144.43	123.75	85.68	2.29
	Yearling	361.36	153.17	102.31	2.20
2004	Calf-fed	175.06	146.13	107.24	2.66
	Yearling	123.86	138.34	122.44	1.77
2005	Calf-fed	NA	NA	NA	NA
	Yearling	169.82	151.93	127.78	1.65
2006	Calf-fed	-100.33	130.96	124.98	1.92
	Yearling	-92.57	139.99	143.79	3.14
2007	Calf-fed	36.28	148.92	111.09	3.61
	Yearling	-69.50	144.89	123.59	3.86
Average[d]	Calf-fed	11.66	118.18	94.10	2.43
	Yearling	9.38	120.87	104.57	2.37
Maximum[d]	Calf-fed	175.06	148.92	124.98	3.68
	Yearling	361.36	153.17	143.79	3.86
Minimum[d]	Calf-fed	-107.66	92.17	69.49	1.88
	Yearling	-162.61	93.85	71.18	1.72
Standard	Calf-fed	98.98	19.46	16.49	0.69
development[d]	Yearling	160.84	21.60	20.86	0.73

[a]The years in the budgets are labeled according to the time calf-feds and yearlings were marketed as live cattle for 1996-2007.
[b]Average weight at purchase for the calf-fed and yearling systems was 643 lbs and 523 lbs, respectively.
[c]Corn price ($/bushel) is an average weekly Omaha cash price on an as-is basis and does not include a dry rolled corn processing fee.
[d]Excludes 1997 calf-fed data and 2005 yearling data.

Results

Table 1 reports profits of each system from 1996 to 2007. It also includes some of the main price variables (i.e., fed-cattle, feeder cattle and corn prices) that affect profits. The calf-fed system had a higher profit or smaller loss relative to yearlings for six out of the ten years.

However, yearlings were more profitable in 1996, 1999, 2003 and 2006. In 1996 and 1999, corn prices were high during the calf-fed finishing period. Furthermore, the fed cattle prices were low when calf-feds were marketed in 1996. Greater returns for the yearling system relative to the calf-fed system in 2003 are attributed to historically high fed-cattle prices in November of 2003 when yearlings were marketed. Table 1 also shows that in 2006, yearlings were sold at a higher price than calf-feds, and despite higher corn prices for yearlings, they were more profitable. Cattle and corn prices influence the relative profit of each system, not just through relative highs or lows, but because of seasonal changes in these markets that correspond to different feeding and marketing times for the two systems.

On average, both production systems reported profits for the years evaluated in the budgets. The calf-fed systems showed an average profit of $2.28/head more than the yearling systems' average profit (Table 1). Note that the calf-fed 1997 data and the yearling 2005 data were not included in the averages, ranges or standard deviations at the bottom of Table 1 in order to more accurately compare the two systems. The calf-fed systems showed a smaller range of profits relative to the yearling systems, as profits were more variable for yearlings as indicated by the standard deviation in Table 1.

The variability in each system's profits is partially the result of fed-cattle, feeder cattle and corn prices. The calf-fed production systems were characterized by a lower maximum, minimum, and average fed-cattle price as compared to the yearling production systems. Furthermore, when converted to a $/head basis, the calf-fed systems' average, maximum, and minimum feeder cattle prices were greater than those in the yearling systems. The calf-fed production systems had a higher average and minimum corn price but lower maximum corn price as compared to the yearling production systems.

While these results provide mixed conclusions about which system is more profitable based on the average and range of the three price variables considered, variability in profits is likely driven by the price variables' standard deviation. Yearling system profits were influenced by fed-cattle, feeder cattle and corn prices that had more variability than they did for calf-feds, which are marketed about 220 fewer total days post-weaning. Another cause for the yearling variability as well as the difference in average profits between the two systems is the low grass gains of yearlings in 2007. These low gains caused compensatory gains in the feedlot, which consequently caused higher finishing costs to be incurred. Had 2007 yearling grass gains been similar to 2006 grass gains, average yearling profits would have increased to $12.93/head, and the average profit difference between the systems would be $1.27/head, with yearlings being the more profitable system. For these reasons, yearling system profits were more variable, suggesting that with yearling systems there may be more risk of loss. Producers should consider this greater variability associated with yearling systems when using backgrounding systems.

Each system also was evaluated by profitable and unprofitable years. While the range and average prices of fed cattle, feeder cattle and corn are not surprising, the corn price standard deviation was much larger in unprofitable years than in those years when a profit was made. This variability suggests corn prices may be the variable creating a proportion of the risk affecting profits, regardless of which production system is used.

The results indicate both systems, on average, exhibit a profit across the years included in the analysis, with calf-fed systems being, on average, more profitable than yearling systems. Overall, the calf-fed systems were $2.28/head more profitable than the yearling systems. Profit differences between the two systems should be relatively small. Based on economic theory, profit differentials would eventually be eroded if profits were significantly higher in one system relative to another. If greater profits were available under one production system, producers would have an economic incentive to produce cattle under that method until the larger supply of cattle from that system decreased selling prices during the corresponding marketing period.

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Effects of Sorting Cattle by Weight and Time of Year on Finishing Performance, Carcass Characteristics and Economics

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Summary

Sorting steers for three different finishing systems (calf-feds, summer yearlings and fall yearlings) resulted in no differences in performance or average carcass characteristics compared to unsorted steers. Sorting decreased variation in hot carcass weight and number of carcasses over 950 lb. Sorting did not increase profit when calf-feds or fall yearlings were sold live compared to unsorted calf-feds and fall yearlings. However, when sold on a grid basis, sorting did increase profit for summer and fall yearlings.

Introduction

Cattle are commonly sorted by weight into different production systems at the time of weaning. The three production systems are calf-feds, summer yearlings and fall yearlings. There are many different variations of these three production systems. In Nebraska, it is common for calves to be born in March and weaned in the fall in October or November. When a calf is weaned, weight is used to determine which production system is best for that particular animal. This is done because calf-feds tend to be excessively fat and yearlings become overweight by the time of slaughter (*2007 Nebraska Beef Report*, pp. 58-60).

The first objective of this study was to determine if sorting cattle for a particular system by initial body weight (BW) decreases variation in hot carcass weight (HCW) and overweight carcasses (> 950 lb) at harvest. The second objective was to determine the economic effects of sorting and feeding genetically similar cattle throughout different times of the year.

Procedure

Experiments

The three production systems compared were calf-feds, summer yearlings and fall yearlings. All cattle entered the UNL facility at the time of weaning in the fall. Calf-feds entered the feedlot at weaning, were finished during the winter months and marketed in May. Summer yearlings grazed cornstalks throughout the winter and were supplemented with wet corn gluten feed at 5 lb/steer daily. Summer yearlings did graze grass for less than 30 days just prior to entering the feedlot in May. The summer yearlings were finished during the summer months and marketed in October. Fall yearlings grazed cornstalks during the winter months, similar to the summer yearlings, and also received 5 lb/steer of wet corn gluten feed daily. When the fall yearlings were removed from cornstalks, they grazed native range throughout the summer months (at University of Nebraska Barta Brothers Ranch) and were fed in the feedlot from September to January.

The year 1 group was comprised of Nebraska ranch direct calves (n = 288), while cattle in year 2 were from a Nebraska sale barn (n = 288). In each year, all cattle were purchased in October. After being limit fed for five consecutive days, weights were collected on two consecutive days. The cattle were then assigned randomly into either a sorted (n = 144) or unsorted group (n = 144) on day 0. The average BW of the sorted and unsorted group was similar. In the unsorted group, cattle were assigned randomly into one of three groups: calf-feds, summer yearlings and fall yearlings, but were never sorted based on BW. The sorted group was sorted based on BW after the five-day limit-feeding period. The heaviest third of the sorted group was placed into the calf-fed production system to minimize overweight carcasses at slaughter. The remaining two-thirds of the sorted group were placed on cornstalks to graze over the winter. In the spring, the sorted group was then sorted based on BW after grazing cornstalks. Of the remaining two-thirds of the sorted group, the heaviest half were fed as summer yearlings during the summer, and the lightest half grazed native range and were fed as fall yearlings to decrease the number of overweight carcasses (Figure 1).

When cattle from each production system (calf-fed, summer yearling and fall yearling) were in the feedlot, there were eight steers/pen and six replications (pens) as sorted and unsorted. This configuration was repeated both years. The experimental design was a 2 x 3 factorial with pen being the experimental unit. The factors were sorted, unsorted and three different feeding time periods (calf-fed, summer yearlings and fall yearlings).

Economics

The profitability of these three production systems was examined under three scenarios: live vs. grid pricing, time of year the cattle were finished and sorted vs. unsorted. The sorted calf-feds were calculated to a maximum breakeven purchase price by subtracting all costs from the final live price and dividing by the weight of the animal at receiving. Total costs included feed cost, yardage, death loss and animal interest, as shown in Table 1, to make comparisons relative

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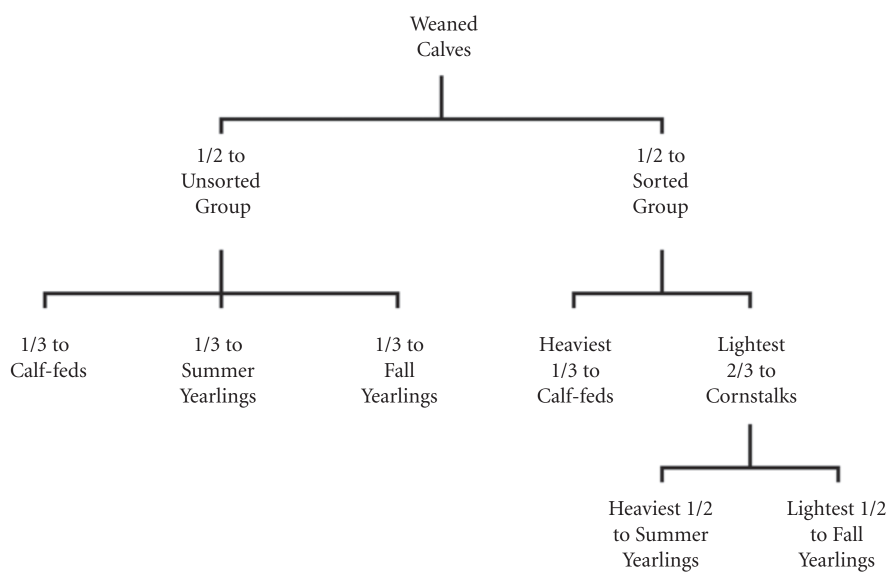
Table 1. Animal price in $/steer along with cost for different parts of the production system broken down by year then by sorted and unsorted for the different production systems (calf-feds, summer yearlings and fall yearlings).

	Year 1						Year 2					
	Sorted			Unsorted			Sorted			Unsorted		
	Calf[1]	Summer[2]	Fall[3]	Calf[1]	Summer[2]	Fall[3]	Calf[1]	Summer[2]	Fall[3]	Calf[1]	Summer[2]	Fall[3]
Initial price	733.68	652.52	593.66	662.10	659.63	634.36	659.15	609.83	592.42	614.10	614.95	615.53
Winter cost[4]		112.15	112.15	112.15	112.15	114.39	114.39	114.39	114.39			
Summer cost[5]		28.51	124.15	28.53	133.32	37.60	117.29	36.81	125.30			
Feed cost	318.46	303.96	280.51	309.97	301.62	297.62	325.24	295.91	291.43	310.07	292.02	314.51
Yardage[6]	66.8	53.20	46.40	66.80	53.20	46.40	78.40	58.00	52.80	78.40	58.00	52.80
Interest[7]	33.59	53.00	62.53	30.90	53.45	66.49	36.70	54.41	66.50	34.51	54.72	68.69
Total cost	1192.18	1239.94	1253.18	1108.00	1245.31	1324.81	1137.66	1205.75	1268.17	1074.34	1206.62	1325.32
Live value	1179.76	1267.63	1286.30	1138.71	1270.80	1367.48	1164.13	1246.01	1270.91	1127.59	1237.49	1327.14
Grid value	1230.37	1252.79	1289.37	1171.75	1236.63	1337.45	1170.12	1231.74	1287.97	1139.51	1209.56	1307.35
Live P/L[8]	-12.43	27.69	33.12	30.70	25.50	42.67	26.46	40.26	2.74	53.25	30.87	1.82
Grid P/L[8]	38.19	12.85	36.19	63.74	-8.681	2.64	32.46	26.00	19.80	65.17	2.94	-17.97

[1]Calf-fed system.
[2]Summer yearling system.
[3]Fall yearling system.
[4]For cornstalks, grazing yardage was charged at a rate of $0.20/head/day and rent (feed cost) was $0.12/head/day along with feed interest.
[5]For grass, grazing yardage was charged at $0.10/head/day along with grass cost and interest for grass.
[6]Yardage for feedlot was charged at $0.40/head/day.
[7]Animal interest for total time period the animal was owned.
[8]P/L = profit or loss.



The sorted group was sorted based on weight at the time of receiving for the cattle entering the feedlot as calf-feds.

The sorted group was sorted based on weight at the time of removal from cornstalk grazing.

Figure 1. Experiment design.

to the sorted calf-feds. The average 2007 dressed price was multiplied by 0.63 to determine the final live price for the cattle (Table 2). The initial feeder cattle price was figured for the sorted calf-feds first. Using the average weight and price of the sorted calf-feds, a feeder cattle price slide was calculated (Dhuyvetter, Extension agricultural economist, Kansas State University), assuming a corn price of $4/bu. The slide included the feeder cattle weight, corn price and predicted fed-cattle price. The price slide was then used to yield feeder cattle prices for different weights of feeder cattle.

The total costs for the finishing period for all three production systems were calculated similarly. Corn was priced at $4/bu, and wet distillers grains were priced at 80% the price of corn (DM basis). The summer yearlings and fall yearlings had additional costs for grazing corn stalks and grass. The costs for the wintering period and summer grazing, which are shown in Table 1, were added to the initial animal price to give the price of the animal entering the feedlot.

To calculate the grid price received, the average 2007 dressed price was used. A seven-year index was used to get the price for the month in which the cattle were marketed and adjusted based on the index. The index-adjusted price was then added to one, minus the percent Choice, multiplied by the Choice-select spread shown in Table 2, in order to calculate the price for yield grade 3 Choice carcasses. The grid base price for the three months in which the cattle were sold (January, May and October) was then averaged to get the final base grid price. Discounts were given for select grade carcasses along with yield grade 4 and 5 carcasses and any carcasses over 950 lb and 1000 lb. Premiums were awarded for upper 2/3 Choice or better and prime quality grades and yield grades 1 and 2 (Table 2).

Table 2. Dressed price/cwt adjusted for live price and a base grid price, along with premiums and discounts used to determine final grid value

Fed Cattle Prices	
2007 Ave. dressed price/cwt	$146.57
Adjusted live price/cwt	$92.34
Grid Base Price	
Final grid base price/cwt	$151.08
Premiums and Discounts/cwt	
Prime	$7.34
Upper 2/3 Choice	$2.07
Choice	$0.00
Select	$-10.01
YG 1	$2.87
YG 2	$1.38
YG 3	$0.00
YG 4	$-13.30
YG5	$-18.53
Over 950	$ -7.03
Over 1000	$-17.99

Results

Weight

There were interactions ($P < 0.01$) between sorting and system for initial BW and HCW (Table 3) by design. The calf-feds in the sorted group had greater initial BW compared to the unsorted calf-feds. There was no difference in initial BW between sorted and unsorted summer yearlings. The unsorted fall yearlings had higher initial BW compared to the sorted fall yearlings. The HCW follows the same pattern as the initial BW. The standard deviations for initial BW and HCW were lower for the sorted groups compared to the unsorted groups for all three systems (Table 3).

There also was a significant interaction for dry matter intake (DMI) ($P < 0.01$) and feed-to-gain ratio (F:G) ($P = 0.03$). The unsorted fall yearlings had the highest DMI. The sorted fall yearlings had the next highest DMI, which was higher than DMI for both the sorted and unsorted summer yearlings and calf-feds. There was no difference in DMI between the sorted and unsorted summer yearlings. However, the sorted and unsorted summer yearlings did have a higher DMI than their calf-fed counterparts. DMI was generally related to BW.

Table 3. Animal performance as simple effects of sorting (sorted and unsorted) and production system (calf-fed, summer yearlings and fall yearlings).

	Sorted			Unsorted			
	Calf-fed	Summer	Fall	Calf-fed	Summer	Fall	System*sort[1]
Initial BW lb	648^{d}	794^{c}	869^{b}	576^{e}	789^{c}	928^{a}	< 0.01
I BW SD lb[2]	48	34	53	587	395		
ADG lb/day	3.55	4.08	4.15	3.59	4.10	4.28	0.80
DMI lb	20.9^{d}	25.3^{c}	27.10^{b}	20.1^{d}	25.1^{c}	29.0^{a}	< 0.01
F:G	5.91^{c}	6.27^{b}	6.57^{a}	5.59^{d}	6.18^{b}	6.81^{a}	< 0.01
HCW lb	811^{d}	858^{c}	873^{b}	774^{e}	856^{c}	919^{a}	< 0.01
HCW SD lb[3]	58	41	62	67	67	88	
Fat in.	0.55	0.57	0.47	0.52	0.53	0.50	0.33
Marbling[4]	572	516	565	566^{e}	+12		
% > 950 lb	3.27^{c}	2.08^{c}	6.40^{bc}	1.04^{c}	10.42^{b}	35.42^{a}	< 0.01
% > 1000 lb	1.19^{fb}	0.00^{b}	1.04^{b}	0.00^{b}	2.08^{b}	17.71^{a}	< 0.01

[1]*P*-value for sorting by production system interaction.
[2]Initial body weight standard deviation.
[3]HCW standard deviation.
[4] USDA called marbling with 400 = Slight^{oo}; 500 = Small^{00}; etc.
[a,b,c,d,e]Means within a row with different superscripts are statistically different.

The unsorted calf-feds had the lowest F:G followed by the sorted calf-feds (Table 3). There was no difference in F:G between the sorted and unsorted summer yearlings, which had a lower F:G than the fall yearlings. Within the fall yearlings system, there was no F:G difference between the sorted and unsorted groups. Many have the perception that heavier calf-feds are the "best doers" and lighter calf-feds are the "poor doers." However, in this study the lightest cattle that entered the feedlot had the lowest F:G (Table 3). There was no interaction for average daily gain (ADG) ($P = 0.80$). Gains were affected by system, with calf-feds having the lowest ADG; however, there was not a difference in ADG between summer and fall yearlings.

There was not a significant sorting by feeding period interaction for fat thickness ($P = 0.32$) and USDA called marbling scores ($P = 0.09$) (Table 3). However, there was a difference due

(Continued on next page)

to the production system ($P < 0.01$) in which the cattle were finished. Fat thickness was not different for calf-feds and summer yearlings. Fall yearlings had less fat thickness compared to the calf-feds and summer yearlings. The summer yearlings had the lowest marbling score, and there was no difference in marbling between the calf-feds and fall yearlings. There was an interaction for the percent of carcasses that had a HCW of 950 lb or higher and 1000 lb or higher ($P < 0.01$). The unsorted fall yearlings had the highest percentage of carcasses over 950 lb, with 35.4%. Of the unsorted summer yearlings, 10.42% had overweight carcasses, followed by 6.4% of the sorted fall yearlings. In each of the remaining three groups, approximately 2% had HCW over 950 lb. The unsorted fall yearlings had the highest percentage of carcasses over 1000 lb (17.71%), which was greater than all other groups.

Pasture gain for summer and fall yearlings in year 2 was poor compared to gain in year 1. The cattle for year 1 had an average BW of 711 lb going onto grass and entered the feedlot weighing 976 lb. Year 2 cattle averaged 724 lb going onto grass and entered the feedlot at 825 lb.

The overall summary from the performance analysis was that the sorted calf-feds had a higher initial feedlot BW compared to the unsorted calf-feds. The unsorted fall yearlings had a higher initial feedlot BW compared to the sorted fall yearlings. The unsorted calf-feds, the lightest cattle to enter the feedlot, were the most efficient. The amount of initial BW and HCW variation was decreased for the sorted groups compared to the unsorted groups. Decreasing the variation of HCW did not affect fat thickness or quality grade. This led to fewer overweight carcasses for the sorted fall yearlings when compared to the unsorted fall yearlings.

Economics

Weights used for the feeder calf prices were 450 lb, 550 lb, 650 lb and 750 lb, with prices of $122.39/cwt, $112.06/cwt, $107.26/cwt and $103.25/cwt, respectively, based on the feeder cattle price slide. The prices of the diets were $0.0887/lb for year 1 and $0.0819/lb for year 2, because of different diets between years. The summer yearlings had the highest live profit ($31.08/steer) on average. The calf-feds were next with an average value of $24.50/steer. The fall yearlings were least profitable of the three groups on average, with a live value of $20.09/steer. The calf-feds had a grid profit of $49.89/steer. The fall yearlings' profit was $12.67/steer, and the summer yearlings' profit was $8.28/steer on average.

The fall yearlings were the least profitable on a live basis, due to this group having the highest production costs of all three groups. The fall yearlings were heaviest, but that did not make them more profitable, due to the extra weight that had to be gained in the feedlot in the second year of the study instead of gaining the weight on grass. In the first year, fall yearlings gained 1.78lb/day on grass compared to 0.66lb/day for year two with 149 days and 152 days on grass, respectively.

On the grid basis, the calf-feds had the highest profit, followed by the fall yearlings. The calf-feds and fall yearlings graded well compared to the summer yearlings. The summer yearlings were least profitable because the percent choice was lowest at 59.4% choice.

The marketing method (i.e., live or grid) used had a large impact on profit or loss. The sorted calf-feds had the largest change in profits of $28.31/steer going from a live to grid basis, with unsorted calf-feds increasing $22.48/steer. The summer yearlings were not profitable going from the live to grid values. The sorted summer yearlings had a smaller decrease in profit ($-14.55/steer) than the unsorted summer yearlings ($-31.06/steer). The summer yearlings decreased in profit primarily because the cattle did not grade USDA Choice. The sorted fall yearlings increased profit by $10.07/steer on the grid compared to live value. However, the unsorted fall yearlings, when going from the live to grid values, lost $24.91/steer, due to the amount of overweight carcasses in the unsorted group. The sorted cattle always had a higher profit when going from a live value to a grid value.

Over all feeding periods, the unsorted cattle had a higher profit on a live basis compared to the sorted cattle, at $30.80/steer and $19.64/steer, respectively, because the unsorted calf-feds were more efficient and ate less than the sorted calf-feds. This greater efficiency decreased the production cost for the unsorted group. On the grid basis, the sorted cattle were better at $27.58/steer compared to the unsorted cattle at $19.64/steer, due to the discounts for overweight carcasses in the unsorted group.

This analysis would indicate sorting cattle for a production system did not increase profit when cattle were marketed live. However, assuming all cattle were sold on a grid, then sorting increased profits. There also are arguments suggesting that cattle be sold on a grid in order to avoid the discounts associated with marketing cattle on a live basis. Discounts may be applied to cattle sold on a live basis because the cattle buyer cannot be certain of the quality of the cattle purchased. The assumption in this paper, however, is that all cattle sold live are given the average price.

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Feeding Distillers Grains and *E. coli* O157:H7

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Rodney A. Moxley1

Summary

The diet of feedlot cattle may affect the bacterial population in the hindgut, including E. coli *O157:H7. Some research studies have shown a relationship between feeding of distillers grains and* E. coli *O157:H7 shedding. However, other studies do not show the same relationship. Our evaluation of research indicates feeding distillers grains is not related to 2007 ground beef recalls. Furthermore, interventions such as vaccination are more important than identifying various feedstuffs that may influence shedding.*

Introduction

There were only eight recalls due to *E. coli* O157:H7 in ground beef in 2006, and all of them were initiated because of company sampling. However, in 2007, there were 20 recalls, nine of which resulted from illness investigation. Health officials looked for reasons why *E. coli* O157:H7 seemed to be a greater problem in 2007 compared to the previous four years. Because the ethanol industry grew in 2007 and feeding ethanol byproducts increased, some theorized feeding ethanol byproducts was the cause of the *E. coli* O157:H7 recalls. Late in 2007, research (Jacob et al., 2008, *Applied and Environmental Microbiology 74*:38) showing a relationship between distillers grains (DG) feeding and *E. coli* O157:H7 shedding was reported.

Discussion

Subsequent studies of the relationship between feeding distillers grains and *E. coli* O157:H7 shedding indicate that some researchers have found a correlation between the two, while others have not.

Jacob et al. (2008, *Journal of Animal Science, 86*:1182) reported a study using 370 feedlot cattle sampled at 122 and 136 days on feed. Overall prevalence of *E. coli* O157:H7 was fairly low (under 10%). On day 122, cattle were statistically more likely to shed *E. coli* O157:H7 when fed 25% DG in the diet. On day 136, feeding DG had no effect on shedding. Jacob et al. (2008, *Applied and Environmental Microbiology 74*:38-43) sampled cattle for 12 weeks during the feeding period. Fecal samples were collected from the pen floor. Feeding DG significantly increased *E. coli* O157:H7 shedding, although no difference was reported in five of the 12 sampling periods.

Jacob et al. (*Zoonoses and Public Health 55*:125) conducted a challenge experiment in which calves were inoculated with nalidixic acid-resistant *E. coli* O157:H7, allowing researchers to estimate the number of *E. coli* O157:H7 shed. Fecal samples were collected for 42 days. *E. coli* O157:H7 shedding was not different for calves fed DG during the first five weeks, but was statistically greater during the last week of sampling. Based on these three studies, researchers concluded that DG feeding increased *E. coli* O157:H7 shedding. In each of the three experiments there were sampling times when DG statistically increased shedding; however, as with most results in *E. coli* O157:H7 research, the results were somewhat inconsistent, making interpretation of the results difficult.

Recently, Jacob et al. (*Journal of Animal Science 86*, E Suppl:26) reported results of an experiment using 700 cattle fed for 150 days — half were fed DG. Pen floor samples were collected weekly or every two weeks; a total of 3,560 samples were collected and analyzed. Overall prevalence of *E. coli* O157:H7 was fairly low (5.1%). Although prevalence of *E. coli* O157:H7 in pen floor fecal samples was numerically higher in cattle fed DG in some sampling weeks, there was no significant effect of DG ($P = 0.2$).

All the previous studies were conducted with steam-flaked corn (SFC) diets with or without 25% (DM basis) DG. This may be important as we compare other research projects and results. Corrigan et al. (2007 *Nebraska Beef Report*, pp. 33-35) reported DG does not respond the same in SFC diets compared to dry-rolled corn (DRC) or high moisture corn diets (HMC). If cattle gains and efficiencies respond differently to DG levels in SFC and DRC or HMC diets, then it is possible any effects on *E. coli* O157:H7 vary as well. Our *E. coli* O157:H7 research is with DRC or HMC only.

It is logical that the diet fed to cattle could influence the growth of *E. coli* O157:H7 in the hindgut, since research has shown the primary reservoir of *E. coli* O157:H7 is the hindgut and *E. coli* O157:H7 attach to the intestinal wall of the hindgut. Interestingly, *E. coli* O157:H7 have no effect on cattle performance. There are two opposing theories on how the diet affects *E. coli* O157:H7 in the hindgut. The first theory is that starch escaping digestion in the rumen and small intestine is fermented in the hindgut, producing volatile fatty acids and lowering pH, thus inhibiting growth of *E. coli* O157:H7. Fox et al. (2007, *Journal of Animal Science* 85:1207-1212) showed support for this theory; steam flaking corn reduced starch in the hindgut and increased *E. coli* O157:H7 shedding. However, Depenbusch et al. (2008, *Journal of Animal Science 86*:632-639) said "*E. coli* O157:H7 was not related to fecal pH or starch." We reanalyzed the data of Peterson et al. (*2007, Journal of Food Protection 70*:287-291) showing that diets with decreasing amounts of corn decreased the amount of starch

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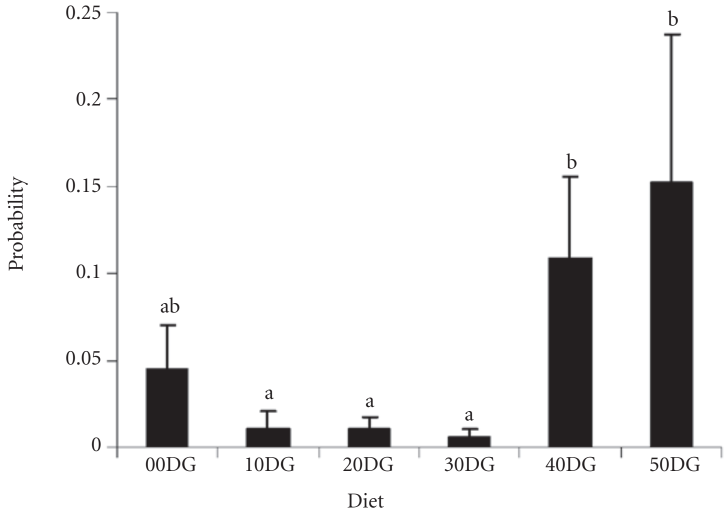

Figure 1. Effect of level of WDGS on *E. coli* O157:H7 colonization by cattle. Adapted from Peterson et al. (*2007 Journal of Food Protection*, 70:2568). 00DG = corn control diet with no WDGS; 10DG = 10% WDGS; 20DG = 20% WDGS; 30DG = 30% WDGS; 40DG = 40% WDGS; 50DG = 50% WDGS. [a,b,c] Treatment means with unlike letters differ.

in the diet. Amount of starch in the diet was not related to *E. coli* O157:H7 shedding (P = .22).

The opposing theory is starch in the hindgut is the substrate for *E. coli* O157:H7, so by reducing the amount of starch getting to the hindgut, *E. coli* O157:H7 would be reduced. Reports of Peterson et al. (2007, *Journal of Food Protection 70*:287-291) and Folmer et al. *(2003, Nebraska Beef Report*, pp. 22-23) did not support this theory. While it is logical that diet affects *E. coli* O157:H7 growth in the hindgut, clearly neither of the two opposing "starch theories" has been "proven."

Peterson et al. (2007, *Journal of Food Protection 70*:2568-2577) focused on vaccination as an *E. coli* O157:H7 intervention. Because the study was superimposed on a nutrition study, we reanalyzed the data (Figure 1). Wet DG were fed as 0%, 10%, 20%, 30%, 40% and 50% of diet dry matter replacing DRC and HMC. In this experiment, samples of the hindgut mucosa, as well as fecal samples, were analyzed. Results were similar but more consistent for the mucosal samples (Figure 1). There was a significant effect of level of DG on *E. coli* O157:H7 shedding; however, it was not a linear relationship. None of the levels of DG feeding were statistically different from the control (ODG). The 10%, 20% and 30% DG levels numerically decreased the shedding of *E. coli* O157:H7. Interestingly, this is within the range of feeding (25%) discussed previously with SFC. Our research is with DRC and HMC while the previous research was with SFC, which may make a difference.

At the 40% and 50% DG feeding level, *E. coli* O157:H7 shedding numerically increased compared to the control. Note that the statistical difference is between the 10%, 20% and 30% DG levels and the 40% and 50% levels. So does DG decrease or increase *E. coli* O157:H7 shedding?

Peterson et al. (2007, *Journal of Food Protection* 70:2568-2577) were studying vaccination. The pattern of *E. coli* O157:H7 in hindgut mucosa

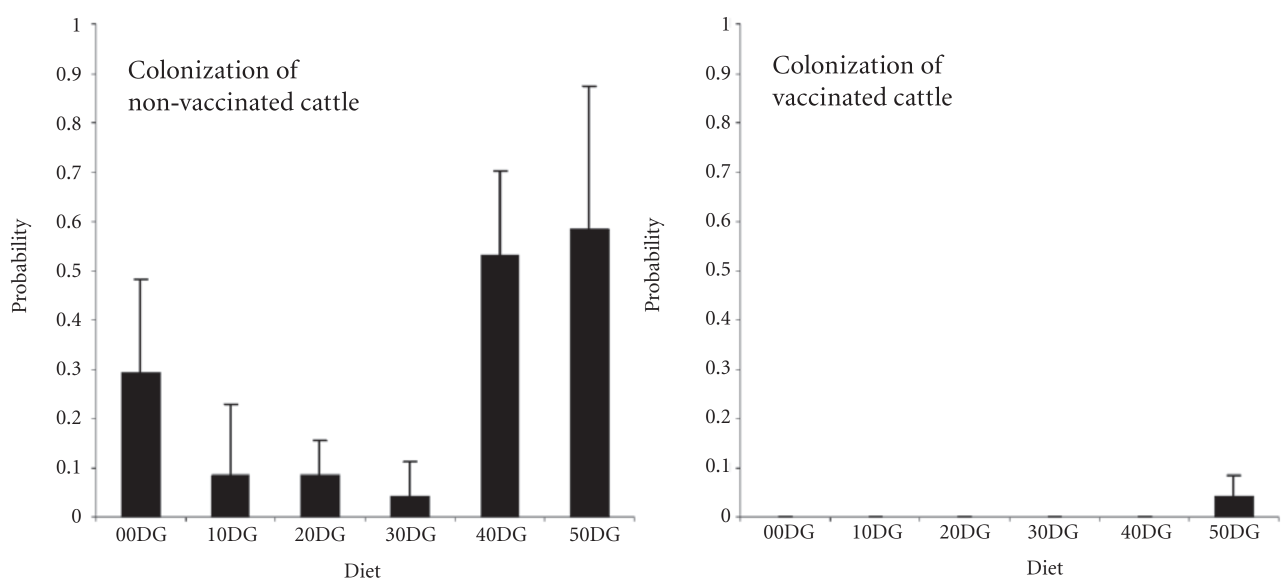

Figure 2. Effect of level of WDGS on *E. coli* O157:H7 colonization of unvaccinated or vaccinated against *E. coli* O157:H7. Adapted from Peterson et al. (2007 *Journal of Food Protection, 70*:2568-2577). 00DG = corn control diet with no WDGS; 10DG = 10% WDGS; 20DG = 20% WDGS; 30DG = 30% WDGS; 40DG = 40% WDGS; 50DG = 50% WDGS.

for unvaccinated cattle was similar to that discussed previously (Figure 2). However, only one steer among the vaccinated cattle tested positive, and that was at the 50% DG feeding level. In four studies involving 1,784 cattle, vaccination has reduced *E. coli* O157:H7 shedding by 65%. This is equivalent to the effect of winter versus summer on shedding. Feeding a direct-fed microbial (Peterson et al., 2007, *Journal of Food Protection 70*:287-291) reduced shedding over two years by 35%. These two interventions plus others being researched have considerable merit.

Conclusions

It is reasonable to think that what we feed cattle might affect the bacterial population of the hindgut.

Research suggests that under some feeding levels and some other yet-to-be-determined conditions, DG may increase *E. coli* O157:H7 shedding.

Results of *E. coli* O157:H7 research in general and specifically with DG feeding are inconsistent. To date, no consistent effect of DG feeding on *E. coli* O157:H7 shedding has been shown.

Response in *E. coli* shedding to DG feeding may be affected by DG level and other dietary ingredients such as the corn type.

Interventions and research on interventions are important.

At this point, there is contradictory evidence that feeding DG, at least at levels being used commercially, increases *E. coli* O157:H7 shedding. Additionally, there is no scientific evidence to suggest that the feeding of DG is the cause of the 2007 recalls.

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An Economic Overview of Ethanol Co-Product Utilization in Nebraska

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Summary

To better understand co-product utilization, inclusion rates, pricing and storage strategies, Nebraska cattle producers were surveyed regarding their co-product feeding and pricing practices. Although nearly 91% of cattle on feed in Nebraska were being fed ethanol co-products in 2007, many types of co-products were being utilized from both ethanol plants in Nebraska and surrounding states. As illustrated by the price data collected, especially those for wet distillers grains plus solubles, opportunities existed for pricing and storage strategies, although more price variation was present in the data collected from the survey as compared to the prices reported by the Agricultural Marketing Service.

Introduction

The variability in co-product prices over time and across markets suggests changing fundamental supply and demand factors are influencing prices. USDA Agricultural Marketing Service (AMS) reports daily average cash prices and a range of prices across multiple plants. Prices paid for co-products by individual cattle producers may vary substantially from these averages depending upon quantities purchased, contract pricing and other factors. One objective of this study was to collect price data from producers and compare the data to AMS prices based on ethanol plant reported prices. Another objective was to collect data on ethanol co-product pricing and storage strategies, co-product inclusion levels in feedlot rations and the percentage of operations utilizing co-products, as well as several other ethanol co-product issues relevant to Nebraska cattle feeders.

Procedure

In February 2008, 1,370 Nebraska cattle feeders and ranchers were surveyed to solicit information about their co-product use and views on feeding and contracting co-products. In addition to distributing surveys to attendees of the 2008 UNL Beef Feedlot Roundtable meetings (n = 87), surveys also were mailed to individuals on the mailing list for the UNL Beef Feedlot Roundtable meetings (n = 399) and the Nebraska Cattlemen Farmer/Stockman and Feedlot Councils (n = 886). Operations listed in the cattle feeder list published by the Ag Promotion and Development Division of the Nebraska Department of Agriculture (n = 36; revised October 2003) and the 2008 Beef Spotter (n = 15) that were not included in the Feedlot Roundtable mailing list also were mailed surveys. Lists were cross-referenced, so the response rate could be calculated using the number of unique individuals surveyed.

Several issues were addressed in the survey, including a general description of the operation, the operation's use of ethanol co-products in feedlot rations, cattle performance in response to feeding co-products and co-product storage and pricing strategies. Individuals also were asked to complete a co-product information sheet for each type of co-product purchased in 2007. If the co-product was purchased from more than one plant, a separate information sheet was completed for each plant. The co-product information sheet included the type, amount and price of the co-product purchased, as well as the location of co-product origination and producer satisfaction regarding several co-product characteristics (e.g., co-product consistency, guaranteed nutrient analysis). All data collected from the survey are for 2007 purchases and feeding use.

Results

From the 1,370 surveys distributed to Nebraska cattle feeders and ranchers, 251 surveys were returned, yielding an 18.3% survey response rate. In order to have an understanding of the type of operations surveyed, general information was collected regarding feedlot size and composition. Of the respondents, the average one-time capacity and current number of cattle on feed were 5,760 head and 4,764 head, respectively (includes feedlots fewer than 100 head to more than 100,000 head). Of the total number of cattle on feed, 49.8% were owned by the feedlots, while 50.2% of cattle on feed were custom fed. Of the total number of cattle custom fed, 48.3% were owned by Nebraska investors, whereas 51.7% were owned by out-of-state investors.

While 59.4% of all cattle operations surveyed included ethanol co-products in feedlot rations, 87.0% of operations with a one-time capacity of more than 1,000 head reported utilizing co-products in rations. As a result, 91.2% of Nebraska cattle on feed represented in this survey were being fed co-products as a component of their ration in 2007. Operations reported purchasing wet distillers grains plus solubles (WDGS) most often for use in their feedlot rations, followed by modified wet distillers grains plus solubles (MWDGS), Sweet Bran® and wet corn gluten feed (WCGF). Furthermore, according to survey results, approximately 11.9% of total ethanol co-products utilized in Nebraska feedlot rations in 2007 were imported from surrounding states, with 82.6% of the co-product being imported from Iowa, followed by Missouri, South Dakota, Kansas, Colorado and Wyoming.

Information regarding cattle performance also was obtained. Seventy-five percent of survey respondents reported that cattle performance (e.g., average daily gain [ADG], feed-to-gain ratio [F:G]) improved when cattle were fed rations containing ethanol co-products compared to rations without co-products. Only 1.9% stated that performance worsened, while 23.6% stated cattle had no change in ADG or F:G when fed ethanol co-products. In addition to cattle performance, respondents were asked to rank their level of agreement (strongly agree, agree, neutral, disagree or strongly disagree) with four statements regarding ethanol co-product characteristics (i.e., co-product consistency, guaranteed nutrient analysis, DM consistency). The statements and average survey responses are shown in Table 1.

Ethanol co-product pricing strategies also were surveyed, and most co-product was priced in 2007 using some sort of contract that was accompanied with a fixed price for the duration of the contract (Table 2). The largest proportion of respondents (54.3%) stated that their typical contract length was 12 months. Additionally, 43.4% of respondents stated they were required to take delivery of a minimum quantity of co-product each week. Of those who reported a minimum delivery requirement, the median minimum delivery was reported as 105.0 tons (approximately four to five semi-loads) per week. (The average minimum delivery requirement was 309.2 tons [approximately 12 semi-loads] per week although this average is relative to a non-normal distribution of data.) Furthermore, 38.4% of the co-product purchased was priced FOB plant while the remaining 61.6% was priced FOB feedlot. Survey responses that did not state whether the co-product was priced FOB plant or FOB feedlot were omitted from all price data analysis (Figures 1 and 2). All price data reported FOB feedlot were adjusted to FOB plant using an assumed mileage charge of $3.50 per loaded mile and an assumed 25 tons of co-product per load. Transportation costs then were calculated by multiplying the number of miles the feedlot is located from the ethanol plant (as reported by survey respondents) by the mileage charge and dividing by the assumed tons of co-product per load. The average calculated transportation cost was $9.70/ton.

Survey respondents also were asked to record the price paid for every type of ethanol co-product purchased each month of 2007. Figure 1 shows the average price paid (FOB plant) for WDGS, MWDGS and corn on a DM basis. On average, WDGS was priced

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Table 1. Producer satisfaction regarding ethanol co-product characteristics.

	% Strongly Agree	% Agree	% Neutral	% Disagree	% Strongly Disagree
The consistency of the product from load to load is satisfactory.	25.12	50.24	15.46	6.76	2.42
I am willing to purchase and use this product again.	39.13	51.21	7.73	0.97	0.97
This product has a guaranteed nutrient analysis.	18.41	42.79	28.86	5.97	3.98
This product has a consistent DM.	21.46	42.44	22.44	11.71	1.95

Table 2. Co-product pricing methods.

	Percent of Respondents[1]
Negotiated each month	5.71
According to the corn price	24.29
Contracted (price is fixed for entire contract)	76.19
Negotiated each load (no contract)	6.67
Other	0.48

[1]Percentages will not total 100 due to the ability of respondents to select multiple answers.

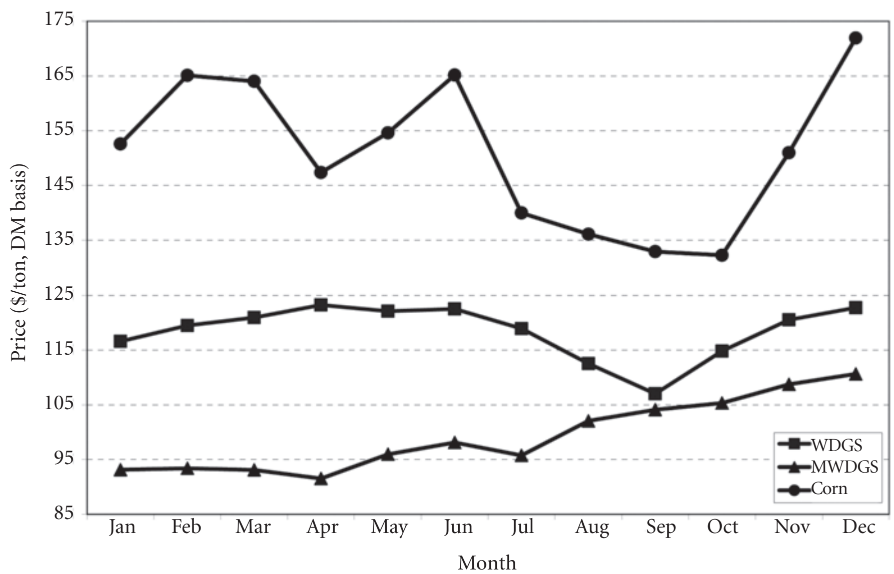

Figure 1. Average WDGS and MWDGS prices paid by producers, FOB plant, and ethanol plant average corn price, dry matter basis, Nebraska, 2007. Corn price from LMIC and USDA AMS (Nebraska Ethanol Plant Report).

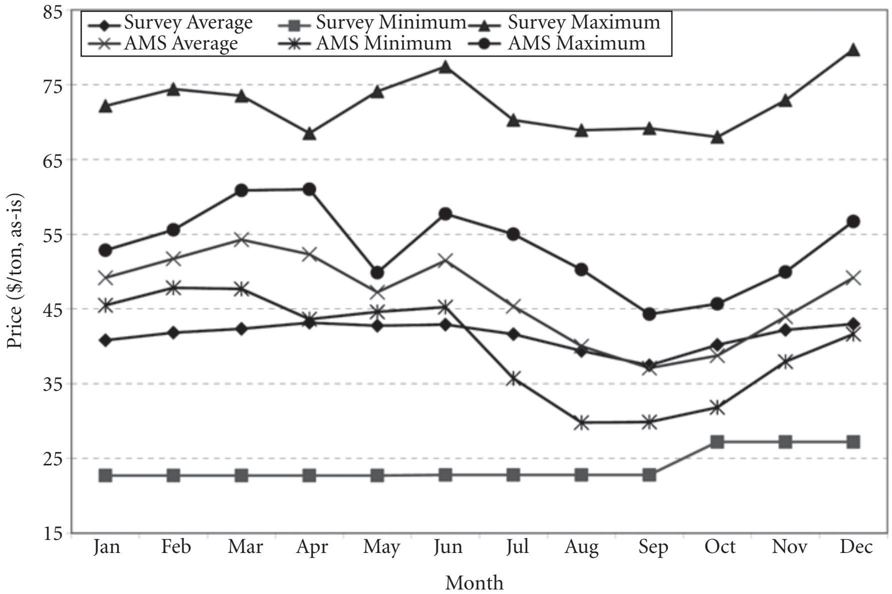

Figure 2. WDGS prices paid by Nebraska producers and reported by AMS, as-is basis, FOB plant, 2007.

(FOB plant) at 78.8% the price of corn, while MWDGS was priced (FOB plant) at 66.3% the price of corn on a DM basis. The large price differential between WDGS and MWDGS for the majority of 2007 may partially be due to the difference in WDGS demand relative to MWDGS during that time period, as only a few Nebraska ethanol plants were marketing MWDGS in 2007. Additionally, the lack of understanding regarding the moisture content of the two co-products may be driving producers to pay more for WDGS than MWDGS on a DM basis. Although MWDGS price tended to increase steadily throughout 2007, WDGS showed a seasonal price trend with lower prices in the summer (and the opportunity for co-product storage). The seasonal low in WDGS price during the late summer months supports the seasonal price trend that has been illustrated by WDGS prices reported by USDA AMS (Figure 2). Although the average survey price is slightly lower compared to that reported by AMS, the minimum and maximum survey prices are nearly $20/ton (as-is) different from the AMS minimum and maximum prices. Prices reported by AMS are multiple plant averages, so some variability in co-product price may be masked as producers are purchasing or contracting co-product above and below the price data reported by AMS. Because of this, it is important for producers to contact ethanol plants or co-product merchandisers when forecasting or estimating co-product prices.

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Using Wet Corn Gluten Feed to Adapt Cattle to Finishing Diets

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Summary

A feedlot trial was conducted to determine if wet corn gluten feed (WCGF) instead of forage could be used to adapt cattle to finishing rations and if this is economically feasible. Treatments were applied only during grain adaptation (26 days), and all steers were finished on a common diet (147 days) containing 35% WCGF. Steers adapted using WCGF had greater ADG and lower F:G. Treatment had no effect on carcass quality. Profits were higher for steers adapted to finishing diets using WCGF rather than those adapted with alfalfa hay.

Introduction

As byproduct availability increases and forage and corn prices continue to vary, feed costs may be reduced by using WCGF in place of forages during the initial adaptation phase. A metabolism trial found greater dry matter intake (DMI) and increased digestibility utilizing wet corn gluten feed (WCGF; Sweet Bran®, Cargill) during grain adaptation when compared to a traditional adaptation using forage *(2009 Nebraska Beef Report,* pp. 56-58).

Objectives of the current study were to determine if adapting cattle to finishing rations using WCGF instead of forage affects 1) performance during the entire finishing period, and 2) feeding profits with different corn and alfalfa hay price scenarios.

Procedure

Animals and Treatments

English x Continental steer calves (n = 240; initial BW = 602 ± 32 lb) were blocked by BW and assigned randomly to one of 12 pens (20 steers/pen). All steers were adapted to the same finishing diet using two different adaptation schemes. Within each scheme, four grain adaptation diets were fed for 5, 7, 7 and 7 days. After adaptation, steers were fed a common finishing diet until slaughter (173 total days; Table 1). Each pen (six pens/treatment) was assigned to one of two grain adaptation treatments. The control treatment (CON) contained 35% Sweet Bran, 15% corn silage and 5% supplement fixed in the diet, with alfalfa hay (AH) decreasing from 37.5% to 0% while a 1:1 ratio of dry-rolled corn (DRC) and high moisture corn (HMC) increased from 7.5% to 45% of the diet (DM basis) for days 1 through 26. The WCGF treatment contained corn silage and supplement at 15% and 5% of the diet, respectively, with Sweet Bran decreasing from 80% to 35% while a 1:1 ratio of DRC and HMC increased from 0% to 45% of the diet (DM basis) for days 1 through 26. A common finishing diet was fed in both treatments from day 27 to finish (173 days).

Prior to trial initiation, steers were limit fed a 1:1 ratio of WCGF and alfalfa hay at 2% of BW to minimize variation in gut fill. Weights were measured two consecutive days (days 0 and 1) to determine initial BW. Orts were collected and weighed when needed throughout the trial and dried in a forced-air oven at 60°C for 48 hours to calculate DMI and stored for further analysis. All steers were implanted with Synovex Choice® (Fort Dodge Animal Health) on days 1 and 85.

On day 174, steers were slaughtered at a commercial abattoir (Greater Omaha Pack, Omaha, Neb.). Hot carcass weights (HCW) and liver scores were collected on the day of slaughter. Following a 48-hour chill, USDA marbling score, 12th rib fat depth and LM area were recorded. A calculated USDA yield grade (YG) was derived from HCW, fat depth, LM area and an assumed 2.5% kidney, pelvic and heart fat (KPH). Carcass adjusted performance was calculated using a common dressing percentage of 63 to determine final BW, ADG and F:G.

Budget Analysis

All prices for trucking, processing, death loss, medical and vet charges, yardage and sale prices were held constant between treatments. Trucking was valued at $3.25 per loaded mile on a triple axel 55,000 lb weight-bearing trailer. Processing, medical and vet charges were valued at $15.00/head. Death loss costs (2%) were calculated using the initial steer value, and yardage was charged at $0.35/head/day. Interest on the feeder steer and feed cost was valued at 8.5%. Prices for purchased cattle were calculated as a breakeven from the CON steers at each grain price ($3.50, $4.50 and $5.50/bushel) and $120.00/ton alfalfa hay (as-fed basis). The 2007 average fed cattle price, $92.10/cwt (USDA AMS livestock market news), was used.

The total cost of the diet was analyzed by pen for DMI. Corn costs varied from $3.50/bu, $4.50/bu and $5.50/bu; mid-bloom alfalfa hay varied from $80.00/ton, $100.00/ton and $120.00/ton (as-fed basis). WCGF was priced at 95% of the price of corn. Processing costs for HMC and DRC were $4.27/ton and $1.43/ton, respectively, above the current price of corn (Macken et al., 2006, *Professional Animal Scientist*). Corn silage with 50% corn and 35% DM was priced at nine times the price of corn ($3.50, $4.50 or $5.50/bushel) and a $3.00 adjustment factor was added to that value (as-fed basis) then adjusted to a DM basis (Guyer and Duey, 1986, *NebGuide*).

The enterprise budget included actual carcass adjusted performance. Final live BW multiplied by $/cwt was used to calculate total profits per head and to calculate profit/loss (revenue

(Continued on next page)

Table 1. Dietary composition and days on feed of adaptation methods (DM basis).

Days on feed Adaptation	1-5 1	6-12 2	13-19 3	20-26 4	27-173 Finisher
CON[1]					
DRC	3.75	8.75	13.75	18.75	22.50
HMC	3.75	8.75	13.75	18.75	22.50
WCGF	35.00	35.00	35.00	35.00	35.00
Corn silage	15.00	15.00	15.00	15.00	15.00
Alfalfa hay	37.50	27.50	17.50	7.50	0.00
Dry supp.[2]	5.00	5.00	5.00	5.00	5.00
WCGF[1]					
DRC	0.00	5.625	11.25	16.875	22.50
HMC	0.00	5.625	11.25	16.875	22.50
WCGF	80.00	68.75	57.50	46.25	35.00
Corn silage	15.00	15.00	15.00	15.00	15.00
Dry supp.[2]	5.00	5.00	5.00	5.00	5.00

[1]Grain adaptation methods: CON = decreasing levels of forage and increasing levels of corn; WCGF = decreasing levels of Sweet Bran and increasing levels of grain (no forage used).
[2]Dry supplement formulated to provide 345 mg/head/day of monensin, 90 mg/head/day of tylosin, and 130 mg/head/day of thiamine.

Table 2. Feedlot performance when evaluating two adaptation methods.

	CON[1]	WCGF[1]	SEM	*P*-value
Performance				
Initial BW, lb	602	601	0.7	0.37
Final BW,[2]	1173	1199	8	<0.01
DMI, lb/day	20.8	20.8	0.3	0.95
ADG, lb	3.30	3.46	0.05	<0.01
F:G[3]	6.31	6.03		<0.01
Carcass Characteristics				
HCW, lb	739	755	5	0.01
Marbling score[4]	511	517	9	0.46
12th Rib fat, in	0.42	0.44	0.01	0.31
LM area, in^2	12.5	12.7	0.1	0.13
Calculated YG[5]	2.88	2.92	0.05	0.52

[1]Grain adaptation methods: CON = decreasing levels of forage and increasing levels of corn: WCGF = decreasing levels of Sweet Bran and increasing levels of grain (no forage used).
[2]Calculated from hot carcass weight, adjusted to a 63% yield.
[3]Calculated from total gain over total DMI, which is reciprocal of F:G.
[4]500 = Small^0.
[5]Where yield grade = 2.5 + 2.5(Fat depth, in) - 0.32(LM area, in^2) + 0.2(KPH fat, %) + 0.0038 (HCW, lb).

Table 3. Economic analysis of grain adaptation with varying prices of alfalfa hay.

	$4.50 X $80.00[1]		$4.50 X $100.00		$4.50 X $120.00		*P*-value[2]
	CON[1]	WCGF[1]	CON[1]	WCGF[1]	CON[1]	WCGF[1]	
Initial Price, $/cwt	105.60	105.60	105.60	105.60	105.60	105.60	
Feed costs, $	307.69	310.84	308.62	310.84	309.55	310.84	0.33
Total costs, $	445.03	448.72	445.99	448.72	446.95	448.72	0.24
Revenue, $/hd	1080.33	1104.28	1080.33	1104.28	1080.33	1104.28	
Cost of gain, $/cwt	76.80	74.11	77.03	74.11	77.26	74.11	<0.01
P/L[4], $/hd	-0.41	20.91	-1.37	20.91	-2.33	20.91	<0.01

[1] Ration combinations with varying alfalfa hay price expressed as DRC price/bushel by alfalfa hay price/ton (DM basis).
[2] No interactions between treatment and alfalfa price (*P* > 0.94). Treatment simple effects presented with *P*-value of main effects noted.
[3]Grain adaptation methods: CON = decreasing levels of forage and increasing levels of corn; WCGF = decreasing levels of Sweet Bran and increasing levels of grain (no forage used).
[4] P/L is profit or loss.

minus total costs) per head. Total feed costs, feed interest and total gain were used to calculate cost of gain (COG).

Results

Cattle Performance

Performance and carcass characteristics are presented in Table 2. By design, initial BW was not different between grain adaptation methods ($P = 0.37$). Final BW at slaughter was greater for steers adapted using WCGF compared to CON fed steers (1,199 vs. 1,173; $P < 0.01$). Intakes did not differ between treatments ($P = 0.95$), but steers adapted with WCGF had greater ADG ($P < 0.01$) and consequently lower F:G ($P < 0.01$). The positive gain response with the WCGF adaptation was likely due to increased diet digestibility (*2009 Nebraska Beef Report,* pp. 56-58) or possibly was caused by a higher energy content in the WCGF adaptation. The only carcass characteristic difference was that HCW was greater ($P = 0.01$) for WCGF adapted steers. USDA marbling score was similar ($P = 0.46$), as well as fat thickness ($P = 0.31$), indicating steers were finished to similar endpoints. Additionally, no differences were observed in LM area ($P = 0.13$) or calculated YG ($P = 0.52$). The increased ADG and decreased F:G for steers adapted with WCGF were due to the 26-day adaptation period, as the diet fed was the same beyond this point.

Budget Analysis

Analysis of varying corn prices of $3.50, $4.50 and $5.50/bushel were compared to varying alfalfa prices of $80.00, $100.00 and $120.00/ton, totaling nine scenarios for each treatment (adjusted to a DM basis). Table 3 shows the budget results when alfalfa hay (AH) prices vary with corn priced at $4.50/bu. No treatment by AH price interaction was observed ($P > 0.94$). Initial steer price ($105.60/cwt) remained constant between treatments, but feed cost and total costs were not statistically different between treatments ($P > 0.24$). Revenue received was greater for WCGF steers compared to the CON steers ($1104.28 vs. $1080.33) due to additional weight at slaughter. Cost of gain increased ($P < 0.01$) for CON steers ($76.80, $77.03, $77.26/cwt) as AH price increased from $80.00 to $100.00 to $120.00/ton. Cost of gain for WCGF steers ($74.11/cwt) remained constant because AH was not included in the grain adaptation diet. Since initial steer price was set to breakeven for CON cattle, profit and loss (P/L) expressed the absolute differences between treatments. WCGF steers were more profitable ($P < 0.01$) than CON steers by $21.32, $22.28 or $23.24 as AH price increased from $80.00, $100.00 or $120.00/ton, respectively.

When DRC was fixed at $3.50/bushel and AH price varied from $80.00 to $100.00 to $120.00/ton, initial price for steers was $116.10/cwt (data not shown). Feed costs were $246.92, $247.87 and $248.81/head, respectively, for CON steers, while WCGF costs were constant ($248.56/head) as AH price increased. Cost of gain was $58.08/cwt for WCGF steers and was $60.42, $60.65 and $60.89/cwt, respectively, for CON cattle as AH price increased from $80.00 to $100.00 to $120.00/ton. Steers fed WCGF were $24.75/head more profitable than CON steers.

When DRC was fixed at $5.50/bushel and AH price varied from $80.00 to $100.00 to $120.00/ton, initial price for steers was $95.20/cwt (data not shown). Feed costs were $376.11, $377.06 and $378.00/head, respectively, for CON steers, while WCGF costs were constant ($380.88/head) as AH price increased. Cost of gain was $89.00/cwt for WCGF steers and $92.04, $92.27 and $92.50/cwt, respectively, for CON cattle as AH price increased from $80.00 to $100.00 to $120.00/ton. Steers fed WCGF were $21.26/head more profitable than CON steers.

The WCGF adapted steers had higher final BW, equal DMI, increased ADG and decreased F:G. Ration costs were greater for WCGF steers, but the steers were more profitable and had lower COG in each scenario. Utilizing WCGF instead of forage increased gain, making this method more economically favorable for starting cattle on feed than conventional feedlot adaptation (CON) methods currently used in industry. Another benefit for the feedlot industry is that this adaptation system could reduce roughage needs by 50%.

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The Effects on Ruminal pH, Feed Intake and Digestibility When Using Wet Corn Gluten Feed to Adapt Cattle to Finishing Diets

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Summary

A 33-day grain adaptation trial was conducted comparing wet corn gluten feed (WCGF; Sweet Bran®, Cargill) fed at decreasing levels (87.5% to 35%) to a traditional grain adaptation with decreasing forage (45% to 7.5%; CON) to test the effects on ruminal pH, dry matter intake (DMI) and in situ *DM digestibility. Steers adapted by decreasing WCGF had greater DMI than CON (P < 0.01). During adaptation, DMI increased and ruminal pH decreased across both treatments. Steers adapted using WCGF had greater* in situ *DM digestion than steers adapted using CON. Diets containing WCGF had greater DM digestibility than diets containing forage, whether incubated in either CON or WCGF fed steers. Decreasing WCGF inclusion instead of forage is a viable method for adapting feedlot cattle to high-concentrate diets.*

Introduction

Wet corn gluten feed (WCGF; Sweet Bran, Cargill) is a low starch, high energy feed that has much greater energy than alfalfa hay (70 vs. 24 NE_g Mcal/cwt). Furthermore, feeding WCGF as a substitute for roughage during grain adaptation may reduce the incidence of sub-acute and acute acidosis because the total starch of the diet is decreased. Therefore, the objectives of the current study were to 1) determine if decreasing the level of WCGF and increasing corn is a preferred method for grain adaptation determined by DMI and ruminal pH measurements when compared to a traditional adaptation diet using forage, and 2) evaluate digestibilities of diets within the adaptation period and between treatments.

Procedure

A metabolism trial was conducted using eight ruminally fistulated steers (641 ± 42 lb). Steers (four/treatment) were adapted to finishing diets across four adaptation diets followed by the finisher. The study consisted of five periods of 5, 7, 7, 7 and 7 days, with the last 7 days on finishing diet. Dietary treatments, grain adaptation and respective days are shown in Table 1. The CON adaptation contained 5% supplement and 5% molasses with levels of alfalfa hay decreasing from 45% to 7.5% and increasing corn levels (DM basis). The WCGF adaptation had supplement and alfalfa hay at 5% and 7.5% of the diet, respectively, with WCGF decreasing from 87.5% to 35%, while corn increased (DM basis). Steers were fed once daily at 0800 and feed refusals were collected and dried to calculate DMI. Continuous intakes were recorded (from load cells on suspended feed bunks) every six seconds and averaged each minute for the entire 33 days on experiment. Steers were placed in stanchions four days of each week where intake and pH were recorded. The four days correspond to the first and last two days of each adaptation diet when submersible pH probes were recording. Dacron bags (50 μm pore size) containing both the CON and WCGF adaptation diets for that period (eight/steer) were incubated 24 hours in each steer during each period to determine DM digestibility (DMD). Sweet Bran was freeze dried, while AH was ground (2.00 mm), and DRC was ground to simulate a masticate grind (6.35 mm). Supplement was replaced by DRC in the *in situ* bags. One steer (CON treatment) was removed due to acidosis after the third adaptation diet, but data were included through period 3.

All data were analyzed as a 2 x 5 factorial using the MIXED procedure of SAS (SAS Inst. Inc.). Day was a repeated measure for pH and intake data. The period x adaptation x day interaction could not be tested because the same days in each

Table 1. Dietary treatments used for evaluating two grain adaptation methods (DM basis).

Days fed	1-5	6-12	13-19	20-26	27-33
Adaptation	1	2	3	4	Finisher
CON[1]					
DRC[2]	45.0	55.0	65.0	75.0	82.5
Alfalfa hay	45.0	35.0	25.0	15.0	7.5
Molasses	5.0	5.0	5.0	5.0	5.0
Supp[4]	5.0	5.0	5.0	5.0	5.0
WCGF[1]					
DRC[2]	0.0	13.13	26.25	39.38	52.5
WCGF[3]	87.5	74.38	61.25	48.13	35.0
Alfalfa hay	7.5	7.5	7.5	7.5	7.5
Supp[4]	5.0	5.0	5.0	5.0	5.0

[1]Adaptation treatments where CON = decreasing forage and increasing corn as steers go through adaptation periods; WCGF = decreasing Sweet Bran and increasing corn as steers go through adaptation periods.
[2] DRC = dry-rolled corn.
[3] WCGF = wet corn gluten feed (Sweet Bran).
[4] Dry supplement formulated to provide 90 mg/head/day of tylosin and 300 mg/head/day monensin; WCGF treatment formulated to provide 150 mg/head/day of thiamine.

adaptation (adaptation 1) were not collected for pH or intake.

Results

No period x adaptation treatment interactions occurred ($P > 0.60$); therefore, main effects of adaptation treatment and period (adaptation diet) are presented. Table 2 expresses the main effects of adaptation treatment on intake and pH. Steers adapted using WCGF had greater ($P < 0.01$) DMI than those adapted with CON (21.78 vs. 16.14 lb.). WCGF steers consumed more meals per day ($P < 0.01$) and tended ($P = 0.07$) to spend more time eating than CON-fed steers. However, intake rate didn't differ across treatments ($P = 0.25$). Average ruminal pH, minimum pH and maximum pH were lower for WCGF steers ($P \leq 0.01$) compared to the CON. The magnitude of pH change was not different between the two adaptation treatments ($P = 0.29$). Ruminal pH variance was greater ($P < 0.05$) for WCGF cattle (0.077 vs. 0.057) compared to CON-fed steers. Time and area below pH 5.6 were increased ($P < 0.05$) for WCGF compared to CON adaptation systems. Time and area below pH 5.3 were not different between the two treatments ($P > 0.17$).

Day within each adaptation diet was evaluated (data not shown). Days 6 and 7 are the last two days on a lower grain adaptation, and day 1 and day 2 are the first two days on the next grain adaptation. These four days were pH collection days in the stanchions, whereas DMI was recorded all seven days. DMI increased ($P < 0.02$) with each day during each adaptation period but the number of meals/day did not differ. Total time spent feeding and intake rate decreased as steers progressed through adaptation ($P \leq 0.01$). The pH measurements were not significant by day ($P > 0.29$), indicating that concentrate transitions were not severe pH changing events for the rumen environment.

Intake and pH differences for the main effect of adaptation periods are presented in Table 3. Intake increased as steers were adapted to the finishing ration ($P = 0.01$) for both CON and WCGF, while meals/day, time spent eating and intake rate were not different ($P > 0.19$). Average ruminal pH, minimum pH and maximum pH decreased ($P < 0.05$) as cattle were adapted to finishing diets. Variance and magnitude of change did not change ($P > 0.81$). Time and area below a pH of 5.6 increased ($P < 0.04$) as steers were adapted to finishing ration, but no effects on time and area below a pH of 5.3 were observed ($P > 0.16$)

In situ DM digestibility (Table 4) had no treatment by incubation diet interactions ($P > 0.18$) for adaptation periods 1 and 2, such interactions were observed for periods 3 and 4 and the finishing period ($P < 0.01$). Steers adapted using WCGF had greater *in situ* DM digestion than steers adapted using CON. Diets containing WCGF were more digestible than diets containing forage whether inserted in either CON or WCGF fed steers. The ruminal environment during the first two periods produced the same digestibility when higher amounts of forage were being fed. As corn concentration increased (periods 3, 4 and

(Continued on next page)

Table 2. Effects of grain adaptation on intake and pH across trial.

	WCGF	CON	*P*-value
Intake			
DMI, lb/day	21.78	16.14	< 0.01
Meals/day	6.25	4.96	< 0.01
Total time, minute	467.00	412.00	0.07
Intake rate, %/hour	17.86	16.51	0.25
Ruminal pH			
Average pH	5.84	6.28	< 0.01
Maximum pH	6.50	6.84	0.01
Minimum pH	5.35	5.79	< 0.01
pH change	1.16	1.06	0.29
pH variance	0.077	0.057	0.05
Time < 5.6, minute	321.0	113.0	< 0.01
Area < 5.6[2]	50.9	18.2	0.02
Time < 5.3, minute	44.4	17.1	0.17
Area < 5.3[2]	5.0	2.5	0.42

[1] Adaptation treatments where CON = decreasing forage and increasing corn as steers go through adaptation periods; WCGF = decreasing Sweet Bran and increasing corn as steers go through adaptation periods.
[2] Area under curve (magnitude of pH < 5.6 or 5.3 by minute).

Table 3. Main effect of adaptation time[1] on intake and pH.

Adaptation:	1	2	3	4	Finisher	*P*-value
Intake						
DMI, lb/day	16.23	18.84	20.22	22.24	22.13	0.01
Meals/day	5.98	5.09	5.45	5.50	5.99	0.19
Total time, min	456.00	435.00	437.00	439.00	430.00	0.99
Intake rate,%/24hr	14.35	16.83	17.89	18.91	17.94	0.20
Ruminal pH						
Average pH	6.29	6.06	5.99	5.95	5.98	0.05
Maximum pH	6.89	6.79	6.62	6.55	6.50	< 0.01
Minimum pH	5.93	5.51	5.51	5.45	5.45	< 0.01
pH change	1.03	1.13	1.16	1.12	1.11	0.91
pH variance	0.06	0.07	0.06	0.07	0.07	0.81
Time < 5.6, min.	29.99	214.65	345.58	244.48	249.87	0.04
Area < 5.6[2]	4.33	33.77	27.41	48.76	58.53	0.03
Time < 5.3, min.	5.99	31.84	14.10	48.75	53.11	0.16
Area < 5.3[2]	1.53	4.67	2.52	2.87	7.10	0.36

[1]Adaptation 1 fed for five days, while adaptations 2, 3, 4 and finishing were fed for seven days each.
[2]Area under curve (magnitude of pH < 5.6 or 5.3 by minute).

Table 4. *In situ* **DM digestibility for either treatment diet when incubated in steers on the two different treatments,**

Diet consumed	CON[1]		WCGF[1]		Treatment[2]	Diet[3]	Interaction[4]
Diet incubated	CON[5]	WCGF[5]	CON[5]	WCGF[5]	*P*-value	*P*-value	*P*-value
Adaptation							
1	53.5	69.6	51.5	66.9	0.55	< 0.01	0.76
2	54.6	65.3	52.3	60.6	0.46	< 0.01	0.18
3	49.6	61.6	69.7	65.8	0.01	0.16	0.01
4	48.5	57.4	64.7	66.8	0.05	< 0.01	< 0.01
Finisher	37.3	45.9	62.8	64.6	< 0.01	< 0.01	0.01

[1] Adaptation treatments where CON = decreasing forage and increasing corn as steers go through adaptation periods; WCGF = decreasing Sweet Bran and increasing corn as steers go through adaptation periods.
[2] Treatment *P*-value = significant differences between what steers consumed.
[3] Diet *P*-value = significant differences between incubation of *in situ* bags.
[4] Interaction between treatment diet and incubation diet.
[5] *In situ* incubation of each treatment during the adaptation period the steers were consuming that ration.

finishing), *in situ* DM digestibility was greater in steers fed WCGF compared to steers fed the CON. Therefore, either digestibility was improved, or the *in situ* methodology is influenced by the rumen environment of CON fed steers.

Decreasing WCGF inclusion instead of forage is a viable method for adapting feedlot cattle to high-concentrate diets based on greater DMI. However, pH was lower for cattle adapted with WCGF instead of forage. One steer did experience acidosis on the CON (forage adaptation) system, but no challenges were observed with steers adapted using WCGF. Steers consuming WCGF likely had decreased pH because their DMI was greater than steers fed CON.

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Effect of the Grains-to-Solubles Ratio in Diets Containing Wet Distillers Grains ± Solubles Fed to Finishing Steers

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Summary

Wet distillers grains plus solubles (WDGS) were fed at 0%, 20% or 40% (DM basis) with varying ratios of distillers grains (WDG) to distillers solubles (DS) to determine effect of inclusion level and amount of solubles on steer performance and carcass characteristics. There was no interaction between WDG inclusion level and WDG:DS ratio. As WDG ± S inclusion increased from 0% to 40% diet DM, final BW and average daily gain (ADG) increased linearly ($P = 0.03$*), while feed-to-gain ratio (F:G) decreased linearly (*$P < 0.01$*). However, performance was not affected by the proportion of DS in WDG ± S (*$P > 0.10$*).*

Introduction

Distillers grains (DG) and distillers solubles (DS) are produced as separate feeds during ethanol production. The two fractions often are mixed to produce dry distillers grains plus solubles (DDGS) or wet distillers grains plus solubles (WDGS). It has been suggested each ethanol plant's capacity and ability to store DS determines whether all, none or a portion of DS will be added back to produce DDG ± S/WDG ± S. In plants producing WDGS, 0 to 25% of the WDG ± S can be comprised of DS and may average 20% (DM basis) (*2007 Nebraska Beef Report*, pp. 17-18). The DS portion contains a higher percentage of fat compared to DG, so including more DS will increase the fat content of distillers byproducts. It has been determined that variation in fat content of WDGS is greater across ethanol plants than within plant, suggesting plant processing method determines variability rather than consistency within plant (*2008 Nebraska Beef Report*, pp. 113-114). Previous research has indicated the fat level in DDGS may influence performance when DS are included at 14.5% and 22.1% of the DDGS composition (DM basis; *2007 Nebraska Beef Report*, pp. 17-18). In that experiment, ADG and F:G were affected by the supplementation level and composition of DDG ± S. A decrease in steer performance occurred when supplemented between 0.5% and 1.0% BW. This was likely due to the supplemental fat level contained in those high DDGS diets. It is hypothesized that the same interaction may occur in finishing diets containing high inclusion levels of WDGS. The amount of DS added back to WDGS may be detrimental to steer performance, if fat content of the diet is too high. Therefore, the current study was conducted to determine if the proportion of DS in WDG ± S affects cattle performance and carcass characteristics in finishing diets.

Procedure

A 140-day finishing trial was conducted utilizing 336 crossbred yearling steers (BW = 854 ± 30 lb) in a randomized complete block design. Five days prior to the initiation of the trial, steers were limit fed to minimize variation in rumen fill (1:1 ratio of alfalfa hay and wet corn gluten feed at 2% BW). Steers were then weighed individually on days 0 and 1 to determine initial BW. Animals were blocked by BW, stratified within block and assigned randomly to one of seven treatments. Eight steers were assigned per pen, with six replications per treatment.

Dietary treatments were designed as a 2 x 3 + 1 factorial arrangement. Dietary treatments are outlined in Table 1. Diets contained WDG ± S at 20% or 40% of diet DM. Within each WDG ± S level, three ratios of wet distillers grains (WDG) to DS were tested (100:0, 85:15 or 70:30). The WDG and DS were obtained from separate ethanol plants and mixed just prior to feeding to ensure an accurate ratio of WDG:DS in each diet treatment. A diet containing 82.5% corn was included in the experiment as a control (CON). All diets contained a 1:1 ratio of dry-rolled corn (DRC) and high-moisture, ensiled corn (HMC), 7.5% alfalfa hay and 5% dry supplement. Molasses was included in the CON. Soypass™ (Rothschild, Wis.) also was included at 2% of the diet DM, replacing corn from day 1 to day 50 to meet the metabolizable protein requirement of those steers. The ether extract content of WDG and DS used for formulation was 10.0% and 27.8%, respectively, using the Soxhlet procedure. Diets were formulated to contain ether extract at 3.1% for CON; 4.6%, 5.1% and 5.7% for 20% WDG (100:0, 85:15, 70:30, respectively); and 5.9%, 6.9% and 8.0% for 40% WDG (100:0, 85:15, 70:30, respectively).

On day 50 of the experiment, calves were implanted with Revalor-S (Intervet, Millsboro, Del.). All steers were slaughtered on day 140 at Greater Omaha (Omaha, Neb.). On the day of slaughter, hot carcass weights (HCW) and liver abscess data were recorded. Following a 48-hour chill, marbling score, 12^{th} rib fat thickness and LM area data were collected. Final carcass adjusted BW, ADG and feed efficiency were calculated by dividing HCW by a common dressing percentage of 63%. Yield grade was calculated using the USDA yield grade equation (yield grade = 2.5 + 2.5(12^{th} rib fat thickness, in) – 0.32(LM area, in^2) + 0.2(KPH fat, %) + 0.0038(HCW, lb).

Cattle performance and carcass data were analyzed using the MIXED procedures of SAS (SAS Institute, Cary, N.C.). Factors in the model included WDG ± S inclusion level,

(Continued on next page)

Table 1. Diet composition and nutrient content (% DM basis).

Item	CON	20% WDG(±S)[1] 100:0	20% WDG(±S)[1] 85:15	20% WDG(±S)[1] 70:30	40% WDG(±S) 100:0	40% WDG(±S) 85:15	40% WDG(±S) 70:30
Corn[2]	82.5	67.5	67.5	67.5	47.5	47.5	47.5
WDG[3]	0.0	20.0	17.0	14.0	40.0	34.0	28.0
Solubles	0.0	0.0	3.0	6.0	0.0	6.0	12.0
Alfalfa hay	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Molasses	5.0	—	—	—	—	—	—
Supplement[4]	5.0[5]	5.0	5.0	5.0	5.0	5.0	5.0
Nutrient Content							
Crude protein	13.7%	15.1%	14.8%	14.5%	20.1%	19.5%	18.9%
Fat							
Formulated[6]	3.1%	4.6%	5.1%	5.7%	5.9%	6.9%	8.0%
Observed[7]	3.1%	4.6%	4.7%	4.9%	5.9%	6.3%	6.7%
Sulfur	0.17%	0.21%	0.24%	0.27%	0.24%	0.30%	0.35%

[1]Dietary treatments = 20% or 40% total WDG ± S inclusion level, with varying ratio of WDG:DS (100:0, 85:15, and 70:30).
[2]Corn = 1:1 ratio of dry-rolled and high-moisture corn (DM basis).
[3]WDG = wet distillers grains without solubles.
[4]Formulated to contain 59.6% fine ground corn, 29.7% limestone, 6.0% salt, 2.6% tallow, 1.0% beef trace mineral premix (10% Mg, 6% Zn, 4.5% Fe, 2% Mg, 0.5% Cu, 0.3% I, and 0.05% Co), 0.30% vitamin premix (1500 IU vitamin A, 3000 IU vitamin D, 3.7 IU vitamin E per g), and 320 mg/head/day monensin, 40g/lb thiamine and 90 mg/head/day tylosin.
[5]CON treatment included 26.7% urea, which replaced fine ground corn.
[6]Formulated fat content of feedstuffs pre-trial determined by Soxhlet procedure. WDG and DS contain 10.0% and 27.8% EE, respectively.
[7]Observed fat content determined using UNL procedure. In this method WDG and solubles contained 10.0% and 16.1% fat, respectively.

Table 2. Main effect of WDG ± S inclusion level on cattle performance and carcass characteristics.

Item	0% WDG ± S	20% WDG ± S	40% WDG ± S	SEM	Lin [1]	Quad [2]
Performance						
Initial BW, lb	857	856	857	1	0.66	0.56
Final BW [3], lb	1373	1400	1403	7	0.03	0.17
DMI, lb/d	25.6	25.5	25.1	0.2	0.31	0.45
ADG, lb/d	3.69	3.88	3.90	0.05	0.02	0.17
F:G [4]	6.94	6.58	6.42		< 0.01	0.31
Carcass Characteristics						
HCW, lb	865	882	884	4	0.02	0.17
12th rib fat, in	0.53	0.56	0.62	0.02	< 0.01	0.63
Marbling score [5]	557	558	540	8	0.46	0.33
LM area, in^2	14.0	14.1	13.8	0.1	0.20	0.33
Calculated yield grade [6]	3.12	3.27	3.48	0.07	< 0.01	0.75

[1]Contrast for the linear effect of treatment *P*-value.
[2]Contrast for the quadratic effect of treatment *P*-value.
[3]Calculated from hot carcass weight, adjusted to a 63% yield.
[4]Calculated from total gain over total DMI.
[5]450 = Slight 50; 500 = Small 0; etc.
[6]Yield grade = 2.5 + 2.5(12th rib fat, in) – 0.32(LM area, in^2) + 0.2(KPH fat, %) + 0.0038(HCW, lb).

WDG:DS ratio and the interaction between the two factors. Weight block served as a random variable, and pen was the experimental unit. The CON treatment was not included in the test for interaction. When no interaction was detected ($P > 0.05$), orthogonal contrasts also were used to test the linear and quadratic effects of WDG ± S level (CON was included to determine response of WDG ± S inclusion versus corn-based diet) and WDG:DS.

Results

WDG ± S Level x WDG:DS Ratio

No interaction was detected between WDG ± S inclusion level and WDG:DS ratio ($P > 0.40$). Therefore, WDG ± S inclusion level and WDG:DS ratio within WDG ± S level are presented as main effects.

WDG ± S Inclusion Level

Performance and carcass characteristics for main effect of WDG ± S inclusion level are presented in Table 2. Carcass adjusted final BW increased linearly as steers consumed increasing amounts of WDG ± S ($P = 0.03$). No significant difference in DMI for steers consuming an increasing amount of WDG ± S was observed ($P > 0.05$). However, ADG increased linearly, while F:G decreased linearly as WDG ± S inclusion increased from 0% to 40% of diet DM ($P < 0.02$). Steers fed increasing amounts of WDG ± S, regardless of proportion of WDG:DS, had a 5.5% to 6.0% advantage in ADG and a 5.5% to 8.3% improvement in F:G compared to CON-fed steers. HCW increased linearly as WDG ± S inclusion level increased from 0% to 40% inclusion ($P = 0.02$). Similarly, 12th rib fat depth linearly increased with WDG ± S inclusion level ($P < 0.01$). Calculated yield grade increased as a result of increased fat depth, although numerically the difference is small ($P < 0.05$). The increase suggests when steers are fed WDG ± S (equal number of days), an increased degree of finish can be expected. No effect on marbling score was observed with increased WDG ± S inclusion ($P > 0.33$).

WDG:DS Ratio

Performance and carcass characteristics for main effect of the ratio of WDG:DS across WDG ± S level are presented in Table 3. There was no effect of varying proportions of DS in WDG ± S on carcass adjusted final BW ($P > 0.23$). Interestingly, ADG and F:G were similar as the proportion of DS increased in WDG ± S ($P > 0.22$). Additionally, HCW, marbling score and LM area were not significantly different ($P > 0.15$). Although not statistically significant, marbling score tended to respond quadratically, with diets containing 15% DS having the lowest numerical marbling score (*P* = 0.10). The numerical differences in marbling score corresponded to a statistically quadratic response in calculated yield grade (*P* = 0.03).

Results of this study indicate that steer performance is improved by the increased energy content of WDG ± S, rather than the ratio of WDG:DS, compared to corn. However, our hypothesis was incorrect in that a higher proportion of DS at the 40% WDG ± S inclusion level did not detrimentally affect performance. Observed dietary fat content was lower than formulated dietary fat content. A new laboratory fat analysis has recently been established for DS, which resulted in DS fat content of 16.1% (observed) versus 27.8% (formulated). Therefore, observed dietary fat was 3.1% for CON; 4.6%, 4.7% and 4.9% for 20% WDG (100:0, 85:15, 70:30, respectively); and 5.9%, 6.3% and 6.7% for 40% WDG (100:0, 85:15, 70:30, respectively). As a result, the difference between 0%, 15% and 30% DS is probably too small for differences in performance to be observed. Additionally, it has been shown finishing steers can consume a total dietary fat content of 7% for WDGS diets without compromising performance. In this study, the highest dietary fat content was observed in the 40% WDG inclusion level (70:30; 6.7% dietary fat). This result also may have contributed to a lack of response, since the upper range of dietary fat tolerance was not reached. Therefore, if ethanol plants add back DS at a proportion of 30% of the total WDGS composition, then presumably cattle performance will not be negatively affected due to dietary fat content when fed diets containing 40% WDGS.

Table 3. Main effect of WDG:DS ratio on cattle performance and carcass characteristics.

Item	100:0	85:15	70:30	SEM	Lin[1]	Quad[2]
Performance						
Initial BW, lb	856	857	857	1	0.11	0.69
Final BW[3], lb	1399	1394	1412	8	0.28	0.23
DMI, lb/d	25.4	25.1	25.5	0.3	0.89	0.30
ADG, lb/d	3.88	3.84	3.96	0.05	0.33	0.23
F:G[4]	6.54	6.49	6.41		0.25	0.61
Carcass Characteristics						
HCW, lb	882	878	889	5	0.28	0.24
12th rib fat, in	0.60	0.57	0.60	0.02	0.79	0.10
Marbling score[5]	545	541	560	10	0.30	0.36
LM area, in^2	13.8	14.1	13.9	0.1	0.87	0.15
Calculated yield grade[6]	3.41	3.25	3.46	0.01	0.60	0.03

[1]Contrast for the linear effect of treatment *P*-value.
[2]Contrast for the quadratic effect of treatment *P*-value.
[3]Calculated from hot carcass weight, adjusted to a 63% yield.
[4]Calculated from total gain over total DMI.
[5]450 = Slight 50; 500 = Small 0; etc.
[6]Yield grade = 2.5 + 2.5(12^{th} rib fat, in) – 0.32(LM area, in^2) + 0.2(KPH fat, %) + 0.0038(HCW, lb).

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Effects of Substituting Wet Distillers Grains with Solubles in a Wet Corn Gluten Feed-Based Diet on Finishing Performance

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Summary

A finishing study evaluated feeding a wet corn gluten feed (WCGF) ration containing no high moisture corn with varying inclusion levels of wet distillers grains plus solubles (WDGS), as well as a control diet containing 20% WDGS and 20% WCGF. Wet distillers grains with solubles replaced WCGF at 10%, 20%, 30% and 40% of the diet. As WDGS replaced WCGF, feed-to-gain ratio (F:G) decreased linearly. However, two steers developed polioencephalomalacia on the treatment that contained 40% WDGS. Steers fed the control diet containing 40% byproduct had greater average daily gain (ADG) and lower F:G than the average of all WCGF:WDGS combination diets. Byproduct feed-based finishing rations can be fed without corn, but performance may be slightly depressed.

Introduction

Feeding WDGS between 15% and 40% of diet dry matter improves performance, with 130% the feeding value of corn (*2008 Nebraska Beef Report*, pp. 35-36). Feeding WCGF also can improve performance (*2008 Nebraska Beef Report*, pp. 33-34). Feeding a ration that replaces all the corn with WCGF was evaluated (*1995 Nebraska Beef Report*, pp. 34-36), but replacing corn with both WDGS and WCGF has not been evaluated. We hypothesized that feeding the two byproducts together would produce a positive associative effect, due to the fat and undegradable protein of WDGS.

The objective of the current research was to determine the effect of replacing all of the corn in a finisher ration with a combination of WCGF and WDGS on both feedlot and carcass performance.

Procedure

A finishing trial was conducted at the UNL research feedlot near Mead, Neb., using yearling crossbred steers (n = 306; BW = 863 ± 55 lb). Steers were limit fed at 2.0% of their BW for five days prior to the initiation of the trial. Steers were weighed on two consecutive days (days 0 and 1) to establish an initial BW. Using the BW obtained on day 0, cattle were blocked by BW, stratified within block and assigned randomly to pens. Six pens (1 replication) contained 11 steers, and the other 24 pens contained 10 steers/pen. Pens were assigned randomly within block to one of six treatments, with five pens per treatments. Six treatments consisted of: 1) control (CON) with 20% WCGF (Sweet Bran®, Cargill, Blair, Neb.), 20% WDGS (Abengoa Bioenergy, York, Neb.), and 50% high moisture corn (HMC); 2) 90% WCGF with 0% WDGS (90WCGF:0WDGS); 3) 80% WCGF with 10% WDGS (80WCGF: 10WDGS); 4) 70% WCGF with 20% WDGS (70WCGF:20WDGS); 5) 60% WCGF with 30% WDGS (60WCGF:30WDGS); and 6) 50%WCGF with 40% WDGS (50WCGF:40WDGS). The WDGS used in this study was from corn and consisted of 32.7% dry matter (DM), 32.4% crude protein (CP), 12.7% fat and 0.74% sulfur. The high-moisture corn (HMC) used in this study was ensiled for approximately 30 days before feeding began, and contained 68.4% DM, 10.3% CP, 4.5% fat and 0.16% sulfur. The WCGF used in this study contained 27.1% CP, 3.0% fat, 0.50% sulfur and 59.4% DM. All diets contained 5% cornstalks and 5% supplement (Table 1). A 21-day adaptation period was utilized, in which a combination of byproduct feeds replaced grass hay at decreasing levels of 32.5%, 22.5%, 12.5% and 5% grass hay fed for three, four, seven and seven days, respectively. Cornstalks and supplement inclusion levels remained constant throughout the entire adaptation and finishing period.

Steers were implanted on day 1 with Revalor-S® (Intervet, Milsboro, Del.) Weekly feed ingredient samples were analyzed for DM at 60°C for 48 hours. Steers in the medium (180 head) and light (66 head) weight blocks were slaughtered on day 127 and steers in the heavy weight block (60 head) were slaughtered on day 107 at Greater Omaha (Omaha, Neb.). Hot carcass weight (HCW) and liver abscess data

Table 1. **Composition of diets fed to yearling steers in a finishing trial measuring effects of varying inclusion levels of WDGS in a WCGF-based ration[1] (%DM).**

		Treatments[2]				
Ingredients	Control	50WCGF 40WDGS	60WCGF 30WDGS	70WCGF 20WDGS	80WCGF 10WDGS	90WCGF 0WDGS
HMC	50	—	—	—	—	—
WCGF	20	50	60	70	80	90
WDGS	20	40	30	20	10	—
Corn stalks	5	5	5	5	5	5
Supplement[3]	5	5	5	5	5	5
Nutrient Composition						
CP	17.6	27.0	26.4	25.9	25.4	24.8
Calcium	0.99	1.01	1.01	1.02	1.02	1.02
Phosphorus	0.55	0.87	0.88	0.89	0.90	0.91
NDF	24.1	36.7	36.8	37.0	37.1	37.2
Fat	5.50	6.65	5.67	4.70	3.73	2.76
Sulfur	0.34	0.56	0.54	0.51	0.49	0.47

[1]Values in table expressed on a DM basis.
[2]Control = 20% WCGF, 20% WDGS; 50WCGF = 50% WCGF, 40% WDGS; 60WCGF = 60% WCGF, 30% WDGS; 70WCGF = 70% WCGF, 20% WDGS; 80WCGF = 80% WCGF, 10% WDGS; 90WCGF = 90% WCGF, 0% WDGS.
[3]Supplements formulated to provide 30g/ton of DM rumensin, 90mg/steer daily tylan and 130mg/steer daily thiamine.

Table 2. Effect of different inclusion levels of WDGS on both feedlot and carcass performance in a WCGF-based ration.[1]

	CON	50WCGF 40WDGS	60WCGF 30WDGS	70WCGF 20WDGS	80WCGF 10WDGS	90WCGF 0WDGS	SEM	Linear P-value	Quadratic P-value	Con vs. Other[5] P-value
Performance										
Initial BW	871	868	870	870	864	861	8	0.27	0.57	0.42
Final BW[2], lb	1258	1243	1216	1204	1234	1222	30	0.59	0.20	0.16
DMI, lb/day	26.55	24.15	25.65	26.82	27.07	28.54	0.60	< 0.01	0.55	0.83
ADG, lb	3.43	3.15	2.92	2.84	3.12	3.04	0.22	0.98	0.19	0.02
F:G	7.88	7.79	8.81	9.54	8.69	9.45	0.58	0.02	0.15	0.04
Carcass Characteristics										
HCW, lb	793	783	766	758	777	770	19	0.59	0.21	0.16
Marbling score[3]	531	511	480	497	517	510	19	0.30	.21	0.07
12th Rib fat, in	0.42	0.38	0.40	0.41	0.40	0.42	0.03	0.29	0.86	0.53
LM area, in^2	12.92	12.83	12.50	12.11	12.42	12.69	0.38	0.65	0.06	0.18
Calculated YG[4]	2.93	2.84	2.82	2.94	2.98	2.91	0.14	0.33	0.61	0.81
Choice percentage	57	47	33	49	56	45	11	0.37	0.85	0.23

[1]CON = 20% WCGF, 20% WDGS; 50WCGF = 50% WCGF, 40% WDGS; 60WCGF = 60% WCGF, 30% WDGS; 70WCGF = 70% WCGF, 20% WDGS; 80WCGF = 80% WCGF, 10% WDGS; 90WCGF = 90% WCGF, 0% WDGS.
[2]Calculated from carcass weight, adjusted to a common dressing percentage (63%).
[3]Marbling score: 400 = Slight^o; 450 = Slight^{50}; 500 = Small^o; etc.
[4]Yield grade: 2.50 + (2.5*fat thickness, in.) - (0.32*REA, in^2) + (0.2*2.5 KPH) + (0.0038*HCW, lb.).
[5]Contrast of control vs. other treatments.

were collected at slaughter. After a 48-hour chill, LM area, 12th rib fat thickness and USDA marbling score were recorded. Final BW, ADG and F:G were calculated using HCW adjusted to a common yield of 63%. Yield grade was calculated using the USDA yield grade equation YG = 2.5 + (fat depth, in.) – 0.32 (LM area, in^2) + 0.2 (KPH fat, %) + 0.0038 (HCW, lb).

Performance and carcass data were analyzed using the MIXED procedure of SAS. The trial was a randomized complete block design with pen as the experimental unit. Orthogonal contrasts were used to detect linear, quadratic, cubic and quartic effects of WDGS replacement of WCGF, excluding the control. A contrast was used to compare the CON to all other diets containing blends of WCGF and WDGS.

Results

Dry matter intake (DMI) decreased linearly ($P < 0.01$) as inclusion level of WDGS increased (Table 2). Cattle fed CON ration were intermediate and as a result were not different from the average of all the WCGF:WDGS rations. The linear decrease in DMI ($P < 0.01$) as WDGS inclusion increased may have been due to the relatively high level of dietary fat and sulfur in the 50WCGF:40WDGS ration. Gain was greater and F:G was lower ($P < 0.04$) when comparing CON to all other treatments. Within levels of WDGS added to WCGF, neither linear nor quadratic contrasts were significant for ADG; however, F:G improved linearly ($P = 0.02$) as inclusion level of WDGS increased. Final BW did not differ among treatments and was unaffected by inclusion level of WDGS. No differences in carcass data were observed among treatments compared to the control; however, there was a trend ($P = 0.07$) for a difference in marbling score. There were no significant differences for HCW, 12th rib fat thickness, calculated yield grade and % yield grade 4 between CON and all other treatments. A tendency for a quadratic response was observed for LM area ($P = 0.06$), with steers fed 70WCGF:20WDGS having the lowest LM area. Significant cubic responses were observed for both marbling score and percent choice ($P = 0.03$).

During the course of the feeding trial, four animals were removed from the trial due to health-related illnesses. Two of the four steers were diagnosed with polio. These animals were on the 50WCGF:40WDGS treatment at the time, which contained the highest level of WDGS. Two of the animals were treated for polio, but were not returned to treatment pens afterward. The other two animals died due to causes unrelated to treatments. The animals that were removed from this study were not included in the performance calculations.

The cattle in this feeding trial did not gain as well as expected, primarily due to harsh weather. Due to the amount of snow, the pens remained wet and muddy during a large portion of the feeding trial, creating an unfavorable environment for the cattle, which likely caused a negative effect on ADG and F:G.

Dietary sulfur levels for this trial ranged from 0.34% for the CON to 0.56% for 50WCGF:40WDGS (Table 1). Dietary sulfur levels increased from 0.47% to 0.56% as WDGS replaced WCGF. Fat levels ranged from 2.8% (90WCGF:0WDGS) to 6.6% (50WCGF:40WDGS), which likely explains the F:G response observed. The relatively high dietary fat and sulfur levels could explain the decrease in DMI observed for cattle fed the 50WCGF:40WDGS treatment. In addition, the high sulfur levels in this treatment accounted for the two animals that were diagnosed with polioencephalomalacia.

In conclusion, the results of this study suggest a byproduct-based ration will perform relatively similar to a typical Nebraska ration with 20% WDGS, 20% WCGF. The results also suggest 40% is the optimal WDGS inclusion level in WCGF-based diets because F:G was lowest for this treatment; however, dietary sulfur levels must be closely monitored.

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Wet Distillers Grains Plus Solubles or Solubles in Feedlot Diets Containing Wet Corn Gluten Feed

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Summary

Effects of the addition of 0% to 40% wet distillers grains plus solubles (WDGS) or 0% to 20% condensed corn distillers solubles (CCDS) to feedlot diets containing high moisture corn (HMC) and 35% wet corn gluten feed (WCGF) were evaluated. As WDGS replaced HMC, average daily gain (ADG) decreased linearly and dry matter intake (DMI) tended to decrease. Replacement of HMC with WDGS in the 35% WCGF diet caused a linear decrease in ADG and a trend for a linear decrease in DMI. When CCDS replaced HMC, no difference in steer performance was observed. The sulfur content, rather than fat content, of WDGS may be the limiting factor with feeding WDGS in combination with WCGF, and solubles may effectively reduce the dietary inclusion of corn by up to 20% of diet DM in finishing diets containing 35% WCGF.

Introduction

Previous research has evaluated feeding combinations of byproducts to replace corn in feedlot diets *(2005 Nebraska Beef Report*, pp. 45-46; *2007 Nebraska Beef Report*, pp. 25-26 and 27-28). These trials combined wet corn gluten feed (WCGF) with wet distillers grains plus solubles (WDGS). These two feeds complement each other, perhaps due to differences in fat and sulfur (S) between the two feeds. Feeding 60% of the diet as a combination of 50% WCGF: 50% WDGS results in ADG and feed-to-gain ratio (F:G) similar to those found when feeding a traditional dry-rolled/high moisture corn (HMC) feedlot diet.

Limited data have been collected on feeding dry-milling condensed corn distillers solubles (CCDS) in feedlot diets, and no data have been collected on feeding CCDS with WCGF. Therefore, the objective of the current study was to evaluate the effect of adding WDGS or CCDS to WCGF in feedlot diets on cattle performance and carcass characteristics.

Procedure

An 82-day finishing study used 279 crossbred steer calves in a randomized complete block design experiment. Steers had been on a common finishing diet for 100 days prior to study initiation. This study was initiated at re-implant processing. Steers were limit fed a WCGF-based diet at 1.8% of BW for five days to capture three-day initial weights. The average BW from the first two days was used to block the steers into three blocks, stratify steers by BW within block and assign steers randomly to pens. Pens then were assigned randomly within each block to one of seven dietary treatments, with five pens per treatment and eight steers per pen.

Dietary treatments (Table 1) consisted of 35% WCGF with either 0% WDGS or CCDS; 13.35%, 26.7% or 40% WDGS; or 6.65%, 13.35% or 20% CCDS replacing HMC in the diet (DM basis). All diets contained 5% ground cornstalks and 5% dry supplement. The WDGS and CCDS were sourced from Abengoa Bioenergy Corporation, York, Neb. The WCGF (Sweet Bran®) was from Cargill, Blair, Neb. The HMC was processed through a roller mill at harvest, ensiled in a bunker silo 166 days prior to study initiation and averaged 30% moisture.

Steers were adapted to finishing diets over six days from a previous finishing ration that contained 25% HMC, 50% WCGF, 15% corn silage, 5% corn stalks and 5% dry supplement, all on a DM basis. Steers were implanted with Synovex Choice (Fort Dodge, Overland Park, Kan.) at trial initiation. All diets provided 350 mg monensin, 127 mg thiamine, and 88 mg of tylosin per steer daily. Feed samples were collected weekly and composited by month to evaluate DM, fat, neutral detergent fiber (NDF), crude protein (CP) and S.

The levels of WDGS and CCDS were formulated to provide equal fat addition from either product, assuming CCDS contained 25% fat and WDGS contained 12.5% fat, based on historical fat analysis with the Soxhlet ether extract procedure. After trial initiation, it was discovered that the Soxhlet lipid extraction procedure over-estimates lipid values for CCDS due to extraction of non-lipid material in the extraction process. Therefore, a new procedure to accurately measure lipid content of CCDS was developed, utilizing a biphasic extraction of lipid material from CCDS into a 1:1 hexane:diethyl ether solvent.

Table 1. Diet composition and analysis for diets containing WCGF with either WDGS or CCDS (DM basis).[1,2]

		Treatments					
Ingredient	Control	13.3 WDGS	26.7 WDGS	40 WDGS	6.7 CCDS	13.3 CCDS	20 CCDS
HMC	55.0	41.7	28.3	15.0	48.3	41.7	35.0
WCGF	35.0	35.0	35.0	35.0	35.0	35.0	35.0
WDGS	0.0	13.3	26.7	40.0	0.0	0.0	0.0
CCDS	0.0	0.0	0.0	0.0	6.7	13.3	20.0
Cornstalks	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Supplement	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Diet Analysis							
Crude protein	15.6	18.8	21.9	25.1	16.8	17.9	19.1
NDF	23.3	26.7	30.2	33.6	22.8	22.3	21.8
Fat	4.1	5.0	5.9	6.9	4.8	5.5	6.2
Sulfur	0.26	0.35	0.44	0.52	0.33	0.39	0.45

[1]All values expressed on a DM basis
[2]HMC = high moisture corn; WCGF = wet corn gluten feed (Sweet Bran); WDGS = wet distillers grains plus solubles; CCDS = dry mill condensed corn distillers solubles; 13.3WDGS = 13.3% WDGS; 26.7WDGS = 26.7% WDGS; 40WDGS = 40% WDGS; 6.7CCDS = 6.7% CCDS; 13.3CCDS = 13.3% CCDS; and 20CCDS = 20% CCDS.

The solvent was then separated from the sample with water before extracting the solvent/lipid mixture and driving off the solvent to capture the lipid. Upon trial completion, the new lipid analysis indicated CCDS had 1.3 times the fat content of the WDGS and therefore did not produce equal levels of fat addition from the WDGS and CCDS sources.

Steers were slaughtered on day 83 at Greater Omaha Pack (Omaha, Neb.), where liver scores and hot carcass weights were recorded. Fat thickness and LM area were measured, and the USDA marbling score was recorded after a 48-hour chill. Hot carcass weight, fat thickness, LM area and assumed 2% kidney, heart and pelvic fat measurements were used to calculate yield grade. Final BW, ADG and F:G were calculated based on hot carcass weight adjusted to a common dressing percentage (63%) in order to minimize errors associated with gut fill.

Data were analyzed using the MIXED procedure of SAS and tested for linear, quadratic and cubic effects of WDGS or CCDS inclusion level.

Seven pens of cattle were removed from the analysis due to incorrect feeding for two days during the study. This resulted in three complete blocks of treatments and two incomplete blocks of treatments.

Table 2. Main effects of WDGS level with 35% WCGF on performance measurements and carcass characteristics.[1]

						P-Value		
Item	Control	13.3 WDGS	26.7 WDGS	40 WDGS	SE	Lin.	Quad.	Cubic
Initial BW, lb	983	984	984	982	2.5	0.85	0.95	0.96
Final BW[2], lb	1295	1293	1282	1270	11.7	0.37	0.77	0.93
DMI, lb/day	22.98	22.67	22.69	21.05	0.488	0.06	0.80	0.86
ADG, lb	3.79	3.76	3.63	3.43	0.134	< 0.01	0.34	0.89
Feed:Gain	6.02	6.02	5.95	6.13	0.144	0.86	0.70	0.77
Carcass Characteristics								
Hot carcass weight, lb	815	815	808	796	7.4	0.38	0.76	0.93
12th rib fat thickness, in	0.58	0.54	0.53	0.51	0.026	0.07	0.80	0.76
LM area, in²	12.85	12.63	12.60	12.37	0.289	0.15	0.98	0.67
Calculated yield grade[3]	3.34	3.31	3.26	3.25	0.105	0.44	0.99	0.97
Marbling score[4]	519	523	535	504	18.1	0.52	0.34	0.46

[1]WDGS = wet distillers grains plus solubles; 13.3WDGS = 13.3% WDGS; 26.7WDGS = 26.7% WDGS; 40WDGS = 40% WDGS.
[2]Calculated from carcass weight, adjusted to a 63% common dressing percentage.
[3]Calculated as 2.5 + (2.5*Fat Depth) + (0.2* 2% KPH) + (0.0038* Hot Carcass Wt.) – (0.32*Ribeye Area) from Meat Evaluation Handbook, 2001.
[4]400 = Slight^0; 500 = Small^0.

Table 3. Main effects of CCDS level with 35% WCGF on performance measurements and carcass characteristics.[1]

						P-Value		
Item	Control	6.7 CCDS	13.3 CCDS	20 CCDS	SE	Lin.	Quad.	Cubic
Initial BW, lb	983	984	985	981	2.5	0.99	0.79	0.92
Final BW[2], lb	1295	1293	1297	1292	11.7	0.96	0.72	0.85
DMI, lb/day	22.98	22.67	22.06	22.55	0.488	0.55	0.80	0.81
ADG, lb	3.79	3.77	3.80	3.79	0.134	0.92	0.72	0.73
Feed:Gain	6.02	6.02	5.78	5.95	0.144	0.52	0.58	0.49
Carcass Characteristics								
Hot carcass weight, lb	815	815	817	814	7.4	0.97	0.71	0.85
12th rib fat thickness, in	0.58	0.55	0.57	0.56	0.026	0.78	0.80	0.16
LM area, in²	12.85	12.67	12.57	12.11	0.289	0.19	0.58	0.68
Calculated yield grade[3]	3.34	3.37	3.43	3.53	0.105	0.15	0.97	0.90
Marbling score[4]	519	516	551	519	18.1	0.24	0.04	0.04

[1]CCDS = dry mill condensed corn distillers solubles; 6.7CCDS = 6.7% CCDS; 13.3CCDS = 13.3% CCDS; and 20CCDS = 20% CCDS.
[2]Calculated from carcass weight, adjusted to a 63% common dressing percentage.
[3]Calculated as 2.5 + (2.5*Fat Depth) + (0.2* 2% KPH) + (0.0038* Hot Carcass Wt.) – (0.32*Ribeye Area) from Meat Evaluation Handbook, 2001.
[4]400 = Slight^0; 500 = Small^0.

Results

As the level of WDGS increased in the diets with 35% WCGF, ADG decreased linearly ($P < 0.01$; Table 2), and DMI tended to decrease linearly ($P = 0.06$); F:G was not affected by treatment. Twelfth rib fat thickness also tended to decrease linearly ($P = 0.07$) as the level of WDGS increased in the diet; however, there were no significant differences in hot carcass weight, LM area, 12th rib fat, yield grade or marbling score.

Steers fed up to 20% CCDS with 35% WCGF had similar feedlot performance and carcass characteristics as steers fed 35% WCGF with no CCDS (Table 3). There was a significant ($P = 0.04$) cubic effect of CCDS inclusion level on the marbling score; however, this effect is difficult to explain and probably not biologically significant.

The steers fed 20% CCDS performed similarly to the steers fed 26.7% WDGS. These two diets contained similar fat levels (6.2% and 5.9% fat for the 20% CCDS and 26.7% WDGS diets, respectively). The S levels were similar for the two diets, with 0.45% and 0.44% S in the 20% CCDS and 26.7% WDGS diets, respectively. When the level of WDGS was increased to 40% of diet DM (6.9% fat and 0.52% S), steer performance decreased. Previous research (Vander Pol et. al., *2006 Nebraska Beef Report* pp. 51-53) suggests that the fat level in the 40% WDGS diet is probably not high enough to depress DMI or ADG. However, one of the first signs of S excess in the diet is depressed DMI with decreased ADG. The cattle on the 40% WDGS with 35% WCGF may have had depressed DMI due to dietary S. However, no steers on this trial were observed with symptoms of, or treated for, polioencephalomalacia.

In summary, these results suggest feeding up to 20% of diet DM as CCDS with 35% WCGF can be used to reduce the percentage of HMC fed in feedlot diets without diminishing cattle performance or carcass characteristics. However, when HMC is replaced with WDGS in 35% WCGF diets, cattle ADG decreases as WDGS inclusion level increases. The S content, rather than fat content, of WDGS may be the limiting factor with feeding WDGS in combination with WCGF.

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Cattle Performance and Economic Analysis of Diets Containing Wet Distillers Grains and Dry-Rolled or Steam-Flaked Corn

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Summary

A finishing study was conducted to determine the effect of utilizing dry-rolled (DRC) or steam-flaked (SFC) corn in diets containing wet distillers grains without solubles (WDG). An interaction between corn processing method and DG level was observed for average daily gain (ADG) and feed-gain ratio (F:G), but not for dry matter intake (DMI). In diets containing DRC, ADG increased quadratically (P = 0.02) as WDG level increased, but no difference was observed in gain when steers were fed SFC diets with increasing level of WDG. Feed efficiency responded quadratically for diets containing DRC, with an optimum WDG inclusion of 20% of diet DM (P < 0.01) No difference in F:G was observed as WDG increased in SFC-based diets.

Introduction

Previous research has determined an interaction between corn processing method and optimum wet distillers grains plus solubles (WDGS) level (*2007 Nebraska Beef Report*, pp. 33-35). In that study, F:G improved with increasing inclusion of WDGS in dry-rolled corn (DRC) based diets. However, in steam-flaked corn (SFC) based diets, F:G remained constant as WDGS inclusion increased from 0% to 40% diet DM. Optimal inclusion with DRC was observed at 40% of diet DM, but only at 15% to 20% with SFC. However, no research has been conducted to determine if an interaction occurs in diets containing wet distillers grains without solubles (WDG).

Wet distillers grains and distillers solubles are produced as separate components during ethanol production. The two fractions are often added together from the individual components to produce WDGS. However, each ethanol plant, based on plant capacity and ability, has the opportunity to add back all, none or a portion of the solubles. It has been hypothesized that rumen pH and concentrate level may negatively impact the response of WDG when steers are fed SFC. It also has been hypothesized that if steers fed SFC-based diets perform similarly to steers fed DRC-based diets with WDG, then feeding DRC may have an economic advantage. Therefore, there were three objectives in the current study. The primary objective was to determine performance when steers consume diets containing WDG and DRC or SFC. The secondary objective was to determine if additional roughage in diets containing SFC and 40% WDG would improve performance. The final objective was to assess the economic impact of different WDG inclusion levels in DRC- or SFC-based diets.

Procedure

Cattle Performance and Carcass Characteristics

A 145-day finishing trial was conducted utilizing 120 crossbred yearling steers (BW = 784 $\pm$ 55 lb) in a randomized complete block design. Steers were fed individually using Calan electronic gates. Five days prior to the initiation of the trial, steers were limit fed to minimize variation in rumen fill (1:1 ratio of alfalfa hay and wet corn gluten feed at 2% BW). Steers were then weighed individually on days -1, 0 and 1 to determine initial BW. Animals were blocked by BW, stratified within blocks and assigned randomly to one of eight treatments in one of four barns. Animal served as the experimental unit, and there were a total of 15 replications per treatment.

Dietary treatments were designed as a 2 x 3 + 2 factorial arrangement (Table 1). Two types of corn processing method (dry-rolled or steam-flaked) were represented in diets containing 0%, 20%, or 40% WDG on a DM basis (0-DRC, 20-DRC, 40-DRC, 0-SFC, 20-SFC and 40-SFC). These diets all contained 7.5% alfalfa hay and 5% dry supplement. Molasses was included in the diets containing 0% WDG to aid in mixing the low moisture diets. Soypass™ (Rothschild, Wis.) also was included in those diets containing 0% WDG at 2% of the diet DM, replacing corn from day 1 to day 50 to meet the metabolizable protein requirement of those calves. Two additional diets were formulated with SFC and 40% WDG and additional roughage to determine the impact on steer performance. Those diets are

Table 1. Diets fed to finishing steers containing dry-rolled or steam-flaked corn with 0%, 20% or 40% wet distillers grains (WDG). All values are expressed as % of diet DM.

Ingredient	0% WDG	20% WDG	40% WDG	40%WDG-MID[1]	40% WDG-HIGH[1]
DRC or SFC [2]	82.5	67.5	47.5	43.8	40.0
WDG	0.0	20.0	40.0	40.0	40.0
Alfalfa	7.5	7.5	7.5	11.3	15.0
Molasses	5.0	0.0	0.0	0.0	0.0
Supplement	5.0	5.0	5.0	5.0	5.0

[1]40% WDG-MID/HIGH = alfalfa hay replaced SFC at 11.3 or 15.0% of diet DM.
[2]DRC = dry-rolled corn; SFC = steam-flaked corn.

Table 2. Effect of corn processing method and wet distillers grains (WDG) level on cattle performance and carcass characteristics.

	DRC			SFC			*P*-value		
Item	0%	20%	40%	0%	20%	40%	CPM x WDG[1]	CPM[2]	WDG[3]
Initial BW, lb	784	782	785	786	784	783	0.99	0.94	0.99
Final BW, lb[4]	1225	1316	1291	1294	1311	1270	0.16	0.49	0.10
DMI, lb/d	21.6	22.5	21.3	22.1	21.5	20.3	0.27	0.28	0.06
ADG, lb[5]	3.05	3.68	3.49	3.50	3.64	3.36	0.09	0.43	0.03
F:G[5,6]	7.14	6.10	6.13	6.33	5.92	6.06	0.02	0.03	<0.01
HCW, lb	772	829	814	815	826	800	0.16	0.49	0.10
12th rib fat, in	0.40	0.49	0.49	0.43	0.47	0.42	0.36	0.88	0.06
Marbling score[7]	513	495	473	493	523	471	0.36	0.41	0.13
LM area, in^2	13.6	14.1	13.5	13.9	14.3	13.9	0.96	0.36	0.38
Calculated yield grade[8]	2.56	2.87	2.97	2.71	2.75	2.65	0.31	0.43	0.41

[1]CPM x WDG = *P*-value for the effect of corn processing method x WDG inclusion level.
[2]CPM = *P*-value for the main effect of corn processing method (DRC or SFC).
[3]WDG = *P*-value for the main effect of wet distillers grain level.
[4]Final BW = HCW / common dressing percent of 63%.
[5]Quadratic response observed within DRC.
[6]F:G = 1/G:F; analyzed as G:F.
[7]450 = Slight 50; 500 = Small 0; etc.
[8]Yield grade = 2.5 + 2.5(12th rib fat, in) – 0.32(LM area, in^2) + 0.2(KPH fat, %) + 0.0038(HCW, lb).

designated 40-MID and 40-HIGH, for 11.3% and 15.0% alfalfa, respectively.

On day 50 of the experiment, calves were implanted with Revalor-S (Intervet, Millsboro, Del.). All steers were slaughtered on day 145 at Greater Omaha (Omaha, Neb.). On the day of slaughter, hot carcass weights (HCW) and liver abscess data were recorded. Following a 48-hour chill, marbling score, 12th rib fat thickness and LM area data were collected. Final BW, ADG and F:G were calculated by dividing HCW by a common dressing percentage of 63%. Yield grade was calculated using the USDA yield grade equation [yield grade = 2.5 + 2.5(12th rib fat thickness, in) - 0.32(LM area, in^2) + 0.2(KPH fat, %) + 0.0038 (HCW, lb)].

Steer performance and carcass data were analyzed using the MIXED procedures of SAS (SAS Institute, Cary, N.C.). The model included corn processing method, WDG inclusion level, and corn processing method by WDG inclusion level interaction. Orthogonal contrasts were used to determine linear and quadratic effects of WDG inclusion levels within corn processing methods when a significant interaction was present ($P < 0.10$). Linear and quadratic responses to increasing roughage level in diets containing 40% WDG and SFC were analyzed separately.

Economic Analysis

Six of the eight diets were utilized to determine the effect of corn and byproduct price on profitability of steers consuming diets containing DRC or SFC with increasing WDG inclusion level. Diets included in the analysis were 0-DRC, 20-DRC, 40-DRC, 0-SFC, 20-SFC and 40-SFC (Table 1). Steers were assumed to have been purchased on day 0 of the experiment and fed for 145 days until slaughter. Two corn prices were utilized ($5.50/bu and $4.00/bu on an as-is basis). Distillers grains, when forward-contracted from the ethanol plant, are hypothesized to be priced 65-80% of the price of corn; therefore, the WDG was priced at either 65% or 80% of the price of corn. Costs of corn processing for DRC and SFC were added to the base corn price and determined by previous research conducted at the University of Nebraska (Macken, C., 2006, The cost of corn processing for finishing cattle, *The Professional Animal Scientist 22*: 23-32). Prices reflect a 20,000-head capacity feedlot utilizing a roller and two flakers processing 48.1 ton/hour and 12 ton/hour for DRC and SFC, respectively. Natural gas and electricity prices reflect the 2007 commercial sector average price $0.272/kL and $0.0624/kwh in Nebraska.

Total processing costs were $0.88/ton and $7.41/ton for DRC and SFC, respectively. Hay price was determined using the monthly composited average price of alfalfa hay for 2007 as reported by USDA-AMS. Molasses and supplement prices were determined according to basal ingredients, priced according to Nebraska Beef Cattle Budgets (*www.extension.unl.edu/publications*).

Fed-cattle price was $92.10/cwt, the 2007 Nebraska average choice slaughter steer price as reported by USDA-AMS. Veterinary, medical and processing costs were charged at $15.00 per head for the finishing period. Marketing costs were determined by multiplying the final steer weight by $1.50/cwt. Interest was assumed to accrue on the animal and all costs of production at 8.5% over the 145-day finishing period. A yardage charge was assessed at $0.35/head/day over the feeding period. The 0-DRC diet was used to calculate break-even (BE) by dividing total cost (less initial steer value) by initial steer weight to determine the price paid for a 700-800 lb feeder steer in May 2007. Cost of gain (COG) was determined by dividing total cost by pounds of weight gain over the feeding period. Profitability of each treatment was determined by adding initial steer value and all costs

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incurred over the feeding period and subtracting that total from the final value of each steer.

Results

Corn Processing Method x WDG Level Interaction

Performance results and carcass characteristics are presented in Table 2. An interaction between corn processing method and WDG level occurred for ADG and F:G ($P < 0.10$). Gain and F:G responded quadratically for steers consuming DRC with increasing WDG inclusion ($P = 0.02$). Optimum inclusion of 20% WDG in DRC-based diets was observed. However in SFC-based diets, ADG and F:G were not affected by WDG inclusion level ($P > 0.18$). Steers consuming SFC were more efficient at 0% WDG inclusion versus cattle consuming DRC at 0% WDG inclusion. However, at 20% and 40% WDG inclusion, there was no difference in F:G between steers consuming SFC (5.92 and 6.06 for 20% and 40% WDG, respectively) or DRC (6.10 and 6.13 for 20% and 40% WDG, respectively). Corn processing method had no effect on final BW, DMI, ADG, F:G, HCW, 12th rib fat, marbling score, LM area or calculated yield grade for steers consuming DRC or SFC ($P > 0.35$).

WDG Inclusion Level

Final carcass adjusted BW responded quadratically as WDG inclusion increased from 0% to 40% ($P < 0.05$). Dry matter intake, on the other hand, decreased linearly as WDG inclusion increased ($P = 0.06$). Additionally, an effect of WDG inclusion was observed for HCW and marbling score ($P < 0.10$). Cattle consuming 20% WDG had the highest numerical HCW over the 0% or 40% WDG inclusion. Marbling score tended to decrease linearly as WDG inclusion increased in the diet ($P = 0.07$).

Roughage Level

As roughage level increased from 7.5% to 15.0% in those diets containing 40% WDG and SFC, DMI tended to increase linearly ($P = 0.07$). There was no effect on ADG across treatments as roughage level increased ($P = 0.99$). Therefore, F:G tended to increase linearly as roughage increased from 7.5% to 15% diet DM ($P = 0.09$).

Profitability Analysis

A partial budget to determine the effect of dietary treatment on profitability is presented in Table 4. In this scenario, corn was priced at $5.50/bu and WDG at 80% of the relative value of corn. However, within corn price, only small numerical differences in diet cost, total cost, COG, BE and profit/loss (P/L) were observed among WDG pricing levels. Therefore, corn and WDG pricing scenarios were combined to make generalized conclusions in the following section. It is important to note that as the price of corn increases from $4.00/bu to $5.50/bu, producers will need to pay $9.88/cwt less for 700-800 lb feeder steers to achieve the same breakeven price.

Table 3. Effect of roughage level inclusion on animal performance and carcass characteristics in steers fed steam-flaked corn and 40% wet distillers grains with increasing roughage.

	Roughage Level[1]			*P*-value		
Item	7.5%	11.3%	15.0%	SEM	Linear	Quadratic
Initial BW, lb	783	781	784	13	0.98	0.89
Final BW[2], lb	1270	1239	1270	22	0.98	0.25
DMI, lb/d	20.3	20.5	21.8	0.6	0.07	0.49
ADG, lb	3.35	3.20	3.36	0.13	0.99	0.32
F:G[3]	6.06	6.37	6.49		0.09	0.23
HCW, lb	800	780	800	14	0.98	0.25
Marbling score[4]	471	466	460	17	0.65	0.96
12th rib fat, in	0.42	0.38	0.41	0.03	0.88	0.37
LM area, in^2	13.9	13.6	13.8	0.4	0.87	0.71
Calculated yield grade[5]	2.65	2.56	2.65	0.2	0.98	0.66

[1]Roughage level treatments: 7.5% = 40-SFC; 11.3% = 40-MID; 15% = 40-HIGH.
[2]Final BW = HCW / common dressing percent of 63%.
[3]F:G = 1 / G:F, analyzed as G:F.
[4]450 = Slight 50; 500 = Small 0; etc.
[5]Yield grade = 2.5 + 2.5(12th rib fat, in) – 0.32(LM area, in^2) + 0.2(KPH fat, %) + 0.0038(HCW, lb).

Table 4. Effect of dietary treatment on profitability of steers fed dry-rolled or steam-flaked corn with wet distillers grains (Corn = $5.50/bu and WDG = 80% the value of corn).

Item	0-DRC	20-DRC	40-DRC	0-SFC	20-SFC	40-SFC
Initial steer value[1], $	680.91	680.91	680.91	680.91	680.91	680.91
Feed cost[2], $	335.68	333.98	302.40	352.47	326.36	292.54
Total cost[3], $	447.32	446.95	414.46	465.42	439.13	404.12
Final steer value[4], $	1128.23	1212.04	1189.01	1191.77	1207.43	1169.67
Cost of gain[5], $	101.43	83.70	81.91	91.62	83.33	82.98
Breakeven[5], $	92.10	85.70	84.85	88.59	85.43	85.44
Profit/Loss, $	0.00	84.14	93.65	45.44	87.39	84.64
Profit/Loss[6], $	0.00	95.30	114.73	45.44	98.03	104.71
Profit/Loss[7], $	0.00	88.52	89.74	47.39	88.08	77.10
Profit/Loss[8], $	0.00	96.61	105.07	47.39	95.81	91.70

[1]Initial steer value determined using experiment average initial weight multiplied by $92.61/cwt.
[2]Feed cost = sum of treatment ingredient prices/lb over the feeding price, using DMI to determine intake; Ingredient price = ([DMI x % ingredient inclusion in each treatment] x ingredient price/lb).
[3]Total cost = diet cost + veterinary and medical + marketing + feedlot interest + animal interest + yardage.
[4]Live sale price = $92.10/cwt.
[5]All prices on a cwt basis.
[6]Profit/Loss: Corn = $5.50/bu and WDG = 65% the value of corn.
[7]Profit/Loss: Corn = $4.00/bu and WDG = 80% the value of corn.
[8]Profit/Loss: Corn = $4.00/bu and WDG = 65% the value of corn.

Total cost over the feeding period is primarily dictated by diet cost, which is determined by corn price and inclusion of WDG. The cost of corn processing is not affected by corn price; however, processing does affect total diet cost. Total diet cost was $15.83/steer higher in diets containing SFC than in diets containing DRC with 0% WDG. However, regardless of corn processing method, as the inclusion of WDG increased in the diet, total diet cost decreased $35.67/steer.

Performance results indicate steers consuming 0% WDG in SFC-based diets had an advantage in ADG and F:G versus steers consuming DRC-based diets. Additionally COG, BE and P/L favored SFC-based diets when the diet contained no WDG. COG was $8.85/cwt lower for steers consuming SFC versus DRC. In SFC-based diets a $3.59/cwt advantage in BE was observed compared to DRC-based diets. Reduced COG and BE corresponded to a $46.41/steer increase in profitability in steers consuming SFC versus DRC.

However, due to the response of WDG inclusion, the net reduction in COG and BE were greater in DRC- versus SFC-based diets. When comparing DRC- and SFC-based diets, the net reduction in COG and BE was realized when WDG was included at 20% or 40% diet DM versus traditional diets containing no WDG. COG was reduced $15.49 to $23.69/cwt in DRC-based diets, but $7.49 to 12.76/cwt in SFC-based diets. Similarly, BE was reduced $6.40 to $8.89/cwt in DRC-based diets, whereas in diets containing SFC, BE was reduced by $3.06 to $4.73/cwt.

Since WDG is priced lower relative to corn, reduced diet costs (by including WDG at 20% or 40% diet DM) are primarily responsible for increased profitability. Profitability increased $87.39 to $104.71/steer and $84.17 to $114.73/steer in SFC- and DRC-based diets containing 20% or 40% WDG, respectively. The greatest increase in profitability was observed in DRC-based diets with 40% WDG inclusion, which increased $114.73/steer over DRC-based diets containing 0% WDG.

In summary, optimum WDG inclusion in DRC-based diets was observed at 20% of diet DM, while in SFC-based diets there was no difference at 20% or 40% WDG inclusion. The response to WDG inclusion was greater in DRC- versus SFC- based diets. Also, adding roughage in diets containing SFC and WDG did not appear to positively influence performance. Results of the economic analysis indicated that SFC-based diets with no WDG had lower COG and BE and were more profitable than DRC-based diets with no WDG. However, the advantage of WDG inclusion was realized in DRC-based diets. DRC-based diets containing WDG have a greater net reduction in COG and BE than SFC-based diets containing WDG. Steers fed DRC and WDG were more profitable compared to those fed SFC-based diets containing WDG, as long as WDG was priced at 65% to 80% of the price of corn.

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Effects of Wet Corn Gluten Feed and Roughage Inclusion Levels in Finishing Diets Containing Modified Distillers Grains Plus Solubles

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Summary

A finishing trial evaluated wet corn gluten feed (WCGF) and roughage inclusion levels in diets containing 30% modified distillers grains plus solubles (MDGS, DM basis) using a 3 x 3 factorial treatment structure. No significant WCGF x roughage level interactions were observed. There was a quadratic response due to WCGF level for dry matter intake (DMI) and average daily gain (ADG), which were lowest for cattle fed 30% WCGF; however, feed-gain ratio (F:G) increased linearly with increasing WCGF. Gain responded quadratically and was lowest for cattle fed 0% corn silage. F:G and DMI increased linearly with increasing corn silage. Feedlot performance was improved by feeding 0% or 15% WCGF compared to 30% WCGF in finishing diets containing 30% MDGS. The optimal level was 7.5% corn silage in diets containing 30% MDGS with or without WCGF.

Introduction

Feedlots have the opportunity to utilize wet corn gluten feed (WCGF), wet distillers grains plus solubles (WDGS) or modified wet distillers grains plus solubles (MDGS). Combinations of WCGF and WDGS making up to 60% of the diet have been shown to improve cattle performance (*2007 Nebraska Beef Report*, pp. 25-28). Furthermore, WCGF is useful in managing acidosis, and it is beneficial to reduce or eliminate roughage levels in finishing diets when WCGF is included (*2004 Nebraska Beef Report*, pp. 61-63). However, in finishing diets containing WDGS, roughage inclusion is still necessary (*2007 Nebraska Beef Report*, pp. 29-32). One possible advantage of feeding a combination of WDGS and WCGF in finishing diets may be that WCGF inclusion could be used to replace roughage.

The objectives of the current study were to: 1) evaluate the effects of feeding WCGF in combination with 30% MDGS (DM basis), and 2) determine the optimum roughage level in diets containing 30% MDGS fed with or without WCGF.

Procedure

Four hundred fifty crossbred steer calves (body weight [BW] = 655 ± 45 lb) were used in a randomized complete block design. Upon arrival, steers were vaccinated and weaned on smooth bromegrass for 21-28 days. Steers were then allowed to graze sorghum stalks for 15 days. While on stalks, steers were supplemented with 5 lb/head/day of WCGF. Steers were brought back to the feedlot five days before initiation of the trial and limit-fed a diet consisting of 50% WCGF and 50% grass hay (DM basis) at 2% of body weight. On day 0 and day 1, steers were individually weighed in order to get an accurate initial BW, and all steers were implanted with Synovex-Choice (Fort Dodge Animal Health, Fort Dodge, Iowa) on day 1. On day 64, steers were re-implanted with Synovex-Choice and poured with Durasect II (Pfizer Animal Health, New York, N.Y.). The weights from day 0 were used to assign steers to treatment. Steers were blocked by BW into three blocks, stratified by BW within block and assigned randomly to one of 45 pens (10 steers/pen). Pens were assigned randomly to one of nine finishing diets (5 pens/diet). During the trial, four steers were removed due to death and one steer was removed for other health reasons. All causes of removal from trial were determined to be unrelated to treatments.

All diets (Table 1) contained 30% MDGS, a mixture of dry-rolled and

Table 1. Composition of finishing diets and formulated nutrient analysis.[1]

Roughage Level[2]:	0			7.5			15		
WCGF Level:	0	15	30	0	15	30	0	15	30
DRC[3]	32.50	25.00	17.50	28.75	21.25	13.75	25.00	17.50	10.00
HMC	32.50	25.00	17.50	28.75	21.25	13.75	25.00	17.50	10.00
MDGS	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
WCGF	—	15.00	30.00	—	15.00	30.00	—	15.00	30.00
Corn silage	—	—	—	7.50	7.50	7.50	15.00	15.00	15.00
Dry Supplement[4]	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Formulated Nutrient Composition									
Crude Protein, %	16.2	17.9	19.5	16.2	17.8	19.4	16.1	17.7	19.3
Ca, %	0.68	0.69	0.70	0.70	0.71	0.72	0.71	0.72	0.74
P, %	0.45	0.54	0.64	0.45	0.54	0.63	0.45	0.54	0.63
K, %	0.60	0.73	0.86	0.67	0.80	0.92	0.73	0.86	0.99
S, %	0.31	0.35	0.39	0.31	0.35	0.39	0.31	0.35	0.39
Ether Extract, %	6.72	6.63	6.54	6.67	6.58	6.49	6.61	6.52	6.43

[1]Values presented on a DM basis.
[2]Dietary inclusion levels of corn silage in the finishing diet were 0, 7.5 or 15.0% of diet DM.
[3]DRC = dry-rolled corn; HMC = high-moisture corn; MDGS = modified distillers grains plus solubles; WCGF = wet corn gluten feed.
[4]All diets were formulated to provide 360 mg/steer daily Rumensin®, 90 mg/steer daily Tylan®, and 130 mg/steer daily thiamine.

Table 2. **Effects of WCGF inclusion level on performance and carcass characteristics of steers fed finishing diets containing 30% MDGS.**

WCGF Inclusion Level[1]:	0.0	15.0	30.0	Lin[2]	Quad[3]
Performance					
Initial BW, lb	655	656	655	0.83	0.58
Final BW, lb[4]	1329	1332	1299	< 0.01	< 0.01
DMI, lb/day	22.28	22.48	22.01	0.15	0.04
ADG, lb	4.03	4.05	3.86	< 0.01	< 0.01
F:G[5]	5.52	5.54	5.70	< 0.01	0.13
Carcass Characteristics					
HCW, lb	837	839	818	< 0.01	< 0.01
12th rib fat, in	0.56	0.58	0.53	0.10	0.07
LM area, in^2	14.1	14.0	14.2	0.81	0.35
Marbling score[6]	511	512	487	0.03	0.15
Choice or above, %	51.6	53.6	41.6	0.11	0.19
Yield grade[7]	2.97	3.05	2.79	0.02	0.01
Liver abscesses, %	0.07	0.05	0.06	0.72	0.66

[1]Dietary inclusion levels of WCGF in the finishing diet (DM basis).
[2]Contrast for the linear effect of WCGF inclusion level *P*-value.
[3]Contrast for the quadratic effect of WCGF inclusion level *P*-value.
[4]Final BW calculated as hot carcass weight divided by a common dressing percentage of 63%.
[5]Analyzed as gain:feed, reciprocal of feed conversion.
[6]Marbling score: 400 = Slight 0, 450 = Slight 50, 500 = Small 0, etc.
[7]Yield grade: 2.50 + (0.0038*HCW, lb) + (0.2*2.0% KPH) + (2.5*12th rib fat, in) - (0.32*LM area, in^2).

Table 3. **Effects of roughage inclusion level on performance and carcass characteristics of steers fed finishing diets containing 30% MDGS.**

Roughage Inclusion Level[1]:	0	7.5	15.0	Lin[2]	Quad[3]
Performance					
Initial BW, lb	656	655	655	0.13	0.23
Final BW, lb[4]	1296	1330	1335	<0.01	0.01
DMI, lb/day	21.06	22.36	23.35	<0.01	0.33
ADG, lb	3.83	4.04	4.07	<0.01	<0.01
F:G[5]	5.49	5.53	5.73	<0.01	0.06
Carcass Characteristics					
HCW, lb	816	838	841	<0.01	0.01
12th rib fat, in	0.51	0.57	0.58	<0.01	0.25
LM area, in^2	14.2	14.1	14.0	0.40	0.74
Marbling score[6]	490	503	517	0.02	0.90
Choice or above, %	40.9	48.2	57.6	0.01	0.85
Yield grade[7]	2.75	2.98	3.08	<0.01	0.32
Liver abscesses, %	0.09	0.06	0.04	0.19	0.90

[1]Dietary inclusion levels of corn silage in the finishing diet were 0, 7.5 or 15.0% of diet DM.
[2]Contrast for the linear effect of roughage inclusion level *P*-value.
[3]Contrast for the quadratic effect of roughage inclusion level *P*-value.
[4]Final BW calculated as hot carcass weight divided by a common dressing percentage of 63%.
[5]Analyzed as gain:feed, reciprocal of feed conversion.
[6]Marbling score: 400 = Slight 0, 450 = Slight 50, 500 = Small 0, etc.
[7]Yield grade: 2.50 + (0.0038*HCW, lb) + (0.2*2.0% KPH) + (2.5*12th rib fat, in) - (0.32*LM area, in^2).

high-moisture corn fed at a 1:1 ratio, and 5% supplement (DM Basis). Treatments were arranged as a 3 x 3 factorial and the factors included in this study were WCGF (ADM, Columbus, Neb.) levels of 0%, 15% or 30% on DM basis and roughage levels of 0%, 7.5% or 15% inclusion. Corn silage was used as the roughage source. Diets were formulated to contain 0.65 % calcium and 0.60% potassium and to supply 360 mg/steer Rumensin® (Elanco Animal Health, Greenfield, Ind.), 90 mg/steer Tylan® (Elanco Animal Health), and 130 mg/steer thiamine daily.

Cattle were adapted to grain by feeding 37.5%, 27.5%, 17.5%, 7.5% and 3.75% alfalfa hay, which replaced the corn mixture in the finishing diets, for 3, 4, 6, 6 and 5 days, respectively. The first four steps included 15% corn silage and were formulated to supply 45%, 35%, 25% and 15% roughage (DM basis). For step 5, corn silage was reduced from 15% to 7.5% for finishing diets containing 0% or 7.5% corn silage. Corn silage was assumed to be 50% forage and 50% grain (DM basis). Steers were fed once daily and allowed *ad libitum* access to feed and water. Cattle were fed for 167 days (December 13, 2007 to May 27, 2008) and harvested at a commercial packing plant (Greater Omaha Pack, Omaha, Neb.). Hot carcass weight and liver scores were collected the day of harvest; 12th rib fat, LM area and USDA marbling score were collected following a 24-hour chill. Yield grade was calculated using the following equation: YG = 2.50 + (0.0038*HCW, lb) + (0.2*2.0% KPH) + (2.5*12th rib fat, in) - (0.32*LM area, in^2) (*Meat Industry Handbook*, 2001). Final BW, ADG and F:G were calculated using hot carcass weight divided by an average dressing percentage of 63%.

Data were analyzed using the MIXED procedure of SAS (Version 9.1, SAS Inc., Cary, N.C.) as a 3 x 3 factorial treatment design. Factors included in the model were WCGF, roughage inclusion level and WCGF x roughage inclusion level interaction. The random variable was weight block. Pen served as the experimental unit. Orthogonal contrasts were used to detect linear and quadratic relationships for the main effect of WCGF level and the main effect of roughage level if no interaction was detected. If an interaction occurred, only simple effects were tested.

Results

The hypothesis was that cattle performance would improve with increasing WCGF level and decreasing roughage levels. Interestingly, this was not the case, as no significant WCGF x roughage inclusion level interactions were observed. Therefore, only main effects of either WCGF level or roughage level are presented. For the

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main effect of the WCGF inclusion level (Table 2), there was a quadratic ($P < 0.05$) response for final BW, ADG and DMI. Final BW, ADG and DMI were highest for cattle fed 15% WCGF and lowest for cattle fed 30% WCGF. As the WCGF inclusion level increased, F:G increased linearly ($P < 0.01$).

For the main effect of the roughage inclusion level (Table 3), there was a quadratic ($P < 0.02$) effect on final BW and ADG, and both were lowest for cattle fed 0% roughage. As the roughage inclusion level increased, DMI and F:G increased (linear; $P < 0.01$). However, F:G was highest for cattle fed 15% corn silage (quadratic; $P = 0.06$). The observed increase in DMI due to increasing roughage level is common and likely due to acidosis control if ADG improves (7.5% silage) or may be due to an energy dilution effect whereby the cattle are attempting to eat to a constant energy level (15% corn silage) if ADG is maximal.

The only observed carcass characteristic differences within WCGF level were HCW, marbling score and yield grade. There was a quadratic ($P < 0.01$) response for HCW and yield grade, which was numerically highest for cattle fed 15% WCGF. There was a linear ($P = 0.03$) decrease for marbling score as the inclusion level of WCGF increased. No differences due to the WCGF inclusion level were observed in incidence of liver abscesses, 12th rib fat thickness, LM area or percentage choice. Roughage level had a quadratic ($P = 0.01$) effect on HCW, which was lowest for cattle fed 0% roughage. A linear ($P < 0.05$) increase due to increasing roughage level was observed for 12th rib fat thickness, marbling score, yield grade and percentage choice. The incidence of liver abscesses and LM area were not affected by roughage level.

These data suggest performance was similar for cattle fed either 0% or 15% WCGF, and cattle performance decreased when feeding 30% WCGF in finishing diets containing 30% MDGS. These results are in agreement with previous research at Nebraska (*2007 Nebraska Beef Report*, pp. 25-26). The previous study also evaluated a control diet without co-products; cattle fed 30% WDGS with 30% WCGF had improved performance compared to the control, but performance was not as good as 30% WDGS alone. In the current study, when roughage was excluded (0%), DMI, ADG and 12th rib fat thickness were decreased compared to diets containing 7.5% or 15% corn silage. These results are in agreement with previous research in which roughage was eliminated from finishing diets containing 30% WDGS (*2007 Nebraska Beef Report*, pp. 29-32).

In summary, feeding 0% or 15% WCGF with 30% MDGS improved cattle performance, compared to feeding 30% WCGF with 30% MDGS. Furthermore, it appears that the optimum roughage level is 7.5% of diet DM when using corn silage in finishing diets containing 30% MDGS with or without WCGF.

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Effects of Roughage Source and Level with the Inclusion of Wet Distillers Grains on Ruminal Metabolism and Nutrient Digestibility

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Summary

Six ruminally cannulated steers were used in a 6 x 6 Latin square with treatments arranged as a 2 x 3 factorial with alfalfa hay or cornstalks included at a normal, low or zero level on an equal neutral detergent fiber (NDF) basis. The base finishing diet contained 30% wet distillers grains plus solubles (WDGS). No source x level interactions were observed. Roughage source had no effect on nutrient intake, dry matter (DM) and organic matter (OM) digestibility or ruminal pH. Digestibility of NDF tended to be higher for alfalfa hay compared to cornstalks. Ruminal pH, DMI and NDF intake increased linearly while nutrient digestibility decreased linearly as roughage level increased. These data indicate that in finishing diets containing 30% wet distillers grains plus solubles (WDGS) roughages can be exchanged on an equal NDF basis and it is not beneficial to completely eliminate roughage sources from the diet.

Introduction

Roughages have been used to control acidosis in feedlot diets. However, corn-milling byproducts may help manage acidosis, suggesting roughages may be reduced or eliminated. Roughage source and level were evaluated and compared to no roughage inclusion in finishing diets containing 30% (DM basis) WDGS (*2007 Nebraska Beef Report*, pp. 29-32). Higher roughage levels increased DMI and average daily gain (ADG), and elimination of roughage resulted in decreased DMI and ADG. Diets containing no roughage or low levels of cornstalks tended to have the lowest feed-to-gain ratio (F:G). Overall, the previous study indicated that at high roughage levels, sources can be exchanged on an equal NDF basis in diets containing 30% WDGS. The objectives of the current study were to determine the effects of roughage source and level on nutrient digestion and ruminal fermentation characteristics.

Procedure

Six ruminally cannulated steers (BW = 762 lb) were used in a 6 x 6 Latin square to determine the effects of roughage source and level in feedlot diets containing WDGS. Treatments were arranged as a 2 x 3 factorial treatment structure with alfalfa hay included at 0%, 4% or 8% and cornstalks included at 0%, 3% or 6% on a DM basis (Table 1). Alfalfa and cornstalks averaged 57.2% and 78.8% NDF, respectively, and dietary treatments were balanced to provide equal percentages of NDF from roughage at each level. All diets contained a mixture of dry-rolled and high-moisture corn fed at a 1:1 ratio and 30% WDGS (DM basis).

Periods were 14 days in length, including a 9-day adaptation period followed by a 5-day collection period to measure ruminal digestibility, fermentation, pH and DMI. Steers were fed individually in pens during the adaptation period and moved into stanchions on day 9 for the collection period. Steers were fed once daily at 0730, and feed refusals were collected daily if present. Chromic oxide (7.5g/dose) was used as an indigestible marker for estimating fecal output and was dosed intraruminally at 0700 and 1900 daily from day 6 through day 14 of each period. Fecal grab samples were collected three times daily during the collection period at 0, 6 and 12 hours post-feeding. Feed intake patterns and ruminal pH measurements were collected as described in the *1998 Nebraska Beef Report,* pp. 71-75. Feed intake measurements included DMI, number of meals per day, total time spent eating and intake rate. Ruminal pH measurements included average, maximum and minimum pH, magnitude of pH change, pH variance, time spent below pH 5.6 and 5.3, and area of pH below 5.6 and 5.3 (time below x magnitude below). Feed ingredients, feed refusals and

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Table 1. Composition of finishing diets.[1]

Roughage Source	Alfalfa			Cornstalks		
Roughage Level[2]:	0	4	8	0	3	6
DRC[3]	32.50	30.50	28.50	32.50	30.98	29.46
HMC[3]	32.50	30.50	28.50	32.50	30.98	26.46
WDGS[3]	30.0	30.0	30.0	30.0	30.0	30.0
Alfalfa hay	—	4.00	8.00	—	—	—
Cornstalks	—	—	—	—	3.04	6.08
Dry supplement[4]	5.0	5.0	5.0	5.0	5.0	5.0
Roughage NDF, %[5]	0.00	2.62	5.25	0.00	2.56	5.11

[1]Values presented on a DM basis.
[2]Percent of diet DM.
[3]DRC = dry-rolled corn; HMC = high-moisture corn; WDGS = wet distillers grains plus solubles.
[4]All diets were formulated to contain a minimum of 0.65 % Ca, 0.60% K, 360 mg/steer daily Rumensin®, 90mg/steer daily Tylan® and 130mg/steer daily thiamine.
[5]NDF supplied from roughage source included in the diet.

Table 2. Main effects of roughage source and level on nutrient intake and digestibility.

	Roughage Source		Roughage Level[1]				*P*-Value[2]		
Item	Alfalfa	Cornstalks	0	3-4	6-8	SEM	Source	Lin.	Quad.
Nutrient Digestibility									
DM									
Intake, lb/day	20.9	20.6	19.4	20.9	21.9	1.4	0.73	0.05	0.83
Digestibility, %	84.4	83.3	86.9	82.7	81.9	0.1	0.30	< 0.01	0.14
OM									
Intake, lb/day	20.5	19.4	19.1	20.5	20.2	0.60	0.23	0.33	0.37
Digestibility, %	85.5	84.5	88.1	84.0	82.9	0.1	0.35	< 0.01	0.18
NDF									
Intake, lb/day	5.04	4.75	4.20	5.04	5.43	0.15	0.19	< 0.01	0.30
Digestibility, %	75.9	72.9	77.3	73.1	72.8	0.1	0.10	0.06	0.31
Intake Patterns									
Meals/day	11.7	12.5	12.1	12.5	11.8	0.7	0.18	0.57	0.37
Time eating/day, minutes	572	573	570	587	561	27	0.93	0.72	0.28
Rate, %/hour	18.9	18.4	18.3	17.3	20.3	1.4	0.77	0.32	0.22

[1]Percent of diet DM.
[2]No differences ($P > 0.20$) due to roughage source x level interaction; Source = main effects of alfalfa versus cornstalks; Lin.= contrast for the linear effect of roughage inclusion level; Quad. = contrast for the quadratic effect of roughage inclusion level.

Table 3. Main effects of roughage source and level on ruminal pH.

	Roughage Source		Roughage Level[1]				*P*-Value[2]		
Item	Alfalfa	Cornstalks	0	3-4	6-8	SEM	Source	Lin.	Quad.
Average pH	5.48	5.52	5.31	5.49	5.70	0.12	0.74	0.01	0.93
Maximum pH	6.14	6.19	5.93	6.11	6.45	0.13	0.73	0.01	0.57
Minimum pH	4.82	4.94	4.47	5.10	5.08	0.22	0.59	0.05	0.17
pH change	1.31	1.24	1.45	1.01	1.37	0.25	0.87	0.80	0.16
pH variance	0.068	0.079	0.064	0.054	0.102	0.025	0.70	0.27	0.33
Time < 5.6, min/day	907	884	1116	919	652	168	0.89	0.02	0.81
Area < 5.6, min/day[3]	331	351	486	343	195	122	0.80	0.01	0.98
Time < 5.3, min/day	511	519	741	519	285	215	0.95	0.01	0.97
Area < 5.3, min/day[3]	119	139	208	123	56	67	0.65	0.02	0.84

[1]Percent of diet DM.
[2]No differences ($P > 0.26$) due to roughage source x level interaction; Source = main effects of alfalfa versus cornstalks; Lin.= contrast for the linear effect of roughage inclusion level; Quad. = contrast for the quadratic effect of roughage inclusion level.
[3]Area below pH of 5.6 or 5.3 is calculated as time below x magnitude below.

fecal samples were freeze-dried for analysis to calculate nutrient digestibility.

Data were analyzed as a 2 x 3 factorial treatment arrangement and Latin square experimental design using the MIXED procedure of SAS. Period was included in the model as a fixed effect, and the random effect was steer. Orthogonal contrasts were used to detect linear and quadratic relationship for the main effect of roughage level if no interaction was detected. If an interaction occurred, only simple effects were tested.

Results

There were no effects on nutrient intake or digestibility due to roughage source x level interactions ($P > 0.20$); therefore, all nutrient intake and digestibility data are presented showing only main effects of roughage source and level (Table 2). There were no differences ($P > 0.18$) for nutrient intake and digestibility between alfalfa hay and cornstalks except for NDF digestibility, which tended to be higher ($P = 0.10$) for alfalfa hay (75.9%) compared to cornstalks (72.9%). Increasing roughage level resulted in a linear increase ($P = 0.05$) in DMI (19.4 lb to 21.9 lb) and NDF intake (1.91 lb to 2.47 lb). Organic matter intake was similar among roughage levels. As roughage level increased, there was a linear decrease in DM (86.9% to 81.9%), OM (88.1% to 82.9%) and NDF (77.3% to 72.8%) digestibility. There were no effects on intake patterns due to roughage source, roughage level or roughage source x level interaction. For alfalfa hay and cornstalks, intake rate was 18.9% and 18.4%, respectively. Intake rate was 18.3%, 17.3% and 20.3% for zero, low and high roughage inclusion levels, respectively.

There were no effects of roughage source or roughage source x level interaction on ruminal pH, so only main effects of roughage source and roughage level are presented in Table 3. For alfalfa hay and cornstalks, ruminal pH averaged 5.48 and 5.52, respectively. Ruminal pH ranged from 4.82 to 6.14 for alfalfa hay and from 4.94 to 6.19 for cornstalks. Average, maximum and minimum ruminal pH increased linearly (*P* = 0.01) due to increasing roughage levels. The pH change or the difference between maximum and minimum pH, as well as pH variance remained fairly constant across roughage levels. Time spent below pH 5.6 or 5.3 and area below 5.6 and 5.3 both decreased linearly (*P* < 0.03) due to increasing roughage levels. A ruminal pH below 5.6 is defined as subacute acidosis. For steers consuming diets containing 0% roughage, ruminal pH was below 5.6 for 1116 minutes/day and below 5.3 for 731 minutes/day. That corresponds to over 18 hours a day that these steers experienced subacute acidosis, and over 12 hours a day were spent at a pH of less than 5.3. When roughage levels were increased to 3-4% and 6-8%, time spent below pH 5.6 was reduced 18% and 42%, respectively.

In conclusion, roughage source did not affect ruminal metabolism or intake patterns. These results agree with observations made in the previous finishing trial and indicate roughages can be exchanged on an equal NDF basis in finishing diets containing 30% WDGS. Nutrient intake and ruminal pH increased linearly due to increasing roughage levels while nutrient digestibility decreased linearly. When 0% roughage was included in the diet, DMI and ruminal pH were markedly reduced, compared to diets containing 3-8% roughage, which is in agreement with observations made in the previous finishing trial. These results further support the finding that it is not beneficial to completely eliminate roughage sources from a finishing diet containing 30% WDGS (DM basis).

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Effects of Feeding High Levels of Byproducts in Different Combinations to Finishing Steers

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Summary

A finishing experiment was conducted to determine the effects of feeding wet distillers grains plus solubles (WDGS) and wet corn gluten feed (WCGF) with or without corn on feedlot performance and economics. Six treatment diets were evaluated: 1) 83% corn; 2) 44% WDGS and 44% corn; 3) 33% WDGS, 33% WCGF and corn; 4) 33% WDGS, 33% WCGF and soyhulls; 5) 44% WDGS and 44% WCGF; and 6) 66% WDGS and grass hay. The highest average daily gain (ADG) and lowest feed-to-gain ratio (F:G) were observed with cattle fed 44% WDGS and corn. The poorest ADG and F:G were observed with cattle fed WDGS, WCGF and soyhulls. All other diets were intermediate in performance. Largest profit was from steers fed 44% WDGS and corn.

Introduction

Wet distillers grains plus solubles (WDGS) and wet corn gluten feed (WCGF) can replace corn in feedlot diets and will generally improve performance when fed up to 30% to 40% of the diet (*2008 Nebraska Beef Report*, pp. 35-36; *2008 Nebraska Beef Report*, pp. 33-34; *2007 Nebraska Beef Report*, pp. 25-26; *2007 Nebraska Beef Report*, pp. 27-28), and are often cheaper than corn. The objective of the current study was to evaluate performance, carcass characteristics and economics when finishing cattle on diets containing WDGS or combinations of WDGS and WCGF at inclusions much greater than those studied in previous research.

Procedure

Finishing Performance

A finishing trial was conducted at the University of Nebraska Research Feedlot near Mead, Neb., using 288 yearling crossbred steers (BW = 823 ± 27 lb). Prior to initiation, steers were limit fed for five days to minimize gut fill differences. On day 0 and day 1, individual steer initial BW data were collected. Steers were blocked by BW, stratified within block and assigned randomly to pen. With eight steers per pen, pen was assigned randomly to one of six diet treatments. A total of 36 pens were utilized to provide six replications per treatment.

The six treatments included: 1) control (CORN) of 82.5% dry-rolled corn (DRC) and 5.0% molasses; 2) 43.8% WDGS and 43.8% DRC (WDGS:corn); 3) low blend with 32.8% WDGS, 32.8% WCGF and 21.9% DRC (LowBlend:corn); 4) soyhulls blend with 32.8% WDGS, 32.8% WCGF and 21.9% soyhulls (LowBlend:hulls); 5) high blend with 43.8% WDGS and 43.8% WCGF (HighBlend); and 6) 65.6% WDGS and 21.9% grass hay (WDGS:hay) all on a DM basis (Table 1). All diets contained 5.0% supplement and 7.5% alfalfa hay. WDGS was purchased at a commercial corn dry-milling plant (Abengoa Bioenergy, York, Neb.) and contained 32% dry matter (DM), 31.6% crude protein (CP), 13.8% fat and 0.75% sulfur. WCGF (SweetBran®, Cargill, Blair, Neb.) contained 26.7% protein, 4.7% fat and 0.56% sulfur. The supplement used for CORN was formulated to have a diet CP of at least 13.0% and included 1.10% urea. Supplement for the byproduct diets was calculated to keep the Ca:P ratio at 1.2 to 1. Supplements also were formulated to provide Rumensin® (Elanco Animal Health) at 320 mg/steer/day, Tylan® (Elanco Animal Health) at 90 mg/steer/day, and thiamine at 130 mg/steer/day.

Steers were adapted to diets for 21 days and received a delayed implant of Revalor-S (Intervet, Millsboro, Del.) 28 days after trial initiation. Steers were fed for 141 days and were slaughtered at a commercial abattoir (Greater Omaha, Omaha, Neb.). Hot carcass weights (HCW) and liver scores were collected on the day of slaughter. After a 48-hour chill, LM area, 12th rib fat thickness and USDA marbling scores were recorded. USDA yield grade (YG) was calculated from HCW, fat depth, LM area and an assumed 2.5% kidney, pelvic and heart fat (KPH). A common dressing percentage (63%) was used to calculate the carcass adjusted performance of final BW, ADG and feed efficiency. Feed efficiency was analyzed as G:F and presented here as F:G.

Lab Analysis

Weekly feed samples were taken and DM tested using a 60^o forced air oven for 48 hours. Composite samples for each ingredient over the feeding period were analyzed for CP, fat and

Table 1. Diet composition of six dietary treatments fed to finishing yearlings (all values on % of diet DM).

Ingredient	CORN	WDGS: corn	Low Blend: corn	Low Blend: hulls	High Blend	WDGS: hay
Alfalfa	7.5	7.5	7.5	7.5	7.5	7.5
DRC[1]	82.5	43.8	21.9	—	—	—
WDGS[2]	—	43.8	32.8	32.8	43.8	65.6
WCGF[3]	—	—	32.8	32.8	43.8	—
Soyhulls	—	—	—	21.9	—	—
Grass hay	—	—	—	—	—	21.9
Molasses	5.0	—	—	—	—	—
Supplement	5.0	5.0	5.0	5.0	5.0	5.0
% diet CP	13.0	19.5	22.6	23.5	26.7	24.3
% diet fat	3.72	8.06	7.16	6.54	8.23	9.64
% diet sulfur	0.153	0.403	0.474	0.476	0.587	0.549

[1]Dry-rolled corn.
[2]Wet distillers grains plus solubles.
[3]Wet corn gluten feed.

Table 2. Effect of byproduct finishing diets on performance and carcass characteristics.

Treatment[1]	CORN	WDGS: corn	Low Blend: corn	Low Blend: hulls	High Blend	WDGS: hay	SEM	P-value
Performance[2]								
IW, lb	823	823	822	824	824	821	1	0.12
FW, lb	1392[b]	1453[a]	1409[b]	1349[c]	1383[b]	1388[b]	17	< 0.01
DMI, lb/d	26.1[xy]	25.2[yz]	26.1[xy]	25.8[xyz]	24.8[z]	26.6[x]	0.6	0.06
ADG, lb	4.03[b]	4.47[a]	4.16[b]	3.73[c]	3.97[b]	4.03[b]	0.12	< 0.01
F:G	6.48[bc]	5.65[a]	6.28[b]	6.93[d]	6.26[b]	6.61[c]	0.13	< 0.01
Carcass Characteristics[3]								
HCW, lb	877[b]	916[a]	888[b]	850[c]	871[b]	875[b]	8	< 0.01
Marb	516[a]	513[a]	502[a]	460[b]	492[a]	491[a]	13	< 0.01
LM area, sq. in.	14.1	13.8	13.7	13.5	13.6	13.6	0.3	0.35
12th rib fat, in.	0.43[a]	0.52[bc]	0.55[c]	0.46[ab]	0.51[bc]	0.52[bc]	0.03	< 0.05
Yield grade	2.9[a]	3.4[b]	3.4[b]	3.1[ab]	3.2[b]	3.3[b]	0.1	< 0.05

[1]CORN = control diet of 82.5% DRC; WDGS:corn = 43.8% WDGS and 43.8% DRC; LowBlend:corn = 32.8% WDGS, 32.8% WCGF, 21.9% DRC; LowBlend:hulls = 32.8% WDGS, 32.8% WCGF, 21.9% soyhulls; HighBlend = 43.8% WDGS and 43.8% WCGF; WDGS:hay = 32.8% WDGS, 32.8% WCGF, 21.9% grass hay.
[2]IW = initial weight; FW = final weight; DMI = dry matter intake; ADG = average daily gain; F:G = lb of feed consumed per lb of weight gained.
[3]HCW = hot carcass weight; Marb = marbling score: 400 = slight 0, 500 = small 0, etc.; LM area = longissimus dorsi muscle area; Yield grade = calculated USDA yield grade (yield grade = 2.5 + (2.5*12th rib fat) + (0.2*KPH%) + (0.0038*HCW) – (0.32*ribeye area).
[a,b,c,d]Within a row, means without common superscript differ ($P < 0.05$).
[x,y,z]Row tends to differ ($P = 0.06$), means without common superscript differ ($P < 0.05$).

sulfur (S). The combustion method was used for CP analysis (AOAC 990.03). Fat was analyzed using a gravimetric fat procedure modified at the University of Nebraska. Samples were sent to a commercial laboratory for sulfur analysis. Diet CP, fat and sulfur are presented in Table 1.

Finishing Economics

Economic analysis was performed on all six diets using 2007 average prices from Livestock Market News, AMS-USDA. Initial steer price was calculated as average initial BW of pen multiplied by 2007 USDA Nebraska auction market price ($107.74/cwt). Final steer price was calculated similarly with average live final BW of pen multiplied by 2007 USDA Nebraska auction market price ($92.10/cwt). Average 2007 prices were used for DRC ($3.91/bu DM); WDGS ($133.24/ton DM; 95% corn price); WCGF ($126.00/ton DM; 90% corn price); soyhulls ($115.24/ton DM); grass hay ($80/ton DM); and alfalfa hay ($120/ton DM). Yardage was charged at $0.35 per steer daily with health and processing costs of $20 per steer and a death loss of 1.5%. Interest was estimated as 7.5% for feed costs and initial steer cost. Total production costs included total feed costs with interest; all health, processing and death loss costs; and initial steer cost with interest. Cost of gain (COG) was calculated by dividing total finishing cost by average gain per pen. Slaughter breakeven (BE) was calculated by dividing the total cost of production by the carcass-adjusted final BW. Profit or loss (P/L) was calculated by subtracting the total cost of production from the final steer value.

The effects of increasing corn price at $3.50, $4.50 and $5.50 /bu also were analyzed, with WDGS considered at three different percentages of corn price (65%, 75% and 85%). All other feed prices remained the same, and WCGF was priced at 90% the price of corn. Calf prices were adjusted for the control diet to break even on production.

Statistical Analysis

All data were analyzed using MIXED procedures of SAS as a randomized complete block design with pen as the experimental unit. The effects of treatment and block were included in the model. Treatment means were compared using a protected F-test and means separation when the F-test statistic was significant.

Results

Five steers were treated with thiamine for polioencephomalacia (polio) and recovered, but were removed from the study. Four of these steers were on the HighBlend diet and one was on the LowBlend:hulls diet. Four steers died, two due to causes unrelated to treatment and two due to polio; one was on the LowBlend:hulls diet (diet S of 0.48%) and the other was on the HighBlend diet (diet S of 0.59%). No steers were diagnosed with polio on the WDGS:hay diet, despite a dietary S of 0.55%.

Steers fed WDGS:hay had greater DMI (Table 2) than those fed WDGS:corn and HighBlend ($P < 0.01$). Intake for steers fed HighBlend was the lowest compared to all diets ($P < 0.01$). ADG was greatest for steers fed WDGS:corn and least for steers fed LowBlend:hulls. Steers fed WDGS:corn had lower F:G compared to all other diets ($P < 0.01$). Steers fed LowBlend:hulls had the highest F:G ($P < 0.01$). Interestingly, steers fed WDGS:hay and HighBlend and steers fed CORN had similar ADG and F:G. This analysis was performed with the animals remaining after eliminating from treatment those that died or were removed. The results would not be as favorable for steers fed HighBlend or steers fed LowBlend:hulls if the deads and removals had been included in the analysis.

Steers fed LowBlend:hulls had the lowest marbling scores and were statistically different ($P < 0.01$) from all other diets. Fat thickness was greatest for steers fed LowBlend:corn and lowest for those fed CORN. Steers fed CORN were also significantly different ($P < 0.05$) from all other diets for fat thickness and had the lowest calculated Yield Grade (YG). Only steers fed LowBlend:hulls were similar to CORN fed steers for calculated YG ($P > 0.05$).

(Continued on next page)

Table 3. Effect of byproduct finishing diets on economics.

Treatment[1]	CORN	WDGS: corn	Low Blend: corn	Low Blend: hulls	High Blend	WDGS: hay	SEM	*P*-value
Deads out[2]								
BE, \$/cwt[4]	91.91[cd]	87.41[a]	90.07[b]	93.24[d]	90.74[bc]	90.41[bc]	0.91	< 0.01
COG, \$/cwt[5]	69.02[c]	60.69[a]	65.02[b]	70.52[c]	65.19[b]	65.02[b]	1.38	< 0.01
P/L, \$/hd[6]	6.64[cd]	70.63[a]	30.43[b]	-14.69[d]	19.31[bc]	24.27[bc]	12.16	< 0.01
Deads in[3]								
BE, \$/cwt[4]	91.49[ab]	86.99[a]	89.66[a]	96.82[b]	103.66[c]	89.99[ab]	3.40	< 0.01
COG, \$/cwt[5]	67.55[a]	59.21[a]	63.55[a]	79.05[a]	103.88[b]	63.55[a]	10.54	< 0.01
P/L, \$/hd[6]	10.76[ab]	74.74[a]	34.54[a]	-56.54[bc]	-126.73[c]	28.38[a]	37.09	< 0.01

[1]CORN = control diet of 82.5% DRC; WDGS:corn = 43.8% WDGS and 43.8% DRC; LowBlend:corn = 32.8% WDGS, 32.8% WCGF, 21.9% DRC; LowBlend:hulls = 32.8% WDGS, 32.8% WCGF, 21.9% soyhulls; HighBlend = 43.8% WDGS and 43.8% WCGF; WDGS:hay= 32.8% WDGS, 32.8% WCGF, 21.9% grass hay.
[2]Dead or removed cattle due to treatment (9 total) not included in performance analysis to calculate economic value of treatments.
[3]Dead or removed cattle due to treatment (9 total) included in performance analysis to calculate economic value of treatments.
[4]Breakeven = (initial steer cost (\$107.74/cwt) + feed cost[7] + interest[8] + health&processing[9] + yardage[10] + death loss[11]) / FW.
[5]Cost of Gain = (feed cost[7] + interest[8] + health&processing[9] + yardage[10] + death loss[11]) / (FW-IW).
[6]Profit/Loss = final steer value (\$92.10/cwt) – (initial steer cost (\$107.74/cwt) + feed cost[7] + interest[8] + health&processing[9] + yardage[10] + death loss[11]).
[7]WDGS (\$133.24/ton DM); WCGF (\$126/ton DM); DRC (\$3.91/bu); alfalfa (\$120/ton DM); grass hay (\$80/ton DM); soyhulls (\$115.24/ton DM)
[8]7.5% interest applied to initial steer value (initial BW *107.74/cwt) and to feed costs.
[9]\$20/steer applied.
[10]\$0.35/steer/d applied.
[11]1.5% death loss applied.
[a,b,c,d]Within a row, means without common superscript differ (*P* < 0.05).

Due to cattle deaths and removals, economics were analyzed with these cattle not included (deads out) in performance calculations and with them included, as well (deads in).

As seen in Table 3, with deads out, WDGS:corn had the lowest breakeven price, along with the lowest cost of gain, and was statistically different (*P* < 0.01) from all other diets. LowBlend:hulls had the highest BE and highest COG (*P* < 0.01). Although economics were statistically similar to CORN, the performance of the steers fed LowBlend:hulls was much poorer. Another comparison of CORN to WDGS:hay was interesting as both sets of steers performed similarly in the feedlot, but the grass hay-fed steers had a higher profit due to the price of corn.

With deads and removals included in the analysis, cattle fed HighBlend and LowBlend:hulls showed much lower profit than all other treatments. Steers fed HighBlend initially showed a profit of \$19.31/head, but inclusion of cattle that died or were removed from treatment turned profit to a loss of -\$126.73/head. Steers fed LowBlend:hulls with deads out had a profit of -\$14.69/steer, which decreased to -\$56.54/head with deads in because of a death (and removal) rate of 12.5% and 4.2% for HighBlend and LowBlend:hulls, respectively.

Steers fed WDGS:corn had the greatest profit (Table 4) regardless of corn price. These steers were the most efficient and sold the most weight. Steers fed WDGS:hay performed similarly to steers fed CORN; however, their profitability was greater due to feeding a less expensive diet and selling the same amount of weight.

Table 4. Economic effects of increasing corn price in relationship to WDGS as a percent of corn price on profit or loss[1] per dietary treatment relative to steers fed corn.

Corn Price \$/bu	WDGS Price[2]	CORN	WDGS: corn	Low Blend: corn	Low Blend: hulls	High Blend	WDGS: hay
3.50	65	—	87.23	30.98	-20.27	19.65	50.45
	75	—	75.73	22.04	-29.11	8.34	32.25
	85	—	64.24	13.10	-37.94	2.98	14.05
4.50	65	—	92.72	31.74	-4.32	24.60	71.52
	75	—	77.94	20.25	-15.68	10.05	48.12
	85	—	63.16	8.76	-27.03	-4.51	24.72
5.50	65	—	98.22	32.50	11.64	29.55	92.60
	75	—	80.15	18.46	-2.24	11.77	64.00
	85	—	62.09	4.42	-16.12	-6.02	35.40

[1]Profit/Loss = final steer value (\$92.10/cwt) – (initial steer cost [price for CORN to breakeven] + feed cost + interest + health&processing + yardage + death loss).
[2]Price of WDGS as a % of corn price.

With the increasing price of corn, the WDGS:hay diet became increasingly competitive in relationship to the CORN and the WDGS:corn diets. With corn at \$5.50/bu and WDGS at 65% the price of corn, the WDGS:hay diet had nearly the same profitability as the WDGS:corn diet. Also, the WDGS:hay diet was consistently more profitable compared to the CORN diet at all price levels and percentages of WDGS.

From this study, we can conclude it is possible to feed byproduct diets with no corn and not forfeit feedlot performance compared to feeding corn diets. The best performance and economic results were observed with steers fed 44% WDGS with corn or a blend of WDGS and WCGF with corn, like the byproduct and corn combinations typical for Nebraska. Knowing that roughage can be substituted on an equal NDF basis (Benton et al., *2007 Nebraska Beef Report*, pp. 29-32), grass hay, alfalfa hay or even cornstalks need to be included at higher levels in diets with very large inclusions of WDGS to manage dietary S as shown with the 66% WDGS and hay diet in this study. Even so, the optimum diet is dependent on prices of WDGS and WCGF relative to the price of corn.

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Sulfur in Distillers Grains

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Summary

Data were compiled from 4,143 cattle on byproduct feeding experiments. Incidence of polioencephalomalacia was small (0.14%) in diets containing 0.46% or less sulfur (S). Incidences of polioencephalomalacia increased when cattle were fed diets above 0.46% S and especially above 0.56%. Phosphoric acid successfully replaced sulfuric acid in ethanol fermentation, but the amount and cost of phosphoric acid likely limit the economic feasibility of its use.

Introduction

Sulfuric acid is used to control pH in fermentation and for cleaning in ethanol production from corn. Sulfuric acid adds sulfur to the byproduct, distillers grains plus solubles. Buckner et al. (*2008 Nebraska Beef Report*, pp. 113-114) found wet distillers grains plus solubles (WDGS) averaged 0.79% S (DM basis) in 1,200 samples from six Nebraska ethanol plants. When WDGS is fed at high levels in finishing diets, the dietary S levels may exceed nutritional guidelines. The National Research Council (1996) suggests the upper limit for S in diets should be 0.40%. However, very few data support that limit. High levels of S in the diet may cause polioencephalomalacia (polio), commonly called "brainers" by the feedlot industry. High S content also may reduce dry matter intake (DMI) and average daily gain (ADG). The objectives of the current research were to: 1) estimate the level of risk for polio at increasing dietary S levels, and 2) determine if phosphoric acid could replace sulfuric acid in the ethanol plant.

Procedure

Data were compiled from experiments on byproduct feeding conducted at the University of Nebraska–Lincoln Research Feedlot (Mead, Neb.) over the past several years. The experiments included calf-fed and yearling cattle. In most experiments, control diets contained no byproducts.

Computerized health records were maintained on all cattle. These records were compared to the S levels in the diets fed to the cattle. Composite samples of all diets were analyzed for S level by Ward Laboratories Inc. (Kearney, Neb.), using a wet digest and colorimetry. The water was tested and contained essentially no S (11 ppm S). All diets provided 75 to 150 mg/head daily of thiamine. Cattle were determined to be polio cases if they were identified by the health crew as showing signs of polio. These cattle were treated with an intravenous injection of thiamine. Some cattle recovered and some died. All cattle that did not recover were necropsied and confirmed as having polio with lesions in the brain.

In order to determine the feasibility of using phosphoric acid as a replacement for sulfuric acid, test runs were conducted by researchers at the Poet Research Center (Sioux Falls, S.D.). Hydrochloric acid is a possible alternative acid choice; however, this acid deteriorates the metal equipment at the ethanol plant. Phosphoric acid is safe for the ethanol plant to use, and the byproduct is safe for animal consumption. A total of 28 batches were fermented using sulfuric acid and eight were fermented using phosphoric acid. Samples were taken of the corn, whole stillage (after distillation), thin stillage and wet distillers grains. The whole stillage was separated into thin stillage and wet distillers grains by continuous flow centrifugation.

Dry matter analysis of corn was conducted by drying at 60°C for 48 hours. The wet samples were freeze dried and DM determined by loss on freeze-drying followed by 60°C oven drying to ensure all the moisture and ethanol were removed. The dry samples were analyzed for nitrogen, sulfur, phosphorus, fat and neutral detergent fiber (NDF). Percentage fat was determined using a method of solvent extraction developed at the University of Nebraska (Bremer et al., *2009 Nebraska Beef Report* pp. 64-65).

Results

Of 4,143 cattle finished in byproduct experiments, 23 were removed from the pens and classified as cases of polio. Eleven of the cattle were from one treatment in one experiment, consuming a diet that contained 0.47% S and no roughage. Based on this observation and others, we believe roughage level is important in minimizing polio incidences. These 11 animals were excluded from the remaining summary because the diet of these cattle did not include the typical 6-7.5% roughage most feedlot diets contain.

Of the cattle consuming diets with less than 20% byproduct (DM basis), 0.1% (1/1000) were diagnosed with polio. This number included cattle on the control diets without byproducts, and we believe it represents the baseline level of expected polio prevalence. Of cattle consuming diets containing 0.46% S or less, 0.14% (3/2147) were diagnosed with polio. When sulfur levels were between 0.47% and 0.56% S, the polio incidence increased to 0.35% (3/566). When dietary S rose above 0.56%, the polio incidence was 6.06% (6/99).

These data suggest that diets at or below 0.46% S have a low risk of producing polio if roughage levels are maintained, allowing the feeding of

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Table 1. Nutrient analysis of samples throughout ethanol production.

	Sulfuric acid	Phosphoric acid	*P*-value
Dry matter (%)			
Corn	89.27	89.42	0.81
Whole stillage	13.72	14.70	0.26
Thin stillage	8.23	8.77	0.36
Wet cake	30.08	30.55	0.42
Crude protein (%)			
Corn	9.64	9.68	0.93
Whole stillage	31.21	30.00	0.08
Thin stillage	22.30	20.21	< 0.01
Wet cake	34.15	34.92	0.12
Fat (%)			
Corn	3.73	3.84	0.92
Whole stillage	14.76	16.18	0.69
Thin stillage	35.46	35.66	0.84
Wet cake	4.79	4.89	0.91
NDF (%)			
Corn	12.01	9.92	0.01
Whole stillage	25.84	22.98	0.48
Thin stillage	1.45	0.83	0.44
Wet cake	39.83	38.62	0.13
Phosphorus (%)			
Corn	0.27	0.29	0.62
Whole stillage	0.96	1.92	< 0.01
Thin stillage	1.55	3.36	< 0.01
Wet cake	0.49	1.08	< 0.01
Sulfur (%)			
Corn	0.15	0.16	0.84
Whole stillage	0.81	0.43	< 0.01
Thin stillage	1.66	0.35	< 0.01
Wet cake	0.71	0.47	< 0.01

WDGS up to about 50% of diet DM. Above 0.46% S in the diet, the risk for polio increases. Typically one load of WDGS lasts 7-10 days in the research feedlot, so a load with high S content would be fed for this extended period of time. Many feedlots feed multiple loads per day, so one load with a high concentration of S would be diluted by other loads. We were not able to identify any loads with high levels of S that related to cases of polio.

The substitution of phosphoric acid for sulfuric acid did not affect fermentation or ethanol yields. Since phosphoric acid does not disassociate as readily as sulfuric acid, approximately 2.5 times more phosphoric acid is required to provide the same pH control. Since phosphoric acid is more expensive and does not disassociate as readily as sulfuric acid, the increased cost of using phosphoric acid would need to be returned through increased cost of WDGS. The added P would have fertilizer value, but it is assumed that at current prices, cattle feeders would be unwilling to pay the higher price for low-S WDGS in order to reduce the risk of polio.

Only minor differences were noted in the protein, fat and neutral detergent fiber (NDF) contents of the corn and byproducts due to acid used in the fermentation (Table 1). Protein content increased 3.1 times in WDGS compared to the corn, as expected.

Sulfur content of the whole stillage was 0.81% when sulfuric acid was used; however, the sulfur value dropped to 0.43% when phosphoric acid was used. The difference (0.38%) represents the sulfur from added sulfuric acid. Sulfur content in whole stillage (0.43%) was 2.7 times the sulfur content of corn (0.16%).

Phosphorus content of the whole stillage was 1.92% when phosphoric acid was used and 0.96% when sulfuric acid was used. The difference (0.96%) represents the P from the added phosphoric acid.

Both S and P contents were greater in thin stillage than in wet cake. In commercial plants, the thin stillage is condensed to about 35% DM and named distillers solubles or "syrup." This condensation does not change the nutrient analysis on a DM basis. The amount of solubles added to the wet cake influences the S and P content of WDGS.

The added P from the use of phosphoric acid increases byproduct P levels. Because these levels are above the requirement of feedlot cattle, all of the extra P is contained in the manure. The P in the manure has value as fertilizer roughly equivalent to the cost of the phosphoric acid. Recovery of the cost and distribution costs of the manure must be considered. At current prices of phosphoric acid and because of the amount of phosphoric acid needed, it doesn't seem economically feasible to replace some or all of the sulfuric acid with phosphoric acid, even though the chemistry is feasible.

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Ruminal Sulfide Levels in Corn Byproduct Diets with Varying Roughage Levels

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Summary

Ruminally fistulated steers with wireless pH probes were utilized to quantify ruminal pH plus hydrogen sulfide (H_2S) levels produced at different times post feeding and to determine the effect of roughage level in high byproducts diets on hydrogen sulfide production. Because of variation in H_2S levels, ruminal pH was not related to high H_2S levels. When treatment means were used, pH and H_2S levels were highly correlated. We observed lower H_2S levels in diets with 7.5% or 15% grass hay compared with no roughage.

Introduction

In a recent finishing study (Wilken et al., *2009 Nebraska Beef Report*, pp. 76-78), steers fed 66% wet distillers grains plus solubles (WDGS) with a higher roughage level (29.4% DM) did not experience polio (sulfur level 0.55%), whereas cattle fed a diet with a somewhat lower level of sulfur (0.48%) and low roughage (7.5% DM) did experience some polio cases. Based on a recent summary of University of Nebraska–Lincoln byproduct research (Vanness et al., *2009 Nebraska Beef Report*, pp. 79-80), cattle can tolerate up to 0.46% sulfur with little risk (0.1%) of polio. The National Research Council (2003) suggests cattle fed corn-based diets can tolerate only 0.30% sulfur in the diet.

It is believed that hydrogen sulfide (H_2S) production by rumen microorganisms is the direct cause of polioencephalomalacia with high dietary S levels. An objective of the current study was to determine the effect of roughage level in high byproduct diets on H_2S levels in the rumen. An added objective was to determine the relationship between ruminal pH and hydrogen sulfide concentration.

Procedure

In Experiment 1, seven ruminally fistulated steers were fed during a 4-week adaptation period. Steers were housed in individual pens with bunks suspended from load cells. Cattle were fed twice daily at 0700 and 1600 with 50% of the feed at each time. Bunks were evaluated and residual feed weighed before the 0700 feeding. All steers were stepped up on the same diet. Each grain adaptation diet was fed for seven days with a common finisher being fed in week 4 (Table 1). Steers were fed decreasing amounts of alfalfa hay and increasing amounts of dry-rolled corn (DRC) for three weeks, with wet distillers grains plus solubles (WDGS) held constant at 50% diet DM. Wireless pH probes were inserted to measure ruminal pH. Measurements were taken every minute and recorded onto a data logger. Loggers were downloaded prior to feeding on the first day of each adaptation diet.

The finishing diet included 50% WDGS (received from Abengoa Bioenergy, York, Neb.), 37.5% DRC, 7.5% alfalfa and 5% supplement. The dietary S level was 0.44%.

Gas samples were collected on the last day of each step. Gas collection devices were inserted through the ruminal cannula prior to feeding on day 7 and samples were collected at 1500 that day and 0600 (prior to feeding) on the next day (day 1 of the next adaptation diet). Four gas samples were taken from each steer at each time point.

In Experiment 2, seven ruminally fistulated steers were used in a 6 x 6 Latin square design. Two steers consumed the same diet throughout the trial. A 3 x 2 factorial treatment design was used. The first factor was three different inclusion levels of grass hay (0%, 7.5% or 15%, DM basis), while the second factor was two different byproduct inclusion levels and sources (Table 2). One of the diets tested by Wilken and others (*2009 Nebraska Beef Report*, pp. 76-78) consisted of a 50:50 blend of wet corn gluten feed (WCGF) and WDGS. That diet was replicated in this experiment. Each period was seven days (six days of adaptation and one day of collection).

Steers were housed in individual pens with bunks suspended from load cells. Bunk measurements were taken every minute. Steers were fed twice daily with equal amounts at 0700 and 1600. Feed amounts were determined and feed refusal weighed if present before the 0700 feeding. Rumen gas samples were collected on day 7 of each period as described above.

Data were analyzed as a 6 x 6 Latin square using the MIXED procedure

(Continued on next page)

Table 1. Diet compositions and nutrient analysis of adaptation diets in Experiment 1.

Items	Diet 1	Diet 2	Diet 3	Finisher
WDGS[1]	50.0	50.0	50.0	50.0
Alfalfa	35.0	25.0	15.0	7.5
DRC[2]	10.0	20.0	30.0	37.5
Supplement	5.00	5.0	5.0	5.00
CP, % DM	24.96	23.89	22.82	22.02
Fat, % DM	6.66	6.90	7.13	7.31
NDF, % DM	29.48	27.32	25.16	23.54
Sulfur, % DM	0.50	0.48	0.46	0.44

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

Table 2. **Diet compositions and nutrient analysis of byproduct combination diets with varying amounts of grass hay in Experiment 2.**

	50% WDGS			37.5% WDGS /37.5%WCGF		
Roughage level:	0	7.5	15	0	7.5	15
WDGS[1]	50.0	50.0	50.0	37.5	37.5	37.5
WCGF[2]	0.0	0.0	0.0	37.5	37.5	37.5
Grass hay	0.0	7.5	15.0	0.0	7.5	15.0
DRC[3]	45.0	37.5	30.0	20.0	13.5	6.0
Supplement	5.0	5.0	5.0	5.0	5.0	5.0
Nutrient composition						
CP, % DM	21.9	21.8	21.7	25.4	25.3	25.2
NDF, % DM	21.8	26.3	30.8	28.4	32.9	37.4
Fat, % DM	7.2	7.2	7.1	6.2	6.2	6.1
Sulfur, % DM	0.43	0.42	0.41	0.47	0.46	0.45

[1]WDGS = wet distillers grains plus solubles.
[2]WCGF = wet corn gluten feed.
[3]DRC = dry-rolled corn.

Table 3. **Effects of adaptation diet on pH and H_2S values in Experiment 1.**

	Diet 1	Diet 2	Diet 3	Finisher	*P*-Value
DMI, (lb/d)	14.70	16.70	19.49	20.62	< 0.01
Average pH	6.05	5.51	5.49	5.51	< 0.01
Max pH	6.65	6.27	6.08	6.19	< 0.01
Min pH	5.54	5.10	5.14	5.15	< 0.01
pH change	1.14	1.17	0.94	1.05	< 0.01
Area < 5.6[1]	0.38	335.39	285.18	1438.79	< 0.01
Area < 5.3[1]	6.51	150.95	91.07	73.09	0.02
H_2S 8 h[2]	8.90	8.30	47.70	121.50	< 0.01
H_2S 23 h[3]	6.20	4.50	21.20	33.30	0.05

[1]Area is magnitude of pH under respective pH by minute.
[2]H_2S values are μmol hydrogen sulfide gas per mL of rumen gas collected 8 hours post feeding.
[3]H_2S values are μmol hydrogen sulfide gas per mL of rumen gas collected 23 hours post feeding.

Table 4. **Main effects of byproduct for intake, ruminal pH and H_2S in Experiment 2.**

Item	WDGS	WDGS/WCGF[1]	SE	*P*-value
DMI (lb/day)	20.6	21.1	0.3	0.15
Average pH	5.69	5.87	0.0	<0.01
Max. pH	6.31	6.47	0.0	<0.01
Min. pH	5.26	5.45	0.0	<0.01
Area < 5.6[2]	253.5	168.2	60.5	0.26
pH change	1.04	1.01	0.0	0.71
pH variance	0.06	0.05	0.0	0.20
H_2S 8 h[3]	53.1	87.9	15.7	0.13
H_2S 23 h[4]	88.2	65.0	20.0	0.28

[1]WDGS = wet distillers grains plus solubles, WCGF = wet corn gluten feed.
[2]Area under curve is magnitude of pH < 5.6 by minute.
[3]Values are μmol hydrogen sulfide/mL rumen gas collected 8 hours post feeding.
[4]Values are μmol hydrogen sulfide/mL rumen gas collected 23 hours post feeding.

of SAS (SAS Inst. Inc.). Treatment was included in the model as a fixed effect with animal being the random effect. No byproduct x grass hay level interactions were observed ($P > 0.23$); therefore, only main effects of byproduct or grass hay levels were reported. The correlation procedure of SAS was used to determine correlations between pH and H_2S values. With the high variability in individual data, treatment means also were used for correlation calculations.

Results

In Experiment 1, H_2S levels increased as roughage decreased (grain adaptation) at both 8 and 23 hours post feeding, ($P < 0.01$ and P = 0.05, respectively; Table 3). We hypothesized that H_2S levels would increase as roughage level decreased during grain adaptation. The increased H_2S production could be a result of reduced dietary fiber or increased dietary starch concentration. Intake increased ($P < 0.01$) as the cattle were adapted over the 21 days prior to the finishing diet.

Average pH, maximum pH and minimum pH decreased ($P < 0.01$) as the cattle were stepped up to the finisher diet. The area under pH 5.6 and 5.3 increased ($P < 0.01$) as cattle were adapted to the finisher diet.

In Experiment 2, there were no byproduct x grass hay level interactions; therefore, main effects are presented (Table 4). Cattle fed the combination byproduct diet had greater dry matter intake (DMI; P = 0.07); however, average, maximum and minimum ruminal pH levels also were higher ($P < 0.01$) than in those who received the diet with lower byproduct inclusion. The H_2S levels were not different between the two diets. No differences were observed between byproduct diets for area under pH 5.6, pH change (maximum-minimum), or pH variance ($P > 0.10$).

With increasing grass hay levels in the diets (Table 5), DMI and average, maximum and minimum ruminal pH increased linearly ($P < 0.03$). No differences were observed for area under pH 5.6, 5.3 or 5.0. At 8 hours post-feeding, H_2S levels declined linearly as grass hay levels in the diets increased ($P < 0.01$). At 23 hours post feeding, a numerical decrease in H_2S was observed with increasing grass hay levels. Because of the relatively high ruminal pH levels with the combination byproduct diet, it might be tempting to remove the roughage from the diet to improve feed efficiency. These data illustrate that the H_2S level of the diet with 7.5% hay was 44% of the H_2S level in the no roughage diet. Therefore, the risk of polio is expected to be much greater for cattle fed the no roughage diet; diets should contain at least 6-7% roughage.

The 7.5% hay diet is probably typical of most commercial feedlot diets.

Doubling the hay level to 15% reduced H_2S levels in the rumen. Approximately 55% less H_2S was produced in the 15% hay diet compared to the 7.5% hay diet at 8 hours post feeding.

At this time, we have not developed a cause-and-effect relationship between ruminal H_2S levels and polio. However, we assume the risk of polio is decreased if ruminal H_2S levels are decreased. Feeding additional roughage with high byproduct diets appears to reduce H_2S levels and therefore the risk of polio.

We hypothesized pH to be positively correlated with the level of H_2S concentration in the rumen. There were no significant correlations using individual animal data at 8 or 23 hours post feeding in either experiment (Table 6). The lack of significant correlations appears to be due to the large variability in H_2S concentrations; therefore, treatment mean correlations were calculated. In Experiment 1, area below pH 5.6 on the same day was correlated to H_2S levels at both 8 (r = 0.94, $P = 0.06$) and 23 hours (r = 0.85, $P = 0.15$) post feeding. In Experiment 2, there was a tendency for the 23-hour H_2S level to increase as average pH decreased (r = -0.92, $P = 0.13$). There also was a tendency for the 8-hour H_2S level to increase as the amount of time below pH 5.6 the previous day increased (r = 0.98, $P = 0.12$) At 23 hours post feeding, H_2S levels increased as the area below pH 5.6 of the same day increased (r = 0.98, $P = 0.13$). We conclude that average ruminal pH is negatively correlated with ruminal H_2S levels. Roughage level in the diet appears to be very important. In these experiments, dietary sulfur levels ranged from 0.47% to 0.41%; the H_2S levels ranged from 125.9 to 29.7µmol/mL of rumen gas. In another study (Vanness et al. *2009 Nebraska Beef Report* pp. 84-85), H_2S levels at 12 hours post feeding ranged from 19.3µmol/mL when dietary S levels were 0.53%, to 13.7µmol/mL when dietary S levels were 0.34%. This does not show a clear relationship between dietary S levels and ruminal H_2S levels. However, this comparison is across experiments and a conclusion cannot be drawn until dietary S levels are compared within an experiment.

Table 5. Main effect of grass hay level in Experiment 2 for intake, ruminal pH and H_2S.

	Grass hay level					
Item	0	7.5	15.0	SE	Lin.	Quad.
DMI, lb/day	20.6	20.4	21.5	0.3	< 0.03	0.08
Average pH	5.62	5.75	5.96	0.0	< 0.01	0.42
Max pH	6.22	6.32	6.62	0.0	< 0.01	0.03
Min pH	5.25	5.37	5.44	0.0	< 0.01	0.58
Area < 5.6[1]	306.0	176.8	149.7	72.0	0.08	0.54
Area < 5.31	73.4	29.6	39.2	20.0	0.19	0.27
Area < 5.0[1]	4.3	2.4	2.4	1.6	0.33	0.59
pH change	1.0	1.0	1.2	0.0	< 0.01	< 0.01
H_2S 8 h[2]	125.9	55.9	29.7	19.0	< 0.01	0.37
H_2S 23 h[3]	91.5	84.1	54.2	30.0	0.45	0.67

[1]Area is magnitude of pH under respective pH by minute.
[2]Values are µmol hydrogen sulfide mL of rumen gas collected 8 hours post feeding.
[3]Values are µmol of hydrogen sulfide mL of rumen gas collected 23 hours after first feeding.

Table 6. Correlation of ruminal pH to H_2S levels at 8 and 23 hours post feeding.

Item	8 hour	P-value	23 hour	*P*-value
Experiment 1				
Individual[1]				
Average pH	0.12	0.95	-0.05	0.79
Area < 5.6	-0.21	0.29	-0.03	0.86
Previous day time < 5.6[2]	-0.05	0.80	0.06	0.73
Time < 5.6	-0.01	0.95	0.01	0.95
Treatment mean[3]				
Average pH	-0.47	0.53	-0.50	0.50
Area < 5.6	0.94	0.06	0.85	0.15
Previous day time < 5.6	0.37	0.63	0.42	0.58
Time < 5.6	0.45	0.55	0.50	0.50
Experiment 2				
Individual[1]				
Average pH	-0.05	0.76	-0.16	0.41
Area < 5.6	-0.06	0.70	0.02	0.90
Previous day time <5.6	-0.00	0.98	0.30	0.11
Time < 5.6	-0.05	0.73	0.23	0.23
Treatment mean[2]				
Average pH	-0.92	0.25	-0.98	0.13
Area < 5.6	0.99	0.07	0.77	0.44
Previous day time < 5.6	0.98	0.12	0.92	0.26
Time < 5.6	0.93	0.25	0.98	0.13

[1]Correlations based on individual animal values for pH and H_2S.
[2]This value is the amount of time ruminal pH was below 5.6 one day prior to H_2S collection.
[3]Correlations based on treatment mean.

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Hydrogen Sulfide Gas Levels Post Feeding

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Summary

Dietary sulfur level is associated with hydrogen sulfide gas (H_2S) levels in the rumen. These studies quantified H_2S levels at different times post feeding with or without added iron (Fe) or copper (Cu) to bind sulfur. In addition, the correlations of ruminal pH measurements to ruminal H_2S gas levels were estimated. Correlations between ruminal pH and hydrogen sulfide levels were not large and Fe and Cu did not affect H_2S levels.

Introduction

Hydrogen sulfide (H_2S) gas is hypothesized to be associated with polioencephalomalacia (polio). In ruminants, sulfur compounds may bind copper (Cu) and iron (Fe) so they become unavailable for the animal. The objective of the current study was to feed Fe and Cu in excess of dietary requirements to bind to S and to prevent S from being metabolized into H_2S. Rumen gas collections at different times post feeding will inform us when H_2S levels peak.

Procedure

In Experiment 1, five ruminally fistulated steers were used in a 4 x 4 Latin square. Two steers were on the same diet throughout the trial. Treatments were as follows: 1) no added mineral; 2) 1500 ppm iron and 100 ppm copper; 3) 3000 ppm iron and 200 ppm copper; and 4) 4500 ppm iron and 300 ppm copper. All animals were fed the same base diet with corresponding treatment supplements. The base diet included 50% wet distillers grains plus solubles (WDGS), 19.5% dry-rolled corn (DRC), 19.5% high-moisture corn (HMC), 6% cornstalks and 5% supplement (DM basis). The base diet had a sulfur content of 0.53%.

Ten-day periods were used with eight days of adaptation and two days of collection. Cattle were housed in individual pens and fed once daily at 0800. Feed refusals were collected and weighed if present. Each individual bunk was suspended from a load cell, bunk weights were collected every minute and meal characteristics were calculated (Table 2).

Gas collection devices were inserted through the ruminal cannula into the rumen on day 9 prior to feeding. Ruminal gas samples were collected at 0, 4, 8 and 12 hours post feeding. Once the gas sample was collected, it was injected into water. Two reagents that react with H_2S were added to these water solutions, creating a blue color that has a wavelength of 670 nm. Samples were plated in a 96-well plate and read on a spectrophotometer at 670 nm. This procedure is similar to a photometric procedure determined by Kung Jr. et al. (*Journal of Dairy Science 81*:2251).

In Experiment 2, nine ruminally fistulated steers were used in a switch back design. The experiment was designed to evaluate a direct-fed microbial (DFM) on the incidence of acidosis as reported by Rolfe et al. (*2009 Nebraska Beef Report* pp. 99-101). The objective of the current experiment was to quantify the amount of H_2S produced at different times post feeding and determine correlations between ruminal pH and H_2S levels. Intake data were collected as in Experiment 1. Wireless pH probes were inserted into the steers to record ruminal pH every minute. The rumen gas cap was sampled for H_2S on the last day of each step during the step-up phase and every seven days while the animals were on the concentrate diet. Samples were taken at 6 and 12 hours post feeding.

For the step-up phase, steers were stepped up onto a finisher with four steps by removing alfalfa and increasing the level of high moisture corn (HMC) in the diet. The final finishing diet contained 57.5% HMC, 30% WDGS, 7.5% alfalfa and 5% supplement on a DM basis (Table 1). The S level of this diet was 0.34%. No additives were used to prevent sulfur from metabolizing in the rumen for this trial. Gas samples were analyzed as described for Experiment 1.

For Experiment 1, data were analyzed using the MIXED procedure of SAS (SAS Inst Inc.). Treatment was included in the model as a fixed effect, with animal being the random effect. No day x treatment interactions were observed ($P > 0.16$); therefore, only main effects of treatment and time are presented.

For Experiment 2, correlation procedure of SAS was used to determine correlations between pH and H_2S values. With the high variability in individual data, correlations were not strong.

Results

In Experiment 1, no significant differences were present among treatments for average meal size, number of meals or average meal length (Table 2). There was a tendency for cattle fed 4500 ppm Fe and 300 ppm Cu to spend less total time eating.

Table 1. Composition of adaptation diets in Experiment 2.

Days	1-7	8-14	9-21	22-28	29-120
Ingredient % DM	Step1	Step 2	Step 3	Step 4	Finisher
WDGS[1]	30.00	30.00	30.00	30.00	30.00
HMC[2]	20.00	30.00	40.00	50.00	57.50
Alfalfa	45.00	35.00	25.00	15.00	7.50
Supplement[3]	5.00	5.00	5.00	5.00	5.00
Dietary sulfur	0.40	0.38	0.37	0.35	0.34

[1]WDGS = wet distillers grains plus solubles.
[2]HMC = high moisture corn.
[3]Supplement contains 65.3% fine ground corn and 27.4% limestone.

Table 2. Experiment 1 meal characteristics[1] and intake for each level of added iron/copper.

		Treatment				
Item	Control	1500/100 Fe:Cu	3000/200 Fe:Cu	4500/300 Fe:Cu	SE	*P*-value
DMI	27.6	26.6	26.4	27.1	0.4	0.05
Number of meals, n	5.8	5.7	5.3	4.7	0.4	0.26
Avg. size, lb	9.5	8.1	9.2	11.0	1.2	0.44
Avg. length, min	125.3	118.8	124.9	128.7	13.1	0.96
Total length, min	607.6	608.2	635.9	541.4	22.5	0.08

[1]Meal characteristics include number of meals consumed per day, lb of feed consumed per meal, and average and total length of meals in minutes.

Table 3. H_2S levels at different hours post feeding for each of the added iron and copper levels in Experiment 1.

		Treatment				
Item	Control	1500/100 Fe:Cu	3000/200 Fe:Cu	4500/300 Fe:Cu	SE	*P*-value
0[1]	3.3	1.5	1.9	2.3	1.0	0.59
4	15.1	19.6	16.4	17.1	5.9	0.96
8	15.7	19.3	13.0	15.1	5.7	0.89
12	20.6	22.8	13.2	20.7	4.5	0.46

[1]H_2S values are expressed as µmol of H_2S per mL of rumen gas collected at 0-12 hours.

Table 4. Average ruminal H_2S[1] concentrations for grain adaptation and finishing diet in Experiment 2.

Diets[2]:	1	2	3	4	Finishing
6 h H_2S	4.60	9.11	10.65	8.92	9.41
12 h H_2S	3.89	6.83	9.08	14.44	16.61

[1]H_2S levels are reported as µmol H_2S per mL of rumen gas collected.
[2]All diets contained 30% wet distillers grains plus solubles and 5% supplement. As cattle were adapted to the finishing diet, the amount of alfalfa hay included decreased from 45 to 35 to 25, 15 and finally 7.5% as the cattle adapted from diets 1, 2, 3, 4 and the finisher, respectively. For every decrease in alfalfa hay, a corresponding increase in HMC was observed.

Table 5. Correlation of pH to H_2S Levels Experiment 2.

Item	6 hour	*P*-value	12 hour	*P*-value
Step-up				
Area < 5.6[1]	0.11	0.54	-0.18	0.31
Previous day time < 5.6[2]	-0.05	0.77	-0.33	0.06
Time < 5.6[3]	-0.17	0.33	-0.36	0.04
Finisher				
Area <5.6	-0.10	0.35	-0.15	0.15
Previous day time <5.6	-0.03	0.74	-0.20	0.05
Time <5.6	-0.19	0.06	-0.25	0.01

[1]Area < 5.6 = Magnitude below pH 5.6 multiplied by minutes below pH 5.6.
[2]This value is the amount of time ruminal pH was below 5.6 one day prior to H_2S collection.
[3]Time < 5.6 = Total time ruminal pH was below 5.6.

Dry matter intake (DMI) was different ($P = 0.05$), with average intakes of 27.6, 26.6, 26.5 and 27.1 lb/day for control (0/0), 1500/100, 3000/200, and 4500/300 ppm Fe/Cu, respectively. No effects ($P > 0.05$) were observed for H_2S levels at 0, 4, 8 or 12 hours post feeding due to Fe and Cu addition (Table 3). A significant difference was seen among time points across all treatments with zero hours post feeding being significantly lower than the other time points ($P < 0.01$). There was no time x treatment interaction ($P = 0.93$). In Experiment 1, a H_2S level of 22.8µmol/mL was seen at 12 hours post feeding when dietary S was 0.53%.

During the step-up phase in Experiment 2, H_2S levels increased numerically as the cattle moved through the adaptation diets. During the step-up phase numerically higher levels of H_2S were seen at 6 hours than at 12 hours for adaptation diets 1-3, while 6-hour values were numerically lower than 12-hour values for the final adaptation diet and the finishing diet (Table 4).

In Experiment 2, the ruminal H_2S concentration was weakly correlated to ruminal pH (Table 5). In general, the 6-hour H_2S values had higher correlation coefficients than the 12-hour values. However all correlation coefficients were relatively low, probably due to high variability within individual H_2S values. Average H_2S levels for cattle at 6 and 12 hours post feeding were 9.01 and 13.7 µmol/mL of rumen gas collected, respectively, for the finishing diet that contained 0.34% S.

Based on the correlations, we conclude that ruminal pH is not a good indicator of increased H_2S production when levels of dietary sulfur are moderately high. At this time we do not have a clear answer as to whether increased H_2S levels are a result of increased dietary sulfur level or decreased ruminal pH.

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Effects of Rumensin® and Tylan® in Finishing Diets with Wet Distillers Grains Plus Solubles

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Summary

A total of 3,632 crossbred steers at three different sites (Nebraska, Colorado and Oklahoma) were utilized in a randomized complete block design (RCBD) study. Data were combined for the Colorado and Oklahoma trials. Steers were fed one of five treatments: 1) Traditional corn diet with Rumensin and Tylan (CORN+RT); 2) Wet distillers grains plus solubles (WDGS); 3) WDGS with Rumensin (WDGS+R); 4) WDGS with Rumensin and Tylan (WDGS+RT); and 5) WDGS with expanded dose range of Rumensin (44.4 g/ton) and Tylan (WDGS+HIRT) to evaluate the effects of Rumensin and Tylan in feedlot diets containing WDGS. In WDGS diets, feed-to-gain ratio (F:G) was improved when Rumensin and Tylan were included (P < 0.05). With the exception of dressing percentage, there were no differences in performance or carcass characteristics when Rumensin was fed at 33.3 g/ton compared to 44.4 g/ton. Treatments containing Tylan resulted in significantly fewer liver abscesses than other treatments. Cattle fed Rumensin and Tylan diets containing WDGS had improved F:G and decreased liver abscesses compared to those receiving diets with no additives, regardless of corn processing method.

Introduction

Replacing dry-rolled or high-moisture corn grain with wet corn distillers grains with solubles improves cattle F:G and average daily gain (ADG; *2008 Nebraska Beef Report*, pp. 39-40). The effects of Rumensin and Tylan in corn by-product diets have not been studied, and it is possible that reduced starch and increased dietary fiber concentration may alter the effectiveness of Rumensin and/or Tylan in finishing cattle diets.

An interaction between grain processing method (i.e., steam-flaking vs. dry-rolled or high-moisture) and cattle response to wet distillers grains exists (*2007 Nebraska Beef Report*, pp. 33-35.). Regional differences affect preferences in grain processing, with steam flaking (SFC) being a predominant method in the Southern and High Plains, and high moisture ensiling (HMC) and dry rolling (DRC) prevalent in the Midwest. One objective of this study was to evaluate the effects of Rumensin and Tylan in diets containing WDGS on cattle performance, carcass characteristics and liver abscesses. The second objective was to compare the response on a regional basis where corn processing method is the major difference.

Procedure

Three separate trials were conducted at research facilities in Nebraska (University of Nebraska ARDC research feedlot), Colorado (Horton Research) and Oklahoma (Bos-Technica Research). A total of 3,632 steers were utilized in a randomized complete block design. Steers were purchased ranch direct or from regional auction markets and received from October 3, 2006, to March 27, 2007. Cattle were processed at each site according to the site's standard procedures, with all cattle receiving viral and clostridial vaccines and parasiticides. All steers were implanted with Revalor-S® (Intervet, Millsboro, Del.) or Synovex® Choice (Fort Dodge Animal Health) at study initiation. Trials were initiated from January 23, 2007, to April 3, 2007.

At the Nebraska site, five days prior to study initiation, steers were limit fed a diet that consisted of 50% alfalfa and 50% wet corn gluten feed (DM basis) at 2% of BW to minimize variation in gastrointestinal fill. On days 0 and 1, steers were individually weighed and the average weight was used to determine starting BW. Based on day 0 weight, steers were blocked by BW into one of four blocks, stratified by weight within block and assigned to pens, and pens were assigned randomly to treatment. A total of 800 British and British x Continental steers were utilized with 20 steers per pen and eight pens per treatment.

At the Oklahoma site, cattle were pen-weighed for initial and final weights. At the Colorado site, cattle were individually weighed for initial and final weights, following procedures similar to those used at the Nebraska site. At the Colorado and Oklahoma sites, a total of 1,400 British and British x Continental and 1,432 Continental steers were utilized, respectively, with 70 to 72 steers per pen and four pens per treatment.

Five dietary treatments at three different sites (Table 1) were utilized in the study. All sites received common Rumensin and Tylan treatments. Diets at Nebraska used a 50:50 combination of high-moisture (HMC) and dry-rolled corn (DRC); at the Colorado and Oklahoma sites, steam-flaked corn (SFC) was utilized as a common grain source. Treatment 1 (CORN+RT) contained corn grain and Rumensin (Elanco Animal Health, Greenfield, Ind.), formulated at 33.3 g monensin/ton DM basis, and Tylan (Elanco Animal Health, Greenfield, Ind.) formulated to provide 90 mg tylosin/steer daily. Treatments 2, 3, 4 and 5 contained 25% WDGS, replacing corn. Treatment 2 (WDGS) contained no active dietary additives; treatment 3 (WDGS+R) contained Rumensin formulated at 33.3 g monensin/ton DM basis; treatment 4 (WDGS+RT) contained Rumensin formulated at 33.3 g monensin/ton DM basis and Tylan formulated to provide 90 mg tylosin/steer daily; and

Table 1. Composition of dietary treatments and analyzed nutrient composition (DM basis).

	Treatments and sites					
Ingredient	0% WDGS (Neb.)	25% WDGS (Neb.)	0%[1] WDGS (Col.)	25%[2] WDGS (Col.)	0%[1] WDGS (Okla.)	25%[2] WDGS (Okla.)
Steam-flaked corn	—	—	73.8	56.0	85.0	62.6
High-moisture corn	39.75	29.75	—	—	—	—
Dry-rolled corn	39.75	29.75	—	—	—	—
WDGS[3]	—	25.0	—	25.0	—	25.0
Corn silage	7.0	7.0	8.0	8.0	—	—
Soybean meal, 47.5%	—	—	5.0	—	—	—
Alfalfa hay	3.5	3.5	4.0	4.0	5.0	5.0
Molasses	5.0	—	—	—	—	—
Choice white grease	—	—	—	—	4.0	1.4
Tallow	—	—	4.0	1.8	—	—
Supplement, meal[4]	5.0	5.0	—	—	—	—
Supplement, pellet	—	—	—	—	6.0	6.0
Supplement, liquid	—	—	5.2	5.2	—	—
Analyzed Nutrient Composition						
Crude protein, %	13.3	15.2	12.9	16.4	12.8	16.0
Fat, %	4.0	6.7	5.4	4.6	7.5	7.3
Calcium, %	0.63	0.66	0.68	0.80	0.73	0.90
Phosphorus, %	0.27	0.41	0.38	0.44	0.29	0.49
Sulfur, %	0.14	0.26	0.17	0.30	0.20	0.28

[1]Monensin was included at 33.3 g/ton and 90 mg of tylosin phosphate per animal via a flush system with water as a carrier.
[2]Monensin was included at 0, 33.3 or 44.4 g/ton and 0 or 90 mg of tylosin phosphate per animal via a flush system with water as a carrier.
[3]Procured from commercial ethanol plants (Neb. = Abegona Bioenergy, York, Neb; Col. = Pacific Ag Products LLC, Windsor, Col.; Okla. = East Kansas Agri Energy, Garnett, Kan.).
[4]Supplement formulated to provide 0, 33.3 or 44.4 g/ton monensin and 0 or 90 mg of tylosin phosphate per animal. Ground corn was the carrier for the supplement.

Table 2. Site 1 (Nebraska) performance, carcass and liver characteristics of steers fed different diets and amounts of Rumensin and Tylan.

	Treatments[1]						
	CORN +RT	WDGS	WDGS +R	WDGS +RT	WDGS +HIRT	SEM	*P*-value
Pens, n	8	8	8	8	8		
Steers, n[2]	160	160	160	160	160		
Average DOF	153	153	153	153	153		
Performance							
Initial BW, lb	725	725	725	726	725	0	0.72
Final BW, lb[3]	1294^{a}	1317^{b}	1326^{b}	1333^{b}	1317^{b}	6	< 0.01
DMI, lb	23.5^{abc}	23.9^{a}	23.6^{ac}	23.4^{bc}	23.0^{b}	0.2	0.02
ADG, lb[3]	3.72^{a}	3.87^{b}	3.93^{b}	3.97^{b}	3.87^{b}	0.04	< 0.01
F:G[4]	6.29^{a}	6.17^{a}	5.99^{b}	5.88^{b}	5.95^{b}		< 0.01
Carcass Characteristics							
HCW, lb	815^{a}	830^{b}	836^{b}	840^{b}	829^{b}	4	< 0.01
12th rib FT, in	0.47^{a}	0.53^{bc}	0.51^{c}	0.54^{b}	0.51^{bc}	0.01	< 0.01
LM area, in^2	13.1	13.1	13.3	13.1	13.0	0.1	0.68
KPH fat, %	2.0	2.0	2.0	2.0	2.0	0.0	0.43
Marbling score[5]	529	540	540	531	547	6	0.30
Calculated YG[6]	2.6^{a}	2.8^{bc}	2.7^{ab}	2.8^{c}	2.8^{bc}	0.0	< 0.01
Liver Abscesses							
Total, %	17.0^{a}	42.4^{b}	40.8^{b}	8.3^{a}	8.9^{a}	3.0	< 0.01
A+, %	4.4^{a}	16.5^{b}	19.1^{b}	3.8^{a}	7.0^{a}	2.2	< 0.01

[1]CORN = corn control; WDGS = wet distillers grains plus solubles; R = monensin at 33.3 g/ton; HIR = monensin at 44.4 g/ton, T = tylosin phosphate formulated for 90 mg/d.
[2]Number of steers at trial initiation.
[3]Calculated from carcass weight adjusted to a 63% common dressing percentage.
[4]Calculated as total gain divided by total DMI and analyzed as G:F. The reciprocal is presented (F:G).
[5]Where 400 = Slight 0, 500 = Small 0.
[6]Calculated as YG = 2.50 + (2.5*FT, in) – (0.32*LM, in^2) + (0.2*KPH, %) + (0.0038*HCW, lb).
[a,b,c]Within a row means without a common superscript letter differ ($P < 0.05$).

treatment 5 (WDGS+HIRT) contained Rumensin formulated at 44.4 g monensin/ton DM basis and Tylan formulated to provide 90 mg tylosin/steer daily. All diets were formulated to meet or exceed the National Research Council (1996) requirements for CP, Ca, P and K (Table 1).

Steers were adapted to the finishing diet with step-up periods that replaced corn grain with alfalfa. Number of steps ranged from 2 to 4 with total step-up periods lasting 14 to 23 days. Steers were fed once daily at Nebraska and Colorado and three times daily at Oklahoma.

Cattle were slaughtered at commercial packing plants where hot carcass weights (HCW) and liver scores were recorded at slaughter time. Following a 36-48 hour chill period, carcass data were collected, including: 12th rib fat thickness, LM area, KPH percentage, called USDA marbling and YG scores. A calculated yield grade was determined from the equation (YG = 2.50 + (2.5*FT, in.) – (0.32*REA, in^2) + (0.2*KPH, %) + (0.0038*HCW, lb.)). Values for final BW, ADG and F:G were calculated using hot carcass weight divided by an average dressing percentage of 63 to minimize errors associated with gastrointestinal tract fill.

For all experiments, performance, carcass and liver abscess data were analyzed using the MIXED procedures of SAS (Version 9.1, SAS Inc., Cary, N.C.) as a randomized complete block design, with pen as the experimental unit and four weight blocks. Data from Nebraska were analyzed separately; data from the Colorado and Oklahoma studies were combined because of the common corn processing method. Combined trial site data were first checked for a trial site x treatment interaction and combined if there was not a significant interaction. When treatment differences were significant based on a protected F-test, means were separated using the PDIFF option of SAS. Pre-planned contrasts included: CORN+RT vs. WDGS+RT; WDGS vs. WDGS+R; WDGS+R vs. WDGS+RT; and WDGS+RT vs. WDGS+HIRT.

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Table 3. Site 2 (Colorado) and 3 (Oklahoma) combined performance, carcass and liver characteristics of steers fed different diets and amounts of Rumensin and Tylan.

	Treatments[1]							
	CORN +RT	WDGS	WDGS +R	WDGS +RT	WDGS +HIRT	SEM	Int[2]	*P*-value
Pens, n	8	8	8	8	8			
Steers, n[3]	566	567	567	566	566			
Average DOF	186	186	186	186	186			
Performance								
Initial BW, lb	708[ab]	712[a]	704[b]	713[a]	710[a]	2	0.20	0.05
Final BW, lb[4]	1406[a]	1381[b]	1384[b]	1402[a]	1402[a]	5	0.73	< 0.01
DMI, lb	20.3[a]	21.0[b]	20.9[b]	20.8[b]	20.8[b]	0.1	0.29	< 0.001
ADG, lb[4]	3.76[a]	3.61[b]	3.66[bc]	3.71[ac]	3.73[ac]	0.02	0.67	< 0.01
F:G[5]	5.40[a]	5.82[d]	5.71[cd]	5.60[bc]	5.57[b]		0.61	< 0.001
Carcass Characteristics								
HCW, lb	886[a]	870[b]	872[b]	883[a]	883[a]	3	0.73	< 0.01
12[th] rib FT, in	0.63	0.62	0.62	0.63	0.63	0.01	0.04	0.68
12[th] rib FT CO, in	0.63[a]	0.65[ab]	0.65[ab]	0.66[ab]	0.67[b]	0.01		
12[th] rib FT OK, in	0.64[a]	0.59[b]	0.60[ab]	0.61[ab]	0.60[ab]	0.01		
LM area, in^2	14.0[a]	13.9[ab]	13.7[b]	13.9[a]	13.9[ab]	0.1	0.16	0.08
KPH fat, %	2.3	2.2	2.2	2.2	2.2	0.0	0.62	0.62
Marbling score[6]	509[a]	503[ab]	503[ab]	496[b]	502[ab]	3	0.62	0.09
Calculated YG[7]	3.5	3.5	3.5	3.5	3.5	0.0	0.06	0.48
Liver Abscesses								
Total, %	15.7[a]	45.9[b]	44.3[b]	17.9[a]	20.3[a]	2.9	0.10	< 0.001
A+, %	7.2	25.6	25.0	8.5	10.6	2.1	< 0.01	< 0.01
A+ CO, %	8.2[a]	35.4[b]	34.7[b]	11.5[a]	12.4[a]	3.8		
A+ OK, %	6.2[a]	15.8[b]	15.4[b]	5.5[a]	8.8[a]	1.7		

[1]CORN = corn control; WDGS = wet distillers grains plus solubles; R = monensin at 33.3 g/ton; HIR = monensin at 44.4 g/ton; T = tylosin phosphate formulated for 90 mg/d.
[2]Interaction *P*-value of site location by treatment.
[3]Number of steers at trial initiation.
[4]Calculated from carcass weight adjusted to a 63% common dressing percentage.
[5]Calculated as total gain divided by total DMI and analyzed as G:F. The reciprocal is presented (F:G).
[6]Where 400 = Slight 0; 500 = Small 0.
[7]Calculated as YG = 2.50 + (2.5*FT, in.) – (0.32*LM, in^2) + (0.2*KPH, %) + (0.0038*HCW, lb.).
[a,b,c,d]Within a row, means without a common superscript letter differ ($P < 0.05$).

Results

Results for Nebraska Trial

Compared to steers fed CORN+RT, steers fed WDGS+RT gained more, were more efficient ($P < 0.05$), and had similar dry matter intake (DMI; Table 2). Wet distillers grains plus solubles fed at 25% (DM basis) had 128% the feeding value of a 50:50 combination of DRC and HMC. Feeding Rumensin increased G:F by 3.1% and feeding Rumensin plus Tylan increased G:F by 4.9% when compared to WDGS without feed additives ($P < 0.05$). With the exception of dressing percentage, there were no differences in performance or carcass characteristics when Rumensin was fed at 33.3 g/ton compared to 44.4 g/ton. Total liver abscesses were significantly greater in steers receiving WDGS (42.4%) and WDGS+R (40.8%), compared to steers receiving treatments containing Tylan, CORN+RT (17.0%), WDGS+RT (8.3%), and WDGS+HIRT (8.9%). Fewer severe liver abscesses also were seen in steers whose diets contained Tylan ($P < 0.05$).

Results for Combined Colorado and Oklahoma Trials

Compared to steers fed CORN+RT, steers fed WDGS+RT were less efficient and had increased DMI (Table 3). Wet distillers grains plus solubles fed at 25% (DM basis) had 87% the feeding value of SFC. Feed efficiency was measured as G:F, which is more statistically valid than F:G. Feeding Rumensin increased G:F numerically by 1.7%, and feeding Rumensin plus Tylan increased G:F by 4.1% compared to WDGS without feed additives ($P < 0.05$). Carcass characteristics, with the exception of HCW, were unaffected by treatment. Hot carcass weight was greatest in steers fed CORN+RT, WDGS+RT and WDGS+HIRT, compared to WDGS and WDGS+R ($P < 0.05$). Total liver abscesses were significantly greater in steers fed WDGS (45.9%) and WDGS+R (44.3%), compared to treatments containing Tylan, CORN+RT (15.7%), WDGS+RT (17.9%) and WDGS+HIRT (20.3%). Additionally, cattle fed Tylan had fewer severe liver abscesses in both the Colorado and Oklahoma studies ($P < 0.01$).

In summary, this study indicates that cattle fed Rumensin and Tylan in diets containing 25% WDGS show improved feed efficiency and decreased liver abscesses compared to those whose diets contain no additives, regardless of corn processing method.

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Effects of Feeding Wet Distillers Grains Plus Solubles on Feedlot Manure Value

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Summary

Feeding wet distillers grains plus solubles (WDGS) improves the fertilizer value and net value of feedlot manure for all feedlot sizes. The net fertilizer value of feedlot manure increased 375% to 550% since 2006. Valuing manure at 2008 fertilizer nutrient prices and feeding 20% or 40% WDGS instead of feeding a corn-based diet improved profitability by $7 to $17 per steer finished ($4 to $11 per ton of manure).

Introduction

Previous research evaluated the effects of dietary ingredients (specifically wet distillers grains plus solubles [WDGS]) on the fertilizer value of manure (*2006 Nebraska Beef Report*, pp. 98-102; *2008 Nebraska Beef Report*, pp. 59-61). These two studies reported that the fertilizer value of feedlot manure increases as the concentration of N and P increase in the diet.

The previous studies did not consider the impact of different fuel and fertilizer prices on manure value. Therefore, the objective of this study was to use the Feed Nutrient Management Planning Economics (FNMP$) model to evaluate the fertilizer value of feedlot manure at different fertilizer and fuel prices.

Procedure

The FNMP$ model (Koelsch et al., 2007; available at *http://water.unl.edu/mnmresources/software* under Software for Manure Management) has been described by Bremer et al. (*2008 Nebraska Beef Report*, pp. 59-61). The model calculates manure management economics based on animal nutrient intake, manure nutrient availability, land requirement for spreading, operating costs and fertilizer value. The model was used to compare 2006 and 2008 manure management costs and manure net values of diets containing 0%, 20% and 40% of diet DM as WDGS. These diets were calculated to have 0.29%, 0.39% and 0.49% phosphorus (P), respectively, and 13.0%, 15.3% and 18.7% crude protein (CP), respectively. These diets were evaluated for 2,500-, 10,000- and 30,000-head feedlots feeding two turns of cattle per year at full capacity.

Key Assumptions

Accounting for storage and field losses, 95% and 23% of excreted P and N, respectively, are available for crop growth. Average feedlot manure was calculated to be 74% ash and 70% DM with 57% reduction in manure organic matter (OM) content from excretion to pen cleaning (*2006 Nebraska Beef Report*, pp. 87-89 and 94-97). The cropping rotation is a corn on soybeans continuous rotation with 185 bu/acre corn and 50 bu/acre soybeans. Manure is applied at the 4-year P-based crop requirement, and 50% of the land around the feedlot is available for manure application. The manure application equipment

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Table 1. Feedlot manure value ($/ton of manure at 70% DM) for three feedlot sizes feeding 0%, 20% or 40% WDGS with either 2006 prices of $0.19/lb N, $0.26/lb P_2O_5, and $1.50/gallon diesel or 2008 prices of $0.55/lb N, $0.98/lb P_2O_5, and $4.50/gallon diesel.

Year	2006			2008		
Feedlot Size	2.500	10,000	30,000	2,500	10,000	30,000
Manure Value						
0% WDGS		4.14			14.23	
20% WDGS		5.62			19.53	
40% WDGS		7.26			25.27	
Spreading Cost						
0% WDGS	2.08	1.67	2.45	2.19	1.85	3.28
20% WDGS	2.27	2.17	3.17	2.41	2.39	4.22
40% WDGS	2.49	2.70	3.92	2.66	2.97	5.16
Net Value						
0% WDGS	2.06	2.47	1.69	12.04	12.38	10.95
20% WDGS	3.36	3.45	2.45	17.12	17.13	15.31
40% WDGS	4.76	4.56	3.34	22.61	22.30	20.11

Table 2. Feedlot manure value ($/head finished) for three feedlot sizes feeding 0, 20, or 40% WDGS with either 2006 prices of $0.19/lb N, $0.26/lb P_2O_5, and $1.50/gallon diesel or 2008 prices of $0.55/lb N, $0.98/lb P_2O_5, and $4.50/gallon diesel.

Year	2006			2008		
Feedlot Size	2.500	10,000	30,000	2,500	10,000	30,000
Manure Value						
0% WDGS		6.72			23.09	
20% WDGS		9.12			31.68	
40% WDGS		11.78			41.01	
Spreading Cost						
0% WDGS	3.37	2.72	3.97	3.55	3.00	5.32
20% WDGS	3.68	3.52	5.12	3.90	3.88	6.84
40% WDGS	4.04	4.38	6.36	4.32	4.82	8.37
Net Value						
0% WDGS	3.35	4.00	2.75	19.54	20.09	17.77
20% WDGS	5.44	5.60	3.97	27.78	27.80	24.84
40% WDGS	7.73	7.40	5.41	36.68	36.19	32.63

Table 3. Average manure value (FOB the feedlot) based on 16.9 lb N and 18.2 lb P_2O_5 per ton of manure at 70% DM.

	P_2O_5, $/lb											
N, $/lb	0.40	0.50	0.60	0.70	0.80	0.90	1.00	1.10	1.20	1.30	1.40	1.50
0.20	10.70	12.53	14.35	16.18	18.01	19.83	21.66	23.49	25.32	27.14	28.97	30.80
0.30	12.39	14.22	16.05	17.87	19.70	21.53	23.36	25.18	27.01	28.84	30.67	32.49
0.40	14.09	15.91	17.74	19.57	21.40	23.22	25.05	26.88	28.71	30.53	32.36	34.19
0.50	15.78	17.61	19.43	21.26	23.09	24.92	26.74	28.57	30.40	32.23	34.05	35.88
0.60	17.47	19.30	21.13	22.96	24.78	26.61	28.44	30.27	32.09	33.92	35.75	37.58
0.70	19.17	21.00	22.82	24.65	26.48	28.30	30.13	31.96	33.79	35.61	37.44	39.27
0.80	20.86	22.69	24.52	26.34	28.17	30.00	31.83	33.65	35.48	37.31	39.14	40.96
0.90	22.56	24.38	26.21	28.04	29.87	31.69	33.52	35.35	37.18	39.00	40.83	42.66
1.00	24.25	26.08	27.90	29.73	31.56	33.39	35.21	37.04	38.87	40.70	42.52	44.35

was chosen to be the most economical and time-effective for each operation size. The optimum manure application equipment for the 2,500- 10,000- and 30,000-head capacity yards included: one 16-ton truck-mounted spreader, one 28-ton truck-mounted spreader, and three 28-ton truck-mounted spreaders, respectively. The labor rate was set at $12/hour. The 2006 fertilizer prices used were $0.19 and $0.26 per lb of N and P_2O_5, respectively. The 2006 fuel price used was $1.50 per gallon diesel fuel. The corresponding 2008 N, P_2O_5 and fuel prices are $0.55, $0.98 and $4.50, respectively. Manure's N and P values are included in the analysis, while no value was assigned to organic matter, potassium, other micro-nutrients and water-holding capacity.

Manure Value Table

A table of manure fertilizer values (FOB the feedlot) at different N and P_2O_5 prices was constructed using average feedlot manure N and P composition based on data collected from six Nebraska feedlots over a one-year period (*2006 Nebraska Beef Report*, pp. 94-97). The N and P values for the manure were 1.21% and 0.57% of DM, respectively. On a DM basis, these values translate into 24.2 and 26.1 lb of N and P_2O_5 per dry ton of manure (16.9 and 18.3 lb of N and P_2O_5 per wet ton at 70% DM).

Results

The values of manure from 2006 and 2008 were expressed per ton of manure (70% DM; Table 1). The manure values were calculated on a "per animal finished" basis (Table 2) to show the effects of proper nutrient management on individual animal profitability. Changes in manure DM and ash (soil contamination) content influenced the manure's nutrient concentration and value. Therefore, collecting accurate manure composition data is an important part of manure management plans and assessing manure value.

Feeding 20% or 40% WDGS increased manure value without management costs by 36% and 76%, respectively, compared to manure from cattle fed a corn-based diet. Manure management costs of a 2,500-head feedlot increased by 10% and 20% when feeding 20% and 40% WDGS, respectively, due to higher hauling costs for longer average haul distances when manure contains greater nutrient concentrations. The costs for larger feedlots (10,000- and 30,000-head) feeding 20% or 40% WDGS increased by 30% and 60%, when feeding 20% or 40% WDGS, respectively. However, the increased costs were more than offset by the increased manure value if 1) manure is applied at a 4-year P-based rate, and 2) manure is valued for its ability to replace N and P fertilizers. Feeding 20% to 40% WDGS resulted in a 40% to 130% increase in manure net value relative to manure from cattle fed corn.

The increase in fertilizer and fuel prices of 2008 compared to 2006 changed the value of manure with minimal impact on spreading costs, which changed manure net value. Manure value increased by 246% from 2006 to 2008. Costs increased by 5% to 34% from 2006 to 2008. This resulted in a 375% to 550% increase in manure net value.

Valuing manure at 2006 fertilizer nutrient prices and feeding 20% or 40% WDGS instead of feeding a corn-based diet improved individual animal profitability by $1.22 to $4.38 per finished steer, respectively, not accounting for improved animal feeding performance from WDGS. Valuing manure at 2008 fertilizer nutrient prices and feeding 20% or 40% WDGS instead of feeding a corn-based diet improved individual animal profitability by $7.07 to $17.14 per finished steer ($4.36 to $10.57 per ton of 70% DM manure).

In conclusion, fertilizer value of manure has dramatically increased in recent times. Feedlot managers who feed WDGS (and other byproducts) may be able to improve operation profitability by increasing manure revenue.

Table 3 provides methods to value manure based on current fertilizer prices. This table assumes average feedlot manure characteristics of 16.9 lb N and 18.2 lb P_2O_5 per ton of manure at 70% DM. Conducting manure nutrient analysis is an important part of accurate manure valuation and a requirement for nutrient management plans. Moisture and ash content of the manure may impact manure value. Therefore, these table values are not accurate for all situations.

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Effect of Dietary Cation-Anion Difference on Feedlot Performance, Nitrogen Mass Balance and Manure pH in Open Feedlot Pens

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Summary

Two experiments were conducted to evaluate the effect of dietary cation-anion difference (DCAD) at two levels (-16 and +20 mEq) on feedlot performance and nutrient mass balance in open feedlots. Decreasing DCAD did not negatively impact cattle performance or carcass characteristics. Feeding negative DCAD diets resulted in lower manure pH in both the winter and summer experiments. Final soil core pH was reduced only in the winter experiment. Percentage of N lost was not influenced by DCAD in either experiment. The decrease in manure pH is likely not enough to reduce the amount of N lost in open feedlot pens.

Introduction

Direct addition of acid to cattle slurry has reduced N losses during storage (Frost et al., 1990, *Journal of Agricultural Science*), and prior to spreading slurry (Stevens et al., 1989, *Journal of Agricultural Science*). Reducing urine and fecal pH on the pen surface may reduce the amount of N lost from open feedlot pens. Urinary pH can be lowered using the dietary cation-anion difference (DCAD, defined as milliequivalents (mEq) of [(Na + K) – (Cl + S)] per 100 g of feed DM). The majority (60-80%) of N excreted by feedlot cattle is in the urine as urea, which is converted into ammonium by the urease enzyme. Lowering urinary pH may reduce the amount of ammonia volatilized by shifting a greater proportion of N into the ammonium form. The objectives of these studies were to evaluate effects of DCAD level on steer performance, soil core and manure pH, and N mass balance.

Procedure

Cattle Performance

Two experiments were conducted using 96 steers each; calves (573 ± 48 lb BW) were fed 196 days from November to May (WINTER) and yearlings (760 ± 56 lb BW) fed 145 days from June to October (SUMMER) to evaluate DCAD level on N balance, manure pH and soil core pH in open feedlots. Steers were blocked by BW, stratified within block and assigned randomly to pen (eight steers/pen). Dietary treatments consisted of negative (-16 mEq, NEG) and positive (+20 mEq, POS) DCAD levels. Basal diets for both experiments consisted of high-moisture and dry-rolled corn fed at a 1:1 ratio, 20% WDGS, 7.5% alfalfa hay and 5% supplement (DM basis). Sodium bicarbonate (1.2% diet DM) replaced a portion of fine ground corn in the positive diet and calcium chloride (0.75% diet DM) replaced a portion of fine ground corn and limestone in the negative diet. Calcium, phosphorus, potassium and sulfur were held constant at 0.65%, 0.40%, 0.72% and 0.33%, respectively, in all diets. Cattle were adapted to finishing diets over a 21-day period, with the corn blend replacing alfalfa hay. Rumensin, Tylan and thiamine premix were formulated for 320, 90 and 130 mg/head/day, respectively, in both experiments assuming a 22 lb dry matter intake (DMI) for WINTER and 24.5 lb DMI for SUMMER.

Steers in the WINTER experiment were implanted on day 1 and day 83 with Synovex Choice (Fort Dodge Animal Health, Overland Park, Kan.). Steers in the SUMMER experiment were implanted once on day 48 with Revalor-S (Intervet Inc. Somerville, N.J.). Steers were slaughtered on day 196 (WINTER) and day 145 (SUMMER) at a commercial abattoir (Greater Omaha, Omaha, Neb.). Hot carcass weights (HCW) and liver scores were recorded on day of slaughter. Fat thickness and LM area were measured after a 48-hour chill, and USDA called marbling score was recorded. Final BW, average daily gain (ADG) and feed-to-gain ratio (F:G) were calculated based on hot carcass weights adjusted to a common dressing percentage of 63%.

Nutrient Balance

Nutrient mass balance experiments were conducted using 12 open feedlot pens with retention ponds to collect runoff. When rainfall occurred, the runoff collected in the retention ponds was drained and quantified using an air bubble flow meter (ISCO, Lincoln, Neb.). Before placing cattle in pens, 16 soil core samples (6-in depth) were taken from each pen in both experiments. After cattle were removed from pens, scraped manure was piled on a cement apron and sampled (n = 30) for nutrient analysis while being loaded. Manure was weighed before it was hauled to the University of Nebraska compost yard. Manure was freeze-dried for nutrient analysis and oven-dried for DM removal calculation. After manure was removed in a manner identical to removal before the experiments, soil core samples were taken from each pen. Soil core samples and manure from pen cleaning were analyzed for pH using a 1:1 ratio of distilled water and as-is sample. Dietary treatments were fed in the same pens for both experiments.

(Continued on next page)

Table 1. Growth performance and carcass characteristics for steers fed during WINTER.

Dietary Treatment[1]:	NEG	POS	SEM	*P*-value
Performance				
Initial BW, lb	574	574	18	0.96
Final BW, lb[2]	1248	1234	24	0.56
DMI, lb/d	19.3	20.1	0.5	0.12
ADG, lb	3.44	3.37	0.11	0.48
Feed: gain[3]	5.66	6.14	0.17	0.05
Carcass characteristics				
Hot carcass weight, lb	787	777	15	0.55
Marbling score[4]	586	586	18	0.99
LM, area in^2.	12.9	12.4	0.3	0.08
12^{th} rib fat, in.	0.59	0.62	0.04	0.39
Yield grade[5]	3.4	3.6	0.1	0.10
Liver abscess, %	7.2	6.3	6.1	0.89

[1]Dietary treatments: NEG = negative dietary cation-anion difference (-16 mEq); POS = positive dietary cation-anion difference (+20 mEq).
[2]Calculated from hot carcass weight, adjusted to a common dressing percentage of 63.
[3]Analyzed as gain:feed, reciprocal of feed conversion.
[4]Marbling score: 400 = $Slight^0$; 450 = $Slight^{50}$; 500 = $Small^0$, etc..
[5]Where yield grade = 2.5 + 2.5(fat thickness, in) – 0.32(LM area, in^2) + 0.2(KPH fat, %) + 0.0038(hot carcass weight, lb).

Table 2. Growth performance and carcass characteristics for steers fed during SUMMER.

Dietary Treatment[1]:	NEG	POS	SEM	*P*-value
Performance				
Initial BW, lb	758	761	6	0.61
Final BW, lb[2]	1345	1345	15	0.99
DMI, lb/d	24.3	25.2	0.5	0.14
ADG, lb	4.05	4.03	0.09	0.82
Feed: gain[3]	6.06	6.32	0.14	0.11
Carcass characteristics				
Hot carcass weight, lb	847	847	9	0.99
Marbling score[4]	523	543	8	0.04
LM, area in^2.	12.5	12.5	0.3	0.99
12^{th} rib fat, in.	0.59	0.57	0.03	0.59
Yield grade[5]	3.7	3.7	0.2	0.73
Liver abscess, %	8.5	15.0	5.7	0.29

[1]Dietary treatments: NEG = negative dietary cation-anion difference (-16 mEq); POS = positive dietary cation-anion difference (+20 mEq).
[2]Calculated from hot carcass weight, adjusted to a common dressing percentage of 63.
[3]Analyzed as gain:feed, reciprocal of feed conversion.
[4]Marbling score: 400 = $Slight^0$; 450 = $Slight^{50}$; 500 = $Small^0$, etc..
[5]Where yield grade = 2.5 + 2.5(fat thickness, in) – 0.32(LM area, in^2) + 0.2(KPH fat, %) + 0.0038(hot carcass weight, lb).

Ingredients were sampled weekly, and feed refusals were analyzed to determine nutrient intake using a weighted composite on a pen basis. Individual steer N retention was calculated using the National Research Council net energy and protein equations (NRC, 1996). Nutrient excretion was determined by subtracting nutrient retention from intake (ASABE, 2005). Total N lost (lb/steer) was calculated by subtracting manure N (corrected for soil N content) and runoff N from excreted N. Percentage of N loss was calculated as N lost divided by N excreted. Animal performance data were analyzed as a randomized complete block design with pen as the experimental unit. The effects of treatment and block were included in the model. Nutrient balance data were analyzed as a completely randomized design with pen as the experimental unit. Stepwise multiple regression analyses were performed to determine the effect of manure pH, initial soil core pH and final soil core pH on the amount of N lost, percentage of N loss and amount of manure N removed.

Results

Feedlot Performance

Dry matter intake, ADG, final BW, and HCW were not different ($P > 0.10$) among treatments in either experiment (Tables 1 and 2). Feed efficiency was improved ($P = 0.05$) for cattle consuming NEG diets compared with POS in the WINTER (5.66 and 6.14, respectively) and numerically improved ($P = 0.11$) in the SUMMER (6.06 and 6.32, respectively). Calculated USDA yield grade and LM area tended ($P = 0.10$ and P = 0.08, respectively) to be greater for cattle consuming NEG diets than those consuming POS diets in the WINTER. Marbling score was greater ($P = 0.04$) for the NEG treatment compared with POS in the SUMMER experiment. Liver scores and 12^{th} rib fat depth were not influenced ($P > 0.10$) by DCAD in either experiment. In both experiments, cattle performance was not reduced due to negative DCAD diets; feed conversions improved in the WINTER and numerically improved in the SUMMER.

Nutrient Balance

Nitrogen intake, retention and excretion were similar ($P > 0.10$) among treatments for both experiments (Tables 3 and 4). Amounts of DM, OM and N removed during pen cleaning also were similar ($P > 0.50$) among treatments in both experiments. Amount of N lost was similar ($P = 0.59$) among treatments in the WINTER (28.4 and 30.8 lb for NEG and POS, respectively). Amount of N lost in the SUMMER tended ($P = 0.07$) to be greater for POS compared with NEG (47.3 and 43.0 lb, respectively). The difference in amount of N lost during the SUMMER may be due in part to a numerically greater amount of N intake and excretion for cattle fed the POS diet. Runoff N was not different

($P > 0.10$) among treatments in both experiments and constituted 1.7% of excreted N in the WINTER and 2.2% of excreted N in the SUMMER. Percentage of N lost (N lost divided by N excreted) did not differ ($P > 0.25$) among treatments in both experiments. Percent N lost was 39.1% and 40.8% in the WINTER, and 61.3% and 64.6% in the SUMMER (for NEG and POS treatments, respectively).

Initial soil core pH for pens was greater in the WINTER ($P = 0.04$) for cattle receiving the NEG treatment than those receiving the POS treatment (8.52 and 8.39, respectively). However, final soil core pH in the WINTER was greater in pens with cattle receiving the POS treatment compared with NEG (8.70 and 8.52, respectively). Manure pH in the WINTER experiment was greater ($P < 0.01$) for the POS treatment compared with NEG (8.80 and 8.40, respectively). Initial soil core pH in the SUMMER was greater ($P = 0.04$) for POS compared with NEG, but final soil core pH did not differ ($P = 0.29$) among treatment (8.01 and 8.07 for NEG and POS, respectively). Manure pH in the SUMMER experiment was greater ($P < 0.01$) for POS compared with NEG (8.12 and 7.70, respectively). Differences observed for manure pH and final soil core pH did not correspond with N mass balance. In the WINTER experiment, manure pH, initial soil core pH and final soil core pH did not explain a significant amount of variability ($P > 0.15$) for manure N, N lost or percent N loss. In the SUMMER experiment, initial soil core pH explained 40% ($P = 0.03$) of the variation for the amount of N lost, and 31% ($P = 0.06$) of the variation for percent N loss. Our hypothesis was that N excreted in the urine would mix primarily with manure in areas of the pen (along the bunk pad and water tank) where cattle excrete feces, resulting in manure pH being a better indicator of N loss.

Table 3. Effect of dietary treatment on soil core pH, manure pH and nitrogen mass balance during WINTER.[1]

Dietary Treatment[2]:	NEG	POS	SEM	*P*-value
N intake	86.8	89.8	2.2	0.21
N retention[3]	14.2	14.4	0.5	0.74
N excretion[4]	72.7	75.4	2.0	0.21
Manure N	41.4	39.1	6.5	0.73
N run-off	1.09	1.42	0.23	0.18
N lost	28.4	30.8	4.5	0.59
N loss, %[5]	39.1	40.8	5.9	0.78
DM removed	4262	4122	806	0.87
OM removed	495	515	72	0.78
Initial core pH	8.52	8.39	0.06	0.04
Final core pH	8.52	8.70	0.05	<0.01
Manure pH	8.40	8.80	0.06	<0.01

[1]Values are expressed as lb/steer over entire feeding period (196 DOF) unless noted.
[2]Dietary treatments: NEG = negative dietary cation-anion difference (-16 mEq); POS = positive dietary cation-anion difference (+20 mEq).
[3]Calculated using the NRC net protein and net energy equations.
[4]Calculated as N intake – N retention.
[5]Calculated as N lost divided by N excreted.

Table 4. Effect of dietary treatment on soil core pH, manure pH, and nitrogen mass balance during SUMMER.[1]

Dietary Treatment[2]:	NEG	POS	SEM	*P*-value
N intake	81.9	84.6	1.8	0.16
N retention[3]	11.5	11.4	0.28	0.56
N excretion[4]	70.3	73.3	1.7	0.11
Manure N	25.9	24.4	3.3	0.67
N run-off	1.51	1.64	0.39	0.76
N lost	43.0	47.3	2.11	0.07
N loss, %[5]	61.3	64.6	3.7	0.39
DM removed	2399	2599	383	0.61
OM removed	383	380	42	0.93
Initial core pH	8.52	8.70	0.08	0.04
Final core pH	8.01	8.07	0.06	0.29
Manure pH	7.70	8.12	0.07	<0.01

[1]Values are expressed as lb/steer over entire feeding period (196 DOF) unless noted.
[2]Dietary treatments: NEG = negative dietary cation-anion difference (-16 mEq); POS = positive dietary cation-anion difference (+20 mEq).
[3]Calculated using the NRC net protein and net energy equations.
[4]Calculated as N intake – N retention.
[5]Calculated as N lost divided by N excreted.

These data suggest that feedlot performance and carcass characteristics are similar for cattle fed with negative and positive DCAD levels in diets with WDGS. The decrease in soil core and manure pH is likely not enough to decrease N losses in open feedlot pens. Calcium carbonate in the feces and the buffering capacity of soil in feedlot pens appears be great enough to offset the lower urinary pH of cattle fed negative DCAD diets.

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Effect of Dietary Cation-Anion Difference on Intake and Urinary pH in High Concentrate Diets

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Summary

Seven experiments evaluated the effect of basal diet and dietary cation-anion difference (DCAD) on urinary and fecal pH, and DMI. Dry-matter intake (DMI) was reduced by DCAD level in dry-rolled corn basal diets but not in diets that included 20% wet distillers grains (WDGS). Urinary pH decreased with DCAD level in all experiments. Fecal pH was not influenced by either DCAD level or basal diet. Altering DCAD in concentrate diets with or without WDGS does impact urinary pH.

Introduction

Nitrogen loss may be reduced by shifting the equilibrium from NH_3 to NH_4 by acidification of cattle waste. The majority (60-80%) of N excreted by feedlot cattle is in the urine. Lowering urinary pH may reduce the amount of ammonia volatilized by shifting a greater proportion of N into the ammonium form. One way to reduce urinary pH is by lowering the dietary cation-anion difference (DCAD). Dietary cation-anion differences can be changed to induce metabolic acidosis, which aids in calcium homeostasis at the onset of lactation (Goff et al., 2004, *Journal of Dairy Science*). Lowering DCAD has an impact on animal performance, blood pH, and urine pH. If urine and pen surface pH can be lowered by altering DCAD in concentrate diets, N losses may be reduced. The objective of these experiments was to determine the influence of basal diet and DCAD level on urinary and fecal pH and DMI.

Procedure

Lambs

Fifteen wether lambs (75 ± 7 lb) were used in five consecutive 3 x 3 Latin squares. Basal diets consisted of 82.5% dry-rolled corn (DRC), 7.5% alfalfa hay, 5% molasses and 5% supplement (DM). Dietary cation-anion difference was calculated as milliequivalents (mEq) of [(Na + K) – (Cl + S)] per 100 g of feed DM. Ammonium chloride, ammonium sulfate and calcium chloride were used to lower DCAD to 0, -8, -16, -24 and -45 mEq, replacing urea, fine ground corn and limestone. Sodium bicarbonate and potassium carbonate were used to increase DCAD to +16, +24, +32 and +40 mEq, replacing fine ground corn. Periods were 14 days in length with an 11-day adaptation to the diet, and 3-day urine collection period. Urine pH was measured immediately after collection at 0700, 1300 and 1900 hours in all experiments. Lambs were fed once daily at 0700 for *ad libitum* intake. Lamb data were analyzed as separate 3 x 3 Latin squares with model effects for period, treatment, time and the treatment x time interaction as fixed effects and lamb as a random effect. Orthogonal contrasts were used to test significance for the highest order polynomial.

Steers

Eight steers (688 $\pm$ 53) were used in two consecutive 4 x 4 Latin squares with basal diets consisting of either dry-rolled corn (DRC) or wet distillers grains (WDGS), replacing DRC at 20% of diet DM, 7.5% alfalfa hay, 5% molasses and 5% supplement (DM). Basal diets were 8 mEq for the DRC diet and -2 mEq for the WDGS diet. Calcium chloride was used to lower DCAD to -2, -12 and -22 mEq in the DRC square and -12, -22 and -32 mEq in the WDGS square. Period length, DM offered, and urine collection procedures were the same as for the lamb experiments. In addition to urine collection, feces were collected at 0700, 1300 and 1900 hours and composited within day for pH measurement. Manure pH was analyzed using a 1:1 ratio of distilled water and as-is sample.

Urinary pH for steers was analyzed as separate 4 x 4 Latin squares with period, treatment, time and the treatment x time interaction as fixed effects and steer as a random effect. Fecal pH for steers was analyzed in a similar manner without time and the treatment x time interaction in the model. Orthogonal contrasts were used to test significance for the highest order polynomial.

Results

Lambs

Dry matter intake was not different ($P > 0.05$) among DCAD level in all experiments. In experiment 1, DMI was similar ($P = 0.81$) among treatments. Dry-matter intake decreased linearly ($P = 0.02$) with DCAD level in experiment 2. Numerically, DMI was lower for the negative DCAD treatments compared with the control (+8) or positive DCAD treatments in experiments 3, 4 and 5.

The treatment x time interaction for urinary pH was not significant ($P > 0.70$) in all experiments. Urinary pH decreased linearly ($P < 0.01$) in all experiments. The differences in urinary pH from the highest to lowest DCAD level in experiments 1 through 5 were 1.65, 2.31, 2.01, 2.65 and 2.70, respectively. From the lamb experiments it appears DCAD does not have a consistent influence on DMI but is effective in manipulating urinary pH at different levels of DCAD.

Table 1. Effect of DCAD level on DMI and urinary pH for lambs.

Experiment	DCAD[1]	DMI, lb/d	Urine pH	DMI[2]	pH[3,4]
1	0	2.93	6.67[a]		
	8	2.88	7.09[b]	0.81	< 0.01
	16	3.05	8.32[c]		
2	-8	3.20	6.10[a]		
	8	3.13	8.21[b]	0.09	< 0.01
	24	2.97	8.41[b]		
3	-16	2.82	6.37[a]		
	8	3.48	8.22[b]	0.49	< 0.01
	32	3.12	8.38[b]		
4	-24	2.31	5.84[a]		
	8	3.24	8.00[b]	0.07	< 0.01
	40	3.79	8.49[c]		
5	-45	2.15	5.88[a]		
	8	3.13	7.98[b]	0.13	< 0.01
	40	3.13	8.58[c]		

[1]Dietary cation-anion difference, mEq of [(Na + K) – (Cl – S)].
[2]F-test statistic for the effect of DCAD level on DMI.
[3]F-test statistic for the effect of DCAD level on urinary pH.
[4] Linear and quadratic ($P < 0.05$) effect of DCAD level on urinary pH in all experiments.
[a,b,c]Within a column, means without a common superscript letter differ ($P < 0.05$) within each experiment.

Table 2. Effect of dietary cation-anion difference and basal diet on DMI, urinary pH and fecal pH of steers.

	DCAD[1]								
Item	8	-2	-12	-22	-32	SEM[2]	*P*-value[3]	Linear[4]	Quadratic[5]
DRC[6]									
DMI, lb/d	20.1[a]	17.2[ab]	18.0[ab]	14.4[c]		1.6	0.05	0.02	0.76
Urinary pH	7.70[a]	6.40[b]	5.90[c]	5.82[c]		0.13	< 0.01	< 0.01	< 0.01
Fecal pH	5.92	5.74	5.74	5.83		0.16	0.63	0.28	0.64
WDGS[7]									
DMI, lb/d		19.1	21.7	19.6	19.7	1.7	0.52	0.96	0.40
Urinary pH		6.14[a]	5.88[b]	5.71[b]	5.90[b]	0.10	< 0.01	< 0.01	< 0.01
Fecal pH		5.86	5.45	5.80	5.61	0.23	0.35	0.16	0.43

[1]Dietary cation-anion difference, mEq of [(Na + K) - (Cl + S)].
[2]Standard error of the mean.
[3]F-test statistic for the effect of DCAD level.
[4]Contrast for the linear effect of DCAD level within experiment.
[5]Contrast for the quadratic effect of DCAD level within experiment.
[6]Dry-rolled corn basal diet.
[7]Wet distillers grains basal diet.
[a,b,c] Within a row, means without a common superscript letter differ ($P < 0.05$).

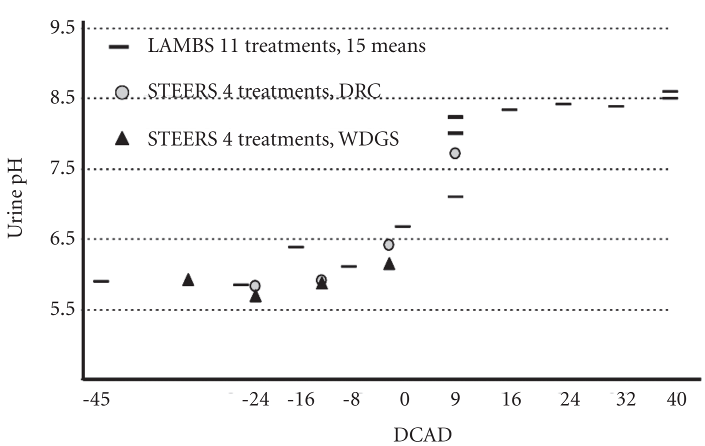

Figure 1. Effect of DCAD level on urinary pH.

Steers

Dry-matter intake for steers in the DRC experiment was greatest ($P = 0.05$) for animals consuming DCAD level +8, lowest for -32, and intermediate for -2 and -12 (Table 1). In the WDGS experiment, DMI was not influenced ($P = 0.52$) by DCAD level (Table 2). The treatment x time interaction for urinary pH was not significant in either experiment ($P > 0.60$). Urinary pH for steers in the DRC experiment decreased quadratically ($P < 0.01$) with DCAD level from 7.70 to 5.82. In the WDGS experiment urinary pH was greater ($P < 0.01$) for -2 compared with -12, -22 and -32 (7.70, 6.40, 5.90 and 5.82, respectively). Fecal pH was not different among DCAD levels in either the DRC or WDGS experiment ($P = 0.63$ and $P = 0.35$, respectively). There also was no relationship (r = 0.02, P = 0.94) of fecal pH to urine pH. Results from the steer experiments are similar to those of the lamb experiments, with an inconsistent influence of DCAD level on DMI. Urinary pH can be manipulated with DCAD level in either DRC or WDGS basal diets while fecal pH is not influenced.

The relative proportions of NH_3 compared to NH_4 are 0.1%, 1%, 10% and 50% at pH of 6, 7, 8 and 9 (Court et al., 1964 *Journal of Soil Science*). When evaluating all DCAD levels from both the lamb and steer experiments, there appears to be a consistent trend in lowering urinary pH (Figure 1). Lowering DCAD in high concentrate diets with or without WDGS decreases urinary pH and may reduce ammonia losses from steers or lambs fed negative DCAD diets.

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Composting or Stockpiling Feedlot Manure: Nutrient Concentration and Recovery

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Summary

Manure stockpiled anaerobically or composted aerobically for 111 days was evaluated for nutrient concentration and recovery. Recovery of dry matter (DM) and organic matter (OM) was not different among storage methods. The proportion of organic nitrogen (N) was greater for composted manure while ammonium N was greater in stockpiles. Recovery of N from stockpiled manure was greater than from compost when ammonium N was measured on "fresh" samples and samples dried down to simulate field application. Anaerobic stockpiling of feedlot manure provides a greater amount of N for crops and similar amounts of DM and OM.

Introduction

Feedlot manure removed from pens in the spring and summer is often stored until crops are harvested in the fall before field application can occur. Methods of handling and storing manure after pen removal have an impact on nutrient recoveries and manure characteristics (*2008 Nebraska Beef Report*, pp. 56-58). Transportation, handling, management and labor costs, as well as land requirements, need to be considered when deciding on a manure storage method (*1997 Nebraska Beef Report*, pp. 77-79). The objective of this research was to compare anaerobic stockpiling and aerobic composting manure storage methods on nutrient concentration and recovery.

Procedure

Manure from 11 open feedlot pens was used to determine the impact of storage method on change in amount and type of N over time for manure anaerobically stockpiled or aerobically composted. In June, scraped manure was piled on the cement apron, sampled, weighed and hauled to the compost yard. Four compost windrows and three stockpiles were constructed. Individual truckloads were weighed and sampled (n = 30) to determine amount of nutrient contribution from pen to each stockpile or windrow. Initial windrows and stockpiles contained 71 ± 1 ton of manure DM. Stockpiles were conical in shape with a base diameter of 28 ft., and windrows were 90 ft. long, 4 ft. tall, and 5 ft. wide at the base.

Windrows were turned using a mechanical compost turner on days 13, 35, 61 and 89. The compost windrows were considered "finished" when the temperature measured at a depth of 48 in. did not increase 2 to 7 days after turning (day 89). The stockpiles were left undisturbed throughout the 111 days of storage, with the exception of core and temperature samples. Stockpile and compost core samples were collected on days 36, 62 and 111. Core samples (n = 4/pile) were taken at a depth of 36 in., mixed, subsampled and frozen until analysis.

Nutrient recoveries were calculated using total ash as an internal marker with the following equation: Nutrient recovery = 100 x [(% ash initial / % ash after) x (% nutrient after / % nutrient before)]. The total amount of nutrient content also was calculated in a similar manner using total ash as a marker for DM. Nutrient concentrations are reported as g/kg; to convert to percent nutrient, divide by 10. Samples were analyzed by a commercial laboratory (Ward Laboratories Inc., Kearney, Neb.) for nutrient composition. Ammonium N was measured on samples as-is and after drying for 24 hours in a 100°C oven to estimate how much N may be lost when manure is spread and exposed to high temperatures. Data were analyzed using the MIXED procedure of SAS with four replications per sampling date for compost and three replications per sampling date for stockpile. Model effects included sampling day, storage method and the sampling day x storage method interaction. Sampling day was used as a repeated measure. A single degree of freedom contrast of stockpile and compost at day 111 also was evaluated.

Results

Temperature of compost measured two to seven days following turning was considered an indicator of active composting. Compost temperature was within 100° and 150°F until the final turn (day 89) when the compost was considered "finished." Percentage DM was generally greater for the compost, compared with stockpiled manure, and varied with rainfall during the 111 days of storage (Table 1). Amount of moisture in a pile often fluctuates more with composting compared with stockpiling because of moisture loss after a turn or the incorporation of water after a rain event. The overall moisture content for compost was slightly lower (28% moisture) than the recommended level of 30-60%. Recovery of DM was not different (P = 0.81) among storage methods on day 111. Concentration of P_2O_5 also was similar (P = 0.40) among storage methods at day 111 (9.0 and 8.7 g/kg DM for stockpile and compost, respectively).

Initial percent OM was low in the manure used in this study (12.8%), which reflected the amount of soil hauled out of the pens during scraping. In the spring before removal of manure, wet conditions allowed for mixing of feces and soil, causing a greater amount of soil to be removed from the pens. Percent OM tended (P = 0.06) to be greater for stockpiled manure compared with compost

Table 1. **Effect of manure storage method on nutrient concentrations and recoveries.**[1]

	Stockpile				Compost						
Day[2]:	0	36	62	111	0	36	62	111	SEM[3]	*P*-value[4]	Contrast[5]
DM %	67.5^{bc}	70.0^{b}	69.3^{bc}	66.6^{c}	68.7^{bc}	76.4^{a}	74.9^{a}	69.3^{bc}	1.0	0.02	
DM recovery, %	100.0	96.0	95.4	95.1	100.0	96.7	96.0	95.2	0.5	0.76	0.81
OM %	13.0	9.4	8.8	8.5	12.4	9.3	8.7	8.0	0.2	0.25	0.06
OM recovery, %	100.0	69.5	64.9	62.5	100.0	73.1	67.7	61.6	3.2	0.70	0.77
Organic C, g/kg DM	75.5	54.6	51.3	49.5	71.7	54.1	50.3	46.2	1.2	0.25	0.06
P_2O_5, g/kg DM	8.8	8.5	8.7	9.0	8.6	8.4	8.8	8.7	0.3	0.89	0.40
C:N	10.9	10.4	9.7	9.3	10.7	10.0	9.3	9.3	0.2	0.39	0.40
N:P	1.97^{a}	1.66^{b}	1.51^{c}	1.54^{c}	1.93^{a}	1.54^{c}	1.44^{c}	1.32^{d}	0.05	0.05	< 0.01

[1]Values are expressed on a 100% DM basis.
[2]Day = sampling date from pen cleaning on day 0.
[3]Pooled standard error of the mean.
[4]*F*-test statistic for storage method by time interaction.
[5]Contrast = Single degree of freedom contrast of stockpile vs. compost on day 111.
[a,b,c,d]Within a row, means without a common superscript letter differ ($P < 0.05$).

Table 2. **Effect of manure storage method and laboratory analysis on nitrogen concentration and recoveries.**[1]

	Stockpile				Compost						
Day[2]:	0	36	62	111	0	36	62	111	SEM[3]	*P*-value[4]	Contrast[5]
Wet laboratory analysis[6]											
Total N recovery, %	100.0	78.5	72.9	75.8	100.0	74.8	72.6	65.6	3.4	0.14	< 0.01
Total N, g/kg DM	7.6^{a}	6.2^{b}	5.9^{bc}	5.9^{bc}	7.3^{a}	5.6^{c}	5.5^{c}	5.0^{d}	0.2	< 0.01	< 0.01
NH_4, g/kg DM	0.9^{ab}	1.5^{a}	1.1^{a}	1.4^{a}	0.9^{ab}	0.6^{bc}	0.4^{c}	0.3^{c}	0.1	< 0.01	< 0.01
NH_4, % total N	11.8^{b}	23.0^{a}	19.3^{a}	22.4^{a}	11.8^{b}	10.2^{bc}	8.0^{c}	6.3^{c}	1.6	< 0.01	< 0.01
Organic N, g/kg DM	6.7^{a}	4.7^{bc}	4.5^{cd}	4.5^{d}	6.4^{a}	4.9^{b}	4.6^{cd}	4.2^{e}	0.1	0.03	0.08
Organic N, % total N	88.3^{a}	76.4^{c}	78.5^{c}	74.0^{d}	88.5^{a}	87.3^{ab}	83.1^{b}	84.7^{b}	1.6	< 0.01	< 0.01
Nitrate N, ppm	0^{d}	33^{d}	133^{bc}	216^{b}	0^{d}	100^{bcd}	500^{a}	475^{a}	57	< 0.01	< 0.01
Dry laboratory analysis[7]											
Total N recovery, %	100.0	75.1	69.9	70.5	100.0	71.8	70.5	65.0	3.2	0.33	0.10
Total N, g/kg DM	7.2	5.6	5.2	5.3	6.9	5.1	5.0	4.7	0.2	0.06	< 0.01
NH_4, g/kg DM	0.4^{d}	0.6^{bc}	0.7^{ab}	0.7^{a}	0.4^{d}	0.5^{c}	0.4^{d}	0.3^{e}	0.1	< 0.01	< 0.01
NH_4, % total N	5.1^{d}	9.9^{b}	13.3^{a}	13.3^{a}	5.4^{d}	9.3^{b}	8.5^{bc}	6.6^{c}	1.2	< 0.01	< 0.01

[1]Values are expressed on a 100% DM basis.
[2]Day = sampling date from pen cleaning on day 0.
[3]Pooled standard error of the mean.
[4]*F*-test statistic for storage method by time interaction.
[5]Contrast = Single degree of freedom contrast of stockpile vs. compost on day 111.
[6]Samples analyzed wet, values expressed on a 100% DM basis.
[7]Samples analyzed after drying in a 100°C oven for 24 hours to estimate ammonia losses.
[a,b,c,d,e]Within a row, means without a common superscript letter differ ($P < 0.05$).

on day 111 (8.5% and 8.0%, respectively). Organic C tended ($P = 0.09$) to be greater for stockpiled manure compared with compost on day 111 (49.5 and 46.2 g/kg DM, respectively). Recovery of OM was not different ($P = 0.77$) among storage methods on day 111 (62.5% and 61.6% for stockpiled and composted manure, respectively).

Ammonium N (% of total N) in the stockpile increased from day 0 and remained at levels higher than in the fresh manure, while the amount of ammonium N in the compost decreased throughout the storage period (Table 2; 22.4% and 6.3% for stockpiled and composted manure on day 111, respectively). The decrease in organic N (% of total N) was greater ($P < 0.01$) for the stockpiles than for composted manure (74.0% and 84.7% on day 111, respectively). Nitrate N (ppm) increased throughout the 111-day storage period for both methods and was greater ($P < 0.01$) for compost than for stockpiled manure on days 62 and 111. Concentration of total N was greater ($P < 0.01$) for stockpiled manure compared with compost on days 36 and 111 (5.9 and 5.0 g/kg DM on day 111, respectively). Similarly, total N recoveries were greater ($P < 0.01$) for stockpiled manure than for compost on day 111 (75.8% and 65.6%, respectively). It is generally assumed that ammonium N is rapidly converted to ammonia N and volatilized, suggesting a greater amount of N loss would occur after stockpiled manure is spread on fields. Results from data obtained using oven-dried samples indicate that total N recovery tended ($P = 0.10$) to be greater for stockpiled manure than for compost (70.5% and 65.0%, respectively), even though a greater amount

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of N may be lost from the ammonium N fraction during spreading.

Organic C was lost at a more rapid rate than N during the storage period, resulting in a decrease in the C:N ratio for both storage methods throughout the 111 days. The C:N ratio was similar ($P = 0.40$) for the two storage methods on day 111. Because phosphorus is not volatilized, the N:P ratio decreases for both storage methods over time. Greater N loss from composting resulted in a lower ($P = 0.05$) N:P ratio at days 36 and 111.

Proportionally, the largest loss of DM, OM and N for both storage methods occurred during the first 36 days of storage. During this time, OM and N losses may be similar for stockpiled manure and compost because oxygen trapped in the stockpile during pen scraping and construction may allow for conditions favorable for aerobic bacteria to break down nutrients. The differences on day 111 for OM and N in stockpiled and composted manure may be due, in part, to the continued addition of oxygen in the compost compared with the anaerobic environment in the stockpile.

The results of this study for N losses were similar to those found in 2008 *(2008 Nebraska Beef Report*, pp. 56-58). When compared on a crop nutrient basis, stockpiling feedlot manure has a greater value than composting. Similar DM recoveries and moisture content of the two storage methods indicate volume and weight are not substantially influenced with either method. Added costs for management, labor, land and equipment needed for composting may not be offset by a decrease in transportation cost to the field. When these factors are coupled with nutrient recoveries, anaerobic stockpiling of feedlot manure may be more economically favorable.

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Impact of a New Direct-Fed Microbial on Intake and Ruminal pH

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Summary

Nine ruminally fistulated steers were used in a metabolism experiment to evaluate the effect of a new direct-fed microbial (DFM) on acidosis. No statistical differences were observed in dry matter intake (DMI). Minimum pH was significantly lower in steers fed the DFM during grain adaptation, resulting in a greater change in ruminal pH and pH variance for steers fed DFM during grain adaptation. However, once steers were on the finishing diet, no differences were detected due to treatment.

Introduction

Roughages such as alfalfa and corn silage have traditionally been utilized to aid in the control of acidosis; however, direct-fed microbial products have been utilized more recently. By definition, direct-fed microbial products must contain a viable microorganism commonly used during periods of high stress when acidosis is frequent. In addition, it has been shown that acidosis is reduced when wet corn gluten is fed, but acidosis still remains an issue when wet distillers grains are fed.

Methodology that combined simultaneous measurement of feed consumption and ruminal pH (via probes placed through the fistula) has enhanced acidosis research. However, cattle are required to be restrained throughout this process and measured for short windows of time (i.e., periods of 5 days); therefore, pH probes that allow for free movement of animals would be advantageous.

The objectives of this research were to: 1) determine the efficacy of a DFM specifically selected to reduce acidosis in diets containing wet distillers grains, and 2) validate the accuracy of self-contained pH probes.

Procedure

Nine ruminally fistulated crossbred steer calves (initial BW = 810 lb) were assigned randomly to one of two treatments in a simple two period cross-over design. Cattle were fed the same diet with the exception of the dietary treatments. Steers received either the DFM (5×10^9 colony-forming units in 0.5 g /day of maltodextrin carrier; +DFM) or a placebo (0.5 g of maltodextrin carrier; CON) in a powder form, which were top-dressed to the diet daily. The active microorganism in this DFM is *Bacillus pumilus* strain 8G134. The grain adaptation phase of the experiment was composed of four 7-day steps (days 1 to 28) and the finishing phase was from day 29 to day 120. Treatments were applied during grain adaptation and through day 75 of the experiment. At that time, dietary treatments were switched for the remaining 45 days of the trial. Table 1 provides diet composition fed throughout the trial.

Steers were individually housed in free box stalls from day 1 to 44, day 50 to 98, and day 104 to 120. Diets were fed in individual feed bunks suspended from load cells. Constant data acquisition of feed disappearance was obtained through use of computer software connected to the feed bunks. Feed weight in each bunk was recorded once every minute and continuously stored for each steer throughout the day. Bunks were read once daily at 0700 and feed offerings were adjusted accordingly for feeding at 0730. All feed refusals were weighed to accurately measure DMI. Measurements included DMI, number of meals per day, time spent eating per day and average meal size.

Self-contained (wireless) pH probes were placed into the rumen of each steer throughout the entire trial. Each probe contained a data logger, 9-volt battery, and an electrode cable housed in a watertight capsule constructed out of PVC material. Each pH electrode was enclosed in a weighted, PVC material cover that maintained the electrode in the ventral sac of the rumen. Ruminal pH was recorded once every minute continuously for seven days. At that time each probe

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Table 1. Diet composition of metabolism steers fed DFM (% of diet DM).

Ingredient	Step 1	Step 2	Step 3	Step 4	Finisher
High-moisture corn	20	30	40	50	57.5
WDGS	30	30	30	30	30
Alfalfa hay	45	35	25	15	7.5
Supplement	5	5	5	5	5

Table 2. Effect of DFM and placebo on feed intake and intake behavior.

	Grain Adaptation Phase[1]			Finishing Phase[2]		
Item	+ DFM	CON	*P*-value	+ DFM	CON	*P*-value
DMI, lb	20.2	19.6	0.85	24.7	24.5	0.92
Meals/day, n	4.61	4.94	0.56	6.00	5.68	0.41
Time eating/day, min	602.6	708.8	0.27	785.2	776.7	0.89
DMI/meals, lb	5.47	5.27	0.84	4.44	4.87	0.38

[1]Grain adaptation phase: days 1-28.
[2]Finishing phase: days 29-120.

Table 3. Effect of DFM and placebo on ruminal pH.

Item	Grain Adaptation Phase[1]			Finishing Phase[2]		
	+ DFM	CON	*P*-value	+ DFM	CON	*P*-value
Average pH	5.49	5.61	0.47	5.49	5.49	0.92
Minimum pH	4.98	5.18	0.15	4.99	4.99	0.99
Maximum pH	6.29	6.21	0.59	6.41	6.36	0.65
pH change	1.37	1.07	0.02	1.42	1.36	0.61
pH variance	0.139	0.066	0.01	0.117	0.111	0.80
Time < 5.6, min	842.0	768.1	0.67	926.7	944.4	0.87
Area < 5.6	395.8	272.7	0.35	349.9	332.8	0.81
Time < 5.3, min	648.6	503.6	0.52	581.5	542.7	0.74
Area < 5.3	209.7	108.4	0.29	121.5	109.1	0.73
Time < 5.0, min	387.6	242.4	0.43	188.7	176.4	0.84
Area < 5.0	91.2	28.8	0.29	19.3	17.7	0.88

[1]Grain adaptation phase: days 1-28.
[2]Finishing phase: days 29-120.

Table 4. Comparison of two pH measurement methods.

Item	Conventional probe	Wireless probe	*P*-value
Period 1[1]	5.49	5.30	0.09
Period 2[2]	5.43	5.51	0.45
Overall[3]	5.46	5.41	0.64

[1]Period 1: days 45 – 49 of finishing phase.
[2]Period 2: days 99 – 103 of finishing phase.
[3]Significant interaction between method and each 5-day period ($P < 0.01$).

Table 5. Effect of DFM on comparison of two pH measurement methods.

Method	+ DFM	CON	*P*-value
Conventional probe	5.45	5.47	0.11
Wireless probe	5.42	5.40	0.13
Overall[1]	5.43	5.43	0.97

[1]Significant interaction between method and diet treatment ($P < 0.03$).

was briefly removed from the rumen, pH data were downloaded, pH electrodes were recalibrated, and then each self-contained pH probe was reinserted into the rumen. Ruminal pH measurements included average, minimum and maximum pH; pH change and variance; and time and area below pH 5.6, 5.3 and 5.0.

Simultaneous ruminal pH collection was necessary to effectively evaluate pH measurement systems. Therefore, in the evening of day 44 and day 98, steers were moved and secured to individual metabolism stanchions and were allowed to adjust to stanchions overnight. Cattle were in stanchions for two 5-day periods (days 45- 49 and days 99-103). Feed intake measurements while steers were in stanchions were identical to those taken when steers were in box stalls. At day 45 and day 99, submersible (conventional) pH electrodes were placed through the fistula into the rumen of each steer and remained in place through the morning of day 49 and day 103, respectively. Each pH electrode was enclosed in a weighted, four-wire metal cover to keep the electrode in a fixed suspended position approximately 4-6 in above the ventral wall of the rumen. Electrodes were linked directly to a computer equipped with data acquisition software to record ruminal pH every six seconds and average ruminal pH every minute throughout the pH data collection phase. At day 49 and day 103, the ruminal pH electrodes were removed and steers were returned to their individual free box stalls. Ruminal pH measurements were the same as those recorded with the self-contained probes.

Data were analyzed by day within period as a repeated measure using the MIXED procedure of SAS. Fixed model effects were period, treatment and period x treatment interaction. Animal nested within treatment was considered a random effect. A protected F-test was used during analyses where numbers represent *P*-value for variation due to dietary treatment or pH measurement method.

Results

Two steers were removed from the trial for approximately three weeks during the finishing phase while on the DFM treatment due to severe acidosis (DMI < 15 lb). These intake data were removed from the analyses of the experiment; however, pH data remained in the analyses.

Intake Behavior

Effects of the DFM on DMI and feeding behavior are presented in Table 2. No significant effects due to the DFM were observed on either DMI or intake behavior. Numerically, however, DMI was greater during both the grain adaptation and finishing periods when steers were fed the DFM. Despite this, we would expect DMI to be lower during finishing without removal of the two acidotic steers. Interestingly, when steers were fed the DFM, meals per day were numerically lower during grain adaptation, but numerically higher during finishing. Likewise, time spent eating per day was numerically lower during grain adaptation and numerically higher during finishing when steers were fed the DFM. In addition, DMI per meal was numerically greater for steers fed DFM during grain adaptation, but numerically lower when they were on the finishing diet.

Ruminal pH

Effect of the DFM on ruminal pH is presented in Table 3. Minimum pH tended to be lower ($P = 0.15$) in steers fed the DFM during the adaptation phase, resulting in a greater change in ruminal pH ($P = 0.02$) and greater pH variance ($P < 0.01$) for steers fed DFM during grain adaptation. No significant differences were observed between DFM and CON once the cattle were on the finishing diet. Despite this, both pH change and variance were numerically greater for steers fed DFM. Although no significant results were found for time and area below differing pH levels, numerically intriguing trends were observed. Time and area below pH 5.6, 5.3 and 5.0 were all numerically higher when steers were fed the DFM throughout the entire trial, with the exception of time below pH 5.6 during finishing. These data suggest that feeding this specific DFM did not positively impact ruminal pH as hypothesized.

Method Comparison

Table 4 provides a summary of the comparison between the conventional probes and the wireless probes. An interaction ($P < 0.01$) between method of pH measurement and each 5-day period in stanchions was observed. The average pH varied from 5.30 to 5.51 between method and period. Interestingly, pH measurement of the wireless probe was lower during the first 5-day period and numerically greater during the second 5-day period.

Effects of DFM using each method is presented in Table 5. A method × diet treatment interaction ($P < 0.03$) was found. The average pH variation was slightly less, ranging from 5.40 to 5.47 between method and diet treatment. However, pH tended to be higher ($P = 0.11$) for the conventional probe system while steers were fed the placebo (CON). Conversely, pH tended to be higher ($P = 0.13$) for the wireless probes when steers were fed the DFM. Due to the small differences, we conclude there is no difference between the methods for measuring pH continuously.

In summary, DMI and eating behavior were not impacted by the addition of the DFM to the diet. Minimum ruminal pH was lower, with greater change and variance in pH observed during grain adaptation for steers fed the DFM. Direct-fed microbials are occasionally added to feedlot rations to reduce acidosis and increase feed efficiency. These data indicate, however, that the inclusion of this new DFM does not aid in control of acidosis. Likewise, two steers were removed due to acidosis and both were on the DFM treatment at the time.

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Effects of Environmental Factors on Body Temperature of Feedlot Cattle

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Summary

Tympanic temperature of 32 Angus steers (919 ± 7.5 lb) was measured with Micro-T ibuttons or the Stowaway data loggers. Environmental variables were collected using weather stations located in the pens to evaluate factors influencing body temperature. A multiple regression analysis was used to evaluate the effects of these factors on body temperature of feedlot cattle. Tympanic temperature tended to be higher for Stowaway compared to Micro-T data loggers (102.6 vs. 102.41°F ± 0.072, respectively; P = 0.053). Tympanic temperature was driven primarily by outgoing solar radiation and wind speed (R^2=0.79).

Introduction

During hot conditions cattle are exposed to an extra heat load as a result of a combination of weather conditions and high-energy diets. Core body temperature (BT) is used as an indicator of cattle comfort. Likewise, it has been widely accepted that in healthy adult cattle, BT ranges from 99.5 to 104.0°F. However, BT is not a constant; rather it shows small circadian fluctuations, which follow the same pattern of changes observed in some environmental variables. Therefore, our objectives were: 1) compare devices to record tympanic temperature, and 2) assess the relationship of different environmental variables on tympanic temperature of feedlot cattle.

Procedure

The relationships among environmental variables and tympanic temperature (TT) were studied during July 5 to 12 of 2007 at the Haskell Agricultural Laboratory in Concord, Neb. A total of 112 predominantly Angus and Angus crossbred steers (7 head/pen, 919.3 ± 7.5 lb) were fed a finishing diet based on dry-rolled corn (76% DM). In each pen, two steers received a Micro-T ibutton data logger, whereas two other steers received a Stowaway data-logger (n = 64). The environmental variables were collected hourly from a weather station located in the feedlot pens. The dry matter intake (DMI) and daily water intake (DWI) were collected daily by pen and then divided by the number of steers in each pen to obtain an estimation of individual water consumption. Data were analyzed graphically using Microsoft Office Excel 2007®, and statistically using JMP® and SAS®. The devices were compared by means of a t-test and an analysis of repeated measures. A multiple regression analysis using the stepwise procedure in SAS was conducted in order to identify the main factors affecting TT. The environmental variables included in the analysis were: air temperature (AT), soil temperature (ST), soil surface temperature (SST), wind speed (WS), relative humidity (RH), temperature-humidity index (THI), solar radiation, plus DMI and DWI. Likewise, data for each one of the four components of solar radiation were collected hourly. Data on incoming and outgoing shortwave radiation were collected using two precision spectral pyranometers (Eppley Lab. Inc.), whereas incoming and outgoing longwave radiation data were collected using two precision infrared radiometers (Eppley Lab. Inc.). Simultaneously, net solar radiation also was collected using a REBS Net Radiometer model Q-7.1 (Radiation and Energy Balance Systems, Inc.).

Results

Device Comparison

Figure 1 displays the average hourly TT for each device, showing similar patterns. The minimum TT was observed early in the morning before sunrise (0600 to 0700). After sunrise, TT increased rapidly and reached the maximum at about 1700 to 1800. The mean TT recorded tended to be slightly higher with the Stowaway device than the Micro-T (102.6 vs. 102.41°F ± 0.072, respectively; P = 0.053). When data were analyzed using the repeated measure procedure, effects for type of device and time of day (P = 0.0475 and P < 0.0001, respectively) were detected, but there was no interaction between device and hour (P = 0.79).

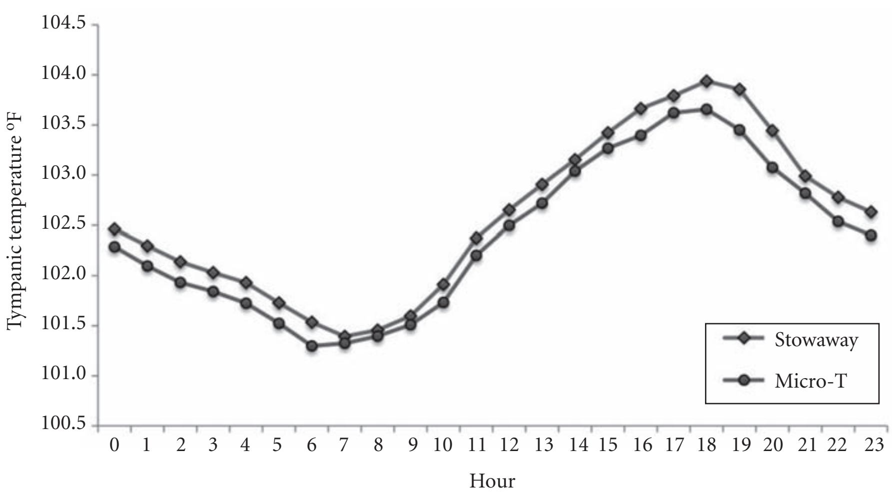

Figure 1. Average tympanic temperature for the period of study by device.

Environmental Factors Affecting Tympanic Temperature

A summary of environmental variables collected is presented in Table 2. The ST and SST were 6.7 and 8.3 degrees higher than AT. However, maximum ST was 4.8 degrees lower than maximum AT, and maximum SST was 22.6 degrees higher than AT. In addition, there was a lag of two hours between maximum SST and maximum AT. The AT reached the maximum around 1600, whereas SST reached maximum at 1400. Average daily net solar radiation (NSR) was 144.26 W*m^{-2}, but ranged from -65.3 during the night to 519.4 W*m^{-2} in the afternoon. The incoming shortwave radiation (SRsin) averaged 320 W*m^{-2}, whereas outgoing longwave radiation (SRlout) averaged 455 W*m^{-2}. The hourly averages of THI, AT, ST, SST and WS showed a similar pattern: an increase after sunrise and a decrease after sunset. The exception to this pattern was RH, which showed an opposite pattern. The largest changes were observed in WS, SST and RH, whereas moderate changes were observed in THI and AT. In addition, maximum SRsin and shortwave outgoing solar radiation (SRsout) were reached in the afternoon between 1200 and 1400 (Figure 2). On the other hand, longwave incoming solar radiation (SRlin) and SRlout presented less variability through the day. Net solar radiation, which is the balance of the incoming and outgoing fluxes from shortwave and longwave streams, follows the same pattern as SRsin.

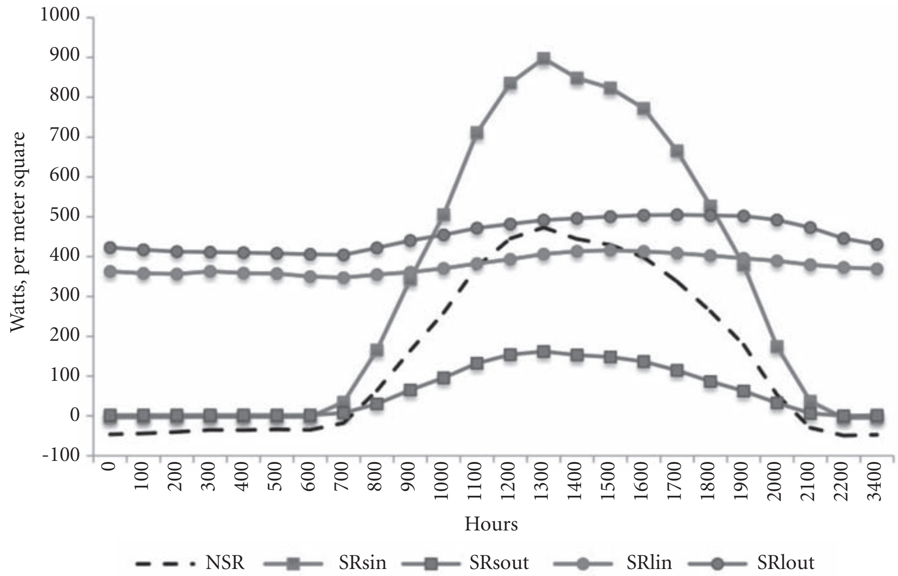

Figure 2. Average hourly components of solar radiation for the experimental period. NSR = net solar radiation (Watts*m^{-2}); SRsin= incoming short-wave solar radiation (Watts*m^{-2}); SRsout= outgoing short-wave solar radiation (Watts*m^{-2}); SRlin= incoming longwave solar radiation (Watts*m^{-2}); SRlout= outgoing longwave solar radiation (Watts*$^{-2}$).

Table 1. Tympanic temperature summary for the period of evaluation.

Item	Stowaway	Micro-T ibutton	Average
Mean	102.60	102.40	102.50
SE	(0.073)	(0.071)	(0.071)
Maximum	105.05	104.68	104.85
Minimum	101.11	100.97	101.15
Range	3.94	3.71	3.7
Number of records	165	165	165

Modeling Tympanic Temperature

The effects of each of the components of solar radiation plus AT, ST, SST, WS and RH variables were assessed together using multiple regression analysis in order to identify those variables that are important to predict BT. These variables were used as predictors, whereas the TT was used as a response variable. The TT was positively correlated with SST (0.73), ST (0.78), THI (0.80), AT (0.81) and SRlout (0.86). Likewise, SRlout was highly correlated with THI (0.93), AT (0.98) and SST (0.91). In order to select the best model, different procedures of selection were assessed (Cp, MSE, SBC, AIC, R^2, Adj R^2 and the multiple regression stepwise procedure). The model including SRlout, ST, AT and WS explains 83.3% of the variability in TT. However, the collinearity analysis demonstrates the existence of redundant information in the variables AT, ST and RSlout. Thus, AT and ST were dropped from the model. After removal of those variables, the model included two factors

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Table 2. Summary of averaged environmental variables collected during the period of evaluation.

Item	RH	AT	THI	WS	ST	SST	NSR	SRsin	SRsout	SRlin	SRlout
Mean	64.60	75.88	71.7	4.85	82.53	84.21	144.26	320.04	53.38	378.89	454.84
SE	(1.43)	(0.80)	(0.56)	(0.25)	(0.31)	(1.36)	(15.78)	(27.53)	(4.91)	(2.71)	(3.41)
Maximum	94.4	95.5	83.6	16.3	90.7	118.1	519.4	991.0	187.0	446.7	529.2
Minimum	33.7	51.81	52.3	1.0	73.6	52.3	-65.3	-8.4	-1.0	296.3	364.0

RH = relative humidity; AT = air temperature; WS = wind speed (mph); ST = soil temperature at 4 inches (F); SST= surface soil temperature (F); NSR = net solar radiation (Watts*m^{-2}); SRsin= incoming shortwave solar radiation (Watts*m^{-2}); SRsout= outgoing shortwave solar radiation (Watts*m^{-2}); SRlin= incoming longwave solar radiation (Watts*m^{-2}); SRlout= outgoing longwave solar radiation (Watts*m^{-2}).

Table 3. Partial regression coefficients ± SE for models assessing environmental factors affecting tympanic temperature in feedlot steers.

Parameter	Estimate	SE	Partial R^2
Intercept	92.84726	0.41423	
Longwave outgoing solar radiation	0.02196	0.00097	0.7373
Wind speed	-0.07515	0.01262	0.0492
Total R^2			0.7865

P values for all statistics < 0.0001.

explaining 78.7% of the variability (Table 3). However, autocorrelations were found among the residuals of the model (autoreg procedure SAS). Thus, a lag was detected at 1 hour and 8 hours and, when accounted for, resulted in an increase in adjusted R^2 (0.97).

The SRlout explained 74% of the variability in TT. In addition, our data indicate a high relationship among SRlout with AT and SST that can be explained because the earth and atmospheres are major sources and sinks of longwave radiation. In addition, most surfaces on the earth are close to being perfect blackbodies — that is, objects that absorb and re-emit all the radiation striking the object's surface for the longwave part of the spectrum. Therefore, the longwave radiation could be playing an important role in the amount of energy (heat) that could be absorbed by the cattle in the pens. Previous research in agriculture indicates that solar radiation flux densities vary significantly among regions due to season, time of day, surrounding terrain elevation and obstructions. Therefore more research under different geographic conditions is required in order to validate the real effect of SRlout on TT. Additionally, WS has been demonstrated to be another important environmental variable that exerts direct effects on animal physiology.

In conclusion, Micro-T data loggers can be used to collect TT without concern. In addition, for steers fed with a typical finishing diet, BT depends mainly on SRlout and WS. These results are in line with our previous observations, indicating that microclimate plays an important role in animal thermal balance.

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Effects of Surface Soil Temperature on Daily Water Intake in Feedlot Cattle

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Summary

The relationships among soil surface temperature (SST), soil temperature (ST) (4 inches depth) and daily water intake (DWI) were studied using data collected between 2004 and 2006. The equations obtained through simple and polynomial linear regression were evaluated using data collected during the summer 2007. An overall model (May-October) and a summer model (June-August) were developed. The best fit was reached with the overall model using SST in a quadratic model (r^2 = 0.86), whereas the summer model fit linearly with SST (r^2 = 0.70). Both models tended to slightly over-predict DWI (13.5% and 12.5%, respectively).

Introduction

In order to adequately quantify environmental effects on thermal balance it is critical that environmental measures be obtained at appropriate locations. Ambient temperature (AT) is usually recorded at an 80 in height, whereas the typical steer height is approximately 55 in, with the middle of the animal estimated at around 35 in height. Likewise, AT decreases with height above ground surface (*2002, Nebraska Beef Report*, pp. 61-65). As a result of animal activity and precipitation, the physical properties of pen surfaces and soil change. There is a reduction in soil porosity due to compacting, which could alter the soil heat conductivity. Thus, we hypothesize that the surface soil temperature could be an important predictor of cattle thermal balance and daily water intake (DWI). Hence, our objective was to assess the use of surface soil temperature (SST) as a predictor of daily water intake in feedlot finished cattle.

Procedure

The relationships among DWI, SST, ST and tympanic temperature (TT) were established using information from a set of experiments conducted from 2002 to 2006. The SST and ST were collected from two weather stations located in the feedlot pens. The DWI was recorded daily for each set of two pens, which shared a common waterer. The data set was divided into two groups: the overall model representing the period May to October and the summer model representing the period June to August. Subsequently, a repeated measures analysis was conducted in order to compare the hourly differences among AT, ST and SST throughout the day. Data were analyzed graphically using Microsoft Office Excel 2007®, and statistically using JMP® and SAS®. Scatterplots and ANOVA were used to assess the relationship and differences among AT, SST and ST. Finally, simple linear and polynomial regression analyses were conducted to obtain DWI equations based on ST and/or SST. A finishing trial conducted during the summer 2007 at the Haskell Ag. Lab in Concord, Neb., was used to evaluate the predictive equations previously obtained. In this trial, 112 crossbred steers were finished (7 head/pen). The DWI, SST and ST were collected for a 51-day period, from June 26 to August 15. In addition, hourly TT was collected for a period of 7 days (July 5 to 12) as an indicator of cattle body temperature. The models were assessed using graphical representation of actual DWI, predicted DWI, and the analysis of the residuals of each model.

Results

Relationships among Air Temperature, Soil Temperature and Tympanic Temperature

The TT of animals follows a circadian rhythm, which is highly influenced by the surrounding environment. Figure 1 displays average hourly ST, SST, AT and TT for July 5-12, 2007. ST had the lowest variation through the day, showing greater values than AT late in the evening and during the night, but lower values than SST during the day. SST was the only variable that exhibited a pattern similar to TT. The ambient and soil temperatures changed with time of day as well as TT (P < 0.0001). ST was greater than AT between 2000 and 0900 hours, whereas no differences were found between 1000 and 1900 hours (P > 0.05). Likewise, SST showed similar values to AT between 2100 and

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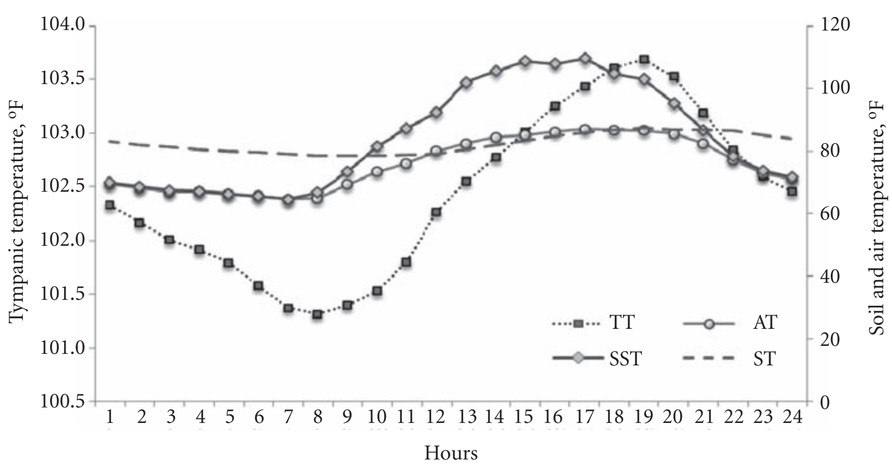

Figure 1. Relationship between surface soil temperature (SST), soil temperature (ST), air temperature (AT), and tympanic temperature (TT) from July 2007.

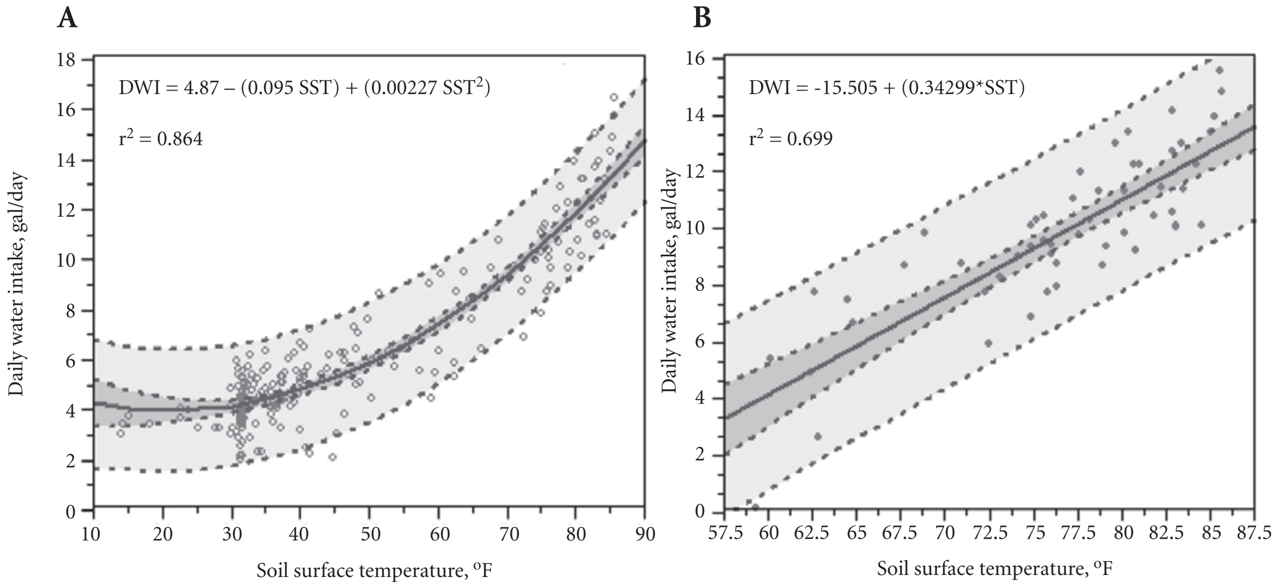

Figure 2. Linear and polynomial regression for daily water intake with surface soil temperature as predictor (A = May-Oct; B = June-August).

Table 1. Statistical summary for the period of evaluation (gallons per day).

Item	Actual free DWI	Summer Model	Overall Model
Mean	10.97	12.57	12.35
SE	(0.298)	(0.222)	(0.179)
Maximum	15.8	16.2	15.5
Minimum	3.8	9.4	9.9
Range	12.1	6.9	5.6

0700 hours ($P > 0.05$). SST seems to be influenced by solar radiation, since values increased quickly after sunrise, reaching their peak between 1300 and 1800 hours (solar radiation data not shown). For the period of study, SST was 8.3 and 1.7°F greater than ST and AT, respectively (84.2 $\pm$ 0.8, 82.5 $\pm$ 0.8, and 75.9 $\pm$ 0.8, $P < 0.0001$), whereas the daily mean TT reached 102.46 $\pm$ 0.81°F. Finally, during the day, AT and ST were similar.

Obtaining DWI Equations

The relationships among DWI, ST and SST were studied by simple linear regression analyses. The analyses were conducted for the overall data representing the period May to October (n = 211 and 362 for SST and ST, respectively, with n = number of days), and the summer data representing the period June to August (n = 97 and 115 for SST and ST, respectively). These analyses indicate SST was a better predictor of DWI than ST for the summer period ($r^2 = 0.70$ vs. 0.64 for SST and ST, respectively), as well as for the overall data ($r^2 = 0.82$ vs. 0.65 for SST and ST, respectively). Figure 2 displays the best fit of DWI using SST as a predictor. The best fit for the overall model was a quadratic relationship ($r^2 = 0.86$, Figure 2A), whereas in the summer model, the best fit was reached with a simple linear regression ($r^2 = 0.70$, Figure 2B).

Model Evaluation

The DWI and SST were collected for a period of 51 days, from June 26 to August 15. The SST records were used to predict the daily water consumption of cattle using equations presented in Figure 2. Table 1 summarizes the average values for actual and predicted DWI. In general, both equations tended to slightly overpredict DWI for each period of study (13.5% and 12.5% for the summer and overall models, respectively). Models properly calculated maximum DWI, but they failed in calculating minimum DWI. This greater variability in actual DWI indicates other factors may influence water consumption. For example, cloudy days may reduce the incidence of the incoming solar radiation and decrease water consumption (data not shown).

Limited information about the effects of soil temperature or soil surface temperature on cattle behavior is available. Previous studies conducted at the University of Nebraska–Lincoln have shown that sprinkling a feedlot pen modifies its microclimate. Water applications to the pen reduce the soil temperature as well as the temperature at 3 feet above the pen surface, and cattle move to and occupy these areas. This demonstrates that soil temperature conditions have a direct effect on the microclimate impacting cattle behavior. Likewise, soil is the main source of long-wave radiation that affects cattle thermal balance. When data from previous research studies were pooled (summer and winter), AT and temperature humidity index (THI) each explained approximately 55% of DWI variability. For data presented herein, r^2 values of 0.86 and 0.70 were obtained for the overall and the summer models, respectively. Therefore, SST seems to be a good predictor of DWI. However, feed yards across the United States present different types of soil textures, degree of soil compaction and organic matter content. All of these, plus other environmental factors, could affect heat conductivity properties, as well as the SST. In conclusion, ST has a significant effect on DWI, whereas SST appears to be a better predictor for DWI compared with other weather variables such as THI and AT.

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Fatty Acid Profile of Three Beef Muscles from Yearlings and Calf-Fed Steers Fed Wet Distillers Grains Plus Solubles

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Summary

Two experiments were conducted to analyze the effects of wet distillers grains plus solubles (WDGS) finishing diets on the fatty acid profile of beef. Ribeye slices (m. Longissimus thoracis*), tenderloins (m.* Psoas major*), and top blades (m.* Infraspinatus*) were analyzed. Calf-fed (Experiment 1) and yearling steers (Experiment 2) (n = 96 each) were allocated into three treatments of 0%, 15% or 30% WDGS (DM basis) for each experiment. For all muscles, polyunsaturated fatty acid (PUFA) levels were higher in beef from animals fed 30% WDGS. Except in tenderloins in Experiment 1, trans fatty acids increased linearly with level of WDGS in the diet. In addition, feeding WDGS increased all trans 18:1 fatty acid isomers except delta 14, which decreased. Feeding WDGS changes the fatty acid profile of beef, which has implications for color stability and shelf life.*

Introduction

Fatty acid profile may influence color, oxidation and flavor of beef. Polyunsaturated fatty acids (PUFA) may support higher oxidation and have detrimental effects on color (*2008 Nebraska Beef Report*, pp. 108-109), which may decrease shelf life and cause economic losses. Research conducted by Jenschke et al. (*2007 Nebraska Beef Report*, pp. 84-85) demonstrated that changes in fatty acid profile in beef can be related to liver-like off-flavor of beef.

Beef contains more trans fatty acids than lamb, pork and poultry. This type of fat is produced via biohydrogenization by microorganisms in the rumen. Although 90% of trans fat consumed by the population comes from non-meat industrialized products, beef contains trans fatty acids such as elaidic (18:1*t*, n-9) and conjugated linoleic acid (CLA).

Research has demonstrated that WDGS has a positive influence on animal performance (Bremer et al., *2008 Nebraska Beef Report*, pp. 33-34). The aim of this research was to identify the effects of finishing diets containing WDGS on the fatty acid profile of beef.

Procedure

Two similar experiments were conducted using 96 steers each. In Experiment 1, calf-fed crossbred steers were allocated to three different finishing diets with 0%, 15%, or 30% WDGS (DM basis) and fed for 133 days. In Experiment 2, yearling crossbred steers were allocated to the same treatments and fed for 115 days. Diet composition was based on dry-rolled corn, high-moisture corn, alfalfa hay and WDGS (Luebbe et al., *2008 Nebraska Beef Report*, pp. 53-55).

For both experiments, a 0.25-in thick ribeye slice (m. *Longissimus thoracis*) was excised from each carcass at the 12th rib and transferred under refrigeration to the Loeffel Meat Laboratory at the University of Nebraska. In addition, 48 carcasses were randomly selected by grade among the 96 (16 per treatment, 8 Choice and 8 Select); the shoulder clods (IMPS #114) and short loins (IMPS #174) were removed, vacuum-packaged and transferred to the University of Nebraska Meat Laboratory. After seven days aging at 39ºF, the tenderloins (m. *Psoas major*) and the top blades (m. *Infraspinatus*) were fabricated from the short loins and shoulder clods, respectively. One, 1-inch thick steak was cut from each tenderloin and top blade. Steaks and the ribeye slice were trimmed, submerged in liquid N, pulverized and stored at -112ºF until the fatty acids analysis could be made.

For fatty acid analysis, total lipid was extracted according to Folch et al. (1957, *Journal of Biological Chemistry 226*:497-509), converted to methyl esters (1964, *Journal of Lipid Research 5*:600-608; 1966, *Analytical Chemistry 38*:514-515), analyzed by gas chromatography and separated through a capillary column. Oven temperature was set at 284ºF to 428ºF, rising 3.6ºF/minute. Oven temperature was held at 428ºF, whereas the temperature of the injector was set at 518ºF. During the analysis, the detector was set at 572ºF and helium was used as a gas carrier. Fatty acids were identified by comparing the retention times with standards. Additionally in Experiment 1, levels of each 18:1 trans delta isomer, such as 6-8, 9, 10, 11, 13 and 14, from tenderloins and top blades were analyzed.

For each experiment, data were analyzed separately. The statistical analysis was conducted using SAS (Version 9.1, Cary, N.C., 2002) as a completely randomized design where animal was the experimental unit. Analysis of variance (ANOVA) using the GLIMMIX procedure was conducted with an alpha level of 0.05. Means were separated using the LSMEANS and identified using DIFF and LINES. Linear and quadratic relationships for all fatty acids and contrasts comparison for trans delta isomers were verified using the MIXED procedure.

Results

Level of PUFA increased linearly as level of WDGS increased for top blades (Table 1), tenderloins (Table 2) and strip loins (Table 3). The major component of PUFA, linoleic acid (18:2, n-6), increased in a linear or quadratic fashion in all cases (Tables 1-3). This result was in agreement with our hypothesis: higher levels of WDGS would increase PUFA. Similar results

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Table 1. Weight percentage of fatty acids[1] of top blade (m. *Infraspinatus*) from calf-fed and yearling steers affected by finishing diets containing WDGS.

	Dietary treatments[2]											
	Calf-fed						Yearling					
Fatty acids	0%	15%	30%	*P*	Linear[3]	Quadratic[3]	0%	15%	30%	*P*	Linear[3]	Quadratic[3]
14:1 (n-5)	0.63^{ab}	0.70^{a}	0.52^{b}	0.01	0.06	0.02	0.71	0.60	0.62	0.16	0.14	0.23
15:0	0.50^{ab}	0.56^{a}	0.47^{b}	0.03	0.45	0.01	0.49	0.48	0.47	0.90	0.64	0.96
16:0	25.06^{a}	24.26^{ab}	23.48^{b}	< 0.01	0.01	0.97	22.17	22.21	22.64	0.42	0.24	0.55
16:1(n-7)	3.12^{a}	2.93^{a}	2.46^{b}	< 0.01	< 0.01	0.27	3.26^{a}	2.94^{b}	2.69^{b}	< 0.01	< 0.01	0.84
17:0	1.54^{ab}	1.68^{a}	1.39^{b}	0.05	0.19	0.03	1.56	1.62	1.51	0.63	0.72	0.37
17:1(n-7)	1.21^{a}	1.24^{a}	1.00^{b}	< 0.01	0.01	0.06	1.42^{a}	1.33^{a}	1.04^{b}	0.02	< 0.01	0.36
18:1*t*	2.17^{b}	2.79^{b}	4.03^{a}	< 0.01	< 0.01	0.29	2.25^{c}	2.80^{b}	4.14^{a}	< 0.01	< 0.01	0.08
18:1(n-9)	38.46	37.37	36.52	0.06	0.02	0.86	40.72^{a}	39.68^{a}	37.57^{b}	< 0.01	< 0.01	0.46
18:1(n-7)	1.73^{a}	1.58^{b}	1.47^{b}	< 0.01	< 0.01	0.80	2.11^{a}	1.93^{b}	1.67^{c}	< 0.01	< 0.01	0.39
18:1Δ13t	0.08^{c}	0.23^{b}	0.37^{a}	< 0.01	< 0.01	0.95	0.15^{c}	0.24^{b}	0.35^{a}	< 0.01	< 0.01	0.51
18:1Δ14*t*	0.38^{a}	0.38^{a}	0.28^{b}	< 0.01	< 0.01	0.08	0.49^{a}	0.40^{b}	0.37^{b}	0.02	< 0.01	0.42
18:2(n-6)	3.00^{c}	3.96^{b}	4.78^{a}	< 0.01	< 0.01	0.82	2.76^{c}	3.63^{b}	4.43^{a}	< 0.01	< 0.01	0.91
22:5	0.19^{a}	0.13^{ab}	0.10^{b}	0.03	0.01	0.70	0.25	0.24	0.24	0.76	0.54	0.86
Omega 6	4.24^{b}	5.07^{b}	6.10^{a}	< 0.01	< 0.01	0.80	3.91^{b}	4.84^{a}	5.62^{a}	< 0.01	< 0.01	0.84
Total trans	4.36^{b}	4.98^{b}	6.15^{a}	< 0.01	< 0.01	0.37	5.12^{b}	5.37^{b}	6.41^{a}	< 0.01	< 0.01	0.08
PUFA	4.60^{b}	5.38^{ab}	6.40^{a}	< 0.01	< 0.01	0.81	4.37^{b}	5.33^{ab}	6.09^{a}	< 0.01	< 0.01	0.81

[1]Weight percentage values are relative proportions of all peaks observed by GC.
[2]Wet distillers grains plus solubles.
[3]Linear and quadratic response to MWDGS level.
[a,b,c]Means in the same row within age groups having different superscripts are significant at $P \leq 0.05$ level.

were found by de Mello Jr. et al. (*2008 Nebraska Beef Report*, pp. 108-109) and Gill et al. (2008, *Journal of Animal Science 86*:923-935). Polyunsaturated fatty acids have weak double bonds between carbon atoms, making the molecule easier to oxidize. Oxidation of lipids is directly proportional to the oxidation of myoglobin pigment, which produces undesirable color and rancid flavor. Consequently, beef quality is compromised when high oxidation occurs.

For both age groups and all muscles, values of vaccenic fatty acid (18:1, n-7) were lower when animals were fed 30% WDGS. Camfield et al. (1997, *Journal of Animal Science 75*:1837-1844) reported that a reduction in this fatty acid is related to increases in liver, soured and metallic flavors.

In our study, there were positive, linear relationships between level of WDGS fed and total trans fatty acids for all muscles, except for tenderloins from calf-fed steers. A linear or quadratic response was identified for two 18:1 delta-trans isomers (18:1Δ13*t* and 18:1Δ14*t*). Generally, values of delta-13 increased and values of delta-14 decreased. Vander Pol et al. (*2007 Nebraska Beef Report*, pp. 39-42) showed that the major component of the trans fatty acid group found in beef, elaidic fatty acid (18:1*t*, n-9), is identified in high levels at the duodenum when WDGS is supplied to cattle.

For monounsaturated fatty acids, values of palmitoleic acid (16:1, n-7) linearly decreased for most muscles

Table 2. Weight percentage of fatty acids[1] of tenderloin (m. *Psoas major*) from calf-fed and yearling steers affected by finishing diets containing WDGS.

	Dietary treatments[2]											
	Calf-fed						Yearling					
Fatty acids	0%	15%	30%	*P*	Linear[3]	Quadratic[3]	0%	15%	30%	*P*	Linear[3]	Quadratic[3]
14:1 (n-5)	0.64^{ab}	0.70^{a}	0.57^{b}	0.04	0.21	0.03	0.69^{a}	0.59^{ab}	0.55^{b}	0.03	< 0.01	0.65
16:0	26.36^{a}	25.45^{ab}	24.62^{b}	< 0.01	< 0.01	0.09	23.99	23.79	23.66	0.65	0.36	0.90
16:1(n-7)	2.59^{a}	2.53^{a}	2.06^{b}	< 0.01	< 0.01	0.09	2.86^{a}	2.46^{b}	2.15^{c}	< 0.01	< 0.01	0.68
17:1(n-7)	0.98	0.90	0.78	0.10	0.03	0.83	1.22^{a}	1.12^{a}	0.92^{b}	< 0.01	< 0.01	0.46
18:0	15.64	15.46	16.58	0.15	0.12	0.22	14.57^{b}	15.24^{ab}	15.56^{b}	0.03	0.01	0.57
18:1*t*	1.30	2.09	1.72	0.56	0.57	0.37	2.86^{c}	3.75^{b}	4.88^{a}	< 0.01	< 0.01	0.72
18:1(n-9)	35.31^{a}	34.55^{a}	33.12^{b}	< 0.01	< 0.01	0.56	37.27^{a}	35.98^{a}	33.69^{b}	< 0.01	< 0.01	0.46
18:1 (n-7)	1.43^{a}	1.37^{ab}	1.26^{b}	0.01	< 0.01	0.62	1.76^{a}	1.57^{b}	1.41^{c}	< 0.01	< 0.01	0.83
18:1Δ13*t*	0.17^{c}	0.27^{b}	0.41^{a}	< 0.01	< 0.01	0.20	0.31	0.30	0.24	0.08	0.03	0.50
18:1Δ14*t*	0.26^{a}	0.28^{a}	0.21^{b}	< 0.01	0.05	0.01	0.13	0.14	0.13	0.90	0.91	0.67
18:2(n-6)	3.08^{c}	4.07^{b}	4.80^{a}	< 0.01	< 0.01	0.66	3.04^{c}	3.84^{b}	5.05^{a}	< 0.01	< 0.01	0.38
18:3(n-3)	0.22	0.23	0.23	0.72	0.54	0.60	0.23^{b}	0.25^{b}	0.28^{a}	< 0.01	< 0.01	0.44
22:5	0.20^{a}	0.17^{ab}	0.15^{b}	0.03	0.01	0.78	0.28	0.25	0.28	0.56	0.83	0.30
Omega 6	4.34^{b}	5.23^{ab}	6.05^{a}	< 0.01	< 0.01	0.92	4.33^{b}	5.08^{b}	6.43^{a}	< 0.01	< 0.01	0.37
Total trans	3.20	4.05	3.66	0.59	0.52	0.33	5.26^{b}	5.94^{b}	6.75^{a}	< 0.01	< 0.01	0.84
PUFA	4.79^{b}	5.68^{ab}	6.48^{a}	< 0.01	< 0.01	0.91	4.95^{b}	5.68^{b}	7.11^{a}	< 0.01	< 0.01	0.33

[1]Weight percentage values are relative proportions of all peaks observed by GC.
[2]Wet distillers grains plus solubles.
[3]Linear and quadratic response to MWDGS level.
[a,b,c]Means in the same row within age groups having different superscripts are significant at $P \leq 0.05$ level.

Table 3. Weight percentage of fatty acids[1] of ribeyes (m. *Longissimus thoracis*) from calf-fed and yearling steers affected by finishing diets containing WDGS

	Dietary treatments[2]											
	Calf-fed						Yearling					
Fatty acids	0%	15%	30%	*P*	Linear[3]	Quadratic[3]	0%	15%	30%	*P*	Linear[3]	Quadratic[3]
14:1 (n-5)	0.64[a]	0.63[a]	0.54[b]	0.04	0.25	0.09	0.74	0.67	0.68	0.41	0.09	0.40
Iso 16:0	0.93	0.90	0.81	0.22	0.43	0.27	0.68[a]	0.56[b]	0.65[a]	0.05	0.98	0.36
16:0	26.35[a]	25.83[ab]	25.12[b]	< 0.01	0.29	0.13	24.14	24.08	24.33	0.81	0.72	0.98
16:1(n-7)	3.50[a]	3.23[b]	2.90[c]	< 0.01	0.29	0.11	3.46[a]	2.97[b]	2.81[b]	< 0.01	< 0.01	0.13
17:0	1.43[b]	1.66[a]	1.43[b]	0.01	0.15	< 0.01	1.47	1.60	1.43	0.10	0.12	0.03
Iso 18:0	0.66	0.73	0.64	0.24	0.54	0.01	0.44[ab]	0.37[b]	0.50[a]	0.04	0.16	0.05
17:1(n-7)	1.08[ab]	1.17[a]	0.98[b]	0.03	0.79	< 0.01	1.26[a]	1.21[a]	1.03[b]	< 0.01	< 0.01	0.14
18:0	13.76[b]	14.13[b]	15.03[a]	0.02	< 0.01	0.33	13.02	13.64	13.28	0.44	0.99	0.47
18:1*t*	2.28[b]	2.61[b]	3.76[a]	< 0.01	< 0.01	0.35	2.59[b]	3.74[a]	4.23[a]	< 0.01	< 0.01	0.54
18:1(n-9)	36.14[a]	34.66[b]	34.02[b]	< 0.01	0.46	0.20	36.89	37.82	36.35	0.46	0.09	0.49
18:1(n-7)	3.20[a]	2.77[b]	2.41[c]	< 0.01	0.02	0.13	1.83[a]	1.56[b]	1.44[c]	< 0.01	< 0.01	0.12
18:1Δ13*t*	0.10[c]	0.51[b]	0.64[a]	< 0.01	< 0.01	< 0.01	0.15[c]	0.27[b]	0.33[a]	< 0.01	< 0.01	0.48
18:1Δ14*t*	0.49	0.48	0.43	0.06	0.88	0.04	0.42[a]	0.37[ab]	0.34[b]	0.01	< 0.01	0.90
18:2*t*	0.003[c]	0.01[b]	0.03[a]	0.01	0.01	0.78	0.02	0.04	0.04	0.24	0.37	0.61
18:2(n-6)	3.27[b]	4.22[a]	4.50[a]	< 0.01	< 0.01	0.04	2.19[c]	3.25[b]	4.15[a]	< 0.01	< 0.01	0.58
20:3	0.29[b]	0.33[ab]	0.35[a]	0.05	< 0.01	< 0.01	0.28	0.25	0.29	0.30	0.14	0.25
Omega 6	4.62[b]	5.60[a]	5.86[a]	< 0.01	< 0.01	0.47	3.81[c]	4.53[b]	5.71[a]	< 0.01	< 0.01	0.69
Total trans	2.87[c]	3.61[b]	4.86[a]	< 0.01	< 0.01	0.33	3.17[b]	4.43[a]	4.94[a]	< 0.01	< 0.01	0.53
PUFA	4.90[b]	5.91[a]	6.23[a]	< 0.01	< 0.01	0.29	4.23[b]	4.91[b]	6.15[a]	< 0.01	< 0.01	0.60

[1]Weight percentage values are relative proportions of all peaks observed by GC.
[2]Wet distillers grains plus solubles.
[3]Linear and quadratic response to MWDGS level.
[a,b,c]Means in the same row within age groups having different superscripts are significant at $P \leq 0.05$ level.

Table 4. Weight percentage of trans-delta 18:1 isomers fatty acids[1] of tenderloin (m. *Psoas major*) from calf-fed steers affected by finishing diets containing WDGS.

	Dietary treatments[2]				Contrast[4]		
18:1 trans	0%	15%	30%	*P*	Linear[3]	Quadratic[3]	0 x WDGS
Δ6-8	0.26[b]	0.31[b]	0.42[a]	< 0.01	< 0.01	0.40	< 0.01
Δ9	0.32	0.29	0.37	0.40	0.45	0.23	0.97
Δ10	1.49[b]	1.91[b]	2.82[a]	< 0.01	< 0.01	0.31	< 0.01
Δ11	0.78[b]	0.86[b]	1.18[a]	< 0.01	< 0.01	0.06	< 0.01
Δ13	0.17[c]	0.27[b]	0.41[a]	< 0.01	< 0.01	0.20	< 0.01
Δ14	0.26[a]	0.28[a]	0.21[b]	< 0.01	0.05	0.01	0.66

[1]Weight percentage values are relative proportions of all peaks observed by GC.
[2]Wet distillers grains plus solubles.
[3]Linear and quadratic response to MWDGS level.
[4]Contrast comparison (0% x 15 and 30%WDGS).
[a,b,c]Means in the same row within age groups having different superscripts are significant at $P \leq 0.05$ level.

Table 5. Weight percentage of trans-delta 18:1 isomers fatty acids[1] of top blade (m. *Infraspinatus*) from calf-fed steers affected by finishing diets containing WDGS.

	Dietary treatments[2]				Contrast[4]		
18:1 trans	0%	15%	30%	*P*	Linear[3]	Quadratic[3]	0 x WDGS
Δ6-8	0.20	0.25	0.31	0.06	< 0.01	0.75	0.03
Δ9	0.22[b]	0.29[b]	0.40[a]	< 0.01	< 0.01	0.41	< 0.01
Δ10	1.24[b]	1.67[b]	2.48[a]	< 0.01	< 0.01	0.32	< 0.01
Δ11	0.53[c]	0.66[b]	0.83[a]	< 0.01	< 0.01	0.45	< 0.01
Δ13	0.08[c]	0.23[b]	0.37[a]	< 0.01	< 0.01	0.95	< 0.01
Δ14	0.38[a]	0.38[a]	0.28[b]	< 0.01	< 0.01	0.08	0.15

[1]Weight percentage values are relative proportions of all peaks observed by GC.
[2]Wet distillers grains plus solubles.
[3]Linear and quadratic response to MWDGS level.
[4]Contrast comparison (0% x 15 and 30%WDGS).
[a,b,c]Means in the same row within age groups having different superscripts are significant at $P \leq 0.05$ level.

and age groups. Except in the longissimus muscle, feeding WDGS also lowered values of oleic acid (18:1, n-9).

Data from Experiment 1 for trans 18:1 isomers are presented in Tables 4 and 5 for tenderloins and top blades, respectively. Significant linear increase in trans-delta isomers of 18:1 fatty acids as a result of increasing WDGS level was observed. Although this relationship was identified, the significance of these changes is unclear, as the impact on human health is still highly questionable despite popular opinion about trans fat (2002, *Science 295*:1464-1466).

In conclusion, feeding WDGS alters the fatty acid profile of beef. The increase of PUFA, Omega 6 and total trans fatty acids was observed in both age groups.

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Fatty Acid Composition of Beef from Cattle Fed Wet Distillers Grains Diets Supplemented with Vitamin E

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Summary

Crossbred yearlings (n = 90) were allotted to one of ten diets containing 0%, 20% and 40% wet distillers grains (WDG) with or without vitamin E supplementation and distillers solubles. Strip loin and tenderloin steaks were obtained and tested for their fatty acid profiles using gas chromatography. WDG diets increased linearly (P < 0.05) the polyunsaturated fatty acids (PUFA) containing 18 or more carbons and trans fatty acids in both muscles. No significant differences were found for total saturated and unsaturated fatty acids. Dietary inclusion of neither vitamin E nor distiller solubles significantly changed PUFA, trans, omega-6 or omega-3 fats in strip loins and tenderloins. Therefore, changes in the fatty acid profile of beef are a consequence of WDG, not the solubles or vitamin E.

Introduction

Fresh beef containing high levels of polyunsaturated fatty acids (PUFA) decreases shelf life by diminishing color and consumer appeal. In addition, compounds produced from oxidation of PUFA give undesirable flavors to beef, thereby making them less attractive to the consumer. Vitamin E (E) is an antioxidant that can easily be incorporated into animal tissues via feeding. Previous studies have shown that vitamin E supplementation mitigates oxidation and thereby increases shelf life of meat (Senaratne et al. *2009 Nebraska Beef Report*, pp. 113-115).

De Mello et al. (*2008 Nebraska Beef Report*, pp. 108-109) showed elevated PUFA in beef from yearlings fed wet distillers grain plus solubles up to 30%. It is unknown if fatty acid changes occur as a result of the distillers solubles or the WDG themselves. Therefore, the aim of the current study was to determine the effect of feeding vitamin E with 0%, 20% and 40% WDG (DM basis) with or without solubles on the fatty acid profile of strip loin and tenderloin muscles.

Procedure

Ninety crossbred steers (n = 336) were randomly allotted to one of six diets containing 0%, 20% or 40% WDG (DM basis) with or without E supplementation (500 IU of α-tocopherol acetate/steer daily). Vitamin E was fed the last 100 days. Distillers solubles also were added to 20% and 40% WDG diets with or without E at ratios of 100:0 and 70:30 (WDG to distillers solubles) to create four additional diets. Diets containing distillers solubles were named high soluble (H) diets, whereas diets containing no distillers solubles were named low soluble (L) diets. Composition of these diets is presented by Godsey et al. (*2009 Nebraska Beef Report*, pp. 59-61). Steers were fed for a total of 140 days and slaughtered at Greater Omaha Packing Co. (Omaha, Neb.). After grading, short loins from 90 carcasses (10 from each treatment – 5 USDA Choice and 5 USDA Select) were vacuum-packed, transported under refrigeration to Loeffel Meat Laboratory at the University of Nebraska-Lincoln and aged for 7 and 28 days at 32 to 36ºF. After fabrication, strip loins (m. *Longissimus lumborum)* and tenderloins (m. *Psoas major*) were sliced into 1-inch thick steaks. Steaks of each sample were immediately vacuum-packaged and stored at -4ºF to avoid oxidation. Each steak was diced, pulverized after dipping in liquid nitrogen, stored at -112ºF and tested for fatty acid composition. Total lipid of each sample was extracted with chloroform:methanol (2:1, v/v) solvent. The extracted lipid was converted to fatty acid methyl esters, and fatty acids were separated by gas chromatography using a capillary column, which was placed in an oven programmed from 284ºF to 428ºF at a rate of 3.6ºF/minute. The injector and detector were programmed to work at 518ºF and 512ºF, respectively. Each lipid extraction was separated into fatty acids by using helium as the carrier gas at a flow rate of 30 mL/minute. Individual fatty acids of each sample were determined by comparing retention times with known standards.

An analysis of variance using the GLIMMIX procedure of SAS (version 9.1, Cary, N.C., 2002) was used to analyze the data as a 2 x 3 x 2 factorial design (absence or presence of E and solubles and three levels of WDG). Significant means of main effects ($P < 0.05$) were separated using LSMEANS. When there was no interaction, linear and quadratic effects of WDG on each fatty acid were tested.

Results

Most of the significant effects on fatty acid composition came from the distillers grains. Very few effects were due to level of solubles and vitamin E. Diets did not significantly influence the total saturated (SFA) and unsaturated fatty acid (UFA) contents of strip loin and tenderloin steaks ($P > 0.05$). Diets significantly decreased the myristoleic (C14:1), palmitoleic (C16:1) and *cis*-10 heptadecenoic (C17:1) fatty acid contents in strip loin and tenderloin steaks (Tables 1 and 2). In addition, monounsaturated fatty acids (MUFA [C18:1 Δ6-9*t,* C18:1 Δ10*t*, C18:1 Δ11*t,* C18:1 Δ13*t,* and C18:1 Δ14*t*] and PUFA [C18:2 Δ9*t*, 12*t*, C18:2 (n-6), and C18:3 (n-3)]) containing 18 or more carbons were found at significantly higher levels in strip loin and tenderloin steaks from cattle fed 20% or 40% WDG than in steaks from cattle fed 0% WDG diets (Tables 1 and 2).

Table 1. Main effects of WDG, solubles, vitamin E and their interactions on mean weight percentage of total fatty acids[a] of strip loin (m. *Longissimus lumborum*) from steers fed with WDG with or without vitamin E and solubles .

Vitamin E	Supplemented with E					Non-supplemented with E					*P*-value			
%WDG + Sol	0	20 L	20 H	40 L	40 H	0	20 L	20 H	40 L	40 H	E	WDG	Sol	E x WDG x Sol
C10:0	0.01	0.00	0.00	0.20	0.00	0.01	0.00	0.02	0.20	0.02	0.08	0.27	0.94	0.86
C12:0	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.04	0.00	0.02	0.0008	0.57	0.003	0.39
C14:0	2.85	2.60	2.88	2.99	2.82	3.13	2.47	3.04	2.89	3.03	0.35	0.16	0.16	0.97
C14:1	0.73	0.61	0.64	0.60	0.55	0.83	0.52	0.59	0.55	0.58	0.07	0.01*	0.26	0.70
C15:0	0.52	0.42	0.49	0.42	0.46	0.53	0.43	0.53	0.46	0.44	0.56	0.01*	0.10	0.37
iso C16:0	0.61	0.52	0.56	0.59	0.72	0.61	0.60	0.60	0.50	0.54	0.42	0.59	0.27	0.42
C16:0	26.35	22.68	25.61	25.10	25.39	26.73	23.05	25.62	25.71	25.26	0.82	0.07	0.17	0.92
C16:1	3.21	2.35	2.78	2.47	2.61	3.49	2.41	2.87	2.41	2.48	0.64	<.0001**	0.06	0.85
C17:0	1.50	1.25	1.42	1.12	1.28	1.40	1.23	1.40	1.31	1.18	0.60	0.01*	0.19	0.31
iso C18:0	0.44	0.41	0.45	0.52	0.61	0.45	0.51	0.49	0.44	0.45	0.60	0.53	0.43	0.89
C17:1	1.36	0.99	1.18	0.83	1.00	1.30	0.99	1.15	0.94	0.92	0.67	<.0001*	0.03	0.46
C18:0	13.62	12.94	13.98	14.98	14.06	13.38	12.92	14.25	15.31	15.26	0.58	0.07	0.58	0.82
C18:1 Δ6-9*t*	0.44	0.50	0.54	0.65	0.73	0.50	0.50	0.43	0.61	0.65	0.41	0.0003*	0.63	0.67
C18:1 Δ10*t*	1.84	1.80	2.22	2.41	3.53	1.61	1.81	2.01	2.03	3.07	0.17	0.0007*	0.001	0.88
C18:1 Δ11*t*	0.45	0.58	0.59	1.86	0.46	0.34	0.68	0.46	1.28	0.96	0.96	0.002*	0.03	0.13
C18:1	40.98	35.00	39.26	35.98	37.22	39.90	34.79	39.10	37.47	36.75	0.86	0.04*	0.13	0.73
C18:1(*n-7*)	0.63	0.39	0.58	0.72	0.65	0.53	0.44	0.56	0.58	0.62	0.36	0.04**	0.24	0.50
C18:1 Δ13*t*	0.02	0.08	0.13	0.25	0.21	0.08	0.09	0.12	0.17	0.27	0.48	<.0001*	0.18	0.16
C18:1 Δ14*t*	0.00	0.00	0.02	0.12	0.07	0.00	0.03	0.01	0.06	0.09	0.96	0.0003*	0.96	0.10
C19:0	0.02	0.03	0.10	0.12	0.07	0.04	0.01	0.06	0.08	0.13	0.99	0.01*	0.13	0.10
C18:2 Δ9*t*, 12*t*	0.01	0.01	0.04	0.07	0.05	0.01	0.00	0.03	0.05	0.10	0.72	0.001*	0.11	0.13
C18:2	2.43	3.79	3.66	5.52	4.90	2.69	4.01	3.74	4.55	4.60	0.68	<.0001*	0.30	0.39
C20:0	0.01	0.01	0.03	0.05	0.01	0.04	0.01	0.04	0.06	0.07	0.62	0.05	0.12	0.91
C18:3	0.05	0.05	0.10	0. 15	0.09	0.08	0.07	0.11	0.09	0.17	0.15	0.02*	0.13	0.06
CLA *c*9, *t*11	0.01	0.00	0.01	0.01	0.00	0.01	0.01	0.02	0.01	0.00	0.38	0.71	0.91	0.72
C20:1	0.04	0.27	0.46	0.48	0.46	0.43	0.39	0.39	0.40	0.480	0.94	0.05	0.08	0.03
C20:2	0.00	0.000	0.02	0.00	0.00	0.00	0.00	0.000	0.01	0.00	0.70	0.083	0.91	0.91
C20:3	0.21	0.16	0.23	0.21	0.27	0.18	0.24	0.23	0.22	0.23	0.86	0.62	0.106	0.71
C20:4	0.75	0.71	0.78	0.84	0.96	0.76	0.84	0.81	0.79	0.72	0.54	0.70	0.71	0.670
Others	1.00	0.87	0.86	0.90	0.83	1.03	0.70	1.29	0.89	0.84	0.35	0.23	0.20	0.12

*Linear relationship between levels of WDG vs. a particular fatty acid.
**Quadratic relationship between levels of WDG vs. a particular fatty acid.
[a]Weight percentage values are relative proportions of all peaks observed by gas chromatography.
SOL = distillers solubles.
CLA = conjugated linoleic acids.

There was a significant increase in trans fat isomers of oleic acid (C18:1) and linoleic acid (C18:2) in strip loin and tenderloin steaks when cattle were fed with WDG diets (Tables 1 and 2), due to the action of rumen microorganisms on unsaturated fats present in the WDG diets, thereby making more trans fats. Moreover, PUFA:SFA, omega-6 (n-6), omega-3 (n-3), and (n-6):(n-3) in strip loins and tenderloins significantly increased with the increasing levels of WDG in the diet (Table 2). However, there were significant differences in MUFA of tenderloin steaks (Table 3). MUFA were significantly higher in tenderloin steaks from cattle fed 0% WDG diets compared to steaks from animals fed 20% or 40% WDG diets.

The effect of vitamin E supplementation on fatty acid profiles of strip loin and tenderloins was not significant for any fatty acids except lauric acid (C12:0). However, there was a significant main effect of vitamin E on unsaturated fats in tenderloins (Table 3). Moreover, solubles in diets significantly increased *cis*-10 heptadecenoic (C17:1) in both strip loin and tenderloins (Table 1 & 2). Neither vitamin E nor solubles showed any significant effect on the levels of PUFA, trans, omega-6 or omega-3 fats of strip loins and tenderloins (Table 2).

As a whole, the presence or absence of vitamin E had few effects on the fatty acids profile of both strip loin and tenderloin. Therefore, results of this study showed that WDG diets significantly increased trans fats and PUFA containing 18 or more carbons in tenderloins and strip loins. The PUFA are liable to oxidize easily and thereby cause detrimental effects on color and sensory attributes of beef.

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Table 2. **Main effects of WDG, solubles, vitamin E and their interactions on mean weight percentage of total fatty acids[a] of tenderloins (m. *Psoas major*) from steers fed with WDG with or without vitamin E and solubles**

Vitamin E	Supplemented with E					Non-supplemented with E					*P*-value			
%WDG + Sol	0	20 L	20 H	40 L	40 H	0	20 L	20 H	40 L	40 H	E	WDG	Sol	E x WDG x Sol
C10:0	0.01	0.02	0.02	0.05	0.01	0.01	0.02	0.28	0.02	0.02	0.22	0.50	0.32	0.33
C12:0	0.01	0.01	0.01	0.02	0.01	0.03	0.02	0.05	0.02	0.02	0.007	0.74	0.32	0.49
C14:0	2.78	2.68	2.86	2.72	2.58	3.06	2.56	2.90	2.68	2.76	0.23	0.05	0.19	0.86
C14:1	0.66	0.57	0.57	0.52	0.45	0.70	0.52	0.59	0.55	0.58	0.10	0.0003*	0.83	0.81
C15:0	0.55	0.49	0.51	0.46	0.49	0.56	0.51	0.53	0.49	0.47	0.47	0.002*	0.59	0.40
iso C16:0	0.54	0.55	0.55	0.52	0.66	0.61	0.55	0.48	0.56	0.60	0.92	0.38	0.50	0.89
C16:0	25.70	24.65	25.19	24.52	24.52	26.33	25.22	25.23	24.93	24.50	0.22	0.001*	0.69	0.83
C16:1	2.53	2.02	2.11	1.82	1.98	2.67	1.95	2.14	1.77	1.91	0.90	< .0001**	0.06	0.70
C17:0	1.49	1.40	1.45	1.15	1.29	1.40	1.44	1.43	1.33	1.22	0.71	< .0001**	0.62	0.16
iso C18:0	0.41	0.46	0.45	0.49	0.46	0.48	0.49	0.40	0.50	0.53	0.44	0.31	0.46	0.33
C17:1	1.06	0.84	0.94	0.60	0.87	1.05	0.85	0.85	0.71	0.72	0.23	< .0001*	0.009	0.28
C18:0	15.48	16.84	16.76	17.59	16.52	15.70	17.46	14.91	17.86	17.44	0.95	0.006*	0.06	0.15
C18:1 Δ6-9*t*	0.39	0.57	0.43	0.52	0.65	0.46	0.43	0.51	0.51	0.56	0.62	0.16	0.38	0.23
C18:1 Δ10*t*	1.92	1.98	1.86	3.82	3.10	1.84	2.34	2.07	2.34	2.67	0.13	< .0001*	0.53	0.09
C18:1 Δ11*t*	0.98	1.33	1.13	1.29	1.53	0.54	1.14	1.33	1.62	1.96	0.95	0.0086*	0.32	0.85
C18:1	37.70	36.30	35.97	33.14	34.47	36.93	35.67	35.93	34.00	33.99	0.48	< .0001*	0.47	0.27
C18:1(*n-7*)	0.43	0.34	0.44	0.65	0.68	0.42	0.30	0.43	0.54	0.49	0.30	0.01**	0.44	0.71
C18:1 Δ13*t*	0.21	0.24	0.24	0.27	0.24	0.20	0.25	0.25	0.24	0.25	0.69	0.04*	0.94	0.43
C18:1 Δ14*t*	0.11	0.17	0.16	0.23	0.17	0.09	0.15	0.17	0.16	0.18	0.35	0.003*	0.64	0.53
C19:0	0.01	0.01	0.01	0.13	0.06	0.01	0.02	0.07	0.06	0.04	0.83	0.002*	0.51	0.95
C18:2 Δ9*t*, 12*t*	0.10	0.15	0.13	0.17	0.15	0.09	0.13	0.13	0.13	0.17	0.49	0.02*	0.95	0.52
C18:2	3.28	4.8	4.20	5.85	5.50	3.14	4.29	3.84	5.22	5.16	0.09	< .0001*	0.11	0.94
C20:0	0.08	0.11	0.07	0.16	0.08	0.06	0.14	0.12	0.12	0.11	0.35	0.001*	0.004	0.42
C18:3	0.20	0.21	0.20	0.24	0.21	0.20	0.21	0.21	0.22	0.23	0.65	0.18	0.38	0.55
CLA *c*9, *t*11	0.02	0.03	0.02	0.03	0.02	0.02	0.03	0.03	0.02	0.02	0.85	0.45	0.71	0.78
C20:1	0.58	0.55	0.55	0.62	0.61	0.57	0.59	0.55	0.52	0.63	0.73	0.41	0.52	0.13
C20:2	0.02	0.01	0.02	0.07	0.02	0.01	0.02	q0.02	0.04	0.04	0.97	0.12	0.33	0.26
C20:3	0.22	0.24	0.24	0.26	0.23	0.20	0.25	0.22	0.27	0.27	0.72	0.02*	0.19	0.26
C20:4	0.84	0.84	0.86	0.84	1.00	0.84	0.85	0.76	0.93	0.89	0.55	0.29	0.83	0.71

*Linear relationships between levels of WDGS vs. a particular fatty acid at $P < 0.05$.
**Quadratic relationship between levels of WDGS vs. a particular fatty acid at $P < 0.05$.
[a]Weight percentage values are relative proportions of all peaks observed by gas chromatography.
SOL = distillers solubles.
CLA = conjugated linoleic acids.

Table 3. **Main effects of WDG, solubles, vitamin E and their interactions on mean weight percentage of total significant ($P < 0.05$) fatty acids[a] of strip loin (M. *longissimus lumborum*) and tenderloins (M. *psoas major*) from steers fed with WDG with or without vitamin E and solubles**

Vitamin E	Supplemented with E					Non-supplemented with E					*P*-value			
%WDG + Sol	0	20 L	20 H	40 L	40 H	0	20 L	20 H	40 L	40 H	E	WDG	Sol	E x WDG x Sol
Strip loin														
SFA	46.32	41.15	45.97	46.38	45.86	46.73	41.62	46.45	47.19	46.86	0.69	0.14	0.20	0.98
UFA	53.05	47.32	53.15	53.20	53.74	52.67	47.85	53.06	52.31	52.77	0.83	0.21	0.13	0.94
MUFA	49.60	42.59	48.32	46.40	47.48	48.95	42.68	48.11	46.59	46.96	0.86	0.07	0.08	0.96
PUFA	3.45	4.72	4.83	6.80	6.26	3.73	5.17	4.95	5.73	5.81	0.72	< .0001*	0.62	0.41
trans	2.92	3.37	4.06	6.12	5.70	0.02	3.55	3.88	4.77	5.76	0.62	< .0001*	0.28	0.24
(*n-6*)	3.39	4.66	4.67	6.57	6.12	3.62	5.10	4.78	5.56	5.54	0.64	< .0001*	0.52	0.52
(*n-3*)	0.05	0.05	0.10	0.15	0.09	0.08	0.07	0.11	0.09	0.17	0.15	0.02*	0.13	0.06
(*n-6*)/(*n-3*)	28.95	31.19	29.25	36.14	33.82	24.57	33.86	31.64	32.88	33.23	0.40	< .0001*	0.13	0.46
PUFA/SFA	0.08	0.12	0.11	0.15	0.14	0.08	0.13	0.09	0.12	0.03	0.09	< .0001*	0.03	0.06
Tenderloin														
SFA	51.26	51.36	50.56	50.94	51.85	50.16	49.96	49.99	49.97	50.69	0.33	0.92	0.21	0.28
UFA	51.26	51.36	50.56	50.94	51.85	50.16	49.96	49.99	49.97	50.69	0.01	0.61	0.61	0.55
MUFA	46.58	45.01	44.89	43.48	44.74	45.66	44.18	44.77	43.15	43.92	0.07	< .0001*	0.09	0.42
PUFA	4.69	6.36	5.67	7.46	7.11	4.50	5.78	5.22	6.82	6.77	0.13	< .0001*	0.15	0.88
trans	4.17	4.93	4.90	6.97	6.53	3.85	4.77	4.87	5.75	6.28	0.25	< .0001*	0.90	0.51
(*n-6*)	4.34	5.95	5.30	6.95	6.73	4.18	5.39	4.82	6.42	6.32	0.14	< .0001*	0.18	0.97
(*n-3*)	0.20	0.21	0.20	0.24	0.21	0.20	0.21	0.21	0.22	0.23	0.65	0.18	0.38	0.56
(*n-6*)/(*n-3*)	21.42	28.25	26.93	29.52	28.75	20.69	25.65	23.44	29.11	27.94	0.14	< .0001*	0.24	0.92
PUFA/SFA	0.10	0.14	0.12	0.16	0.15	0.09	0.12	0.12	0.14	0.14	0.15	< .0001*	0.36	0.84

*Linear relationships between levels of WDGS vs. a particular fatty acid.
**Quadratic relationship between levels of WDGS vs. a particular fatty acid.
[a]Weight percentage values are relative proportions of all peaks observed by gas chromatography.
SOL = distillers solubles.

Vitamin E Mitigates the Boost in Lipid Oxidation of Beef Due to Wet Distillers Grains Feeding

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Summary

Beef tenderloin and strip loin steaks were obtained from yearlings (n = 90) fed 0%, 20% and 40% wet distillers grains (DM basis) with or without distillers solubles and vitamin E supplementation. Our aim was to increase the shelf life of case-ready beef by vitamin E supplementation to minimize the potential of lipid oxidation due to wet distiller grains feeding. Data from this study indicate that vitamin E supplementation significantly mitigates the increased oxidation potential of tenderloin and strip loin steaks during retail display due to WDG feeding.

Introduction

The major issue of meat at retail display is the alteration of freshness due to oxidation. Meat containing more polyunsaturated fatty acids (PUFA) is prone to oxidize, producing many secondary byproducts, which subsequently deteriorate the color and flavor of meat. Godsey et al. (*2009 Nebraska Beef Report*, pp. 66-69) have shown that feeding efficiency and average daily gain increase linearly as inclusion levels of wet distillers grains increase. However, many studies have shown that feeding wet distillers grains (WDG) to cattle increases the PUFA content of beef, which reduces the shelf life of meat due to rapid oxidation (Senaratne et al., *2009 Nebraska Beef Report*, pp. 110-112, and de Mello et al., *2008 Nebraska Beef Report*, pp. 108-109).

Studies have shown that animal diets supplemented with antioxidants can increase the level of antioxidant incorporation in meat, thereby suppressing lipid oxidation. Vitamin E (E) or α-tocopherol is one of the most promising antioxidants used in animal feeding. Although an abundance of feeding trials with E supplementation have been conducted to minimize oxidation of fresh meat, no work has been carried out on the effect of WDG diets supplemented with E on fresh beef. Therefore, this study was conducted to determine the effects of WDG feeding on maintaining quality of beef by E supplementation.

Procedure

Ninety crossbred steers were randomly assigned to ten diets containing 0%, 20% or 40% WDG (DM basis) with or without E supplementation and distillers solubles. All the conditions at feeding, slaughter and meat fabrication were similar to procedures described by Senaratne et al. (*2009 Nebraska Beef Report*, pp. 116-117). Strip loin (m. *Longissimus lumborum)* and tenderloin (m. *Psoas major)* steaks were cut one-inch thick after 7 and 28 days of aging at 32 ± 36°F. One steak of each sample was immediately vacuum-packaged and stored at -4°F to avoid oxidation until tested for thiobarbituric acid reactive substances (TBARS). Other steaks of each muscle were split in half and packaged aerobically on Styrofoam trays. They then were placed on a table in a cooler maintained at 32-36°F under continuous 1000-1800 lux warm white fluorescence lighting for seven days to simulate retail display conditions. A piece of each steak was collected at day 4 and day 7 of retail display, vacuum packaged and stored at -4°F. Finally, frozen steaks were macerated after dipping in liquid nitrogen and stored under -112°F until they were tested for TBARS.

Table 1. Main effects and their interactions on percentage discoloration of strip loin (m. *Longissimus lumborum*) **steaks during retail display.**

Effects	*P*-value
WDG	< .0001*
SOL	0.0003*
WDG × SOL	0.5787
E	0.0002*
E × WDG	0.0711
E × SOL	0.5236
E × WDG × SOL	0.0836
Aging	< .0001*
WDG × aging	0.1596
SOL × aging	0.4532
WDG × SOL × aging	0.3058
E × aging	0.1128
E × WDG × aging	0.9251
E × SOL × aging	0.3841
E × WDG × SOL × aging	0.6322
D	< .0001*
WDG × D	0.0002*
SOL × D	0.1283
WDG × SOL × D	0.1346
E × D	< .0001*
E × WDG × D	0.4206
E × SOL × D	0.6120
E × WDG × SOL × D	0.9974
Aging × D	< .0001*
WDG × aging × D	0.0965
SOL × aging × D	0.0001*
WDG × SOL × aging × D	0.5016
E × aging × D	0.4454
E × WDG × aging × D	0.0311*
E × SOL × aging × D	0.2351
E × WDG × SOL × aging × D	0.4154

*Main or interaction effects are significant at $P < 0.05$.
SOL = distillers solubles (L and H).
D = retail display day (0, 4 and 7 days).

Results were subjected to the GLIMMIX procedure of SAS (version 9.1, Cary, N.C., 2002) as split plot design with repeated measures. Levels of WDG (0%, 20% and 40%), vitamin E (with or without), distillers solubles (low and high) and their interactions were considered as the main plot variables, while aging periods and day of retail display and their interactions were analyzed as subplot variables. Significant main effects and their interactions were identified at $P < 0.05$.

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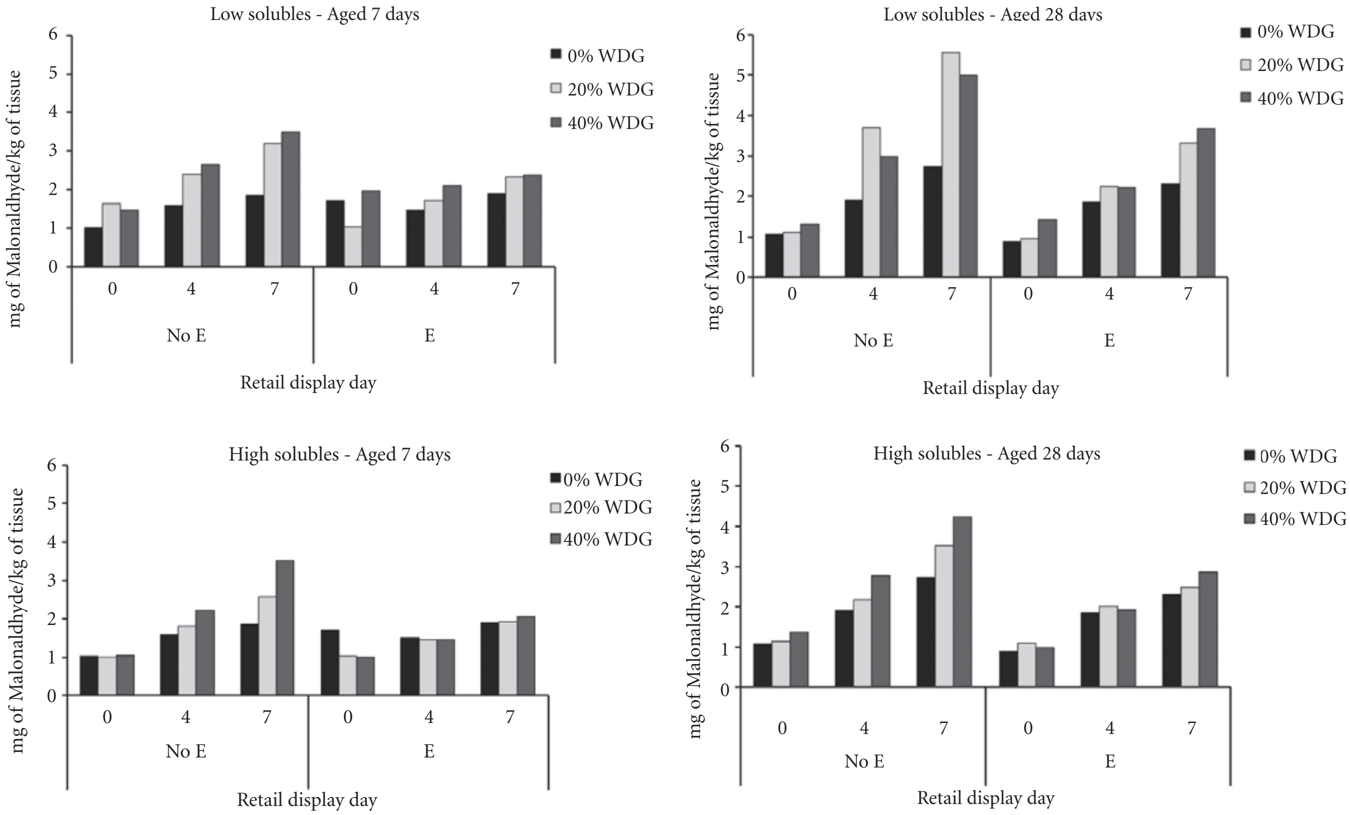

Figure 1. TBARS of 7- and 28-day aged strip loin (M. ***longissimus lumborum*****) steaks from animals fed diets containing 0%, 20% or 40% WDG with or without E supplementation and distillers solubles.**

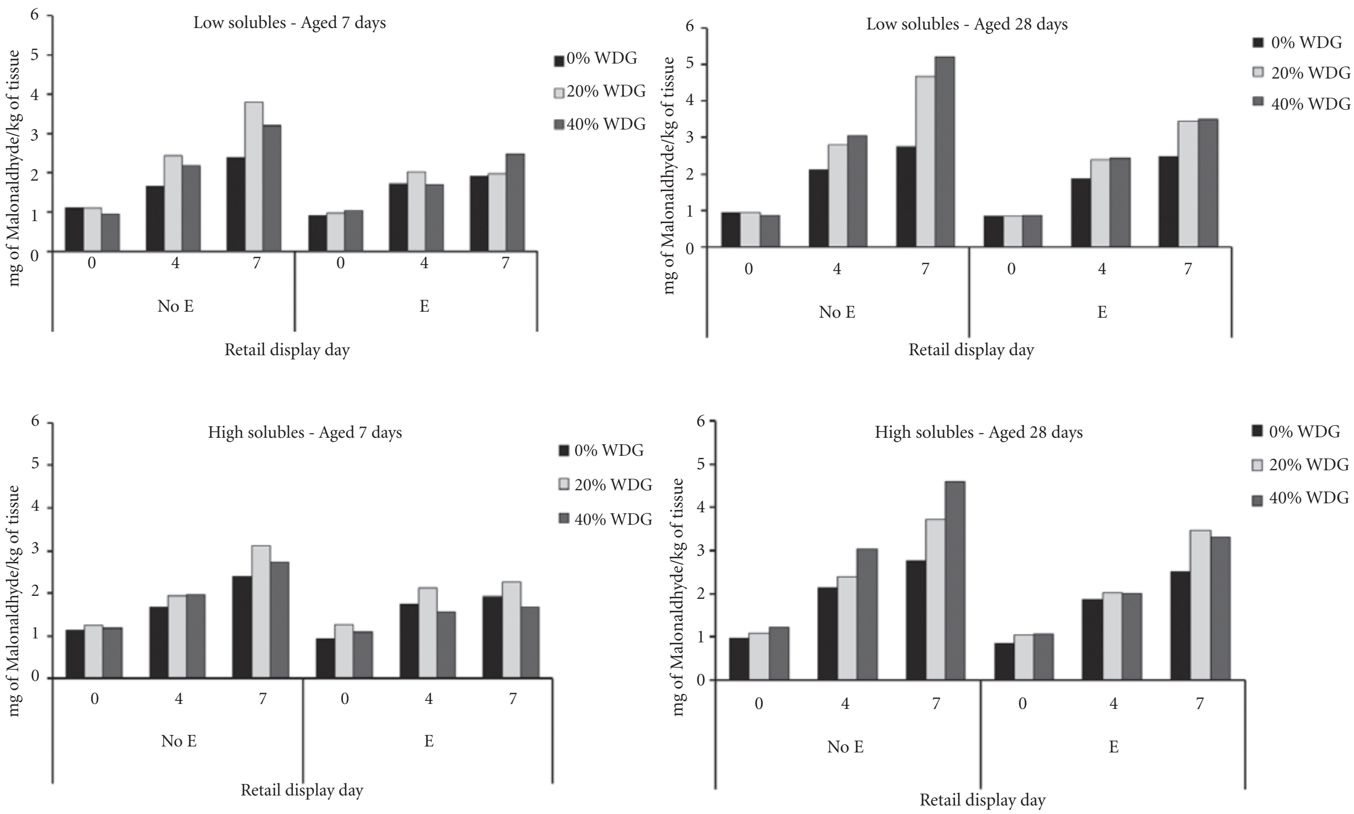

Figure 2. TBARS of 7- and 28-day aged strip loin (M. ***psoas major*****) steaks from animals fed diets containing 0%, 20% or 40% WDG with or without E supplementation and distillers solubles.**

Table 2. Main effects and their interactions on percentage discoloration of strip loin (m. *Psoas major*) steaks during retail display.

Effects	*P*-value
WDG	0.0010*
SOL	0.1692
WDG × SOL	0.8923
E	0.0001*
E × WDG	0.3033
E × SOL	0.4756
E × WDG × SOL	0.2613
Aging	< .0001*
WDG × aging	< .0001*
SOL × aging	0.7562
WDG × SOL × aging	0.1731
E × aging	0.2955
E × WDG × aging	0.0811
E × SOL × aging	0.7701
E × WDG × SOL × aging	0.4429
D	< .0001*
WDG × D	0.0402*
SOL × D	0.1008
WDG × SOL × D	0.8997
E × D	0.0132*
E × WDG × D	0.5946
E × SOL × D	0.6181
E × WDG × SOL × D	0.8590
Aging × D	< .0001*
WDG × aging × D	0.0168*
SOL × aging × D	0.8461
WDG × SOL × aging × D	0.6782
E × aging × D	0.1214
E × WDG × aging × D	0.1180
E × SOL × aging × D	0.2257
E × WDG × SOL × aging*D	0.7717

*Main or interaction effects are significant at $P < 0.05$.
SOL = distillers solubles (L and H).
D = retail display day (0, 4 and 7 days).

Results

The significance of main effects and their interactions on oxidation of strip loin and tenderloin steaks are shown in Tables 1 and 2. Since there were significant interactions of E x WDG x aging period x retail display day ($P = 0.0311$) and of solubles x aging period x retail display day ($P = 0.0001$) on TBARS values on oxidation of strip loin steaks, significant main effects were not considered (Table 1). In addition, there were also significant interactions of WDG x aging period x retail display day ($P = 0.0168$) and of E x retail display day ($P = 0.0132$) on oxidation of tenderloin steaks (Table 2); therefore, the main effects were not considered.

Aging increased oxidation; therefore, the TBARS of day 28 aged strip loin and tenderloin steaks from cattle fed rations containing high and low solubles were greater than those aged seven days (Figure 1 and 2). As time of retail display increased, the oxidation or TBARS values of strip and tenderloin steaks significantly increased from day 0 to day 7 of retail display (Figures 1 and 2).

Steaks from cattle fed E supplemented diets showed significantly lower TBARS values compared to steaks from animals fed non-supplemented diets (Figures 1 and 2). That was likely due to impediment of oxidation by the antioxidant, vitamin E.

It appears that greater oxidation occurred in steaks from animals fed diets lower in distillers solubles. The hypothesis was that higher levels of solubles would contribute to greater oxidation. We have no explanation for these contrary results.

As a whole, results of this study indicate that vitamin E supplementation is able to minimize the increased oxidation during retail display of tenderloin and strip loin steaks due to WDG feeding.

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[2]This project was funded by the National Beef Council.

Effect of Wet Distillers Grain Feeding Supplemented with Vitamin E on Case Life of Beef

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Summary

Aged (7 and 28 days) strip loins (m. Longissimus lumborum*) from 90 yearling steers were used to assess the effect of supplemental vitamin E in diets containing wet distillers grains (WDG) with or without distillers solubles on surface discoloration of steaks during retail display. The greatest negative effects occurred as a result of aging, followed by the presence of solubles and then by the level of WDG. As discoloration increased, the importance of vitamin E in reducing discoloration also increased. Feeding WDG diets supplemented with vitamin E mitigates the surface discoloration of aged beef strip loin steaks during retail display.*

Introduction

Consumers prefer to purchase the freshest meat at meat stores, and bright red color of meat is the gauge for consumers to determine the freshness of meat. Meat containing more polyunsaturated fatty acids (PUFA) is prone to oxidization, which causes a deterioration of sensory characteristics, color and shelf life of meat. Many studies have shown that feeding wet distillers grains (WDG) to cattle increases the PUFA content of beef, which reduces the shelf life of meat due to rapid oxidation (Senaratne et al., *2009 Nebraska Beef Report*, pp. 110-112; de Mello et al., *2008 Nebraska Beef Report,* pp. 108-109; 110-111).

Therefore, this study was designed to determine whether vitamin E (E) supplementation with WDG diets could delay the surface discoloration of strip loin (m. *Longissimus lumborum)* steaks during a retail display period after short-term and long-term aging.

Procedure

Ninety crossbred steers were randomly allotted to one of 10 diets containing 0%, 20%, 40 % WDG (DM basis) with or without vitamin E supplementation and distillers solubles as described by Senaratne et al. (*2009 Nebraska Beef Report*, pp. 113-115). All the conditions at feeding, slaughter and meat fabrication were similar to procedures mentioned by Senaratne et al. Short loins were removed from 48-hour-chilled carcasses, vacuum-packed and transported under refrigeration to Loeffel Meat Laboratory at the University of Nebraska–Lincoln. Strip loin steaks (m. *Longissimus lumborum)* were cut (1-inch thick) after seven and 28 days of aging at 32 ± 3ºF. Steaks were packaged aerobically on Styrofoam trays and placed on a table in a cooler maintained at 32 ± 36ºF under continuous 1000-1800 lux warm white fluorescence lighting for seven days to provide simulated retail display conditions. The subjective percentage surface discoloration of each steak was evaluated every day by a panel of three.

Statistical analysis was performed as described by Senaratne et al. (*2009 Nebraska Beef Report*, pp. 113-115) using the GLIMMIX procedure of SAS (version 9.1, Cary, N.C., 2002).

Results

Because there was a five-way interaction ($P < 0.0001$) among amount of WDG, level of vitamin E, level of solubles, aging period and length of retail display for surface discoloration of strip steaks (Table 1), significant main effects and other interactions were neglected. Generally, there were few meaningful differences among steaks aged seven days — all treatments were acceptable in terms of discoloration. However, higher levels of WDG and higher levels of solubles resulted in greater discoloration, regardless of aging period (Figure 1). The effect of WDG was likely due to a significant linear increment of PUFA levels, as shown by Senaratne et al. (*2009 Nebraska Beef Report*, pp. 110-112). It should be noted that the level of added distillers solubles was well above current industry practice.

Steaks from beef aged for 28 days discolored at a more rapid rate than those from beef aged seven days,

Table 1. Significant ($P < 0.05$) main effects and their interactions on percentage discoloration of strip steaks during retail display.

Effects	*P*-value
Solubles	0.02
Aging	< .0001
Retail display days	< .0001
Solubles × aging	0.03
Solubles × retail display days	< .0001
WDG × retail display days	0.0002
Aging × retail display days	< .0001
Vit E × WDG × solubles	0.04
WDG × aging × retail display days	< .0001
Solubles × aging × retail display days	< .0001
Vit E × WDG × solubles × aging	0.04
Wdg × solubles × aging × retail display days	< .0001
Vit E × WDG × aging × retail display days	< .0001
Vit E × WDG × solubles × aging × retail display days	< .0001
WDG × solubles × aging × retail display days	< .0001

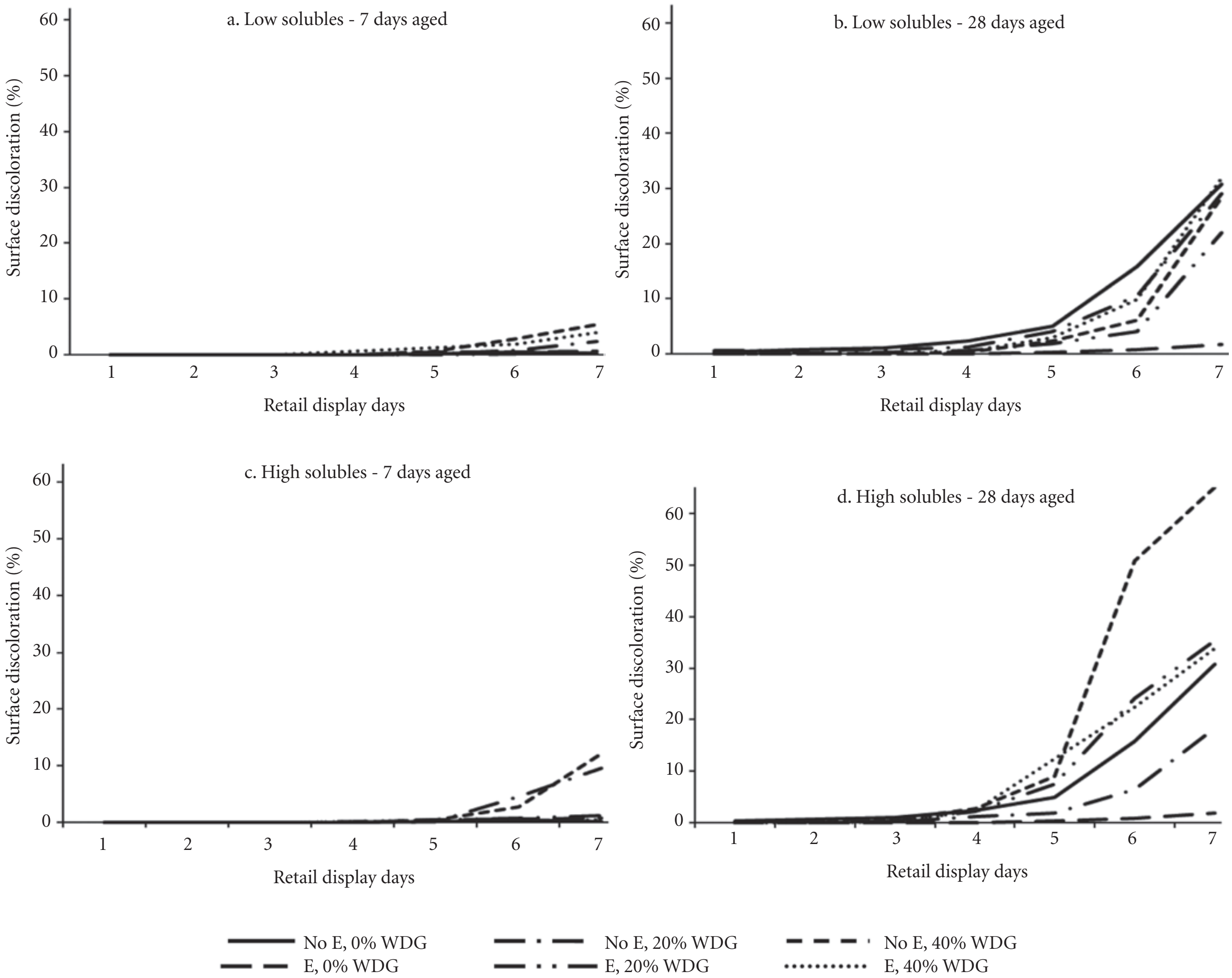

Figure 1. Mean percentage surface discoloration during retail display of 7- and 28-day aged strip steaks (m. *Longissimus lumborum*) from steers fed WDG with or without E and distillers solubles.

likely due to a decline in the protective activities of some enzymes against oxidation and destruction of cell integrity, thereby increasing susceptibility of PUFA to oxidation. After 28 days of aging, the increase in discoloration as a result of higher levels of WDG was of greater magnitude than after seven days of aging (Figure 1 b and d). This was also true for the effect of distillers solubles. The presence of vitamin E reduced the extent of discoloration, especially after 28 days of aging. Steaks from cattle fed 20% or 40% WDG without E showed significantly higher surface discoloration compared to steaks from animals fed WDG with E (Figure 1).

Generally, steaks with 20% surface discoloration are deemed unacceptable by consumers. Figure 1 indicates that steaks from cattle fed high levels of WDG, without supplemental vitamin E, and aged 28 days were likely to discolor at a more rapid rate. The presence of distillers solubles exacerbated the problem. In this study, the greatest negative effects occurred as a result of aging, followed by the presence of solubles and then by the level of WDG. As discoloration increased, the significance of vitamin E also increased.

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Modified Wet Distillers Grains Finishing Diets May Increase the Levels of Polyunsaturated and Trans Fatty Acids of Beef

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Summary

Yearling steers (n=268) were fed 0%, 10%, 20%, 30%, 40% or 50 % modified wet distillers grains with solubles (MWDGS; DM basis). Marbling attributes, intramuscular fat content and fatty acid profile of beef were analyzed. Treatments did not alter marbling score, marbling distribution or fat content. Slight differences were identified for marbling texture of Choice carcasses. Values of polyunsaturated, Omega 6 and trans fatty acids linearly increased as levels of modified wet distillers grains increased. Feeding this byproduct increases polyunsaturated, trans and Omega 6 fatty acids in beef.

Introduction

Modified wet distillers grains with solubles (MWDGS) are ethanol byproducts that usually contain 45-50% DM, whereas wet distillers grains with solubles are 35% DM. A study conducted by de Mello Jr. et al. (*2008 Nebraska Beef Report*, pp. 124-125) showed that levels up to 30% of WDGS may be added into finishing diets without detriment to the relationship between marbling and intramuscular fat. De Mello Jr. et al. (*2008 Nebraska Beef Report*, pp. 120-121) reported elevated values of polyunsaturated fatty acids (PUFA), conjugated linoleic acid (CLA), linoleic isomer 18:2 and total trans fatty acids in beef from animals finished with diets containing 30% WDGS. Also, Gill et al. (2008, *Journal of Animal Science 86*: 923-935) showed that feeding dry distillers grains increased concentrations of Omega 6 fatty acids and Omega 6:Omega 3 ratio in beef when compared to steam-flaked corn. The aim of the current study was to verify the effects of high levels of MWDGS on marbling attributes, intramuscular fat content and fatty acid profile of beef.

Procedure

Two-hundred sixty-eight yearling, crossbred steers were allocated to six treatments (0%, 10%, 20%, 30%, 40% or 50% MWDGS DM basis) and fed for 176 days. Marbling score, texture and distribution were called by a USDA grading supervisor at 48 hours postmortem. After grading, a 0.25 - in thick ribeye slice (m. *Longissimus thoracis*) was excised from each carcass and transferred under refrigeration to the Loeffel Meat Laboratory at the University of Nebraska–Lincoln. The slices were pulverized using liquid nitrogen and stored at -112°F until analyzed. Total lipid was determined by ether extraction using the Soxhlet procedure. For fatty acid analysis, total lipid was extracted with a chloroform:methanol mixture. The lipid extract was converted into fatty acid methyl esters to be separated by gas chromatography (GC). A capillary column (0.25 mm x 100 mm) was set in the GC oven initially programmed at 284°F. Oven temperature increased to 428°F at a rate of 3.6°F/minute, and the injector and detector were programmed to work at 518°F and 572°F, respectively. During the GC analysis, samples were carried by helium and each fatty acid was identified based upon the retention time of known standards. The analysis of the data was conducted using SAS (Version 9.1, Cary, N.C., 2002). An analysis of variance (ANOVA) using the GLIMMIX procedure was conducted with an alpha level of 0.05. Means were separated using the LSMEANS and identified using DIFF and LINES. Linear and quadratic relationships were verified using the MIXED procedure. The feeding performance data have been reported by Huls et al. (*2008 Nebraska Beef Report*, pp. 36-38).

Table 1. MWDGS finishing diets on marbling score, marbling distribution and intramuscular fat content.

	Dietary treatments[1]								
Attributes	0%	10%	20%	30%	40%	50%	*P*-value	Linear[3]	Quadratic[3]
Score	Slight^{93}	Slight^{93}	Small^{02}	Small^{01}	Slight^{95}	Slight^{93}	0.76	0.13	0.14
Distribution[2]	1.12	1.20	1.13	1.17	1.22	1.21	0.71	0.12	0.83
Fat, %	7.43	7.95	8.68	8.61	8.11	8.03	0.18	0.67	0.02

[1]Modified wet distillers grains plus solubles (DM basis).
[2]Even = 1, Uneven = 2.
[3]Linear and quadratic response to MWDGS level.

Table 2. MWDGS finishing diets on marbling texture.[1]

	Dietary treatments[2]								
USDA Grade	0%	10%	20%	30%	40%	50%	*P*-value	Linear[3]	Quadratic[3]
Choice	1.74^{Aa}	1.65^{Aa}	1.67^{Aa}	1.42^{B}	1.91^{Aa}	1.44^{Ba}	0.02	0.41	0.91
Select	1.11^{b}	1.23^{b}	1.18^{b}	1.24	1.08^{b}	1.15^{b}	0.02	0.75	0.37

[1]Fine = 1, Medium = 2, Coarse = 3.
[2]Modified wet distillers grains plus solubles (DM basis).
[3]Linear and quadratic response to MWDGS level.
[A,B]Means in the same row having different superscripts are significant at $P \leq 0.05$ level.
[a,b]Means in the same column having different superscripts are significant at $P \leq 0.05$ level.

Table 3. **Weight percentage of fatty acids[1] of ribeye slices (m. *Longissimus thoracis*) from steers fed MWDGS finishing diets.**

Fatty acids	Dietary treatments[2]						*P*-value	Linear[3]	Quadratic[3]
	0%	10%	20%	30%	40%	50%			
Iso 16:0	0.54^{ab}	0.55^{a}	0.42^{c}	0.44^{bc}	0.43^{c}	0.49^{abc}	0.04	0.22	0.09
16:0	26.00^{a}	25.46^{b}	25.15^{b}	24.38^{c}	24.39^{c}	24.45^{c}	< 0.01	< 0.01	0.02
16:1(n-7)	3.37^{a}	3.12^{b}	2.82^{c}	2.76^{cd}	2.56^{de}	2.45^{e}	< 0.01	< 0.01	0.06
17:1(n-7)	1.16^{a}	1.10^{a}	0.98^{b}	0.89^{c}	0.82^{dc}	0.78^{d}	< 0.01	< 0.01	0.28
18:0	12.55^{d}	13.44^{c}	13.92^{cb}	14.21^{b}	14.34^{b}	15.10^{a}	< 0.01	< 0.01	0.31
18:1*t*	3.85^{d}	4.31^{d}	5.51^{c}	5.81^{c}	7.49^{a}	6.71^{b}	< 0.01	< 0.01	0.07
18:1(n-9)	36.45^{a}	35.76^{ab}	34.15^{bc}	34.01^{c}	32.76^{c}	32.86^{c}	< 0.01	<0.01	0.25
18:1 (n-7)	2.33^{a}	1.95^{b}	1.76^{bc}	1.59^{c}	1.59^{c}	1.33^{d}	< 0.01	< 0.01	0.12
18:1Δ13*t*	0.18^{e}	0.33^{d}	0.45^{c}	0.51^{bc}	0.65^{a}	0.55^{b}	< 0.01	< 0.01	< 0.01
18:1Δ14*t*	0.39^{a}	0.31^{b}	0.29^{bc}	0.27^{bc}	0.24^{cd}	0.21^{d}	< 0.01	< 0.01	0.22
18:2T	0.06^{c}	0.07^{bc}	0.10^{a}	0.11^{a}	0.12^{a}	0.09^{ab}	< 0.01	< 0.01	0.01
18:3(n-3)	0.17^{b}	0.19^{ab}	0.20^{a}	0.20^{a}	0.21^{a}	0.22^{a}	0.02	< 0.01	0.51
18:2(n-6)	3.13^{d}	3.92^{c}	4.29^{c}	4.85^{b}	5.07^{b}	5.64^{a}	< 0.01	< 0.01	0.28
20:0	0.02^{b}	0.04^{ab}	0.06^{a}	0.05^{ab}	0.06^{a}	0.06^{a}	0.02	0.02	0.07
20:1	0.50^{a}	0.44^{b}	0.50^{a}	0.52^{a}	0.51^{a}	0.48^{ab}	0.05	0.62	0.36
Omega 6	3.80^{d}	4.65^{c}	4.90^{c}	5.50^{b}	5.72^{b}	6.37^{a}	< 0.01	< 0.01	0.55
Total trans	6.82^{c}	6.98^{c}	8.13^{b}	8.31^{b}	8.90^{b}	10.12^{a}	< 0.01	< 0.01	0.46
PUFA	4.08^{d}	4.95^{c}	5.24^{c}	5.85^{b}	6.08^{b}	6.71^{a}	< 0.01	< 0.01	0.46

[1]Weight percentage values are relative proportions of all peaks observed by GC.
[2]Modified wet distillers grains plus solubles (MWDGS).
[3]Linear and quadratic response to MWDGS level.
[a,b,c,d]Means in the same row having different superscripts are significant at $P \leq 0.05$.

Results

Except for 20% MWDGS ($P = 0.11$), all treatments showed linear relationships between marbling score and fat content ($P \leq 0.05$). The test of common slopes revealed that all of them were statistically similar ($P = 0.45$). Feeding MWDGS did not alter the relationship between marbling and intramuscular fat. Dietary treatments did not significantly alter marbling score or marbling distribution (Table 1). However, a quadratic effect on fat content was observed where the highest values were obtained by feeding 20% to 30% MWDGS. For marbling texture, there was a small significant interaction between treatments and USDA grade ($P = 0.02$). Choice carcasses from treatments 0%, 10%, 20% and 40% MWDGS had higher values of coarser texture than those from treatments of 30% and 50% MWDGS (Table 2). Although a statistical difference was observed, there was no consistent pattern to indicate an optimum level of MWDGS for marbling texture.

Values of PUFA linearly increased as levels of MWDGS increased (Table 3). Those fatty acids are more easily oxidized when compared with saturated fatty acids (SFA) (2007, *Journal of the American Leather Chemists Association 102*:99-105). Higher levels of oxidation may compromise dependent attributes such as color and flavor (2000, *Meat Science 54*:49-57). Values of Omega 6 fatty acids were elevated as levels of MWDGS increased. Similar results were presented by de Mello Jr. (*2008 Nebraska Beef Report,* pp. 120-121) when levels of WDGS were increased in finishing diets. The major component of the Omega 6 fatty acid and PUFA is the linoleic isomer 18:2 (n-6). Therefore, this fatty acid showed response similar to Omega 6 and PUFA. Values of monounsaturated fatty acids such as palmitoleic (16:1 n-7) and 10-heptadecenoic (17:1 n-7) were lower when higher levels of MWDGS were added into the diets. Similar tendencies were observed for oleic (18:1 n-9) and cis vaccenic (18:1, n-7) acids. Oleic isomers 18:1Δ13*t* and 18:1Δ14*t* responded directly (quadratically) and inversely (linearly) to higher levels of MWDGS, respectively. Trans fatty acids were higher in beef from steers fed 40% MWDGS. Lower values were observed in beef from animals fed 0% or 10%. The major component of this group is the oleic isomer 18:1*t*. This fatty acid also showed higher values in beef from animals fed 40%.

In conclusion, finishing diets containing MWDGS did not affect marbling score, marbling distribution and intramuscular fat content of beef. Minimal effects were found for marbling texture. However, significant linear effects on fatty acid profile, such as increased PUFA, were observed.

[1]Amilton S. de Mello Jr, graduate student; Lasika S. Senaratne, graduate student; Timothy Carr, professor, Nutrition and Health Sciences; Galen E. Erickson, professor, Animal Science; Chris R. Calkins, professor, Animal Science, Lincoln, Neb. Mike E. R. Dugan, Agriculture and Agri-Food Canada, Lacombe, AB, Canada.
[2]This project was funded in part by the Beef Checkoff and the Nebraska Beef Council.

A Rapid Method to Evaluate Oxidation Capacity of Fresh Beef

Lasika S. Senaratne
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Amilton S. de Mello Jr.
Timothy P. Carr[1]

Summary

A method to determine the capacity of beef to oxidize was developed by spectrophotometrically measuring the formation of conjugated dienes after inducing oxidation. The assay was tested by comparing the oxidation capacity and oxidation products (2-thiobabutaric acid reactive substances) of beef stored in a cooler with various packaging types. There was an inverse relationship between oxidation capacity and oxidation products. As oxidation increases, the oxidation capacity of samples declines. This method of measuring oxidation capacity provides useful information without having to wait for oxidation to occur.

Introduction

Oxidation is the primary cause of color and flavor deterioration in beef during storage. This reduction in color stability reduces shelf life in the retail case. Lipid oxidation is influenced by total fat content, especially polyunsaturated fatty acids (PUFA), oxygen exposure, and the presence or absence of antioxidants. The most common method of evaluating oxidation in meat is measurement of 2-thiobarbituric acid reactive substances (TBARS) or malonaldehyde, an intermediate byproduct in lipid oxidation. Unfortunately, this method quantifies oxidation after it happens or after beef oxidizes. The first objective of the current study was to develop a rapid and easy method to predict total oxidation potential of fresh beef before oxidation occurs naturally. The method was based on the spectrophotometric measurement of conjugated diene hydroperoxide production from PUFA in beef by *in vitro* induction of lipid oxidation with copper. The second objective of the study was to assess results from the new method against oxidation changes measured by TBARS for ground, intact and vacuum-packaged beef during cooler storage.

Procedure

Experiment 1

Nine different solvents (n-Propanol, Hexane, Dimethyl sulfoxide, Ethanol, Methanol, Chloroform, 2-Propanol, Tween 20 and Triton X 100) at different concentrations were tested for lipid solubility and interference with absorbance at 234 nm in phosphate-buffered saline (PBS), pH 7.4 with 0.15 M NaCl. The highest fat solubility and least interference with absorbance at 234 nm in PBS (pH 7.4) were observed for 20% 2-propanol; therefore, it was selected as the solvent for the meat extraction.

Samples from three different top blade (m. *Infraspinatus)* muscles of beef were evaluated. A powdered sample (1 g) was dissolved in 10 mL of 20% 2-propanol in 0.1 N PBS, vortexed for 1 minute and centrifuged at 2000 × g for 5 minutes at 39ºF. Then, 1 mL of the supernatant was dissolved in 9 mL of 20% 2-propanol in 0.1 N PBS. Absorbances of the sample were taken at 234 nm, and the spectrophotometer was set to zero using the initial reading of each sample. Oxidation of samples was continuously measured spectrophotometrically every 2 minutes by monitoring conjugated diene formation catalyzed by addition of 50 µL of 0.005 M $CuSO_4$ at 99ºF. The developed method was validated by monitoring *in vitro* oxidation of different concentrations of commercially available PUFA (0.2, 0.4, 0.6 and 0.8 g of linoleic acid/L). Each sample was tested in triplicate.

Experiment 2

Three beef eye-of-round steaks (m. *Semitendinosus*) were purchased from a fresh beef retail market in Lincoln, Neb. Each steak was cut into three equal-weight pieces. Each piece was randomly assigned to one of three treatments (retail overwrap as ground or whole; vacuum-packaged as a whole piece). All of the treated samples were stored in the cold at 32 ± 36ºF for 21 days. A 10 g sample of each piece was removed on day 0, 3, 7, 14 and 21 of storage and tested for conjugated diene formation using the assay developed in experiment 1 and TBARS using the 2-thiobarbuteric acid reactive substance assay.

An analysis of variance (ANOVA) using the GLIMMIX procedure of SAS (version 9.1, Cary, N.C., 2002) was used to analyze the data. Significant means of each treatment indicated by ANOVA were separated using LSMEANS, DIFF and LINES functions while simple effects of interactions were evaluated by using the LSMEANS, SLICE and SLICEDIFF functions at $P \leq 0.05$ significance. Correlation between conjugated diene formation and TBARS values of beef stored at cooler were analyzed by PROC CORR and PROC REG functions of SAS.

Results

Experiment 1

Of all solvents tested, 20% 2-proponol had the highest fat solubility and least interference with the absorbance at 234 nm in PBS, pH 7.4, and therefore was selected as the solvent for the meat extraction (data not shown). The time course for oxidation of beef muscle extract showed three consecutive phases, a lag phase (up to 2 minutes), during which diene absorbance increased slowly, a propagation phase (up to 6 minutes), during which dienes absorbance increased rapidly, and, finally, a plateau or decomposition phase (Figure 1). All the replicates of each muscle showed similar magnitudes of absorbance throughout the diene formation. The assay was validated by monitoring *in vitro* oxidation of different concentrations of PUFA (0.2, 0.4, 0.6 and 0.8 g of linoleic acid/L). The pattern of diene formation increased with the increased concentration of linoleic acid (Figure 2). The new technique revealed that total time required to predict oxidation potential was 20 minutes, since there was no significant difference in absorbance beyond 20 minutes ($P = 0.28$). Therefore, absorbance taken at 20 minutes after incubation at 99°F with $CuSO_4$ was considered the maximum production of conjugated dienes in a beef sample, and that amount was used as the dependent variable to compare treatments in consecutive experiment 2.

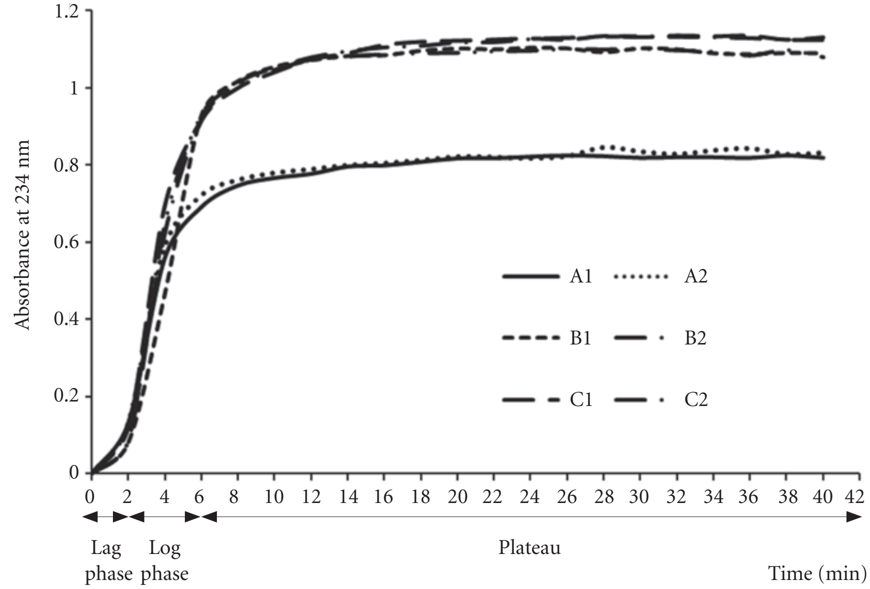


Figure 1. Continuous production of conjugated dienes of three (A, B and C) top blades (m. *Infraspinatus*) of beef in duplicates.

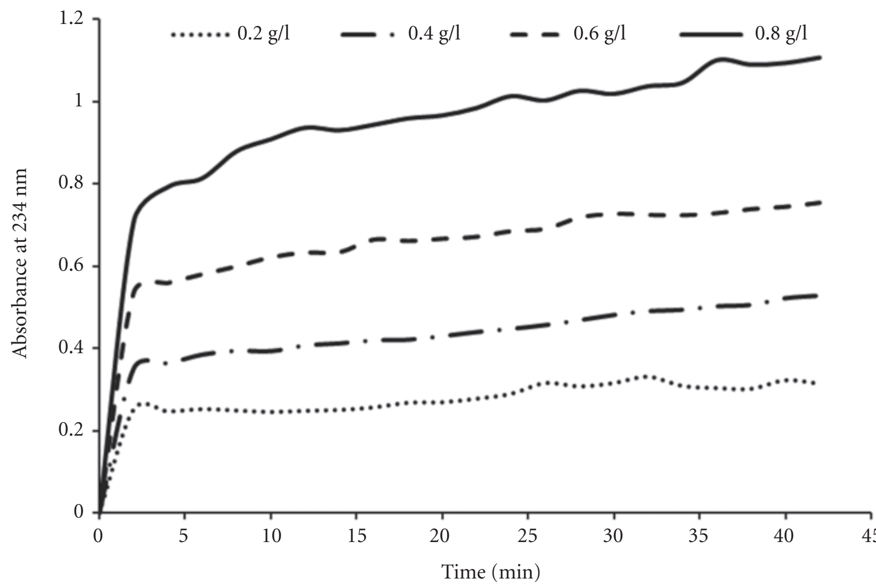


Figure 2. Conjugated diene formation of 0.2, 0.4, 0.6 and 0.8 g of linoleic acid/L.

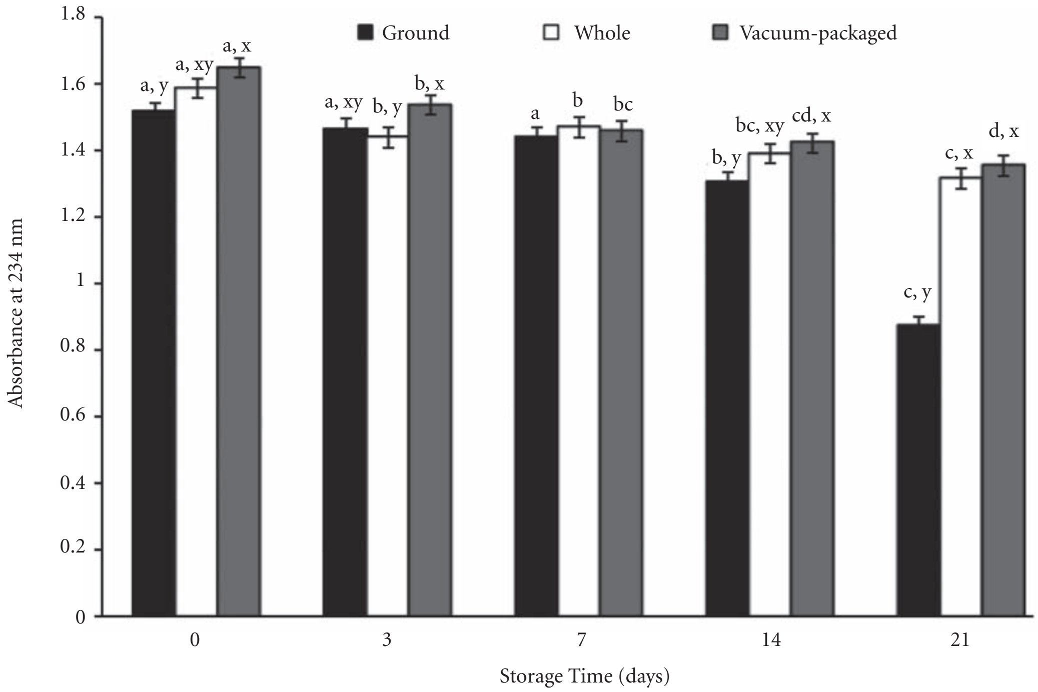
Experiment 2

There was a significant interaction between sample type and day of storage. Oxidation was greatest with cell membrane destruction (grinding) and least when exposure to oxygen was minimized (vacuum packaging). Therefore, oxidation capacity or conjugated diene formation decreased gradually ($P = < 0.001$) in all treatments during cold storage, indicating that oxidation occurred (Figure 3). The order of magnitude of reduction in oxidation capacity was ground, whole and then vacuum-packaged beef. A high reduction in oxidation potential of ground beef during cold storage was due to maximized exposure of PUFA in cell membranes to proxidants as a consequence of grinding. Therefore, there were significant ($P \leq 0.05$) reductions in oxidation capacity of ground beef at each level of cold storage except storage at days 3 and 7. In whole muscle, oxidation capacity at day 0 was significantly ($P \leq 0.05$) higher than that at days 3, 7, 14 and 21, since PUFA located on the surface of the beef piece more easily reacted with oxygen than did PUFA located inside the beef piece. Vacuum packaging prevented exposure of PUFA to proxidants (oxygen) and therefore oxidation potential of vacuum-packaged beef slowly decreased during cold storage.

An important concept with this new method of measuring oxidation capacity is that an increase in sample oxidation results in a decrease in subsequent oxidation capacity. Thus, the gradual decrease in oxidation capacity for all treatments during cooler storage is indicative that oxidation occurred. The greatest reduction in oxidation capacity, and thus the most extensive oxidation, was observed in ground samples over time, followed by whole muscles that were wrapped in oxygen-permeable film, and then by vacuum-packaged samples.

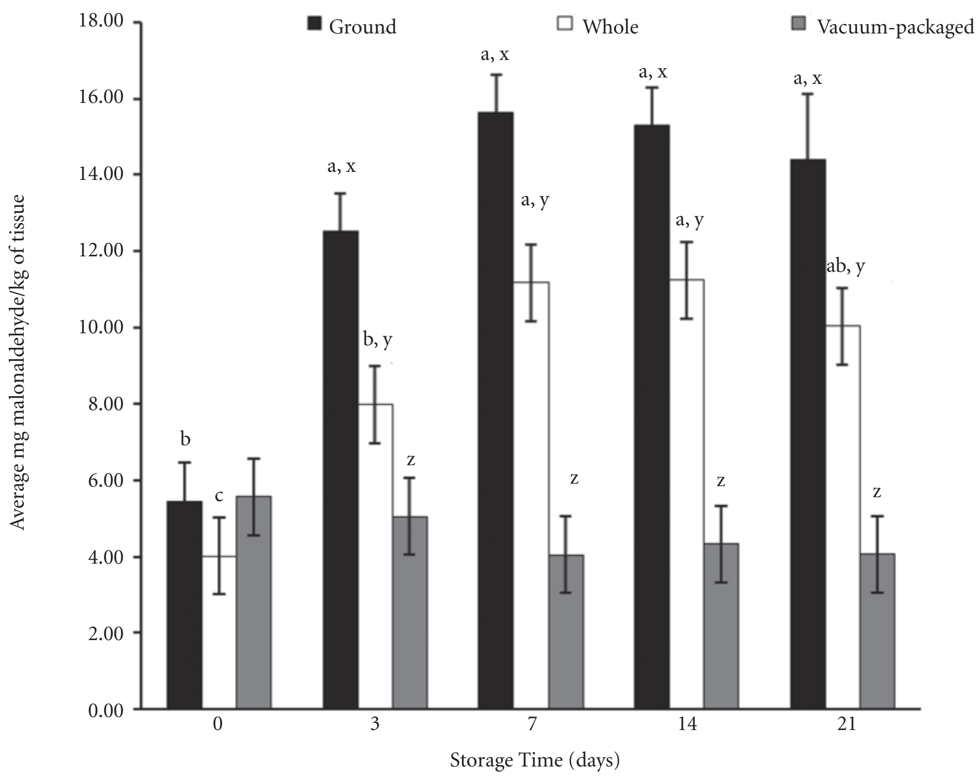
The TBARS of ground and whole beef increased with time of cold storage ($P \leq 0.05$), whereas TBARS of vacuum-packaged beef did not significantly ($P > 0.05$) change during the

(Continued on next page)



[a-d]Means within type of beef stored with different superscripts are significantly different ($P \leq 0.05$).
[x-y]Means within time point with different superscripts are significantly different ($P \leq 0.05$).

Figure 3. Conjugated diene formation of ground, whole and vacuum-packaged beef eye of round (m. *Semitendinosus*) at cold storage for 0, 3, 7, 14 and 21 days.



[a-b]Means within each type of beef stored with different superscripts are significantly different ($P \leq 0.05$).
[x-z]Means of storage type of beef within each time point with different superscripts are significantly different ($P \leq 0.05$).

Figure 4. Mean TBARS values (mg of Malonaldehyde/kg of tissue) of ground, whole and vacuum-packaged beef eye of round (m. *Semitendinosus*) at cold storage for 0, 3, 7, 14 and 21 days.

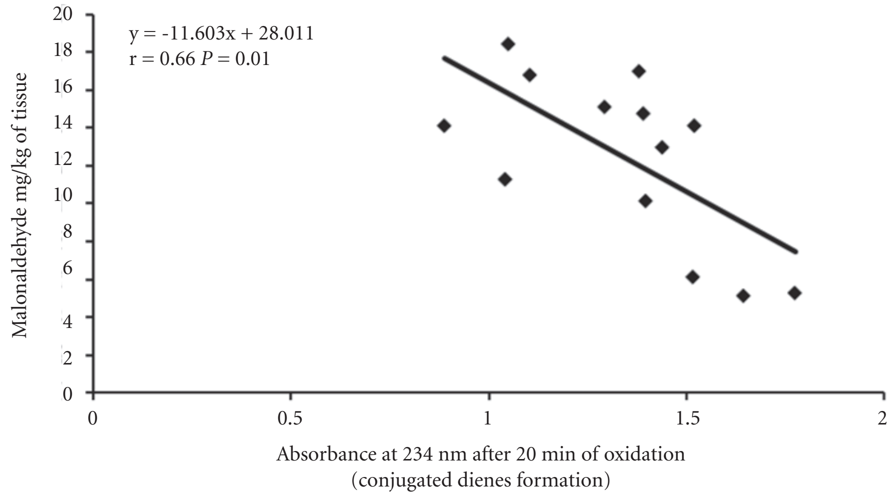


Figure 5. Relationship between TBARS production to conjugated dienes formation during 0, 3, 7, 14 and 21 days of cold storage of ground beef eye of round (m. *Semitendinosus*).

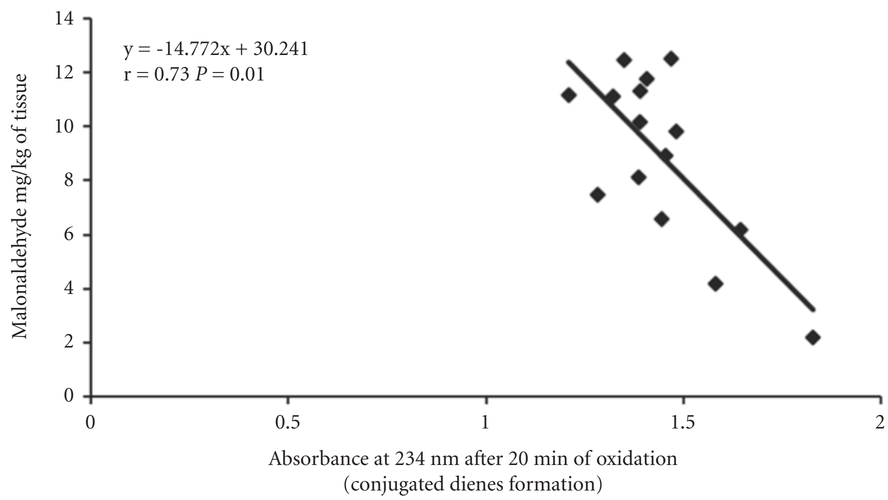


Figure 6. Relationship between TBARS production to conjugated dienes formation during 0, 3, 7, 14 and 21 days of cold storage for whole piece beef eye of round (m. *Semitendinosus*).

storage period (Figure 4). The TBARS values after storage were highest for ground beef and lowest for vacuum-packaged beef ($P \leq 0.05$). Therefore, there were significant negative linear relationships between oxidation capacity and TBARS in ground ($P = 0.014$) and whole ($P = 0.002$) beef during cold storage (Figures 5 and 6, respectively). The correlation coefficient (r) between conjugated dienes formed at 20 minutes and the TBARS of ground and whole pieces of beef eye of round during cold storage for 0, 3, 7, 14 and 21 days were 0.62 and 0.70, respectively. However, we were unable to see any significant linear correlation between conjugated diene formation and TBARS of vacuum-packaged beef stored at cold storage at different days.

Therefore, the new technique reveals that the oxidation capacity of beef decreases during cold storage and the reduction in oxidation capacity is concomitant with an increase in TBARS. Thus, this method of measuring oxidation capacity provides useful information without having to wait for oxidation to occur.

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Statistics Used in the Nebraska Beef Report and Their Purpose

The purpose of beef cattle and beef product research at UNL is to provide reference information that represents the various populations (cows, calves, heifers, feeders, carcasses, retail products, etc.) of beef production. Obviously, the researcher cannot apply treatments to every member of a population; therefore, he or 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* (beginning pp. 339) 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 ranges 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 treatment 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 and 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, byproduct, or feed additive) or increasing amounts of a nutrient (protein, calcium, or vitamin E). The L and Q contrasts provide information regarding the shape of the response. Linear indicates a straight line response and quadratic indicates a curved response. *P*-values for these contrasts have the same interpretation as described above.
- **Correlation (r) —** Correlation indicates amount of linear relationship of two measurements. The correlation coefficient can range from –1 to 1. Values near zero indicate a weak relationship, values near 1 indicate a strong positive relationship, and a value of –1 indicates a strong negative relationship.

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. Animal Science majors can also easily 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
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Animal Management
Consultant
Education
Marketing
Technical Service
Meat Processing
Meat Safety
Quality Assurance
Research and Development
Veterinary Medicine

Scholarships – Thanks to the generous contributions of our supporters listed below, each year the Animal Science Department offers 44 scholarships to Animal Science students.

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