2011 Nebraska Beef Cattle Report [complete]

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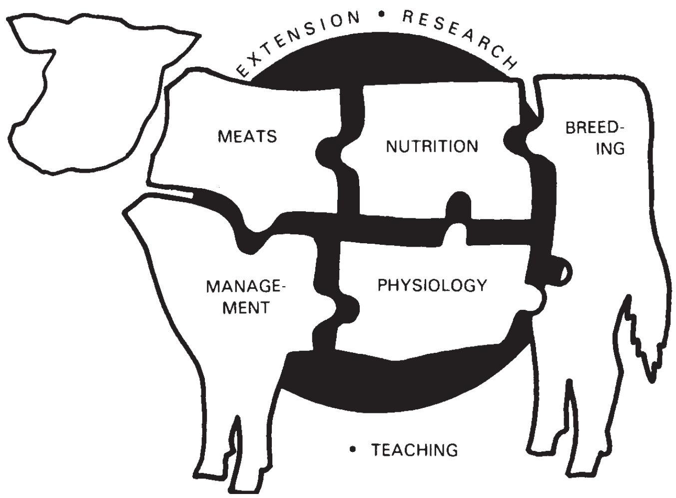

Agricultural Research Division
University of Nebraska Extension
Institute of Agriculture and Natural Resources
University of Nebraska–Lincoln

2011 Beef Cattle Report

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Winter Grazing System and Supplementation of Beef Cows During Late Gestation Influence Heifer Progeny

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Summary

*Effects of cow winter grazing system and supplementation on heifer progeny were evaluated. Cows grazed range (**WR**) or corn residue (**CR**) with (**PS**) or without (**NS**) supplement. Both PS and CR increased weaning weight. Heifers from WR-NS dams weighed less at breeding and pregnancy diagnosis than WR-PS. Heifers from PS dams were younger at puberty, and pregnancy rate tended to be greater. Heifers from CR-PS dams gained the least and were least efficient. First-calf production and rebreeding were similar. There appear to be fetal programming effects of dam winter grazing system and supplementation on heifer progeny.*

Introduction

Previous reports indicate no reproductive benefits from protein supplementation of spring calving beef cows grazing dormant Sandhills range during late gestation, despite the fact nutrient requirements are greater than nutrient content of the grazed forage. Supplementation of the dam during late gestation increases progeny weaning BW and increases fertility of heifer progeny. A study with steer mates to heifers utilized in the current study found late gestation supplementation altered post-weaning growth, carcass composition, and calf health in the feedlot, potentially through fetal programming.

The fetal programming hypothesis states postnatal growth and physiology can be influenced by stimuli experienced *in utero*. Previous research utilizing the same cowherd indicates dam protein supplementation increases heifer BW and fertility. There is potential for maternal nutrition to affect not only cow productivity but lifelong productivity of the heifer calf.

The objective of the current study was to determine the effects of grazing dormant Sandhills range or corn crop residue, with or without supplementation, on gain, feed efficiency, and reproduction in heifer-calf progeny.

Procedure

Cow and Calf Management

A three year study utilized composite Red Angus x Simmental cows and their progeny at Gudmundsen Sandhills Laboratory (GSL), Whitman, Neb. (preweaning data collection) and West Central Research and Extension Center (WCREC), North Platte, Neb. (postweaning data collection). Cows were used in a completely randomized design with a 2 x 2 factorial arrangement of treatments to determine effects of grazing dormant Sandhills winter range (**WR**) or corn crop residue (**CR**) and receiving CP supplement (**PS**) or no supplement (**NS**) on cow and heifer progeny performance. One hundred nine pregnant, spring-calving cows (1,098 ± 33 lb initial BW) between 3 and 5 years of age were stratified by age and weaning BW 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 BW of their previous calf and assigned randomly to treatment to replace cows removed from the study and to increase numbers as forage availability allowed. Data are reported for 2005 (109 cows), 2006 (114 cows), and 2007 (116 cows).

From late November until early March each year, cows grazing winter range were divided into four, 79-acre upland pastures; two pastures received CP supplement, and two did not. From November to March each year, cows grazing CR were maintained in four fields; two fields received CP supplement, two did not. Cows were shipped approximately 52 miles to corn residue fields on Nov. 15th and returned to GSL on Feb. 25th each year. Irrigated corn fields were planted in April and harvested in October, with an average annual yield of 200 bu/ac. On a pasture or field basis, cows received the equivalent of 1 lb/day of a 28% CP (DM basis) supplement three times/week or no CP supplement from Dec. 1 until Feb. 28 on WR, or until Feb. 25th on CR. The supplement contained 62.0% dried distillers grains plus solubles, 11% wheat middlings, 9.0% cottonseed meal, 5.0% dried corn gluten feed, 5.0% molasses, 2.0% urea, and 6.0% vitamin and trace mineral premix. The supplement was formulated to meet vitamin and trace mineral requirements of the 3-year-old cows and supply 80 mg /head/day monensin (Rumensin, Elanco Animal Health, Indianapolis, Ind.).

After winter grazing, cows were managed in a single group and fed hay harvested from subirrigated meadows and CP supplement. The average calving date was March 26. Cows returned to upland range in late May and remained in a single group throughout the breeding season until the subsequent winter grazing period. Cows were exposed to fertile bulls at a ratio of approximately 1 bull to 25 cows for 60 days each year, beginning on approximately June 5.

(Continued on next page)

Table 1. **Effects of grazing winter range or corn residue and protein supplementation during the last trimester of gestation on heifer growth performance.**

	Treatment[1]							
	WR		CR			Treatment P-value[2]		
Trait	PS	NS	PS	NS	SEM	Sys	Supp	S*S
n	6	6	6	6	—	—	—	—
Calf birth date, Julian d	84	86	80	87	2	0.51	0.04	0.24
Calf birth BW, lb	77.4	74.5	78.7	79.4	2.0	0.07	0.49	0.27
Calf weaning BW, lb	507	481	516	509	13	0.03	0.04	0.17
Adj. calf weaning BW, lb	478	454	478	485	9	0.02	0.15	0.03
Post-weaning ADG, lb	1.10	1.08	1.06	1.10	0.11	0.86	0.72	0.25
Pre-breeding BW, lb	712	679	710	717	33	0.17	0.24	0.11
Preg. diagnosis BW, lb	809	780	811	825	24	0.06	0.54	0.09

[1]WR = dams grazed dormant winter range during late gestation; CR = dams grazed corn residue during late gestation; PS = dams supplemented with the equivalent of 1 lb/day 28% CP cake during late gestation; NS = dams not supplemented.
[2]Sys = winter grazing system main effect; Supp = protein supplementation main effect; S*S = winter grazing system by protein supplementation treatment interaction.

Heifer Calf Management

Treatments included only dam winter grazing system and late gestation CP supplementation; no further treatments were applied to calves. Approximately 14 days following weaning, calves were transported to the WCREC, North Platte, Neb. Heifers remained in a single group for approximately 55 days following transport to the WCREC, and grazed a dormant winter pasture. Subsequently, heifers were offered a diet containing 20% wet corn gluten feed (**WCGF**) and 80% prairie hay (DM basis) *ad libitum* for 45 days. Interim BW and blood samples were collected every 10-11 days. Heifers from WR cows in year 1 and a subset of heifers from WR and CR dams in years 2 and 3 were assigned randomly to one of four pens containing Calan individual feeding systems (American Calan, Northwood, N.H.) to evaluate individual feed efficiency.

After a 30-day adaptation and training period, heifers were individually fed for a minimum of 84 days. Heifers were exposed to ambient temperature and light conditions. Three-day consecutive BW were taken at the beginning and end of the feeding period following a five day limit feeding period.

Following completion of the individual feeding period in early May each year, heifers returned to GSL. Heifers were exposed to bulls (1:25; bull:heifer) for 45 days. Estrus was synchronized with a single injection of $PGF_{2\alpha}$ administered 108 hours after bulls were placed with the heifers. Pregnancy diagnosis was performed via transrectal ultrasonography approximately 45 days following the breeding season.

Statistical Analysis

As treatments were applied on a field basis, winter pasture (n = 4/year) or corn residue field (n = 4/year) were considered the experimental units for heifer performance and reproductive data. In addition, CP was or was not provided to two winter pastures and two corn residue fields per year (n = 4/CP treatment/year). Data were analyzed using PROC MIXED of SAS (SAS Inst., Inc., Cary, N.C.). The statistical model included winter grazing system, CP supplementation, and the interaction. Cow age was included as a covariate for heifer calf data collected until weaning, where it represented a significant source of variation. Pasture nested with the effect of year x grazing treatment x CP treatment was included as a random variable in all analyses. In addition, pen nested within rep x year was included for data collected during and immediately after individual feeding, including gain, feed efficiency, and first season reproductive data.

Results

Heifer Performance and Reproduction

Heifer performance data are displayed in Table 1. Dams receiving PS calved four days earlier ($P = 0.04$) than NS cows; however, birth date was unaffected ($P = 0.51$) by winter development system. Cows grazing CR tended to give birth to heavier ($P = 0.07$) calves than WR cows, but PS did not affect ($P = 0.49$) calf birth BW. Heifer progeny weaning BW and adjusted weaning BW were greater ($P \leq 0.04$) if the dam grazed CR. Adjusted weaning BW was lowest ($P = 0.03$) if the dam received NS while grazing WR. Weaning BW of steer mates from dams grazing WR with NS was lower than all other treatment groups. Supplementation appears to be necessary to attain maximal production of offspring from dams grazing WR.

Neither PS nor winter development system affected ($P > 0.10$) heifer ADG from weaning until the time they entered the Calan gates, or from weaning until breeding. There does not appear to be any compensatory gain of heifers from WR-NS dams, which supports a fetal programming hypothesis indicating a potential physiologic or genetic change in growth not remedied by dietary changes. Heifers from dams previously grazing CR with PS had a lower

Table 2. Effects of grazing winter range or corn residue and protein supplementation during the last trimester of gestation on heifer reproduction.

	Treatment[1]							
	WR		CR			Treatment *P*-value[2]		
Trait	PS	NS	PS	NS	SEM	Sys	Supp	S*S
n	6	6	6	6	—	—	—	—
Age at puberty, days	355	370	348	361	9	0.32	0.09	0.95
BW at puberty, lb	615	619	626	635	24	0.50	0.72	0.90
Pubertal, %	91	74	79	84	7	0.71	0.38	0.11
Pregnant, %	91	77	88	83	7	0.96	0.13	0.45

[1]WR = dams grazed dormant winter range during late gestation; CR = dams grazed corn residue during late gestation; PS = dams supplemented with the equivalent of 1 lb/day 28% CP cake during late gestation; NS = dams not supplemented.
[2]Sys = winter grazing system main effect; Supp = protein supplementation main effect; S*S = winter grazing system by protein supplementation treatment interaction.

($P = 0.03$) ADG during the individual feeding period than all other heifers. Pre-breeding BW of WR-NS heifers tended to be lower ($P = 0.11$) than other treatments. The reduced BW at weaning appears to be maintained to pre-breeding, which agrees with previous research. Post-weaning ADG was similar ($P \geq 0.25$) among treatments resulting in continued lower ($P = 0.09$) BW at pregnancy diagnosis for WR-NS heifers, which is similar to previous findings. Steer progeny mates from cows receiving NS during gestation displayed more illness during post-weaning development than counterparts from PS dams. However, there was no effect ($P \geq 0.21$) of winter system or PS on illness between birth and weaning or between weaning and breeding in heifer progeny.

First season reproductive data for heifer progeny are presented in Table 2. Heifers from dams receiving PS during late gestation tended ($P = 0.09$) to be younger at puberty than heifers from dams receiving NS; however, age at puberty was not affected ($P = 0.32$) by winter development system. Body weight at puberty was similar ($P \geq 0.50$) among treatments. There also tended ($P = 0.11$) to be fewer heifers pubertal at breeding from dams previously grazing WR with NS which may be at least partially due to the lower BW at this time, as reducing BW at breeding reduces the number of heifers attaining puberty by breeding. Potentially related to pubertal status, heifers from NS dams tended ($P = 0.13$) to have lower pregnancy rates during the 45-day breeding season. Martin et al. (2007, *Journal of Animal Science,* 85:841-847) also reported providing PS to dams grazing WR improves subsequent pregnancy rate of heifer progeny. In the current study, pubertal status and pregnancy were modified by dam nutrition. Thus, these and previous data provide evidence of a fetal programming effect on reproduction. Winter development system did not affect final pregnancy rate ($P = 0.96$).

Heifer Feed Efficiency

Dry matter intake was similar ($P \geq 0.17$) for heifers born to dams previously grazing WR or CR with or without PS. The ADG of heifers from dams grazing CR with PS was lower ($P = 0.03$) during the individual feeding period, compared to all other heifers. Thus, heifers from CR-PS dams gained less efficiently (G:F; $P = 0.04$) than heifers from dams in other treatment groups. In contrast, there were no differences ($P > 0.10$) in efficiency when expressed as RFI. Heifers from CR-PS dams represent the most adequately nourished group while heifers from WR-NS dams are the most restricted. This provides evidence for an efficiency adjustment in response to fetal environment, whereby heifer fetuses exposed to restricted nutrients (i.e., nonsupplemented dams) during gestation actually become more efficient in later life.

Heifer Progeny Calf Production

Heifer BW and BCS prior to calving were similar ($P \geq 0.14$) among treatment groups. Birth date, birth BW, and percentage of calves born in the first 21 days were also similar ($P \geq 0.29$) among treatment groups. Prior to the second breeding season, heifers from dams previously grazing WR with NS tended ($P = 0.09$) to have lower BW than other treatment groups; however, BCS was not different ($P \geq 0.16$). As heifer BW prior to calving was similar, the difference in BW prior to the second breeding season may indicate a difference in nutrient partitioning among treatment groups during the early postpartum period. This hypothesis is supported by the observation that at weaning, heifer BW and BCS were similar among treatment groups ($P \geq 0.20$). Weaning BW and 205-day adjusted BW of calves born to heifer progeny were similar ($P \geq 0.28$) among treatments. Similar to previous data, reducing pre-breeding BW by either post-weaning ADG restriction or modulation of late gestation dam nutrition may impact first pregnancy outcome; pregnancy rate after the second breeding season was similar ($P \geq 0.97$) among treatments.

[1]Rick N. Funston, associate professor of Animal Science, West Central Research and Extension Center, North Platte, Neb.; Jeremy L. Martin, former graduate student; Adam F. Summers, graduate student; Don C. Adams, director, West Central Research and Extension Center; Jacqueline A. Musgrave, research technician, Gudmundsen Sandhills Laboratory, Whitman, Neb.; T. L. Meyer, research technician, West Central Research and Extension Center; Daniel M. Larson, former graduate student.

Influencing Steer Performance Through Maternal Nutrition

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Summary

*Cows were fed a 28% CP cube at one of two supplement levels, high (**HN**) or low (**LN**), while grazing dormant winter range during late gestation to determine the effects of maternal supplementation level on male progeny performance and carcass characteristics. Steer initial BW did not differ between treatments; however, year 1 steers from cows fed higher supplement levels had greater final BW, HCW, marbling scores, and carcass value compared with steers from cows receiving lower supplement levels. Year 2 HN steers had greater proportions grading USDA quality grade modest or greater when compared to steers from both treatments in year 1, but only differed numerically from LN steers from year 2. Steer performance and carcass characteristics were improved in year 1 when dam protein supplementation levels were increased.*

Introduction

Providing protein supplementation through winter grazing has been a common practice in the Nebraska Sandhills (2006 *Nebraska Beef Cattle Report*, pp. 7-9; 2009 *Nebraska Beef Cattle Report,* pp. 5-8). Late gestation protein supplementation has increased progeny weaning BW (2006 *Nebraska Beef Cattle Report,* pp. 7-9; 2009 *Nebraska Beef Cattle Report,* pp. 5-8), improved post-weaning calf health, increased HCW, and increased the proportion of calves grading USDA Choice or greater (2009 *Nebraska Beef Report*, pp. 5-8). These results indicate maternal nutrition during gestation can influence postnatal growth and health, which is hypothesized as fetal programming. The objective of the current study was to evaluate the effects of two dam protein supplementation levels while grazing dormant Sandhills forage on subsequent steer progeny growth, feed efficiency, and carcass quality.

Procedure

Cow and Calf Management

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

A two-year study was conducted at two units of the Rex Ranch, Ashby, Neb. Spring calving multiparous composite beef cows comprised of 50% Red Angus, 25% Simmental, and 25% South Devon or other breeds were managed in a year-round grazing system. Cows were pasture exposed to bulls of similar breeding at each location for 70 days beginning mid-June through August. Forty-five days following the breeding season, pregnancy rates were determined via rectal palpation.

Cows grazed dormant forage pastures from November to late February with a protein supplement (28% CP cubes) delivered three times weekly. The supplement offered was 62.0% dried distillers grains plus solubles, 11.0% wheat middlings, 9.0% cottonseed meal, 5.0% dried corn gluten feed, 5.0% molasses, 2.0% urea, and 6.0% vitamin and trace mineral premix. The supplement was formulated to meet the vitamin and trace mineral requirements of the cows.

Cows were offered supplement and meadow hay at both locations at the discretion of the manager with cows at one location (year 1 = 754; year 2 = 700) receiving higher levels of supplement (**HN**; 2.62 lb/day year 1; 2.05 lb/day year 2) and cows at the second location (year 1 = 673; year 2 = 766) being fed lower levels of supplement (**LN**; 0.85 lb/day year 1; 0.94 lb/day year 2). During calving (March and April) cows received meadow hay in the form of large round bales with HN cows receiving 13.9 lb/day in year 1 and 12.0 lb/day in year 2, and LN cows receiving 10.2 and 14.4 lb/day in year 1 and year 2, respectively. After weaning (early to mid-September), calves grazed meadow pasture while receiving 3 lb/day of the CP supplement until shipping (year 1 = Nov. 12; year 2 = Nov. 18).

Steer Calf Management

A random sample of steers from each treatment group (year 1 = 50 HN, 50 LN; year 2 = 50 HN, 50 LN) were shipped approximately 132 miles to the West Central Research and Extension Center, North Platte, Neb. Steers were grouped together in one pen and fed a starter diet (20% CP, DM basis) for five days prior to being weighed on 2 consecutive days to determine initial BW. Implants providing 20 mg of estradiol benzoate and 200 mg progesterone (Synovex S, Fort Dodge Animal Health, Overland Park, Kan.) were administered at second initial weight collection. Steers were transitioned to a finishing diet (16% CP, DM basis) over a 21 day period. Approximately 100 days prior to slaughter, steers were implanted with 24 mg estradiol and 120 mg trenbolone acetate (Revalor S, Intervet, Millsboro, Del.). Steers were slaughtered at a commercial abattoir 218 days after entering the feedlot. Final BW was calculated from HCW using a common dressing percentage (63%), and carcass data were collected after a 24-hour chill.

To determine the effect of the two supplementation levels on profitability, a partial budget analysis was conducted. Supplementation costs included a delivery charge ($0.03/lb) and were valued similar to Larson et al. (2009, *Journal of Animal Science,* 87: 1147-1155). Meadow hay values were taken from Nebraska state average monthly price based on USDA Agricultural Marketing Service. Calf sale prices were the Nebraska weighted average feeder cattle price reported for the given year at the time of entry into the feedlot, as reported by the USDA Agricultural Marketing Service. Feedlot ration costs were valued at $0.064/lb and non-feed costs were charged at $0.50/day, including veterinary charges, trucking,

Table1. Effects of maternal protein supplementation level on progeny steer feedlot performance.

	Treatment[1]							
	HN		LN			Treatment *P*-value[2]		
Item	Year 1	Year 2	Year 1	Year 2	SEM	Trt	Yr	Trt×Yr
Initial BW, lb	525	476	519	468	5	0.17	< 0.01	0.82
Re-implant BW, lb	1010	902	975	906	9	0.09	< 0.01	0.03
Final BW[3], lb	1388	1253	1330	1263	13	0.07	< 0.01	0.01
Initial to reimplant, lb/day	4.26	3.73	4.00	3.85	0.056	0.20	< 0.01	< 0.01
Reimplant to harvest, lb/day	3.63	3.38	3.41	3.43	0.066	0.21	0.08	0.04
Overall lb/day	3.96	3.57	3.72	3.65	0.049	0.11	< 0.01	< 0.01
DMI[4], lb/day	18.52	17.74	18.04	17.90	0.103	0.12	< 0.01	< 0.01
G:F	0.213	0.200	0.206	0.203	0.001	0.15	< 0.01	< 0.01

[1]HN = dams supplemented with 2.62 and 2.05 lb/day 28% CP cube (DM basis) during late gestation and 12.98 and 12.0 lb/day meadow hay during calving, year 1 and 2, respectively; LN = dams supplemented with 0.85 and 0.94 lb/day protein supplement during late gestation and 10.2 and 14.4 lb/day meadow hay during calving, year 1 and 2 respectively.
[2]Trt = dam treatment; Yr = year; Trt×Yr = dam treatment by year interactions.
[3]Final BW calculated based on a common dressing percentage (63%).
[4]DMI calculated using a modified prediction formula from Tedeschi et al. (2006) where DMI = (4.18 + (0.898 x ADG) + (0.0006 x ($MBW^{0.75}$) + (0.019 x EBF)) ÷ 0.4536.

yardage, and implants. The value of the steer at harvest was based on the Nebraska dressed steer price for the day of harvest, with grid premium and discounts applied as reported by USDA Agricultural Marketing Service. Differences in partial budget net returns were summarized for the cow-calf and feedlot phases.

Statistical Analysis

Supplementation levels were applied to the dams on a location level (n = 1) during a two-year period; therefore, location was considered the experimental unit for steer performance and carcass data. Data were analyzed using PROC MIXED (SAS Inst. Inc., Cary, N.C.) with a $P \leq 0.10$. The statistical model included dam treatment, year, and the interaction. The proportion of steers grading USDA Choice and USDA quality grade of modest or higher were analyzed using χ^2 procedures in PROC FREQ of SAS.

Results

Steer Production

Steer feedlot performance data are presented in Table 1. Initial BW did not differ ($P = 0.17$) between HN and LN steers; however, steers in year 1 were 49 and 51 lb heavier ($P < 0.01$) for HN and LN steers compared with HN and LN steers from year 2, respectively. Re-implant BW and final BW were greatest ($P = 0.03$; 0.01, respectively) for steers from year 1 HN, and differed from year 1 LN steers; however, there were no differences in re-implant or final BW for steers from year 2. Data from Larson et al. (2009, *Journal of Animal Science,* 87: 1147-1155) and Stalker et al. (2006 *Nebraska Beef Cattle Report,* pp. 7-9) indicate steer calves from dams supplemented protein while grazing dormant winter range have greater BW at initial feedlot entry compared to calves from nonsupplemented cows. Calves from those studies were placed in the feedlot 14 days post-weaning; whereas calves in this study were not shipped to the feedlot until approximately eight weeks after weaning, and were allowed to graze subirrigated meadows and received 3.0 lb/day of 28% CP cube supplement. In the studies conducted by Stalker et al. (2006 *Nebraska Beef Cattle Report,* pp. 7-9) and Larson et al. (2009, *Journal of Animal Science,* 87: 1147-1155) pregnant cows were supplemented with either 1.0 lb/day supplement or no supplement. In the present study, cows were provided supplement at both locations with HN cows receiving approximately 2.5 times more supplement than LN cows, and LN cows receiving supplement levels similar to Stalker et al. (2006 *Nebraska Beef Cattle Report,* pp. 7-9) and Larson et al. (2009, *Journal of Animal Science,* 87: 1147-1155).

Average daily gain differed (< 0.01) due to the interaction of dam treatment and year. Steer average DMI was calculated using a modified DMI prediction equation from Tedeschi et al. (2006, *Journal of Animal Science*, 84: 767-777) where DMI = (4.18 + (0.898 x ADG) + (0.0006 x (**$MBW^{0.75}$**) + (0.019 x **EBF**)) ÷ 0.4536 and where $MBW^{0.75}$ EBF represents empty mean metabolic body weight and body fat percentage. Empty body fat percentage was calculated using a modified equation from Guiroy et al. (2001, *Journal of Animal Science*, 79: 1983-1995) where EBF = 17.76107 + (11.8908 x 12th rib fat depth) + (0.0088 X HCW) + (0.81855 x [(marbling score/100) + 1] – (0.4356 x LM area). These equations were developed to predict individual intake in a group environment, similar to the design utilized in this study. Dry matter intake was greatest ($P < 0.01$) for year 1 HN steers and lowest for year 1 LN steers, and efficiency calculated as gain: feed indicated HN steers from year 1 had greater ($P < 0.01$) G:F ratios than all other groups.

Steer carcass data are summarized in Table 2. Hot carcass weights were greater ($P = 0.01$) for steers from year 1 HN cows compared to steers from year 1 LN cows. There were no significant differences ($P = 0.95$) in HCW between steers from HN and LN cows in year 2. The proportion of steers grading USDA Choice was 32 and 33% greater ($P < 0.01$) for HN and LN steers from year 2 compared to year 1. Furthermore, steers from year 2 HN cows had a greater ($P = 0.03$) proportion grade USDA modest or greater compared to steers from year 1 HN and LN cows.

Steers from HN cows had greater ($P \leq 0.05$) marbling scores compared to steers from LN cows, and year 2 steers

(Continued on next page)

Table 2. Effects of maternal protein supplementation level on progeny steer carcass data.

	Treatment[1]							
	HN		LN			Treatment P-value[2]		
Item	Year 1	Year 2	Year 1	Year 2	SEM	Trt	Yr	Trt×Yr
HCW, lb	874	790	838	796	8	0.07	< 0.01	0.01
Marbling score[3]	410	458	388	441	10	0.05	< 0.01	0.79
12-th rib fat, in	0.48	0.46	0.50	0.44	0.02	0.93	0.08	0.44
LM area, in^2	14.63	12.61	14.43	12.39	0.19	0.26	<0.01	0.96
Yield grade	2.74	3.02	2.71	3.07	0.10	0.95	< 0.01	0.64
Quality grade, % Sm[4] or greater	46	78	48	81		0.78	<0.01	< 0.01
Quality grade, % Md[5] of greater	12	29	4	19		0.07	< 0.01	0.03

[1]HN = dams supplemented with 2.62 and 2.05 lb/day 28% CP cube (DM basis) during late gestation and 12.98 and 12.0 lb/day meadow hay during calving, year 1 and 2, respectively; LN = dams supplemented with 0.85 and 0.94 lb/day protein supplement during late gestation and 10.2 and 14.4 lb/day meadow hay during calving, year 1 and 2 respectively.
[2]Trt = dam treatment; Yr = year; Trt×Yr = dam treatment by year interactions.
[3]Where 400 = small^0.
[4]Sm = small quality grade, USDA low Choice.
[5]Md = modest quality grade, USDA average Choice.

had greater ($P < 0.01$) marbling scores compared to year 1 steers. In a review on fetal skeletal muscle development, Du et al. (2010, *Journal of Animal Science*, 88: E55-E60) reported the importance of maternal nutrition on muscle development and the ability to increase intramuscular fat deposits, which later lead to marbling. Greater marbling scores reported in HN steers compared to LN steers could result from fetal programming. Increased maternal supplementation can lead to recruitment of mesenchymal stem cells to adipogenesis rather than myogenesis, increasing intramuscular fat levels. There were no differences ($P \geq 0.26$) in 12th rib fat, LM area, or yield grade when comparing steers from HN to LN cows; however, differences were significant ($P < 0.08$) between year 1 and year 2.

Table 3. Partial budget analysis of maternal protein supplementation during last trimester of gestation to weaning and weaning to harvest.

	Treatment[1]			
	HN		LN	
Item	Year 1	Year 2	Year 1	Year 2
Cow-calf phase				
Costs, $/cow				
Protein Supplement	7.41	5.79	2.42	2.67
Meadow Hay	51.15	45.52	37.54	54.53
Returns, $/calf				
Calf sale price[2]	626.28	469.95	617.09	467.11
Net profit difference	567.72	418.64	577.13	409.91
Feedlot phase				
Costs, $/steer				
Purchase cost[3]	661.70	509.41	654.09	500.38
Feedlot feed cost[4]	365.67	354.69	358.96	357.13
Returns, $/steer				
Carcass Value	1302.63	1030.54	1247.68	1040.83
Net profit difference	275.26	166.44	234.63	183.32

[1]HN = dams supplemented with 2.62 and 2.05 lb/d 28% CP cube (DM basis) during late gestation and 12.98 and 12.0 lb/day meadow hay during calving, year 1 and 2, respectively; LN = dams supplemented with 0.85 and 0.94 lb/day protein supplement during late gestation and 10.2 and 14.4 lb/day meadow hay during calving, year 1 and 2 respectively.
[2]Value of steer and heifer calves after grazing meadow hay and receiving 3.0 lb/day 28% CP cube (DM basis) for approximately 8 weeks.
[3]Value of steer calves.
[4]Value based on $0.064/lb feed cost for 218 days and including yardage at $0.50/day.

Economic Analysis

Data for the economic analysis are summarized in Table 3. Data represent actual values for the years of the study (2007-2009). In year 1, if calves were sold in November, HN calves were valued at $9.19/calf greater than calves from LN cows; however, net returns for HN calves were $9.41/calf less than those for LN calves due to increased amounts of supplement and hay offered to HN cows. Year 2 calves also had greater sale values for HN calves; however, unlike year 1, HN calf value was $8.73/calf greater than LN calves due to increased hay amounts offered to LN cows during year 2. Carcass value was greater for year 1 steers compared to year 2 steers from both treatments. In year 1 net profit difference through the feedlot phase was $40.63/steer greater for steers born to HN cows compared to LN cows; however, in year 2, returns were $16.88/steer greater for LN steers compared to HN steers. Differences between returns are related to HCW. In year 1, HCW was significantly greater ($P < 0.01$) for HN steers compared to LN calves, whereas in year 2 difference in returns is due to numerical, not statistical, difference in HCW ($P = 0.95$). Fed cattle base prices were $20.81/cwt higher in year 1 compared to year 2, which along with the heavier HCW from year 1 added to the differences in carcass values from the two different years.

Providing increased late gestation supplementation to dams did not affect steer initial BW at feedlot entry; however, steers from HN cows in year 1 had greater final BW and HCW than steers from LN cows. Average marbling scores were greater for HN calves compared to LN calves suggesting a fetal programming effect with increased dam supplementation altering fetal development.

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Integration of DNA Marker Information into Breeding Value Predictions

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Summary

Calves from 20 herds representing seven breeds were genotyped with a reduced DNA marker panel for weaning weight. The marker panel used was derived using MARC Cycle VII animals. The results suggest marker effects based on this small panel are not robust across breeds and that methodology exists to integrate genomic information into the prediction of breeding values in a single breed context.

Introduction

Currently, several commercial DNA tests (marker panels) are available for complex traits. In the fall of 2009, the American Angus Association integrated the results of an Angus-specific marker panel from a single commercial company into their national cattle evaluation for carcass traits. Despite this advancement, there still exists tremendous confusion by producers as to the efficacy of DNA diagnostics within and across breeds. The Weight Trait Project (WTP) was designed to address issues associated with creating and implementing DNA-based selection in conjunction with expected progeny differences (EPDs). The WTP is a unified effort among researchers, breed associations, seedstock producers, and a DNA testing company to improve the process of developing and validating DNA tests and to investigate the infrastructure necessary for the flow of information needed to deliver Marker-Assisted EPDs to producers. Consequently, the objectives of the current study were to illustrate methodology for incorporating DNA marker information into breeding value predictions for the trait of weaning weight, and develop mechanisms for disseminating this information to producers.

Procedure

Single nucleotide polymorphisms (SNPs), the smallest change in DNA sequence, for weaning weight were identified through an association study of markers on the Illumina 50K assay with weight traits collected at the U.S. Meat Animal Research Center (USMARC). The Ilumina assay provides the opportunity to detect DNA variations at more than 50,000 locations across the cattle genome.

Weaning weight records (N = 3,328) of calves from the following populations were used in the selection at USMARC of SNPs associated with adjusted weaning weight. The total pedigree included 5,222 animals. Of the 3,328 calves in the training population, the average breed contributions were 26% Angus, 19% Hereford, and 6.5% each of Red Angus, Simmental, Charolais, Limousin, and Gelbvieh. Thus, the effective number of animals contributing to training by breed were 871 Angus, 632 Hereford, and 215 each of Red Angus, Simmental, Charolais, Limousin, and Gelbvieh.

Breed associations representing the seven breeds (Table 1) in the USMARC Cycle VII population identified seedstock producers in the region surrounding USMARC to provide DNA samples (hair follicles from the tail switch) from calves born in the 2009 calf crop and their dams. A reduced panel of 192 SNPs was constructed based on the most significant SNPs from the USMARC association analysis with the addition of 192 SNPs from IGENITY® (96 trained on yearling weight in an Angus population and the other 96 from the IGENITY parentage panel). In total, the reduced panel consisted of 384 SNPs. IGENITY served as the genetic service provider partner in this project and genotyped animals with the reduced panel. After editing SNPs based on deviation from Hardy-Weinberg Equilibrium (a statistical criterion based on expected genotype frequencies), and call rates, a total of 159 of the diagnostic SNPs (not parentage) were used in the analysis. The population included over 19,000 animals from 20 seedstock enterprises and four university herds. Bull calves (n = 3,500) were genotyped with the reduced panel, and molecular breeding values (MBVs) were calculated based on prediction equations derived at USMARC for weaning weight (WW) and post-weaning gain (PWG). Data, including a four-generation pedigree, adjusted weaning weight phenotypes, and pedigree index EPDs were obtained from the respective breed associations for each herd in the project. MBVs were fit as a correlated trait in both two- and three-trait animal models. Contemporary group effects included herd and sex of calf. Weaning weight was fit with both a direct and maternal component while MBVs were assumed to have only a direct genetic component.

Results

Heritabilities for weaning weight (direct and maternal) and MBVs (WW and PWG) by breed are summarized in Table 1. In general, the heritability estimates for WW direct were within expected ranges except for Simmental, which is likely due to the data structure of the Simmental herds in this study. Heritability estimates for

(Continued on next page)

both WW and PWG MBVs were lower than the expected value of 1.0, suggesting considerable error associated with prediction of MBVs, either due to genotyping error or low call rates. Genetic correlations between MBVs and weaning weight (direct and maternal) are presented in Table 2. In general, the genetic correlations are low to moderate with relatively large standard errors. The number of markers used in the current panel and the fact that almost half of the selected markers did not produce usable results might explain the poor performance and thus low genetic correlations. Given these correlations, the proportion of genetic variation for weaning weight explained by the panel (r_g^2) ranged from 0 to 7.8%. One possible reason for the large range in genetic correlations among breeds is that the associations between markers and growth traits are more breed-specific than had been hoped.

Table 1. Heritabilities (SE) by breed for weaning weight (direct and maternal) and molecular breeding values (MBV) for weaning weight (WW) direct and post-weaning gain (PWG).

Breed	Weaning Weight Direct	Weaning Weight Maternal	WW MBV	PWG MBV
Angus	0.23 (0.02)	0.12 (0.01)	0.87(0.16)	0.88 (0.16)
Red Angus	0.24 (0.03)	0.15 (0.02)	0.67 (0.16)	0.57 (0.14)
Charolais	0.12 (0.13)	0.08 (0.02)	0.33 (0.16)	0.32 (0.17)
Gelbvieh	0.22 (0.02)	0.08 (0.01)	0.64 (0.18)	0.38 (0.18)
Hereford	0.14 (0.04)	0.14 (0.04)	0.83 (0.15)	0.74 (0.19)
Limousin	0.27 (0.02)	0.10 (0.01)	0.60 (0.19)	0.72 (0.21)
Simmental	0.75 (0.03)	0.32 (0.02)	0.61 (0.16)	0.36 (0.15)

Table 2. Genetic correlations (SE) by breed between weaning weight (direct and maternal) and molecular breeding values (MBV) for weaning weight (WW) and-post weaning gain (PWG).

	Weaning Weight Direct		Weaning Weight Maternal	
Breed	WW MBV	PWG MBV	WW MBV	PWG MBV
Angus	0.00 (0.10)	0.14 (0.10)	0.00 (0.17)	-0.04 (0.17)
Red Angus	0.10 (0.10)	0.35 (0.09)	0.02 (0.16)	-0.18 (0.15)
Charolais	0.28 (0.15)	-0.06 (0.17)	0.14 (0.20)	0.05 (0.22)
Gelbvieh	0.25 (0.13)	0.25 (0.12)	-0.22 (0.22)	-0.03 (0.22)
Hereford	0.20 (0.20)	0.29 (0.20)	0.06 (0.28)	-0.06 (0.29)
Limousin	0.24 (0.12)	0.18 (0.12)	-0.53 (0.22)	-0.08 (0.23)
Simmental	-0.05 (0.08)	-0.06 (0.08)	0.22 (0.13)	0.19 (0.12)

Implications

Results from the current study suggest that the reduced panel is not sufficient to meaningfully impact the accuracy of breeding value predictions. Furthermore, the unexpectedly low heritability estimates associated with the MBVs suggest that considerable room for improvement exists in the genotyping platform. Although the standard errors associated with the genetic correlations are large, the point estimates do vary across breeds. The current project developed a unique and vast resource for the future development of methodology related to the incorporation of marker data into national cattle evaluations utilizing resources from researchers, extension personnel, producers, breed associations, and a commercial DNA testing company.

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Granulosa Cell Gene Expression is Altered in Follicles from Cows with Differing Reproductive Longevity

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Summary

Heifers and cows that were culled from the herd due to failure to become pregnant were categorized into groups with low (≤ 2 year), moderate (>2 and < 6 year) or high (≥ 6 year) fertility. Antral follicle counts were numerically lower in the low group and increased in the moderate- and high-fertility group. Granulosa cells from dominant follicles in moderate- and high-fertility cows had a greater ratio of Vascular Endothelial Growth Factor 164 (VEGF164) to VEGF164B compared to the low-fertility cows. Furthermore, there was more CARTPT in granulosa cells from subordinate follicles in moderate- and high-fertility cows than low. Gene expression is altered in granulosa cells from cows differing in fertility, suggesting these are candidate genes that may be used as markers to assist in determining reproductive longevity in beef cows.

Introduction

Cows that stay in the herd longer and continue to produce a calf have greater reproductive longevity. While we may be able to predict reproductive longevity by a combination of number of antral follicles on the ovary, ovarian size, and reproductive tract score, there are no conclusive genetic or phenotypic markers of reproductive fertility in beef cattle. The long-term goal is to develop markers of reproductive longevity that may be implemented prior to selecting replacement heifers. A first step for this goal is to determine what genes are altered in granulosa cells (cells that communicate with and support egg maturation) to determine how ovarian follicle development (and development of the egg) may differ in cows culled from the herd at different ages due to pregnancy failure.

Procedure

All procedures were approved by the University of Nebraska–Lincoln Institutional Animal Care and Use Committee (IACUC).

Beef cows ranging in age from 1.5 to 11 years were synchronized with a modified Co-Synch protocol, and upon CIDR removal were injected with Lutalyse, and ovaries were removed by flank laparotomy (surgical incision) 36 hours later to obtain dominant and subordinate follicles prior to ovulation. Ovaries were weighed, measured for length and width, and all visible surface follicles were counted. Granulosa cells were collected and extracted for RNA. Quantitative Polymerase Chain Reaction (QPCR) was conducted to determine expression of genes known to influence follicle growth (VEGF164), follicle arrest (VEGF164B), and atresia (CARTPT). The expression of these genes was also correlated to follicle diameter (another potential biomarker of fertility).

Results

The number of antral follicles (follicles with fluid-filled cavities) present on the ovaries of cows from each fertility group is presented in Figure 1. While the numbers were numerically lower in the low-fertility group and increased to the high-fertility group, none of the groups were statistically different from each other. Figure 2 depicts the percentage of low (< 30), medium (30-60), and high (> 60) antral follicle counts (AFC) on the ovaries of cows for each

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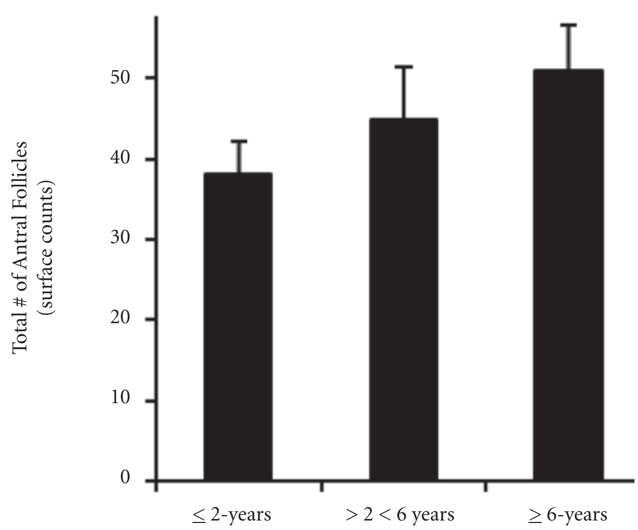

Figure 1. Total number of antral follicles in different fertility groups. These values were not significantly different from each other.

fertility classification. Because there are still low antral follicle count cows present in the high-fertility group, we cannot use antral follicle counts as the only method to predict reproductive longevity. Low antral follicle count appears to be only a risk factor for infertility, not a sole determining factor. Furthermore, because our analysis of antral follicle count is retrospective, and antral follicle count decreases as animals get older, the low antral follicle count cows in the older cow groups may be due to them getting closer to the end of their reproductive lifespan. Thus, we decided to evaluate expression of genes that have been shown to influence follicle development to determine if we could detect any differences that may result in less than optimal follicle development and egg maturation.

Our laboratory has previously determined in rodents that treatment with VEGF164 stimulates follicle development, promoting early-stage follicles to later stages of development. Furthermore, treatment with VEGF165b inhibited follicle progression and arrested follicles at early stages of development. Therefore, our objective was to determine if the ratio of VEGF164 angiogenic to VEGF164B anti-angiogenic isoforms in granulosa cells from dominant follicles was greater in high-fertility cows and reduced in the low-fertility group. In Figure 3, the ratio of VEGF164 to VEGF164B is reduced in cows culled from the herd at less than or equal to 2 years of age when compared to either the moderate- or high-fertility group. Thus, the dominant follicles in the low-fertility group had less VEGF164 and more VEGF164B messenger RNA (mRNA) in their granulosa cells. Furthermore, the diameter of the dominant follicles in the low-fertility group was numerically less but not significantly different (data not shown). This suggests that the dominant follicles in the ≤ 2 years of age group are not growing optimally. This may affect egg maturation and development, resulting in less viable or fertile eggs.

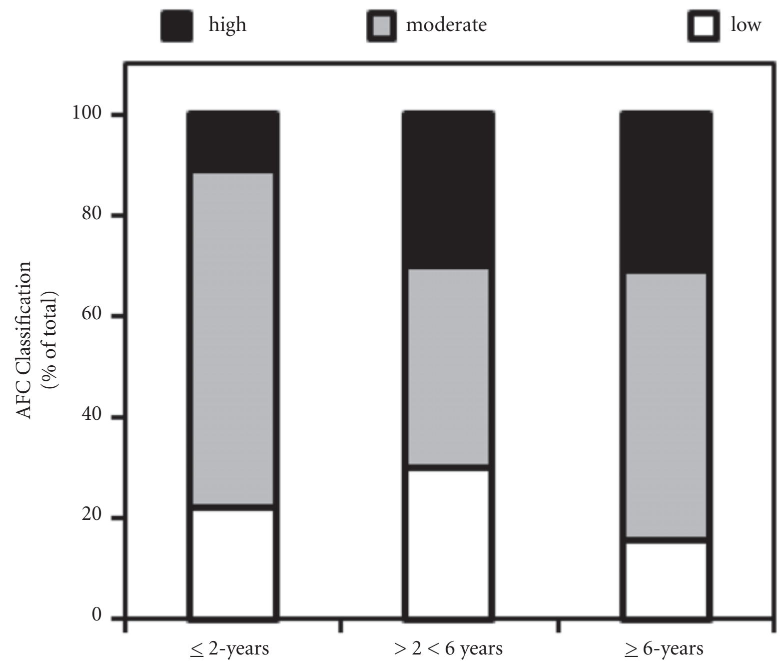

Figure 2. Percentage of cows that were categorized as high, medium or low antral follicle counts (AFC) in each fertility group.

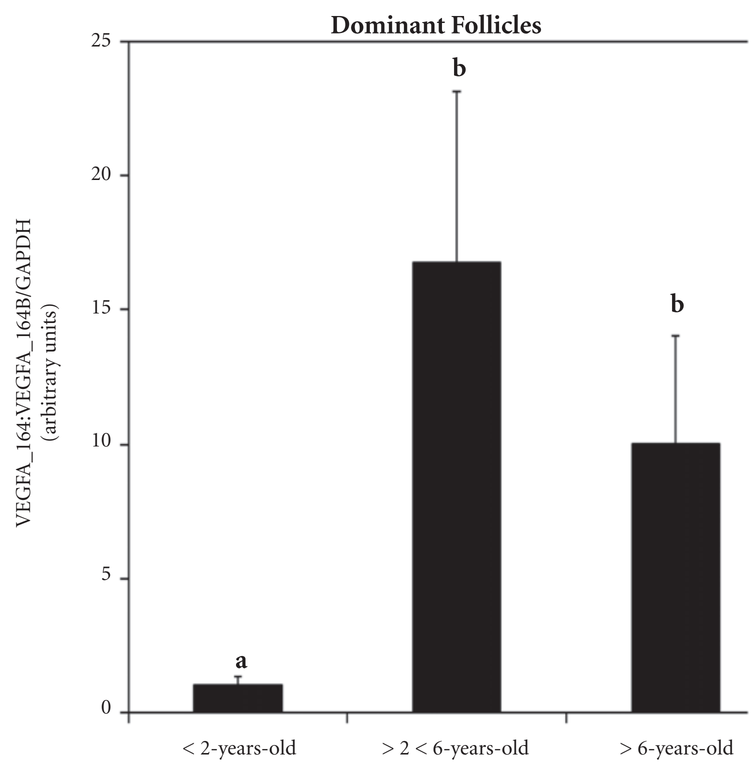

Figure 3. Quantitative PCR for VEGF164/VEGF164B ratio in granulosa cells from dominant follicles in cows with different fertility. Different subscripts indicate significance at P < 0.05.

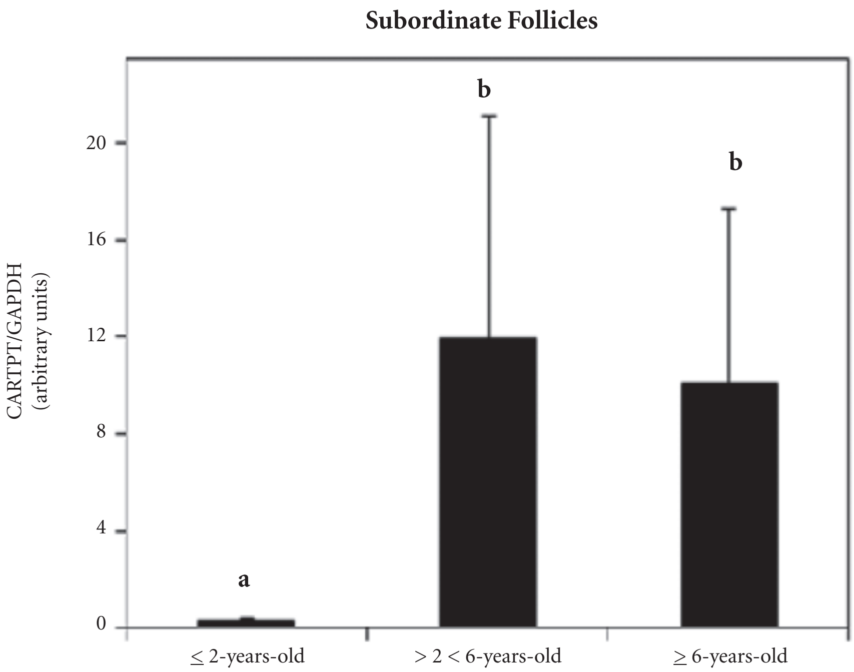

Figure 4. Quantitative PCR for CARTPT in granulosa cells from subordinate follicles taken from cows with different fertility. Different subscripts indicate significance at $P < 0.05$.

Interestingly, subordinate follicle diameters among the fertility groups were different, with the cows in low fertility being the smallest, the moderate were greater than the low, and the high having the largest follicle diameter (data not shown). The differences in subordinate follicle growth may be directly related to factors being produced by the dominant follicle. Also, when CARTPT, a gene expressed in subordinate and dominant follicles undergoing atresia, was measured, there was dramatically more expressed in subordinate follicles from the moderate- and high-fertility group than the low (Figure 4). This further supports our hypothesis that gene expression profiles are altered and may not be optimal in the low-fertility group, which possibly reflects why they failed to become pregnant.

Implications

Finding genes that predict fertility and reproductive longevity would allow for selection of heifers prior to their development to puberty and would increase profitability of cow/calf producers.

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Performance of Growing Cattle Fed Corn Silage or Grazing Corn Residue from Second Generation Insect-Protected (MON 89034), Parental, or Reference Corn Hybrids

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Summary

Effects of feeding second generation insect-protected transgenic corn (MON 89034) on growing steer performance was evaluated in two experiments. In Experiment 1, a corn silage-based diet was fed to growing steers in pens, and the transgenic test hybrid was compared to a non-transgenic parental hybrid and two commercially available reference hybrids. In Experiment 2, steers grazing corn residue of the transgenic test hybrid were compared to steers grazing a non-transgenic parental hybrid. In both experiments, growing performance was not affected by source of corn silage or residue.

Introduction

Given that the majority of domestic corn production is used for livestock feed and the highest percentage is fed to feedlot cattle, it is important for producers to know if cattle perform similarly when fed transgenic corn compared to non-transgenic corn. Furthermore, it is also essential to see comparable results when grazing transgenic crop residue or feeding transgenic silage in growing situations.

The objective of Experiment 1 was to compare the performance of growing steers fed second generation insect-protected corn silage (MON 89034) with the non-transgenic parental hybrid (DKC 63-78) and two non-transgenic reference hybrids (DKC 61-42 and DKC 62-30). The objective of Experiment 2 was to compare the performance of steers grazing the insect-protected (MON 89034) corn residue with that of steers grazing the non-transgenic parental hybrid (DKC 63-78).

Procedure

Experiment 1

Animals. Crossbred British x Continental steers (n = 240; initial BW = 614 ± 44 lb) were used in a randomized complete block design experiment. Steers were received at the University of Nebraska Agricultural Development and Research Center (Ithaca, Neb.) during the fall of 2009. Steers were weighed and vaccinated (Bovishield Gold 5, Somubac, Dectomax) and treated with Micotil (Elanco Animal Health) on arrival. Following a 14- to 21-day receiving period, steers were limit fed five days to minimize variation in rumen fill. The limit fed ration contained a 1:1 ratio of wet corn gluten feed and alfalfa hay fed at 2% BW. Steers were weighed individually on two consecutive days in the morning before feeding to obtain an accurate initial BW. Steers were blocked by BW, stratified within block, and assigned randomly to 1 of 20 pens based on day 0 BW. Pens were then assigned randomly to one of four treatments. Diets for each treatment are shown in Table 1.

Treatments. Treatments consisted of two reference hybrids, a non-transgenic parental hybrid, and the second-generation Bt hybrid (MON 89034). All corn was grown at the Agricultural Research and Development Center near Ithaca, Neb., under identity preserved methods. All hybrids were cut for silage at similar moisture levels (34.2% DM ± 2.1%) and stored in silo bags by hybrid. Samples of all hybrids were collected and sent to Monsanto Company, where the presence or absence of the genes was verified.

Table 1. Growing Diet Composition (%DM).[1]

Ingredient	MON	PAR	REF1	REF2
Corn silage W				80.0
Corn silage X	80.0			
Corn silage Y		80.0		
Corn silage Z			80.0	
WDGS	15.0	15.0	15.0	15.0
Supplement[2]				
Fine ground milo	3.006	3.006	3.006	3.006
Limestone	0.916	0.916	0.916	0.916
Salt	0.300	0.300	0.300	0.300
Urea	0.574	0.574	0.574	0.574
Tallow	0.125	0.125	0.125	0.125
Trace mineral	0.050	0.050	0.050	0.050
Vitamin A-D-E	0.015	0.015	0.015	0.015
Rumensin-80	0.014	0.014	0.014	0.014
Nutrient composition				
CP	13.3	12.6	12.7	13.4
NDF	39.4	35.7	33.0	36.3
Ca	0.67	0.53	0.54	0.70
P	0.28	0.27	0.27	0.36
K	0.78	0.78	0.89	0.82

[1]REF1 = reference hybrid DKC 61-42, REF2 = reference hybrid DKC 62-30, PAR = non-transgenic parental hybrid, MON = corn silage containing Cry1A.105 and Cry2Ab2 proteins (MON 89034).
[2]Formulated to provide 200mg/head/day.

Table 2. Growing Performance on Corn Silage-based Diet for 86 days.[1]

Variable	MON	PAR	REF1	REF2	*P*-value
Initial BW, lb	613	616	612	614	.01
Ending BW, lb	925	927	925	919	.53
DMI, lb/day	20.4	20.8	20.9	20.8	.40
ADG, lb	3.63	3.62	3.64	3.54	.56
F:G[2]	5.62	5.74	5.75	5.89	.25

[1]REF1 = reference hybrid DKC 61-42, REF2 = reference hybrid DKC 62-30, PAR = non-transgenic parental hybrid, MON = corn silage containing Cry 1A.105 and Cry2Ab2 proteins (MON 89034).
[2]Analyzed as gain:feed, reported as feed:gain.

Table 3. Grazing Performance.

	MON	PAR	SEM	*P*-value
Initial BW, lb	547	550	1	.07
Ending BW, lb	567	566	4	.89
ADG, lb	0.52	0.39	.06	.20

MON = corn containing Cry1A.105 and Cry2Ab2 proteins (MON 89034), PAR = non-transgenic parental hybrid.

Prior to experiment initiation, corn silage samples were collected and sent to a commercial laboratory (Romer Labs, Union, Mo.) to test for the presence of mycotoxins. Small amounts of Deoxynivalenol (Vomitoxin) and Zearalenone were found in the test hybrid (MON) and the non-transgenic parental hybrid (PAR) silage. In all samples, the amount of mycotoxins present was well below the level for concern. Ingredient and diet samples were collected weekly, composited by month, and sent to a commercial laboratory (Dairy One, Ithaca, N.Y.) for nutrient analysis.

Data were analyzed using the MIXED procedures of SAS (SAS Institute, Cary, N.C.). Pens were the experimental unit (5/treatment). Block was treated as a fixed effect in the model. Only one replication was included in the heavy block, with four replications in the other weight block. Data were analyzed and statistics are based on this analysis. However, least square means are not presented due to adjustment for unequal replication of blocks. Arithmetic means are presented by treatment (Table 2).

The study was blind to feedlot personnel. Each hybrid was assigned a letter before beginning the trial. All treatments, silage bags, pen assignments, feed sheets, and observation documents were designated by letter to limit possible partiality to treatment.

Experiment 2

Animals. Crossbred British x Continental steers (n = 64; initial BW = 549 ± 17 lb) were used in a completely randomized design experiment. Prior to initiation of the trial, steers were limit fed five days to minimize variation in rumen fill (1:1 blend of wet corn gluten feed and alfalfa hay at 2% BW). Individual weights were taken on two consecutive days in the morning before feeding to obtain an accurate initial BW. Steers were stratified by BW recorded on day 0 and assigned randomly to a paddock (8 steers/paddock) and treatment. Steers were fed a supplement (2.5 lb/steer daily) formulated to meet protein requirements. The supplement was dry distillers grain-based (93.8%) and included limestone, tallow, Rumensin-80, trace minerals, selenium, and vitamin A-D-E.

Treatments. Treatments consisted of two 30.7-acre fields separated into four 7.7-acre paddocks per field. The fields consisted of corn crop residue from either the second generation insect-protected corn (MON 89034) or the non-transgenic parental hybrid (DKC 63-78).

Residual corn from each paddock was estimated by sampling three random 300 x 2.5 ft strips. Whole and partial ears were collected and shelled to determine bushels of acre residual corn for each paddock and hybrid. Shelled corn was dried in a 60°C oven for 48 hours to determine DM/acre of residual corn. Downed corn in MON 89034 paddocks was estimated at 101.0 lb DM/ac or 2.41 bu/ac. Estimates of downed corn in the PAR paddocks were 103.3 lb DM/ac or 2.48 bu/ac.

Data were analyzed using the MIXED procedures of SAS (SAS Institute, Cary, N.C.). Paddocks were the experimental unit (4/treatment).

Due to adverse winter weather conditions, the experiment ended on day 40, earlier than originally planned. One steer from MON treatment died due to weather related stress on day 39 and was removed from experiment analysis.

Results

Growing performance is shown in Table 2. No significant differences were observed. Because initial BW was statistically different, it was used as a covariate of analysis. Across-treatment averages were 20.7, 3.61, and 5.75 for DMI, ADG, and F:G, respectively. Steers fed MON were numerically the most efficient at 5.62 F:G. Cattle fed silage-based growing rations had very good DMI, ADG, and F:G due to good feeding conditions from February to May. No statistical differences were observed in grazing experiment performance (Table 3).

Cattle in this trial were not affected by source of corn, whether grazing residue or fed silage from transgenic or non-transgenic hybrids. Intake and ADG were numerically similar and certainly suggest no performance problems in the feeding value of transgenic corn when compared to non-transgenic corn. Mon 89034 is nutritionally equivalent to non-transgenic corn.

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Nutrient Composition of Spoiled and Non-Spoiled Wet Byproducts Mixed and Stored With Straw

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Summary

Wet corn byproducts were mixed with straw and stored in 55 gallon barrels for 56 days to simulate bunker storage. The spoilage process caused a decrease in fat content and an increase in pH, NDF, ash, and CP. Covering with plastic or distillers solubles reduced the amount of spoilage and the change in nutrient composition.

Introduction

Mixing wet distillers grains plus solubles (WDGS) or distillers solubles (DS) with straw allows storage in bunkers (*2008 Nebraska Beef Cattle Report*, pp. 23-25; *2010 Nebraska Beef Cattle Report*, pp. 21-25). When the surface of WDGS is exposed to air it will spoil. As previous research shows, spoilage process will result in loss of DM at the surface of the bunker (*2010 Nebraska Beef Cattle Report*, pp. 21-25). To minimize the amount of spoilage to surfaces exposed to oxygen, several cover treatments may be applied.

Along with a loss of DM, nutrient composition of stored mixes may change during spoilage. In most cases, producers feed the spoiled material along with the unspoiled. The purpose of this experiment was to determine the nutritional composition of the spoiled feed fractions and how different covers affect these nutritional changes.

Procedure

Storage

To simulate bunker storage, 55 gallon barrels were packed with one of two mixes: 70% WDGS and 30% straw mixture or 60% DS and 40% straw (both on a DM basis). Barrels were filled to approximately the same weight (300 lb) and packed to similar heights. All barrels (except DS: straw open-outside) were stored inside the Animal Science building at the University of Nebraska–Lincoln in a temperature-controlled room. Table 1 describes the barrel covers that were assigned randomly to barrels with two replications per treatment.

Table 1. Cover treatments.

WDGS: Straw	
Open	Barrels were left uncovered.
Open + H_2O	Uncovered with water added at a rate of 0.6 in weekly to mimic average Nebraska precipitation.
Plastic	Six mil plastic covering the surface of the mixture, weighed down with sand, and the edges sealed with tape. This treatment would be comparable to plastic and tires in a bunker setting.
Salt	Salt was sprinkled over the surface of the mixture at a rate of 1 lb/ft^2.
Distillers solubles (DS)	DS were poured over the surface of the mixture to make a 3-inch layer (45 lb as-is).
DS + Salt	DS and salt added at rates previously discussed and mixed together before application.
DS + Salt + H_2O	DS and salt added at rates previously discussed and water added at 0.6 inch weekly.
DS: Straw	
Open, inside	Barrels left uncovered and stored inside.
Open, outside	Barrels left uncovered and stored outside at the University of Nebraska Feedlot near Mead, Neb., and exposed to any rainfall.

Opening Barrels

After 56 days of storage, each barrel was opened by carefully removing the solubles layer (if applied), the spoiled portion, and then the nonspoiled portion. When salt was used as a cover,

Figure 1. Picture of a portion of the spoiled material removed from an open barrel. Layers of moisture loss, mold, and decomposition can be seen.

Table 2. WDGS: Straw nutrient composition and losses.

		Open	Open + H_2O	Plastic	Salt	DS[4]	DS + Salt	DS + Salt + H_2O
DM %[1]	**SP[2]**	44.0	25.3	39.0	43.6	37.4	39.3	32.3
	N[3]	36.3	33.7	41.2	39.4	39.3	38.0	34.2
pH	**SP**	8.1	7.6	7.2	8.5	6.5	5.4	6.0
	N	4.1	4.5	3.9	4.0	3.9	4.1	4.0
Fat %	**SP**	4.9	6.0	7.2	4.1	10.0	7.4	9.5
	N	10.6	10.5	10.1	10.2	10.1	10.5	9.4
NDF %	**SP**	52.9	55.3	49.3	50.5	38.1	35.2	41.7
	N	42.2	43.0	45.4	48.3	44.3	40.9	43.7
Ash %	**SP**	12.0	14.2	12.0	19.1	13.9	20.0	17.7
	N	8.1	8.7	8.2	8.3	8.8	11.0	11.4
CP %	**SP**	28.7	25.9	29.3	24.0	29.9	25.6	26.1
	N	27.6	27.9	25.7	25.5	23.7	25.5	24.7
DM loss, %		3.4	3.4	0	.82	0.07	0	0
Spoilage, %		3.9	3.9	0.61	3.8	2.0	2.1	1.5

[1]140°F forced air oven DM%
[2]Spoiled material
[3]Nonspoiled material
[4]Distillers solubles

Table 3. DS: straw nutrient composition (DM) and losses.

		Open-Inside	Open-Outside
DM, %[1]	**SP[2]**	41.3	43.2
	N[3]	44.5	41.5
pH	**SP**	7.5	7.0
	N	4.0	4.1
Fat, %	**SP**	5.9	7.1
	N	13.2	13.0
NDF, %	**SP**	46.2	43.8
	N	35.1	36.5
Ash, %	**SP**	19.0	18.3
	N	12.1	11.8
CP, %	**SP**	23.2	22.3
	N	18.2	19.4
DM loss, %		2.7	1.8
Spoilage, %		4.9	3.9

[1]140°F forced air oven DM%
[2]Spoiled material
[3]Nonspoiled material

it was collected and analyzed as part of the spoiled layer. As in previous research, it was assumed that all of the spoilage occurred from the top down as it was exposed to the air. The spoilage was determined by appearance and texture as seen in Figure 1. As each layer was removed, representative samples were collected and used for analysis. Subsamples were dried in 140°F forced air oven for 48 hours to obtain DM. Additional samples were freeze-dried and ground through a Wiley Mill (1 mm screen) and analyzed for pH, fat, neutral detergent fiber (NDF), ash, and CP, and reported on a DM basis.

The nonspoiled material was assumed to be unchanged and, therefore, equivalent to the starting mix. Data were analyzed using the mixed procedures of SAS using barrel as the experimental unit.

Results

Interactions ($P < 0.01$) resulted between the cover treatment and spoilage layer for pH, fat, NDF, ash, and CP with the WDGS: Straw mixture and CP for the DS: Straw mixture (Tables 2 and 3). Overall, there was a decrease in fat and increases in pH, NDF, ash, and CP. The most important of these to consider is the loss of fat content. The greatest loss of fat resulted when salt was used as a cover or when barrels were left uncovered. Fat decreased from 10.2 to 4.1% DM and 10.6 to 4.9% DM, respectively. The microbes that are causing the spoilage utilize fat in the distillers products as an energy source. Therefore, the used fat is lost for the animals' use when it is time to feed. Using DS as a cover resulted in no change in fat content for the spoiled fraction. The other treatments were intermediate in terms of fat loss in the spoilage process.

The spoilage process also caused the pH of the mixture to increase from its initial pH of about 4.0 to a final pH of 8.5 with a salt cover, and 6.0 with the DS + Salt + H_20. The NDF content (% of DM) generally increased as spoilage occurred. The greatest change occurred in the open barrels with or without water added, with a 12.3 and 10.6 percentage unit increase in NDF, respectively. A 2.2% increase was the smallest change recorded with the salt covering, but it must be noted that the salt covering was not separated from the spoiled material. When separating the DS layer from the spoiled layer, not all of the DS could be removed; therefore, some was collected in the spoiled layer. This may be the reason that the spoiled portions of the barrels covered with DS resulted in a decreased NDF content.

The results for ash content of the mixtures showed the largest increase with the salt covering, but again the salt was included in the spoiled material. The CP content generally increased with each cover. This is due to the microbes utilizing the fat and soluble carbohydrates, thus increasing the ash and CP contents.

From previous research focusing on shrinkage and DM loss, covers like plastic and DS minimized the air contact and were found to be the best covers, resulting in the smallest amount of spoilage (Tables 2 and 3). The mixes left uncovered (open) resulted in the greatest amount of spoilage. This is closely associated with the difference in nutritional composition. The plastic and DS covers allowed for the least amount of air to reach the surface of the mix, and resulted in the least amount of spoilage.

In conclusion, the loss of fat and increase in ash and NDF reduce available energy in spoiled feed. The spoiled feed is not as nutrient dense as nonspoiled material.

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Use of Dry-rolled Corn, Dry or Wet Distillers Grains Plus Solubles as an Energy Source in High Forage Diets for Growing Cattle

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Summary

One hundred twenty crossbred steers were used to determine the energy value of distillers grains relative to corn in high-forage diets. Diets included dry distillers grains plus solubles (DDGS), wet distillers grains plus solubles (WDGS) or dry-rolled corn (DRC), with sorghum silage, grass hay, and supplement. Each block of steers, by design, had similar dry matter intake (DMI) and average daily gain (ADG) across treatments. In this study, WDGS and DDGS contained 120% and 114%, respectively, the energy of DRC when fed in forage-based diets.

Introduction

Past research has shown that in forage-based diets, feeding starch as an energy source can suppress forage digestion. Using dry distillers grains plus solubles (DDGS) or wet distillers grains plus solubles (WDGS) in place of dry-rolled corn (DRC) can reduce the negative associative effects that starch can have on fiber digestion. In forage-based diets, DDGS and WDGS have been shown to contain 118% to 130% (*2003 Nebraska Beef Report*, pp. 8-10) and 130% (*2009 Nebraska Beef Cattle Report*, pp. 28-29), respectively, the energy value of DRC, depending upon level fed. However, research evaluating the energy value of both DDGS and WDGS in the same study is limited in forage-based diets. The objective of this study was to determine the energy value of DDGS and WDGS relative to DRC in forage-based diets within the same experiment.

Procedure

Cattle Performance

One hundred twenty crossbred steers in two weight blocks (543 ± 22 lb) were used in an 84-day growing trial to compare the energy value of DDGS and WDGS, at differing levels, to DRC in a forage-based diet. Calves were blocked into two weight groups, stratified within block and assigned randomly to one of seven diets. Animals were randomly paired into groups of three based on BW and fed either the low or high levels of each diet: 1) DRC, 2) DDGS, or 3) WDGS. Prior to initial and ending BW, steers were limit fed a common diet, containing 60.0% Sweet Bran®, 20.0% grass hay, and 20.0% alfalfa to reduce variation in gut fill. Weights were obtained three consecutive days following each limit-feeding period.

Diets were formulated using the NRC (1996) model and were formulated to meet energy and metabolizable protein requirements. Diets were calculated to contain the same amount of energy assuming DGS contains 108% TDN. Gain was predicted at 1.74 lb/day for the low inclusion level at 15% and 2.37 lb/day for the high inclusion level at 30% DGS. Dry-rolled corn diets were formulated to equal these ADG, which calculated to 22% and 50% corn for low and high inclusion, respectively. Bunks were evaluated daily and managed based on the animal within each pair eating the least as a percentage of BW. Feed refusals were collected weekly, and DM of the feed refused was subtracted from DM offered to determine DMI.

For all diets, a 60:40 blend of grass hay and sorghum silage was fed, with DDGS, WDGS or DRC replacing this blend (Table 1). All diets contained a supplement that included urea to meet degradable intake protein requirements. Soypass® was used in the control diet and DRC treatments to provide undegradable intake protein (UIP) to meet the metabolizable protein requirement. Fat content of DDGS and WDGS was 11.0 and 11.0%, NDF was 36.9 and 37.8%, and CP was 30.2 and 31.0%, respectively. Fat content of DRC was 3.5 %, NDF 10.0%, and CP 9.5%. The NDF of sorghum silage and brome hay was 60.0 and 76.6%, respectively.

Table 1. Diet composition.

	Diet Treatment[1]						
	Control	DRC		DDGS		WDGS	
Ingredients	60:40	22	50	15	30	15	30
Grass hay	56.52	43.08	26.26	49.5	40.5	49.5	40.5
Sorghum silage	37.68	28.72	17.44	33.0	27.0	33.0	27.0
DRC	—	22.0	50.0	—	—	—	—
DDGS	—	—	—	15.0	30.0	—	—
WDGS	—	—	—	—	—	15.0	30.0
Urea	0.65	1.05	1.51	1.13	1.13	1.13	1.13
Soypass®	3.80	3.70	3.45	—	—	—	—
Limestone	0.82	0.943	0.943	0.943	0.943	0.943	0.943
Salt	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Trace mineral premix	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Vitamin ADE premix	0.015	0.15	0.015	0.15	0.015	0.15	0.15
Tallow	0.141	0.151	0.157	0.061	0.061	0.061	0.061

[1]Represented as a percentage of diet DM.

Table 2. **Effect of feeding low or high levels of dry-rolled corn, dry distillers grains plus solubles or wet distillers grains plus solubles.**

	Diet Treatment				
Item	DRC	DDGS	WDGS	SEM	*P*-value
Initial BW, lb	620	622	620	7.77	0.96
Ending BW, lb	803	801	798	8.72	0.91
DMI, lb/day	15.9	16.2	15.8	0.25	0.89
ADG	2.18	2.13	2.13	0.07	0.81
F:G	7.30	7.58	7.41	0.01	0.98

Table 3. **Main effects of feeding differing levels of dry-rolled corn, dry distillers grains plus solubles, or wet distillers grains plus solubles.**

Item	Control	Low	High	Linear
Initial BW, lb	622	620	621	0.94
Ending BW, lb	742	778	821	<0.01
DMI, lb/day	15.3	15.6	16.3	0.44
ADG	1.43	1.89	2.41	<0.01
F:G	10.75	8.26	6.76	<0.01

The NRC (1996) model predicts gain using DMI and dietary energy content. Therefore, energy content of the feed can be predicted if gain and DMI are known. Intake, diet composition, BW, and ADG were used to calculate the energy value of WDGS and DDGS in the treatment diets. The TDN of DRC utilized for this experiment had been determined in a similar manner at 83% (*2003 Nebraska Beef Cattle Report*, pp. 8-10), thus results for DDGS and WDGS could be expressed relative to corn.

Data were analyzed using the MIXED procedure of SAS with alpha = 0.10. The model included the level of byproduct inclusion and type of feed. Animal was considered the experimental unit (18 head/treatment) for cattle performance.

Results

Cattle Performance

There were no interactions between level of supplement inclusion (low or high) and type of feed (DRC, DDGS, or WDGS). By design, type of feed (DRC, DDGS, or WDGS) did not impact initial BW, ending BW, DMI, ADG, or F:G (Table 2). The main effect of level of inclusion is shown in Table 3. Ending BW and ADG increased linearly as the level of energy increased in the diets, while F:G linearly decreased ($P < 0.01$). This linear improvement was expected as the amount of grain or byproduct included increased, so did the level of energy. Intake was not different between levels ($P = 0.64$).

The TDN value for corn was set at 83% (*2003 Nebraska Beef Report*, pp. 8-10), 52% for hay, and 65% for sorghum silage. Using the NRC (1996) to calculate TDN, net energy (NE) adjusters were set at 104.5%. The resulting TDN value of DDGS and WDGS was 94.5% and 99.2%, respectively. Therefore, the estimated energy value of DDGS and WDGS was 114% and 120% the value of corn (94.5 ÷ 83 and 99.2 ÷ 83).

This trial reiterates that distillers grains (dry or wet) have a high energy value relative to corn in forage-based diets. The level of starch present at low amounts, the energy density of fat, undegradable protein and corn fiber are the possible reasons contributing to greater energy value compared to corn as a supplement.

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Effect of Corn Hybrid on Amount of Residue Available for Grazing

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Summary

Twelve corn hybrids were evaluated to determine differences in corn grain yield and crop residue DM. Hybrids did not differ in corn grain yield but differed in amount of stems, leaves, husks, and cobs. Differences also existed in the ratio of corn grain to total residue production and corn grain to leaf and husk, indicating potential differences in plant efficiency independent of the amount of grain produced.

Introduction

Many variables should be considered in the effective management of corn residue as a source of grazed forage. Cattle will select the highest quality parts of corn residue first. Wilson et. al. (*2004 Nebraska Beef Cattle Report*, pp. 13-15) reported that husk (3.6% CP and 67% IVDMD) and leaf (7.8% CP and 47% IVDMD) were more palatable than stem (4.5% CP and 45% IVDMD) and cob (2.2% CP and 35% IVDMD). Fernandez-Rivera and Klopfenstein (1989, *Journal of Animal Science*, 67:597) observed that 65 to 72% of DM utilized was represented by leaf and husk. Therefore, relative amount of plant parts, as well as their quality, could affect performance by grazing animals. The objectives of our research were to determine 1) whether differences exist among hybrids in the amount of residue available for grazing and in the ratio of corn grain to total residue produced, and 2) whether residue from different corn hybrids differs in quality.

Procedure

Hybrids that represented a wide range of production traits were selected from test plots near Paxton and Scottsbluff, Neb. The following hybrids were evaluated at Paxton: Pioneer P0541XR, P1173HR, P1395XR, Dekalb 59-35, 61-04, NK N68B-GT, N74C-3000GT, Croplan Genetic 5757 VT3, Golden Harvest 8211 3000GT, and Midwest Genetics 76482R. Plots received center pivot irrigation and had a silt loam soil type. Dekalb 42-91 and Mycogen 2R416 were produced at Scottsbluff.

The plot contained four rows per hybrid and rows were 30 inches apart. Plants were selected randomly for each hybrid by measuring 100 ft then sampling the 10th plant down, alternating between the four rows for each sample. Each plant was cut at ground level, and the entire plant was collected. Plant density was measured by counting the number of plants present in a 15 ft length of row.

Each plant was sorted into the following parts: stems, leaves (including leaf sheath), husks, cobs, and corn grain. Plant parts were dried in a forced air oven at 140°F to determine DM yield per plant. Plant part samples were composited into five samples per hybrid and analyzed for *in-vitro* organic matter disappearance (IVOMD). IVOMD was determined using a 48-hour incubation of 0.5 g of sample in a 1:1 mixture of McDougall's buffer (1 g/L urea) and rumen fluid collected from ruminally fistulated steers. Samples were incubated in a water bath at 39°C and swirled every 12 hours. After incubation, samples were filtered, dried for 24 hours, and burned in an ash oven to determine the DM and OM content for the calculation of IVOMD.

Results

Corn grain yield among hybrids (251 bu/ac at 15.5% moisture; 11,813 lb/ac ± 319, DM basis) at Paxton were not different. Differences were present between hybrids in the amount of stems, leaves, husks, and cobs (Table 1). Total residue production (sum of stems, leaves, husks, and cobs) was different among hybrids. However, differences also existed in the ratio of corn grain to total residue production and corn grain to leaf and husk, indicating potential differences in plant efficiency. Wilson, et al. (*2004 Nebraska Beef Cattle Report,* pp. 13-15) reported an average of 16 lb leaf and husk produced per bushel grain

Table 1. Composition of corn residue components of 10 corn hybrids (dry matter).

Hybrid[1]	5	8	10	21	25	29	35	38	46	48	SE	*P*-value
Grain[2], bu/ac	257	251	249	266	254	239	246	247	214	231	11	0.23
Stem, lb/ac	4411	4022	3896	3946	3760	3321	4521	4719	5384	4524	199	<0.01
Husk, lb/ac	808	993	828	811	882	984	1009	784	864	610	73	0.01
Leaf, lb/ac	2551	3173	2817	3133	2917	3010	3323	2991	3255	2603	184	0.05
Cob, lb/ac	1386	1628	1305	1396	1471	1387	1702	1412	1297	1123	79	<0.01
Total, lb/ac	9157[a]	9816[ab]	8846[a]	9286[a]	9030[a]	8702[a]	10555[b]	9905[ab]	10782[b]	8860[a]	477	0.02

[1]Hybrids are as follows: 5, Golden Harvest 8211 3000GT; 8, Pioneer P0541XR; 10, Croplan Genetic 5757 VT3; 21, Dekalb 59-35; 25, Midwest Genetics 76482R; 29, NK N68B-GT; 35, Dekalb 61-04; 38, Pioneer P1173HR; 46, Pioneer P1395XR; and 48, NK N74C-3000GT.
[2]15.5% moisture.

Table 2. *In vitro* **organic matter disappearance (%) of 10 corn hybrids from Paxton, Neb.**

Hybrid[1]	5	8	10	21	25	29	35	38	46	48	SE	*P*-value
Husk	60.5	56.8	56.0	56.1	54.5	55.7	56.0	57.0	58.0	58.5	1.1	<0.01
Leaf	51.5	52.1	52.1	50.7	50.8	52.0	49.9	51.8	50.9	51.9	0.6	<0.01
Stem	48.3	47.8	46.4	47.9	46.0	46.7	46.0	47.9	50.4	49.0	1.0	<0.01
Cob	47.1	48.2	46.6	46.9	47.0	45.2	46.8	51.0	49.1	52.6	1.0	<0.01

[1]Hybrids are as follows: 5, Golden Harvest 8211 3000GT; 8, Pioneer P0541XR; 10, Croplan Genetic 5757 VT3; 21, Dekalb 59-35; 25, Midwest Genetics 76482R; 29, NK N68B-GT; 35, Dekalb 61-04; 38, Pioneer P1173HR; 46, Pioneer P1395XR; and 48, NK N74C-3000GT.

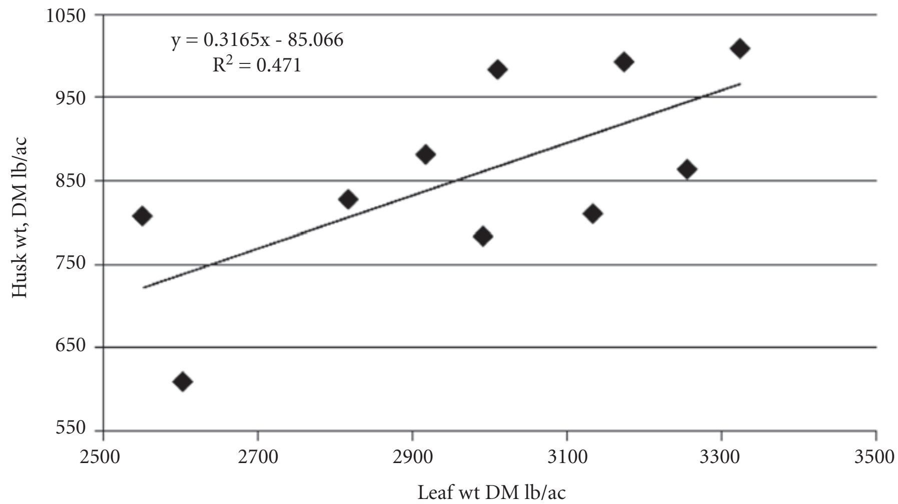

Figure 1. Relationship between leaf and husk weight.

Table 3. *In vitro* **organic matter disappearance of two corn hybrids from Scottsbluff, Neb.**

	Hybrid	
	1[1]	2[1]
Husks[2], lb/ac	806	724
Leaves[2], lb/ac	1296	1475
Stems[2], lb/ac	2073	1820
Cobs[2], lb/ac	984	957
Grain[3], bu/ac	152.2	143.6
***In vitro* Digestibility**		
Husk, %	60.4	61.0
Leaf, %	56.4	57.3
Stem, %	54.5	53.2
Cob, %	46.4	50.8

[1]Hybrids are as follows: 1, Dekalb 42-91; 2, Mycogen 2R416.
[2]Values reported on a dry matter basis.
[3]15.5% moisture.

yield for corn producing 43 to 183 bu/ac. Leaf and husk produced per bushel grain in the current study ranged from 14 to 19 lb. Corn hybrids differed in the amount of residue produced independent of the amount of grain. The correlation was very low (Figure 1).

Since corn hybrids differed in the amount of residue they produced, possible differences exist in the amount of residue available for cattle to graze. The production of leaf and husk ranged from 3,267 to 4,407 lb/ac. A 1,200 lb cow will consume about 785 lb/month in a corn residue grazing situation (DM basis; NRC, 1996). Assuming a 50% utilization of the leaf and husk (*2004 Nebraska Beef Cattle Report,* pp. 13-15) the high and low husk and leaf producing hybrids could support 2.8 and 2.0 cows/ac for one month. If corn residue cost $6.00/ac, this would equate to $2.15 and $2.90/cow monthly for the high and low leaf and husk producing hybrids, respectively. The findings of this study indicate differences in total residue, as well as the ratio of grain yield to total residue, do exist among hybrids. These differences can equate to potential economic differences among hybrids in the grazing value of the corn residue.

There was variation in digestibility among hybrids for the respective plant parts (Table 2). However, the digestibility among hybrids was not consistent across plant parts. Greater digestibility was observed for leaf and husk material compared to stem and cob material, but varied among hybrids. Digestibility of leaf or husk material was not highly correlated with leaf or husk residue weight ($P = 0.45$, $R^2 = 0.07$ for leaf, and $P = 0.23$, $R^2 = 0.17$ for husk). Wilson reported a high correlation between total leaf and husk material (DM lb/ac) and grain yield (bu/acre; *2004 Nebraska Beef Cattle Report,* pp. 13-15), across a wide range of growing conditions and hybrids. However, a relationship among hybrids was not observed in this trial ($P = 0.87$, $R^2 = 0.004$). Husk and leaf weight (DM lb/ac) were correlated (Figure 1; $P = 0.03$, $R^2 = 0.47$); weight of husk material increased as weight of leaf material increased.

The two hybrids at Scottsbluff had lower grain yields (Table 3). The amount of residue was roughly proportional to the grain yield. The amount of leaf plus husk was 14 and 15 lb/bu. The *in vitro* digestibility of the leaves and husks was generally greater than the values for the leaves and husks from Paxton.

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Supplementing DDGS to Steers Grazing Smooth Bromegrass Pastures

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Table 1. Pasture performance of steers grazing smooth bromegrass.

	CON	FERT	SUPP	SEM	*P*-value
Days		158	158	158	
Initial BW, lb	718	716	713	12.78	0.96
End BW, lb	959^{a}	954^{a}	1046^{b}	15.4	<0.01
ADG, lb/day	1.53^{a}	1.51^{a}	2.11^{b}	.07	<0.01

^{a,b} Means in a row without a common superscript differ ($P < 0.01$).

Summary

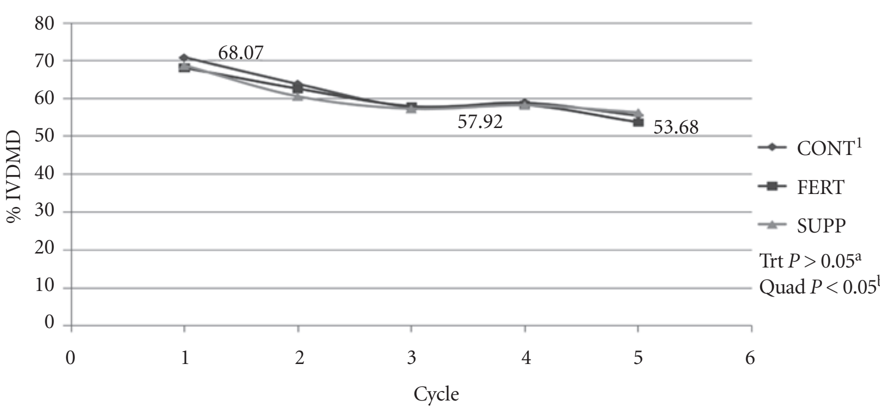
Five years of data were summarized to evaluate cattle and pasture performance when smooth bromegrass pastures were fertilized or cattle were supplemented daily with dried distillers grains with solubles (DDGS) on non-fertilized pastures. Cattle were supplemented at 0.6% of BW for an average of 158 days. Supplemented cattle gained 0.59 lb/day more than unsupplemented cattle. As forage quality declined over the grazing season, ADG also declined but the cattle's response to DDGS supplementation increased. Each 1 lb of DDGS supplement replaced approximately 1 lb of forage intake. Pastures with supplemented cattle had increased forage production compared to control pastures but less forage production than fertilized pastures.

Introduction

Supplementing with DDGS has been shown to increase ADG while decreasing forage intakes in cattle (*2005 Nebraska Beef Cattle Report*, pp. 18-20). Cattle supplemented with DDGS will have excess N in their diet, which will be excreted on the pastures in the form of urea in the urine. This urea is quickly broken down in the soil and utilized by plants to increase production. Rotating the cattle between paddocks during the growing season will ensure a more even application of this excess N from the urine onto the pastures. The objective of this trial was to compare the effects of different grazing and supplementation strategies on both pasture and cattle performance by evaluating pasture production, cattle intake, and weight gain.

Procedure

Two hundred and twenty-five yearling steers (716 ± 13 lb) were used in a randomized complete block design over the course of five years on smooth bromegrass pastures at the University of Nebraska–Lincoln Agricultural Research and Development Center near Mead, Neb. Treatments consisted of pastures fertilized in the spring with 80 lb N/ac (FERT) and stocked at 4 AUM/ac, pastures stocked with cattle that received 0.6% of BW or 4.2 to 6.2 lb of DM/steer daily as DDGS (SUPP), and nonfertilized pastures that were stocked at 69% of the other two treatments (CON). Pasture was the experimental unit and was replicated three times. Pastures were divided equally into six paddocks that were rotationally grazed. The grazing season lasted from late April through September each year and was divided into 5 cycles with cycles 1 and 5 being 24 days in length and cycles 2, 3, and 4 being 36 days in length. Put-and-take yearling steers were used to maintain similar grazing pressure among treatments. Beginning and ending BW were measured on three consecutive days after a five-day limit fed period to reduce fill effects. Weights also were collected after each cycle and were shrunk 4% to account for rumen fill. Ruminally fistulated steers were used to collect diet samples from each treatment during each cycle. These samples were then evaluated for forage DM, CP, and IVDMD. This information was then used to estimate forage intakes using the NRC (1996) beef cattle model.



^{a}No statistical differences between treatments over time.
^{b}Quadratic relationship between IVDMD and time of grazing.
[1]Pastures were either nonfertilized (CONT), fertilized with N at 80 lb/ac (FERT), or nonfertilized and steers were supplemented with 0.6% of BW of DDGS daily for the entire grazing period (SUPP).

Figure 1. *In vitro* dry matter digestibility of smooth bromegrass over the grazing season.

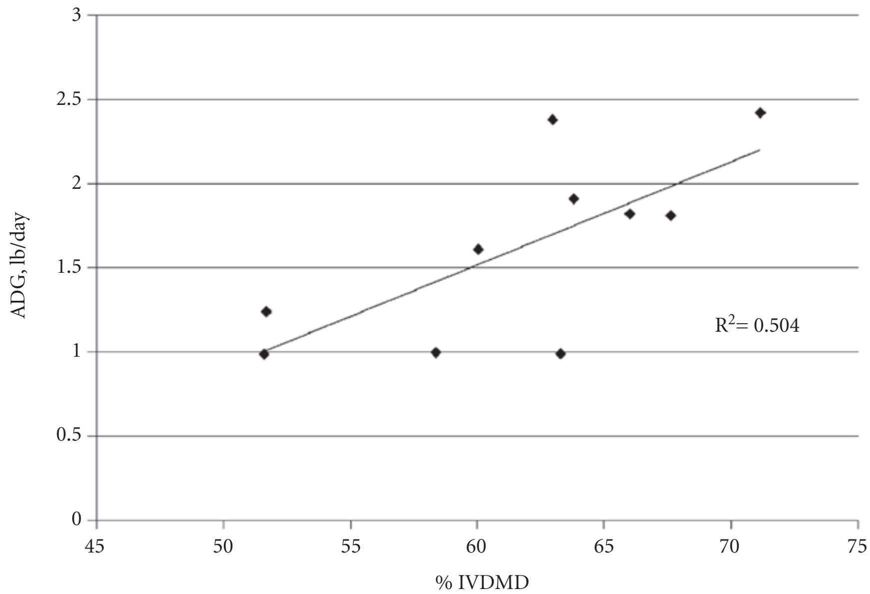


Figure 2. ADG of unsupplemented cattle in relation to IVDMD of smooth bromegrass over the grazing season.

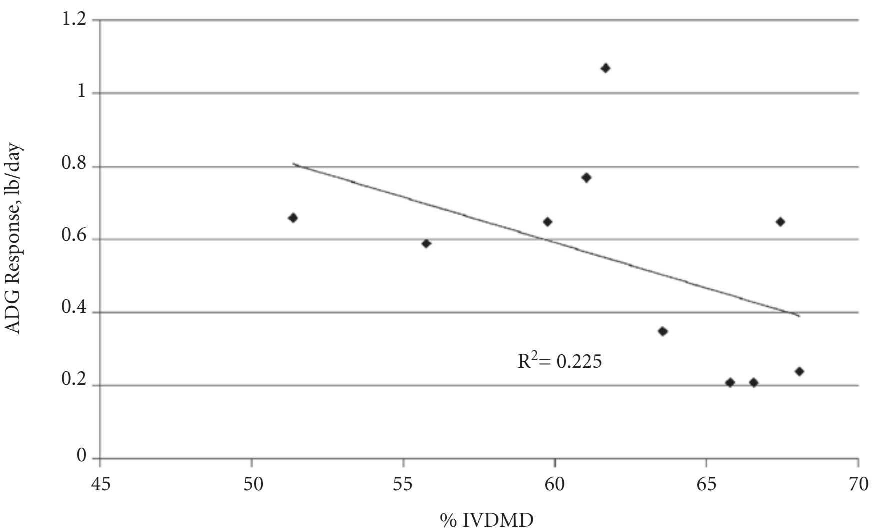


Figure 3. ADG response of supplemented cattle in relation to IVDMD of smooth bromegrass over the grazing season.

Results

Average daily gain was different between treatments ($P < 0.01$; Table 1), with supplemented steers gaining 0.59 lb/day more than steers on either of the unsupplemented treatments. This resulted in supplemented cattle weighing 90 lb more than unsupplmented cattle at the end of the grazing season. Pasture IVDMD did not differ between treatments ($P > 0.05$; Figure 1) so the increased gain of the SUPP steers can be attributed to the energy from fat and undegradable intake protein of the DDGS (*2006 Nebraska Beef Cattle Report*, pp. 27-29). Interim weights between cycles show increased response to the DDGS is not equal throughout the season. Pasture IVDMD also was not constant across the grazing season, with higher quality forage in cycles 1 and 2 and a decline in IVDMD through cycles 3, 4, and 5 (Figure 1). As IVDMD declined through the grazing season, ADG of the cattle also declined (Figure 2). The response of the SUPP cattle to the DDGS was defined as their increased gain over the gain of the unsupplemented cattle. As IVDMD and ADG of the cattle declined, the cattle's response to the DDGS actually increased (Figure 3). In cycles 1 and 2, the supplemented steers' ADG response was 0.33 lb/day. In cycles 3, 4, and 5, IVDMD of the smooth bromegrass declined and ADG response increased to 0.75 lb/day. This suggests that supplementing grazing cattle at key points in the grazing season may be beneficial. Forage production showed a quadratic response for all treatments, with peak production reached in cycle 2. The FERT pastures had the largest forage production per acre overall, while CON pastures had the least growth, and SUPP pastures were intermediate in forage production. Because the CON cattle had 45% more area than the other two treatments, forage availability per animal was similar among all treatments. The NRC model predicts that CON steers had an intake of 18.9 lb/day of bromegrass. Assuming DDGS has a TDN value of 108%, SUPP steers had an intake of 12.8 lb/day of bromegrass plus 5.1 lb/day of DDGS. The CON cattle were stocked at 69% of SUPP cattle, and SUPP steers had 68% of the forage intake of CON steers. Daily supplementation of DDGS to steers grazing smooth bromegrass pastures improved both cattle and pasture performance compared to the control.

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Economic Analysis of Supplementing DDGS to Grazing Steers

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Summary

A five-year study from 2005-2009 was conducted to evaluate differences in three grazing management strategies for backgrounding calves on smooth bromegrass pastures. Economic budgets were used to calculate profit differences. Steers supplemented an average of 5.3 lb/day of distillers grains were 90 lb heavier than either of the unsupplemented groups, which resulted in increased revenue of $49.38 for supplemented steers. Land costs were the same per AUM for all treatments but were decreased on a per head basis for pastures with supplemented cattle because cattle were stocked at higher rates than the control. Profit was greatest for the supplemented steers, although the relationship between prices for land, N fertilizer, and DDGS affects the relative profitability of the treatments.

Introduction

Supplementing cattle with dry distiller's grains with solubles (DDGS) supplies the cattle with excess N in their diet, which is excreted in the form of urea in the urine. Supplementing with DDGS also increases ADG of the cattle and allows pastures to be stocked at the same rate as pastures fertilized with 80 lb N/acre in the spring (*2009 Nebraska Beef Cattle Report*, pp. 22-24). The objective of this study was to examine the relationship between input costs and effects of different grazing management strategies utilizing DDGS on the profitability of backgrounding calves.

Procedure

Biological data were collected over a five-year period (*2011 Nebraska Beef Cattle Report*, pp. 24-25). Three grazing strategies were evaluated: 1) Pastures fertilized in the spring with 80 lb/N acre and stocked at 4 AUM/acre; 2) Nonfertilized pastures with calves supplemented daily with DDGS at 0.6% of their BW and stocked at 4 AUM/acre; and 3) Control pastures with no fertilizer applied or cattle supplementation and stocked at 2.8 AUM/acre.

Economics

All prices were based on averages from 2005-2009 (Table 1). Initial steer cost was based on average Nebraska sale barn prices in April for 700-750 lb steers. Yardage was included at $0.10 per steer daily to account for labor in building and maintaining fences as well as daily checking of animals and watering. An $8.33/steer health and processing fee was charged over the grazing period. Death loss of 0.5% was charged, based on initial steer cost. Cash rent for pastures was based on $23.86/AUM, the Nebraska average pasture rent. Fertilizer prices of $419.20/ton were based on urea prices in April compiled by the National Agricultural Statistics Service (USDA, 2010) plus a $4.00/ton application fee. Interest rates were obtained from the Federal Reserve Bank of Kansas City and averaged 7.6%. Simple interest was charged on initial steer cost and cash rent cost for one-half of the grazing period. DDGS prices in Nebraska from April through September were reported by USDA-AMS and averaged $116.80/ton on a 90% DM basis, plus a $24/ton delivery and handling fee. Prices for feeders in October at Nebraska sale barns were used to determine final live value on the steers. Because of the price slide associated with feeder cattle, different values were used for the unsupplemented steers compared to the supplemented steers because the supplemented steers gained more weight over the grazing season. Costs of gain (COG) over the grazing period were calculated by dividing total costs, minus initial steer cost and interest, by the total weight gained by the animal during the grazing season. Breakeven prices were calculated by dividing total costs by the final shrunk BW of the animal at the end of the grazing season. Profitability was calculated as total live value of the animal in October minus total costs during the grazing season.

Results

Initial cost of the steers was not different by treatment (P = 0.96) and averaged $794.69/head. Distillers grain costs for the supplemented cattle equaled $59.14/head based on steers

Table 1. Economic evaluation of grazing management and supplementation strategies for steers grazing smooth bromegrass.

	CON	FERT	SUPP[1]	SEM	P-value
Initial BW, lb	718	716	713	12.78	0.96
Ending BW, lb	959[a]	954[a]	1046[b]	15.4	<0.01
Head days	868	912	898	19.24	0.26
Initial Cost, $/head	796.95	795.63	791.50	14.20	0.96
DDGS, $/head			59.14		
Fertilizer, $/head		35.48			
Land Cash Rent, $/head	105.71	69.65	70.78		
Yardage, $/head	15.84	15.84	15.84		
Health and Processing, $/head	8.33	8.33	8.33		
Death Loss, $/head	3.98	3.98	3.96		
Interest, $/head	23.16	22.23	22.14		
Total Cost, $/head	953.97	951.14	971.69	14.63	0.56
Total Revenue, $/head	947.77[a]	942.43[a]	994.48[b]	14.97	0.03
Profit, $/head	-6.20[a]	-8.71[a]	22.79[b]	8.11	0.02
COG, $/cwt gained	56.48[a]	56.86[a]	47.93[b]	0.02	<0.01
Breakeven, $/cwt ending weight	99.46[a]	99.72[a]	92.89[b]	0.01	<0.01

[a,b]Means within a row with unlike superscripts differ (P < 0.05).
[1]Pastures were either nonfertilized (CON), fertilized with N at 80 lb/acre (FERT), or nonfertilized and steers were supplemented with 0.6% of BW of DDGS daily for the entire grazing period (SUPP).

Table 2. **Effects of varying N fertilizer and land prices on costs of gain for steers grazing fertilized smooth bromegrass in eastern Nebraska.**

Fertilizer prices, $/lb N	Land prices, $/AUM										
	20	21	22	23	24	25	26	27	28	29	30
0.30	0.45	0.46	0.47	0.49	0.50	0.51	0.52	0.54	0.55	0.56	0.57
0.35	0.46	0.48	0.49	0.50	0.51	0.53	0.54	0.55	0.56	0.58	0.59
0.40	0.48	0.49	0.50	0.52	0.53	0.54	0.55	0.57	0.58	0.59	0.60
0.45	0.49	0.51	0.52	0.53	0.54	0.56	0.57	0.58	0.59	0.60	0.62
0.50	0.51	0.52	0.53	0.55	0.56	0.57	0.58	0.59	0.61	0.62	0.63
0.55	0.52	0.54	0.55	0.56	0.57	0.58	0.60	0.61	0.62	0.63	0.65
0.60	0.54	0.55	0.56	0.57	0.59	0.60	0.61	0.62	0.64	0.65	0.66
0.65	0.55	0.56	0.58	0.59	0.60	0.61	0.63	0.64	0.65	0.66	0.67
0.70	0.57	0.58	0.59	0.60	0.62	0.63	0.64	0.65	0.66	0.68	0.69
0.75	0.58	0.59	0.61	0.62	0.63	0.64	0.65	0.67	0.68	0.69	0.70
0.80	0.60	0.61	0.62	0.63	0.64	0.66	0.67	0.68	0.69	0.71	0.72
0.85	0.61	0.62	0.63	0.65	0.66	0.67	0.68	0.70	0.71	0.72	0.73
0.90	0.62	0.64	0.65	0.66	0.67	0.69	0.70	0.71	0.72	0.73	0.75

Table 3. **Effects of varying DDGS and land prices on costs of gain for steers supplemented with DDGS while grazing smooth bromegrass in eastern Nebraska.**

DDGS prices, $/ton	Land prices, $/AUM										
	20	21	22	23	24	25	26	27	28	29	30
50	0.32	0.33	0.34	0.35	0.36	0.37	0.38	0.38	0.39	0.40	0.41
60	0.34	0.34	0.35	0.36	0.37	0.38	0.39	0.40	0.41	0.41	0.42
70	0.35	0.36	0.37	0.37	0.38	0.39	0.40	0.41	0.42	0.43	0.44
80	0.36	0.37	0.38	0.39	0.40	0.40	0.41	0.42	0.43	0.44	0.45
90	0.37	0.38	0.39	0.40	0.41	0.42	0.43	0.43	0.44	0.45	0.46
100	0.39	0.39	0.40	0.41	0.42	0.43	0.44	0.45	0.46	0.46	0.47
110	0.40	0.41	0.42	0.42	0.43	0.44	0.45	0.46	0.47	0.48	0.49
120	0.41	0.42	0.43	0.44	0.45	0.45	0.46	0.47	0.48	0.49	0.50
130	0.42	0.43	0.44	0.45	0.46	0.47	0.48	0.49	0.49	0.50	0.51
140	0.44	0.45	0.45	0.46	0.47	0.48	0.49	0.50	0.51	0.52	0.52
150	0.45	0.46	0.47	0.48	0.48	0.49	0.50	0.51	0.52	0.53	0.54
160	0.46	0.47	0.48	0.49	0.50	0.51	0.51	0.52	0.53	0.54	0.55
170	0.47	0.48	0.49	0.50	0.51	0.52	0.53	0.54	0.54	0.55	0.56
180	0.49	0.50	0.50	0.51	0.52	0.53	0.54	0.55	0.56	0.57	0.57
190	0.50	0.51	0.52	0.53	0.53	0.54	0.55	0.56	0.57	0.58	0.59
200	0.51	0.52	0.53	0.54	0.55	0.56	0.56	0.57	0.58	0.59	0.60

eating on average 5.3 lb/steer/day of DDGS. Fertilized pastures had an increased cost of $35.48/head for the application of 80 lb N/acre in the spring.

Cash rent values for land differed by treatment because of the different stocking rates used. The control pastures were stocked at 3.39 AUM/acre on average over the entire five years. Multiplying this by the average Nebraska cash rent price of $23.86/AUM results in a price of $80.89/acre for all treatments. Multiplying this by the number of acres, then dividing by the number of head days, and then multiplying by the average number of grazing days gives the cost of land per steer for each treatment. Cash rent was $105.71/head for the control, $69.65/head for the fertilized pastures, and $70.78/head for the supplemented steers.

Revenue was equal to final BW of the steers multiplied by $98.81/cwt for the unsupplemented cattle and multiplied by $95.01/cwt for the heavier, supplemented cattle. Total revenue was greatest for supplemented steers ($P < 0.05$). Profitability was greatest for supplemented steers at $22.79/head, while both of the unsupplemented treatments lost money at -$8.71/head and -$6.20/head for the fertilized and control treatments, respectively. Cost of gain and breakeven prices were lowest for the supplemented steers ($P < 0.01$).

As prices for land, N fertilizer, and DDGS fluctuate over time, profitability of these treatments will be impacted. In Tables 2 and 3, all input costs are held constant while land, N fertilizer, and DDGS prices vary, showing the resulting effect on COG. All prices above and to the left of the dividing line represent profitable COGs, assuming a constant cattle price. Prices below and to the right of the dividing line represent COGs where producers would lose money. For the fertilized treatment, in order to breakeven, producers need to keep COG at or below $0.53/lb (Table 2); for the supplemented treatment it is $0.54/lb (Table 3). As land prices increase, the incentive to use either N fertilizer or DDGS supplementation increases. The supplemented treatment is the most profitable, with current N fertilizer prices above $400/ton for urea and DDGS prices below $100/ton.

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Replacement of Grazed Forage with WDGS and Poor Quality Hay Mixtures

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Summary

A grazing study was conducted at the Gudmundsen Sandhills Laboratory, Whitman, Neb., to evaluate the effects of mixtures of wet distillers grains (WDGS) and straw or hay on grazed forage intake. There was no difference in ADG between the control and 70% hay/30% WDGS; however, steers supplemented with 60:40 blends of straw or hay with WDGS had higher ADG than the other two treatments. Range forage intake was decreased by 44% to 54% when steers were supplemented with the mixes. Feeding a mixture of WDGS and low-quality harvested-forage to cattle grazing rangeland may allow increasing stocking rate without decreasing animal performance.

Introduction

The increasing value of rangelands has led producers to look for alternatives that allow stocking rates to increase without needing additional land. With increased production of ethanol in Nebraska, the supply of wet distillers grains plus solubles (WDGS) is increasing, making the prices competitive relative to rangeland forage. Because intake in grazing situations is limited by fill, replacement of grazed forage using low-quality harvested forages mixed with WDGS to increase palatability seems to be a good way to increase carrying capacity or provide additional forage in years affected by drought. Previous research has shown mixing WDGS with wheat straw decreased grazed forage intake and improved animal performance (*2008 Nebraska Beef Cattle Report*, pp. 29-31; *2010 Nebraska Beef Cattle Report*, pp. 19-21). However, low-quality hay is more readily available than wheat straw in the Sandhills. The objective of our study was to determine the effect of supplementing WDGS mixed with low-quality hay compared to wheat straw on range forage replacement and animal performance.

Procedure

The experiment was conducted during the summer of 2009 at the University of Nebraska Gudmundsen Sandhills Laboratory located near Whitman, Neb. Treatments were assigned randomly to 20 paddocks and consisted of: 1) control (CON) at the recommended stocking rate (0.7 AUM/acre), 2) double stocked (1.32 AUM/acre) and supplemented with a mixture of 60% straw and 40% WDGS (STRAW), 3) double stocked (1.37 AUM/acre) and supplemented with 60% hay and 40% WDGS (LOHAY), and 4) double stocked (1.36 AUM/acre) and supplemented with 70% hay and 30% WDGS (HIHAY).

Forty summer-born yearling steers (712 ± 75 lb initial weight) were stratified by BW and assigned randomly to treatment, using five steers per replication (two blocks). Steers were limit fed a mixture of 60% hay and 40% WDGS at 2% of BW daily for five days to eliminate variation due to gut fill, and weighed for three consecutive days at the beginning and at the end of the trial. The averages of the three-day weights were used as the initial and ending body weights. Cattle in the control treatment received 0.8 lb/day of a protein supplement to meet their metabolizable protein requirements, composed of 50% soypass, 45% corn gluten meal, and 5% molasses. The WDGS and hay or straw were mixed in a vertical mixer and stored in silage bags for 30 days prior to the initiation of the trial. Cattle in the supplemented treatments were offered 8 lb/steer DM daily of the mixes in feed bunks located next to the paddocks to accurately measure any feed refusals.

The experiment was replicated over two blocks based on location (east and west) due to variations in species composition and topography. Within a block, each treatment was applied to five paddocks that were rotationally grazed, with a single occupation per paddock, during the experimental period of 68 days from June 18 to Aug. 26, with days of grazing per paddock adjusted to account for stage of plant growth. The control paddocks had 2.4 acres while the paddocks grazed at double stocking rates were divided in half on a diagonal with a temporary electric fence to decrease area of grazing, allowing the cattle to graze 1.2 acre per grazing period.

At the conclusion of grazing of each paddock, standing crop was determined by clipping all standing vegetation at ground level in 5 randomly placed quadrats (2.69 ft^2) in each paddock. Samples were sorted by live grass, standing dead grass, forbs, shrubs, and litter. Samples were dried in a forced air oven for 48 hours at 60°C. Forage quality IVOMD, CP, and NDF were analyzed from extrusa samples collected from each paddock at midpoint of grazing period using esophageally fistulated cows. *In vitro* organic matter digestibility was determined using the Tilley and Terry method (1963) modified by the addition of 1g/L of urea to the McDougall's buffer. Two separate *in vitro* runs were conducted and five forage standards of different qualities and known *in vivo* OM digestibilities were included in all of the IVOMD runs. To correct the IVOMD to *in vivo* values, regression equations were generated for each run, by regressing the IVOMD values of the standards

Table 1. Animal performance.

	Control	High	Low	Straw	SE	*P*-value
Initial BW (lb)	722	720	727	706	26.16	0.95
Ending BW (lb)	795	797	823	798	24	0.82
ADG (lb)	1.08[a]	1.13[a]	1.42[b]	1.40[b]	0.11	0.04

[a,b]Different letters represent differences between treatments ($P < 0.05$).

Table 2. Forage quality by paddock (time)[1]

Item	1	2	3	4	5	SE	*P*-value
IVOMD %	55[a]	54[ab]	53[ab]	52[b]	53[ab]	0.71	0.03
NDF %	73[ab]	73[ab]	68[a]	73[ab]	78[b]	2.97	0.04
CP %	8.8[a]	9.1[a]	7.7[b]	7.1[b]	6.8[b]	0.32	<0.001

[1]Sequence of grazing of paddocks, June 18 to Aug. 26.
[a,b]Different letters represent differences between treatments ($P < 0.05$).

on their known digestibilities.

Range forage intake was estimated using the 1996 beef NRC model. The model uses net energy content of the diet in conjunction with feed intake to predict animal performance. Therefore, if animal performance and energy values of the supplements and range forage consumed are known, range forage intake can be predicted. Data for animal ADG, supplement intake, and energy content of the supplements were obtained from the trial. Net energy for maintenance and gain were calculated from *in vitro* estimates of TDN using the NE equations in the Beef NRC. All data were analyzed using the MIXED procedure of SAS (SAS Inst. Inc., Cary, N.C.).

Results

Similar ADG was observed for the CON and HIHAY treatments ($P = 0.46$); however, steers in the LOHAY and STRAW treatments showed significantly higher ADG than the steers in the CON ($P < 0.05$). Steers in the LOHAY and STRAW treatments also outgained HIHAY treatment steers by 0.28 lb and 0.26 lb per day, respectively ($P < 0.05$; Table 1). These data show animal performance was either not affected or improved when supplementing with low-quality forage mixed with WDGS.

Range forage quality was not affected by supplementation treatment. During the grazing period, average values of 54%, 73%, and 7.9% were found for IVOMD, NDF, and CP, respectively. Table 2 shows the variation in range forage quality through the grazing season. IVOMD decreased during the grazing period, with highest value observed early in the season in the first paddock (55%) and the lowest towards the end of the season in the fourth paddock (52%). Variation in NDF did not show a consistent pattern, decreasing from 73% to 68% from paddock 1 to 3 and then increasing again to 78% from paddock 3 to 5 ($P < 0.05$). Average percentages of CP tended to decline during the grazing period, with 8.8% and 9.1% early and 7.7%, 7.1% and 6.8% late ($P < 0.05$). From these results it can be observed that forage quality decreased later in the growing season. This could be attributable to the fact that nutrient content decreases as the plant becomes more mature later in the growing season, and also to the large amount of rainfall that occurred during the experimental period, which caused the forage to grow and mature even more rapidly, increasing forage availability but decreasing forage quality.

Daily range forage and supplement intakes are presented in Table 3. Supplementation with a low-quality harvested forage and WDGS reduced intake of range forage by 54%, 48% and 44% for the HIHAY, STRAW, and LOHAY treatments, respectively, compared to the CON. A difference also was detected between the HIHAY and LOHAY treatments; steers offered the mix with higher proportion of hay consumed 26% less grazed forage than the animals in the LOHAY treatment. Grazed forage intake for steers in the STRAW treatment was intermediate between the LOHAY and HIHAY treatments. Consumption of the supplement was not different among treatments, with steers consuming 0.92% BW of the mixes. Total DMI was similar among treatments, varying between 17.8 lb and 15.8 lb — the highest value for the CON and the lowest for the HIGH treatment. Considering the amount of range forage replaced and the amount of supplement consumed by the supplemented treatments, we calculate that 1 lb of the HIHAY, LOHAY, and STRAW treatments replaced 1.28 lb, 1.11 lb, and 1.18 lb of range forage, respectively.

The amount of standing crop after the paddocks were grazed was significantly higher for the CON than for the other three treatments ($P < 0.05$); however, there was not a significant difference among the supplemented treatments (Table 3). Since the stocking rates were doubled in the supplemented groups, less standing crop might be expected for these groups. However, our objective was to replace range forage with the mixtures of hay (straw) and WDGS. The lower standing crop at conclusion of grazing indicates we were not completely successful. Perhaps more of the mixtures should have been fed. On average, the mixtures were 44% of total intake.

Total NDF consumed was examined to see if it had an effect on DMI (Table 3). Diets composed of forages are thought to be limited by physical distention in the gastrointestinal tract. When NDF from total DMI was considered, steers in the CON treatment showed higher NDF intake (12.9 lb) than the steers in the supplemented groups;

(Continued on next page)

however, NDF intake was similar among the HIHAY, LOHAY and STRAW treatments (10.7, 11.3, and 11 lb respectively). Even though NDF intakes between supplemented and control treatments were not the same, there could have been a similar filling effect, since a great percentage of the NDF in supplemented groups came from hay and wheat straw that are composed mainly of stems, which are more bulky than grazed forage.

The findings of this study show mixing WDGS with low-quality forage is an effective tool to increase stocking rates without hurting animal performance, and the reduction in intake increased with the level of fiber in the supplement. From these results the 70:30 blend seems to be the best combination to get the higher amount of grazed forage replacement.

Table 3. Range forage, mix, and NDF intake, and standing crop residue.

	Control	HIHAY	LOHAY	Straw	SE	*P*-value
Range forage intake (lb)	17.8	8.3	9.9	9.4		
Mix intake (lb)	0	7.5	7	7.2		
Total DM intake (lb)	17.8	15.8	16.9	16.6		
NDF intake (lb)	12.9	10.7	11.3	11		
Standing crop (lb/acre)	980[a]	707[b]	729[b]	707[b]	47	0.0013

[a,b]Different letters represent differences between treatments ($P < 0.05$).

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Supplementing Modified Wet Distillers Grains with Solubles to Long Yearling Steers Grazing Native Range

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Galen E. Erickson
Dennis E. Bauer[1]

Summary

Modified wet distillers grains with solubles (MDGS) were supplemented on the ground to yearling steers with access to native range during summer grazing. Supplemented steers had greater ADG than non-supplemented steers, and were heavier entering the feedlot. Supplemented steers also required 24 fewer days in the feedlot to reach a constant end point, compared to non-supplemented steers. Energy calculations suggest 1.0 lb of MDGS replaced 0.65 lb of summer range.

Introduction

Yearling production systems capitalize on the use of the animal to harvest forage, as opposed to more intensive systems that require harvested forages and longer grain feeding. Yearling production systems are further segregated into: short yearlings, which are received in the fall, backgrounded during the winter, then re-enter the feedlot in the spring; or long yearlings, which are received in the fall and backgrounded for approximately one year, at which time they re-enter the feedlot. Co-products of the corn dry milling industry fit well into forage production systems, because distillers grains provide a highly fermentable fiber source that does not negatively impact forage digestion (*2004 Nebraska Beef Cattle Report*, pp. 22-24), and also supply additional UIP to meet metabolizable protein deficiencies common to lighter weight cattle grazing forage.

The objective of the current research was to determine effects of supplementing modified wet distillers grains with solubles (MDGS) on the ground to long yearling steers while grazing native Sandhills range.

Procedure

Two hundred forty long yearling steers (BW = 505 ± 14 lb) were backgrounded on cornstalk residue from late fall to mid-spring (145 days) in 2007 and 2008. While grazing cornstalks, calves were supplemented 5.0 lb/steer daily of Sweet Bran® (Cargill, Blair, Neb.) each year. Following backgrounding, steers were allowed to graze smooth bromegrass pastures for approximately 21 days. Before grazing smooth bromegrass pastures, calves were weighed, stratified by BW, and assigned randomly to summer grazing treatments. After grazing brome, steers were relocated to graze Sandhills range at the University of Nebraska Barta Brothers Ranch near Rose, Neb. Summer grazing treatments included: grazing native range with no supplementation (CON), and grazing native range with MDGS supplementation at 0.6% BW (SUPP). Weights were projected using ADG for determination of summer grazing supplementation. Modified wet distillers grains with solubles were fed daily on the ground with a tractor and feed wagon, allowing steers to be distributed to different locations within each pasture at the time of feeding. Steers grazed Sandhills range for an average of 136 days before entering the feedlot in late September each year. Steers were limit fed at 1.8% BW (DM basis) for five days before smooth-bromegrass grazing and after summer grazing; initial and final BW for summer were the mean of weights taken on two consecutive days. Upon re-entry in the feedlot, steers were targeted to harvest at a constant backfat depth of 5 inches.

Data were analyzed using the Mixed Procedure of SAS (SAS Institute, Cary N.C.) as a completely randomized design; feedlot pen was the experimental unit. Summer grazing treatment was considered a fixed effect, with animal nested within summer grazing treatment and residual as random effects.

Results

At the time of summer treatment assignment, BW was not different between SUPP and CON steers ($P = 0.36$); however, SUPP steers had 0.68 lb greater ($P < 0.01$) ADG during summer grazing than CON steers (Table 1). Consequently, SUPP steers were 103 lb heavier ($P < 0.01$) than CON steers at feedlot entry. When taken to a constant end point, SUPP steers required 24 fewer ($P < 0.01$) days on feed during the finishing phase, compared to CON steers.

Using summer performance data, *in vitro* dry matter digestibility of the native Sandhills range from the two previous years, and NRC energy equations, it was determined that 0.65 lb grass was saved for every 1.0 lb MDGS fed (DM basis). Based on previous research (*2010 Nebraska Beef Cattle Report,* pp. 17-18), loss of MDGS fed on the ground was estimated at 15%, which was accounted for when estimating forage replacement. Also, based on visual appraisal, feeding MDGS on the ground did not have a negative impact on native range.

A meta-analysis of 12 pasture grazing experiments (*2009 Nebraska Beef Cattle Report*, pp. 37-39) where dried distillers grains with solubles (DDGS) was fed in a bunk, found a quadratic response to DDGS for ADG

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($y = -0.0124x^2 + 0.1866x + 1.507$; Linear < 0.01; Quadratic = 0.17). Figure 1 shows the meta-analysis quadratic response to ADG when supplementing DDGS, with the ADG for CON and SUPP steers from the current experiment included. These data suggest response to MDGS may exceed that of DDGS for ADG during grazing. Recall, these results were based on two years of data; however, the experiment will be replicated one more year to provide additional power. Supplementing MDGS on the ground at 0.6% BW (DM basis) to long yearling steers grazing native range increased ADG during summer grazing.

A simple economic analysis was conducted on data from cattle performance. The MDGS was priced at $0.06/lb DM and $0.10/animal was charged daily for feeding the MDGS (above routine animal care). The grass saved (0.65 lb/lb MDGS) was priced at $0.04/lb (equals $27/AUM). Based on these prices, the cost of gain for the additional 103 lb gained by supplementing MDGS was $0.36/lb.

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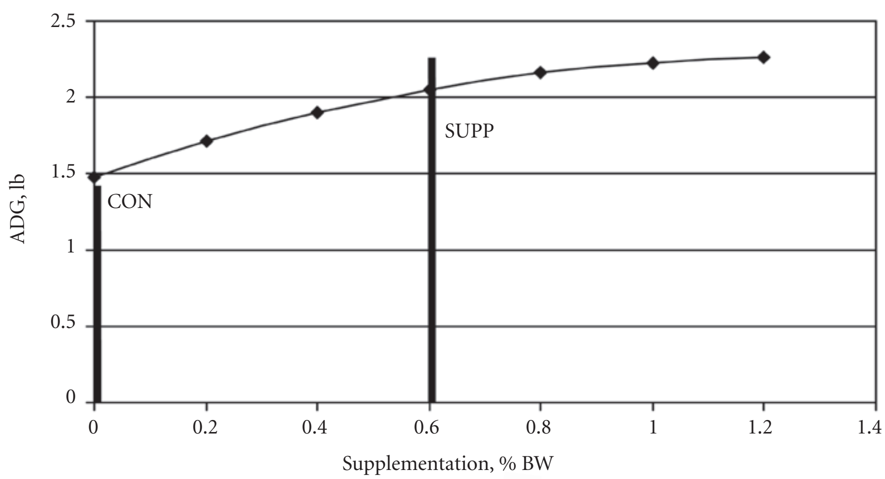
Table 1. Effects of supplementing modified wet distillers grains (MDGS) during summer grazing on performance of long yearling steers.

Item	CON[1]	SUPP[2]	*P*-value
Initial BW[3], lb	505	504	0.79
Spring BW[4], lb	747	750	0.36
Summer BW[5], lb	929	1032	<0.01
Summer ADG[6], lb	1.39	2.07	<0.01
Feedlot BW[7], lb	1409	1412	0.85
Feedlot DMI[8], lb	30.0	30.1	0.75
Feedlot ADG[9], lb	3.83	3.77	0.47
Feedlot GF[10]	0.128	0.125	0.21
Feedlot DOF[11], day	125	101	<0.01
HCW, lb	887	890	0.84
REA, sq. in	13.38	13.70	0.19
BF, in	0.50	0.52	0.49
MARB	590	546	0.01
CYG	3.33	2.97	0.06

[1]CON = cattle grazing native range with no supplementation.
[2]SUPP = cattle grazing native range with MDGS supplementation at 0.6% BW.
[3]Initial BW = weight taken during first fall.
[4]Spring BW = weight taken after grazing corn stalks.
[5]Summer BW = weight taken after grazing summer pastures.
[6]Summer ADG = gain attained when grazing summer pastures.
[7]Feedlot BW = carcass adjusted final body weight.
[8]Feedlot DMI = intake during feedlot finishing phase.
[9]ADG = gain during feedlot finishing phase.
[10]Feedlot GF = feed efficiency during feedlot finishing phase.
[11]Feedlot DOF = days required to finish CON and SUPP cattle to constant back fat depth during feedlot finishing phase.



[1] = response to gain from current trial with MDGS; [2] = quadratic response to gain from previous research with DDGS.

Figure 1. Effect of supplementing modified wet distillers grains during summer grazing[1] on ADG compared to meta-analysis[2].

Effect of Stocking Rate on Animal Performance and Diet Quality While Grazing Cornstalks

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Summary

Four treatments were used to evaluate levels of corn residue removal on nutrient quality and cattle performance over time. Treatments included no removal of residue, stocking rates of one or two animal unit months/acre (AUM/acre), or baling. Residue samples were taken before and after grazing from all treatment paddocks to determine residue amounts, and were analyzed for OM, CP, NDF, and in vitro *organic matter digestibility (IVOMD). Cattle weights and BCS scores were recorded prior to and at the conclusion of the trial. Cattle consumed husk and leaf material first, followed by cobs at a lesser rate. Husk and leaf material had greater digestibility and CP than stem or cob material. A decrease in cattle performance was observed in the 2 AUM/acre treatment group.*

Introduction

Grazing cornstalks offers producers an inexpensive feed source and helps minimize purchased feed costs during the winter. Cornstalk grazing is unique because all forage for consumption is available at the beginning of grazing. Cattle prefer to eat the corn grain first, followed by the highly digestible husk and leaf material (*2004 Nebraska Beef Cattle Report,* pp. 13-15). Stem and cob residues are consumed at a much lower rate.

Demand for corn grain increases supply of corn residue, but weather and demand by cattle producers for grazing may reduce availability; therefore, producers may increase stocking rates. Increasing the stocking rate limits the amount of highly digestible forage available to each animal; therefore, digestible residue decreases at an increasing rate. The decreasing quality of forage available for consumption also leads to decreased animal performance.

The objectives of this study were to 1) evaluate animal performance by measuring BW and body condition score (BCS) change, and 2) compare changes in nutrient quality of residue at two different levels of residue removal by increasing the stocking rate of cattle.

Procedure

Fifteen non-lactating, crossbred, beef cows (1,250 ± 199 lb) in the third trimester of pregnancy, and 63 first-calf, crossbred, beef heifers (879 ± 82 lb), also in the third trimester of pregnancy, were assigned randomly to treatment paddocks. Paddocks were assigned randomly to one of four treatments with 2 replications per treatment.

Treatments included no removal (CON), light grazing (LG), heavy grazing (HG), and baling (BALE). The grazing treatments were designed to provide stocking rates of 1.0 and 2.0 animal unit months per acre (AUM/ac) for the light and heavy grazing paddocks respectively. Treatments were applied to eight 16.25-acre paddocks, on a 130-acre center pivot irrigated field of corn residue for 55 days from December to February.

Residue samples were collected prior to grazing at 10 locations within each paddock using a 1/2 m^2 quadrat. Ten samples were collected after grazing from the LG and HG paddocks, as well as three samples from the CON and BALE paddocks. After collection, samples were sorted by plant part (leaf, stem, husk, cob, and grain) and composited into one sample of each part per paddock and per date. Leaf, stem, husk, and cob samples were analyzed for DM, OM, CP, and *in vitro* organic matter disappearance (IVOMD).

Animals were weighed and assessed for BCS prior to trial initiation and after grazing. Cattle were supplemented with a 28% CP distillers grain cube at a rate of 1 lb/cow daily. Supplement was formulated to provide 80 mg/lb of Rumensin.

Data were analyzed as a randomized complete block design, with treatment group as the experimental unit and paddock as random.

Results

Proportions and nutrient values of residues available before and after grazing are summarized in Table 1. Previous reports indicate cattle

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Table 1. Proportions and nutrient values of residue available and consumed.[1]

Item	Leaf	Husk	Stem	Cob	SEM	*P*-value
	Plant Parts					
Before grazing						
Percent of residue (OM basis)	34	10	42	14		
OM lb/ac	2144	620	2666	898	121	<0.001
CP, %	5.8	3.9	3.3	4.2	0.2	0.002
NDF, %	73.2	88.5	82.4	88.0	1.1	<0.001
IVOMD %	54.2	57.3	49.6	48.6	0.7	<0.001
After grazing						
Percent of residue OM	29	4	50	16		
OM lb/acre	1478	180	2595	567	135	<0.001
CP, %	5.4	5.0	3.0	3.4	0.2	0.002
NDF, %	79.5	85.9	84.8	89.0	1.1	<0.001
IVOMD %	51.7	58.1	47.2	46.9	0.7	<0.001

[1]All values are expressed on a % of OM basis.

remove less than 1/3 of the organic matter available from the field, and baling removes approximately 80%. In this trial, cattle removed 17-24% of the available organic matter, and baling removed 2.7 tons of OM/acre or 82%. Grazing removed between 1,065 and 1,480 lb OM/acre ($P < 0.01$). Of the residue removed by grazing, leaf and husk material were consumed in the greatest amount, approximately 1,100 lb OM/acre (71-88%), followed by cobs at approximately 330 lb OM/acre, or 23%. Proportions of residue removed by grazing in this trial are consistent with past research.

Crude protein content of the plant parts was also influenced by time ($P < 0.01$). Protein content of leaf, stem, and cob material was greater before grazing than after grazing. Husk material increased slightly in CP content from 3.9 to 5.0% on a DM basis. The increase could be attributed to insufficient sample collection or microbe activity during decomposition. Decomposition of plant material is characterized by a microbial breakdown of organic matter. Microbes consume the plant cell solubles first, decreasing the amount of organic matter. Crude protein is expressed as a percentage based on OM content, therefore with less OM, the CP percentage will increase.

No significant interactions were observed for NDF content of plant parts across treatments ($P > 0.05$). However, differences in NDF content between individual plant parts were observed ($P < 0.01$). Husk and cob material had a greater NDF content than leaf and stem material, both before and after grazing. Numerically, NDF content was greater at the end for leaf, stem, and cob material. Higher NDF content could be attributed to insufficient sample collection or microbe activity during decomposition. Neutral detergent fiber content is also expressed as a percentage of organic matter, so although the NDF content of the material may not change, the NDF percentage increases.

No significant interactions were observed for IVOMD ($P > 0.05$). Differences between individual plant parts and time points were observed ($P < 0.01$). Digestibility for husk and leaf (57% and 54% respectively) material was greater than stem and cob material (49% and 48%, respectively) at trial initiation. Digestibility values were slightly decreased at the conclusion of the trial. Digestibility of leaf and cob material in this trial was greater than values observed in previous research (*2004 Nebraska Beef Cattle Report,* pp. 13-15). Past research observed greater digestibility for husk and stem material.

In retrospect, treatment groups were stocked at 1.39 and 2.78 AUM's for the LG and HG treatments, respectively. Cattle performance was affected by treatment ($P < 0.01$; Table 2). Mature cows lost BW on both the LG and HG treatments. Heifers in the LG treatment groups gained 10 lb on average while heifers in the HG treatment group maintained their weight prior to trial initiation. The body condition score of the cows and heifers changed less than one-half of a body condition score across treatments.

This study indicates cattle will consume husk and leaf material before cobs and will rarely consume stems. Husk and leaf material have greater digestibility and CP content compared to stem and cob material. Grazing cornstalks removes less than one-third of the residue material available while baling removes approximately 80%. Cattle performance data indicate that beef cows can successfully be maintained on corn residue when leaf and husk digestibility is between 50% and 58%.

Table 2. Cow and heifer performance grazing cornstalks at two stocking rates.

	Treatment		*P*-value	Cattle Type		*P*-value
	LG[1]	HG[2]		Cows	Heifers	
BW change, lb	-11	-68	0.05	-68	-12	0.05
BCS change	0.10	-0.20	0.01	-0.21	-0.04	0.71

[1]Light grazing, 1.39 AUM/acre.
[2]Heavy grazing, 2.78 AUM/acre.

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Digestibility of Crop Residues After Chemical Treatment and Anaerobic Storage

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Summary

Two experiments were conducted to evaluate factors affecting crop residue digestibility. Corn stover, corn cobs, and wheat straw were alkaline treated at low (35%) or high (50%) moisture and then anaerobically stored at 30ºC or 40ºC. Chemical treatment increased in vitro *DM digestibility of all residues by 14 to 21 percentage units (35% to 62% improvement). Samples stored at 50% DM and 40ºC were most digestible. Cobs were inherently more digestible than straw or corn stalks. Percentage of total improvement in DM digestibility by optimizing DM, ambient temperature, and chemical treatment was: stalks, 43%; wheat straw, 38%;, and cobs, 34%. Digestibility of low quality crop residues can be improved markedly by chemical treatment.*

Introduction

Agricultural crop residues typically are used as roughage or bedding for cattle because of their inherent poor digestibility. Many studies have shown that digestibility of forages and crop residues can be improved by treatment with sodium hydroxide, calcium oxide, or a blend of the two. Historically, the improvements in digestibility from calcium oxide have been moderate. Calcium oxide compared to sodium hydroxide, however, is easier to handle and presents lesser human health risks. Therefore, the objective of this study was to determine the optimum treatment combinations for improving DM and fiber digestibility of different crop residues for eventual on-farm treatment options.

Procedure

Experiment 1

The first experiment was designed as a 3x4x2 factorial with 4 replications. Treatments included: three crop residues (ground stalks, corn cobs, and wheat straw), four chemical treatments (5% CaO, 4% CaO +1% NaOH, and 3% CaO +2% NaOH plus a control stored anaerobicaly), and moisture content (35% and 50% DM). The CaO was standard quicklime (Mississippi Lime Company, Kansas City, Mo.). The CaO and NaOH (pellets) were solubilized in water to form concentrated caustic solutions, which then were applied to residues. Chemical treatments were applied to forage on a DM basis, along with water, to the targeted DM level. Samples were mixed in a batch mixer and sealed using a food grade vacuum bagger. Bags were stored anaerobically at room temperature and allowed to react for 30 days. Bags were then opened and sampled. Samples were freeze dried and ground to pass through a 1-mm screen. Samples were assayed for *in vitro* DM digestibility (IVDMD). Inoculum for IVDMD was obtained by collecting a mixture of rumen fluid (strained through four layers of cheesecloth) from two steers consuming a 30% concentrate–70% roughage diet. Inoculum was mixed with McDougall's buffer at a 1:1 ratio along with 1 gram of urea/L of rumen fluid. A 0.5 gram sample was added to a 200 mL test tube, and 50 mL of inoculum was added. Test tubes were placed in a water bath at 39ºC and allowed to ferment for 48 hours. Fermentation was ended by adding 6 mL of 20% HCl per test tube, along with 2 ml of 5% pepsin solution. Tubes were placed back in the water bath for an additional 24 hours. Residue was filtered, dried at 100ºC, and weighed to determine IVDMD.

Experiment 2

A second experiment was conducted to evaluate the effects of temperature and storage time on digestibility. The experiment was designed as a 2x3x2x3 factorial with 3 replications. Treatments included two chemical treatments (5% CaO, and 3% CaO +2% NaOH), three crop residues (ground stalks, corn cobs, and wheat straw), two temperatures (40ºC or ambient temperature), and three storage times (7, 14, and 28 days). Water was added during treatment to adjust all samples to 60% DM. Effects of temperature were applied using an incubator set at 40ºC. All other procedures (application of chemical treatment and analysis) were the same as Experiment 1.

Statistical Analysis

Data were analyzed using the MIXED procedure of SAS (SAS Institute, Cary, N.C.). The effects of treatment and all interactions were analyzed and separated using the pDiff option.

Results

Experiment 1

Data are summarized in Table 1. The three-way interaction between crop residue type, treatment, and DM was significant. All main effects were significant. Dry matter digestibility was greatest for cobs, intermediate with straw, and least with stalks. Chemical treatment was effective in improving IVDMD ($P < 0.001$). Dry matter digestibility was greater for treatments containing NaOH, compared with CaO alone. Dry matter digestibility was improved for 50% compared to 35% DM. The reason this occurred is unclear. At 50% DM, 3% CaO + 2% NaOH relative to CaO improved IVDMD 14.5% and 10% for

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corn cobs and wheat straw, respectively; however, this increase was not observed for stalks.

Experiment 2

We hypothesized that temperature may increase the rate and extent of the chemical reaction. Generally, the rate of most chemical reactions doubles with every 10°C increase in temperature. A higher temperature may also better reflect the environment inside a bunker or ag-bag, as the heat resulting from the exothermic reaction of chemical treatment is retained. Length of anaerobic storage did not affect digestibility, suggesting that extent of digestibility was not improved by anaerobically storing treated residues for more than seven days (Table 2). Temperature was effective in increasing digestibility by approximately 1 percentage unit. Similar to Experiment 1, the difference between 5% CaO and 3% CaO + 2% NaOH was significant ($P < 0.001$) and revealed an approximate 5 percentage unit improvement for digestibility when NaOH was used. The relative ranking in crop residue digestibility was similar to that observed in Experiment 1. The conclusion from this experiment is that on-farm chemical treatment of crop residues could be completed fairly quickly. Regression analysis showed increases in IVDMD for all chemical treatments relative to control. Bagging at 50% DM appears to be an optimum for extent of IVDMD. Using 5% CaO increased overall IVDMD by 11 percentage units compared to control. The difference in IVDMD between 4% CaO + 1% NaOH and 3% CaO + 2% NaOH was less than 1 percentage unit. The use of 3% CaO +2% NaOH significantly increased digestibility almost 15 percentage units, relative to control. Addition of 3% CaO + 2% NaOH, compared to 5% CaO, increased digestibility an additional 4 percentage units. Whether this difference between NaOH and CaO would impact performance has yet to be determined.

Table 1. Simple effects of chemical treatment, crop residue, and DM on IVDMD[1] in Experiment 1.

Item	Control	5% CaO	4% CaO 1% NaOH	3% CaO 2% NaOH
35% DM				
Cobs	40.37[a]	50.01[c]	54.67[b]	48.70[c]
Straw	36.52[a]	50.14[b]	50.94[b]	52.01[b]
Stalks	31.06[a]	41.99[b]	42.94[b]	41.09[b]
50% DM				
Cobs	42.46[a]	54.77[b]	55.36[b]	62.79[c]
Straw	33.38[a]	50.18[b]	51.59[b]	54.61[c]
Stalks	27.17[a]	39.99[b]	41.53[b]	40.31[b]

[abc]Within a row, values lacking common superscripts differ ($P < 0.05$).
[1]*In vitro* DM digestibility.

Table 2. Simple effects of chemical treatment, crop residue, and DM on IVDMD in Experiment 2.

Item	5% CaO	3% CaO 2% NaOH
30°C		
Cobs	44.3[e]	50.0[b]
Straw	43.2[e]	46.1[d]
Stalks	40.7[f]	43.3[e]
40°C		
Cobs	48.5[c]	51.7[a]
Straw	43.9[e]	48.5[c]
Stalks	37.8[g]	43.3[e]

[abcdefg]Values lacking common superscripts differ ($P < 0.05$).

[1]Adam L. Shreck, graduate student; Crystal D. Buckner, research technician; Galen E. Erickson, associate professor; Terry J. Klopfenstein, professor, University of Nebraska–Lincoln Department of Animal Science; Michael J. Cecava, Archer Daniels Midland Company Research Division, Decatur, Ill.

Economics for Feeding Distillers Grains to Finishing Cattle

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Summary

Cattle CODE, an economic budget model for predicting feeding returns for distillers grains, was updated and four new economic scenarios were evaluated. Feeding WDGS resulted in larger economic returns compared to MDGS and DDGS when the hauling distance from the ethanol plant to the feedlot was less than 60 miles and the dietary inclusion was up to 40% DM. However, these economic returns were dependent on the price paid for the products. If MDGS and DDGS were priced based on their drying costs, then economic returns decreased compared to WDGS.

Introduction

Cattle performance is different for each of these DGS when fed in finishing diets (up to 40% of diet DM). Equations from meta-analysis summaries (*2011 Nebraska Beef Cattle Report*, pp 40-41) were used in an updated version of Cattle CODE (*www.beef.unl.edu*) to predict cattle performance when feeding distillers grains plus solubles (DGS) as wet (WDGS), modified (MDGS), and dry (DDGS). This model evaluates marginal feeding returns for feeding DGS compared to a traditional corn diet (*2008 Nebraska Beef Cattle Report*, pp. 42-44).

Economic returns can vary depending on the price paid for the DGS, dietary inclusion level of DGS, days on feed (DOF) to reach the same final BW, location of the feedlot relative to an ethanol plant, and additional feeding costs associated with feeding wetter diets at the feedlot. New scenarios were conducted to evaluate some of these relative differences.

Procedure

Cattle CODE uses the individual's actual DMI and F:G for a conventional corn-only diet to predict DMI and F:G for diets containing DGS using the meta-analysis equations. The model then calculates ADG and DOF based on the user's feeder and finished cattle weights. The individual also enters their feed costs and DM content, trucking cost and miles of hauling DGS to the feedlot, daily yardage costs, processing and health costs per head, cattle death loss, and interest rate. Feeding costs at the feedlot are calculated assuming that these costs are one-third of the yardage costs.

The following general inputs were used for the corn-based diet and remained the same for feeding any inclusion of DGS: 740 lb feeder steer valued at $117.70/cwt, 1,300 lb finished cattle valued at $96.00/cwt, $20.00 per head for processing and health costs, $0.35 per head daily for yardage costs, 1.5% cattle death loss, and 8.1% cattle loan interest rate. Corn was priced at $3.30/ bushel for DRC (88% DM) and $2.95/bushel for HMC (78% DM), and brome grass hay (88% DM) was priced at $88.00/ton and used at 7% of diet DM. Dry supplement (95% DM, 4% of the diet DM) and urea (100% DM) were priced at $190 and $320/ton (as-is basis), respectively. These inputs generate $0 profit for the corn-only diet.

Byproduct feeding scenarios were predicted by using 24 lb DMI and 6.5 F:G for cattle fed the 89% corn-only diet, which results in 3.69 lb/day (ADG). This calculates to 152 DOF, which is about the industry average for cattle on feed.

Results

Using the meta-analysis equations in this model, cattle performance (particularly ADG and F:G) improved when feeding WDGS, MDGS, or DDGS up to 40% of diet DM. Compared to a corn-only diet, these improvements were greater for WDGS, intermediate for MDGS, and lower for DDGS. Therefore, fewer DOF were needed, making WDGS the most advantageous product to use from a cattle performance standpoint. However, WDGS contains more moisture and would require more hauling costs. Therefore, the following four economic scenarios were conducted to evaluate additional DGS economic feeding differences.

The first scenario evaluated (spring 2010) DGS prices and corn price ($3.30/bu for DRC). These DGS prices were $34/ton for WDGS, $46/ton for MDGS, and $100/ton for DDGS. On an equal 100% DM basis, these costs were $106.25, $95.83, and $111.11/ ton for WDGS, MDGS, and DDGS, respectively. Surprisingly, MDGS was priced cheaper than WDGS on an equal DM basis, while MDGS requires more costs for production due to some partial drying costs. All byproducts were assumed to be shipped 50 miles from the ethanol plant to the feedlot. This scenario is presented in Figure 1. Economic returns from feeding DGS increased with increasing DGS inclusion in the diet, regardless of drying type. However, the returns were greater for WDGS and MDGS ($30/head or more for inclusions of 20% to 40% of diet DM) compared to that of DDGS, largely due to the cattle performance advantages of feeding the wet products. We would have expected the economic returns for WDGS to be greater than that of MDGS; however, these were quite similar. The MDGS was, at the time, priced cheaper than WDGS on the same DM basis, resulting in a positive economic return for MDGS. This may reflect greater demand for WDGS because of higher feeding value or because of lack of appropriate accounting for DM in pricing. On a wet basis, WDGS was $10/ton less expensive but on a dry basis was $5/ ton more expensive.

In a second scenario, the same prices for DGS and corn were used, but these prices were quoted as pur-

(Continued on next page)

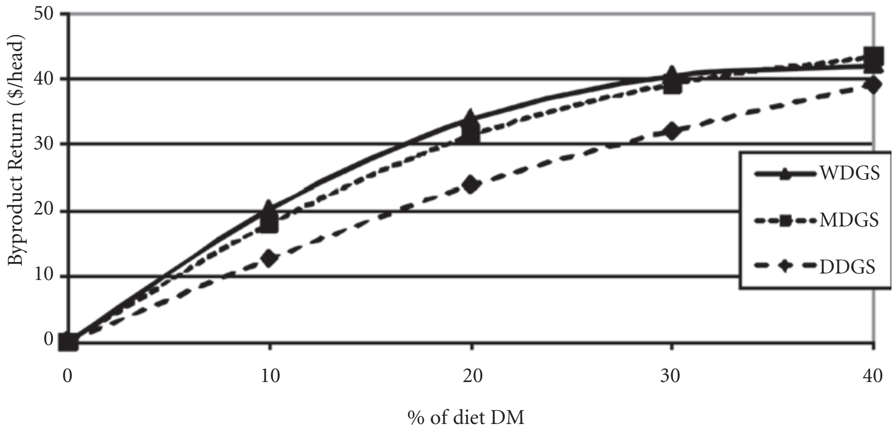

Figure 1. Economic returns for feeding WDGS, MDGS, and DDGS using current prices and hauling these products 50 miles to the feedlot.

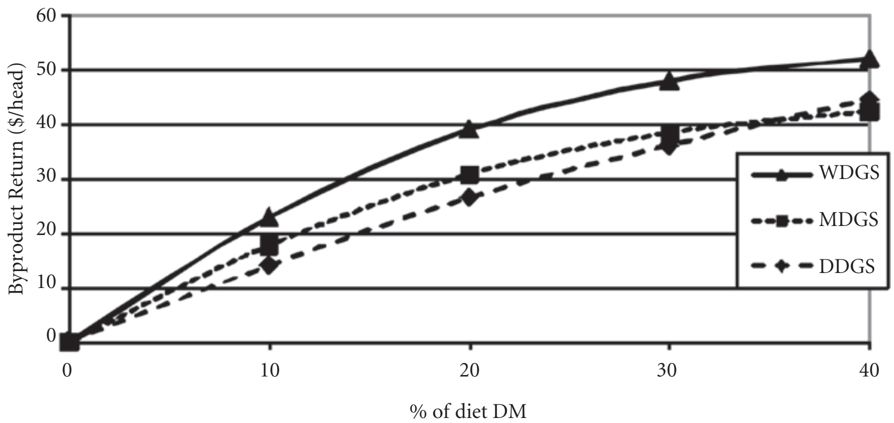

Figure 2. Economic returns for feeding WDGS, MDGS, and DDGS using current prices delivered to the feedlot (0 miles hauling).

chased and delivered prices at the feedlot (hence, no trucking costs to the yard). This prediction is illustrated in Figure 2. The economic advantage to feeding any type of DGS improved compared to the first scenario due to no trucking costs for delivering to the feedlot. Although MDGS was still priced cheaper on a DM basis than WDGS, there was a greater advantage to feeding WDGS due to no costs of hauling a very wet product to the feedlot. The economic returns for MDGS and DDGS were similar to each other and were more profitable than a corn-only diet, but they remained less than the returns for WDGS. These results closely resemble the cattle performance response due to feeding these products.

To evaluate hauling differences to the feedlot between WDGS and MDGS, a third scenario was conducted. Hauling distances of 10 or 60 miles from an ethanol plant to a feedlot were used along with DGS and corn prices (as previously stated). This economic scenario is presented in Figure 3. As expected, hauling either product for 10 miles to the feedlot resulted in greater economic returns compared to hauling for 60 miles. The profitability for these products at 10 miles for hauling continued to increase as inclusion of WDGS or MDGS increased in the diet. Hauling these products 60 miles to the feedlot remained profitable (up to $40/head) compared to a corn-only diet. Generally, more economic returns are possible when feeding WDGS up to 40% of diet DM and up to 60 miles from the ethanol plant, even when MDGS is priced cheaper than WDGS. However, these returns for WDGS were similar to MDGS at 30% to 40% of diet DM when DGS was hauled 60 miles. The improved cattle performance for feeding WDGS and MDGS often offsets costs associated with hauling the wet feeds. For instance, WDGS and MDGS can be hauled 265 and 350 miles to the feedlot, respectively, when including these DGS at 30% of diet DM before the scenario becomes a break-even compared to feeding a corn-only diet.

The previous three scenarios were conducted using current DGS prices, which resulted in a lower price for

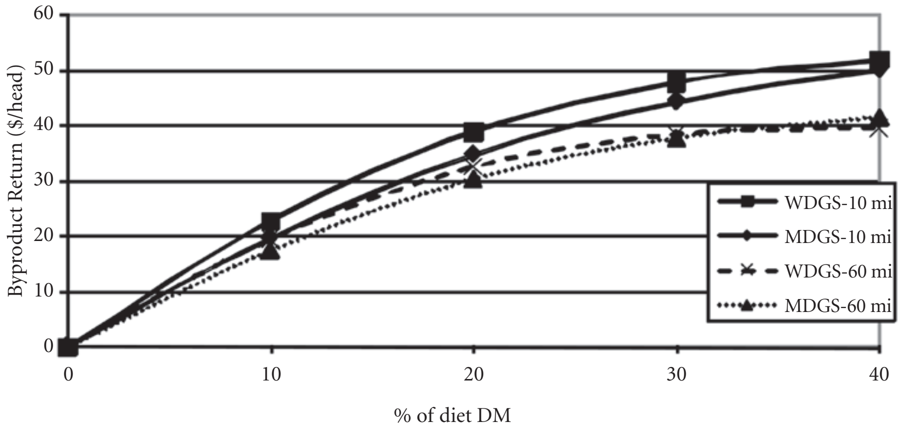

Figure 3. Economic returns for feeding WDGS and MDGS using current prices and 10 or 60 miles hauling distance from an ethanol plant to a feedlot.

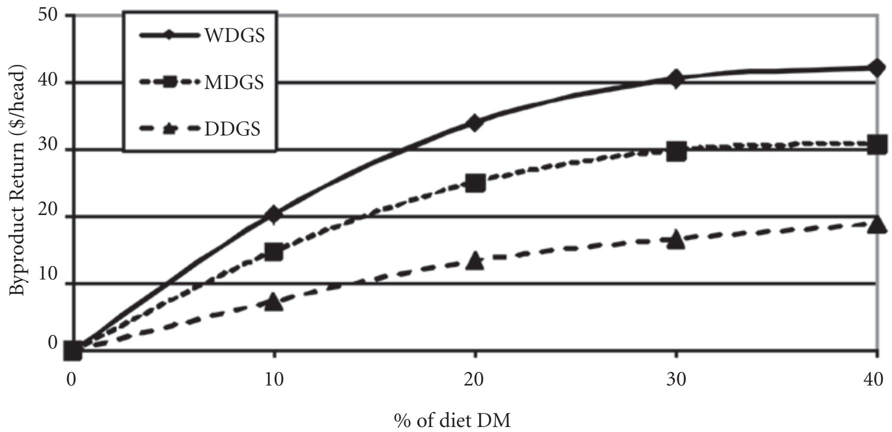

Figure 4. Economic returns when MDGS and DDGS are priced based on current WDGS price plus additional costs of drying the products.

MDGS than WDGS. Ethanol plants must incur more costs to dry WDGS to any higher DM content than 35%, so DGS would logically be priced based on the costs ethanol plants must incur to dry the products. Therefore, MDGS and DDGS should be priced higher than WDGS on an equal moisture basis. The additional costs to dry products include the capital costs of dryers and natural gas. An estimated $30/ton is the cost ethanol plants have in drying a ton of a 90% dry product. A fourth scenario (Figure 4) was conducted using the current price of WDGS at $34/ton (as-is, ~32% DM) and $55 and $126/ton for MDGS and DDGS, respectively, accounting for drying costs, both of which were greater than in previous scenarios. Each of the DGS was hauled 50 miles to a feedlot. The economic returns for WDGS were exactly the same as in the first scenario, resulting in profit potential of up to $40/head. However, the economic returns for MDGS and DDGS were less. These economic returns remained below $20 and $30/head at any dietary inclusion level up to 40% DM for DDGS and MDGS, respectively. Therefore, if DGS were actually priced based on the additional drying costs that ethanol plants must pay to dry MDGS or DDGS, there would be a greater advantage to feeding WDGS.

In conclusion, our scenarios provide some guidance for making economic decisions regarding feeding different types of DGS. Cattle CODE is available and the relationships in our study should be compared to evaluations conducted by feeders using their current prices and conditions.

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Meta-Analysis of Feeding Calf-Feds or Yearlings Wet Distillers Grains with Different Corn Processing Types

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Galen E. Erickson
Terry J. Klopfenstein[1]

Summary

Meta-analyses of University of Nebraska–Lincoln feedlot research feeding wet corn distillers grains plus solubles (WDGS) with dry-rolled corn (DRC) and high moisture corn (HMC) to either calf-feds or yearlings was conducted to calculate the feeding values of WDGS relative to corn. The feeding value of wet distillers grains plus solubles (WDGS) was superior to dry-rolled corn (DRC) and high moisture corn (HMC). The feeding value of WDGS was greater for yearlings than for calf-feds. The combination of WDGS and HMC provided cattle performance superior to DRC with or without WDGS.

Introduction

Previous research evaluated feeding corn wet distillers grains with solubles (WDGS; 32% DM) to winter calf-feds and summer yearlings in a confinement barn (*1993 Nebraska Beef Cattle Report*, pp. 43-46). The researchers reported a greater feeding value of WDGS replacing 40% of diet DM as dry-rolled corn (DRC) for yearlings than calf-feds, 151% and 134% of the feeding value of DRC, respectively.Previous research also evaluated feeding WDGS with DRC, high moisture corn (HMC), or a blend of both corn types (*2006 Nebraska Beef Cattle Report*, pp. 48-50; *2007 Nebraska Beef Cattle Report*, pp. 33-35). In the 2006 feeding trial, 30% WDGS (DM basis) was fed and F:G was numerically superior for steers fed HMC compared to DRC or a DRC and HMC blend. However, in this trial 0% WDGS diets were not fed to evaluate the response to WDGS from different corn processing types. The 2007 trial evaluated the response to feeding 0%, 15%, 27.5%, and 40% WDGS (DM basis) with either DRC or HMC. A greater response to WDGS was observed with less intensely processed DRC compared to HMC. However, F:G for HMC fed steers was superior to F:G of DRC fed steers with up to 40% WDGS.

The corn processing and cattle type interactions with WDGS were initially evaluated with treatment means from 16 finishing trials (*2010 Nebraska Beef Cattle Report*, pp. 61-62). Since the 2010 report, additional UNL WDGS finishing trials have been identified for inclusion in the meta-analysis. In addition, pen mean observations were compiled for the studies to better account for variation between trials as compared to treatment means previously utilized.

Therefore, a pen level meta-analysis of University of Nebraska feedlot research was conducted to evaluate the interactions of cattle type and corn processing method on cattle performance with WDGS inclusion level.

Procedure

Pen mean cattle performance data from 20 UNL feedlot trials where WDGS replaced DRC or a DRC and HMC blend were compiled for statistical analysis. The criteria for trial inclusion in the dataset were the same as for the 2010 meta-analysis. In all trials, WDGS replaced DRC, HMC, or a blend of the two corn types in diets (0% to 50% of diet DM). Four additional UNL feedlot trials have been completed since the 2010 analysis (*2011 Nebraska Beef Cattle Report*, pp. 90-91; *2011 Nebraska Beef Cattle Report*, pp. 50-52; *2011 Nebraska Beef Cattle Report*, pp. 68-69; *2011 Nebraska Beef Cattle Report,* pp. 55-56). The data are for 350 pen observations representing 3,365 steers. Winter calf-feds were fed in seven trials, summer yearlings were fed in 10 trials, and fall long yearlings were fed in three trials. Steers were fed DRC in 11 trials and a blend of DRC and HMC in nine trials (1:1 ratio of DRC:HMC for six trials and 2:3 ratio of DRC:HMC for three trials), and HMC as the only corn source in one trial. The meta-analysis methodology to analyze the data has been previously reported (*2010 Nebraska Beef Cattle Report*, pp. 61-62). In short, an iterative PROC MIXED procedure of SAS was used to summarize quantitative findings from multiple studies.

Two analyses of the data were conducted. The initial analysis was for the overall effect of WDGS inclusion, regardless of cattle type and corn processing method, to update previously reported WDGS feeding values. The calf-fed trials and yearling trials were then separated, and the effect of corn processing method on F:G was analyzed within cattle type.

Results

Replacement of corn up to 40% of diet DM as WDGS resulted in superior performance compared to cattle fed no WDGS (Table 1). These data agree with the previous meta-analyses. Dry matter intake, ADG, F:G, 12th rib fat, and marbling score improved quadratically as WDGS inclusion level increased. The feeding value of WDGS was consistently greater than corn when WDGS was included up to 40% of diet DM. The feeding value was greater at lower WDGS inclusion levels and decreased as inclusion level increased. All steers fed in the data sets were part of the following system. The UNL research feedlot utilizes spring born, predominately black, crossbred steers weaned

Table 1. Finishing steer performance when fed different dietary inclusions of wet distillers grains plus solubles (WDGS).

WDGS Inclusion[1]:	0WDGS	10WDGS	20WDGS	30WDGS	40WDGS	Lin[2]	Quad[2]
DMI, lb/day	23.0	23.3	23.3	23.0	22.4	0.01	< 0.01
ADG, lb	3.53	3.77	3.90	3.93	3.87	< 0.01	< 0.01
F:G	6.47	6.16	5.96	5.83	5.78	< 0.01	< 0.01
12th rib fat, in	0.48	0.52	0.54	0.55	0.55	< 0.01	0.01
Marbling score[3]	528	535	537	534	525	0.19	< 0.01
Feeding value, %[4]		150	143	136	130		

[1]Dietary treatment levels (DM basis) of wet distillers grains plus solubles (WDGS), 0WDGS = 0% WDGS, 10WDGS = 10% WDGS, 20WDGS = 20% WDGS, 30WDGS = 30% WDGS, 40WDGS = 40% WDGS.
[2]Estimation equation linear and quadratic term t-statistic for variable of interest response to WDGS level.
[3]500 = Small^{0}.
[4]Percentage of corn feeding value, calculated from predicted F:G relative to 0WDGS F:G, divided by WDGS inclusion.

Table 2. Finishing steer performance when calf-feds or yearlings were fed different dietary inclusions of wet distillers grains plus solubles (WDGS) replacing dry-rolled corn (DRC) or a blend of DRC and high-moisture corn (HMC).

WDGS Inclusion[1]:	0WDGS	10WDGS	20WDGS	30WDGS	40WDGS
Winter Calf-feds					
DRC diet, F:G	6.17	5.95	5.75	5.56	5.38
Feeding Value,% of DRC[2]		136	136	136	136
DRC and HMC Blend, F:G	6.17	6.02	5.89	5.76	5.63
Feeding Value,% of Corn Blend[2]		124	124	124	124
Summer Yearlings					
DRC diet, F:G	6.76	6.34	6.05	5.86	5.76
Feeding Value, % of DRC[2]		167	159	151	143
DRC and HMC Blend, F:G	6.76	6.41	6.19	6.06	6.02
Feeding Value,% of Corn Blend[2]		154	146	138	131

[1]Dietary treatment levels (DM basis) of wet distillers grains plus solubles (WDGS), 0WDGS = 0% WDGS, 10WDGS = 10% WDGS, 20WDGS = 20% WDGS, 30WDGS = 30% WDGS, 40WDGS = 40% WDGS.
[2]Percentage of respective corn processing type feeding value, calculated from predicted F:G relative to 0WDGS F:G, divided by WDGS inclusion.

in the fall for most research trials. After an initial receiving period, the largest steers are fed as calf-feds in the winter; the medium steers are fed as short yearlings in the summer after wintering on cornstalks; and the small steers are wintered on cornstalks, grazed on grass the following summer, and finished in the fall to market by 24 months of age. We realize that season of feeding and steer age are confounded in this system. However, the confinement barn study mentioned in the introduction provided a moderate environment for both winter and summer steer feeding and fed cattle as either calf-feds or yearlings in two consecutive years. The study indicated greater feeding value of WDGS for yearlings than calf-feds.As expected, calf-feds were more efficient than yearlings (Table 2). The feeding value of WDGS, regardless of corn processing type, was greater for yearlings than for calf-feds. The feeding value of WDGS was a constant 136% of DRC and a constant 124% of a DRC and HMC blend for calf-feds due to linear improvement in F:G as WDGS replaced corn. Yearling performance improved quadratically as WDGS level increased, regardless of corn processing type. The feeding value of WDGS for yearlings decreased linearly in both DRC and blended corn diets. Feeding value of WDGS replacing 20-40% of diet DM for yearlings decreased from 159 to 143% of DRC, and from 146 to 131% for a blend of DRC and HMC.

The feeding values of DRC and a blend of DRC and HMC were similar for 0% WDGS fed steers within cattle type. The feeding value of WDGS was greater when WDGS replaced DRC as compared to a corn blend at any inclusion level of WDGS.

Only one trial has evaluated feeding WDGS, replacing HMC with WDGS in diets and feeding WDGS replacing DRC (*2007 Nebraska Beef Cattle Report*, pp. 33-35). The trial evaluated replacing each corn type with up to 40% of diet DM as WDGS. The DRC 0% WDGS cattle performed similarly to the winter DRC-only fed cattle of the meta-analysis. The HMC had 115% of the feeding value of DRC in the trial. The data for the HMC fed cattle have been plotted on the graph with the meta-analysis equations. The improvement in F:G of increasing WDGS from 0% to 40% WDGS in HMC diets is less than the improvement in F:G of DRC and corn blend due to HMC having a greater feeding value than DRC. As HMC is replaced by WDGS, the feeding value replacement is less than the feeding value differential of WDGS and DRC, because HMC is greater than DRC. These data suggest the combination of 47.5% of diet DM as HMC and 40% of diet DM as WDGS has a feeding value equal to 122% of DRC. The results of this trial reiterate the conclusion that the feeding value of WDGS was superior to DRC and HMC. The feeding value of WDGS was greater for yearlings than for calf-feds. The feeding value of WDGS was greater in DRC diets than in corn blend diets. The combination of WDGS and HMC provided cattle performance superior to DRC with or without WDGS.

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Impact of Distillers Grains Moisture and Inclusion Level on Greenhouse Gas Emissions in the Corn-Ethanol-Livestock Life Cycle

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Kenneth G. Cassman
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Summary

Updated meta-analysis of cattle performance equations were incorporated into the Biofuel Energy Systems Simulator (BESS) to more accurately evaluate the greenhouse gas (GHG) benefit of corn ethanol relative to gasoline. Partial drying or complete drying of wet distillers grains (DGS) reduces the feeding value of DGS for cattle and increases ethanol GHG emissions. Feeding wet DGS provides the optimum GHG benefit relative to gasoline, with associated ethanol emissions being 40% of gasoline. Ethanol production with dried DGS results in about 60% of the GHG emissions of gasoline when dry DGS is fed to feedlot cattle, dairy cows, and finishing swine.

Introduction

The Biofuel Energy Systems Simulator (BESS; *www.bess.unl.edu*) was developed to compare ethanol produced from the corn-ethanol-livestock life cycle to gasoline as a combustible motor fuel. A discussion of energy and associated GHG emissions associated with corn production, ethanol plant operation, and livestock response to DGS feeding parameters of BESS have been published (*2010 Nebraska Beef Cattle Report*, pp. 56-57).

The corn and protein replacement value of DGS is moisture level, dietary inclusion level, and livestock type dependent. Previous University of Nebraska–Lincoln research has evaluated feeding wet DGS (WDGS; 68% moisture), modified DGS (MDGS; 54% moisture), and dried DGS (DDGS; 10% moisture) to feedlot cattle. The DGS products all contained greater feeding value than corn, but feeding value decreases as moisture level decreases and as inclusion level increases for feedlot cattle. Dairy and finishing swine research does not indicate a feeding value of DGS greater than the corn and soybean meal replaced in diets. Therefore, there is a direct replacement of corn and soybean meal (lb for lb of DM) when DGS is fed to these animal classes.

Previous cattle performance equations of the BESS model were developed, with initial studies feeding wet, modified, and dry DGS to feedlot cattle. Several trials have been completed since the BESS model was developed. Meta-analysis equations developed from these larger databases will improve the accuracy of predicted BESS outcomes.

Therefore, an updated evaluation of the impact of distiller grains (DGS) moisture and inclusion level on GHG emissions from the corn-ethanol-livestock life cycle on ethanol relative to gasoline was conducted.

Procedure

The methodology for meta-analysis of pen mean observations to develop cattle performance equations when fed WDGS have been published elsewhere in this publication *(2011 Nebraska Beef Cattle Report,* pp. 40-41). This methodology was utilized to revise cattle performance equations when fed MDGS and DDGS. Modified DGS equations were developed from four UNL feedlot trials representing 85 pens and 680 steers (*2008 Nebraska Beef Cattle Report*, pp. 36-38; *2008 Nebraska Beef Cattle Report*, pp. 53-56; *2009 Nebraska Beef Cattle Report*, pp. 43-46; *2011 Nebraska Beef Cattle Report,* pp. 50-52). Dried DGS equations were developed from four UNL feedlot trials representing 66 pens and 581 steers (*1994 Nebraska Beef Cattle Report*, pp. 38-40; *2006 Nebraska Beef Cattle Report*, pp. 57-58; *2011 Nebraska Beef Cattle Report,* pp. 50-52; *2011 Nebraska Beef Cattle Report,* pp. 62-64).

These equations were incorporated into BESS to evaluate the impact of feeding WDGS, MDGS, and DDGS to feedlot cattle and dairy cattle on the GHG emissions of ethanol compared to gasoline. The feeding of DDGS to finishing swine also was evaluated.

Results

Meta-analysis of feedlot steer performance when fed DGS at different moistures and inclusion levels are presented in Table 1. The MDGS and DDGS values have been scaled to the WDGS 0% DGS intercepts so that performance of the different moisture products may be directly compared. The feeding value of WDGS was 143% to 130% of the corn replaced in the diet from 20% to 40% of diet DM. Using the same approach, the feeding value of MDGS was 124% to 117%, and 112% for DDGS. These data indicate a similar relationship of the different moisture DGS products as a study where all three DGS moistures were fed in the same trial *(2011 Nebraska Beef Cattle Report*, pp. 50-52)

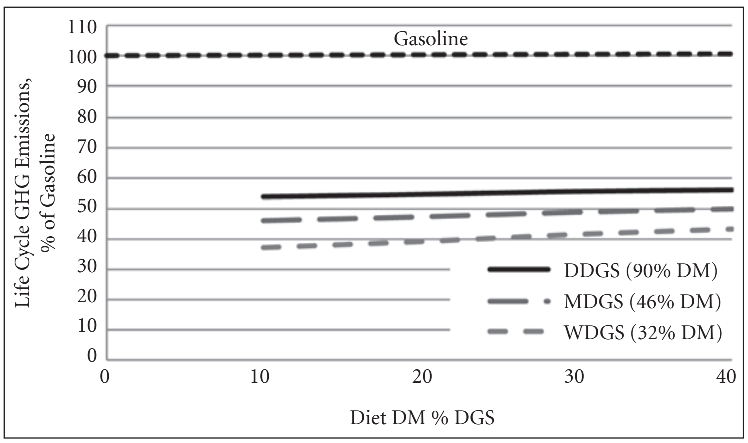
Corn ethanol GHG emissions were less than 60% of gasoline (97.7 $gC0_2e/MJ$) for all scenarios analyzed (Figures 1A and 1B). Feeding WDGS to feedlot cattle provided optimum ethanol GHG emissions relative to gasoline, with 38% to 43% of gasoline GHG emissions for 10% to 40% of diet DM as WDGS, respectively. Ethanol GHG emissions, when MDGS was fed to feedlot cattle, were intermediate of WDGS and DDGS and were 46%

Table 1. **Finishing steer performance when fed different dietary inclusions of corn wet distillers grains plus solubles (WDGS), modified distillers grains plus solubles (MDGS), or dried distillers grains plus solubles (DDGS) replacing dry-rolled and high-moisture corn.**

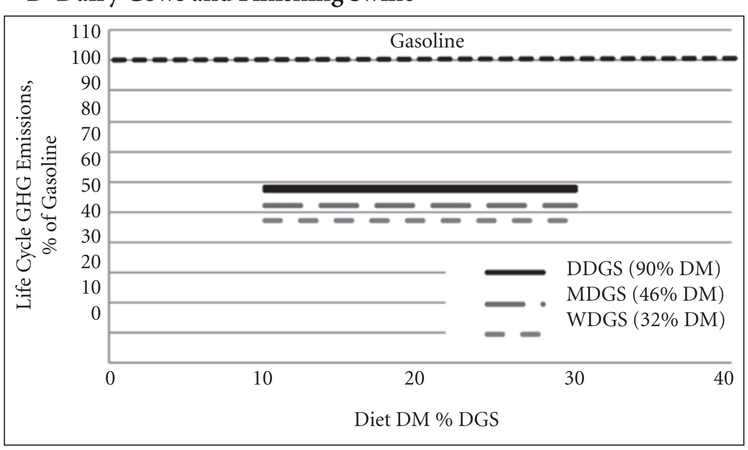
DGS Inclusion[1]:	0DGS	10DGS	20DGS	30DGS	40DGS	Lin[2]	Quad[2]
WDGS							
DMI, lb/day	23.0	23.3	23.3	23.0	22.4	0.01	< 0.01
ADG, lb	3.53	3.77	3.90	3.93	3.87	< 0.01	< 0.01
F:G	6.47	6.16	5.96	5.83	5.78	< 0.01	< 0.01
Feeding value, %[3]		150	143	136	130		
MDGS							
DMI, lb/day	23.0	23.8	24.1	24.0	23.4	0.95	< 0.01
ADG, lb	3.53	3.77	3.90	3.92	3.83	< 0.01	< 0.01
F:G	6.47	6.29	6.17	6.10	6.07	< 0.01	0.05
Feeding value, %[3]		128	124	120	117		
DDGS							
DMI, lb/day	23.0	24.0	24.6	24.9	24.9	< 0.01	0.03
ADG, lb	3.53	3.66	3.78	3.91	4.03	< 0.01	0.50
F:G	6.47	6.39	6.32	6.25	6.18	< 0.01	0.45
Feeding value, %[3]		112	112	112	112		

[1]Dietary treatment levels (DM basis) of distillers grains plus solubles (DGS), 0DGS = 0% DGS, 10DGS = 10% DGS, 20DGS = 20% DGS, 30DGS = 30% DGS, 40DGS = 40% DGS.
[2]Estimation equation linear and quadratic term t-statistic for variable of interest response to DGS level.
[3]Percent of corn feeding value, calculated from predicted F:G relative to 0WDGS F:G, divided by DGS inclusion.

A–Feedlot Cattle



B–Dairy Cows and Finishing Swine



Figures 1A and 1B. **Comparison of greenhouse gas (GHG) emissions from ethanol to gasoline when accounting for distillers grains moisture, level of dietary inclusion, and livestock class fed.**

to 50% and 54% to 56% of gasoline, respectively, for MDGS and DDGS. Ethanol GHG emissions were less beneficial when DDGS was fed instead of MDGS, and both DDGS and MDGS were less beneficial than WDGS for both beef and dairy. Greenhouse gas emissions of ethanol were similar when DDGS was fed to beef, dairy, and swine.

Ethanol plant energy use and associated GHG emissions are related to the moisture level of DGS produced. All ethanol plants produce WDGS. Some plants choose to remove moisture from WDGS to form DDGS. Ethanol plants producing DDGS require 1.7 times as much energy as ethanol plants producing WDGS. The amount of energy required to haul DGS to feedlots and within feedlots also is dependent on DGS moisture content.

The expanded cattle performance calculations included in this analysis further validate that feeding WDGS to feedlot cattle is the optimum feed use of DGS based on feeding performance and GHG emissions. Partial drying (MDGS) or complete drying (DDGS) of DGS reduces the environmental GHG benefit of corn ethanol relative to gasoline. These benefits are due to ethanol plants not having to use as much energy to run DGS dryers in the plants, and improved feedlot cattle performance when DGS is fed in the wet form instead of drier forms.

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Performance and Carcass Characteristics of Finishing Steers Fed Low-Fat and Normal-Fat Wet Distillers Grains

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Summary

Wet distillers grains plus solubles (WDGS) varying in fat content (6.7 vs. 12.9 %) were fed at 35% of the diet DM to compare fat level from WDGS on cattle performance and carcass characteristics. Final BW, hot carcass weight, and ADG were increased for steers fed 12.9% fat WDGS compared to steers fed corn or 6.7% fat WDGS. Steers fed 6.7% fat WDGS or corn control diets had identical DMI, ADG, and F:G.

Introduction

Wet distillers grains plus solubles (WDGS) is produced by combining the distillers grains and distillers solubles fractions, which can be variable from plant to plant, changing the fat content of the final product. Fat content of WDGS also can be decreased as ethanol plants are evaluating methods to remove a portion of the oil. The objective of this study was to determine the feeding performance and carcass characteristics of feedlot steers fed a normal-fat WDGS diet compared to a low-fat WDGS diet.

Procedure

Ninety-six crossbred yearling steers (879 ± 114 lb) were stratified and blocked by BW and assigned randomly to pens within block and strata, and pens assigned randomly to one of three treatments. Treatments included a corn control with no distillers grains (CON), low-fat WDGS (LFAT), and normal-fat WDGS (NFAT). Twelve pens were used to provide 4 replications per treatment.

A 1:1 ratio of dry-rolled corn (DRC), and high-moisture corn (HMC) was replaced when WDGS was added at 35% of the diet DM (Table 1). All diets contained 10% sorghum silage and 5% supplement (DM basis). The CON diet was formulated to provide 12.5% CP by including 0.75% urea in the diet provided in the supplement. Soypass® also was included in the CON diet at 1.0% of diet DM for the first 40 days to meet the metabolizable protein requirement of the steers. Thiamine was provided through the supplement in the treatments with WDGS at 150 mg/head/day. All diets were formulated to provide 30 g/ton (DM) Rumensin and 90 mg/head/day Tylan.

Composite feed ingredient samples were analyzed for DM, CP, sulfur,

Table 1. Diet composition and nutrient analysis of finishing diets fed to yearling steers, expressed as percentage of diet DM.

Ingredients	Control	Low-fat WDGS	Normal-fat WDGS
DRC	42.5	25.0	25.0
HMC	42.5	25.0	25.0
WDGS	—	35.0	35.0
Sorghum silage	10.0	10.0	10.0
Supplement	5.0	5.0	5.0
Fine ground corn	1.22	3.09	3.09
Limestone	1.43	1.38	1.38
Urea	0.75	—	—
Soypass[1]	1.0	—	—
Tallow	0.125	0.125	0.125
Salt	0.3	0.3	0.3
Trace mineral premix	0.05	0.05	0.05
Rumensin premix	0.019	0.019	0.019
Vitamin premix	0.015	0.015	0.015
Tylan premix	0.008	0.008	0.008
Thiamine	—	0.0139	0.0139
CP, %	13.6	17.9	17.8
Fat, %	3.64	4.72	6.91
Sulfur, %	0.12	0.37	0.41

[1]Soypass® included at 1.0% of diet DM during the first 40 days, then replaced with fine ground corn.

Table 2. Yearling steer finishing feedlot performance when fed a control, low-fat WDGS, and normal-fat WDGS diet.

	Treatments				
	Control	Low-Fat WDGS	Normal-Fat WDGS	SEM	*P*-value
Performance					
Initial BW, lb	889	886	886	1.6	0.38
Final BW[1], lb	1295	1294	1331	9.42	0.04
DMI, lb/day	24.4	24.4	24.4	0.55	0.99
ADG, lb	3.41	3.41	3.71	0.07	0.02
F:G[2]	7.19	7.19	6.58	—	0.12
Carcass Characteristics					
HCW, lb	816	815	839	5.78	0.04
Marbling score[3]	614	591	617	0.29	0.61
12th rib fat, in	0.47	0.52	0.53	0.03	0.25
LM area, in^2	13.4	12.9	13.1	0.34	0.62

[1]Calculated from HCW, adjusted to a 63% yield.
[2]Calculated and analyzed from G:F, which is the reciprocal of F:G.
[3]450=Slight50, 500=Small0.

and fat. The low-fat WDGS contained 34.8% CP, 6.7% fat, and 0.85% sulfur. The normal-fat WDGS contained 34.5% CP, 12.9% fat, and 0.94% sulfur. Steers were slaughtered at a commercial abattoir (Greater Omaha Pack, Omaha, Neb.) in two weight blocks, heavy and light, at either 102 or 131 days on feed. Hot carcass weights (HCW) and liver scores were collected on the day of slaughter. After a 48-hour chill, marbling score, 12th rib fat thickness, and LM area data were collected. Final carcass adjusted BW, ADG and F:G were calculated by dividing HCW by a common dressing percentage of 63%.

Cattle performance and carcass characteristics were analyzed using the MIXED procedure of SAS. Pen was considered the experimental unit, and treatments were analyzed as a randomized complete block design.

Results

Performance and carcass characteristics are presented in Table 2. Carcass adjusted final BW and HCW were greater, by 36 and 23 pounds, respectively, for the NFAT treatment compared to the CON and LFAT treatments ($P < 0.03$). Average daily gain was 0.3 lb/day greater for the NFAT treatment compared to the CON and LFAT treatments ($P = 0.02$). No differences were observed across treatments for LM area, 12th rib fat thickness, marbling, or DMI ($P > 0.25$). A tendency for a decrease in F:G ($P > 0.12$) was observed for the NFAT treatment. Interestingly, the carcass adjusted final BW, HCW, and ADG for the CON and LFAT treatments were identical.

This study indicates that cattle performance and carcass characteristics when feeding low-fat WDGS are comparable to feeding a corn-based diet. Low-fat WDGS has a lower energy value than normal fat WDGS due to the lower fat content, which decreases gain and weights, and likely increases F:G.

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Review: Lipid Addition to Corn Finishing Diets

Virgil R. Bremer
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Summary

The fat content of distillers grains with solubles (DGS) partially accounts for DGS feeding value being greater than corn. Finishing diets containing DGS to supply up to 8% of diet DM as fat may be fed without depressing cattle performance. However, feeding diets containing 8% diet fat with corn oil depresses cattle performance. The difference in rumen metabolism of these two fats is due to physical protection of DGS fat from interaction with rumen microbes. Due to an unknown mechanism, condensed corn distillers solubles, a liquid fat source, does not limit ruminal metabolism like corn oil. Optimum dietary fat level is dependent on the sources of fat in the diet.

Introduction

Based on greater caloric density of fat versus starch and protein, it makes sense to replace a portion of lesser energy starch or protein from feedlot diets with fat. However, there are upper limits to the level of dietary fat that cattle in a feedlot can ingest without affecting rumen function and depressing feeding performance. These upper limits may be lipid source dependant based on the degree of fatty acid saturation and physical structure. Therefore, University of Nebraska–Lincoln feedlot research evaluating fat addition to dry-rolled (DRC) and high-moisture corn (HMC) diets was summarized to evaluate feeding traditional and byproduct fat sources.

Procedure

A series of six feedlot and metabolism studies evaluating different fat sources compared to distillers grains with solubles (DGS) were reviewed to better understand fat metabolism of different feedstuffs. Evaluated was the addition of fat to corn diets from corn oil, tallow, condensed corn distillers soluble (CCDS), or DGS, in addition to the impact of decreasing lipid content of DGS on cattle feeding performance (*2004 Nebraska Beef Cattle Report*, pp. 45-48; *2007 Nebraska Beef Cattle Report*, pp. 39-42; 2009 *Nebraska Beef Cattle Report*, pp. 64-66; 2010 *Nebraska Beef Cattle Report*, pp. 74-76; *2011 Nebraska Beef Cattle Report,* pp. 44-45).

Review

CCDS and DGS Products

Both CCDS and DGS fats are from the dry milling ethanol industry. These fats both have been subjected to a low pH environment during the fermentation process of producing ethanol and heating to distill ethanol. Once the ethanol is removed, the remaining stillage is centrifuged to separate the liquid distillers solubles fraction from the remaining fermentation solids. Water is removed from the soluble stream (95% moisture) to form CCDS (65% moisture). Often times, the CCDS are combined back with the grains fraction to make wet DGS (WDGS; 65% moisture). The WDGS may have additional heat energy applied to produce dry DGS (DDGS; 10% moisture). The CCDS accounts for about 20% of DGS DM. Some ethanol plants also sell CCDS as a separate feed ingredient.

Different Forms of Fat

Corn oil, CCDS, and DGS fat all originate from corn. However, these fats are not equal in feeding value. Differences are partially due to physical form. Fat in vegetable oils is mainly in the form of unsaturated fatty acids. Unsaturated fats differ from saturated fats in the bonding structure of the carbons in the fatty acid molecules. Saturated fats are "saturated" when they have as many hydrogen atoms attached to the carbons as possible. Unsaturated fats have fatty acids that contain stronger bonds between carbons that can accept additional hydrogens and alter the shape of the fatty acids. Corn oil is a liquid at room temperature, and thus, unsaturated and is readily available for rumen microbial interaction. The CCDS also is a liquid. The fat of CCDS is slightly more saturated than the fat in corn oil due to the fermentation and heat used to produce ethanol. However, CCDS not only contains fat (10-35% of CCDS DM) but also protein from yeast cells and corn, in addition to other nutrients. The fat in the grains fraction of DGS is trapped in the ground corn germ particles. This fat is protected from interaction with rumen microbes due to the germ particles physically inhibiting interaction of lipid with microbes. The ratio of CCDS to grains at the ethanol plant and CCDS % fat impacts the final fat profile of DGS. The corn fiber and protein also are concentrated in grains fraction of DGS.

Beef tallow is an example of how ruminants can modify dietary unsaturated fatty acids to a more saturated fatty acid profile. The tallow is from cattle fed unsaturated corn fatty acids, but the ruminal microbes have altered the corn oil fat before the fat was incorporated into carcass tissues. The more saturated fatty acids of tallow are not as detrimental to microbial function in the rumen as corn oil.

Fat and Rumen Function

The ruminant has the unique ability to modify dietary unsaturated fatty acids to saturated fatty acids with rumen microbes. This process is known as biohydrogenation. Fatty acid biohydrogenation is what causes beef to have harder fat than pork. One of the explanations of why the microbes biohydrogenate the fatty acids is to combat the inhibition of fermentation that can occur with unsaturated fatty acids. Another explanation is that the unsaturated fatty acids serve as a sink for free hydrogen ions in the rumen.

Results

Cattle Performance When Fed Different Fat Sources

Replacing a blend of DRC and HMC to create diets with 6.4% total diet ether extract, with either 2.5% corn oil or 20% of diet DM with WDGS, resulted in similar or improved feeding performance relative to the corn diet for individually fed heifers. When total diet ether extract was increased to 8.8%, with either 5% corn oil or 40% WDGS, feed conversion was greater for the 40% WDGS diet relative to 20% WDGS. The 5% corn oil diet resulted in depressed performance relative to the corn diet. This trial indicated that 8.8% diet fat from 5% corn oil was detrimental to rumen function.

In a second trial, HMC was replaced by 1.3% or 2.6% tallow or 20% or 40% DDGS in diets containing 20% wet corn gluten feed (WCGF; Sweet Bran®). Feeding performance was similar for all treatments. Maximum dietary ether extract was 6.0% and 5.0% for tallow and DDGS, respectively. This trial indicates that 2.6% tallow was not enough saturated fat to depress cattle performance with 20% WCGF diets.

A third finishing trial evaluated replacing HMC in 35% WCGF diets with either CCDS or WDGS. Inclusion of 20% of diet DM as CCDS or 40% WDGS resulted in diets containing 6.2% and 6.9% diet fat, respectively. The CCDS diets resulted in similar performance as the WDGS diets. The combined interpretation of the first and third studies shows that CCDS does not depress feeding performance like corn oil. These data substantiate that the form of fat in DGS and CCDS have a different effect on rumen function relative to corn oil.

Two metabolism trials evaluated fat digestion of corn, WDGS, and corn with corn oil diets. Both studies found less ruminal biohydrogenation of WDGS fatty acids, compared to corn and corn with corn oil diets. Steaks from steers consuming WDGS had increased proportion of unsaturated fatty acids relative to saturated fatty acids compared to steaks from corn fed cattle. One of the metabolism studies also evaluated CCDS lipid biohydrogenation and noted that omasal contents from CCDS fed steers were biohydrogenated to a similar level of saturation as omasal content from corn, corn oil, and tallow diets and omasal contents of WDGS fed steers were less satuated than the other treatments. These trials indicate that CCDS diet fat is not protected from biohydrogenation like the grains fraction of WDGS.

A finishing trial evaluated feeding 35% of diet DM as wet distillers grains without CCDS (6.7% fat; DM basis), 35% normal WDGS (13.0% fat; DM basis), and a corn diet. Dry matter intake was similar for all three treatments. However, ADG of the lower fat WDGS was similar to the corn diet and the ADG of the normal WDGS fed steers was superior to the other two diets. The feeding values of the lower fat distillers grains and normal WDGS were 102% and 127 % of corn, respectively. This trial indicates the importance of the lipid component of DGS on the feeding value of DGS products.

High fat DGS finishing diets (8% dietary fat) may be fed to feedlot cattle with improved performance relative to cattle fed corn. Feeding 8% fat diets containing corn and corn oil depresses feeding performance compared to corn fed cattle. The difference in ruminant biological processing of corn oil and DGS diets is partially due to the physical form of the fat in DGS being protected from interaction with ruminal microbes. Although CCDS fatty acids are not protected from ruminal biohydrogenation, CCDS fat does not appear to limit ruminal fermentation like diets with corn oil. The CCDS fat in WDGS partially accounts for WDGS feeding value being greater than corn.

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Comparing Different Drying Methods for Distillers Grains and its Effects on Feedlot Cattle Performance

Brandon L. Nuttelman
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Galen E. Erickson
Terry J. Klopfenstein[1]

Summary

An experiment was conducted to evaluate the effect of drying distillers grains plus solubles on cattle performance. The control diet contained no distillers grains. The six additional diets contained 35% distillers grains that were 1) wet distillers grains plus solubles (WDGS), 2) dried distillers grains plus solubles (DDGS), 3) dried distillers grains plus wet solubles at time of feeding (DDG + Solubles), 4) dried distillers grains plus solubles plus water (DDGS + H_2O), 5) modified distillers grains with solubles added prior to drier (MDGSPre), and 6) modified distillers grains with solubles added after the drier (MDGSPost). Cattle fed diets with distillers grains had greater ADG and DMI, and lower F:G than the diet with no distillers grains. Diets containing WDGS, MDGSPre, and MDGSPost had lower F:G than other treatments. Drying of solubles had little impact on the feeding value of distillers grains.

Introduction

Drying distillers grains plus solubles had a negative impact on the feeding value of distillers grains in feedlot diets (*2011 Nebraska Beef Cattle Report,* pp. 50-52). Although distillers grains are produced from a different milling process, research with corn bran (*2002 Nebraska Beef Cattle Report,* pp. 72) suggests that drying distillers grains may not alter the feeding value in feedlot diets, but drying the solubles onto the distillers grains may negatively affect the feeding value of distillers grains plus solubles. Distillers grains and distillers solubles are produced as separate feeds during ethanol production. Therefore, the objective of this study was to determine if drying solubles onto distillers grains affects the feeding value of distillers grains plus solubles included in feedlot diets.

Procedure

Green Plains Renewable Energy, Inc. produced five different distillers grains by changing the timing of drying the distillers grains. All distillers grains were produced during the same week from the same plant and stored in silo bags prior to the initiation of the study to eliminate variation in composition of distillers grains. The five different types of distillers grains produced were: 1) WDGS — solubles were added to wet grains; 2) DDGS — solubles were added to wet grains and then dried ~ 90.0% DM; 3) DDG — wet grains were dried with no solubles added; 4) MDGSPre — solubles were added to wet grains and then dried to ~ 47.5% DM; and 5) MDGSPost — wet grains were partially dried and then solubles were added at the same ratio to the partially dried grains resulting in ~ 48.0% DM distillers grains. As a result there were three types where solubles were not dried, and there were two types with solubles dried onto the grains.

Crossbred, calf-fed steers (n = 420; 671 ± 46 lb) were utilized to determine the feeding value of distillers grains as a result of different drying methods. A randomized complete block design was used with an unstructured treatment design. Six days prior to the initiation of the study, steers were limit fed (2% BW) a common diet consisting of 47.5% alfalfa hay, 47.5% wet corn gluten feed, and 5.0% supplement to eliminate variation due to gut fill. On day 0 and 1 of the experiment, steers were weighed and the average of the two-day weights was used as the initial BW. Steers were blocked by BW, stratified within block, and assigned randomly to one of 42 feedlot pens (10 steers/

Table 1. Diet composition.

	Treatments[1]						
	CON	WDGS	DDGS	DDGS +H_2O	MDGSPre	MDGSPost	DDG+ Solubles
HMC	43.4	25.9	25.9	25.9	25.9	25.9	25.9
DRC	43.4	25.9	25.9	25.9	25.9	25.9	25.9
Distillers Grains	—	33.0	35.0	35.0	33.0	35.0	28.0
Solubles	—	2.1	—	—	2.1	—	7.0
Sorghum Silage	4.1	4.1	4.1	4.1	4.1	4.1	4.1
Grass Hay	4.1	4.1	4.1	4.1	4.1	4.1	4.1
Supplement[2]	5.0	5.0	5.0	5.0	5.0	5.0	5.0

[1]CON — Control diet with no distillers grains. WDGS — Wet distillers grains included at 35% of Diet DM. DDGS — Dry distillers grains with solubles added to grains prior to the dryer. DDGS+H_2O — Dried distillers grains with soluble added to grains prior to the dryer and H_2O added at time of feeding to reconstitute DDGS to same DM as MDGSPre and MDGSPost. MDGSPre — Modified distillers grains with soluble added to grains prior to the dryer. MDGSPost — Modified distillers grains with solubles added to grains post dryer. DDG+Solubles — Dried distillers grains with solubles added to grains at time of feeding (~ 80% grains and 20% solubles DM).
[2]Supplements were formulated to provide 330 mg/head/day of Rumensin; 90 mg/head/day of Tylosin.

Table 2. Nutrient composition of distillers grains.

	Type of distillers grains[1]					
	WDGS	DDGS	DDG	MDGSPre	MDGSPost	Solubles
CP, %	33.5	31.8	34.6	31.3	32.3	25.9
Fat, %	12.2	11.5	7.5	12.2	12.8	21.7
NDF, %	37.8	36.9	47.1	35.9	36.6	—
S, %	0.76	0.77	0.63	0.70	0.84	1.26

[1]CON — Control diet with no distillers grains. WDGS — Wet distillers grains included at 35% of Diet DM. DDGS — Dry distillers grains with solubles added to grains prior to dryer. DDGS+H_2O —Dried distillers grains with solubles added to grains prior to the dryer and H_2O added at time of feeding to reconstitute DDGS to same DM as MDGSPre and MDGSPost. MDGSPre — Modified distillers grains with solubles added to grains prior to the dryer. MDGSPost — Modified distillers grains with solubles added to grains post dryer. DDG+Solubles — Dried distillers grains with solubles added to grains at time of feeding (~ 80% grains and 20% solubles DM).

Table 3. **Growth performance and carcass characteristics.**

	Treatments[1]								
	CON	WDGS	DDGS	DDGS+H_2O	MDGSPre	MDGSPost	DDG+Solubles	SEM	*P*-value
Performance									
Initial BW, lb	691	692	690	689	690	692	690	1	0.34
Final BW, lb[2]	1268[a]	1370[b]	1346[b]	1356[b]	1370[b]	1372[b]	1374[b]	11	< 0.01
ADG, lb	3.09[a]	3.63[b]	3.51[b]	3.58[b]	3.64[b]	3.64[b]	3.66[b]	0.06 [b]	< 0.01
DMI, lb/d	20.4[a]	21.8[b]	22.5[bc]	22.4[b]	22.1[b]	22.4[b]	23.4[c]	0.4	< 0.01
Feed:gain[3]	6.61[a]	6.01[d]	6.40 [ab]	6.22[bc]	6.08[cd]	6.13[cd]	6.40 [ab]	0.01	< 0.01
Carcass Characteristics									
HCW, lb	799[a]	863[b]	848[b]	856[b]	863[b]	864[b]	866[b]	7	< 0.01
Marbling Score[4]	509	539	545	539	529	523	551	13	0.32
12th rib fat, in.	0.43[a]	0.58[b]	0.56[b]	0.55[b]	0.56[b]	0.55[b]	0.55[b]	0.04	0.02
LM, area in.[2]	12.7	13.0	12.9	12.8	13.0	12.9	13.3	1.2	0.38

[a,b,c,d]Means with different superscripts differ ($P < 0.05$) for treatments.
[1]CON — Control diet with no distillers grains. WDGS — Wet distillers grains included at 35% of Diet DM. DDGS — Dry distillers grains with soluble added to grains prior to the dryer. DDGS+H_2O — Dried distillers grains with solubles added to grains prior to the dryer and H_2O added at time of feeding to reconstitute DDGS to same DM as MDGSPre and MDGSPost. MDGSPre — Modified distillers grains with solubles added to grains prior to the dryer. MDGSPost — Modified distillers grains with solubles added to grains post dryer. DDG+Solubles — Dried distillers grains with solubles added to grains at time of feeding (~ 80% grains and 20% solubles DM).
[2] Calculated from hot carcass weight, adjusted to a common dressing percentage of 63.0%.
[3] Analyzed as gain:feed, reciprocal of feed conversion.
[4] Marbling score: 400 = Slight^0; 450 = Slight^{50}; 500 = Slight^0, etc.

pen). Pens were assigned randomly to one of seven treatments. Treatments are presented in Table 1 and consisted of: 1) corn-based control (CON); 2) WDGS; 3) MDGSPre; 4) MDGSPost; 5) DDGS; 6) DDGS + H_2O; and 7) DDG + Solubles. Distillers grains were included in the diet at 35% of the diet DM. Water was added to DDGS to bring the ingredient DM equal to the MDGSPost. Solubles that were added to DDG were sampled and analyzed for fat content (Table 2). Solubles inclusion level was adjusted according to differences in fat level between loads so the fat portion from DDG + Solubles was similar to DDGS. Due to difficulties at the plant at the time of making the products, 100% of the solubles could not be added to WDGS and MDGSPre. Therefore, solubles were added to WDGS and MDGSPre at the time of feeding and consisted of 32.9% grains and 2.1% solubles. Corn consisted of a 1:1 ratio of high-moisture:dry-rolled corn, and all diets contained 4.1% grass hay, 4.1% sorghum silage, and 5.0% supplement.

Steers were implanted on day 1 of the study with Revalor-XS. Cattle were on feed for 187 days and slaughtered at a commercial abbotair (*Greater Omaha Pack, Omaha, Neb.).* Hot carcass weights 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 common dressing percentage of 63% was used to calculate carcass adjusted performance to determine final BW, ADG, and F:G.

Performance and carcass data were analyzed using the MIXED procedure of SAS. The model included block and dietary treatment. Pen was the experimental unit (6 pens/treatment). Differences were considered significant when $P \leq 0.05$.

Results

Cattle growth performance and carcass characteristics are presented in Table 3. Cattle fed distillers grains were heavier than CON ($P < 0.01$). Average daily gain was similar for cattle on diets containing distillers grains, but was less for CON ($P < 0.01$). Dry matter intake was different between diets ($P < 0.01$). Steers fed CON had the lowest DMI, and DDG + Solubles had the greatest DMI, but was not different from DDGS. There were no differences between the remaining distillers grains for DMI. Cattle on WDGS had the lowest F:G, but were not different from steers fed MDGSPre or MDGSPost ($P > 0.23$). Both MDGSPre and MDGSPost gained as efficiently as DDGS + H_2O, but were different from CON, DDGS, and DDG + Solubles ($P < 0.03$). Feed conversion tended to be greater for CON compared to DDGS and DDG + Solubles ($P = 0.07$), but was not different for DDGS and DDG + Solubles ($P = 0.99$).

Cattle on distillers grains diets gained more, and as a result had heavier HCW ($P < 0.01$). Cattle fed diets containing distillers grains were fatter at harvest than CON ($P = 0.02$). There were no differences for marbling score or LM area ($P > 0.32$).

Drying distillers grains had a negative effect on the feeding value. However, contrary to the hypothesis, the addition of solubles to dried distillers grains at the time of feeding did not change the feeding value compared to DDGS. In addition, drying the solubles for MDGSPre did not affect the feeding value when compared to MDGSPost where the solubles were not dried onto the grains.

These data suggest drying the solubles does not alter the feeding value of distillers grains plus solubles. Adding water to DDGS did not change F:G when compared to DDGS without water, suggesting that the increased feeding value of WDGS compared to DDGS is more than just the benefits of added moisture in the diet. In conclusion, drying distillers grains plus solubles does have a negative impact on the feeding value in feedlot diets when compared to WDGS. Drying the solubles onto distillers grains does not explain this change in feeding value.

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Comparing Dry, Wet, or Modified Distillers Grains Plus Solubles on Feedlot Cattle Performance

Brandon L. Nuttelman
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Terry J. Klopfenstein[1]

Summary

Three types of distillers grains (DG): 1) wet distillers grains plus solubles (WDGS), 2) dried distillers grains plus solubles (DDGS), or 3) modified distillers grains plus solubles (MDGS), included at 3 levels: 20%, 30%, or 40% the diet DM, and a corn-based control compared the effect of drying distillers grains on feedlot performance. Type of DG had no effect on ADG (P = 0.30), but DMI increased for MDGS and DDGS compared to WDGS (P < 0.01). Therefore, F:G was improved for WDGS (P < 0.01) compared to MDGS and DDGS. Gain was greater and F:G was lower when DG were fed compared to the corn control. The feeding value of WDGS was 35.4% and 17.8% greater than DDGS and MDGS, respectively. The feeding value was 45.7%, 26.5%, and 9.3% more than corn for WDGS, MDGS, and DDGS, respectively.

Introduction

A University of Nebraska–Lincoln pen mean meta-analysis (*2011 Nebraska Beef Cattle Report,* pp. 40-41) determined a feeding value for wet distillers grains plus solubles (WDGS), modified distillers grains plus solubles (MDGS), and dried distillers grains plus solubles (DDGS) relative to dry-rolled corn (DRC) in feedlot diets. The feeding value for WDGS is 143 - 130%, 124 - 117% for MDGS, and 112% for DDGS. However, little research has been conducted comparing WDGS, DDGS, and MDGS in the same study. Therefore, the objective of this study was to compare the effects of drying ethanol co-products produced from the dry milling process on feedlot cattle performance by feeding WDGS, MDGS, and DDGS in the same study.

Procedure

Crossbred, yearling steers (n = 440; 778 ± 42 lb) were utilized in a randomized complete block design. Treatments were arranged in a 3 x 3 + 1 factorial treatment structure, with three types of distillers grains (DG), three inclusions of DG (20%, 30%, or 40% diet DM), and a negative corn-based control (CON). Steers were blocked by BW, stratified within block, and assigned randomly to pen (55 pens; 8 steers/pen). Pens were assigned randomly to one of 10 treatments. The CON treatment was repeated within replication (10 replications), whereas all other treatments had 5 replications.

Basal ingredients consisted of a high-moisture and dry-rolled corn blend (HMC:DRC) fed at a 60:40 ratio (DM basis), 15% corn silage, and 5% dry supplement (DM basis; Table 1). Distillers grains replaced HMC:DRC. Steers were adapted to the finishing diet by feeding 37.5%, 27.5%, 17.5%, and 7.5% alfalfa hay (DM basis), replaced with HMC:DRC for 3, 4, 7, and 7 days, respectively. The supplements for diets containing 20% DG contained urea at 0.47% of the diet to ensure there was not a deficiency in degradable intake protein. All diets were formulated to provide a minimum of 13.0% CP, 0.6% Ca, 0.25% P, and 0.6% K. Supplements for all diets were formulated to provide 360 mg/steer daily of monensin (Rumensin, Elanco Animal Health), 90 mg/steer daily of tylosin (Tylan, Elanco Animal Health), and 150 mg of thiamine per steer daily.

Table 1. Nutrient composition of wet, modified, and dry distillers grains.

	WDGS[1]	MDGS[1]	DDGS[1]
% CP	31.1	31.0	30.9
% Sulfur	0.81	0.70	0.71
% Fat	11.9	12.4	11.9
% NDF	34.1	34.4	32.3

[1]WDGS = wet distillers grains plus solubles; MDGS = modified distillers grains plus solubles; DDGS = dried distillers grains plus solubles.

Table 2. Main effects of type of distillers grains on cattle performance and carcass characteristics.

	Type of Distillers Grains[1]				
	WDGS	MDGS	DDGS	SEM	*P*-value
Performance					
Initial BW, lb	767	767	768	1	0.83
Final BW, lb[2]	1400	1409	1392	10	0.51
DMI, lb/day	24.8[a]	26.4[b]	27.1[b]	0.07	< 0.01
ADG, lb	4.11	4.17	4.05	0.3	0.30
F:G[3]	6.06[a]	6.33[b]	6.67[c]	0.01	< 0.01
Carcass Characteristics					
HCW, lb	882	887	877	6	0.52
12th rib fat, in	0.63	0.64	0.60	0.1	0.15
Marbling Score[4]	610	599	602	9	0.69
LM area, in^2	13.3	13.2	13.4	0.15	0.50

[a,b,c]Means with different superscripts differ (*P* < 0.05).
[1]WDGS = wet distillers grains plus solubles; MDGS = modified distillers grains plus solubles; DDGS = dried distillers grains plus solubles.
[2]Calculated from hot carcass weight, adjusted to a common dressing percentage of 63.0%.
[3]Analyzed as gain:feed, reciprocal of feed conversion (F:G).
[4]Marbling score: 400 = Slight^0; 450 = Slight^{50}; 500 = Slight^0, etc.

Table 3. Main effect of level on cattle performance and carcass characteristics.

	Level[1]					With 0 level[2]		Without 0 level[3]	
	0	20	30	40	SEM	Lin	Quad	Lin	Quad
Performance									
Initial BW, lb	800	767	799	738	1	0.34	0.18	0.17	0.13
Final BW, lb[4]	1319[a]	1396[b]	1390[b]	1413[b]	15	< 0.01	0.05	0.24	0.25
DMI, lb/day	24.6[a]	26.3[b]	25.9[b]	26.2[b]	0.4	0.01	0.09	0.74	0.36
ADG, lb	3.58[a]	4.08[b]	4.05[b]	4.19[b]	0.07	< 0.04	0.04	0.26	0.25
F:G[5]	6.85[a]	6.41[b,x]	6.37[b,x,y]	6.21[b,y]	0.01	< 0.01	0.04	0.05	0.48
Carcass Characteristics									
HCW, lb	831	879	876	890	7	< 0.01	0.05	0.22	0.25
12[th] rib fat, in	0.50	0.62	0.62	0.65	0.02	< 0.01	0.08	0.12	0.40
Marbling Score[6]	607	609	599	603	11	0.63	0.99	0.70	0.52
LM area, in^2	13.3	13.2	13.3	13.4	0.1	0.74	0.17	0.18	0.68

[a,b]Means with different superscripts differ ($P < 0.05$) for main effect of 0, 20, 30, and 40% distillers grains inclusion level.
[x,y] Means with different superscripts differ ($P < 0.05$) for main effect of 20, 30, and 40% distillers grains inclusion level.
[1]% inclusion of distillers grains (DM)
[2]Contrast for the linear and quadratic effect of treatment *P* – value with main effects of 0, 20, 30, and 40% distillers grains inclusion level.
[3]Contrast for the linear and quadratic effect of treatment *P* – value with main effects of 20, 30, and 40% distillers grains inclusion level.
[4]Calculated from hot carcass weight, adjusted to a common dressing percentage of 63.0%.
[5]Analyzed as gain:feed, reciprocal of feed conversion (F:G).
[6]Marbling score: 400 = Slight^0; 450 = Slight^{50}; 500 = Slight^0, etc.

All three types of DG were purchased and stored in a separate silo bag at the feedlot prior to the initiation of the trial to eliminate variation in the supply of distillers grains over the duration of the study. The DDGS and MDGS were produced and purchased from the same plant, and the WDGS was purchased from a different plant. During the bagging process, each DG was sampled and analyzed for CP, fat, S, and NDF (Table 1). The WDGS contained 0.1 percentage units more S than either DDGS or MDGS. Therefore, calcium sulfate was included in supplements for treatments containing DDGS or MDGS to equalize S intake across treatments that contained distillers grains.

Steers were implanted on day 1 of the trial with Component TE-IS, and re-implanted on day 69 with Component TE-S. Cattle were limit fed a common diet at 2.0% BW that contained 47.5% wet corn gluten feed, 47.5% alfalfa hay, and 5.0% supplement for five consecutive days to eliminate variation due to gut fill. Following the limit feeding period, steers were individually weighed on day 0 and day 1, and the average of the two weights was used to obtain an accurate initial BW. Feed refusals 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.

Steers were slaughtered on day 154 at a commercial abattoir (*Greater Omaha Pack, Omaha, Neb.)*. Liver scores and HCW were collected on the day of slaughter. Following a 48-hour chill, USDA marbling score, 12[th] rib fat depth, and LM area were recorded. A common dressing percentage of 63% was used to calculate carcass adjusted performance to determine final BW, ADG, and F:G.

The difference in F:G between the different types of DG was divided by the F:G of the DDGS treatment and the average inclusion level of DG (30% DM) to determine the differences in feeding value between types of DG. The same calculations were used to calculate the improved feeding value of each DG compared to the CON treatment.

Data were analyzed using the MIXED procedure of SAS. Pen was the experimental unit and treatments were analyzed as a randomized complete block design. Initially, the 3x3 factorial was tested for an interaction. If no significant interaction was observed, then main effects of distillers type were evaluated. Also, orthogonal polynomial contrasts were constructed to evaluate a response curve (linear and quadratic) for distillers grains level. If an interaction occurred, then simple effects of different inclusions of each distillers type were evaluated. Orthogonal polynomial contrasts also were constructed to determine a response curve (linear, quadratic, and cubic) to compare the level of distillers grains against the CON. Proc IML was used to obtain appropriate coefficients for unbalanced inclusion levels.

Results

Cattle Performance

There were no type x level interactions ($P > 0.16$) for the 3 x 3 factorial. Therefore, the main effects of DG type, DG level, and DG level compared against CON are presented.

Type of Distillers Grains

Performance and carcass characteristics for type of DG are presented in Table 2. There were no differences observed for ADG ($P = 0.30$) between WDGS, MDGS, and DDGS. Steers fed WDGS had 1.61 and 2.29 lb/day lower ($P < 0.01$) DMI than MDGS and DDGS, respectively. As a result, steers fed WDGS had lower F:G ($P < 0.01$) compared to steers fed MDGS or DDGS. Cattle fed MDGS tended ($P = 0.06$) to have lower F:G than steers consuming DDGS. There were no differences observed between type of DG for carcass traits ($P > 0.15$).

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Level of Distillers Grains

Performance and carcass characteristics for level of DG are presented in Table 3. First, main effects of 20%, 30%, and 40% inclusion level are discussed and then followed with the comparison to CON. There were no differences for final BW, DMI, or ADG between 20%, 30%, and 40% DG inclusion level ($P > 0.24$). Cattle fed 40% DG had a lower ($P = 0.05$) F:G than 20% DG. Carcass characteristics were not different ($P > 0.12$) between levels of DG. When comparing CON to 20%, 30%, and 40% DG, there was a linear ($P = 0.01$) increase in DMI, quadratic ($P = 0.04$) increase in ADG, and linear ($P < 0.01$) decrease in F:G. The increase in ADG and decrease in F:G occurred when DG inclusion increased from 0% to 20% inclusion. Increasing dietary inclusion of DG increased HCW quadratically ($P = 0.05$) and increased fat depth ($P < 0.01$) linearly when CON was included. Although there was a difference observed in fat depth, the 0% level had 0.50 in and is a good indication that all steers achieved acceptable feeding endpoints, regardless of treatment. There were no effects on marbling score or LM area ($P > 0.63$).

Based on F:G, calculated feeding values of DG were greater than HMC:DRC, regardless of type of DG. The feeding value of WDGS, MDGS, and DDGS were 45.7%, 26.5%, and 9.3% greater than HMC:DRC. The feeding value of WDGS was 36.0% and 17.9% greater than DDGS and MDGS, respectively.

This study agrees with previous research that found including DG, regardless of moisture level, up to 40% of the diet (DM basis) will improve F:G compared to corn-based diets. Also, this study suggests that partially or completely drying DG has a negative effect on its feeding value compared to WDGS.

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The Effect of Drying Distillers Grains on Nutrient Metabolism

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Summary

Ruminally cannulated steers were used in a 4 x 6 unbalanced Latin square. Treatments consisted of a corn-based control (CON), wet distillers grains plus solubles (WDGS), modified distillers grains plus solubles (MDGS), or dry distillers grains plus solubles (DDGS) included at 40% of the diet DM. There were no differences (P > 0.73) observed for DMI, or for DM, OM, or fat digestibility. Steers fed diets containing distillers grains had greater NDF intake compared to CON (P < 0.01). There were no differences in NDF digestibility between WDGS, MDGS, and DDGS (P > 0.37); however, CON diets had lower (P < 0.06) NDF digestibility than WDGS and DDGS. Average ruminal pH tended (P = 0.14) to be impacted by dietary treatment with steers fed DDGS having a greater pH than steers fed CON, MDGS, and WDGS, which were not different from one another.

Introduction

Differences in the feeding value between wet distillers grains plus solubles (WDGS), modified distillers grains plus solubles (MDGS), and dry distillers grains plus solubles (DDGS) have been reported (*2011 Nebraska Beef Cattle Report,* pp. 50-52). The previous report indicates the feeding value of distillers grains is negatively impacted during the drying process, even though the cause of the negative impact of the drying process is unknown. Therefore, the objective of this study was to determine the effects of drying distillers grains on intake and digestibility of the DM, OM, NDF, and fat, as well as ruminal pH measurements by evaluating WDGS, MDGS, and DDGS compared to corn.

Table 1. Effects of diet on nutrient intake and digestibility.

	Treatment[1]					
	CON	WDGS	MDGS	DDGS	SEM	*P*-value
DM						
Intake, lb/day	21.5	20.6	22.1	21.6	1.2	0.83
Digestibility, %	78.0	77.2	76.5	75.2	2.2	0.84
OM						
Intake, lb/day	20.1	18.7	20.3	19.7	1.1	0.74
Digestibility, %	79.7	79.2	78.4	76.8	2.2	0.81
NDF						
Intake, lb/day	3.4[a]	4.9[b]	5.0[b]	5.4[b]	0.3	< 0.01
Digestibility, %	35.8[a]	55.5[b]	48.0[a,b]	51.6[b]	5.5	0.10
Fat						
Intake, lb/day	0.8[a]	1.5[b]	1.4[b]	1.4[b]	0.1	< 0.01
Digestibility, %	85.9	89.3	88.2	87.4	2.1	0.73

[1]WDGS = wet distillers grains plus solubles; MDGS = modified distillers grains plus solubles; DDGS = dried distillers grains plus solubles.
[a,b]Means with different superscripts differ ($P < 0.10$)

Procedure

Six ruminally cannulated steers (BW = 1,150 lb) were used in a 4 x 6 unbalanced Latin square to determine the effects on nutrient metabolism when distillers grains are dried. An unstructured treatment design was used. Treatments consisted of a corn control and WDGS, MDGS, or DDGS included at 40% of the diet DM. Corn fed in all treatments was a 60:40 blend of high-moisture:dry-rolled corn and all diets contained 15% corn silage and 5.0% supplement. The feed ingredients were the same source as the feedlot study previously reported (*2011 Nebraska Beef Cattle Report, pp. 50-52*).

Period duration was 21 days, including a 14-day adaptation period followed by a 7-day pH data and a 5-day fecal sample collection period. Chromic oxide (7.5g/dose) was dosed intraruminally at 0800 and 1600 hour daily beginning on day 15 in each period to estimate fecal output. Fecal samples were collected daily at 0700, 1200, and 1600 hour on day 17 to day 20, composited by period, and analyzed for chromium content to determine nutrient digestibility. Steers were fed once daily at 0800 hours and feed refusals were collected at this time. Continuous pH measurements were taken using wireless pH probes placed in the rumen. Measurements were taken every minute and data were downloaded at the end of each collection period.

Data were analyzed as a unbalanced Latin square design using the MIXED procedure of SAS (SAS Institute, Cary, N.C.). Period was included in the model as a fixed effect, and the random effect was steer.

Results

Data for nutrient intake and digestibility are presented in Table 1. Treatment did not affect DMI or digestibility of DM or OM ($P > 0.73$). Steers fed diets containing distillers grains had greater NDF intake compared to CON ($P < 0.01$). There were no differences for NDF digestibility between WDGS, MDGS, and DDGS ($P > 0.37$). However, CON diets had lower NDF digestibility ($P < 0.06$) compared to WDGS and DDGS. Fat intake was greater for diets containing DG ($P < 0.01$); however, fat digestibility was not different ($P = 0.73$).

Rumen pH data are presented in Table 2. Average ruminal pH tended to be impacted ($P = 0.14$) by dietary treatment with steers fed DDGS having a greater pH ($P < 0.09$) than steers

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fed CON, MDGS, and WDGS, which were not different from one another ($P > 0.73$). Minimum pH was greatest for DDGS ($P < 0.01$). Diets containg WDGS and MDGS were not different, but WDGS was greater than CON ($P = 0.06$). Maximum pH was not different between diets ($P = 0.29$). Time below pH 5.6, pH magnitude, and pH variance were not different between treatments ($P > 0.11$). Diets containing WDGS had a greater area of pH below 5.6 compared to CON, MDGS, and DDGS ($P = 0.02$).

The lack of difference for intake and digestibility of DM, OM, NDF, and fat intake and digestibility between WDGS, MDGS, and DDGS does not explain the difference in the feeding value observed in the feedlot study (*2011 Nebraska Beef Cattle Report,* pp. 50-52). Minor differences in pH measurements do not explain differences in feeding value either. Additional research needs to be conducted to determine why the energy value of DG is negatively affected during the drying process.

Table 2. Effects of diet on ruminal pH.

	Treatment[1]					
	CON	WDGS	MDGS	DDGS	SEM	*P*-value
Average pH	5.73	5.70	5.69	5.92	0.08	0.14
Maximum pH	6.53	6.42	6.36	6.87	0.07	0.29
Minimum pH	5.05[a]	5.16[b]	5.13[a,b]	5.36[c]	0.07	< 0.01
pH Magnitude	1.46	1.29	1.20	1.16	0.13	0.27
pH Variance	0.139	0.087	0.096	0.097	0.019	0.11
Time < 5.6, min/day	496	695	560	309	127	0.23
Area < 5.6	106[a]	224[b]	128[a]	106[a]	38	0.02

[1]WDGS = wet distillers grains plus solubles; MDGS = modified distillers grains plus solubles; DDGS = dried distillers grains plus solubles.
[a,b]Means with different superscripts differ ($P < 0.10$)

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Effect of Feeding More Than 70% Wet Distillers Grains Plus Solubles On Feedlot Cattle Performance

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Summary

A finishing trial evaluated effects of feeding greater than 70% wet distillers grains plus solubles (WDGS) on feedlot cattle performance. The WDGS was fed at 40, 70, 77, and 85% of diet dry matter (DM), while roughage levels ranged from 5 to 25% across treatments. Larger ADG and G:F were observed with 40% WDGS and 5% roughage. Higher levels of WDGS were successfully fed with levels of roughage above 8% but the diets were less profitable than the 40% WDGS diet.

Introduction

Replacing corn up to 50% of diet DM as WDGS resulted in superior performance compared to cattle fed 0% WDGS (*2010 Nebraska Beef Cattle Report,* pp. 61-62). The feeding value was consistently greater for WDGS up to 50% of diet DM, compared to corn. Incidences of polioencephalomalacia (polio) increased slightly when cattle were fed diets above 0.46% sulfur and dramatically increased when greater than 0.56% with roughages at 5-7% (*2009, Nebraska Beef Report,* pp. 79-80*; 2010 Nebraska Beef Cattle Report*, pp. 68-69). Polio risk is decreased when roughage level is maintained or increased in the ration. Another trial (*2009, Nebraska Beef Cattle Report,* pp. 76-78) determined effects of feeding WDGS with or without corn on feedlot performance. The objectives of our study were to evaluate the effects of feeding increased amounts of WDGS with typical or increasing levels of roughage on feedlot cattle performance and economics.

Procedure

A finishing study was conducted using 336 crossbred steers (BW = 741 ± 20 lb) that were assigned randomly (8 steers/pen) in a randomized complete block design. Two consecutive day individual weights were collected for initial BW. Cattle were stratified by BW within respective weight block and assigned randomly to 42 pens. Seven treatments included: 1) control (CON) of 85% dry-rolled corn (DRC), 4.7% wheat straw, and 5.0% molasses; 2) (40-5) 40% WDGS, 50.3% DRC, and 4.7% wheat straw, ; 3) (70-8) 70% WDGS, 16.8% DRC, and 8.2% wheat straw; 4) (77-9) 77.5% WDGS, 8.4% DRC, and 9.1% wheat straw; 5) (85-10) 85% WDGS and 10% wheat straw; 6) (77-17) 77.5% WDGS and 17.5% wheat straw; 7) (70-25) 70% WDGS and 25% wheat straw all on a DM basis. Table 1 provides DM, fat, CP, and S of WDGS used in this trial. All diets contained a supplement at 5.0%, which was to keep the Ca:P ratio at a minimum of 1.2 to 1. Supplements also were formulated to provide Rumensin at 30 g/ton DM , Tylan at 90 mg/steer/day, and thiamine at 130 mg/steer/day.

An adaptation period of 21 days was utilized and steers received Revelor-XS on day 1 of the feeding trial. Steers on treatments CON, 40-5, 70-8, and 77-17 were fed for 183 days, from November to May, and steers on treatments 85-10, 77-17, and 70-25 were fed for 225 days, from November to June, to achieve similar final BW. Steers were harvested at a commercial abattoir (*Greater OmahPack, 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 carcass adjusted performance of final BW, ADG, and feed efficiency.

Weekly feed samples were taken for DM analysis using a 60 forced air oven for 48-hours. Composite samples for each ingredient over the feeding period were analyzed for CP, fat, and sulfur (S).

Finishing Economics

Budgets were created for all seven diets using the average 2008 five-area yearly weighted direct slaughter steer live price from USDA Market News Service ($93.13/cwt). Initial steer price was calculated as the average initial BW of pens multiplied by $126.39/cwt to make the CON steers profit equal zero. The price of corn was set at $3.50/bu, WDGS price was constant at 85% the price of corn, and wheat straw was constant at $72.70/DM ton (delivered and processed). Yardage was charged at $0.40 per steer daily with health and processing costs of $20 per steer and a death loss of 1.5%. Interest was estimated as 8.0% 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

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Table 1. Composition of diets.

	Corn				No corn		
Ingredient	CON	40-5	70-8	77-9	85-10	77-17	70-25
WDGS[1]	—	40	70	77-5	85	77.5	70
DRC[2]	85	50.3	16.8	8.4	—	—	—
Wheat straw	4.7	4.7	8.2	9.1	10	17.5	25
% Sulfur	0.11	0.41	0.63	0.68	0.74	0.68	0.63
% Fat	3.61	7.23	9.66	10.26	10.80	9.90	9.00

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

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.

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

Performance Results

Two steers were pulled from the trial for respiratory illness, and no steers were diagnosed with polio. Cattle performance data are summarized in Table 2. Treatments 85-10, 77-17, and 70-25 were fed for a total of 225 days to achieve similar final BW, where treatments CON, 40-5, 70-8, and 77-9 were fed for 183 days. Steers fed the 40-5 had the greatest ($P < 0.01$) ADG, F:G, and HCW; however, F: G was similar to steers fed the 77-9. Steers fed 70-25 had the least ($P < 0.01$) ADG, F:G, and HCW. DMI was the greatest ($P < 0.05$) for the 40-5 and CON followed by the 70-8 and 77-17 steers, 77-9, and lastly the 70-25 and 85-10 steers. Steers being fed the CON, 70-8, and 77-9 had similar ADG, followed by steers fed 77-17, then 85-10, which were different ($P < 0.01$). Steers fed CON, 85-10, and 77-17 had similar G:F ($P > 0.10$) but less ($P < 0.05$) than 40-5, 70-8, and 77-9. However, steers fed 85-10, 77-17, and 70-25 were fed 42 days longer. Carcass characteristics also are reported in Table 2. Overall, 40-5 had the greatest and 70-25 had the least marbling scores, LM area, 12th rib fat, and YG when compared to the other treatments. Marbling score was greatest ($P < 0.05$) for CON and 40-5, least ($P < 0.05$) for 70-25, and intermediate for the other treatments. Fat depth at the 12th rib was greatest for the 40-5 treatment, followed by the intermediate treatments and CON having subtle differences. The lowest rib fat was observed for cattle fed the 70-25 treatment.

Table 2. Performance results for treatments.

Dietary Treatment[1]:	CON	40-5	70-8	77-9	85-10	70-17	70-25	SEM
Performance								
DOF	183	183	183	183	225	225	225	—
Initial BW, lb	594	595	593	593	595	593	593	9
Final BW, lb	1254[b]	1389[a]	1261[b]	1246[b]	1242[b]	1282[b]	1153[c]	15
DMI, lb/day	22.6[b]	22.9[a]	20.2[b]	19.1[c]	17.8[d]	19.1[bc]	18.2[d]	0.24
ADG, lb	3.60[a]	4.33[a]	3.65[b]	3.57[b]	2.88[d]	3.07[c]	2.49[e]	0.06
F:G	6.25[b]	5.29[a]	5.52[b]	5.35[ab]	6.17[c]	6.37[c]	2.63[d]	—
Carcass Characteristics								
HCW, lb	790[b]	875[a]	795[b]	785[b]	783[b]	807[b]	726[c]	9.62
Marbling score	525[a]	523[a]	491[b]	468[bc]	457[c]	467[bc]	404[d]	9.12
LM area, in^2	12.35[ab]	12.[9a]	12.22[bc]	12.10[bc]	11.63[c]	11.75[c]	11.97[bc]	0.002
12th rib fat, in	0.42[c]	0.61[a]	0.48[bc]	0.44[bc]	0.43[c]	0.5[b]	0.27[d]	0.02
YG	3.0[de]	3.7[a]	3.4[bc]	3.2[cde]	3.3[cd]	3.6[ab]	2.5[f]	0.1

[1]CON = control diet of 85% DRC; 40-5 = 40% WDGS and 5% wheat straw; 70-8 = 70% WDGS and 8% wheat straw; 77-9 = 77% WDGS and 9% wheat straw; 85-10 = 85% WDGS and 10% wheat straw; 77-17 = 77% WDGS and 17% wheat straw; 70-25 = 70% WDGS and 25% wheat straw.
[a,b,c,d,e,f]Within a row, means without common superscript differ (P<0.05).

Table 3. Effect of Inclusion of WDGS on economics when corn is \$3.50/bu and WDGS is 85% the price of corn.

	Treatments[1] (%DM)						
Dietary Treatments[1]	CON	40-5	70-8	77-9	85-10	77-17	70-25
BE, \$/cwt[2]	93.13	84.18	89.87	89.52	95.42	91.73	101.20
P/L, \$/head[3]	0.00	124.33	54.61	45.02	-28.42	17.97	-93.04
COG, \$/cwt[4]	64.00	52.90	55.35	55.94	67.58	61.90	75.02

[1]CON = control diet of 85% DRC; 40-5 = 40% WDGS and 5% wheat straw; 70-8 = 70% WDGS and 8% wheat straw; 77-9 = 77% WDGS and 9% wheat straw; 85-10 = 85% WDGS and 10% wheat straw; 77-17 = 77% WDGS and 17% wheat straw; 70-25 = 70% WDGS and 25% wheat straw.
[2]Breakeven (BE) = (initial steer cost (\$126.39/cwt) + feed cost[5] + interest[6] + health&processing[7] + yardage[8] + deathloss[9]) / FW.
[3]Profit/Loss (P/L) = final steer value (\$93.13/cwt) – (initial steer cost (\$126.39/cwt) + feed cost[5] + interest[6] + health & processing[7] + yardage[8] + deathloss[9]).
[4]Cost of Gain (COG) = (feed cost[5] + interest[6] + health&processing[7] + yardage[8] + deathloss[9]) / (FW-IW).
[5]Feedcost = DRC(\$3.50/bu); WDGS (\$125/DM ton); Wheat straw (\$72.70/DM ton).
[6]Interest = 8.0% interest applied to initial steer value (initial BW * \$126.39/cwt) and to feed costs.
[7]Health & Processing = \$20/steer applied
[8]Yardage = \$0.40/steer/d applied
[9]Death loss = 1.5% death loss applied

Economic Results

When corn is priced at \$3.50/bu and WDGS is 85% the cost of corn, then the 70-25 treatment had the greatest breakeven value at \$101.20. The 40-5 treatment had the lowest breakeven value at \$84.18/cwt, followed by the 77-9, 70-8, 77-17, CON, and lastly 85-10. When CON is equal to zero, the greatest loss is seen with the 70-25 treatment at -\$93.04/head followed by 85-10, and the greatest profit is observed with the 40-5 treatment with \$124.33 followed by the 70-8, 77-9, and lastly the 77-17. Likewise, COG was greatest for the 70-25 treatment, followed by the 85-10, and 77-17 due to these treatments having lower final BW and extended DOF. The 40-5 treatment has the least COG, followed by the 70-8 and 77-9, which were similar, and lastly CON with a COG at \$64.00/cwt. Treatments with the blend of WDGS and some inclusion of corn (70-8, 77-9) had greater profit, lower COG, and lower breakeven prices than the treatments with no corn (85-10, 77-17, 70-25) or the CON treatment.

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Effects Of Feeding A Combination Of Modified Distillers Grains Plus Solubles and Wet Corn Gluten Feed to Adapt Cattle to Finishing Diets

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Summary

Two 39-day metabolism trials were conducted using a combination of modified distillers grains and wet corn gluten feed (Synergy, ADM) to adapt beef cattle to finishing diets (SYNERGY). During adaptation, DMI expressed as % of BW tended to be greater for steers on traditional grain adaptation with forage (CON) compared to SYNERGY during the first period (steps 1), but was not different in subsequent adaptation diets (steps 2, 3, and 4). Average ruminal pH was lower for SYNERGY on steps 1 and 2 compared to CON in Experiment 1 with no difference observed in Experiment 2. No difference in ruminal pH was observed between treatments for steps 3 and 4. Both adaptation methods resulted in safe ruminal pH and H_2S concentrations (<36μmol/L gas). Significant difference was observed for DM digestibility (DMD) between treatments during step 1 with higher values for the SYNERGY treatment.

Introduction

Metabolism and feedlot research using wet corn gluten feed produced by Cargill (Sweet Bran®; Blair, Neb.) to adapt beef cattle found that decreasing Sweet Bran instead of forage is a viable method for adapting feedlot cattle to feedlot finishing diets (2009 *Nebraska Beef Cattle Report,* pp. 53-55, 56-58). A metabolism trial has been conducted using wet distillers grains plus solubles (WDGS) to adapt cattle, and the results suggest WDGS may be used instead of forage, but no performance data are available and DMI was lower for the WDGS treatment initially (2010 *Nebraska Beef Cattle Report,* pp. 66-67). Therefore, the objective of this study was to test a combination of modified distillers grains plus solubles (MDGS) and wet corn gluten feed (WCGF), and evaluate the responses in ruminal pH, intake, H_2S concentration, *in situ* fiber digestibility, and DM digestibility when compared to the traditional forage method of cattle adaptation to finishing diets. The combination of MDGS and WCGF was similar to a new feed produced by ADM (Synergy, Columbus, Neb.).

Procedure

Experiment 1

Six yearling crossbred steers (BW = 891 ± 44 lb) with rumen fistula were brought off pasture following summer grazing to represent yearlings that would enter a feedlot. Steers were assigned randomly into one of two adaptation treatments in a CRD with three steers per treatment. One week before the start of the experiment, the steers were fed 20 lb/day of grass hay (DM). Table 1 represents diets for the SYNERGY and CON treatments. SYNERGY steers were fed decreasing levels of the MDGS and WCGF combination (87.5% to 30%) while CON animals were fed the traditional grain adaptation diets with decreasing forage from 45% to 7.5%. In both adaptation schemes, dry-rolled corn increased (up to 57.5%). Cattle were fed *ad libitum* once daily. Five adaptation diets were used to increase corn with diets fed

(Continued on next page)

Table 1. Adaptation and finishing diets using a combination of WCGF and MDGS compared to forage during the adaptation period.

Days fed:	1 to 9	10 to 16	17 to 23	24 to 30	31 to 39
Adaptation:	Step 1	Step 2	Step 3	Step 4	Finisher
CONTROL					
DRC[1]	20	30	40	50	57.5
Alfalfa	45	35	25	15	7.5
MDGS[2]	18	18	18	18	18
WCGF[3]	12	12	12	12	12
Supplement[3]	5	5	5	5	5
SYNERGY					
DRC[1]	0	14.4	28.8	43.2	57.5
Alfalfa	7.5	7.5	7.5	7.5	7.5
MDGS[2]	52.5	43.9	35.2	26.6	18
WCGF[3]	35	29.2	23.5	17.7	12
Supplement[3]	5	5	5	5	5

[1]DRC: Dry-rolled corn.
[2]MDGS: Modified distillers grains plus solubles.
[3]WCGF: Wet corn gluten feed.
[4]Supplement formulated to provide 90 mg/head/day of tylosin, 360 mg/head/day of monensin and 150 mg/head/day of thiamine.

Table 2. Analyzed nutrient analysis for feeds fed, % DM.

Analysis	MDGS	WCGF	DRC	Alfalfa
DM	62.5	44.1	86.4	87.8
CP	32.5	21.3	7.9	18.6
Ether Extract	11.3	3.3	3.9	0.9
NDF	38.6	54.7	10.4	63.9
Sulfur	0.81	0.48	0.11	0.29
Ash	0.06	0.04	0.01	0.09

Table 3. **Experiment1 results for DMI, ruminal pH, H_2S production, and total tract DM digestibility for the adaptation period when comparing forage and co-product diets to adapt cattle to a high grain finishing diet.**

	Adaptation 1			Adaptation 2			Adaptation 3			Adaptation 4		
Treatments	Control	Synergy	*P*-value	Control	Synergy	*P*-value	Control	Synergy	*P*-value	Control	Synergy	*P*-value
DMI, % BW	2.32	2.05	0.09	2.72	2.37	0.18	2.93	2.67	0.34	2.98	2.79	0.37
Average pH	6.18	5.76	<0.01	6.07	5.75	<0.01	5.89	5.84	0.44	5.62	5.67	0.75
Maximum pH	6.38	6.54	<0.01	6.66	6.32	<0.01	6.52	6.41	0.11	6.27	6.36	0.63
Minimum pH	5.8	5.48	<0.01	5.48	5.4	0.24	5.31	5.36	0.53	5.1	5.26	0.36
pH variance	0.03	0.05	0.23	0.06	0.04	0.17	0.07	0.04	0.02	0.07	0.05	0.04
Area <5.6[1]	6.85	21.44	0.29	6.7	40.3	0.03	51.54	48.8	0.92	191.64	149.04	0.65
Time <5.6, min.	82.3	173.1	0.38	36.55	411.03	0.02	307.29	318.94	0.93	740.43	688.74	0.81
H_2S, μmol/L	24.81	13.94	0.2	24.49	6.11	<0.01	31.12	23.51	0.52	36.36	24.05	0.35
DM digestibility, %	57.69	67.96	0.05									

[1]Area under curve (magnitude of pH < 5.6 by minute).

9, 7, 7, 7, and 9 days, respectively. The last 9-day period consisted of a common finishing diet containing *Synergy* at 30% of diet DM. All diets provided 320 to 360 mg/steer of Rumensin, 90 mg/steer of Tylan, and 150 mg/steer of thiamine daily. Steers were fed once daily at 0800, and feed refusals were collected and dried to calculate DMI. Intake and pH (wireless pH probes) measurements were collected every minute during the entire study. Ruminal gas samples were collected eight hours post feeding on the last two days of each period, and H_2S concentrations were analyzed. Dacron bags (50 mm pore size) containing alfalfa and corn bran were incubated for 24 and 32 hours each to determine *in situ* NDF digestibility. Chromic oxide (Cr_2O_3) was intraruminally dosed at 7.5g at 0700 and 1700 hour daily during the first and last period of the study to determine total tract digestibility. Fecal samples were collected at 0600, 1200, and 1800 hour on days 6, 7, 8, and 9 (step 1) and also days 36, 37, 38, and 39 (finisher period). Fecal composites were analyzed via atomic absorption spectrophotometer for quantification of chromium.

Table 4. **Experiment 1 results for DMI, ruminal pH, H_2S production and DM digestibility during finishing diet.**

Treatments	Control	Synergy	SEM	P-value
DMI, % BW	2.85	2.80	0.11	0.74
Average pH	5.61	5.80	0.19	<0.01
Maximum pH	6.23	6.41	0.09	0.13
Minimum pH	5.36	5.18	0.06	0.02
pH variance	0.06	0.04	0.006	0.02
Area <5.6[1]	170.61	39.67	50.49	0.06
Time <5.6, min.	731.21	320.29	149.90	0.05
Area <5.3[1]	26.61	0.18	12.68	0.10
Time <5.3, min.	242.47	8.57	97.67	0.07
H_2S, μmol/L	22.44	22.14	12.79	0.98
DMD, %	67.89	70.68	2.77	0.51

[1]Area under curve (magnitude of pH < 5.6 by minute).

Experiment 2

Six fistulated calf-fed steers (BW = 564 ± 30 lb) were used to repeat Experiment 1 for DMI, ruminal pH, and total tract DM digestibility.

The same methods of data collection and statistical analyses described for Experiment 1 were applied to Experiment 2, except H_2S concentration and *in situ* NDF digestibility were not measured on Experiment 2.

Data were analyzed using the GLIMMIX procedure of SAS. Steer was considered the experimental unit, and the residual was used to test for treatment effects. Variables were DMI, ruminal pH, ruminal H_2S concentration, *in situ* fiber digestibility and total tract DM digestibility, for the first adaptation diet and the finishing diet.

Results

Experiment 1

During adaptation, DMI expressed as % of BW tended ($P = 0.09$) to be greater for steers fed CON compared to SYNERGY during step 1, but was

Table 5. **Experiment 2 results for DMI, ruminal pH, H_2S production, and total tract DM digestibility for the adaptation period when comparing forage and co-product diets to adapt cattle to a high grain finishing diet.**

	Adaptation 1			Adaptation 2			Adaptation 3			Adaptation 4		
Treatments	Control	Synergy	*P*-value	Control	Synergy	*P*-value	Control	Synergy	*P*-value	Control	Synergy	*P*-value
DMI, % BW	2.33	1.95	0.14	2.68	2.76	0.64	2.93	2.71	0.08	3.15	2.8	0.32
Average pH	6.1	6.61	0.29	6.22	6.15	0.59	6.23	6.13	0.33	6.06	5.95	0.31
Maximum pH	6.75	6.75	0.99	6.88	6.65	0.33	6.92	6.5	0.16	6.87	6.46	0.18
Minimum pH	5.53	6.31	0.19	5.17	5.27	0.88	5.61	5.78	0.13	5.54	5.53	0.95
pH variance	0.24	0.18	0.15	0.27	0.21	0.25	0.29	0.15	0.07	0.27	0.19	0.22
Area <5.6[1]	2.63	5.33	0.49	7.23	4.77	0.71	2	0	0.15	3.54	4.91	0.77
Time <5.6, min.	38.29	108.84	0.28	9.5	6.53	0.73	28.16	0	0.14	52.39	10.22	0.26
DM digestibility, %	57.58	68.64	0.27									

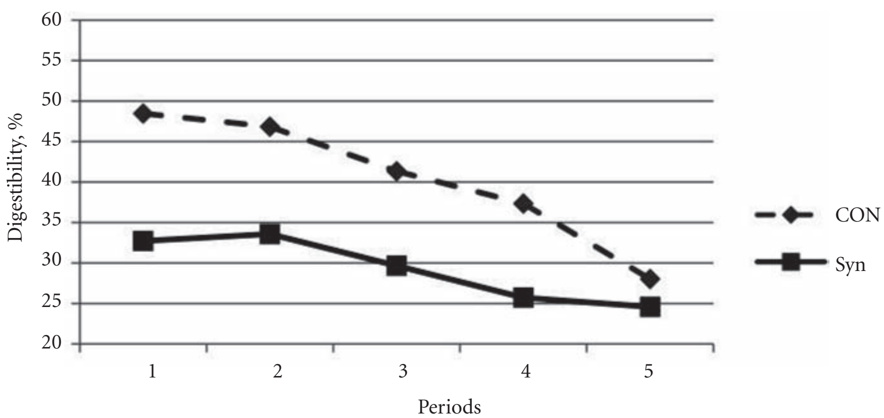
[1]Area under curve (magnitude of pH < 5.6 by minute).

Table 6. **Experiment 2 results for DMI, ruminal pH, H_2S production and DM digestibility during finishing diet.**

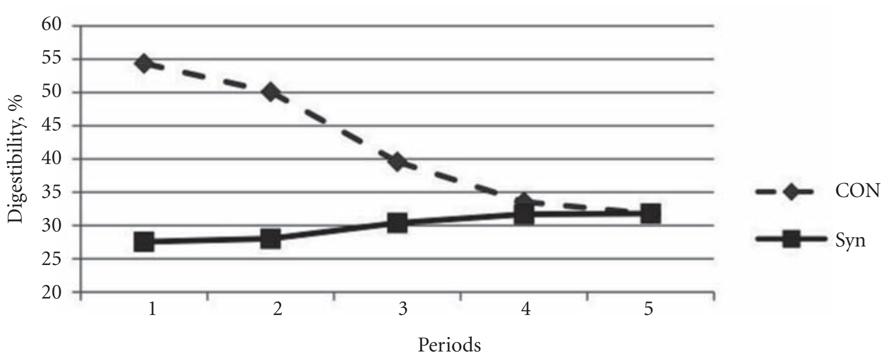
Treatments	Control	Synergy	SEM	P-value
DMI, % BW	3.17	3.08	0.21	0.66
Average pH	5.91	6.14	0.06	0.03
Maximum pH	6.36	6.88	0.05	<0.01
Minimum pH	5.47	5.62	0.05	0.05
pH variance	0.18	0.26	0.02	0.03
Area <5.6[1]	6.88	0.96	3.32	0.17
Time <5.6, min.	92.11	19.97	43.87	0.20
DMD, %	56.64	73.07	4.03	0.02

[1]Area under curve (magnitude of pH < 5.6 by minute).

In situ **NDF digestibility (alfalfa)**



In situ **NDF digestibility (corn bran)**



Figures 1 and 2 represent the *in situ* digestibility during the four adaptation steps and finishing diet for forage and byproduct treatments for alfalfa and corn bran NDF digestibility (32 hour time frame).

not different in subsequent adaptation diets ($P > 0.20$). Average pH was lower ($P < 0.01$) for SYNERGY on step 1 and 2 compared to CON (5.76 vs. 6.18; 5.75 vs. 6.07, respectively). No difference ($P > 0.44$) was observed between treatments for ruminal pH during steps 3 and 4. Average pH was lower ($P < 0.01$) for CON on the last period when both treatments were being fed the same diet (5.61 vs. 5.80), suggesting that SYNERGY adaptation treatment may have a positive effect with finishing diets containing 30% of the *Synergy* product. Area and time below pH 5.6 followed the same pattern with greater values (21.44 and 173.10 vs. 6.85 and 82.30) on the second period ($P < 0.03$) and lower values (39.67 and 320.29 vs. 170.61 and 731.21) during the finisher period ($P < 0.06$) for the SYNERGY compared to CON. Variance of pH was significantly different on the last three periods with higher values for animals fed the CON diets. Both adaptation methods resulted in average ruminal pH (> 5.6). H_2S concentrations observed were always lower than 36µmol/L gas with the SYNERGY treatment group being less than the CON group. Statistical difference ($P < 0.10$) was observed for DM digestibility between treatments for step 1, with higher values for the SYNERGY treatment, and no difference was observed during the finishing diet. A three-way interaction was observed for the *in situ* DMD for type of feed (alfalfa and corn bran), time (24 and 32 hours) and whether incubated in CON or SYNERGY steers. One time was chosen (32 hours) to represent the trends observed for NDF digestibility, and it is presented in Figure 1. Corn bran was more digestible during all adaptation periods compared to alfalfa.

Experiment 2.

DMI expressed as % of BW was greater for steers fed CON compared to SYNERGY during the third period, but was not different during other adaptation periods ($P > 0.14$). Average pH was only different ($P < 0.03$) during the finishing period with greater values for SYNERGY (6.14 vs. 5.91). No difference ($P > 0.29$) was observed between treatments in ruminal pH for adaptation 1, 2, 3, and 4. Area and time below pH 5.6 were not significantly different among treatments during Experiment 2 in any of the periods. Variance of pH was significantly different in Adaptation 3 with higher values for animals fed the CON diets. However, DM digestibility was numerically greater ($P < 0.27$) for the SYNERGY treatment compared to CON (68.64 vs. 57.58) during step 1, and significant in the finisher.

Results suggest that decreasing inclusio of a combination of distillers grains and gluten feed was as effective as the traditional method using forage for adapting feedlot cattle to high-concentrate diets.

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Effect of Source and Level of Sulfur on Rumen Metabolism and Finishing Performance

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Summary

Five ruminally fistulated steers fitted with rumen gas extraction cannula plugs were utilized to quantify ruminal pH and hydrogen sulfide (H_2S) levels produced at different times post feeding. Diets consisted of 1) 28.5% WDGS, 37.5% Sweet Bran®, 4% corn bran, 0% alfalfa hay; 2) 28.5% WDGS, 37.5% Sweet Bran, 7.5% alfalfa, 4% corn bran; 3) 44% WDGS, 44% Sweet Bran, 7.5% alfalfa; 4) 50% WDGS, 37.5% DRC, 7.5% alfalfa; and 5) 87.5% Sweet Bran, 7.5% Aafalfa. Dry matter intake was different ($P = 0.05$) across treatments. Steers fed diets containing 44% WDGS and 44% Sweet Bran had greater ($P < 0.01$) levels of H_2S compared to other diets; however, cattle fed 87.5% Sweet Bran produced less ($P < 0.05$) H_2S compared to the other four dietary treatments.

Introduction

In past finishing studies, feedlot cattle fed diets containing corn milling byproducts with dietary sulfur levels of 0.45% (2010 Journal of Animal Science, 88:1061-1072) and 0.48% (Wilken et al., *2009 Nebraska Beef Report*, pp. 76-78) have been shown to induce polioencephalomalacia (polio); however, other diets with similar % sulfur did not. A summary of byproduct research (Vanness et al., *2009 Nebraska Beef Cattle Report*, pp. 79-80) conducted at the University of Nebraska–Lincoln concluded cattle can tolerate up to 0.46% sulfur with minimal risk of polio (0.1% polio). Vanness et al. (*2009 Nebraska Beef Cattle Report*, pp. 81-83) observed a negative correlation between ruminal pH and ruminal H_2S concentration and concluded that dietary roughage level is important in order to minimize the risk of polio. The objective of our study was to determine impact of source and level of sulfur on ruminal pH, continuous DMI, and H_2S in beef cattle finishing diets.

Procedure

Five ruminally cannulated crossbred yearling steers (initial BW=739±40 lb) were used in a 5x5 Latin square designed experiment. The five diets consisted of 1) 28.5% wet distillers grains plus solubles (WDGS), 37.5% Sweet Bran (Cargill; Blair, Neb.), 25% dry-rolled corn (DRC), and 4% corn bran; 2) 28.5% WDGS, 37.5% Sweet Bran, 17.5% DRC, 7.5% alfalfa, and 4% corn bran; 3) 44% WDGS, 44% Sweet Bran, and 7.5% alfalfa; 4) 50% WDGS, 37.5% DRC, and 7.5% alfalfa; and 5) 87.5% Sweet Bran and 7.5% alfalfa (DM basis; Table 1). All diets included 5% supplement which provided 30 g/ton Rumensin (Elanco Animal Health; Greenfield, Ind.), 90 mg/steer daily Tylan (Elanco Animal Health), and 130 mg/steer daily thiamine. Steers were fed for *ad libitum* intake once daily at 0800. Periods were 14 days long with an 11 day adaptation to the diet and a 3 day collection period.

Steers were housed in individual pens with bunks suspended from load cells. Feed amounts were determined and feed refusal weighed, if present, before the 0800 feeding. Wireless pH probes were inserted before the 0800 feeding on the first collection day. The probes were used to collect continuous ruminal pH measurements every minute. Ruminal pH data were recorded onto a data logger, which was downloaded before the start of the 0700 period.

Gas samples were collected twice daily (8 and 12 hours post feeding) on the last three days of each period. Rumen gas collection was achieved by inserting a 21-inch artificial insemination pipette straw into a specially equipped cannula plug. Twenty mL of rumen gas was extracted from the rumen by use of a 35-mL syringe. Five mL of gas was injected into a 30-mL glass serum bottle with a rubber stopper. The rumen gas samples were later analyzed for H_2S. This process was replicated six times per animal.

Data were analyzed as a 5x5 Latin square using the Glimmix procedure of SAS (SAS Institute, Cary, N.C.). Animal was treated as a random effect with treatment being a fixed effect.

Results

Dry matter intake was significantly impacted by dietary treatments ($P = 0.05$; Table 2). Steers fed Diet 2 (28.5% WDGS, 37.5% Sweet Bran, 7.5% alfalfa) consumed more feed (24.8 lb) compared to cattle fed Diet 3 (22.5 lb; 44% WDGS, 44% Sweet

Table 1. Diet compositions and dietary sulfur level of experimental diets (DM basis).

Item	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5
WDGS	28.5	28.5	44.0	50.0	0
Sweet Bran®	37.5	37.5	44.0	0	87.5
DRC	25.0	17.5	0	37.5	0
Alfalfa	0	7.5	7.5	7.5	7.5
Corn Bran	4.0	4.0	0	0	0
Supplement[1]	5.0	5.0	5.0	5.0	5.0
Nutrient composition					
Sulfur, % DM	0.45	0.46	0.58	0.45	0.46

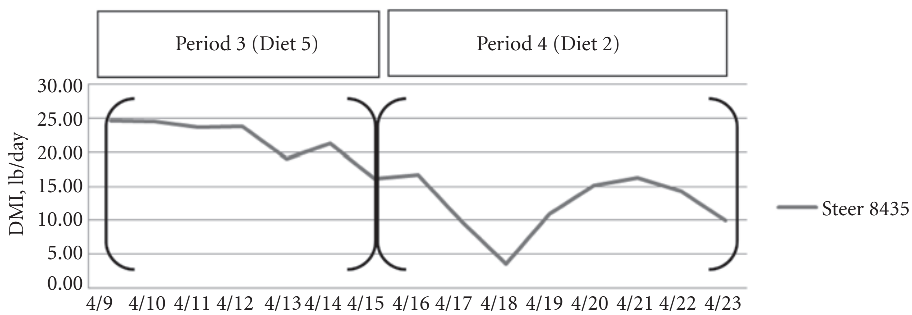
[1]Supplement formulated to provide 30 g/ton Rumensin, 90 mg/head/day Tylan, and 130 mg/head/day thiamine.

Table 2. Effect of source and level of sulfur on intake, ruminal pH, and H_2S[1].

Item	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	SEM	*P*-value
DMI, lb/day	23.5^{ab}	24.8^{a}	22.5^{b}	23.9^{ab}	24.4^{a}	1.56	0.05
Average pH	5.67	5.90	5.96	5.89	6.11	0.13	0.22
Maximum pH	6.30	6.55	6.70	6.59	6.69	0.13	0.20
Minimum pH	5.28	5.38	5.48	5.36	5.61	0.09	0.11
pH variance	0.05	0.06	0.07	0.08	0.05	0.06	0.58
Time <5.6, min/day	656.7^{a}	145.1^{b}	150.9^{b}	461.1^{ab}	116.9^{b}	133.5	0.03
Area <5.6, min/day[2]	90.3	11.3	15.8	84.7	16.8	28.0	0.10
H_2S[3]	46.2^{a}	48.4^{a}	61.1^{b}	50.3^{a}	32.3^{c}	6.81	<0.01
Sulfur, g/day[4]	48.8	49.9	60.6	49.4	50.3		

[abc]Within a row means without a common superscript differ ($P < 0.05$).
[1]**Diet 1** = 28.5% WDGS, 37.5% Sweet Bran, no Alfalfa; **Diet 2** = 28.5% WDGS, 37.5% Sweet Bran 7.5% Alfalfa; **Diet 3** = 44% WDGS, 44% Sweet Bran, **Diet 4** = 50% WDGS, **Diet 5** = 87.5% Sweet Bran.
[2]Area under curve is magnitude of pH <5.6.
[3]Values are µmol hydrogen sulfide/L rumen gas collected.
[4]Grams of sulfur consumed per treatment diet per day.

Table 3. Dry matter intake of steer that had to be removed from trial due to polio.



Bran). Rumen H_2S levels were also impacted ($P < 0.01$) by dietary treatment. Diet 5 (87.5% Sweet Bran) produced the lowest (31.6 µmol H_2S/L, $P < 0.05$) level of H_2S compared to the other four treatments. Diet 3 (44% WDGS, 44% Sweet Bran) produced the greatest (61.1, $P < 0.05$) level of H_2S compared to the other treatments. Steers fed Diet 3 (44% WDGS, 44% Sweet Bran) ingested 60.6 g/day of sulfur which was about 10 g more than that of the 87.5% Sweet Bran diet (50.3 g/day). The dietary sulfur level of Diet 3 (44% WDGS, 44% Sweet Bran) was 0.58% (DM basis) compared to Diet 5 (0.46%). Treatments 1 (28.5% WDGS, 37.5% Sweet Bran, no alfalfa), 2 (28.5% WDGS, 37.5% Sweet Bran, 7.5% alfalfa), and 4 (50% WDGS) all had the same level ($P > 0.05$) of H_2S. Dietary sulfur levels were 0.45, 0.46, and 0.45% (DM basis) respectively for diets 1, 2, and 3. Grams of sulfur ingested per day were also relatively similar across the three treatments.

Results from the current study indicate H_2S level appears to be indicative of the sulfur level of the diet. However, when steers were fed a diet that contained 87.5% Sweet Bran which had a dietary sulfur level of 0.46%, the diet promoted lower H_2S levels compared to diets that contained similar levels of sulfur (Diets 1, 2, and 4).

Rumen pH was not affected by treatment (ave. pH, max pH, and pH variance); however, time < 5.6 was greater ($P = 0.03$) for Diet 1 compared to Diets 2, 3, and 5. Diet 1 (28.5% WDGS, 37.5% Sweet Bran, no alfalfa) was not different for time < 5.6 compared to diet 4 (50% WDGS). Area < 5.6 also tended ($P = 0.10$) to be greater for diet 1 (28.5% WDGS, 37.5% Sweet Bran, no alfalfa) compared to the other treatments.

The relatively high H_2S measurements observed for the 44% WDGS, 44% Sweet Bran diet may explain some of the polio cases noted for a similar diet fed in another experiment (Wilken et al., *2009 Nebraska Beef Cattle Report*, pp. 76-78). Wilken et al. (2009) removed four steers from the trial due to polio attributed to dietary sulfur (0.59%). Similar polio cases have been noted for Diets 1 (28.5% WDGS, 37.5% Sweet Bran, 25% DRC) and 4 (50% WDGS, 37.5% DRC). Both of these diets had similar H_2S levels (Diet 1 = 46.2 µmol /L, Diet 4 = 50.3 µmol /L); however, Diet 2 (28.5% WDGS, 37.5 Sweet Bran, 17.5% DRC, 7.5% alfalfa) also had similar H_2S levels. No polio cases have been noted for cattle consuming diets similar to Diet 2 (Loza et al., *2005 Nebraska Beef Cattle Report*, pp. 45-46). Also, the dietary sulfur for Diet 5 (87.5% Sweet Bran) was closely comparable (0.46%) to Diets 1, 2, and 4 but produced significantly less H_2S (32.2 µmol /L).

During the course of the study, a steer had to be removed from the trial due to polio-related illness. During Period 4 while the steer was on Diet 2 (28.5% WDGS, 37.5% Sweet Bran, 7.5% alfalfa) the animal began exhibiting signs considered typical of a steer suffering from polio (poor coordination, disoriented, and refusing to stand). The steer was removed from the trial, treated for the illness, and died due to polio (necropsy confirmed). During Periods 1, 2, 3, and 4, the steer's DMI averaged 21.1, 22.5, 24.8, and 12.5 lb respectively. Table 3 represents the steady decline in the steer's DMI for Periods 3 and 4. Average rumen pH during Periods 1, 2, and 3 were 5.58, 5.87, and 6.29 respectively. Hydrogen sulfide gas was also collected during periods 1, 2, and 3 and were 72.6, 75.7, and 29.5 µmol/L respectively. Unfortunately, H_2S measurements were not collected at time of polio onset. Also, the diet the steer was consuming at the time of the polio insult had not produced polio in previous feedlot experiments.

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Effects of Sulfur Concentration in Distillers Grains With Solubles in Finishing Cattle Diets

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Summary

Effect of dietary sulfur on beef cattle fed diets containing wet or dry distillers grains with solubles (DGS) was evaluated. Sulfur concentration in DGS was either 0.82 or 1.16%. Steers (n = 120; IBW = 761 ± 75 lb) were individually fed ad libitum. Intake decreased when wet and dry 1.16% S DGS were fed. Gain decreased as wet DGS that was 1.16% S increased in the diet to 40%. Feeding wet DGS improved F:G, regardless of sulfur content. Fat thickness and HCW decreased as wet and dry 1.16% S DGS increased in the diet. High sulfur DGS reduced DMI and ADG when fed at high levels to cattle, but it depended on whether fed as wet or dry DGS.

Introduction

The importance of sulfur levels in beef cattle finishing diets and the consequent ruminal hydrogen sulfide (H_2S) production, due to the risk of polioencephalomalacia, has been reported (*2009 Nebraska Beef Cattle Report*, pp. 79-80; *2010 Nebraska Beef Cattle Report*, pp. 68-69). Before dietary sulfur reaches critical levels for animal health, animal growth performance also may be affected. Additionally, since dry and wet distillers grains with solubles have different energetic values, sulfur effects from these two co-products may be different. Therefore, the objective of our study was to determine the effect of dietary sulfur in beef cattle finishing diets formulated with wet or dry distillers grains with solubles that differ in S concentration.

Procedure

Cattle Background

One hundred and twenty crossbred beef steers (761 ± 75 lb BW) previously used in a growth experiment were adapted to electronic Calan gates and fed individually the experimental diets for 110 days.

Feeding and Experimental Design

Steers were allocated by weight in an unbalanced 2x2x3+1 randomized block design. Following a five-day limit feeding period (2% BW — bromegrass hay), cattle were weighed on three consecutive days, and stratified by BW based on day -1, and 0. Nine steers were assigned randomly to 1 of the 12 treatments, and 12 steers were used in a control diet (Table 1).

Cattle were implanted on day 1 with Component TE-IS and on day 77 with Component TE-S, and fed from June 12 to Oct. 12, 2009 (151 days). Cattle were adapted to a high-grain finishing diet over 21 days by increasing intake (starting with 14 lb and increasing 0.5 lb/day until *ad libitum*). As levels of co-product inclusion were applied, the 4 high (40%) inclusion and control diets were mixed daily, using Roto mix feed trucks. The control diet was mixed with the 40% inclusion to target the lower (20 and 30%) co-product inclusions. Diets and individual ingredients were sampled weekly.

Treatments and Diet Composition

Treatments (Table 1) were applied as a 2x2x3+1 factorial treatment design with factor of co-product moisture (wet or dry distiller grains), sulfur concentration (0.82 or 1.16% of DM in the co-product), and co-product level of inclusion (20, 30, and

Table 1. Dietary treatments and chemical composition of diets containing wet or dry distillers grains with solubles, with high or low sulfur concentration in the co-product, and subsequent levels of inclusion.

		DDGS[1]			WDGS[1]		
	CONTROL	20%	30%	40%	20%	30%	40%
DDGS from 0.82 or 1.16 % S	—	20.0	30.0	40.0	—	—	—
WDGS from 0.82 or 1.16 % S	—	—	—	—	20.0	30.0	40.0
High-moisture corn	48.0	36.0	30.0	24.0	36.0	30.0	24.0
Dry-rolled corn	32.0	24.0	20.0	16.0	24.0	20.0	16.0
Corn silage	15.0	15.0	15.0	15.0	15.0	15.0	15.0
Supplement [2]	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Low-sulfur diet chemical composition, % DM							
CP	13.1	14.4	14.5	16.1	13.9	13.8	15.1
Fat	4.0	5.6	6.3	7.0	5.9	6.9	7.8
NDF	14.9	19.3	21.5	23.7	18.0	19.5	21.0
Sulfur	0.13	0.26	0.33	0.40	0.26	0.33	0.40
High-sulfur diet chemical composition , % DM							
CP	—	15.1	15.7	17.7	14.6	14.9	16.9
Fat	—	5.5	6.2	6.9	6.1	7.2	7.6
NDF	—	18.2	19.8	21.4	17.1	18.1	20.0
Sulfur	—	0.33	0.43	0.54	0.33	0.43	0.54

[1]DDGS and WDGS = Dry distillers grains with solubles and wet distillers grains plus solubles, respectively.
[2]Supplement - There were three supplements for all 13 diets: one for the control, one for 20% DGS inclusion, and one for 30 + 40% DGS. All supplements were formulated to provide 30 g/ton DM Monensin, 90 mg/steer/day of Tylosin, and 150 mg/steer/day of Thiamine.

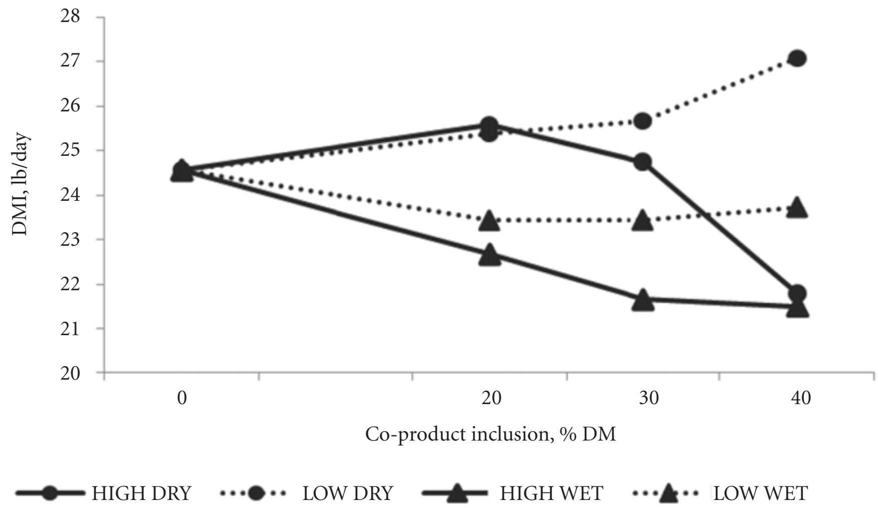

Figure 1. Dry matter intake, lb/day. High and low mean sulfur concentration in the co-product (1.16 and 0.82%, respectively); wet and dry mean diets based on WDGS and DDGS, respectively. Intake decreased linearly (*P* < 0.01)when wet 1.16% S DGS (HIGH WET) were fed; decreased quadratically (*P* < 0.01)when dry 1.16 % S DGS (HIGH DRY) were fed; and increased linearly (*P* = 0.02)when dry 0.82% S DGS (LOW DRY) were fed.

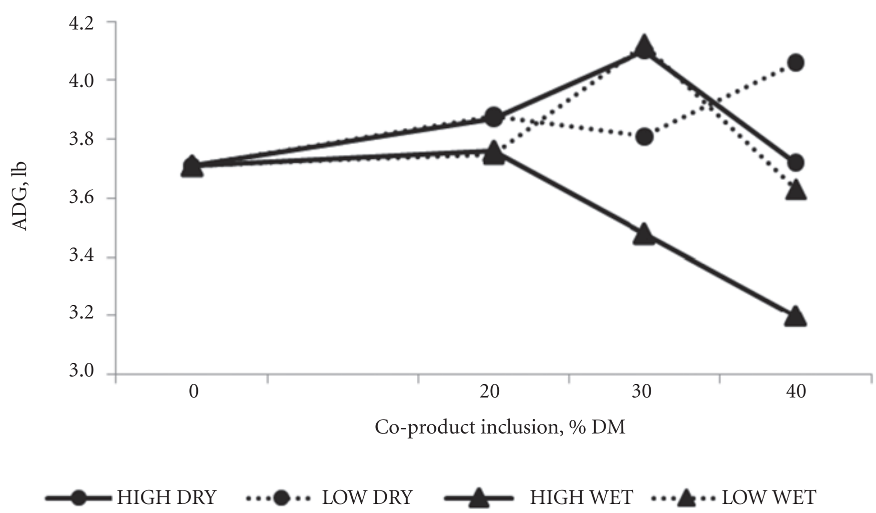

Figure 2. Average daily gain, lb. High and low means sulfur concentration in the co-product (1.16 and 0.82%, respectively); wet and dry mean diets based on WDGS and DDGS, respectively. Gain decreased linearly (*P* = 0.02) when wet 1.16% S DGS (HIGH WET) were fed.

40% DM basis). A corn control diet (Control: no co-product) was also fed. Co-products were obtained from two different dry mill ethanol plants: as either wet or dry DGS. A blend (60:40 DM basis) of high-moisture and dry-rolled corn was replaced as DGS increased.

Measurements and Statistical Analysis

Steers were fed individually *ad libitum* once daily in the morning. Bunks were evaluated prior to feeding and the amount offered adjusted daily. Refusals were removed once a week and subsampled. Dry matter intakes were calculated from DM offered, subtracting DM refused. Final BW was calculated from HCW assuming 62% dressing percentage. Cattle were shipped to a commercial packing plant (Greater Omaha, Omoaha, Neb.) where fat thickness and rib eye area were measured through a digital camera device. Since the steers were fed individually, each animal was considered an experimental unit. The factorial evaluation (3x2x2) was analyzed using GLIMMIX procedure of SAS. Orthogonal contrasts between the control and other diets also were tested for linear and quadratic effects of DGS level with sulfur concentration and whether wet or dry.

Results

Intake linearly increased (*P* = 0.02) when dry 0.82% S DGS was included in the diet, but DMI was not affected when wet 0.82% S DGS was fed (Figure 1). Greater DMI for dry DGS compared to wet DGS suggests dry DGS has lower energy content compared to wet DGS. However, regardless of whether fed wet or dry, high sulfur concentration decreased DMI. Intake decreased linearly (*P* < 0.01) for wet DGS and quadratically (*P* < 0.01) for dry DGS that was 1.16% S.

Gain (Figure 2) decreased linearly (*P* = 0.02) when wet 1.16% S DGS was increased in the diet. Feeding greater sulfur decreased DMI and ADG for steers fed wet DGS. These data suggest drying either changes sulfur availability or conversion to H_2S. Other diets did not result in a similar pattern. Steers fed wet DGS had improved F:G with similar ADG

(Continued on next page)

(Figure 3). A quadratic response ($P < 0.05$) was observed for F:G when wet DGS increased in the diet, with the best F:G at 20 and 30%, regardless of sulfur content.

A linear ($P < 0.05$) decrease was observed for fat thickness as wet and dry 1.16% S DGS increased in the diet, while no changes were observed for wet and dry 0.82% S DGS diets (Figure 4).

High sulfur DGS reduces DMI, ADG, HCW and fat thickness when fed at 40% of inclusion in beef cattle finishing diets, but depends on whether fed wet or dry. Wet DGS improves feed efficiency compared to dry DGS.

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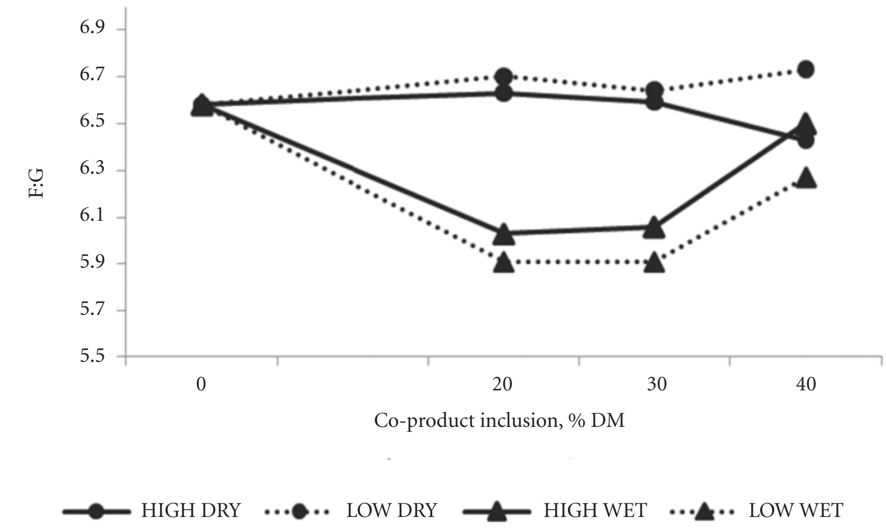

Figure 3. Feed efficiency. High and low means sulfur concentration in the co-product (1.16 and 0.82%, respectively); wet and dry mean diets based on WDGS and DDGS, respectively; Quadratic (*P* < 0.05) response for F:G when wet DGS (HIGH WET and LOW WET) were fed, with the best F:G at 20 and 30%, regardless of sulfur content.

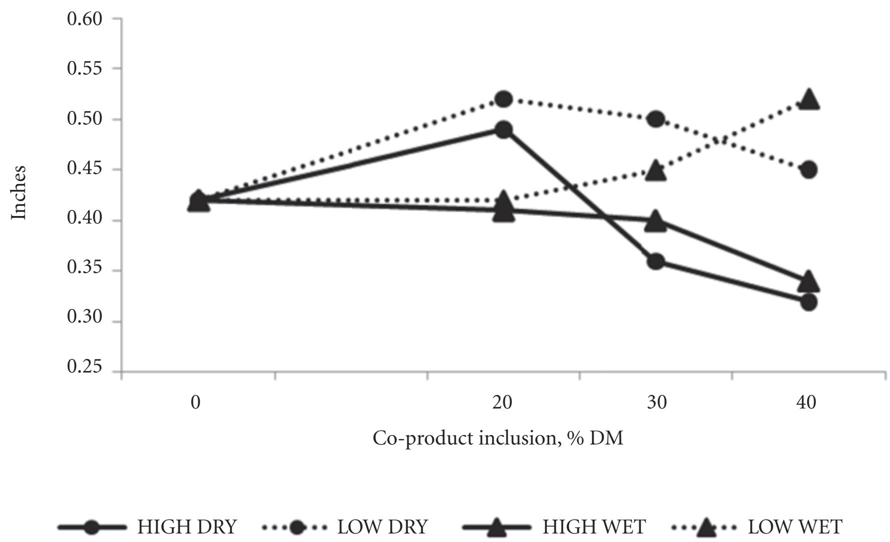

Figure 4. Fat thickness, inches. High and low means sulfur concentration in the co-product (1.16 and 0.82%, respectively); wet and dry mean diets based on WDGS and DDGS, respectively; linear decrease (*P* < 0.05) of fat thickness for wet and dry 1.16% S DGS (HIGH WET and HIGH DRY).

Effects of Adaptation Diets containing Wet Distillers Grains With Solubles or Wet Corn Gluten Feed on Ruminal pH, Intake and Hydrogen Sulfide

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Summary

A grain adaptation metabolism trial was conducted to compare wet corn gluten feed (WCGF, Sweet Bran®, Cargill) to wet distillers grains with solubles (WDGS). In both strategies, co-products were fed at decreasing levels (87.5% to 35% of DM). The WCGF step-up strategy resulted in greater DMI than WDGS for cattle fed steps 1, 2, and 3. The average of ruminal pH was lower for WDGS with steps 2 and 3 compared to WCGF. No differences in H_2S between treatments were observed. Both WCGF and WDGS adaptation strategies resulted in safe ruminal pH, DMI, and H_2S, even when S levels were high.

Introduction

Using co-products containing high energy and low starch content, such as wet corn gluten feed (Sweet Bran, Cargill) are a viable adaptation strategy for beef cattle finishing diets (*2009 Nebraska Beef Cattle Report*, pp. 53-55; *2009 Nebraska Beef Cattle Report*, pp. 56-58) when compared to traditional forage step-up diets. Wet distillers grains with solubles (WDGS) also appear to safely adapt cattle to finishing diets when compared to a traditional adaptation method (*2010 Nebraska Beef Cattle Report*, pp. 66-67). However, DMI, ruminal pH, and hydrogen sulfide concentration of cattle managed under WCGF vs WDGS adaptation strategies are unknown, since the previous studies only compared these co-products against traditional adaptation methods containing roughage. Therefore, the objective of the current study was to determine impact of grain adaptation using strategies based on WCGF or WDGS as measured by ruminal pH, DMI, and ruminal H_2S concentration.

Procedure

Cattle Background

Six crossbred beef steers (661 ± 49 lb BW) were received as weaned calves in early February 2009 at the Animal Science Complex. Animals were ruminally fistulated and fed at maintenance based on bromegrass hay and a supplement containing macro and micro minerals at 2% BW until the beginning of the experimental period (May 1).

Diets, Feeding and Experimental Design

Cattle were stratified and assigned to one of the two adaptation strategies in a completely randomized design. The experiment was divided into six periods of seven days each. The first four periods consisted of decreasing co-products and increasing DRC in the diets. After 28 days, steers were fed a finishing diet containing 35% (DM basis) of each respective co-product. In the last period, a common diet containing a 1:1 blend of WDGS and WCGF for 35% total co-product inclusion was fed (Table 1). Bunks were read once daily prior to feeding, and steers were fed *ad libitum* once a day at 0800. Mean sulfur concentrations in the co-products were 0.87% and 0.49% of DM for WDGS and WCGF, respectively.

Measurements and Statistical Analysis

Dry matter intakes were calculated based on DM offered after subtracting DM refused. As the bunks were equipped with individual load cells, meal size was also evaluated. On day 0, pH probes were calibrated to take measurements at each minute and introduced into the rumen via rumen cannula, and downloaded at the end of each period. Ruminal gas samples were collected on day six and seven of each period, once daily eight hours post feeding, through devices inserted via rumen cannula prior to feeding on day six. Six gas samples were taken from each steer at each time point.

(Continued on next page)

Table 1. Dietary strategy to adapt cattle to finishing diets in a metabolism trial.

	Adaptation					
Ingredients, % DM	Step 1	Step 2	Step 3	Step 4	Finishing	Blend 1:1
WDGS[1]	87.50	74.38	61.25	48.13	35.00	17.50
WCGF	0.00	0.00	0.00	0.00	0.00	17.50
Dry rolled corn	0.00	13.13	26.25	39.38	52.50	52.50
Alfalfa hay	7.50	7.50	7.50	7.50	7.50	7.50
Supplement[2]	5.00	5.00	5.00	5.00	5.00	5.00
WDGS	0.00	0.00	0.00	0.00	0.00	17.50
WCGF[1]	87.50	74.38	61.25	48.13	35.00	17.50
Dry rolled corn	0.00	13.13	26.25	39.38	52.50	52.50
Alfalfa hay	7.50	7.50	7.50	7.50	7.50	7.50
Supplement[2]	5.00	5.00	5.00	5.00	5.00	5.00

[1]Adaptation treatment: WDGS and WCGF = decreasing wet distillers grains or wet corn gluten feed (Sweet Bran®) to 35% (DM basis) in the finishing diet, and increasing DRC during adaptation periods.
[2]Supplement: diets providing 30 g/ton of DM of Monensin, 90 mg/steer/day of Tylosin, and 150 mg/steer/day of Thiamine.

Hydrogen sulfide concentration was analyzed with a spectrophotometer. As each period consisted of a different diet, adaptation strategies were compared within each period individually, using GLIMMIX procedure of SAS. Data were analyzed with day as a repeated measure for pH and intake data, and values from the last period (Blend) used as a covariant for all variables.

Results

Steers fed WDGS adaptation strategy had lower ($P < 0.03$) DMI for steps 1 through 3 (Tables 2, 3, and 4). This effect may be partially explained by the fact that during these initial steps the high inclusion of WDGS (87.5%, 74.8% and 61.3 % of DM, respectively) resulted in high levels of fat and sulfur, compared to the WCGF strategy. Steers fed WDGS adaptation strategy also showed lower ($P < 0.04$) meal size during all steps and when fed the finisher diets.

Subtle differences on ruminal pH variables were observed after step 2 (Table 3). Steers on the WDGS adaptation strategy had lower pH average (steps 2, 3, 4, and finisher), greater time below pH 5.6 (steps 2, 3, and finisher), and greater area below pH 5.6 (steps 3, finisher, and blend). Albeit, both adaptation strategies had safe pH patterns, as variance was not different during the adaptation period. Moreover, the pH averages across all steps did not deviate much from the average of each respective finisher diet (Figure 1), showing a consistent pattern of ruminal pH for both adaptation strategies.

No differences ($P > 0.19$) and small concentrations of ruminal H_2S were observed, even for the initial steps of the WDGS adaptation strategy (Tables 2, 3, 4, and 5), that contained high inclusion of co-product. Hydrogen sulfide values were not high for the WDGS strategy during these initial steps; because DMI was also relatively low, S intake was also lower. It is unclear if S caused the depression in DMI. Regardless, S intake was low despite elevated dietary S concentrations.

Table 2. Intake, ruminal pH, and hydrogen sulfide during the adaptation period: STEP 1.

	Treatments[1]			
Variables – Step 1	WCGF	WDGS	*SEM*	*P*-value
Co-product inclusion, %	87.5	87.5		
Intake				
DMI, lb/day	17.28	9.24	1.19	0.02
Meal size, lb DM	3.06	1.61	0.26	0.04
Ruminal pH				
Average	6.11	6.02	0.19	0.75
Variance	0.037	0.049	0.013	0.38
Time below 5.6, min	211	371	192	0.58
Area below 5.6, min*pH	19	35	28	0.71
Ruminal gas sample				
Hydrogen sulfide, µmol/L	2.43	2.98	1.97	0.85

[1]Treatment: WDGS and WCGF = decreasing co-products to 35% (DM basis) in the finishing diet, and increasing DRC as steers go through adaptation periods.

Table 3. Intake, ruminal pH, and hydrogen sulfide during the adaptation period: STEP 2.

	Treatments[1]			
Variables – Step 2	WCGF	WDGS	*SEM*	*P*-value
Co-product inclusion, %	74.37	74.37		
Intake				
DMI, lb/day	21.12	15.10	0.33	< .01
Meal size, lb DM	2.20	2.40	0.04	0.04
Ruminal pH				
Average	5.69	5.39	0.02	< .01
Variance	0.039	0.027	0.010	0.26
Time below 5.6, min	372	979	83	0.01
Area below 5.6, min*pH	71	167	30	0.12
Ruminal gas sample				
Hydrogen sulfide, µmol/L	0.64	0.45	0.11	0.29

[1]Treatment: WDGS and WCGF = decreasing co-products to 35% (DM basis) in the finishing diet, and increasing DRC as steers go through adaptation periods.

Table 4. Intake, ruminal pH, and hydrogen sulfide during the adaptation period: STEP 3.

	Treatments[1]			
Variables – Step 3	WCGF	WDGS	*SEM*	*P*-value
Co-product inclusion, %	61.25	61.25		
Intake				
DMI, lb/day	22.0	19.25	0.46	0.03
Meal size, lb DM	2.58	2.04	0.51	0.03
Ruminal pH				
Average	5.85	5.57	0.02	< .01
Variance	0.041	0.046	0.006	0.49
Time below 5.6, min	233	861	78	0.01
Area below 5.6, min*pH	19	153	34	0.08
Ruminal gas sample				
Hydrogen sulfide, µmol/L	10.92	25.45	6.15	0.19

[1]Treatment: WDGS and WCGF = decreasing co-products to 35% (DM basis) in the finishing diet, and increasing DRC as steers go through adaptation periods.

Table 5. Intake, ruminal pH, and hydrogen sulfide during the adaptation period: STEP 4.

	Treatments[1]			
Variables – Step 4	WCGF	WDGS	*SEM*	*P*-value
Co-product inclusion, %	48.12	48.12		
Intake				
DMI, lb/day	21.56	19.93	0.68	0.20
Meal size, lb DM	4.28	3.22	0.29	0.02
Ruminal pH				
Average	5.67	5.55	0.04	0.07
Variance	0.051	0.046	0.005	0.77
Time below 5.6, min	592	858	93	0.14
Area below 5.6, min*pH	81	208	43	0.15
Ruminal gas sample				
Hydrogen sulfide, µmol/L	2.42	4.56	2.20	0.57

[1]Treatment: WDGS and WCGF = decreasing co-products to 35% DM basis) in the finishing diet, and increasing DRC as steers go through adaptation periods.

Table 6. Intake, ruminal pH, and hydrogen sulfide during the adaptation period: FINISHER.

	Treatments[1]			
Variables – Finisher	WCGF	WDGS	*SEM*	*P*-value
Co-product inclusion, %	35	35		
Intake				
DMI, lb/day	23.30	21.47	0.68	0.16
Meal size, lb DM	4.94	3.57	0.42	< .01
Ruminal pH				
Average	5.69	5.49	0.06	0.09
Variance	0.050	0.047	0.003	0.86
Time below 5.6, min	570	996	110	0.07
Area below 5.6, min*pH	92	253	44	0.10
Ruminal gas sample				
Hydrogen sulfide, µmol/L	1.73	2.55	1.08	0.68

[1]Treatment: WDGS and WCGF = decreasing co-products to 35% (DM basis) in the finishing diet, and increasing DRC as steers go through adaptation periods.

Table 7. Intake, ruminal pH, and hydrogen sulfide during the adaptation period: BLEND.

	Treatments[1]			
Variables – Blend	WCGF	WDGS	*SEM*	*P*-value
Co-product inclusion, %				
WCGF	17.50	17.50		
WDGS	17.50	17.50		
Intake				
DMI, lb/day	22.91	23.63	0.35	0.22
Meal size, lb DM	5.20	4.30	0.11	< .01
Ruminal pH				
Average	5.75	5.72	0.01	0.13
Variance	0.060	0.047	0.013	0.02
Time below 5.6, min	493	414	0.01	< .01
Area below 5.6, min*pH	79	130	8.0	0.01
Ruminal gas sample				
Hydrogen sulfide, µmol/L	5.66	0.71	0.34	< .01

[1]Treatment: WDGS and WCGF = decreasing co-products to 35% (DM basis) in the finishing diet, and increasing DRC as steers go through adaptation periods.

Both adaptation strategies appear to adapt cattle to finishing diets. Ruminal pH averages during the adaptation period and the average of the finisher diet of each respective adaptation strategy were similar. Due to DMI observed in this experiment, both adaptation strategies showed safe values of ruminal hydrogen sulfide concentration. However, before recommending the WDGS adaptation strategy, this treatment should be evaluated in a feedlot experiment.

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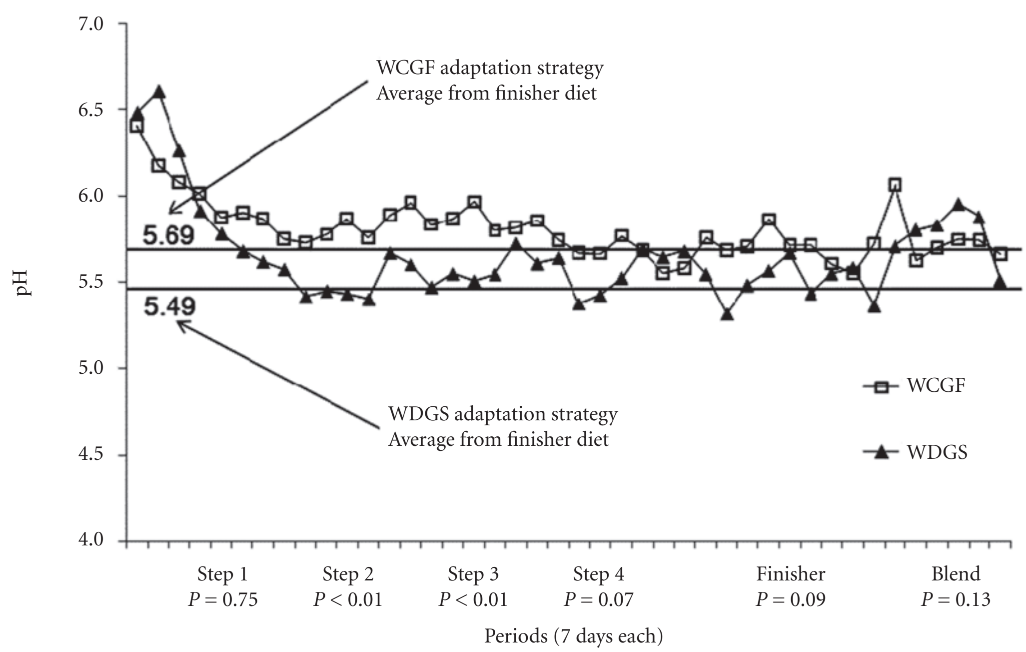

Figure 1. Daily ruminal pH across all experimental evaluation (42 days). *P*-values on the "x" axis represent difference between treatments inside of each period.

Effects of Sulfur Content of Distillers Grains in Beef Cattle Finishing Diets on Intake, Ruminal pH, and Hydrogen Sulfide

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Summary

A metabolism study was conducted to evaluate dietary sulfur (S) in beef cattle finishing diets formulated with wet and dry distillers grains with solubles (DGS) containing low (0.82%) and high (1.16%) S concentration. There was no interaction between moisture and S for intake, DM digestibility, or hydrogen sulfide (H_2S). Steers fed low S DGS consumed more feed than steers fed high S DGS. Subtle differences were observed for ruminal pH variables. Propionate and butyrate concentrations decreased when high sulfur DGS was fed. Sulfur of DGS impacts intake, VFA, and ruminal H_2S concentration. Wet DGS may be more prone to conversion of S to H_2S in the rumen than dry DGS.

Introduction

In recent growth performance study (*2011 Nebraska Beef Cattle Report*, pp. 62-64), steers fed high sulfur DGS diets showed lower DMI and ADG, even though total sulfur concentration in the diets was not greater than the threshold for polio. A possible hypothesis for this effect is that ruminal H_2S concentration, after being absorbed, can negatively impact energy metabolism. Likewise, the impact of elevated dietary sulfur on ruminal fermentation is unknown. Therefore, the objective of this study was to determine the effects of dietary sulfur in beef cattle finishing diets on intake, ruminal pH, H_2S, and volatile fatty acids concentration when cattle are fed wet or dry distillers grains with solubles.

Procedure

Diets, Feeding, and Experimental Design

Six ruminally fistulated crossbred beef steers (840 ± 68 lb BW) previously used in a 42-day adaptation trial were assigned to one of the five treatments. A 5x6 unbalanced Latin square design (six steers and five diets) was used. Steers were fed once daily *ad libitum* through five periods (14 days each), totaling 70 days. Treatments were arranged as a 2x2+1 factorial treatment design, with factors being moisture (wet or dry DGS included at 40% of diet DM), sulfur (S) concentration (0.82 and 1.16% in the co-product for low and high, respectively), and a diet (Match) containing wet DGS from high S provided at 31.44% of diet DM, to match the low S wet DGS treatment (Table 1).

Measurements and Statistical Analysis

All periods were 14 days, with seven days for adaptation and seven days for collection. Intakes were calculated based on DM offered after subtracting DM refused, and analyzed for the last seven days of each period. On day eight, pH probes were calibrated to take measures at each minute, introduced through the cannula into the rumen. Ruminal gas samples were collected on days 12, 13, and 14 of each period, once daily, 8 hours post feeding, through devices inserted in the ruminal cannula prior to feeding on day 12, and H_2S concentration analyzed with a spectrophotometer. On day 14, ruminal fluid was collected through a manual vacuum pump at 8, 13, and 22 hours post feeding, and frozen immediately for VFA. Chromium oxide (7.5g in gel capsules) was added into the rumen twice daily, every day, and spot fecal samples were collected twice daily on the last five days of each period to estimate fecal output and DM digestibility (DMD). Data were analyzed using the GLIMMIX procedures of SAS. Interaction between sulfur and moisture was tested. If not significant, the main effects

Table 1. Dietary treatments and chemical composition of diets containing wet or dry distillers grains with solubles, and with high or low sulfur concentration in the co-product.

Ingredients, % DM[3]	Low Sulfur[1]		High Sulfur		Match[2]
	Wet	Dry	Wet	Dry	Wet
DDGS	—	40.0	—	40.0	—
WDGS	40.0	—	40.0	—	31.44
High moisture corn	24.0	24.0	24.0	24.0	29.13
Dry rolled corn	16.0	16.0	16.0	16.0	19.42
Corn silage	15.0	15.0	15.0	15.0	15.0
Supplement[4]	5.0	5.0	5.0	5.0	5.0
Diet composition, % DM					
CP	16.14	15.12	17.67	16.62	15.62
Fat	6.99	7.78	6.89	8.16	6.36
NDF	23.67	21.01	21.35	19.12	19.63
Sulfur	0.40	0.40	0.54	0.54	0.40

[1]Low and High sulfur co-products being 0.82 and 1.16% S, respectively.
[2]Match: Diet containing high sulfur wet distillers grains with solubles, in amount to equal low sulfur diet sulfur content.
[3]DDGS = Dry distillers grains with solubles and WDGS = wet distillers grains with solubles.
[4]Supplements: All supplements were formulated to provide 30 g/ton of DM of Monensin, 90 mg/steer/day of Tylosin, and 150 mg/steer/day of thiamine.

Table 2. Dry matter digestibility, pH variables and volatile fatty acids of diets containing wet or dry DGS with high or low sulfur concentration.

						P- values			
Variables	Low Sulfur[1]		High Sulfur		Match[2]	Main effects		Inter.	Contrast
	Wet	Dry	Wet	Dry	Wet	Moisture	Sulfur	MxS	Match x Low S Wet
Intake, lb/day									
Dry matter	22.0	24.2	18.9	21.8	19.5	< .01	< .01	0.21	< .01
Hydrogen sulfide concentration, µmol/L of ruminal gas									
H_2S	7.09	0	17.2	4.95	1.87	0.06	0.13	0.81	0.15
In vivo *Digestibility, %*									
Dry matter	70.1	69.3	66.7	69.7	72.4	0.38	0.32	0.16	0.20
pH variables									
Average	5.72[b]	5.84[a]	5.86[a]	5.75[b]	5.74	0.37	0.43	< .01	0.86
Variance	0.08	0.08	0.07	0.08	0.1	0.48	0.59	0.16	0.03
Time below 5.6[3]	705[a]	408[b]	499[b]	571[a]	628	0.76	0.55	< .01	0.48
Area below 5.6[3]	114[a]	68[b]	66[b]	103[a]	121	0.76	0.55	< .01	0.56
Volatile fatty acids, mMol/100 mMol of total VFA									
Total, mMol/mL	111.7	115.8	119.5	112.7	119.7	0.50	0.69	0.14	0.19
Acetate	54.3	55.4	55.6	54.7	56.4	0.95	0.89	0.64	0.49
Propionate	22.9	23.9	20.7	21.9	20.2	0.18	0.01	0.92	0.23
A:P ratio	2.41	2.49	2.72	2.60	2.83	0.88	0.13	0.47	0.16
Butyrate	16.9	14.8	18.6	17.0	18.4	0.10	0.08	0.82	0.89

[1]Low and High sulfur co-products being 0.82 and 1.16% S, respectively.
[2]Match: Diet containing high sulfur wet distillers grains with solubles, but just in amount enough (31.44%) to target low sulfur diet content.
[3]Time below pH 5.6, min; Area below pH 5.6, min*pH.

were studied. Day was accounted as a repeated measure for pH and intake. Period was a repeated measure for DMD, and time point for VFA data. A single degree-of-freedom contrast was used to compare the Match diet with low sulfur wet DGS diet.

Results

No interaction ($P > 0.16$) was observed between moisture and S for DMI, DMD, or H_2S concentration. Steers fed dry DGS had greater DMI ($P < 0.01$) than steers fed wet DGS. Likewise, steers fed low S DGS consumed more ($P < 0.01$) than steers fed high S DGS (Table 2). Similar effects for DMI were also observed for steers fed identical diets in a growth study (*2011 Nebraska Beef Cattle Report*, pp. 62-64). Lower intake observed for steers fed wet DGS was probably due to greater energy for wet DGS compared to dry DGS. Steers fed high S DGS also had lower DMI than steers fed low S DGS. Dry matter intake was greater ($P < 0.01$) when wet low S DGS at 40% was compared to wet high S at 31.44% inclusion (Match). Lower level of co-product inclusion and more corn (8.56%), not dietary S, may cause the DMI effect.

Greater ($P = 0.06$) H_2S concentration was observed for wet DGS compared to dry DGS (Table 2). Diets containing wet DGS appear to provide greater availability of sulfur for microorganism fermentation and subsequent H_2S production. This observation matches with the lower DMI and ADG observed by steers fed high sulfur wet DGS in the growth performance study (*2011 Nebraska Beef Cattle Report*, pp. 62-64). When included at 40% of diet DM, high S DGS tended ($P = 0.13$) to increase ruminal H_2S concentration compared to low S DGS.

An interaction between moisture and S was observed for average of ruminal pH ($P < 0.01$). Steers fed high S wet and low S dry DGS had greater average pH compared to low S wet and high S dry DGS. Also, greater time and area below pH 5.6 were observed for steers fed low S wet and high S dry DGS, but these differences were subtle. Dry matter digestibility was not affected by sulfur concentration or types of DGS (Table 2), which does not explain performance differences.

No difference was observed for acetate molar proportion in ruminal fluid samples. However, steers fed high sulfur diets showed lower ($P = 0.01$) propionate concentration and tended ($P = 0.13$) to show greater A:P ratio compared to low sulfur diets. There was no interaction of sulfur x moisture for butyrate concentration. However, steers fed wet DGS and high sulfur diets showed greater ($P \leq 0.10$) concentration of this VFA compared to dry and low sulfur treatments (Table 2).

Sulfur of DGS impacts DMI and ruminal H_2S production, which may be more pronounced with wet DGS. Ruminal propionate and butyrate concentrations were also affected by high sulfur DGS diets.

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Economic Impact of Sulfur Levels in Distillers Grains Diets Fed to Beef Cattle

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Summary

*An economic evaluation of a growth performance study (*2011 Nebraska Beef Cattle Report, *pp. 62-64) comparing wet or dry distillers grains with solubles (DGS) containing varying levels of sulfur was conducted. Diets containing DGS were more profitable than the control diets containing no co-product (Control). Wet DGS showed greater profitability than Control and dry DGS diets. Sulfur content in dry DGS did not affect profitability. Profits were lowest for Control and greatest for wet DGS (0.82% S) at 30% inclusion. Low sulfur concentration in wet DGS allows shipment to feedlots further away.*

Introduction

Dietary sulfur affected cattle growth performance, even before sulfur levels reached critical levels for animal health (*2011 Nebraska Beef Cattle Report*, pp. 62-64). Feedlot owners may lose money even when polioencephalomalacia incidence is zero because ADG can be reduced by high sulfur concentration in distillers grains. The objectives of our evaluation were to 1) build a deterministic enterprise budget that evaluates sulfur concentration and level of inclusion of wet or dry distillers grains with solubles for beef cattle finishing diets, and 2) determine how much freight cost can be supported by differences in animal performance.

Procedure

Treatments and Experimental Design

Data from a growth performance study were used for an economic evaluation. Steers (n = 120; BW = 761 ± 75 lb) were fed in individual bunks (Calan system) for 151 days. They were assigned in a randomized complete block design to 1 of the 13 treatments that were based on the combination of: three levels of DGS inclusion (20%, 30%, and 40% DM basis), fed dry or wet, with low (0.82%) or high (1.16%) sulfur concentration [S] in the DGS. A control diet was also evaluated with no DGS. All diets contained 5% supplement, 15% corn silage, and a blend of high-moisture and dry-rolled corn (60:40), which was replaced by DGS in those diets (*2011 Nebraska Beef Cattle Report*, pp. 62-64).

Cost Inputs

Corn processing cost was assumed to be $1.58 and $4.71/ton of DM for dry-rolled and high-moisture corn, respectively. Corn silage was based on corn price (scenario specified below), varying from $106.00 to $136.00/ton of DM. Different diets required specific supplements for which costs were individually estimated (average supplement cost = $250.00/ton DM). Yardage cost was assumed at $0.40 and $0.45/head/day for steers fed dry and wet diets, respectively (higher for wet diets due to the greater amount fed on an as-is basis and more time feeding). As the treatments did not provide any animal health problems, $25.00/head for processing and medication was added to the cost for all diets. A typical implant strategy cost of $5.00/head was used. Fed and feeder cattle prices were $96.00 and $115.00/cwt, respectively. Death loss was assumed to be 1.5% and the cattle and feed interest rate of 7.5% was used. A freight cost of $3.50/mile and a distance of 35 miles were assumed for delivery of DGS.

Several budget scenarios were created based on different corn prices ($3.50, $4.00, and $4.50/bu). Co-product prices were fixed at 75%, 85%, and 95% of the corn price, on DM basis. In each of these scenarios, overall profitability ($/head) and profitability above the control treatment were calculated. As the final BW was different among the steers fed different diets, the highest average of final BW diet was utilized, and extra days calculated to reach this BW were used for all cattle. As a result, overall profitability and profitability above the control treatment were compared on the same final BW.

Profit was analyzed using PROC GLIMMIX procedure of SAS (factorial 3x2x2). Orthogonal contrast between the control and other diets was used to test linear and quadratic effects of level of DGS.

Results

The Control (no co-product inclusion) was profitable only when corn price was less than $3.50/bu ($0.86, -$37.55, and -$75.95/head for corn price at $3.50, $4.00, and $4.50/bu, respectively). When corn price was more than $4.00/bu and DGS was priced at 85% or 95% of the corn price, profitability was negative for diets containing dry DGS, regardless of S content of DGS. Diets containing wet DGS were profitable in almost all scenarios, except when wet 1.16% S DGS (high S concentration) was fed at 40% inclusion and corn was priced

Table 1. **Distance (miles) that wet distillers grains with solubles (WDGS) can be shipped to equalize profitability of dry distillers grains with solubles (DDGS).**

	20%[1]		30%		40%	
Sulfur concentration in the co-product	Miles	Profit[3]	Miles	Profit	Miles	Profit
Low sulfur (0.82%)	431	4.87	252	21.51	105	34.84
High sulfur (1.16%)	303	15.02	179	24.60	# [2]	—

[1]20, 30 and 40% = percentage of co-product inclusion (DM basis).
[2]Wet co-product will not be more profitable than the dry co-product.
[3]Profit = $/head.

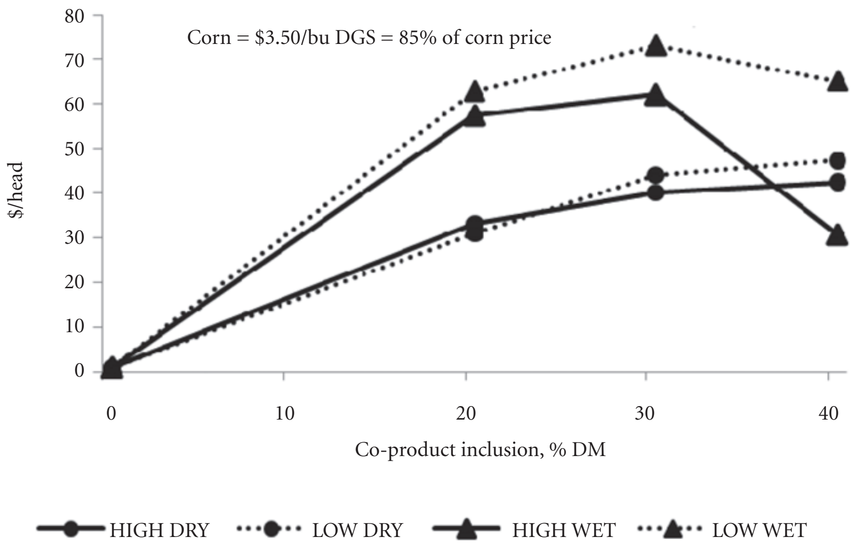

Figure 1. Overall profit ($/head). Corn price at $3.50/bu and DGS at 75% of corn price.

more than $4.00/bu, and when corn was priced at $4.50/bu and DGS at 95% of corn price, in which all diets were not profitable.

Based on the assumption that diets with no co-product are usually close to the breakeven, due to adjustment of cattle prices, evaluating profit above the Control diet may be more appropriate. All diets containing DGS were more profitable than the Control diet. Profit above the Control diet for steers fed DGS with 0.82 or 1.16% S did not differ ($P > 0.05$), except when wet 1.16% S DGS at 40% inclusion was fed (Figure 1). However, in general, steers fed wet DGS were more profitable than steers fed dry DGS. Feeding wet DGS diets had a quadratic ($P \leq 0.05$) response for profit above the Control, in which the greatest values were observed for 20 and 30% inclusion. Steers fed dry DGS showed linear ($P < 0.05$) increase in profit above the control as the co-product increased in the diet, although lower than wet DGS diets.

Corn price definitely has a large importance on cattle profitability. The exercise using scenarios with increasing corn price showed us that each $0.50/bu of increase in corn price was responsible for $35.00 of decrease in overall profitability ($/head). Also, it is important to remember that when corn price goes up, usually feeder cattle price goes down making positive adjustments on cattle profit; however, the shape of the lines shown in Figure 1 did not change. Albeit, the relationship between cattle and corn price usually is not quickly reflected by subtle changes in corn price.

Additionally, as expected when distillers grains price goes up, cattle profit goes down; however, this impact has less importance compared to the effect of corn price. For example, for each 10 percentage units of increase in co-product price (co-product as a percentage of corn price), around $9.00/head is missed in overall profitability. Again, the shape of the response shown in Figure 1 is not changed, only the magnitude of response.

The greater moisture content of wet DGS influences co-product price at the feedlot due to freight cost. Table 1 shows the amount of miles that wet DGS with high and/or low sulfur can be shipped to results in profitability equal to dry DGS. Higher profitability can be reached with higher co-product inclusions. The distances in miles that wet DGS can be shipped to provide the same profit of dry DGS decrease when high-sulfur wet DGS is utilized, because steers fed high-sulfur diets had lower performance and freight was higher for wet co-products on a DM basis.

In conclusion, diets containing wet 1.16% S DGS at 40% inclusion was less profitable compared to 0.82% S wet DGS. High-sulfur content wet DGS and lower wet co-product inclusions (20 or 30%) are still desirable as opposed to using dry DGS. The diet containing wet DGS with 0.82% sulfur at 30% inclusion was the most profitable treatment, while the diet containing no DGS inclusion was the least. Low sulfur concentration in wet DGS allows shipment to feedlots further away from the plant.

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Effects of Lactobacillus Acidophilus and Yucca Schidigera on Finishing Performance and Carcass Traits of Feedlot Cattle

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Summary

A finishing trial evaluated effects of feeding a direct-fed microbial product(Nova-Cell®) and a saponin feed additive (Ruma Just®) as a 2x2 factorial in steam-flaked corn-based diets containing 11% wet distillers grains (DM basis). No interaction was observed between Nova-Cell and Ruma Just (P > 0.13). Feeding either Ruma Just or Nova-Cell had no impact (P = 0.20) on final BW, DMI, ADG, or F:G. Neither Nova-Cell or Ruma Just affected (P = 0.10) HCW, 12th rib fat, or LM Area. Marbling appeared to be improved (P = 0.03) when Ruma Just was added to the finishing diet.

Introduction

Feeding trials evaluating efficacy of direct-fed microbials (DFM) have indicated increases in ADG and decreases in F:G in feedlot cattle, enhanced milk production in dairy cows, and improved health and performance of young calves (2003, Journal of Animal Science, 81:E120-E132). In the production of DFM, species of bacteria identified as beneficial to the host animal are extracted from mixed cultures of bacteria. Single cultures like *Lactobacillus* potentially prevent ruminal acidosis in dairy cows (2002 Journal of Dairy Science, 85:429-433), and reduce fecal shedding of *Escherichia coli* 0157:H7 (2003 Journal of Animal Science, 81:E120-E132).

Yucca saponins increased ADG in feedlot cattle fed high-grain diets (1982, Western Section, American Society of Animal Science, 33:45-46). These steroidal saponins come from *Yucca Schidigera*. Other research has indicated saponins may increase propionate concentration (1994 Journal of Animal Science, 36:698-709). The purpose of the current study was to evaluate the effects of Nova-Cell (DFM, Nova Microbial Technologies, Omaha, Neb.) and Ruma-Just (Yucca Schidigera, Nova Microbial Technologies) alone or in combination on finishing performance and carcass characteristics.

Procedure

Yearling British x Continental steers (n = 384; initial BW=721±51 lb) were used in an experiment conducted at the Panhandle Research Feedlot (University of Nebraska–Lincoln Panhandle Research and Extension Center). Prior to the start of the experiment, cattle were given Bovi-Shield Gold (Pfizer Animal Health, New York, N.Y.), Vision 7 (Intervet/Shering-Plough, Millsboro, Del), Ivomec (Merial, Duluth, Ga.), Component TE-IS (Elanco Animal Health; Greenfield, Ind.), electronic and visual ID along with a UNL hot brand. Steers were reimplanted on day 55 with Component TE-S. Cattle were limit fed (2% of BW) a 50% forage diet for a total of five days before the initiation of the trial in an effort to reduce variation in gut fill at time of weighing. Steers were individually weighed two consecutive days (day 0 and day 1) after the limit feeding period to obtain an initial BW. Cattle were stratified by BW within respective weight block (8 blocks) and assigned randomly to 32 pens (12 steers/pen). Treatments (n = 4; 8 replications) were assigned randomly to pens within weight blocks. Treatments were arranged as a 2x2 factorial and consisted of 1) Control (no feed additives); 2) Ruma Just *(Yucca Schidigera*); 3) Nova-Cell (*Lactobacillus Acidophilus* NCFM); and Ruma Just and Nova-Cell.

A 21-day grain adaptation period was used, in which incremental percentages of steam-flaked corn replaced alfalfa hay to allow cattle to become acclimated to the final finishing diet. The final diet consisted of 71.9% steam-flaked corn, 7.3% corn silage, 3.7% alfalfa hay, 11% wet distillers grains plus solubles, and 6% liquid supplement (DM basis). The liquid supplement was formulated to provide 30 g/ton Rumensin (Elanco Animla Health; Greenfield, Ind.) and 8.8 g/ton Tylan (Elanco Animal Health). Diets containing the DFM product were formulated to provide 500 million CFU/steer daily of Nova-Cell and diets containing *Yucca Schidigera* were formulated to provide 1.0 g/steer daily of Ruma Just. Nova-Cell was stored at 32ºF and was applied to the ration by use of a micro ingredient machine. Ruma Just was also added to the diets during mixing by a micro ingredient machine separate from the machine that applied the DFM product. After feeding diets containing Nova-Cell or Ruma Just, the feed truck was loaded with a diet that was to be fed to cattle not involved in the current study. This was done in an effort to eliminate the risk of cross contamination of either Nova-Cell or Ruma Just in diets that were not designated to contain either feed additive.

Feed bunks were visually evaluated each morning and were managed to allow for trace amounts of feed to remain in each bunk before feed

Table 1. Finishing performance of steers fed diets containing Nova-Cell and Ruma Just either alone or in combination.

	Control	Ruma Just	Nova-Cell	Ruma Just & Nova-Cell	SEM	Ruma Just *P*-value	Nova-Cell *P*-value	Inter *P*-value
Pens	8	8	8	8				
Steers	96	96	96	96				
Carcass-adjusted performance[3]								
Initial BW, lb	721	721	722	721	2.03	0.96	0.82	0.52
Final BW, lb	1357	1370	1366	1368	13.1	0.34	0.87	0.52
DMI, lb/day	23.4	23.6	23.7	23.7	0.30	0.93	0.20	0.88
ADG, lb/day	3.62	3.69	3.67	3.68	0.07	0.27	0.96	0.60
F:G	6.58	6.49	6.57	6.54		0.24[4]	0.30[4]	0.71[4]
Live performance[1,2]								
Final BW, lb	1356	1361	1364	1361	13.1	0.97	0.52	0.50
ADG, lb/day	3.61	3.64	3.66	3.64	0.07	0.94	0.57	0.61
F:G	6.59	6.57	6.61	6.63		0.92[4]	0.75[4]	0.47[4]

[1]All BW are shrunk 4% except initial BW.
[2]Live performance calculated from live BW on a pen basis collected prior to study initiation and on day of slaughter.
[3]Carcass adjusted performance calculated using 63% dressing percentage for all four treatments.
[4]*P*-value calculated form G:F.

Table 2. Carcass characteristics of steers fed diets containing Nova-Cell and Ruma Just either alone or in combination.

	Control	Ruma Just	Nova-Cell	Ruma Just & Nova-Cell	SEM	Ruma Just *P*-value	Nova-Cell *P*-value	Inter *P*-value
Carcass characteristics								
Hot carcass weight, lb	855	863	861	862	8.23	0.32	0.86	0.51
Marbling[1]	605	617	609	620	10.2	0.03	0.92	0.45
Fat depth, in	0.58	0.58	0.58	0.57	0.01	0.78	0.89	0.13
LM Area in^2	12.6	12.6	12.8	12.7	0.19	0.21	0.10	1.00
Calculated YG[2]	3.55	3.61	3.55	3.56	0.08	0.20	0.27	0.39
Dressing %	63.1	63.4	63.1	63.5	0.32	0.06	0.44	0.96

[1]500 = $Small^0$, 600 = $modest^0$, etc.
[2]Calculated as 2.50 + (2.5*fat depth, in) - (0.32*LM Area, in^2) + (0.2*2.5 KPH) + (0.0038*HCW, lb)

delivery. Cattle were individually weighed at the end of the trial. This BW (shrunk by 4%) was used to calculate live performance. Carcass adjusted performance was calculated using carcass weights adjusted to a common dressing percentage of 63%. Blocks 1-4 were on feed for 162 days while blocks 5-8 were on feed for 189 days.

Cattle were slaughtered at a commercial abbatoir (Cargill Meat Solutions, Fort Morgan, Colo.) on two different dates. Carcass data were collected by trained professionals from Diamond T Livestock Services (Yuma, Colo.). Hot carcass weight and liver score data were collected on the day of slaughter. Carcass 12^{th} rib fat, preliminary yield grade, percentage of KPH, marbling score, LM area, and USDA quality grades were recorded following a 48-hour carcass chill. Animal performance and carcass data were analyzed using the mixed procedure of SAS (SAS Inst. Inc., Cary, N.C.) as a randomized complete block design with pen as the experimental unit. The Proc Glimmix procedure of SAS was used for determining the quality grade distribution.

Results

No significant interactions between Nova-Cell and Ruma Just were detected for the finishing performance and carcass characteristic data. There were no differences in DMI due to the main effect of Ruma Just (Table 1). Ruma Just also had no impact on finishing performance calculated on a live basis which included final BW, ADG, or F:G ($P > 0.05$). Finishing performance data analyzed on a carcass-adjusted basis indicated no differences in final BW, ADG, or F:G ($P > 0.05$). The main effect of Nova-Cell did not impact ($P = 0.20$) finishing performance characteristics (final BW, ADG, DMI, and F:G). The same finishing performance data calculated on a live basis also indicated no effect ($P = 0.52$) of Nova-Cell on finishing performance.

The addition of Nova-Cell to the finishing diets did not impact ($P = 0.86$) HCW, marbling, or fat depth (Table 2). However there was a tendency for cattle fed Nova-Cell to have slightly larger LM Area ($P = 0.10$). Neither Ruma Just nor Nova-Cell impacted calculated YG ($P = 0.20$). Cattle fed diets containing Ruma Just tended to have greater dressing percentages ($P = 0.06$). Feeding Ruma Just had no impact ($P = 0.21$) on HCW, fat depth, or LM area; however, marbling was increased ($P = 0.03$; 617) for steers in the Ruma Just treatment group. The difference detected in marbling due to the supplementation of Ruma Just did not translate to differences in quality grade data. Cattle fed diets containing Ruma Just tended ($P = 0.09$) to grade better than cattle that did not receive Ruma Just; however, no significant differences were detected. The main effect of Nova-Cell also did not impact quality grade ($P = 0.98$).

Data from the current study indicate that Ruma Just and Nova-Cell did not significantly impact finishing performance. However, the addition of Ruma Just to finishing diets appeared to increase marbling.

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Feeding Strategies of Optaflexx on Growth Performance and Carcass Characteristics of Feedlot Steers

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Summary

Live BW and carcass traits of steer calves were evaluated after feeding Optaflexx (200mg/day) for 35 days on an intermittent basis or continuously. The negative control consisted of 63 days on the same diet without Optaflexx, whereas the positive control consisted of Optaflexx supplemented daily during the last 35 days prior to harvest. The four-day intermittent treatment consisted of feeding Optaflexx for seven days, followed by four days of no Optaflexx, while the seven-day intermittent treatment consisted of seven days on Optaflexx, followed by seven days off. In both the four-day and seven-day intermittent treatments, cattle received Optaflexx for a total of 35 days. Regardless of the delivery pattern, feeding Optaflexx increased ADG, DMI, and live BW. Feeding 200 mg per steer daily of Optaflexx for a total of 35 days in either four-day or seven-day intermittent patterns was as effective but no more so as continuous feeding for a 35-day period.

Introduction

Ractopamine hydrochloride (Optaflexx; Elanco Animal Health, Indianapolis, Ind.) increases live weight gain and gain efficiency. Optaflexx is approved for continuous feeding to feedlot cattle during the last 28 to 42 days prior to harvest at a dose ranging from 70 to 430 mg per steer daily or 9.1 to 27.3 g/ton of DM. Continuous feeding of Optaflexx for 42, 35, and 28 days prior to harvest at doses up to 200 mg per steer increased live BW by 16.4, 18.1, and 18.8 lb, respectively, compared with a control diet, and improved ADG by 0.53 lb/day in feedlot steers. In addition, LM area also was larger for treated animals, with no effect on fat depth. Additionally, about 87% of the live weight response has been observed in the first 28 days compared to 42 days when Optaflexx was fed at 200 mg/steer daily (*2006 Nebraska Beef Cattle Report, pp. 72-74, 2007 Nebraska Beef Cattle Report, pp. 65 - 67*). Studies in pigs indicate that intermittent use of Optaflexx increases ADG, F:G, and BW. Our objective was to evaluate the effects of intermittent use of Optaflexx on growth and carcass characteristics of feedlot steers.

Procedure

Crossbred steer calves (BW = 1057 ± 26 lb) were assigned to two blocks based on reimplant BW. The heavy block consisted of 1 replication of 40 steers, and the light block consisted of 7 replications of 280 steers. Steers were assigned randomly to a pen within block and pens assigned randomly to 1 of the 4 treatments (8 pens/treatment; 10 steers/pen). The treatments consisted of no delivery of Optaflexx (NONE), continuously feeding of Optaflexx throughout the last 35 days prior to harvest (CONTIN), intermittent seven day feeding Optaflexx followed by four days of withdrawal (4-dINT) and intermittent seven days feeding Optaflexx followed by seven days of withdrawal (7-dINT). The three treatments with Optaflexx resulted in a total of 35 days of feeding Optaflexx but on different days. Steers were managed during the pre-trial phase (102 days) in the actual experiment pens after being assigned within a block (4 pens for the heavy block and 28 pens for the light block). Three animals were removed from three different pens prior to Optaflexx feeding due to death or health reasons. Before the start of the trial, each steer was weighed on two consecutive days after feed restriction (decrease of 2 lb/day of DM during three days). Pens of animals were weighed weekly, with a 4% shrink factor applied to the BW, throughout the 63 days of the Optaflexx treatment period and prior to harvest.

Table 1. Diet composition and analyzed nutrient analysis for diets fed.

Ingredient	% of DM
High-moisture Corn	50.0
Wet Corn Gluten Feed	40.0
Ground Wheat Straw	5.0
Dry Supplement	5.0
Analyzed Nutrient Analysis, % DM	
DM	66.3
CP	14.3
Ether Extract	4.3
Calcium	0.66
Phosphorus	0.54
Potassium	0.74

Steers were implanted with Component TE-IS initially and re-implanted with Component TE-S 98 days prior to harvest. Steers were fed once per day at approximately 0830 hour, and the Optaflexx supplement was top dressed in a supplement at a rate of 0.5 lb per steer to ensure that steers received the amount of 200 mg of Optaflexx per day. The carrier used was fine ground corn. Steers received 0.5 lb of fine ground corn when not on Optaflexx or for the negative control treatment. Diets were formulated to meet or exceed NRC (1996) requirements for metabolizable protein, Ca, P, and K. High-moisture corn was fed at 50% of diet DM, wet corn gluten feed (Sweet Bran®, Cargill, Blair, Neb.) at 40% of DM and ground wheat straw at 5% of DM (Table 1). Diets were prepared by loading the HMC, WCGF, ground wheat straw, and then by adding dry supplement in the mixer/delivery box (Roto-Mix® model 420, *Roto-Mix, Dodge City, Kan.*). Rumensin and Tylan were fed to all steers, with consumptions of 348 and 90 mg/head/daily, respectively. Feeds and feeding procedures remained the same throughout

Table 2. Growth performance of steers fed Optaflexx in continuous vs. intermittent patterns.

Treatments	NONE[1]	CONTIN[2]	4-dINT[3]	7-dINT[4]	SEM	P-value
Live Performance						
Initial BW, lb	1077	1076	1074	1090	8.7	0.28
Live Final BW, lb	1352[a]	1366[b]	1365[b]	1385[c]	10.7	0.04
DMI, lb/day	22.3[a]	22.0[a]	22.3[a]	22.9[b]	0.31	0.05
ADG, lb	4.36[a]	4.61[b]	4.61[b]	4.68[b]	0.09	<0.01
F:G[5]	5.33	5.14	5.21	5.22		0.09
Carcass Adjusted Performance						
FBW, lb	1347	1356	1351	1371	11.5	0.19
ADG, lb	4.36	4.45	4.40	4.47	0.12	0.40
F:G[5]	5.32	5.12	5.24	5.23		0.52

[1]NONE: treatment did not receive Optaflexx.
[2]CONTIN: treatment received Optaflexx for 35 days continuously.
[3]4-dINT: treatment received intermittent seven day feeding Optaflexx followed by four days of withdrawal.
[4]7-dINT: treatment received intermittent seven day feeding Optaflexx followed by seven days of withdrawal.
[5]Analyzed as G:F, reported as F:G.

Table 3. Carcass characteristics of steers fed Optaflexx in continuous vs. intermittent patterns.

Treatments	NONE[1]	CONTIN[2]	4-dINT[3]	7-dINT[4]	SEM	P-value
Carcass Characteristics						
HCW, lb	848	854	851	864	7.3	0.18
Dressing, %[a]	62.8	62.5	62.4	62.4	0.22	0.25
12th rib fat, in	0.5	0.48	0.49	0.52	0.03	0.51
Marbling score[b]	507	485	506	505	14	0.37
LM area, in^2	14.6	15.1	14.5	14.6	0.2	0.09
USDA yield grade[c]	2.73[a]	2.76[a]	2.45[b]	2.78[a]	0.1	<0.01

[1]NONE: treatment did not receive Optaflexx.
[2]CONTIN: treatment received Optaflexx for 35 days continuously.
[3]4-dINT: treatment received intermittent seven day feeding Optaflexx followed by four days of withdrawal.
[4]7-dINT: treatment received intermittent 7 day feeding Optaflexx followed by seven days of withdrawal.
[a]Dressing percentage = carcass weight / average live weight (4% shrink).
[b]USDA marbling score where 450 = slight50, 500 = small0, and 550 = small50
[c]USDA calculated yield grade = 2.50 + (2.5*FT, in) – (0.32*LM area, in^2) + (0.2*KPH, %) + (0.0038*HCW).

the pre-trial and trial phases, except for the use of the top dressing with or without Optaflexx that occurred only during the last 63 days prior to harvest.

Feed samples were collected from each load and each supplement (with or without Optaflexx) every other week, during the mixer discharge in the beginning, middle, and end of each load. Optaflexx supplements were sampled from supplement bags. Samples were processed and analyzed for DM content, CP, Ca, P, K, and ether extract.

All steers were harvested on the same day after 165 days on feed, and 63 days of Optaflexx treatment period. At harvest, HCW were collected, and after approximately a 48-hour chill, LM area and fat thickness were measured. Bone score, lean score, and KPH were subjectively assigned by a University of Nebraska–Lincoln research technician, and marbling score was assigned by a USDA grader. Yield grade was calculated using the equation (YG= 2.50 + (2.5*FT, in) – (0.32*LM area, in^2) + (0.2*KPH, %) + (0.0038*HCW, lb)).

Growth performance was evaluated on a 4% shrunk weight basis, across and within the Optaflexx treatment period. Data from the randomized complete block design were analyzed using a mixed model analysis (Proc Mixed, SAS), with treatment and block included in the model as fixed variables. Pen was the experimental unit. Data were analyzed using a protected *F*-test and means separated using a bonfevroni t-test when the F-test variable was significant (i.e., alpha = 0.05).

Results

Results for feedlot performance and carcass characteristics are presented in Table 2 and Table 3, respectively. Dry matter intake was affected ($P = 0.05$) by Optaflexx 7-dINT treatment with steers consuming slightly more DM than all other treatments.

Live BW increased ($P < 0.04$) for all Optaflexx treatments compared to NONE. Optaflexx 7-dINT was also significantly different from the CONTIN and 4-dINT. The CONTIN was 14 lb heavier than the NONE, the 4-dINT was 13 lb (no difference when compared with the CONTIN) and the 7-dINT was 33 lb heavier than the NONE, and approximately 19 lb heavier than the CONTIN and 4-dINT treatments. Live ADG was also affected positively by the Optaflexx treatments compared to NONE, providing an increase of approximately 0.29 lb/day.

On a carcass basis, treatments were not different when compared to NONE, except for the calculated yield grade trait that decreased for the 4-dINT treatment when compared to all other treatments due to differences in KPH scores. Positive trends for carcass adjusted final BW, HCW, and LM area were observed mainly for the 7-dINT treatment when compared to the others. Efficiency analyses show that steers on Optaflexx treatments had numerically lower F:G than NONE (values numerically lower and P values less than 0.20).

Results from this experiment indicate that 200 mg/steer daily of Optaflexx fed intermittently increases DMI, ADG, and Live BW. Tendencies for a larger LM area on the positive control and better F:G on all Optaflexx treatments were also observed.

In conclusion, withdrawing Optaflexx for seven or four days then re-feeding, when compared to continuous, had no effect on live ADG or F:G.

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Feedlot Cattle Performance When Fed Silage and Grain From Second-Generation Insect Protected Corn, Parental Line or Reference Hybrids

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Summary

Feed conversion and carcass characteristics of cattle fed second generation insect-protected (Bt) corn and corn silage was compared to those fed a nontransgenic parental hybrid and two commercially available nontransgenic reference hybrids. Finishing performance and carcass characteristics were not influenced as a result of corn source.

Introduction

Insect-protected corn hybrids (Bt) made up 63% of the total corn acres in 2009, according to the United States Department of Agriculture's Economic Research Service. Monsanto has developed MON 89034 as a second generation insect protection product to provide enhanced benefits for the control of lepidopteran insect pests. MON 89034 produces Cry1A.105 and Cry2Ab2 proteins derived from *Bacillus thuringiensis,* which are active against *Ostrinia* species such as European corn borer and Asian corn borer, *Diatraea* species such as southwestern corn borer and sugarcane borer, and helps control fall armyworm and corn earworm. Since the mode of action of Cry1A.105 and Cry2Ab2 are different, the combination of the two proteins provides a much more effective insect resistance management tool. With a high percentage of the corn being fed directly to cattle in feedlots, it is vital for producers to know if cattle fed MON 89034 will perform similarly to cattle fed nontransgenic hybrids.

The objective of this study was to compare the performance and carcass characteristics of finishing steers fed second generation insect-protected (Bt) corn (MON 89034) and corn silage with the nontransgenic parental hybrid (DKC 63-78) and the two nontransgenic reference hybrids (DKC 61-42 and DKC 62-30).

Procedure

Animals

British x Continental crossbred steers (initial BW = 639 ± 31 lb) were used in a randomized complete block design experiment. Steers (n = 240) were received at the University of Nebraska Agricultural Research and Development Center (Ithaca, Neb.) in the fall of 2009. On arrival, steers were weighed, vaccinated (Bovishield Gold 5, Somubac, Dectomax), and treated with Micotil (Elanco Animal Health). Following a 14-21 day receiving period, steers were limit fed five days to minimize variation in rumen fill. The limit fed ration contained a 1:1 ratio of wet corn gluten feed and alfalfa hay fed at 2% BW. Steers were weighed individually on two consecutive days in the morning before feeding to obtain an accurate initial BW. Steers were blocked by BW, stratified within block, and assigned randomly to pens (10 steers/pen) based on day 0 BW. Pens were assigned randomly to one of four treatments.

Treatments

Treatments consisted of two reference hybrids, a genetically related nontransgenic hybrid, and the second generation Bt hybrid (MON 89034). All corn was grown at the Agricultural Research and Development Center near Ithaca, Neb. under identity preserved methods. All hybrids were cut for silage at similar moisture levels (34.2% DM ± 2.1%) and stored in silo bags by hybrid. Corn was stored in bins by hybrid prior to dry rolling, at which time the hybrids were stored in separate commodity bays. Samples of all hybrids were collected and sent to Monsanto Company where the presence or absence of the genes was verified.

Steers were adjusted to the final diet over 21 days, with ground alfalfa hay replacing corn. Alfalfa hay levels were decreased from 37.5%, 27.5%, 17.5%, and 7.5% for 3, 4, 7, and 7 days. Final diets are shown in Table 1 and contained 65.0% DRC, 15.0% corn silage, 15.0% WDGS, and 5.0% supplement.

Prior to initiation of the study, samples of corn and corn silage were collected and sent to a commercial laboratory (Romer Labs, Union, Mo.) to test for the presence of mycotoxins. Small amounts of Zearalenone and Deoxynivalenol (Vomitoxin) were found in the test hybrid (MON) and the nontransgenic parental hybrid (PAR) corn silage. Small amounts of Deoxynivalenol were also detected in all samples of whole corn, as well as Zearalenone and Fumonisin B1 and B2 in DKC 62-30 (REF2). In all samples, the levels of mycotoxins detected were well below the level of concern. Ingredient and diet samples were collected weekly, composited by month, and sent to a commercial laboratory (Dairy One, Ithaca, N.Y.) for nutrient analysis.

Individual BW was collected on day 0 and day 1 of the trial. Steers were implanted with Revalor-IS on day 1 and reimplanted with Revalor-S on day 84. All steers were slaughtered on day 175 at Greater Omaha (Omaha, Neb.). Hot carcass weight (HCW) and liver abscess data were recorded on the day of slaughter. After a 48-hour chill, USDA marbling score, 12th rib fat thickness, and LM area were

Table 1. Diet ingredient and nutrient composition (% DM).

Ingredient[1]	MON	PAR	REF1	REF2
Corn W				65.0
Corn X	65.0			
Corn Y		65.0		
Corn Z			65.0	
Corn Silage W				15.0
Corn Silage X	15.0			
Corn Silage Y		15.0		
Corn Silage Z			15.0	
WDGS	15.0	15.0	15.0	15.0
Supplement				
Fine Ground Milo	2.300	2.300	2.300	2.300
Limestone	1.681	1.681	1.681	1.681
Salt	0.300	0.300	0.300	0.300
Urea	0.400	0.400	0.400	0.400
Potassium Chloride	0.099	0.099	0.099	0.099
Tallow	0.125	0.125	0.125	0.125
Trace Mineral	0.050	0.050	0.050	0.050
Vitamin A-D-E	0.015	0.015	0.015	0.015
Rumensin-80	0.019	0.019	0.019	0.019
Tylan-40	0.011	0.011	0.011	0.011
Nutrient Composition				
CP	13.4	13.3	12.3	13.6
NDF	15.5	16.6	14.9	16.5
Ca	0.58	0.64	0.56	0.62
P	0.35	0.36	0.32	0.36
K	0.53	0.56	0.55	0.58

[1]REF1 = reference hybrid DKC 61-42, REF2 = reference hybrid DKC 62-30, PAR = nontransgenic parental hybrid, MON = corn and corn silage containing Cry1A.105 and Cry2Ab2 proteins (MON 89034).

Table 2. Animal performance[1].

Variable	MON 89034	Parental	Reference 1	Reference 2	*P*-value
Performance					
Initial BW, lb	638	640	637	639	0.02
Final BW, lb[2]	1294	1290	1293	1287	0.94
DMI, lb/day	22.3	22.6	21.9	22.5	0.96
ADG, lb	3.74	3.71	3.75	3.70	0.31
Feed:Gain[3]	5.97	6.09	5.85	6.07	0.13
Carcass Characteristics					
HCW, lb	815	813	815	811	0.93
Marbling score[4]	573	561	581	565	0.55
12th rib fat, in	0.51	0.49	0.53	0.52	0.82
LM area, in^2	13.0	13.1	13.0	12.9	0.70
Calculated YG[5]	3.21	3.13	3.24	3.22	0.78
% Choice	79.6	71.7	74.1	68.3	0.41

[1]REF1 = reference hybrid DKC 61-42, REF2 = reference hybrid DKC 62-30, PAR = nontransgenic parental hybrid, MON = corn rootworm resistant hybrid MON 89034.
[2]Final weight calculated as hot carcass weight divided by 0.63.
[3]Analyzed as gain:feed, reported as feed:gain.
[4]500 = Small 0, 600 = Modest 0.
[5]YG calculation = 2.50 + (2.5 * 12th rib fat thickness) – (.32 * LM area) + (.2 * KPH (2.5)) + (.0038 * HCW).

collected. Hot carcass weights were used to calculate adjusted final BW by dividing HCW by a common dressing percentage of 63%. Average daily gain and G:F were determined from adjusted final BW. Data were analyzed as G:F and reported as F:G.

One steer from the transgenic test treatment (MON) and one from DKC 61-42 (REF1) treatment died from non-treatment related illnesses during the trial. One steer from REF1 was removed from the study for a reason not related to the treatment.

Data were analyzed using the MIXED procedures of SAS (SAS Institute, Cary, N.C.). Pens were the experimental unit (6/treatment). Block was treated as a fixed effect in the model. Only 1 replication was included in heavy block, with 5 replications in the other weight block. Therefore, data were analyzed and statistics are based on this analysis. However, least square means are not presented due to adjustment for unequal replication of blocks. Arithmetic means are presented by treatment.

The study was blind to feedlot personnel. Each hybrid was assigned a letter before beginning the trial. All treatments, silage bags, commodity bays, pen assignments, feed sheets, and observation documents were designated by letter to limit possible partiality to treatment.

Results

Performance and carcass data are shown in Table 2. No significant differences in ADG, F:G, or carcass characteristics were observed among treatments. Due to a statistical difference in initial BW (3 lb difference), initial BW was used as a covariate of analysis and unadjusted treatment means are reported. The average across all treatments for ADG and F:G were 3.73 and 6.00, respectively. Steers fed MON and REF1 had numerically better F:G ratios, with a tendency ($P = 0.13$) for more efficient feed conversion in steers fed REF1.

The source of corn, whether transgenic or nontransgenic, had no significant effect on the performance or carcass characteristics of the cattle in this trial. These data indicate performance and carcass characteristics of cattle fed MON 89034 were not different from cattle fed nontransgenic corn. MON 89034 is nutritionally equivalent to nontransgenic corn.

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Effects of Glycerin in Steam Flaked Corn Feedlot Diets

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Summary

Glycerin was fed at 0%, 3%, 6%, and 9% (DM basis) in a steam-flaked, corn-based (SFC) diet to determine the effects on performance and carcass characteristics. Glycerin linearly increased (P = 0.02) final BW, ADG linearly increased (P = 0.02), and F:G linearly decreased (P < 0.01) by 7.1%. The data suggests glycerin can be added up to 9% inclusion to improve performance.

Introduction

Biodiesel is derived from vegetable oils and animal fats. The primary byproduct from biodiesel production is glycerin, which accounts for approximately 10% of the initial oil. Glycerin is gluconeogenic and has been used as an energy source in the poultry and swine industries, as well as dairy cattle industry; however, there are limited data in beef cattle. We hypothesized that glycerin would be comparable to SFC in feedlot diets. The objective of this study was to evaluate the effects of different levels of glycerin on the performance and carcass characteristics of feedlot steers fed a steam-flaked, corn-based diet.

Procedure

British x Continental cross steers (n = 515; BW = 939 ± 81 lb) were used in a complete randomized block design. Upon arrival, individual BW were collected, steers were stratified by BW, assigned to 10 blocks, and assigned randomly to one of 40 pens (12 – 13 steers/pen). Treatment diets (n = 4; Table 1) were assigned randomly to pens. Treatments were glycerin inclusions of 0%, 3%, 6%, and 9% (DM basis; Table 1). The initial processing consisted of vaccinations and de-worming. Adaptation diets, which consisted of three periods of seven days each, had the roughage level decreased while the concentrate level increased. Corn silage was decreased (30%, 23%, and 17% [DM basis], respectively) and alfalfa hay was decreased (15%, 12%, and 8.5% [DM basis], respectively) while corn (dry-rolled corn in step 1 and SFC for steps 2 and 3) was increased (41%, 51%, and 62.7% [DM basis], respectively). Cattle were limit fed during step 3 at 2% of BW. Supplemental glycerin was not used during the adaptation period. Glycerin contained less than 0.005% methanol and 7% (DM) sodium chloride. Finishing diets were balanced for sodium with decreasing sodium chloride with increasing glycerin inclusion. Soybean meal was included to make the finishing diets isonitrogenous (Table 2). The liquid supplement (6.18% diet DM) contained Rumensin (30 g/ton) and Tylan (9 g/ton). On day 0, which occurred after the 21-day adaptation period, cattle were individually weighed for initial trial BW, implanted with Component TE-200, and began the finisher diet. Diets were fed once daily throughout the trial.

Cattle were fed 85, 118, or 126 days by BW block and harvested at a commercial packing plant (Cargill Meat Solutions, Fort Morgan, Colo.). Carcass data were collected (Diamond T Livestock Services Inc., Gunnison, Colo.) and calculated yield grade. To account for any gut-fill, the final BW

Table 1. Finishing diet composition (% DM basis).

	Glycerin			
Ingredient	0%	3%	6%	9%
Steam-Flaked Corn	79.29	75.93	72.58	69.22
Soybean Meal	3.14	3.69	4.24	4.80
Alfalfa Hay	3.60	3.60	3.60	3.60
Corn Silage	7.20	7.20	7.20	7.20
Glycerin[1]	0.00	3.00	6.00	9.00
NaCl	0.59	0.40	0.20	0.00
Supplement[2]	6.18	6.18	6.18	6.18

[1]DM 85%; NaCl 7% (DM basis); methanol < 0.005%
[2]Liquid supplement formulated to supply: Rumensin 30 g/ton and Tylan 9 g/ton

Table 2. Finishing diet nutrient analysis (% DM basis)[1].

	Glycerin			
Nutrient	0%	3%	6%	9%
DM, %	72.1	72.5	74.0	71.4
TDN, %	91.1	90.4	91.4	90.4
NE_m, MCal/lb	1.03	1.02	1.04	1.02
NE_g, MCal/lb	0.72	0.71	0.72	0.71
CP, %	13.2	13.5	12.8	12.8
Ca, %	0.90	0.78	0.79	0.73
P, %	0.30	0.28	0.28	0.25
Ca:P	3.0:1	2.8:1	2.8:1	2.9:1

[1]Analyses conducted by Servi-Tech Laboratories, Hastings, Neb.

Table 3. Effects of glycerin on performance.

Item	Glycerin 0%	3%	6%	9%	*P*-value[1] Linear	Quadratic
Initial BW, lb	939^{ab}	942^{ab}	946^{b}	935^{a}	0.84	0.06
Final BW, lb[2]	1331^{d}	1340de	1349^{e}	1349^{e}	0.02	0.57
DMI, lb/day	23.8^{b}	24.0^{b}	24.0^{b}	23.1^{a}	0.04	0.05
ADG, lb	3.45^{d}	3.52^{de}	3.59^{e}	3.59^{e}	0.02	0.74
F:G	6.90^{c}	6.80^{bc}	6.67^{b}	6.41^{a}	< 0.01	0.25

[1]Orthogonal contrasts; no cubic response ($P > 0.18$).
[2]HCW / 63% average dressing percentage.
[a,b,c]Means within rows differ ($P < 0.05$).
[d,e]Means within rows differ ($P < 0.10$).

Table 4. Effects of glycerin on carcass characteristics.

Item	Glycerin 0%	3%	6%	9%	*P*-value[1] Linear	Quadratic
HCW (lb)	836^{a}	838^{ab}	847^{b}	845^{b}	0.03	0.55
Dressing (%)	62.8	62.7	62.9	62.7	0.95	0.87
12th rib fat (in)	0.46	0.45	0.44	0.45	0.83	0.37
LM area (sq in)	12.3	12.4	12.5	12.4	0.09	0.12
USDA YG[2]	3.29	3.23	3.22	3.28	0.80	0.24
Marbling[3]	560	558	568	554	0.92	0.36
					Chi-Square	
Choice and above (%) [4]	86.1	83.1	85.7	82.5	0.82	
Prime (%) [4]	1.6	0.0	2.4	0.0	0.14	
Upper choice (%) [4]	7.8	3.9	5.6	2.4	0.22	
Mid choice (%) [4]	22.4	30.0	33.3	23.0	0.14	
Lower choice (%) [4]	54.2	49.2	44.4	57.1	0.19	
Select (%) [4]	14.0	16.9	14.3	17.5	0.82	

[1]Orthogonal contrasts; no cubic response ($P > 0.18$).
[2]Calculated Yield Grade = 2.5 + (2.5*12th rib fat, in) + (0.0038*HCW, lb) – (0.32*LM area, in^2) + (0.2*KPH, %).
[3]400 = slight 0; 500 = small 0.
[4]Analyzed by chi-square.
[a,b]Means within rows differ ($P < 0.10$).

was adjusted to a common dressing percentage of 63% and calculated from HCW. The carcass adjusted final BW was used to calculate ADG and F:G.

Data were analyzed using the MIXED procedure of SAS (Version 9.1, SAS Inc., Cary, N.C.). The factors included in the model were glycerin inclusion and block, where the weight block was a fixed variable and initial BW was used as a co-variate. Orthogonal contrasts were used for linear, quadratic, and cubic relationships for glycerin inclusion. Chi-square was used for USDA quality grade distribution. Pen was the experimental unit.

Results

When glycerin inclusion increased, final BW increased linearly ($P = 0.02$); Table 3. A quadratic response ($P = 0.05$) was observed for DMI as glycerin increased with the 3% and 6% inclusion being greater than the 0% or 9%. Gain increased linearly ($P = 0.02$) with increased glycerin and F:G decreased linearly ($P < 0.01$). The only carcass difference was a linear ($P = 0.03$) increase in HCW, where 6% inclusion had the heaviest carcasses (Table 4). There tended to be a linear ($P = 0.09$) increase in LM area with increased glycerin inclusion.

In summary, when replacing SFC with glycerin up to a 9% inclusion (DM basis), no adverse effects were observed for carcass characteristics, while ADG was improved up to 4.1%, and F:G was improved up to 7.1%. These data suggest glycerin is a suitable energy replacement in finishing diets containing steam-flaked corn.

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Protein, Fiber, and Digestibility of Selected Alternative Crops for Beef Cattle

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Summary

Field peas, dry edible beans, pumpkins, chicory, beets, and beet pulp grown in western Nebraska were analyzed for their salvage value in beef cattle diets when they do not meet specifications for human consumption. The digestibilities of all the crops were high (61-88%). Beet pulp, beet root, and chicory root were low in CP (< 7%) while all other crops were greater than 9%. Neutral and acid detergent fiber were ≤ 50%. Lectins in raw dry edible beans force them to be limited to < 2% of diet DM. Palatability of chicory root can reduce intake.

Introduction

Several unique crops are grown in western Nebraska primarily for human consumption. However, weather conditions, markets, or other factors may cause them to be unsuitable for human consumption and alternative uses or a salvage value is required for the crop. Livestock feeding is often a logical solution for crops deemed unacceptable for human consumption. More specifically, since beef production accounts for approximately 50% of western Nebraska's economy, the value of these crops for cattle feeding becomes important. This information could be used to determine how to include these crops in beef cattle rations should the opportunity arise. Crops selected for analysis included field peas, dry edible beans, pumpkins, chicory, whole beets, and beet pulp.

Field Peas

Field peas are becoming increasingly popular in western Nebraska as an alternative to fallow in dryland wheat production rotations. As a legume, peas add nitrogen to the soil, and their early maturity date (July-August) complements fall wheat planting nicely.

Dry Edible Beans

Nebraska is one of the leading states in the nation in dry edible bean production. In particular, the North Platte River Valley is known for its consistently high quality bean production, and is responsible for over 85% of the Great Northern beans produced in the nation. Not all the beans produced are suitable for human consumption. Broken or discolored beans as well as frost damaged, diseased, or high moisture beans are available for livestock consumption. Typically, cull beans are used as a binder and protein source in range supplements for grazing cattle. Previous research has shown cull beans can be fed without adversely affecting performance up to 2% of diet DM. The adverse effects associated with feeding cull beans are thought to be due to proteins called lectins that interfere with protein digestion and cause watery diarrhea. Apparently the heat required for pelleting is insufficient to denature these proteins.

Pumpkins

Pumpkins are grown in western Nebraska for decorative purposes in the fall as well as for human consumption. Pumpkins with blemishes are typically discarded and many pumpkins are broken or damaged during harvest, making them unacceptable for market. Furthermore, after October 31, the market for decorative pumpkins plummets and many pumpkins are left to rot in the fields. Some producers have grazed pumpkin fields in conjunction with cornstalk fields, but little is known about the nutritive value of pumpkins for beef cattle.

Chicory

Chicory is grown primarily for its inulin content. Inulin is a fructose-based sweetener used as a flavoring for coffee or as a coffee substitute. Inulin also has been reported to improve intestinal health in humans. Additionally, the leaves can be added as greens in salads. Occasionally, chicory is available for livestock consumption. While chicory is commonly added to pet food diets, its use in livestock diets has been more limited.

Whole Sugarbeet Roots, Tops, and Beet Pulp

Nebraska is ranked 6th in U.S. sugarbeet production. The sugarbeet industry makes a substantial contribution to the western Nebraska economy. Occasionally however, environmental conditions prevent harvesting the beets prior to ground-freezing conditions and just as with chicory, questions arise concerning grazing unharvested fields of sugarbeets. Beet pulp is by definition a co-product of the sugar production industry. However, it is a readily available product approximately five months out of the year and can be stored for later use. It is consistently available whereas whole sugarbeets typically are not. Therefore, its value to the beef cattle industry warrants discussion.

Procedure

Field peas and dry edible beans were subsampled after the crops were harvested. Whole bean plants (black beans) were randomly selected from a test plot after it was determined the beans were not going to be acceptable for harvest. Pumpkins were randomly selected from a local producer's farm after October 31, when no more pumpkins would be sold from the field. Chicory and beets were randomly selected from

Table 1. Nutrient content of field peas, pumpkins, sugarbeet pulp, dry beans, and chicory.

Item	DM	IVDMD[1]	CP	NDF	ADF
Field Peas	87.0	82.7	15.1	9.5	8.0
Carving Pumpkin	11.9	71.4	14.3	36.8	25.6
Pie Pumpkin	16.5	61.0	14.4	38.6	32.5
Sugarbeet Pulp	26.1	76.1	6.6	45.4	27.4
Whole Sugarbeet Root	23.8	86.8	3.3	15.4	6.7
Whole Sugarbeet Leaves	36.7	65.2	10.9	50.8	24.0
Black Beans	96.9	83.5	15.4	14.3	4.7
Great Northern Beans	98.2	88.0	15.0	7.2	3.7
Pinto Beans	98.3	84.6	14.5	12.0	5.9
Total bean plant (black beans) after frost	90.4	66.3	9.0	38.6	32.4
Chicory Roots	26.1	88.9	3.7	8.6	5.3
Chicory Leaves	17.6	67.3	8.5	23.6	21.4

[1]IVDMD values were adjusted based on the average of 5 *in vivo* forage standards.

the fields prior to harvest, while the beet pulp was subsampled from Western Sugar in Scottsbluff, Neb. as the beets were being processed. Dry matter was then determined on all crops in a 100°F oven for 48-72 hours. Samples were ground and analyzed in triplicate for CP, natural detergent fiber (NDF), and acid detergent fiber (ADF), and *in vitro* dry matter digestibility (IVDMD, similar to TDN). The IVDMD procedure included a 48-hour incubation in rumen fluid followed by a 24-hour pepsin digestion. Samples were analyzed with five forage samples of a known *in vivo* value. On average, the *in vitro* method over-estimated the known forage samples 5%. Therefore, the test samples were adjusted 5% as well.

Results and Discussion

Field Peas

Previous research indicated field peas can be fed whole or processed with an optimum inclusion level of 20% DM. Field peas are highly digestible, high in CP, and low in fiber (Table 1). Previous research (*2010 Nebraska Beef Cattle Report*, pp. 107-108) indicated they are palatable, maintain performance, and enhance carcass tenderness.

Dry Edible Beans

Previously reported CP values for beans have ranged from 22-24% (DM basis). The analysis for this report only ranged from 14.5-16% (Table 1). Great Northern beans were lower in NDF and ADF than pintos or black beans while digestibility and CP were similar for all beans analyzed. Analysis was also conducted on whole bean plants after frost to determine the feeding value of the whole plant if it were to be baled rather than harvested at all. The CP was much lower and the NDF and ADF much higher (Table 1), but the high percentage of raw beans would still warrant feeding with caution.

Pumpkins

The analysis presented in Table 1 indicates DM digestibility and CP to be high (61-71% and 14.3% DM, respectively) and the fiber to be moderate (25-38% DM). Carving pumpkins tended to be lower in DM and ADF and have greater digestibility than pie pumpkins. CP and NDF were similar for both types of pumpkins. These data suggest pumpkins are a good source of energy and adequate in protein.

Chicory

Past research (1999 Nebraska Beef Report, pp. 37-39) has included the ground root in growing diets as a replacement for silage at <30% (DM basis). Results were comparable to using beet pulp to replace silage, but with lower intakes, probably due to the palatability of the chicory root. Average quality analysis for both roots and leaves of four varieties of chicory are presented in Table 1. The chicory root is high in DM digestibility, but very low in CP, NDF, and ADF. The leaves however, contain moderate DM digestibility, NDF, and ADF, and adequate CP. Typically, tops are destroyed and left in the field for organic matter at harvest and are not available to feed to cattle. Questions occasionally arise about grazing unharvested fields and therefore quality analysis of the tops would be meaningful; however, the risk of cattle choking on small up-rooted chicory roots is an issue to be considered.

Whole Sugarbeet Roots, Tops, and Beet Pulp

Analyzed whole sugarbeet plants were similar in DM digestibility, CP, and ADF to whole chicory (Table 1). The NDF, however, was higher in whole sugarbeets. The removal of the sugar increases CP, NDF, and ADF content as compared to the whole root. However, beet pulp has a high IVDMD, moderate NDF and ADF with a fairly low CP value (Table 1). Therefore, it is typically included in growing calf rations at < 30% (dry matter basis). Additional research is currently being conducted on the use of beet pulp in gestating cow and feedlot finishing diets.

Implications

All crops analyzed in this study were highly digestible with low to moderate protein content and could be included in beef cattle diets to decrease ration costs.

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Mud Effects on Feedlot Cattle

Terry L. Mader[1]

Summary

Estimated mud depth and benefits of bedding were simulated under winter environmental conditions. In general, providing greater pen area per animal decreased mud depth. At lower temperatures (16°F), 250 or 350 ft^2 of pen space produced similar depths of mud and approximately 1 inch less than with the 150 ft^2 allocations. Under the coldest (16°F) and wettest (6 inches total precipitation) conditions, cost of gain (COG) was 56.1% ($1.07/lb) greater than with no precipitation falling at 26°F, while use of bedding reduced COG to $0.80 /lb or just 17.3% greater than COG under more ideal conditions at 26°F.

Introduction

Managing cattle in periods of adverse weather can be challenging. Winter cold and wind, combined with precipitation, can increase the maintenance requirement of feedlot cattle and decrease performance. While cold stress alone can reduce profits, it is most detrimental when combined with mud. Cattle in mud have a tendency to eat less frequently at a time when the muddy hair coat reduces insulation. Thus, cattle performance can be reduced for multiple reasons. The objectives of this study were to develop models to predict mud effects and related mitigation strategies for feedlot cattle.

Procedure

Data from cattle feeding studies conducted in Canada, California, Colorado, Nebraska, North Dakota, and South Dakota (references available upon request) were used to assess effects of mud and bedding on feedlot cattle. An initial model was developed to assess effects of muddy conditions on feedlot cattle feed intake and daily gain. Estimates of mud depth were determined based on quantity of rain and snowfall, feedlot layout, feedlot soil and surface properties, and stocking densities. From performance profiles, algorithms were derived to estimate maintenance energy requirements based on mud depth and environmental conditions.

To counter effects of mud, bedding can be used to absorb excess moisture. Therefore, a subsequent submodel of the first model was developed to determine the effects of bedding on cattle performance. Performance assessments were based on amounts and type of bedding used, environmental conditions, and estimates of feedlot pen conditions as defined from the previous model used for determining feedlot mud depth. Bedding quantities needed to absorb excess moisture can be calculated based on water holding capacity of the soil and potential for run-off. However, quantity of bedding (lb/head/day) needed is comparable to the potential mud depth. Thus, approximately 1 lb of bedding is needed daily to overcome impacts of 1 inch of mud.

Model simulations were conducted based on feedlot pen soil profiles that were composed of predominantly clay-based soils, reasonably clear of manure, with a 3% slope. A 120-day feeding period was simulated for cattle averaging 1,000 lb. Pen densities of 150, 250, and 350 ft^2/animal were compared. Average winter temperatures of 16°F, 26°F, and 36°F were compared under low (2 inches) and high (6 inches) quantities of total precipitation between December 1 and April 1. Temperature and precipitation varied by week and month to simulate variable winter conditions. Estimates of daily water intake were used to determine moisture accumulations attributed to urinary output. Environmental conditions, in conjunction with feedlot and animal variables, were used to determine pen surface conditions and bedding requirements. Mud depth is an estimate of the depth of mud or mud and snow mix. Simulations were based on 50% of all snowfall blowing out of pens (50% remaining) with snow compaction rates varying, depending on stocking densities. Cost of gain was based on performance estimates. Feed ($150/dry ton), yardage ($0.35/head/day), and other costs comparable to those found in Nebraska feedyards were used. Bedding was charged out at $60/ton. Manure hauling and additional pen cleaning charges associated with bedding were prorated on a per head basis at $6/wet ton. Weight of bedding removed from the feedlot was estimated to be four times the original bedding weight, which would include the bedding, absorbed water, and attached mud and manure particles.

Results

For simulation purposes, a constant daily dry matter intake (DMI) of 22 lb was used. Under colder conditions, intakes would be expected to be greater; however, under muddy and/or adverse feeding and pen conditions, DMI would be expected to be lower. The first data column indicates what the performance and cost of gain (COG) are under ideal (68°F) feeding conditions. Percent changes in winter maintenance energy requirements (NEm) and COG were determined based on those ideal conditions. In general, providing greater area per animal decreases mud depth (Table 1). However, at lower temperatures (16°F), 250 or 350 ft^2 of pen space produced similar depths of mud with mud depths approximately 1 inch less than with the 150 ft^2 allocations. The difference may be largely due to precipitation coming in the form of snow, and the effects of total precipitation combined with urinary output begin to diminish in the winter with greater pen space allocations. Thus, at temperatures approaching 10°F below freezing or more, the potential for mud depth does not increase as pen space increases from 250 to 350 ft^2/animal. As a result of snow accumulation, snow/mud depth increases until temperatures warm up and snow begins to melt, allowing moisture to leave the pen through run-off. In general, at temperatures that are below freezing, animals continue to disturb the snow/soil interface, which increases snow/mud depth. The impact of body heat from animals lying on the ground also contributes to snow melting and/or mixing with surface soil particles. This phenome-

Table 1. Estimated mud depth, change in net energy for maintenance (NEm), and cost of gain for feedlot cattle under different simulations.

Pen space, ft²/animal:	250	150	150	150	150	250	250	250	250	350	350	350	350
120-day precipitation, inches:	0	2	2	6	6	2	2	6	6	2	2	6	6
Mean temperature,°F:	68	36	16	36	16	36	16	36	16	36	16	36	16
Mud depth, inches	0.00	1.96	3.47	3.95	8.48	0.40	2.52	2.38	7.52	0.02	2.51	1.72	7.52
NEm, % change[1]	—	25.6	48.7	37.1	91.3	17.8	41.9	27.9	82.2	16.1	41.9	24.3	82.2
DMI, lb/day	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0
ADG, lb	3.71	3.23	2.78	3.01	1.94	3.37	2.91	3.18	2.12	3.41	2.91	3.25	2.12
F:G	5.93	6.82	7.91	7.32	11.32	6.52	7.55	6.91	10.36	6.46	7.55	6.77	10.36
Cost of gain/ lb, $	0.61	0.70	0.82	0.76	1.17	0.67	0.78	0.71	1.07	0.67	0.78	0.70	1.07
% change[2]	—	15.1	33.5	23.5	91.1	10.0	27.5	16.6	74.8	8.9	27.4	14.2	74.8

[1]Change (%) in NEm; at 26°F with no mud, NEm is approximately 20% greater than at 68°F.
[2]Compared to ideal feeding conditions averaging 68°F (first numerical column).

Table 2. Projected effects of mud and bedding on feedlot cattle.

Space, ft²/animal:	250	250	250	250	250	250	250
120 days precipitation, in:	0	2	2	2	6	6	6
Mean temperature,°F:	26	36	26	16	36	26	16
Estimated mud depth, inches	0.00	0.40	2.01	2.52	2.38	6.63	7.52
NEm, % change	—	1.8	11.2	16.0	11.9	43.9	56.2
Intake, lb	22.00	22.00	22.00	22.00	22.00	22.00	22.00
Without bedding							
ADG, lb	3.31	3.37	3.10	2.91	3.18	2.47	2.12
Change, %	—	1.8	-6.4	-12.1	-4.0	-25.6	-35.9
Feed/gain	6.64	6.52	7.10	7.55	6.91	8.92	10.36
Cost of gain, $/day							
Yardage and interest	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Health and feed	1.77	1.77	1.77	1.77	1.77	1.77	1.77
Total	2.27	2.27	2.27	2.27	2.27	2.27	2.27
Cost of gain/lb	0.68	0.67	0.73	0.78	0.71	0.92	1.07
Change, %	—	-1.8	6.9	13.8	4.1	34.4	56.1
With bedding[1]							
ADG, lb	3.31	3.41	3.31	3.22	3.41	3.31	3.22
Change, %	—	2.9	0	-2.9	2.9	0	-2.9
Feed/gain	6.64	6.45	6.64	6.83	6.45	6.64	6.83
Change, %	—	-2.8	0	3.0	-2.8	0	3.0
Cost of gain, $/day							
Subtotal (less bedding)	2.27	2.27	2.27	2.27	2.27	2.27	2.27
Bedding	0.00	0.01	0.06	0.08	0.07	0.20	0.23
Scraping and hauling, prorated	0.00	0.01	0.02	0.03	0.03	0.08	0.09
Total	2.27	2.29	2.35	2.38	2.37	2.55	2.59
Cost of gain/lb	0.68	0.67	0.71	0.74	0.70	0.77	0.80
Change, %	0	-2.1	3.7	7.4	1.5	12.3	17.3

[1]Bedding cost is $60/ton; scraping and hauling cost is $6/wet ton. Hauled weight is assumed to be four times original dry bedding weight.

non is enhanced as pen space declines.

Although these mud depths may not always be fully realized, the potential for mud depth (or a comparable effect) increases under conditions in which precipitation comes as snow rather than as rain. Thus, snow remaining in pens will provide a constant source of moisture, keeping cattle wet and mixing with pen surface particles, with the same effect as increasing mud depth. Precipitation that comes as rain (warmer temperatures) can easily run off and contribute less to muddy conditions or wet cattle. Costs of gain are greater under colder conditions due to the effects of increased mud depth, which contributes to wetter and colder cattle and directly impacts NEm.

Table 2 displays the COG for various simulated mud depth, with and without bedding. In all instances, benefits of bedding were observed. Under lower precipitation conditions, even a small amount of bedding was useful, although the amount required per head per day ranged from 0.4 to 2.5 lb under these conditions.

Even though simulations indicated a benefit for adding even a small amount of bedding, it is unlikely that bedding amounts less than 1 lb could be effectively distributed daily to absorb the moisture needed to produce these results. Thus, for average mud depths of less than 1 to 2 inches, depending on pen design, bedding may not be practical or recommended. In addition, with low average mud depths, the probability of having some dry places in the pen would be high. Nevertheless, the benefits of bedding, as determined by the percentage change in COG, were much greater under high versus low moisture conditions. Under the coldest (16°F) and wettest conditions, COG was 56.1% ($1.07/lb) greater than with no precipitation falling at 26°F, while the use of bedding reduced the COG to $0.80/lb or to just 17.3% greater than COG under more ideal conditions at 26°F.

Based on results of studies conducted primarily in the western and northern plains, the impacts of mud on feedlot cattle are substantial, but the use of bedding can help minimize the adverse effects. If bedding prices and/or cost of handling the bedding or handling and hauling the resulting waste increase, the cost/benefit ratios may change. In addition, applied bedding does not have to be equally distributed throughout the pen, but initially needs to provide comfortable space (20 to 40 ft²/animal) for each animal to avoid competition. Bedding will generally be distributed by the cattle. It should be noted that if bedding is used heavily, the dynamics of pen drying may differ in bedded versus non-bedded-pens when environmental conditions for drying improve. This is due to the enhanced water-holding capacity of soil containing more fiber. However, in virtually every bedding study in which an economical analysis was reported, a benefit to bedding was found during prevailing winter weather.

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Effect of Pen Cleaning Frequency and Feeding Distillers Grains and Wheat Straw on Nutrient Mass Balance and Performance of Feedlot Steers

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Summary

Two experiments, calves fed November to May (WINTER) and yearlings fed May to September (SUMMER), were conducted to evaluate the effects of feeding a high level of wet distillers grains plus soluble (WDGS) and wheat straw or a corn control diet (CON) on average daily gain (ADG), feed-to-gain (F:G), manure nitrogen (N), and N losses. In both experiments, the CON treatment had greater dry matter intake (DMI), ADG hot carcass weight (HCW), marbling and fat depth. There was greater N intake and N excretion for both the WINTER and SUMMER experiments on the WDGS. However, for the WINTER experiment there was no difference in the amount of N in the manure due to diet or pen cleaning frequency. In the SUMMER experiment, cleaning pens monthly almost doubled dry matter (DM), organic matter (OM), and N removed in manure. There was a tendency for the WDGS treatment to have greater N loss than the control treatment in the WINTER experiment and a significant increase in N losses for the WDGS treatment in the SUMMER experiment, despite the greater amount of manure N removed.

Introduction

One method that reduces N losses from feedlots is the addition of carbon (C) to the pen surface to increase C:N. Research at UNL has used either direct or indirect methods to increase the C:N ratio. Corn milling byproducts are a common indirect method used to increase the C:N ratio on the pen surface through the manure. Corn bran was effective in reducing N losses *(2000 Nebraska Beef Cattle Report*, pp. 54-57), but cattle performance suffered. When steep was added to the corn bran treatment (*2004 Nebraska Beef Cattle Report*, pp. 61-63; *2005 Nebraska Beef Cattle Report*, pp. 54-56), ADG and F:G improved while N losses were reduced. Feeding wet DGS increased the amount of OM and N in the manure (*2008 Nebraska Beef Cattle Report*, pp. 53-56) but not to the same extent as corn bran. Pen cleaning frequency reduces the amount of time manure is exposed to the environment, therefore, reducing amount of N lost through volatilization. Cleaning pens approximately every 28 days has been reported to increase the amount of DM, OM, and N in the manure as well as decrease the N loss compared to cleaning at the end of the feeding period (*2004 Nebraska Beef Cattle Report*, pp. 72-73). Effects of feeding either a high level of wet distillers grains plus solubles with added fiber from wheat straw or a corn-based diet and pen cleaning frequency on cattle performance and nutrient mass balance were evaluated in our study.

Procedure

Cattle Performance

Two experiments were conducted using 128 steers each, calves (686 +/- 22 lb) fed for 173 days from November to May (WINTER) and yearlings (805 +/- 11 lb) fed for 145 days from May to October (SUMMER) to evaluate the effect of feeding high levels of both distillers grains and wheat straw compared to a corn-based diet. Steers were stratified by body weight (BW) and assigned randomly to 16 pens (8 steers/pen). The SUMMER and WINTER dietary treatments consisted of 1) 85% dry-rolled corn, 5% molasses, 5% wheat straw, 5% supplement (CON), or 2) 70% WDGS and 25% wheat straw, 5% supplement (WDGS + straw). For the 21-day adaptation period, alfalfa hay was replaced by dry-rolled corn in the CON treatment. Wheat straw was kept constant through the adaptation period and WDGS replaced alfalfa hay. A supplement contained Rumensin, Tylan, and Thiamine at 30 g/ton DM, 90, and 130 mg/steer daily, respectively, in both experiments.

Steer calves in the WINTER trial were implanted on day 1 with Synovex Choice (Fort Dodge Animal Health) followed by a re-implant on day 85 with Synovex Choice. Yearling steers on the SUMMER trial were implanted with Revalor-S (Intervet Schering-Plough Animal Health) on day 35 of the feeding period. Due to the goal of harvesting steers at similar BW, the WINTER CON treatment was slaughtered on day 173 and the WDGS + straw treatment was slaughtered on day 229. For the SUMMER, the yearling steers were slaughtered on day 144 for the CON and day 159 for the WDGS + straw of the feeding experiment. Steers were harvested at a commercial abattoir (Greater Omaha) and hot carcass weight and liver scores were recorded on day of slaughter. Fat thickness, lean matter area, and USDA called marbling score were collected after a 48-hour chill. Final BW, ADG, and G:F were calculated based on HCW adjusted to a common dressing percentage of 63%. Feed efficiency data were analyzed as G:F and reported as F:G.

Nutrient Mass Balance

Runoff N was determined using 12 open feedlot pens with retention ponds to collect runoff from

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

Dietary Treatments[1]	CON	WDGS + straw	SEM	*P*-value[2]
WINTER[3]				
Performance				
DMI, lb	22.6	18.5	0.3	<0.01
ADG, lb	3.57	2.36	0.4	<0.01
Feed: Gain	6.33	7.81	.002	<0.01
SUMMER[4]				
Performance				
DMI, lb	23.6	21.1	0.3	<0.01
ADG, lb	3.15	2.62	0.05	<0.01
Feed: Gain	7.47	8.00	0.003	0.04

[1]Dietary treatments: CON = Control corn-based diet, WDGS + straw = 70% WDGS, 25% wheat straw.
[2]*F*-test statistic for dietary treatment.
[3] CON – fed for 173 days, WDGS – fed for 229 days.
[4] CON – fed for 144 days, WDGS – fed for 156 days.

Table 2. Effect of dietary treatment on nitrogen mass balance[1] during WINTER[2] trial.

Dietary treatment[3]	CON	WDGS + straw	SEM	*P*-value[4]
N intake	76.3	123.1	1.1	<0.01
N retention[5]	12.1	11.9	0.3	0.25
N excretion[6]	64.2	111.4	1.1	<0.01
Manure N[7]	23.6	26.2	3.5	0.63
N Run-off	—	—	—	—
N Lost	40.4	85.1	4.2	<0.01
N loss%[8]	62.9	76.4	5.1	0.08
DM removed	4776	5257	672	0.62
OM removed	1114	1418	170	0.23

[1]N mass balance analyzed for equal days across treatments.
[2]Values are expressed as lb/steer over entire feeding period (WINTER – fed for 173 days, SUMMER – fed for 144 days).
[3]Dietary treatments: CON = Control corn-based diet, WDGS + straw= 70% WDGS, 25% wheat straw.
[4]*F*-test statistic for dietary treatment.
[5]Calculated using the NRC net protein and net energy equations.
[6]Calculated as N intake – N retention.
[7]Manure N with correction for soil N.
[8]Calculated as N loss divided by N excretion.

Table 3. Effect of pen cleaning frequency on nitrogen mass balance[1] during WINTER[2] trial.

Pen cleaning frequency[3]	End	Monthly	SEM	*P*-value[4]
N intake	100	99	1.103	0.39
N retention[5]	12.13	11.90	0.27	0.91
N excretion[6]	88.42	87.10	1.13	0.41
Manure N[7]	21.83	28.00	3.5	0.24
N Run-off	—	—	—	—
N Lost	66.37	59.10	4.19	0.21
N loss%[8]	73.5	65.5	5.1	0.29
DM removed	3837	6194	670	0.03
OM removed	1005	1526	170	0.05

[1]N mass balance analyzed for equal days across treatments.
[2]Values are expressed as lb/steer over entire feeding period (WINTER – fed for 173 day, SUMMER – fed for 144 days).
[3]Pen cleaning frequency: end = cleaned at end of feeding period, monthly = cleaned every 28 days.
[4]*F*-test statistic for dietary treatment.
[5]Calculated using the NRC net protein and net energy equations.
[6]Calculated as N intake – N retention.
[7]Manure N with correction for soil N.
[8]Calculated as N lost divided by N excretion.

rainfall. When runoff did occur, it was collected in the retention ponds and they were drained, sampled, and quantified. Pens that were randomly assigned to the 28-day pen cleaning schedule were scraped and the manure was piled on a cement apron and sampled for nutrient analysis while being loaded. Pens that were assigned to the end-of-the-feeding-period cleaning were subjected to this cleaning after the steers were removed for harvest. Manure was then weighed before it was hauled to the University of Nebraska compost yard, where treatments were kept separated. Manure samples were then freeze dried for nutrient analysis and oven dried for DM calculation. 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 NRC net energy and protein equations (NRC, 1996). Nutrient excretion was determined by subtracting nutrient retention from intake. Total N lost (lb/steer) was calculated by subtracting manure N and runoff N from excreted N. Percentage of N loss was calculated as N lost divided by N excreted.

Animal performance and nutrient balance data were analyzed using the MIXED procedures of SAS as a 2 X 2 factorial design with the factors being dietary treatments and timing of pen cleaning.

Results

Cattle Performance

There was no interaction between dietary treatments or pen cleaning frequency ($P > 0.24$) for either SUMMER or WINTER trials; therefore, only main effects will be discussed. In the WINTER, cattle fed the WDGS + straw had lower DMI (18.5 lb/day versus 22.6 lb/day). Average daily gain was also lower in the WDGS + straw treatment (2.36 versus 3.57 lb), which resulted in a greater F:G ($P < 0.01$) compared to the cattle consuming the CON treatment.

(Continued on next page)

Cattle fed during the SUMMER trial had similar performance results as the WINTER calf-feds. Intake was lower for the WDGS + straw treatment ($P < 0.01$) as well as ADG ($P < 0.01$), which resulted in a higher F:G (8.00 lb versus 7.47 lb ($P = 0.04$)). This lower performance (Table 1) for the WDGS + straw treatment is most likely due to the high inclusion of wheat straw in the diet, which was added to help increase the amount of OM on the pen surface and prevent sulfur-related polio-encephalomalacia (2009 *Nebraska Beef Cattle Report*, pp. 79-80).

Nutrient Balance

There was no interaction between dietary treatments or pen cleaning frequency ($P > 0.10$) for either SUMMER or WINTER trials; therefore, only main effects will be discussed.

Steers fed during the WINTER had greater N intake and N excretion when consuming the WDGS + straw treatment ($P <0.01$, Table 2). However, manure N was similar for the CON and WDGS + straw treatments. Therefore, because WDGS + straw calves excreted more N with the same amount in manure as the CON calves, the calves consuming the WDGS + straw had greater N losses ($P < 0.01$). There was a tendency ($P = 0.08$) for the WDGS + straw steers to have a greater N loss (76.4% vs. 62.9%) when expressed as a percentage of N excreted. There was not enough precipitation during the WINTER trial to generate runoff. The dry matter and OM removed were similar across dietary treatments ($P > 0.10$). Amount of DM removed was greater for pens cleaned monthly compared to those cleaned at the end of the feeding period ($P = 0.03$) (Table 3).

Steers on trial in the SUMMER consuming the WDGS + straw had greater ($P<0.01$) N intake and N excretion, due to excess CP with the WDGS + straw treatment compared to the CON treatment (24% versus 12%, Table 4). Runoff N was not impacted ($P = 0.28$) by either dietary treatments or pen cleaning frequency; however, there was almost double the amount of manure N, DM, and OM removed for the steers consuming the WDGS + straw compared to the CON ($P < 0.01$). Table 5 reports the pen cleaning frequency results. Monthly pen cleaning also almost doubled ($P < 0.01$) the amount of N, DM, and OM removed in the manure. Despite increases in manure N, N losses were greater ($P < 0.01$) for the WDGS + straw compared to the CON treatment. Cleaning pens monthly decreased ($P < 0.01$) N losses by 8.4 lb or 50.5% compared to cleaning at the end of the feeding period. Runoff N did not constitute much of what was excreted, resulting in 3.5% of N excreted for the CON treatment and 2.2% for the WDGS + straw.

These data indicate feeding 70% WDGS with 25% wheat straw does decrease DMI, ADG, and F:G year around. Feeding WDGS at 70% diet DM increased N intake and N excretion due to the high concentration of CP in the byproduct. Cleaning feedlot pens monthly does increase total amount of manure removed, but there is also a greater amount of OM and N removed.

Table 4. Effect of dietary treatment on nitrogen mass balance[1] during SUMMER[2] trial.

Dietary treatment[3]	CON	WDGS + straw	SEM	P-value[4]
N intake	63.8	115.1	1.1	<0.01
N retention[5]	8.8	8.4	0.1	0.02
N excretion[6]	55.0	106.7	1.1	<0.01
Manure N[7]	17.4	31.7	1.7	<0.01
N Runoff	1.9	2.3	0.63	0.64
N Lost	33.5	69.9	2.2	<0.01
N loss%[8]	60.9	65.5	2.5	<0.01
DM removed	7784	12287	947	<0.01
OM removed	1160	2317	98	<0.01

[1]N mass balance analyzed for equal days across treatments.
[2]Values are expressed as lb/steer over entire feeding period (WINTER – fed for 173 days, SUMMER – fed for 144 days).
[3]Dietary treatments: CON = Control corn-based diet, WDGS + straw= 70% WDGS, 25% wheat straw.
[4]F-test statistic for dietary treatment.
[5]Calculated using the NRC net protein and net energy equations.
[6]Calculated as N intake – N retention.
[7]Manure N with correction for soil N.
[8]Calculated as N loss divided by N excretion.

Table 5. Effect of pen cleaning frequency on nitrogen mass balance[1] during SUMMER[1].

Pen cleaning frequency[2]	End	Monthly	SEM	P-value[3]
N intake	90	89	0.68	0.68
N retention[4]	8.56	8.60	0.79	0.91
N excretion[5]	81.21	80.50	0.13	0.79
Manure N[6]	16.82	32.26	1.70	<0.01
N Run-off	3.51	5.76	1.39	0.28
N Lost	60.92	42.47	2.21	<0.01
N lost%[7]	164.6	114.06	5.53	<0.01
DM removed	6090	13981	941	<0.01
OM removed	1252	2225	98	<0.01

[1]Values are expressed as lb/steer over entire feeding period (WINTER – fed for 173 days, SUMMER – fed for 144 days).
[2]Pen cleaning frequency: end = cleaned at end of feeding period, monthly = cleaned every 28 days.
[3]F-test statistic for dietary treatment.
[4]Calculated using the NRC net protein and net energy equations.
[5]Calculated as N intake – N retention.
[6]Manure N with correction for soil N.
[7]Calculated as N lost divided by N excretion.

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Relationship Between Morbidity and Performance in Feedlot Cattle

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Summary

Five datasets from Canada, Oklahoma, Illinois, and Nebraska were used to determine the impact of bovine respiratory disease (BRD) on performance, with emphasis on dry matter intake (DMI) and feed to gain ratio (F:G). Data included pens and individually fed cattle. In general, cattle treated for BRD had lower DMI and average daily gain (ADG) with little to no effect on F:G. When BRD occured early in the feeding period (<30 days), little change in performance was observed.

Introduction

A common perception is that bovine respiratory disease (BRD) causes a depression in ADG and presumably feed efficiency. Pen level research supports the conclusion that cattle within pens treated for BRD have lower ADG compared to healthy pen mates and lighter carcasses when the pen is marketed at one time. These cattle also tend to be leaner and have less marbling. However, it is not clear when ADG is decreased whether DMI is impacted because individual DMI is not measured within feedlot pens. It is also unclear whether feeding those cattle treated for BRD longer would improve carcass weight and quality to match healthy pen mates. Likewise, whether the cause of decreased carcass quality is due to BRD or depressed ADG is unknown. It seems reasonable that cattle contracting BRD later in the feeding period would be more negatively impacted compared to steers contracting BRD at receiving or early in the feeding period. Therefore, the objective of this compilation of research is to determine the impact of BRD on ADG, DMI, and F:G of finishing cattle using both pen and individual feeding trials.

Procedure

Data from two commercial feedlots in Alberta, Canada (Western Feedlots) were obtained to evaluate impact of BRD on performance. Incidence of BRD across these lots varied from 0 to 70% throughout the entire feeding period. The effect of percentage of cattle in a pen treated for BRD on lot close-out DMI, ADG, and F:G were evaluated with n = 978 lots (276, 116 cattle) finished at two Alberta, Canada feedlots in 2007 and 2008. Lots in the dataset had 0 to 70% pen incidence of BRD, and all lots contained greater than 100 cattle. Lots were categorized by < 5%, 5-10%, 10-15%, 15-20%, 20-25%, 25-30%, 30-35%, or > 35% of cattle in the lot treated for BRD and analyzed for linear and quadratic response in lot performance as BRD incidence increased. A subset of these cattle (n = 33,074 cattle) had individual carcass data linked to individual steer within each lot so performance and BRD treatment could be matched with carcass data. The carcass data were used to evaluate effects of cattle being treated zero, one, or two or more times for BRD on linear and quadratic responses of cattle gain and carcass characteristics.

The effect of days on feed at BRD treatment on individual animal DMI, ADG, and F:G was evaluated with three datasets. Two datasets included individually fed growing (n = 900; 16% BRD treatment) and finishing (n = 987; 19% BRD treatment) cattle fed at the University of Nebraska–Lincoln ARDC Feedlot. Cattle were housed in confinement barns containing 30 cattle each with individual DMI collected using Calan gates. Each animal had access to an individual bunk and a common water source within barn. Individual cattle performance was also analyzed with a third dataset of 1,940 individual finishing cattle with 10% average incidence of BRD fed over four years at the University of Illinois-Urbana GrowSafe facility. Steers were housed on indoor slatted pens of 8-40 steers each with common bunks and water sources within pen. Categories in all three datasets included no treatment, BRD treatment < 30 days on trial, and BRD treatment > 30 days on trial. An individual animal could only be classified in one of the categories. Category priority was given to the treatment closest to completion of the trial. Initial BW was used as a covariate, and the random effects of dietary treatment within trial and pen effects also were accounted for. The categorical data were analyzed with the Proc GLIMMIX procedures of SAS (SAS Inc., Cary, NC). Feed efficiency (G:F) was used for statistical analyses, but has been converted to F:G in data summaries. Because of unequal replications within BRD categories, standard errors are reported by category instead of pooled errors. When appropriate (i.e., differences in significance are observed), initial BW was used as a covariate to correct for differences in performance due to lighter starting BW and isolate the impact of BRD on performance.

Results

When cattle were categorized for BRD incidence by lot in commercial feedlots, DMI and ADG of the lot were impacted ($P < 0.001$) by the percentage within the pen that had been treated for BRD (and presumably contracted BRD). This impact was independent of initial BW, which was used as a covariate. Table 1 illustrates that as more

(Continued on next page)

Table 1. Bovine respiratory disease (BRD) impact on performance when categorized by incidence at two commercial feedlots in Alberta, Canada that included over 276,000 head and 978 lots of cattle.

	Respiratory disease incidence within the lot[1]								*P*-Value[2]		
	0 - 5	5 - 10	10 - 15	15 - 20	20 - 25	25 - 30	30 - 35	> 35	*F-test*	Linear	Quadratic
Steers, n	19,938	36,195	44,056	46,382	47,010	34,374	22,088	26,073			
Lots, n	131	162	161	151	140	90	69	74			
Morbidity, %	3.1	7.6	12.6	17.5	22.3	27.5	32.4	42.3	<0.001	<0.001	<0.001
Initial BW, lb	620	610	617	622	614	612	602	612	0.05	0.08	0.60
DMI, lb/day	19.6	19.4	19.2	19.0	18.9	19.0	18.7	18.7	<0.001	<0.001	0.001
ADG, lb	3.50	3.45	3.46	3.39	3.40	3.40	3.35	3.39	<0.001	<0.001	0.03
F:G	5.61	5.64	5.55	5.64	5.57	5.59	5.59	5.53	0.03	0.08	0.53

[1]Respiratory disease incidence categorized by percent of cattle identified as morbid.
[2]*P*-value for F-test statistic and linear effect of BRD percentage within lots of cattle.

cattle within the pen get sick, DMI decreased linearly ($P < 0.001$; and quadratically). The decrease in DMI was about 1 lb less for cattle with 35% incidence compared to lots with less than 5% and most of this decrease in DMI occurred in pens that went from 5% or less to 15% or more BRD. Likewise, as BRD incidence increased within a lot, ADG decreased linearly ($P < 0.001$; and quadratically) with about a 0.10 to 0.15 lb/day lower ADG for lots with 30% or more of cattle treated compared to low incidences of BRD. While significant, the impact on F:G was sporadic and difficult to interpret. In general, no clear trend was observed for F:G.

A subset of these lots had individual carcass data matched with individuals within lots; however, individual DMI response is not possible as these are unknown in pen situations. A quadratic decrease ($P < 0.001$) in final BW and ADG was observed as BRD treatments increased (Table 2). A quadratic decrease ($P < 0.001$) was observed in HCW as number of BRD treatments increased with a 1.7 lb decrease for one treatment compared to none and an additional 26 lb decrease when cattle were treated two or more times compared to only once. Marbling, fat depth, USDA Choice, and USDA YG all decreased linearly ($P < 0.001$) as number of BRD treatments increased.

Performance of individually fed cattle fed growing diets was impacted by BRD, but depended on the timing of disease onset. It should be noted that 139 of 900 head were treated for BRD prior to starting the growing period (i.e., sick during a receiving period prior to start) and DMI, ADG, or F:G were not impacted (Table 3). A small number of cattle were treated either in the first 30 days (3 of 900) or treated after the first 30 days (5

Table 2. Impact of respiratory disease (BRD) on individual BW, ADG, and carcass characteristics of 33,073 steers fed in commercial pens linked with carcass data by individual that is categorized by zero, one, and two or more treatments for BRD.

	Respiratory disease treatment[1]				*P*-value[2]		
	0	1	2+	SEM	F-test	Linear	Quadratic
Steers, n	30,911	1,823	339				
DOF[3], day	260.4	260.6	260.7	21.4	0.52	0.41	0.95
Initial BW, lb	630.8	632.6	640.3	29.3	0.10	0.04	0.34
Final BW, lb	1377.4	1374.6	1331.2	62.5	<0.001	<0.001	<0.001
ADG, lb	3.12	3.10	2.94	0.12	<0.001	<0.001	<0.001
HCW, lb	826.4	824.7	798.7	37.5	<0.001	<0.001	<0.001
Marbling[4]	516.8	503.0	489.8	13.0	<0.001	<0.001	<0.001
LM area, in^2	12.7	12.7	12.4	0.2	<0.001	<0.001	<0.001
Fat depth, in	0.42	0.40	0.37	0.03	<0.001	<0.001	0.49
USDA Choice, %	51.3	42.1	36.9	0.07	<0.001	<0.001	0.25
USDA YG[5]	3.17	3.10	3.04	0.11	<0.001	<0.001	0.74

[1]Respiratory treatment number that includes no treatments (0), 1 treatment, and 2 or more treatments (2+).
[2]P-value for F-test statistic and linear or quadratic effects of BRD treatment number.
[3]DOF is days on feed at the feedlot.
[4]Marbling score where 500 = small0.
[5]USDA Yield Grade.

Table 3. Growing cattle performance of individually fed cattle categorized by respiratory disease incidence at UNL.

	Respiratory disease treatment[1]								*P*-value[2]	
	None		Prior to Trial		< 30 dof		> 30 dof			
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Treatment	Initial BW
Cattle, n	753		139		3		5			
Initial BW, lb	608	5.5	604	6.8	612	30.7	587	23.8	0.69	
DMI, lb/day	14.7[b]	0.27	14.5[b]	0.31	14.2[b]	1.12	12.9[a]	0.87	0.10	< 0.01
ADG, lb	1.88[b]	0.065	1.84[b]	0.071	1.73[a,b]	0.232	1.29[a]	0.183	< 0.01	0.60
G:F	0.125	0.0028	0.124	0.0035	0.117	0.0155	0.080	0.012	< 0.01	< 0.01
F:G	8.00		8.06		8.55		12.50			

[1]Respiratory treatment history includes cattle that were not identified as sick (None), pulled and treated prior to finishing beginning (Prior to Trial), pulled and treated within the first 30 days on finishing diets (< 30 dof), and pulled and treated after the first 30 days on finishing diets (> 30 dof).
[2]P-value due to respiratory treatment history and the p-value for using initial BW as a covariate.

Table 4. Impact of respiratory disease on finishing performance and carcass characteristics of individually-fed cattle at UNL.

	Respiratory disease treatment[1]								P-value[2]	
	None		Prior to Trial		< 30 dof		> 30 dof			
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Treatment	Initial BW
Cattle, n	799		160		9		19			
Initial BW, lb	816[b]	9.5	825[b]	10.4	758[a]	21.7	809[b]	16.9	0.01	
DMI, lb/day	22.0	0.23	22.3	0.28	21.4	0.78	21.3	0.58	0.22	< 0.01
ADG, lb	3.33	0.042	3.43	0.058	3.22	0.193	3.20	0.141	0.16	0.67
G:F	0.152	0.0013	0.154	0.0020	0.152	0.0072	0.155	0.0052	0.66	< 0.01
F:G	6.58		6.49		6.58		6.45			
Carcass Weight, lb	801	5.6	808	6.5	789	16.8	794	12.6	0.21	< 0.01
Fat Thickness, in	0.44	0.007	0.43	0.011	0.40	0.042	0.40	0.031	0.40	< 0.01
Marbling Score[3]	506	4.0	497	6.9	498	31.4	509	18.8	0.67	0.48

[1]Respiratory treatment history includes cattle that were not identified as sick (None), pulled and treated prior to finishing beginning (Prior to Trial), pulled and treated within the first 30 days on finishing diets (< 30 dof), and pulled and treated after the first 30 days on finishing diets (> 30 dof).
[2]P-value due to respiratory treatment history and the p-value for using initial BW as a covariate.
[3]USDA marbling score with 500 = small0

Table 5. University of Illinois performance data categorized by respiratory disease of steers with individual intake measured using the GrowSafe system.

	Respiratory disease treatment[1]								P-value[2]	
	None		Prior to Trial		< 30 dof		> 30 dof			
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Treatment	Initial BW
Head	1748		46		66		80			
Initial BW, lb	731[b]	6.4	667[a]	13.9	690[a]	13.0	721[b]	11.1	< 0.01	
DOF, d [3]	165[a]	1.3	172[b]	2.4	170[b]	2.3	168[a,b]	2.0	< 0.01	
DMI, lb/day	23.0[b]	0.14	23.1[b]	0.36	23.4[b]	0.33	21.9[a]	0.28	< 0.01	< 0.01
ADG, lb	3.65[b]	0.019	3.62[b]	0.071	3.72[b]	0.062	3.43[a]	0.054	< 0.01	< 0.01
G:F	0.160	0.0009	0.159	0.0025	0.161	0.0023	0.157	0.0019	0.51	< 0.01
F:G	6.25		6.29		6.21		6.37			
HCW, lb	838[b]	2.8	838[b]	7.5	845[b]	6.8	819[a]	5.8	< 0.01	< 0.01
Fat thickness, in	0.50[b]	0.005	0.57[c]	0.021	0.50[b]	0.018	0.46[a]	0.016	< 0.01	< 0.01
Marbling score [4]	560[b]	2.7	554[a,b]	12.1	545[a,b]	10.3	531[a]	9.2	0.01	< 0.01

[1]Respiratory treatment history includes cattle that were not identified as sick (None), pulled and treated prior to finishing beginning (Prior to Trial), pulled and treated within the first 30 days on finishing diets (< 30 dof), and pulled and treated after the first 30 days on finishing diets (> 30 dof).
[2]P-value due to respiratory treatment history and the p-value for using initial BW as a covariate.
[3]DOF is days on feed at the feedlot.
[4]USDA marbling score with 500 = small0.

of 900). While a small number of observations are available, cattle treated after the first 30 days had depressed DMI, and ADG and greater F:G.

With 987 finishing cattle that were individually fed at UNL, there was no significant effect of BRD treatment history on DMI, ADG, or F:G ($P > 0.16$; Table 4). However, the 28 head treated during the feeding period had numerically lower DMI and ADG, but very similar F:G. It is unclear whether BRD incidence was too low to distinguish performance differences due to BRD treatment history. Carcass weight, fat depth, and marbling also were not affected ($P > 0.21$).

With 1,940 finishing steers with individual intakes from the University of Illinois, there was an impact of BRD treatment history on performance. Steers that were treated after 30 days on finishing diets had lower DMI ($P < 0.01$), lower ADG ($P < 0.01$), but similar F:G ($P = 0.51$) to steers never treated, treated during receiving, or treated during the first 30 days on feed (Table 5). No differences ($P > 0.10$) were observed for DMI, ADG, or F:G for steers treated the first 30 days of the feeding period, during receiving, or not treated for BRD. Carcass characteristics followed a very similar trend as performance with steers treated after 30 days on finishing diets having lower HCW, less fat thickness, and less marbling ($P < 0.01$) compared to steers either treated earlier than 30 days on feed or not treated for BRD.

Cattle that get respiratory disease are likely affected in terms of depressed DMI and ADG for a short period. If BRD occurs early, cattle can likely recover and little impact is observed even on DMI and ADG. Despite lower DMI and ADG, F:G is not impacted in finishing studies summarized but may be negatively impacted in growing situations.

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Effects of a Dietary Antioxidant on Performance and Carcass Characteristics of Feedlot Cattle With or Without WDGS

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Summary

Effect of a dietary antioxidant in diets with or without wet distillers grains plus solubles (WDGS) was evaluated for performance and carcass characteristics. The 2 x 2 factorial design consisted of 1) an antioxidant at 0 or 150 ppm (Agrado Plus) and 2) WDGS at 0 or 30%, which replaced dry-rolled corn. Feeding the antioxidant did not affect performance (P > 0.31) or carcass characteristics (P > 0.25). Feeding WDGS increased (P < 0.01) final body weight (BW), dry matter intake (DMI), and average daily gain (ADG) while decreasing the feed to gain (F:G) ratio (P < 0.01). Carcass characteristics were affected (P < 0.01) by feeding WDGS, which increased HCW and fatness.

Introduction

Feeding wet distillers grain plus solubles (WDGS) is becoming a common practice. However, WDGS contains high levels of unsaturated fatty acids that are prone to oxidation, which may increase oxidative stress (*2007 Nebraska Beef Cattle Report*, pp. 39-42; *2008 Nebraska Beef Cattle Report*, pp. 108-109; *2009 Nebraska Beef Cattle Report*, pp. 110-111; *2010 Nebraska Beef Cattle Report*, pp. 97-98). Dietary antioxidants may control excessive lipid oxidation and decrease negative effects by reducing the peroxidation of fatty acids (*2009 Nebraska Beef Cattle Report*, pp. 113-115).

The objectives of our study were to evaluate live performance and carcass characteristics of feedlot cattle receiving finishing diets, with or without a dietary antioxidant (ethoxyquin and tertiary-butyl-hydroquinone), in dry-rolled, corn-based diets with or without WDGS.

Procedure

Four hundred eighty British x Continental yearling steers (BW = 779 lb) were acclimated to the feedlot for five or six days, respectively, prior to initial processing, which included: 1) ear tags; 2) vaccinations; 3) de-worming; 4) implanting with Component TE-IS with Tylan® (Vetlife/Elanco, Overland Park, KS); and 5) individually weighing on two consecutive days for an average initial BW. Cattle were re-implanted with Component TE-S with Tylan® on day 71.

Cattle were stratified by BW, assigned to eight weight blocks and assigned randomly to 32 pens. Four treatment diets were assigned randomly to pens within each block, with eight pens per treatment and 15 steers per pen. A 21-day adaptation period consisted of three periods, each seven days, where roughage was replaced with an equal amount of concentrate. Two diets consisted of dry-rolled corn (DRC) (78%), soybean meal/urea pellet (1.86:1; 4%), corn silage (12%) and a liquid supplement (6%) with or without a dietary antioxidant (AOX) (0 or 150 ppm Agrado Plus, Novus International, Inc., St. Louis, MO) and two diets consisted of DRC (52%), WDGS (30%), corn silage (12%), and a liquid supplement (6%) with or without a dietary antioxidant (0 or 150 ppm Agrado Plus). The liquid supplement contained Rumensin (345 mg/hd/day) and Tylan (90 mg/hd/day). Diets containing WDGS had a CP level of 14.8%, compared to 13.4 % in the corn-based diets (Table 1). Fat level was greater for the WDGS compared to the corn-based diets.

When approximately 60% of steers within a block were expected to grade USDA Choice, the steers were sent to a commercial abattoir. Half of the weight blocks were fed 145 days and the other half for 160 days. On the day of slaughter, hot carcass weights (HCW) were recorded. Following a 24-hour chill, 12th rib fat thickness, lean muscle (LM) area, marbling score, USDA QG And USDA YG were recorded. To account for any gut-fill, the final live BW was adjusted using a common dressing percentage of 63% calculated from HCW. The carcass-adjusted final BW was used to calculate ADG and F:G.

Performance and carcass characteristics were analyzed as a 2 x 2 factorial using the PROC MIXED procedure of SAS (Version 9.1, SAS Inc., Cary, N.C.). Pen was used as the experimental unit. The factors included in the model were WDGS inclusion and dietary antioxidant inclusion, with weight block as a fixed variable and initial BW as a covariate. PROC FREQ was used in the Chi-square analyses of USDA QG distribution.

Results

No WDGS level x AOX level interaction was observed for performance ($P > 0.32$) or carcass characteristics ($P > 0.34$); therefore, only main effects were evaluated. Main effects of dietary antioxidant are reported in Table 2 and were not significantly different for performance ($P > 0.30$) or carcass characteristics ($P > 0.24$).

Performance and carcass characteristics for WDGS main effects have been summarized in Table 3. Initial BW was lighter ($P < 0.01$) for steers receiving the 30% WDGS; however, the difference was only 2 pounds. Final BW increased ($P < 0.01$) with WDGS inclusion (1387 lb to 1483 lb). Daily intake increased ($P < 0.01$) from 24.0 lb/day to 24.7 lb/day with

Table 1. Finishing diet nutrient analysis (% DM basis)[1].

	Treatment			
Nutrient	Control	Agrado Plus	WDGS + Agrado Plus	WDGS
DM, %	78.9	78.9	62.4	62.4
CP, %	13.4	13.4	14.8	14.8
Fat, %	3.73	3.73	5.74	5.74
S, %	0.15	0.15	0.25	0.25
Vit A, IU/lb	4914	4730	4775	4959
Vit D, IU/lb	140	121	121	140
Vit E, IU/lb	13	13	16	16

[1]Calculated from *Nutrient Requirements of Beef Cattle: Seventh Revised Edition: Update 2000.*

Table 2. Main effects of Agrado Plus on performance and carcass characteristics.

	Treatment			
Item	0 ppm	150 ppm	SE	*P*-value
Initial BW, lb	779	779	0.6	0.94
Final BW, lb[1]	1434	1436	5.2	0.84
DMI, lb/day	24.3	24.4	0.08	0.31
ADG, lb	4.27	4.28	0.04	0.90
F:G	5.71	5.74	0.04	0.70
HCW, lb	903	905	3.3	0.81
12th rib fat, in	0.60	0.60	0.01	0.68
LM area, in^2	14.2	14.2	0.13	0.70
USDA YG[2]	3.32	3.28	0.05	0.60
Marbling[3]	550	542	4.8	0.25

[1]HCW / 63% average dressing.
[2]Calculated Yield Grade = 2.5 + (2.5*12th rib fat, in) + (0.0038*HCW, lb) – (0.32*LM area, in^2) + (0.2*KPH, %).
[3]400 = slight 0; 500 = small 0.

Table 3. Main effects of WDGS on performance and carcass characteristics.

	Treatment			
Item	0% WDGS	30% WDGS	SE	*P*-value
Initial BW, lb	780	778	0.6	<0.01
Final BW, lb[1]	1387	1483	5.7	< 0.01
DMI, lb/day	24.0	24.7	0.09	< 0.01
ADG, lb	3.95	4.59	0.04	< 0.01
F:G	6.08	5.37	0.05	< 0.01
HCW, lb	873	934	3.6	< 0.01
12th rib fat, in	0.52	0.68	0.01	< 0.01
LM area, in^2	14.3	14.1	0.15	0.21
USDA YG[2]	2.93	3.67	0.06	< 0.01
Marbling[3]	542	550	5.3	0.35

[1]HCW / 63% average dressing.
[2]Calculated Yield Grade = 2.5 + (2.5*12th rib fat, in) + (0.0038*HCW, lb) – (0.32*LM area, in^2) + (0.2*KPH, %).
[3]400 = slight 0; 500 = small0.

WDGS inclusion. Gain increased ($P < 0.01$) when including WDGS in the diet (3.95 lb to 4.59 lb). WDGS inclusion resulted in a decrease ($P < 0.01$) in F:G (6.08 lb to 5.37 lb). Carcasses were heavier ($P < 0.01$), 12th rib fat increased ($P < 0.01$), and USDA YG increased ($P < 0.01$) with WDGS inclusion. Percentage USDA Choice and above tended to increase ($P = 0.14$), and percentage USDA Select tended to decrease ($P = 0.13$) when including WDGS. No differences were observed between treatments for LM area ($P = 0.21$) or marbling scores ($P = 0.35$).

Inclusion of a synthetic dietary antioxidant (ethoxyquin and tertiary-butyl-hydroquinone) at 150 ppm (DM basis) had no significant effect on performance or carcass characteristics. Conversely, WDGS inclusion resulted in a typical response on performance (*2008 Nebraska Beef Cattle Report*, pp.35-36; *2010 Nebraska Beef Cattle Report*, pp. 61-62) and increased carcass fatness (*2007 Nebraska Beef Cattle Report*, pp. 33-35). When WDGS was included at 30% diet DM, in a dry-rolled, corn-based diet, WDGS had a feeding value of 142% based on F:G, with a 16% increase in ADG and a 12% decrease in F:G.

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Effects of Feeding High Levels of Wet Distillers Grains and Straw on Beef Quality

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Summary

Cattle (n = 336; 595 ± 20 lb) were fed one of seven diets (corn/5% straw; 40% distillers grain (DG)/5% straw; 70% DG/8% straw; 70% DG/25% straw; 77.5% DG/9% straw; 77.5% DG/17% straw, and 85% DG/10% straw – DM basis) to measure effects of feeding high levels of DG on shelf life of aged beef. Except for 70% DG/25% straw, strip loins were cut into three steaks each after 20 days of postmortem aging for 0, 4, and 7 days of retail display. The treatment having 70% DG/8% straw had the greatest oxidation status. Trans fatty acids and polyunsaturated fatty acids increased significantly in the strips of cattle fed high levels of WDGS and straw. Treatments with the highest levels of DG (85% DG/10% straw) or straw (77.5% DG/17% straw) had the most discoloration and were darkest at day three and four of retail display.

Introduction

Wet distillers grains plus soluble (WDGS) can be used as a replacement for corn and provide supplemental protein. Feeding WDGS decreases the feed to gain ratio (F:G) in cattle and is very economical to use in Nebraska (*2010 Nebraska Beef Cattle Report,* pp. 42-43 and 61-62). Previous research has shown an increase in discoloration of steaks when cattle are fed with high levels of distillers grain (*2010 Nebraska Beef Cattle Report,* pp. 99-101). Beef from cattle fed high levels of WDGS contains large amounts of polyunsaturated fatty acids (PUFA) which are responsible for increased rancidity in meat and decreased color stability (*2009 Nebraska Beef Cattle Report,* pp. 107-109). This research was conducted to determine if meat quality continues to change when very high levels of WDGS (> 50%) are fed with straw to maintain rumen pH and manage any sulfur related challenges.

Procedure

Cattle (n = 336; 595 ± 20 lb) were assigned randomly to one of the 36 pens. Pens were assigned randomly to one of seven dietary treatments (corn/5% straw; 40% DG/5% straw, 70% DG/8% straw, 70% DG/25% straw, 77.5% DG/9% straw, 77.5% DG/17% straw, and 85% DG/10% straw – DM basis) as described by Rich et al. (*2011 Nebraska Beef Cattle Report,* pp. 84-86). Steers on corn/5% straw, 40/5, 70/8, and 77.5/9 diets were fed up to 183 days and the remaining 70/25, 77.5/17 and 85/10 diets were fed 225 days so as to attain similar final BW. Strip loins (m. *Longissimus lumborum*), 9-15 per treatment (all USDA Choice), (IMPS # 180 PSO2; NAMP, 2007) were collected from Greater Omaha Packing Co. (except that no loins were obtained for the 70/25 treatment) and cut into three steaks (1 inch thick) after 20 days of postmortem aging. The first steak of each muscle was vacuum packaged using nylon-polyethylene vacuum pouches (3 mil STD barrier, Prime Sources, St. Louis, Mo.) on a Multivac Packaging machine (MULTIVAC C500, Multivac Inc., Kansas City, Mo.) and frozen for laboratory analyses of fat content, 0 day oxidative rancidity (TBARS), fatty acids and proximate analysis. The second and third steaks of each muscle were packaged on Styrofoam trays (Styro-Tech, Denver, Colo.), overwrapped with oxygen permeable polyvinyl chloride film and placed on a table in a cooler maintained at 32-36°F for a retail display. Steaks from four days were analyzed for oxidative rancidity (TBARS) and steaks from seven days were analyzed for color and TBARS analysis.

For this experiment, TBARS were run to measure the rancidity of the muscle as explained by Senaratne et al., *2009 Nebraska Beef Cattle Report,* pp. 113-115. Fatty acid composition in a steak was determined by following the same procedures as described by de Mello Jr. et al (*2008 Nebraska Beef Cattle Report,* pp. 108-109). Subjective color evaluation was done by three to four trained panelists from the Department of Animal Science at the University of Nebraska–Lincoln. Color evaluation was based on the discoloration percentage that ranges from 0 to 100%. The objective color was read with the Hunter Lab® Mini Scan XE Plus (Model 45/0-L, Hunter Laboratory Associates, Inc., Reston, Va.) a portable colorimeter equipped with a 1-inch aperture and using illuminant D65 at 10° standard observer. Color was read on the strip loin steaks (m. *longissimus lumborum*) that were kept for seven days in a retail display. In colorimeter readings, the average

Table 1. Amount of malondialdehyde mg/kg (oxidative rancidity) from strips (m. *longissimus lumborum*) of steers fed high level of WDGS with straw.

Treatment	Amount
Control 5 St[1]	0.30[b]
40 DG 5 St[2]	0.31[b]
70 DG 8 St[3]	2.43[a]
77.5 DG 9 St[4]	1.76[ab]
77.5 DG 17 St[5]	2.28[ab]
85 DG 10 St[6]	1.75[ab]

LS-means with the different letters [a,b] are significantly different at $P < 0.05$.
[1]Control 5 St: corn diet and 5% straw.
[2]40 DG 5 St: diet with 40% WDGS and 5% straw.
[3]70 DG 8 St: diet with 70% WDGS and 8% straw.
[4]77.5 DG 9 St: diet with 77.5% WDGS and 9% straw.
[5]77.5 DG 17 St: diet with 77.5% WDGS and 17% straw.
[6]85 DG 10 St: diet with 85% WDGS and 10% straw.

Table 2. Amount of fat and moisture percentage from USDA Choice grade strips (m. *longissimus lumborum*) of steers fed high levels of WDGS with straw.

	Treatments							Contrasts	
Attribute	Control 5 st[1]	40 DG 5 St[2]	70 DG 8 St[3]	77.5 DG 9 St[4]	77.5 DG 17 St[5]	85 DG 10 St[6]	*P*-Value	Control vs. WDGS	Non-straw vs. straw
Marbling	Mt 42[abc]	Mt 64[a]	Mt 52[ab]	Mt 22[bc]	Mt 61[a]	Mt 21[c]	0.02	0.85	0.12
Fat content (%)	9.25[bc]	10.38[ab]	9.25[bc]	7.53[d]	10.79[a]	8.68[dc]	0.0003	0.87	0.06
Moisture content (%)	71.95[a]	71.62[a]	71.53[ab]	71.47[ab]	70.72[b]	69.87[c]	< 0.0001	0.002	0.08

[a,b,c, d]Means in the same row having different superscripts are significantly different at $P < 0.05$.
[1]Control 5 St: corn diet and 5% straw.
[2]40 DG 5 St: diet with 40% WDGS and 5% straw.
[3]70 DG 8 St: diet with 70% WDGS and 8% straw.
[4]77.5 DG 9 St: diet with 77.5% WDGS and 9% straw.
[5]77.5 DG 17 St: diet with 77.5% WDGS and 17% straw.
[6]85 DG 10 St: diet with 85% WDGS and 10% straw.
Mt in marbling refers to modest [500-599] in Choice grade.

Table 3. Weight percentage[1] of fatty acids of strip (m. *longissimus lumborum*) steaks from steers fed high levels of wet distillers grains with straw.

	Dietary Treatments (% WDGS – DM basis)						
Fatty acids	Control[1] 5 St	40 DG 5 St[2]	70 DG 8 St[3]	77.5 DG 9 St[4]	77.5 DG 17 St[5]	85 DG 10 St[6]	*P*- value
14:1-(n-5) - Myristoleic	0.75[a]	0.55[b]	0.43[bc]	0.43[bc]	0.46[bc]	0.42[c]	<0.01
15:0 - Pentadecanoic	0.55[a]	0.53[ab]	0.47[bc]	0.47[bc]	0.38[d]	0.46[c]	<0.01
ISO 16:0 - Isopalmitic	0.43[a]	0.26[c]	0.44[a]	0.39[ab]	0.31[bc]	0.39[ab]	<0.01
16:0 - Palmitic	26.23[a]	24.44[b]	23.56[c]	22.68[cd]	22.48[d]	23.39[cd]	<0.01
16:1- (n-7) - Palmitoleic	3.85[a]	2.54[b]	2.31[bc]	2.08[c]	2.47[bc]	2.25[bc]	<0.01
17:0 - Heptadecanoic	1.52[a]	1.46[a]	1.18[b]	1.21[b]	0.84[c]	1.00[c]	<0.01
ISO 18:0 - Isosetearic	0.29[bc]	0.23[c]	0.43[a]	0.38[ab]	0.36[ab]	0.42[a]	<0.01
17:1- (n-7) - heptadecenoic	1.30[a]	0.86[b]	0.68[c]	0.68[cd]	0.52[d]	0.56[cd]	<0.01
18:0 - stearic	12.70[d]	14.94[c]	16.42[b]	16.35[bc]	17.86[ab]	18.74[a]	<0.01
18:1T- Elaidic	2.14[c]	4.74[b]	6.73[a]	7.51[a]	5.60[b]	5.49[b]	<0.01
18:1- (n-9)- Oleic	38.38[a]	35.90[b]	31.74[c]	32.21[c]	34.75[b]	32.25[c]	<0.01
(18:1 n-7)- Vaccenic	1.49[a]	1.06[b]	1.39[a]	1.47[a]	0.81[b]	0.94[b]	<0.01
18:1 Δ 13	0.11[d]	0.21[b]	0.24[ab]	0.27[a]	0.17[c]	0.22[b]	<0.01
18:1 Δ 14	0.04[b]	0.07[ab]	0.07[ab]	0.07[ab]	0.08[a]	0.08[a]	0.11
18:2T- Linoelaidic	0.08[c]	0.19[b]	0.2[ab]	0.23[ab]	0.23[a]	0.20[ab]	<0.01
19:0- Nonadecanoic	0.07[c]	0.24[b]	0.26[ab]	0.28[ab]	0.30[a]	0.28[a]	<0.01
18:2- (n-6)- Linoleic	3.27[d]	5.45[c]	6.83[a]	6.69[a]	5.85[a]	6.30[ab]	<0.01
20:0- Eicosanoic	0.04[b]	0.11[a]	0.11[a]	0.13[a]	0.14[a]	0.14[a]	<0.01
18:3- (n-3)- Linolenic	0.12[b]	0.21[a]	0.21[a]	0.25[a]	0.22[a]	0.25[a]	<0.01
20:1- (n-9)- Eicosenoic	0.25[c]	0.35[bc]	0.29[bc]	0.41[ab]	0.52[a]	0.31[bc]	<0.01
CLA *c9, t11*	0[b]	0.01[a]	0[b]	0[b]	0[b]	0[b]	0.1
CLA *c12, t10*	0.01[c]	0.05[b]	0.06[ab]	0.10[a]	0.09[ab]	0.10[a]	<0.01
20:2- Eicosadienoic acid	0.07[a]	0.08[a]	0.05[a]	0.03[a]	0.04[a]	0.10[a]	0.33
20:3- (n-6)- Homogamma Linolenic	0.26[ab]	0.21[b]	0.30[a]	0.30[a]	0.23[b]	0.26[ab]	0.02
20:4- (n-6)- Arachidonic	0.83[a]	0.57[b]	0.91[a]	0.82[a]	0.60[b]	0.80[a]	<0.01
22:4- Adrenic acid	0.02[a]	0.03[a]	0.03[a]	0.02[a]	0.03[a]	0.03[a]	0.96
22:5- (n-3)- Docosapentaenoic	0.02[a]	0[a]	0.02[a]	0.04[a]	0.02[a]	0.01[a]	0.61
Trans	2.37[d]	5.28[c]	7.31[ab]	8.20[a]	6.18[bc]	6.09[c]	<0.01
PUFA	4.67[d]	6.80[c]	8.62[a]	8.50[a]	7.32[bc]	8.06[ab]	<0.01
OMEGA 3	0.15[c]	0.21[bc]	0.23[ab]	0.29[a]	0.25[ab]	0.26[ab]	<0.01
OMEGA 6	4.37[d]	6.26[c]	8.07[a]	7.84[a]	6.70[bc]	7.40[ab]	<0.01
OMEGA6:3	29.39[a]	30.49[a]	32.52[a]	28.21[a]	28.28[a]	29.13[a]	0.77

[1]Weight percentage values are relative proportions of all peaks observed by gas chromatography.
[a,b,c,d]Means in the same row having different superscripts are significant at $P \leq 0.05$.
[1]Control 5 St: corn diet and 5% straw.
[2]40 DG 5 St: diet with 40% WDGS and 5% straw.
[3]70 DG 8 St: diet with 70% WDGS and 8% straw.
[4]77.5 DG 9 St: diet with 77.5% WDGS and 9% straw.
[5]77.5 DG 17 St: diet with 77.5% WDGS and 17% straw.
[6]85 DG 10 St: diet with 85% WDGS and 10% straw.

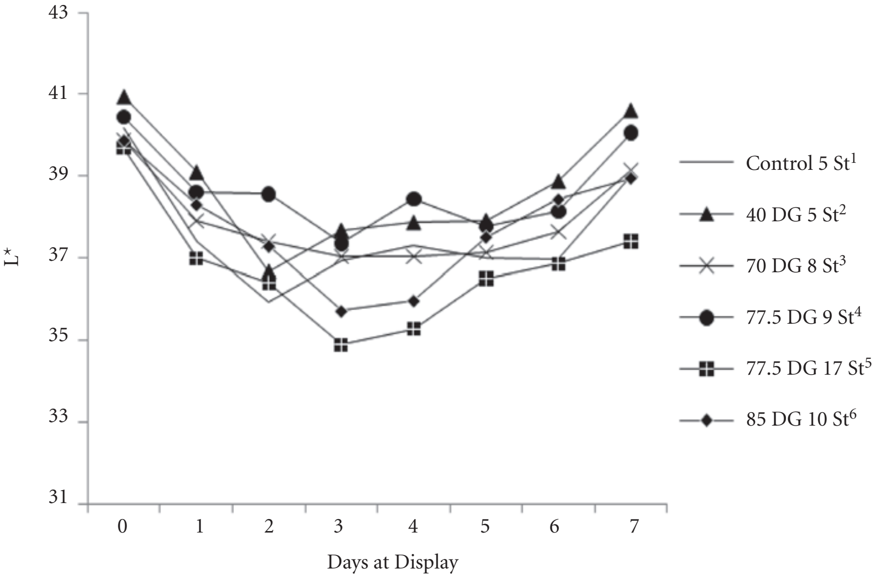
(Continued on next page)

of L* (measure of darkness to lightness), a* (measure of redness), and b* (measure of yellowness) were taken. Data were analyzed using the GLIMMIX procedure of SAS (Version 9.2, SAS Institute Inc. 2009). Where significance ($P \leq 0.05$) was indicated by ANOVA, means separations were performed using the LSMEANS and DIFF functions of SAS.

Results

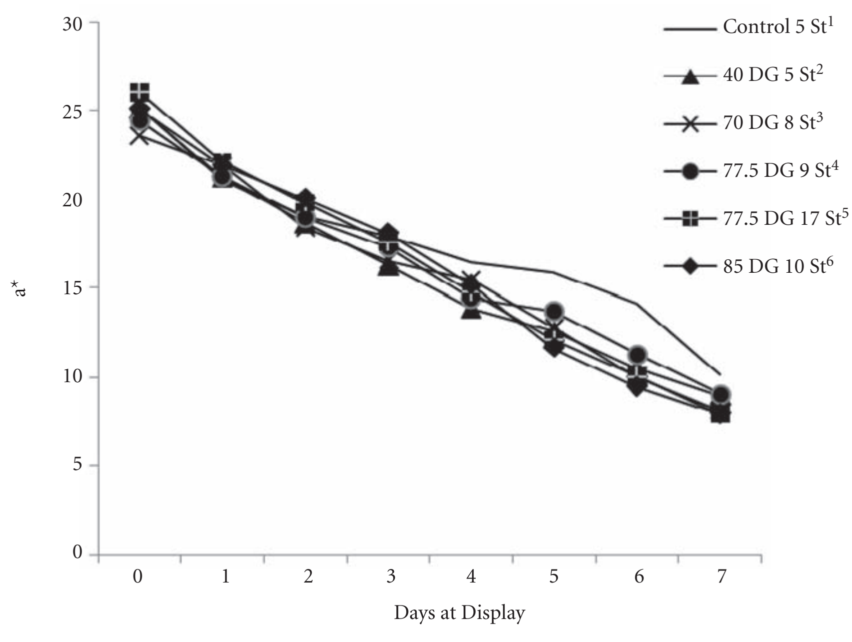
Oxymyoglobin becomes stable when there is high partial pressure and concentration of oxygen (O_2). High concentration of O_2 and O_2-permeable film ultimately leads to higher lipid oxidation. There was no significant treatment-by-day effect for oxidative rancidity in the strip steaks of steers; however, oxidative rancidity was significantly different among dietary treatments (Table 1). Steaks from cattle fed 70% DG/8% straw were more prone to oxidation than steaks from cattle fed corn or 40% DG/5% straw. Although the amount of straw added in the diet (77.5% DG/17% straw) was almost double in comparison to other diets, there were no statistical differences among treatments containing straw.

The steaks for the research were USDA Choice; their marbling data, fat content, and moisture content are shown in Table 2. The effects of these treatments on overall grade and marbling are shown elsewhere in this Beef Cattle Report (*2011 Nebraska Beef Cattle Report*, pp. 55-56). As shown in Table 3, strips from cattle fed high levels of WDGS and straw had significantly greater levels of polyunsaturated fatty acids (PUFA) and trans fatty acids in comparison to the corn-fed group whereas there was a significant decrease of 18:1 n-7 fatty acid in cattle fed high levels of WDGS and straw. Camfield et al. (1997, *Journal of Animal Science* 75:1837-1844) reported that PUFA are responsible for discoloration of meat whereas lower levels of 18:1 n-7 fatty acid are associated with off flavor production. de Mello Jr. et al. (*2008 Nebraska Beef Cattle Report,* pp. 110-111) reported



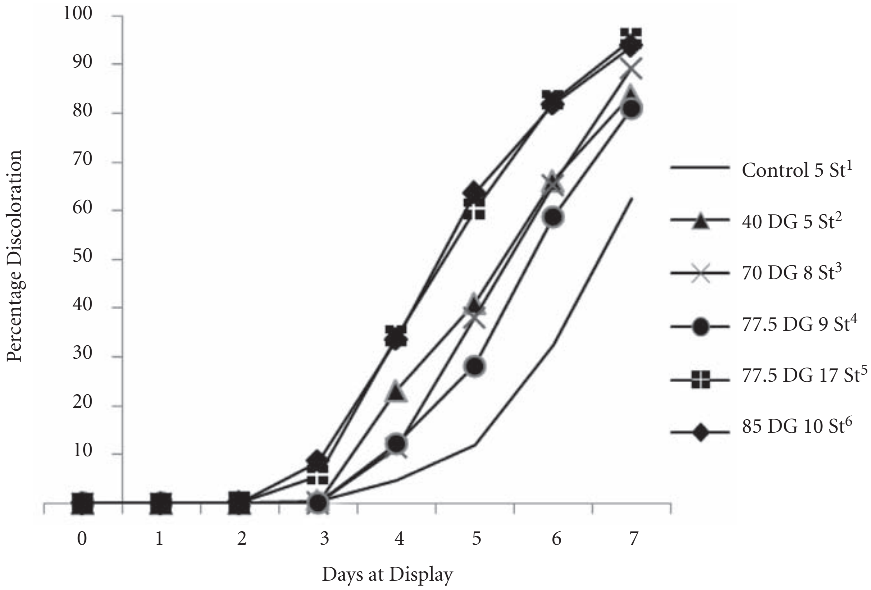
[1]Control 5 St: corn diet and 5% straw.
[2]40 DG 5 St: diet with 40% WDGS and 5% straw.
[3]70 DG 8 St: diet with 70% WDGS and 8% straw.
[4]77.5 DG 9 St: diet with 77.5% WDGS and 9% straw.
[5]77.5 DG 17 St: diet with 77.5% WDGS and 17% straw.
[6]85 DG 10 St: diet with 85% WDGS and 10% straw.

Figure 1. L* values of strips steaks (m. *longissimus lumborum*) from steers fed corn, high level WDGS, and straw.



[1]Control 5 St: corn diet and 5% straw.
[2]40 DG 5 St: diet with 40% WDGS and 5% straw.
[3]70 DG 8 St: diet with 70% WDGS and 8% straw.
[4]77.5 DG 9 St: diet with 77.5% WDGS and 9% straw.
[5]77.5 DG 17 St: diet with 77.5% WDGS and 17% straw.
[6]85 DG 10 St: diet with 85% WDGS and 10% straw.

Figure 2. a* values of strips steaks (m. *longissimus lumborum*) from steers fed corn, high level WDGS, and straw.



[1]Control 5 St: corn diet and 5% straw.
[2]40 DG 5 St: diet with 40% WDGS and 5% straw.
[3]70 DG 8 St: diet with 70% WDGS and 8% straw.
[4]77.5 DG 9 St: diet with 77.5% WDGS and 9% straw.
[5]77.5 DG 17 St: diet with 77.5% WDGS and 17% straw.
[6]85 DG 10 St: diet with 85% WDGS and 10% straw.

Figure 3. Visual discoloration of strips steaks (m. *longissimus lumborum*) from steers fed corn, high level WDGS, and straw.

increases in PUFA and trans fatty acid levels from feeding WDGS. Similar results were shown by de Mello Jr. et al. (2009 *Nebraska Beef Cattle Report*, pp. 107-109) and Senaratne et al., (2009 *Nebraska Beef Cattle Report*, pp. 110-112).

The L* (lightness) values decreased then increased from day 0 to 7 of retail display for all treatments (Figure 1). The treatments with the most DG (85% DG/10% straw) or straw (77.5 %DG/17% straw) were darkest at day 3 and day 4. The a* (redness) values decreased from day 0 to 7. Steaks from cattle fed corn were superior in redness from four to seven days of retail display in comparison with the steers fed high levels of WDGS (Figure 2). Discoloration percentage increased with retail display time. Meat from cattle fed 85% DG/10% straw and 77.5% DG/17% straw had the greatest discoloration whereas cattle fed corn had the lowest discoloration (Figure 3). It should be noted that animals receiving these treatments were fed 42 days longer than most of the other treatments in order to reach an appropriate slaughter endpoint. Senaratne et al. (*2009 Nebraska Beef Cattle Report,* pp. 116-117) demonstrated that 40% of distillers grains with solubles resulted in greater discoloration regardless of aging period.

In summary, meat from cattle fed high levels of WDGS had significantly greater values of oxidation, trans-fatty acids, and PUFA compared to corn/5% straw and 40% DG/5% straw. The treatments with the highest levels of WDGS (85% DG/10% straw) or straw (77.5% DG/17% straw) had the lowest color stability (lower L* values) and highest discoloration. There did not seem to be any changes to beef quality with added straw when high levels of WDGS are fed, but adding straw dramatically changed performance (Rich et al., *2011 Nebraska Beef Cattle Report,* pp. 84-86).

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Low-fat Wet Distillers Grains and Beef Quality

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Summary

A low-fat (4.72%) wet distillers grain (LFWDG) diet was compared to a traditional wet distillers grain with solubles (WDGS) diet and a corn-based diet. All wet distillers diets increased polyunsaturated fatty acids in comparison to the control. The LFWDG diet caused greater oxidative rancidity and had a decreased shelf life; however, there was no change in sensory properties. The LFWDG diet evaluated in this study caused decreased oxidative stability of the muscle compared to the TWDGS and the control diets.

Introduction

Previous studies found inclusion of WDGS in the diet increases the amount of oxidation in beef. Feeding WDGS diets to cattle elevated levels of polyunsaturated fatty acids (PUFA), decreased shelf life, and increased oxidative rancidity (*2009 Nebraska Beef Cattle Report*, pp. 107-109 and 110-112). This occurs because of the fat in WDGS that is not biohydrogenated (saturated) in the rumen. Many ethanol plants are either partially removing oil or evaluating methods to remove oil from the WDGS for other uses than cattle feed. If the amount of oil (fat) in WDGS is reduced, oxidation may be decreased. The hypothesis of this project was feeding low-fat wet DG (LFWDG) would minimize oxidation problems, thereby retaining shelf life of the product.

Procedure

Ninety-six feedlot crossbred yearling steers were allocated to three different finishing diets: LFWDG, traditional wet DG with solubles (TWDGS), and a corn-based diet and were fed for 131 days (*2011 Nebraska Beef Cattle Report* pp. 44-45). The TWDGS diet contained distillers solubles and was 6.91% fat, while the solubles were omitted from the LFWDG diets, which contained 4.72% fat. Forty-five carcasses grading USDA Choice, 15 from each treatment, were randomly selected and their respective strip loins collected, vacuum packaged, and shipped to the Loeffel Meat Laboratory at the University of Nebraska–Lincoln. After aging at 33ºF for 12 days post-mortem, the strip loins were fabricated. Seven steaks were cut from the strip loin. Four 1-inch steaks were cut for taste panels and Warner-Bratzler Shear Force (WBSF) testing. The remaining loin sections were cut into ½-inch steaks and oxidation measured with the Thiobarbituric Acid Assay (TBARS) test. Day zero steaks were vacuum packaged and immediately frozen in -20ºF freezer.

Day 4 and day 7 steaks were placed into Styrofoam trays and overwrapped with oxygen-permeable film. Steaks were randomly placed into two retail display cases (37 ± 2ºF) to simulate retail display conditions. In this simulation, the steaks were exposed to continuous 1,000-1,800 lux warm white fluorescent lighting. At the end of their assigned aging period, steaks were removed from the retail display case and frozen in a -20ºF freezer until further testing.

Objective and Subjective Color

Objective color measurements were collected each day for seven days. Using a Minolta Chromameter CR-400 (Minolta Camera Company, Osaka, Japan) with an 8 mm diameter measurement area and a 11 mm diameter illumination area, illuminant D65 and a 2º standard observer, L* (brightness), a* (redness) and b* (blue to yellow) values were recorded. Six different readings were taken from each steak and averaged. Subjective color was also measured every day for seven days in which the score was based upon percent oxidation; 0% indicating no discoloration, 100% indicating discoloration of the entire steak.

Oxidation

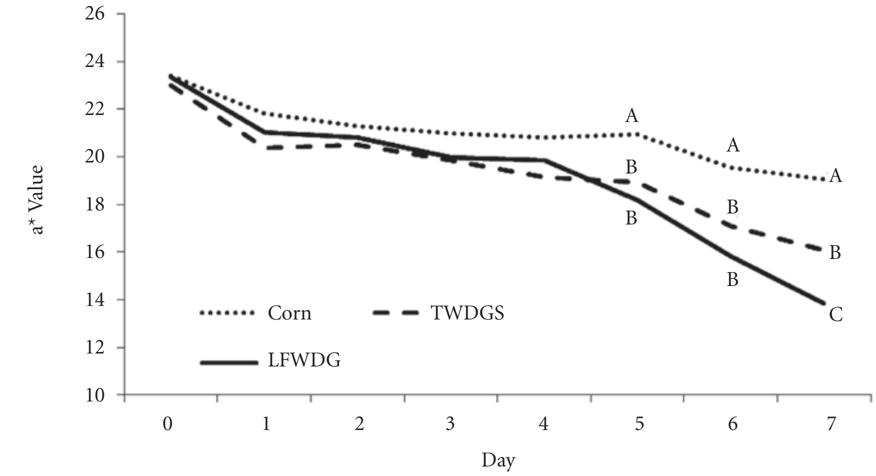
Steaks were removed from freezer storage and cut into small pieces while partially frozen. The pieces were then flash frozen in liquid nitrogen and powdered in a grinder. Powdered samples were then analyzed using the TBARS standard protocol.

Warner-Bratzler Shear Force and Cooking Loss

Steaks for the Warner-Bratzler Shear Force testing were thawed overnight in a cooler and then grilled on Hamilton Beach Indoor/Outdoor grills. Steaks were weighed and the temperature was taken before steaks were placed on the grill and then once again when they reached 160ºF. A thermocouple was placed in the geometric center of each steak; this allowed for a more accurate reading of temperature. Steaks were cooked on one side until the center temperature reached 95ºF and then turned over until it reached 160ºF. The steak was then removed from the grill and weighed. Cooking loss was calculated. Steaks were covered with oxygen-permeable film and placed in a cooler. Twenty-four hours later, the cooked steaks were cored into ½-inch cores and sheared to test Warner-Bratzler Shear Force.

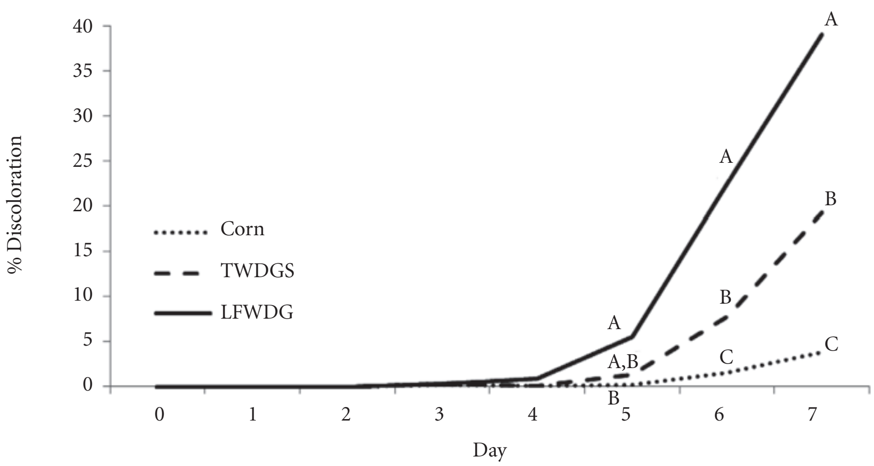
Taste Panel

Steaks from days 0 and 7 of retail display were shipped to the University of Florida for consumer evaluation.



Corn, TWDGS (traditional levels of fat wet distillers grains with solubles), LFWDG (low-fat wet distillers grains).
A,B,CMeans having different superscripts are different within days of display $P \leq 0.05$.

Figure 1. a* (redness) values for strip loin (M. *longissimus lumborum*) steaks from steers traditional levels of WDGS, low-fat WDG and corn-based diets in retail display.



Corn, TWDGS (traditional levels of fat wet distiller grains with solubles), LFWDG (low-fat wet distiller grains).
A,B,CMeans having different superscripts are different within days of display $P \leq 0.05$.

Figure 2. Percent discoloration of strip loin (M. longissimus lumborum) steaks from steers traditional levels of WDGS, low-fat WDG, and corn-based diets in retail display.

Prior to cooking, steaks were thawed for 18 hours at 39°F. Steaks were cooked on grated, nonstick electric grills that were preheated for 20 minutes. Steaks were cooked in the same manner as the steaks for the Warner-Bratzler Shear Force testing steaks. Internal temperatures were monitored and placed in the geometric center of each steak. Upon reaching 160°F, steaks were served to 7-11 trained panelists while still warm. Panelists evaluated six samples; two sample cubes that were 1.27 cm^3 per sample, served in warmed, covered containers. Sensory sessions were conducted once or twice daily in a positive pressure ventilated room with lighting and cubicles designed for objective meat sensory analysis. Each sample was evaluated for juiciness (8 = extremely juicy; 1 = extremely dry), flavor (8 = extremely intense beef flavor; 1 = extremely bland beef flavor), tenderness (8 = extremely tender; 1 = extremely tough), connective tissue (8 = none detected; 1 = abundant amount), and off-flavor (1 = extreme off-flavor, 6 = no off-flavor detected). Along with objectively scoring off-flavor, if an off-flavor was noticed, the panelists were asked to describe or characterize the off-flavor to the best of their ability.

Fatty Acid Profile

Gas chromatography was used to determine the fatty acid profile of all the beef samples and the feed samples as well. A Chrompack CP-Sil 88 (0.25 mm x 100 m) was used. Injector temperature was set at 518°F and the detector temperature was set at 572°F. Head pressure was 40 psi and the flow rate was at 1.0 mL/min.

Mineral Analysis

Frozen, powdered meat samples were sent to a commercial laboratory (Ward Laboratories, Inc., Kearney, Neb.) to be tested for mineral composition using atomic adsorption spectroscopy. The amount of Ca, P, K, Mg, Zn, Fe, Mn, Cu, S, and Na. Ca, P, K, Mg, S, and Na was expressed as a percentage of dry matter, while Zn, Fe, Mn, and Cu were reported in ppm on a dry matter basis.

Results

Compared to the other treatments, the objective a* values (redness) of steaks from cattle fed LFWDG declined at a faster rate and to a greater degree (Figure 1). This decline started at day 4 of retail display. Steak discoloration data (Figure 2) correlated strongly with the objective color data. Moreover, the lipid oxidation tests (TBARS) have the same trend (Figure 3). The lipid oxidation values were significantly larger at days 4 and 7 in the LFWDG diet when compared to TWGDS and the corn-based diets.

There were no day by dietary treatment interactions for any attribute ($P > 0.05$). There were day effects for overall tenderness

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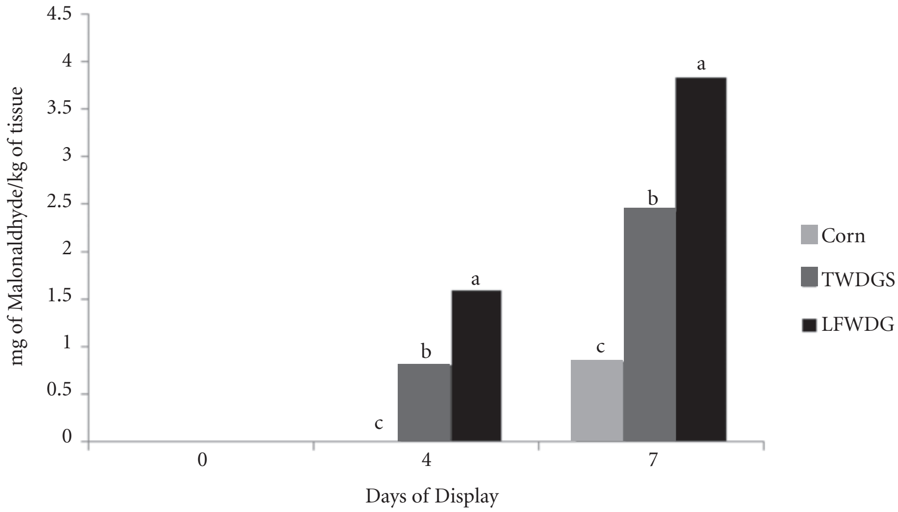
[(<0.0001) 0 day = 5.65 and 7 day = 5.86], connective tissue [(0.0006) 0 day = 6.09 and 7 day = 6.29] and off-flavor [(0.04) 0 day = 5.54 and 7 day = 5.04]. As days of aging increased, tenderness scores increased. Similarly, as days of aging increased, off-flavor was also more apparent. Sensory panels and WBSF test results did not yield many significant differences, and the differences that were present favored the TWDGS diet, which was equal or superior to the control diet (Table 1). There was no significant difference in shear force values among the treatments.

Steaks from cattle fed TWDGS contained significantly more Ca and Na than controls, which likely came from the solubles fraction of the diet (Table 2). In contrast, steaks from cattle fed LFWDG contained less Mn and Cu than the controls. None of these differences would be expected to support greater oxidation of the meat.

The percentages of PUFA and transfatty acids were significantly higher in beef from cattle fed distillers grain-based diets compared to the corn control. Most of the increase in PUFA occurred as a result of increased concentrations of C 18:1 fatty acids. A difference in PUFA of 0.40 (about 10%) was found between LFWDGS (4.86) and TWDGS (4.46), and this difference, while not significant, would support the increased amount of discoloration and lipid oxidation, especially toward the end of the retail display period. Fat percentage and moisture content were not affected by the dietary treatments ($P = 0.9707$ and $P = 0.9839$, respectively).

Although the LFWDG diet contained less fat on a percentage basis than the TWDGS diet (4.72% vs 6.91%), all of that fat was found in the grains portion of the wet DG. Much of the fat in the TWDGS diet came from the distillers solubles. We hypothesize that fats in the distillers soluble are hydrogenated in the rumen, while those contained within the grains fraction are more protected from biohydrogenation. This would explain why beef from cattle fed the LFWDG diet tended to have more PUFA, and



Corn, TWDGS (traditional levels of fat wet distillers grains with solubles), LFWDG (low-fat wet distillers grains).
[a,b,c]Means having different superscripts are different within days of display $P \leq 0.05$.

Figure 3. Lipid oxidation values for strip loin (m. *longissimus lumborum*) steaks from steers traditional levels of WDGS, low-fat WDG and corn-based diets.

Table 1. Sensory attributes of strip loin steaks from steers fed high and low fat WDG(S).

	Dietary treatments [1]			
Attributes[2]	Corn	TWDGS	LFWDG	*P*-value
Juiciness	5.24	5.18	5.08	0.15
Beef Flavor Intensity	5.61	5.63	5.65	0.88
Overall Tenderness	5.71^b	5.89^a	5.67^b	< 0.01
Connective Tissue	6.20	6.21	6.16	0.74
Off-flavor	5.46^b	5.59^a	5.42^b	0.02
WBSF (kg)	2.79	2.81	2.93	0.59

[1]Corn, TWDGS (traditional fat WDGS), LFWDG (low-fat WDG).
[2]Juiciness (1 extremely dry – 8 extremely juicy); beef flavor intensity (1 extremely bland – 8 extremely intense); overall tenderness (1 extremely tough – 8 extremely tender); connective tissue (1 abundant amount – 8 none detected); Off-flavor (1 strong/extreme off-flavor – 8 none detected).
[a, b]Means in the same row having different superscripts are different at $P \leq 0.05$.

Table 2. Least square means of mineral composition of strip loins (m. *longissimus lumborum*) from cattle fed different dietary regimes.

	Diet Composition[1]			
	Corn	TWDGS	LFWDG	*P*-value
Ca[2]	0.027^b	0.039^a	$0.031^{a,b}$	0.023
P[2]	0.184	0.188	0.187	0.423
K[2]	0.391	0.396	0.398	0.873
Mg[2]	0.031	0.035	0.033	0.194
Zn[3]	35	35	34	0.899
Fe[3]	$41^{a,b}$	50^a	36^b	0.072
Mn[3]	1.47^a	$1.00^{a,b}$	0.47^b	0.076
Cu[3]	2.44^a	$1.80^{a,b}$	1.54^b	0.046
S[2]	0.187	0.189	0.191	0.651
Na[2]	0.050^b	0.055^a	0.051^b	0.041

[1] Corn, TWDGS (traditional levels of fat wet distillers grains with solubles), LFWDG (low-fat wet distillers grains).
[2] % on dry matter basis.
[3] ppm on dry matter basis.
[a, b] Means in same rows having different superscripts are different at $P \leq 0.05$.

Table 3. Weight percentage of fatty acids[1] and fat content of strip loin steaks (m. *longissimus lumborum*) from steers fed high and low fat WDG(S).

	Dietary Treatments[2]			
Fatty Acid	Corn	LFWDG	TWDGS	*P*-value
10:0	0.03	0.03	0.05	0.41
12:0	0.05	0.04	0.04	0.83
14:0	2.82	2.62	2.59	0.27
14:1 (n-5)	0.65	0.63	0.61	0.68
15:0	0.53[a]	0.46[b]	0.41[b]	0.01
iso 16:0	0.16	0.16	0.15	0.86
16:0	24.67[a]	23.50[b]	23.01[b]	0.01
16:1 (n-7)	3.12[a]	2.84[ab]	2.72[b]	0.03
17:0	1.65[a]	1.37[b]	1.43[b]	0.0001
iso 18:0	0.08	0.10	0.11	0.20
17:1 (n-7)	1.50[a]	1.22[b]	1.22[b]	<0.0001
18:0	13.02	13.12	13.98	0.12
18:1 *trans*	2.46[b]	3.68[a]	3.49[a]	0.01
18:1 (n-9)	42.55	41.55	42.19	0.58
18:1 (n-7)	1.11	0.85	0.92	0.24
18:1 δ13	0.15	0.18	0.16	0.81
18:1 δ14	0.14[b]	0.19[a]	0.18[a]	0.03
18:2 *trans*	0.04[b]	0.07[a]	0.08[a]	0.0003
19:0	0.06	0.08	0.07	0.75
18:2 (n-6)	2.16[c]	3.81[a]	3.43[b]	<0.0001
20:0	0.43[b]	0.52[a]	0.48[ab]	0.05
18:3 (n-3)	0.07[b]	0.11[a]	0.10[a]	0.02
20:1 (n-9)	0.07	0.04	0.06	0.21
18:2 *cis* 9 *trans* 11	0.03 [b]	0.07 [a]	0.06 [ab]	0.02
18:2 *cis* 10 *trans* 12	0.01	0.01	0.01	0.29
20:3 (n-6)	0.12[b]	0.17[a]	0.17[a]	0.0013
20:4 (n-6)	0.39	0.45	0.44	0.44
20:5 (n-3)	0.03	0.03	0.03	0.66
22:4 (n-6)	0.05	0.05	0.06	0.06
22:5 (n-3)	0.09	0.10	0.09	0.70
PUFA	2.99[b]	4.86[a]	4.46[a]	<0.0001
MUFA	51.76	51.17	51.54	0.79
Total Trans	2.50[b]	3.75[a]	3.57[a]	0.01
SFA	43.51	42.00	42.33	0.19
Others	1.74[b]	1.97[a]	1.67[b]	0.01
Omega 3	0.19[b]	0.23[a]	0.22[ab]	0.10
Omega 6	2.72[b]	4.48[a]	4.09[a]	<0.0001
Omega 6: Omega 3	16.99	20.15	19.29	0.50

[1]Weight percentage values are relative proportions of all peaks observed by Gas Chromatography.
[2]Corn, TWDGS (traditional levels of fat in wet distillers grains with solubles), LFWDG (low-fat wet distillers grains).
[a, b, c]Means in the same row having different superscripts are significant at $P \leq 0.05$.

it may explain decreased shelf life and increased oxidative rancidity of the samples from the LFWDG diets. In summary, LFWDG decreased shelf life and increased oxidative rancidity in retail displayed strip loin steaks.

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Shelf Life of m. *longissimus lumborum* from Beef Fed Antioxidants and Wet Distillers Grains

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Summary

Crossbred steers (n = 483) were fed dry-rolled corn based finishing diets containing 0 or 30% wet distillers grains with the synthetic antioxidants, ethoxyquin and tertiary butyl hydroquinone (AGRADO®PLUS). Synthetic antioxidants reduced lipid and color deterioration of strip steaks at the end of the retail display period under high or atmospheric oxygen packaging conditions.

Introduction

de Mello Jr. et al. (*2008 Nebraska Beef Cattle Report*, pp. 116-117) and Senaratne et al. (*2009 Nebraska Beef Cattle Report*, pp. 110-111) have shown that WDGS increase polyunsaturated fatty acids (PUFA) in beef. Elevated levels of PUFA in beef may affect color and flavor of beef, eventually affecting consumer appeal at retail. Feeding vitamin E, an antioxidant, with WDGS has shown to be a promising strategy to mitigate detrimental effects on beef due to feeding WDGS (Senaratne et al. *2009 Nebraska Beef Cattle Report*, pp. 113-115), but it may increase the feeding cost.

Feedlot studies with a mixture of synthetic antioxidant, ethoxyquin, and tertiary butyl hydroquinone (AG; AGRADO®PLUS) have shown improvement in average daily gain and a decrease in morbidity and mortality of cattle by improving the antioxidant capacity at the ruminal and postruminal stages of digestion (Han et al. *2002 Journal of Animal Science*, *80,* pp. 1117-1123). Others (Moore et al. 2010 *Proceedings 43rd Midwestern Sectional Animal Science Meetings*, pp. 86) have reported AGRADO®PLUS supplementation affects neither performance nor carcass characteristics of feedlot cattle. Feeding AGRADO®PLUS may increase the antioxidant level of muscles. Our study evaluated the antioxidant effects of feeding AGRADO®PLUS with WDGS diets on color and lipid stability, and tenderness of beef m. *longissimus lumborum* during its shelf life.

Procedure

Crossbred (British × Continental) yearling steers (n = 483; initial BW = 942 kg ± 2.2 lb) were randomly assigned to one of four dry-rolled corn-based diets, contained 0%, or 30% (DM basis) wet distillers grains plus solubles (WDGS) with or without AGRADO®PLUS (AG; 150 ppm/steer/day) supplementation. Steers were fed a total of 145 (at first trial) or 160 days (at second trial) and slaughtered. Carcasses were chilled for 48 hours before grading. After grading, both sides of the beef loin, short loins (IMPS # 174; NAMP, 2007) from a total of 80 (40 from each trial) USDA Choice carcasses (10 from each dietary treatment) were vacuum-packaged and transported under refrigeration. After aging for either 8 or 29 days at 36ºF, m. *longissimus lumborum* muscles were removed from the beef loins. Each strip loin was cut into six 1-inch-thick steaks from the anterior to the posterior. The first (for oxidation; 0 day retail displayed) and fourth (for shear force; 0 day retail displayed) steaks were immediately vacuum-packaged and stored at -4ºF. The second and third steaks were split into halves and assigned for four and seven days oxidation analysis either under overwrapped (OW) or high-oxygen modified atmospheric packaging (HiO_2-MAP) systems. Fifth and sixth steaks were allotted for seven days retail display shear force analysis under OW and HiO_2-MAP packaging systems, respectively. Surface discoloration ratings were determined on steaks assigned for seven days retail display shear force analysis. All steaks assigned for OW retail display were packaged (oxidation as four pieces per tray, shear force as two steaks per tray) on Styrofoam trays and overwrapped with oxygen permeable polyvinyl chloride film. All steaks assigned for HiO_2-MAP retail display were packaged (steaks arrangement was similar to OW packaging system) on high foam-barrier polypropylene trays with a gas mixture (80% O_2: 20% CO_2) and mechanically sealed with oxygen impermeable film. Overwrapped and HiO_2-MAP packaged 8 and 29 days aged steaks, placed on a table in a cooler (at 0 ± 36ºF) were exposed to continuous 1,000-1,800 lux warm white fluorescence lighting to provide simulated retail display conditions. Steaks (8 and 29 days aged) assigned for four and seven days of retail display were removed from tables accordingly for oxidation and shear force analysis, and immediately vacuum-packaged and stored at -4ºF.

A six-person trained panel subjectively evaluated the percentage surface discoloration. Discoloration ratings were made on each steak from 0 to 7 days of retail display at 24-hour intervals.

The 2-thiobarbuteric acid reactive substance (TBARS) assay was used to measure the oxidation status of 8- and 29-day aged steaks in both packaging systems displayed for 0, 4 and 7 days in simulated retail display.

Tenderness evaluations were performed by Warner-Bratzler shear force testing (WBSF).

Data were analyzed by ANOVA in the GLIMMIX procedure of SAS (version 9.2, Cary, N.C., 2009) as a split-split-split-plot design with dietary treatments as the whole-plot treatment, aging period as the first split-

Table 1. Means of percentage discoloration of overwrapped (OW) and high oxygen (HiO_2-MAP) packaged strip loins (m. *longissimus lumborum*) aged for 8 and 29 days, during 7 days of simulated retail display conditions.

		Retail display (days)								Contrasts (*P*-value)			
Aging (days)	Treatments	0	1	2	3	4	5	6	7	Corn vs. WDGS	Corn vs. Corn + AG	WDGS vs. WDGS + AG	No AG vs. AG
HiO_2-MAP 8	Corn	0.00^{b}	0.00^{b}	0.00^{b}	0.00^{b}	0.00^{b}	0.00^{b}	0.47^{b}	3.12^{a}	0.68	0.20	0.18	0.06
	30%WDGS	0.00	0.00	0.00	0.00	0.00	0.23	0.64	2.23				
	Corn+AG	0.00	0.00	0.00	0.00	0.00	0.04	0.21	0.76				
	30%WDGS+AG	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.28				
HiO_2-MAP 29	Corn	0.00^{c}	0.00^{c}	0.00^{c}	0.00^{c}	0.00^{c}	0.93^{c}	8.42^{b}	17.07^{aA}	0.73	0.43	0.89	0.64
	30%WDGS	0.00^{c}	0.00^{c}	0.00^{c}	0.00^{c}	0.00^{c}	0.30^{c}	5.16^{b}	18.12^{aA}				
	Corn+AG	0.00^{c}	0.00^{c}	0.00^{c}	0.00^{c}	0.00^{c}	0.49^{c}	4.42^{b}	11.42^{aB}				
	30%WDGS+AG	0.00^{c}	0.00^{c}	0.00^{c}	0.00^{c}	0.04^{c}	0.65^{c}	6.65^{b}	17.99^{aA}				
OW 8	Corn	0.00^{d}	0.09^{d}	0.09^{d}	0.33^{d}	1.65^{d}	5.20^{c}	12.12^{b}	24.06^{aA}	0.34	0.65	0.09	0.39
	30%WDGS	0.00^{d}	0.00^{d}	0.00^{d}	0.32^{d}	1.53^{d}	5.46^{c}	12.61^{b}	27.71^{aA}				
	Corn+AG	0.00^{d}	0.00^{d}	0.00^{d}	0.32^{d}	1.94^{d}	6.63^{c}	13.52^{b}	26.24^{aA}				
	30%WDGS+AG	0.00^{d}	0.00^{d}	0.00^{d}	0.01^{d}	1.62^{cd}	3.79^{c}	8.44^{b}	15.72^{aB}				
OW 29	Corn	0.00^{f}	0.00^{f}	0.24^{f}	2.53^{e}	9.73^{dA}	19.57^{cA}	28.38^{bA}	39.49^{aA}	0.56	0.14	0.98	0.29
	30%WDGS	0.00^{e}	0.00^{e}	0.06^{e}	1.18^{e}	5.73^{dAB}	15.68^{cAB}	27.30^{bA}	42.86^{aA}				
	Corn+AG	0.00^{e}	0.00^{e}	0.03^{e}	0.74^{e}	4.80^{dB}	11.69^{cB}	19.33^{bB}	29.13^{aB}				
	30%WDGS+AG	0.00^{e}	0.00^{e}	0.15^{e}	1.25^{e}	5.01^{dB}	14.65^{cB}	28.03^{bA}	43.08^{aA}				

[a-f]Comparison within a row, means lacking a common superscript were different at $P < 0.05$.
[A-B]Comparison within a column by aging, means lacking a common superscript were different at $P < 0.05$.
WDGS – Wet distillers grains plus solubles, AG – AGRADO®PLUS.
P-value for treatment×packaging×aging×day < 0.0001.

plot treatment, packaging systems as the second split-plot treatment, and retail display time (repeated measures) as the third split-plot treatment, with the animal as the experimental unit. Separation of means was conducted using LSMEANS procedure with PDIFF and SLICEDIFF options at $P \leq 0.05$. In addition, the CONTRAST statements in SAS were used to compare the effects of feeding Corn *vs.* WDGS, Corn *vs.* Corn+AG, WDGS *vs.* WDGS+AG, and No AG *vs.* AG.

Results

Four-way interaction effects of treatment × packaging × aging × day on steaks surface discoloration were significant (Table 1; $P < 0.0001$). Discoloration increased during retail display time in both packaging systems and both aging periods. However, steaks in the OW packaging system were significantly more discolored compared to steaks in HiO_2-MAP system (less than 20% surface discoloration). Similar results have been reported by de Mello Jr. et al. (*2010 Nebraska Beef Cattle Report*, pp. 99-101). A possible reason for less discoloration when beef is exposed to higher levels of oxygen is conversion of myoglobin into stable oxymyoglobin (cherry red color). Steaks (29 days aged in both packaging systems) from cattle fed corn plus AG had significantly ($P < 0.05$) less discoloration at the end of the retail display period ($P < 0.05$) than steaks from cattle fed any other diet/treatment. The effectiveness of AG supplementation in reducing discoloration was prominent when meat was aged longer. Although the trends were the same, anti-discoloration effect of AG supplementation was not statistically significant when cattle were fed WDGS. The reason for high discoloration even after adding AG into the diet is likely due to the increase of easily oxidizable, polyunsaturated fatty acids in beef from feeding WDGS. de Mello Jr. et al (*2008 Nebraska Beef Cattle Report*, pp. 116-117) and Senaratne et al. (*2009 Nebraska Beef Cattle Report*, pp. 110-111) reported that feeding WDGS increased PUFA level in beef compared to corn control diets.

There were significant (Table 2; $P = 0.04$) three-way interaction effects of treatment × aging × day on lipid oxidation. As aging and retail display time increased, lipid oxidation also increased. However, there were no significant differences among eight day aged steaks from cattle fed different diets. The only significant ($P < 0.05$) difference in dietary treatments could be seen in 29-day aged steaks at the end of retail display. Similar to discoloration results, steaks from corn plus AG diets had the lowest oxidation. Steaks from AG supplemented cattle had significantly ($P < 0.05$) lower lipid oxidation compared to steaks from cattle not on AG supplementation. Feeding AG helped reduce oxidation of increased PUFA content when cattle were fed WDGS. As expected, TBARS analysis did not show significantly higher lipid oxidation on steaks from HiO_2-MAP systems compared to steaks from OW packaging systems (although, numerically higher). This might be due to the dilution effect of oxidized lipid on the surface of the thick steaks when preparation for TBARS analysis.

The WBSF values of steaks significantly ($P = 0.03$) decreased when aging and retail display time increased. Steaks from HiO_2-MAP systems after seven days retail display had significantly ($P < 0.0001$) higher WBSF values (by 1.01 lbs) compared to steaks from OW packaging systems (data not shown). The main effect

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of dietary treatments significantly influenced WBSF, with no confound effects from aging time (Table3; $P = 0.02$). Steaks from corn plus AG fed cattle were significantly less tender compared to steaks from other diets. When comparing steaks from AG fed cattle and steaks from AG nonsupplemented diets, steaks from AG supplemented cattle were significantly ($P = 0.04$) tougher. Complete understanding for decreasing tenderness of steaks from AG supplemented cattle is still lacking, although protein oxidation and polymerization are suspected.

Feeding feedlot cattle with a mixture of antioxidants (ethoxyquin and tertiary butyl hydroquinone) contained within AGRADO®PLUS shows positive antioxidant effects against myoglobin and lipid oxidations of beef strip loins toward the end of the retail display period. However, the antioxidant effect of AGRADO®PLUS in reducing lipid and color oxidations of strip loin steaks is reduced with feeding wet distillers grains. The AGRADO®PLUS feed supplementation appears as a viable means to increase lipid and color stability of beef during retail display.

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[2]This project was funded by Novus International Inc., St. Louis, Missouri, 63141.

Table 2. Means of thiobabituric acid reactive substances values of overwrapped (OW) and high oxygen (HiO_2-MAP) packaged strip loins (m. *longissimus lumborum*) aged for 8 and 29 days, during 7 days of simulated retail display conditions.

		Treatments				Contrasts (*P* value)			
Aging (days)	Day (days)	Corn	30% WDGS	Corn + AG	30% WDGS + AG	Corn vs. WDGS	Corn vs. Corn+AG	WDGS vs. WDGS+AG	No AG vs. AG
8	0	0.09^{b}	0.02^{b}	0.09	0.05^{b}	0.18	0.83	0.66	0.64
	4	0.10^{b}	0.22^{b}	0.15	0.19^{ab}	0.32	0.64	0.80	0.87
	7	0.44^{a}	0.67^{a}	0.37	0.38^{a}	0.39	0.70	0.14	0.19
29	0	0.01^{c}	0.32^{c}	0.16^{c}	0.18^{c}	0.11	0.32	0.37	0.95
	4	1.00^{b}	1.06^{b}	0.66^{b}	0.69^{b}	0.76	0.13	0.11	0.03
	7	2.07^{Aa}	2.17^{Aa}	1.11^{Ba}	1.62^{ABa}	0.18	0.003	0.09	0.001

[A-B]Comparison within a row by treatment, means lacking a common superscript were different at $P < 0.05$.
[a-c]Comparison within a column, means lacking a common superscript were different at $P < 0.05$.
WDGS – Wet distillers grains plus solubles, AG – AGRADO®PLUS
P-value for treatment×aging×day = 0.0388.

Table 3. Means of Warner-Bratzler shear force value (lb) of overwrapped (OW) and high oxygen (HiO_2-MAP) packaged strip loins (m. *longissimus lumborum*) aged for 8 and 29 days, during 7 days of simulated retail display conditions.

Treatments				Contrasts (*P* value)			
Corn	30% WDGS	Corn + AG	30%WDGS +AG	Corn vs. WDGS	Corn vs. Corn+AG	WDGS vs. WDGS+AG	No AG vs. AG
6.11^{B}	6.06^{B}	6.57^{A}	6.15^{B}	0.06	0.01	0.62	0.04

[A-B]Comparison within a row, means lacking a common superscript were different at $P < 0.05$.
WDGS – Wet distillers grains plus solubles, AG – AGRADO®PLUS.
P-value for treatment = 0.0200.

Effects of the Synthetic Antioxidants on Shelf Life of m. *psoas major* and m. *triceps brachii* Muscles from Beef Fed Wet Distillers Grains

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Summary

Feedlot finishing steers (n = 483) were randomly allotted to four dry-rolled corn based diets containing 0 or 30% wet distillers grains with or without the synthetic antioxidants supplementation (ethoxyquin and tertiary butyl hydroquinone in AGRADO®PLUS). This study intended to minimize detrimental effects of feeding wet distillers grains on color and lipid oxidation of beef tenderloin and clod heart muscles during retail display by feeding a synthetic antioxidant mixture. Feeding AGRADO®PLUS significantly reduced meat discoloration and lipid oxidation.

Introduction

de Mello Jr., et al. (*2008 Nebraska Beef Cattle Report*, pp. 116-117) and Senaratne et al. (*2009 Nebraska Beef Cattle Report*, pp. 110-111) reported wet distillers grains (WDGS) diets increase polyunsaturated fatty acids (PUFA) in beef, and thereby it negatively affects beef color, lipid oxidation, and flavor during retail display. Senaratne et al. (*2009 Nebraska Beef Cattle Report*, pp. 113-115) reported vitamin E supplementation (500 IU/head/day for last 100 days) significantly reduced these detrimental effects of feeding WDGS on beef retail displayed. A mixture of synthetic antioxidants, ethoxyquin, and tertiary butyl hydroquinone in AGRADO®PLUS (AG) might be beneficial in reducing the negative effects of feeding WDGS on beef shelf life. This study was a part of a previous study conducted by Senaratne et al. (*2011 Nebraska Beef Cattle Report,* pp. 105-108). Since muscles are structurally and biochemically different from each other, this study aimed to investigate the effects of AG supplementation on shelf life of tenderloins (m. *psoas major*) and clod heart (m. *triceps brachii*) muscles from finishing beef steers fed WDGS.

Procedure

Crossbred steers were allotted to one of four dry-rolled corn-based diets containing 0% and 30% WDGS (DM basis) with or without AG supplementation at 150 ppm/head/day. All conditions at feeding, slaughter, and grading were similar to procedures described by Senaratne et al. (*2011 Nebraska Beef Cattle Report*, pp. 105-108). In addition to beef loin, short loin, beef chuck, and shoulder clod (IMPS # 144; NAMP, 2007) were also collected and aged for either 8 or 29 days in a cooler. After each aging period, tenderloins (m. *psoas major*; IMPS # 1190A; NAMP, 2007) and clod hearts (m. *triceps brachii*; IMPS # 114E; NAMP, 2007) were fabricated. Tenderloins were cut into three 1-inch-thick steaks from the posterior end, whereas three 1-inch-thick steaks were removed from the middle of the clod hearts. The first anterior steaks of each muscle were vacuum packaged and stored at -4°F. Additional steaks were aerobically packaged on Styrofoam trays and assigned for 4 or 7 days retail display. Lipid oxidation measurements (0, 4, and 7 days) and subjective surface discoloration ratings (1 to 7 days) were conducted. All conditions at packaging, retail display, discoloration evaluation, lipid oxidation measurements, and statistical analysis were similar to procedures mentioned by Senaratne et al. (*2011 Nebraska Beef Cattle Report*, pp. 105-108).

Results

There were significant ($P < .0001$) three-way interaction effects of treatment × aging × day on percentage discoloration of tenderloin and clod heart (Table 1) steaks. Discoloration of all muscle steaks increased during retail display time after each aging period. No significant discoloration differences ($P > 0.05$) were detected among dietary treatments for 8- and 29-day aged tenderloin and clod heart steaks until three days of retail display. After that, steaks (from both aging periods) from cattle fed corn with AG supplementation had the lowest discoloration ($P < 0.05$). Both steaks from WDGS-fed cattle (with or without AG) had significantly ($P < 0.05$) higher surface discolorations compared to steaks from corn-fed cattle (with or without AG). The effectiveness of AG supplementation in reducing discoloration was prominent when meat was aged longer. However, the anti-discoloration effect of AG supplementation were not significant when cattle were fed WDGS. The reason for high discoloration even after adding AG into the diet is likely due to the increase of easily oxidizable, PUFA in beef from feeding WDGS. de Mello Jr., et al. (*2008 Nebraska Beef Cattle Report*, pp. 116-117) and Senaratne et al. (*2009 Nebraska Beef Cattle Report*, pp. 110-111) reported that feeding WDGS increased PUFA level in beef compared to corn control diets and compromised color.

There were significant two-way interaction effects of treatment × day on lipid oxidation of tenderloins (Table 2; $P = 0.0279$) and clod heart (Table 2; $P = 0.0011$) steaks. As aging and retail display time increased lipid oxidation also increased ($P < 0.0001$). Both steak types from cattle fed AG had significantly ($P < 0.05$) lower TBARS values

(Continued on next page)

Table 1. Means of percentage discoloration of 8 and 29 days aged tenderloins (m. psoas major) during 7 days of simulated retail display conditions.

Muscle	Aging (days)	Treatments	Retail display (days) 0	1	2	3	4	5	6	7	Contrasts(P value) Corn vs. WDGS	Corn vs. Corn + AG	WDGS vs. WDGS+AG	No AG vs. AG
Tenderloins	8	Corn+AG	0.2	0.26^{e}	0.91^{e}	4.24^{de}	9.05^{dB}	18.20^{cC}	31.61^{bC}	44.25^{aC}	<.0001	0.17	0.0008	0.0008
		30% WDGS+AG	0.40^{f}	0.36^{f}	1.12^{ef}	6.16^{e}	13.46^{dB}	28.40^{cB}	46.18^{bB}	63.84^{aB}				
		Corn	0.55	0.92^{e}	1.48^{e}	5.07^{e}	11.50^{dB}	25.05^{cBC}	43.16^{bB}	61.12^{aB}				
		30%WDGS	0.71^{f}	1.15^{f}	3.17^{f}	11.98^{e}	26.55^{dA}	49.34^{cA}	76.92^{bA}	87.40^{aA}				
	29	Corn+AG	0	0.00^{e}	0.53^{e}	3.05^{e}	19.79^{dB}	32.29^{cB}	50.00^{bC}	62.77^{aC}	0.0016	0.46	0.52	0.33
		30%WDGS+AG	0.00^{f}	0.00^{f}	0.79^{ef}	5.74^{e}	29.93^{dA}	52.49^{cA}	69.42^{bA}	80.62^{aA}				
		Corn	0	0.00^{e}	0.33^{e}	2.21^{e}	18.71^{dB}	39.23^{cB}	58.80^{bB}	72.03^{aB}				
		30%WDGS	0.00^{f}	0.00^{f}	2.88^{f}	9.63^{e}	34.51^{dA}	54.68^{cA}	75.65^{bA}	81.18^{aA}				
Clod hearts	8	Corn+AG	0.00^{g}	0.41^{g}	5.02^{f}	12.10^{e}	19.78^{d}	33.75^{cB}	50.97^{bB}	64.13^{aB}	0.24	0.42	0.29	0.19
		30%WDGS+AG	0.04^{f}	0.26^{f}	4.16^{f}	11.66^{e}	19.78^{d}	35.75^{cAB}	54.80^{bAB}	72.60^{aA}				
		Corn	0.02^{g}	0.32^{fg}	4.18^{f}	11.61^{e}	21.70^{d}	36.32^{cAB}	54.41^{bAB}	72.19^{aA}				
		30%WDGS	0.09^{g}	0.36^{g}	5.15^{f}	13.56^{e}	25.33^{d}	42.48^{cA}	60.81^{bA}7	1.08^{aA}				
	29	Corn+AG	0	0.00^{e}	0.33^{e}	2.91^{e}	15.39^{dB}	32.10^{cB}	46.89^{bB}	60.58^{aC}	0.01	0.55	0.61	0.43
		30%WDGS+AG	0	0.00^{e}	0.36^{e}	3.66^{e}	22.09^{dAB}	43.86^{cA}	64.53^{bA}	76.18^{aA}				
		Corn	0	0.00^{e}	0.17^{e}	2.79^{e}	16.48^{dB}	35.94^{cB}	50.93^{bB}	68.21^{aB}				
		30%WDGS	0.00^{f}	0.00^{f}	0.74^{f}	5.51^{e}	23.67^{dA}	43.03^{cA}	69.51^{bA}	82.41^{aA}				

$^{a-g}$Comparison within a row, means lacking a common superscript were different at $P < 0.05$.
$^{A-C}$Comparison within a column by muscle type and aging time, means lacking a common superscript were different at $P < 0.05$. WDGS = wet distillers grains; AG = AGRADO®PLUS.
P-value for treatment × aging × day - <0.0001 for tenderloins and clod hearts.

Table 2. Means of thiobarbituric acid reactive substances (TBARS) values of tenderloins (m. *psoas major*), aged for 8 and 29 days, during 7 days of simulated retail display conditions.

Muscle	Day (days)	Treatments Corn	30% WDGS	Corn +AG	30% WDGS +AG	Contrasts (P value) Corn vs. WDGS	Corn vs. Corn+AG	WDGS vs. WDGS+AG	No Agrado vs. AG
Tenderloins	0	0.04^{ABc}	0.07^{Ac}	0.01^{Bc}	0.01^{Bc}	0.41	0.29	0.02	0.02
	4	1.16^{ABb}	1.38^{Ab}	0.59^{Cb}	0.88^{BCb}	0.14	0.02	0.04	0.003
	7	1.81^{ABa}	2.06^{Aa}	1.40^{Ba}	1.64^{ABa}	0.27	0.20	0.18	0.06
Clod hearts	0	0.23^{Ac}	0.10^{Bc}	0.08^{Bc}	0.03^{Bc}	0.04	0.03	0.32	0.02
	4	1.84^{ABb}	2.00^{Ab}	1.42^{Bb}	1.66^{ABb}	0.35	0.16	0.26	0.08
	7	3.27^{ABa}	3.78^{Aa}	2.46^{Ba}	3.05^{ABa}	0.10	0.08	0.12	0.02

$^{A-C}$Comparison within a row, means lacking a common superscript were different at $P < 0.05$.
$^{a-c}$Comparison within a column by muscle type, means lacking a common superscript were different at $P < 0.05$.
WDGS = wet distillers grains; AG = AGRADO® PLUS.
P-value for treatment × day = 0.0279 for tenderloins and 0.0011 for clod hearts.

compared to steaks from cattle fed no AG supplementation. The highest lipid oxidation was observed for all muscle steaks from cattle fed 30% WDGS diets with no AG; whereas, the lowest oxidation values were detected for steaks from corn plus AG fed cattle during retail display ($P < 0.05$). However, the effectiveness of AG supplementation in reducing lipid oxidation of both muscle steaks was reduced with feeding WDGS. Feeding AG helped to reduce oxidation of increased PUFA content when cattle were fed WDGS.

In conclusion, feeding feedlot cattle a mixture of antioxidants (ethoxyquin and tertiary butyl hydroquinone) contained within AGRADO® PLUS shows positive antioxidant effects against myoglobin (color) and lipid oxidations of beef tenderloins and clod hearts muscles during retail display. However, the antioxidant effect of AGRADO PLUS in reducing lipid and color oxidations of beef steaks appears to be reduced with feeding wet distillers grains, likely due to increase of polyunsaturated fatty acids in beef. The AGRADO PLUS feed supplement appears to be a viable means to increase lipid and color stability of beef tenderloins and clod heart steaks during retail display.

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Intramuscular Tenderness and Muscle Fiber Orientation of Beef Round Muscles

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Summary

Intramuscular tenderness and muscle fiber orientation variations of beef round m. adductor femoris *(AF), m.* biceps femoris *(BF), m.* semimembranosus *(SM), and m. semitendinosus (ST) were investigated. The first two proximal steaks of long head of BF were more tender than the rest. The tenderness decreased from the middle of the ST muscle to both ends. The anterior sides of the long head BF and ST were tougher than their posterior sides. The first four steaks of the SM were more tender than rest of the muscle. There was a significant tenderness increment from the middle of the AF to its both ends. Based on tenderness values, the first two to four steaks of long head BF, SM, and AF and middle steaks of ST, could be marketed as premium quality steaks.*

Introduction

Since most beef round muscles are large and long, the tenderness varies within the muscles from one end to the other. The knowledge of muscle fiber direction is important during meat fabrication so that muscles can be cut across the grain to improve the tenderness. Muscle fiber directions along the muscles of the beef round have not been documented. Characterization of all muscles in the beef round, based on their intramuscular tenderness and muscle fiber orientation variations, therefore is necessary to apply value-added strategies for the beef round. This study, attempted first to identify tender portions of beef round muscles, m. *adductor femoris* (AF), m. *biceps femoris* (**BF**), *semimembranosus* (**SM**), and m. *semitendinosus* (**ST**) that could be marketed as "premium" round steaks or single muscle steaks based on tenderness, and second determined fabrication specifications for the beef round muscles based on their muscle fiber orientation.

Procedure

Ten of each beef round, top untrimmed (IMPS #168; *NAMP, 2007*), beef round, outside round (IMPS #171B; *NAMP, 2007*), and beef round, eye of round (IMPS #171C; *NAMP, 2007*) were purchased as USDA Choice boxed beef subprimals and aged for 14 days from boxed date. The BF, ST, SM, and AF were fabricated from relevant subprimals. The anterior and distal directions of each muscle were tracked. Crust-frozen muscles were cut into 1-inch-thick steaks from the proximal to distal end, perpendicular to the long axis. Steaks were vacuum packaged and stored at -4ºF.

Thawed steaks were grilled to an internal temperature of 160ºF. Grilled steaks were cooled at 39ºF for 24 hours. A 2 inch-wide region in the middle of grilled BF, SM, and AF was marked from posterior to anterior sides as posterior, middle, and anterior regions (Figure 1b, 3b, and 4b). Grilled ST steaks were horizontally divided into three regions from the medial to lateral as medial, middle, and lateral regions (Figure 2b). Each region of BF, SM, and AF were again subdivided into two sections as medial and lateral (Figure 1b, 3b, and 4b). Medial, middle, and lateral regions of ST steaks were also subdivided into anterior and posterior sections. From each section of a steak, 0.5 inch-diameter cores were prepared parallel to the muscle fiber orientation and sheared on an Instron Universal Testing Machine with a triangular Warner-Bratzler shear attachment. An individual peak Warner-Bratzler shear force (WBSF) for each steak section was used for the statistical analysis. The WBSF values of each section of steaks were calculated and used to construct intramuscular tenderness maps based on a color scheme (white – tender < 8.6 lb); gray – intermediate tender 8.6 – 10.8 lb; and black – though >10.8 lb; Von Seggern et al. *2005 Journal of Animal Science,* pp. 39-51).

Before removing cores, a digital image of muscle fiber orientation on the longitudinal section of the steak was captured using a digital camera (Model # DSC-S730 cyber-shot 7.2 megapixels, SONY Corp., China). The muscle fiber orientation on each digital picture was measured using a protractor, and expressed in degrees horizontally along the long axis of the muscle from the proximal to the distal at every inch. The fiber orientation with the angle was illustrated on a longitudinal section of the muscle along the long axis from the proximal to the distal.

Warner-Bratzler shear force values were analyzed by using the ANOVA in GLIMMIX procedure of SAS (version 9.1), with a model including region or steak (from proximal to distal) of BF, ST, SM, and AF muscles. The side differences (anterior *vs* posterior or anterior/posterior *vs* middle, and medial *vs* lateral or medial/lateral *vs* middle) of each muscle steak were determined using the CONTRAST option in SAS. Least square means were calculated for each section using the LSMEANS and mean separation was performed using the DIFF and LINES options of SAS at $P < 0.05$.

Results

The most proximal two steaks of the BF, which were closest to the sirloin/round separation, was the most tender region of the muscle (Figure 1a). The long head of BF had its highest WBSF value in the middle region 4 to 8 inches from the sirloin/round

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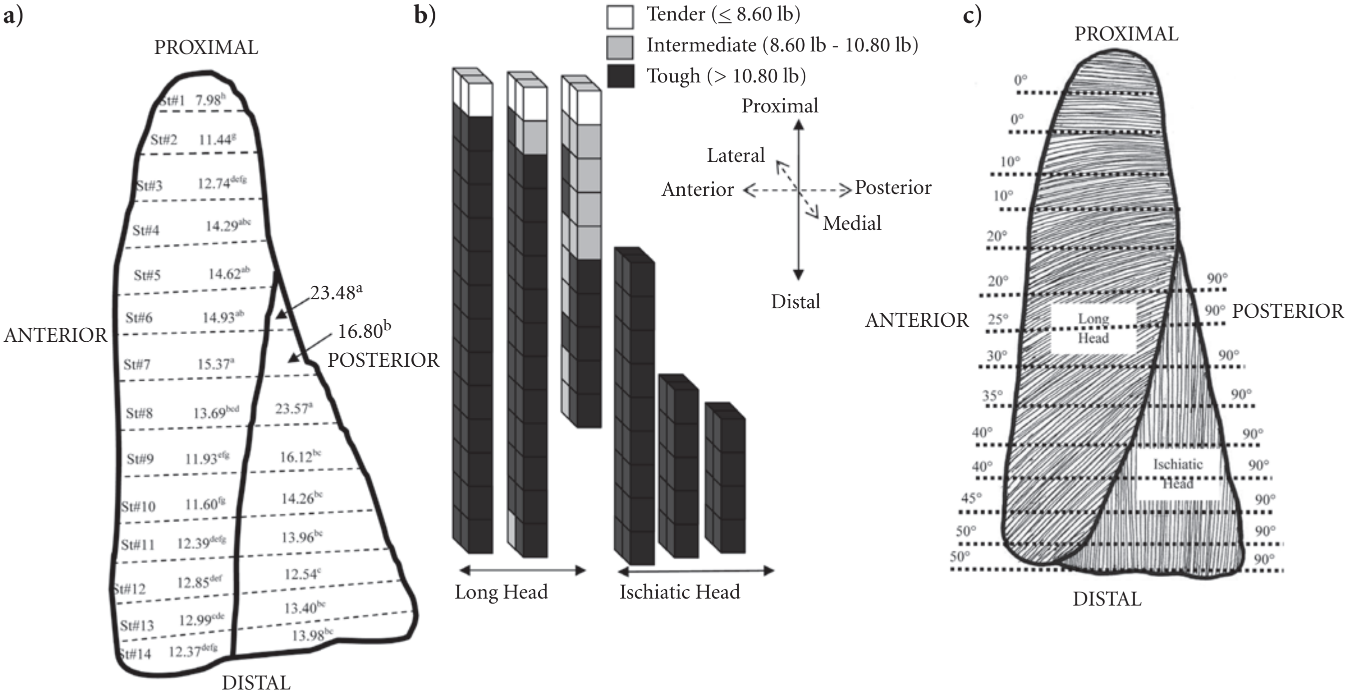

Figure 1. **a. Least square means Warner Bratzler shear force (WBSF) values (lb) of each steak of m. *biceps femoris* long head (P <0 .0001) and ischiatic head (P <.0001). b. Intramuscular tenderness variation map of m. *biceps femoris* based on WBSF values (lb). c. Intramuscular muscle fiber orientation map of m. *biceps femoris.* [a-h]Within the same figure, means lacking a common superscript were different (P < 0.05).**

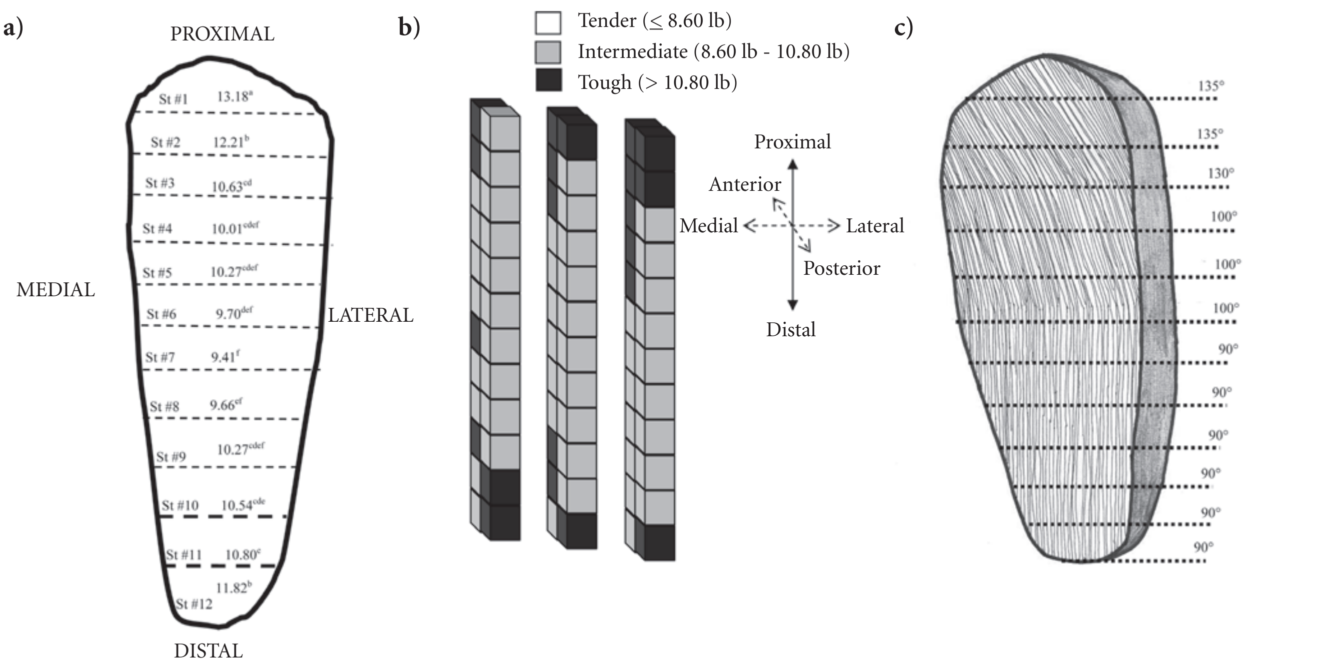

Figure 2. **a. Least square means Warner Bratzler shear force (WBSF) values (lb) of each steak of m. *semitendinosus* (P < 0 .0001). b. Intramuscular tenderness variation map of m. *semitendinosus* based on WBSF values (lb). c. Intramuscular muscle fiber orientation map of m. *semitendinosus*. [a-f]Within the same figure, means lacking a common superscript were different (P < 0.05).**

separation (steak 4 to 8; Figure 1b) and intermediate shear force values toward the distal end. The lateral side (steak 5, 6, and 8) of the long head of BF was significantly (P < 0.05) tougher than the medial side (towards the femur; data not shown). In addition, the anterior and the middle sides of the long head of BF were significantly (P < 0.05, data not shown) less tender than the posterior side (steak 1 to 10; Figure 1b). There was no significant (P > 0.05) difference in posterior and anterior sides of the ischiatic head of the BF. The WBSF values of this study indicated that the most proximal two steaks of the long head BF were in steak quality. The muscle

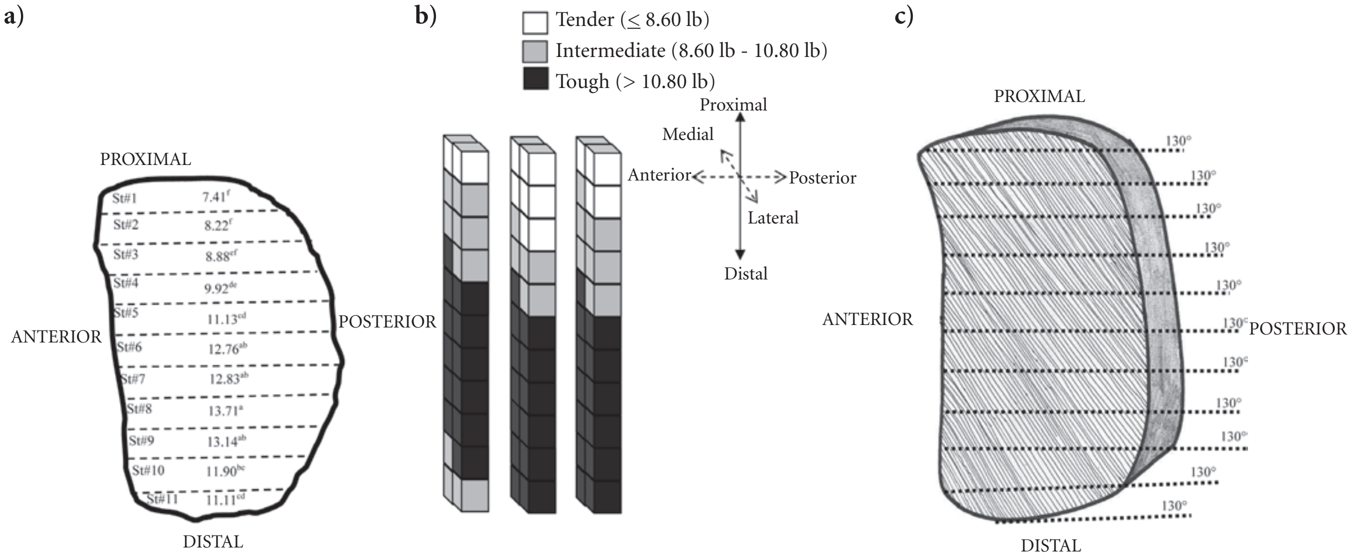

Figure 3. a. Least square means Warner Bratzler shear force (WBSF) values (lb) of each steak of m. *semimembranosus* (P < 0 .0001). b. Intramuscular tenderness variation map of m. m. *semimembranosus* **based on WBSF values (lb). c. Intramuscular muscle fiber orientation map of m. *semimembranosus.* [a–f] Within the same figure, means lacking a common superscript were different (P < 0.05). The WBSF (lower values – tender; higher values – tough).**

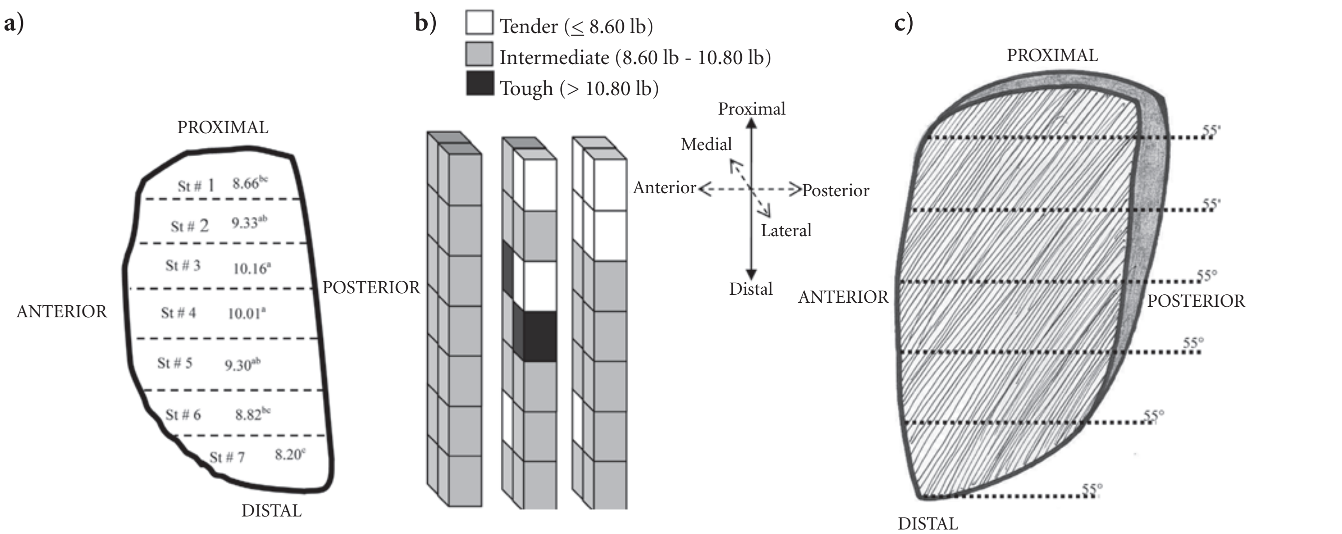

Figure 4. a. Least square means Warner Bratzler shear force (WBSF) values (lb) of each steak of m. *adductor femoris* (P = 0.002). b. Intramuscular tenderness variation map of m. m. *adductor femoris* based on WBSF values (lb). c. Intramuscular muscle fiber orientation map of m. *adductor femoris.* [a–c] Within the same figure, means lacking a common superscript were different (P < 0.05).

fiber orientation of BF was bipennate (Figure 1c). At the sirloin/round separation region (steak 1 to 4) of the BF long head had more horizontal fiber orientation than the rest of the muscle (Figure 1c). Then, the degrees of inclination of muscle fibers of the long head BF were gradually more angular to the horizontal axis of the muscle. There was no variation of muscle fiber orientation in the ischiatic head of BF from the proximal to the distal. Muscle fibers of the ischiatic head of BF were parallel to the long axis of the muscle.

There was significant (P < .0001) tenderness variation in the ST from the proximal to the distal (Figure 2a). The tenderness of the ST decreased from middle of the muscle to both ends (the proximal and the distal). The medial side (steak 2 to 4) of the ST was significantly (P < 0.05) more tender than the lateral side. The posterior side of the ST was significantly (P < 0.05; Figure 2b) more tender than the anterior side of the muscle up to 9 inches from the proximal end. The middle side of the ST did not (P > 0.05) differ in tenderness from the medial or lateral side of the muscle, except for the first 2 inches from the proximal end. The muscle fiber orientation of the ST was fusiform (Figure 2c). Tenderness mapping data suggests cutting the muscle into steaks perpendicular to the long axis of the muscle from the proximal to

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the distal and selling middle tender steaks as "premium" to the rest.

The proximal end of the SM muscle up to 4 inches (steak 1 – 3) had significantly (*P* < 0.05) lower shear force values than the rest of the SM muscle (Figure 3a). The lateral side (steak 7 -8; Figure 3b) of the SM was less tender (*P* < 0.05) than the medial. There was no (*P* < 0.05) tenderness variation between the posterior and anterior sides of the muscle. The muscle fiber angle of the SM is 130° to the horizontal axis of the muscle along the muscle from proximal to distal making unipennate fiber orientation (Figure 3c). The most proximal steaks (steak 1 – 3 or 5) were in steak quality compared to the rest; therefore, the five proximal steaks could be marketed as SM "premium" steaks and the rest could be sold as regular SM steaks or as a roast.

The proximal and distal ends (steak 1, 6, and 7) of the AF were more tender than the center part of the muscle (Figure 4a). Overall tenderness variations between medial and lateral sides or posterior and anterior sides were not significant (*P* > 0.05). The fiber arrangement of the AF was unipennate (Figure 4c). Tenderness and muscle fiber orientation maps of the study propose that the first two proximal and three distal steaks could be sold as "premium" AF steaks and the rest as regular steaks.

A clear intramuscular tenderness variation in the beef round muscles based on different anatomical orientations is present. The first few steaks of large beef round muscles (BF, SM, and AF and the middle steaks of ST) are more tender and could be sold at a premium compared to other steaks from the same muscles. Intramuscular tenderness and muscle fiber orientation of the beef round muscle provide a complete guide for individual muscle fabrication, which would be needed by the meat industry for development of innovative meat cuts for optimum eating quality, and by academia for research purposes.

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Marketing Source-Verified Beef to Restaurant Patrons

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Summary

To determine consumer ordering behaviors in high-end restaurants and to see if consumers are interested in the origin of their beef, both an online survey and in-restaurant taste testing were conducted. About two-thirds of the participants in the in-restaurant taste testing ordered the steak with either the state or farm-of-origin description. Compared to a non-source verified steak, taste participants were willing to pay $4.74 more for the steak with the state-of-origin description, and $8.75 more for the steak with the farm-of-origin description. Almost all of the participants acknowledged the best beef comes from the Midwest, specifically naming Nebraska as a state that raises high-quality beef. These data suggest there is consumer interest in a source-verified beef product in high-end restaurants.

Introduction

Patrons in high-end restaurants are often willing to pay more for a premium product. Also, trends that are popular in high-end restaurants are frequently emulated in more casual restaurants.

Consumers are becoming more educated about the origin of their meat and use source-verification as a way of guaranteeing safety and quality. Restaurants and producers could create a market by offering products that are either source-verified or traceable from farm to restaurant. In order for this to be a viable option, there has to be a financial incentive. The objectives of this research were to determine factors influencing consumer purchasing decisions in high-end restaurants and to see if consumers are interested in knowing the origin of their beef.

Procedure

Online Survey

All surveys and protocols performed in this study were approved by the University of Nebraska–Lincoln Institutional Review Board. A survey was created and hosted by an online survey site (surveymonkey.com, 1999-2010) for a month. The survey asked consumers questions about their ordering behaviors, opinions on source-verification, and several demographic topics.

High-end restaurants in Connecticut (n = 3) and Arizona (n = 3) distributed postcards and sent out email blasts informing consumers of the online survey. An incentive in the form of a coupon for a free dessert, money off of a next meal, or an invitation to an in-restaurant steak tasting was offered for those that completed the survey. Results were composited and analyzed (n = 1087).

In-restaurant Tasting

From the six restaurants advertising the online survey, three were chosen to host an in-restaurant taste testing — two in Connecticut and one in Arizona. Participants (n = 192) were asked to select one of four New York strip steaks from a specialty menu. All descriptions stated steaks were USDA Choice and had superior flavor and tenderness. The primary differences between the descriptions were price and origin specification (no origin, region, state, or farm). Price was randomly assigned to each steak, and all steaks came from the same farm in Nebraska. All strip loins were upper 2/3 Choice, aged for 28 days, cut into approximately 14 oz steaks, and shipped fresh to the restaurants. After the meal, participants were given a short questionnaire and asked to rate sensory attributes of their steak (overall appearance, aroma, flavor, juiciness, tenderness, and overall acceptability).

Statistics

Results for both the online survey and in-restaurant steak tasting were analyzed using the frequency procedure in SAS (Version 9.1, SAS Institute Inc., Cary, N.C., 2004) to determine frequencies. The experimental unit was individual participant. In addition, a logistic panel regression model was used to analyze how much consumers are willing to pay for source-verified beef using the in-restaurant steak tasting data.

Results

Online Survey

Most of the participants were female (58%), 50 years of age or older (54%), and Caucasian (85%). For annual personal income, participants tended to make $100,000 or less (45%), and a fairly large number (34%) refused to reveal their personal income. Participants were fairly equally distributed in where they lived, with 47% residing in urban areas and 45% claiming residency in rural areas.

Most of the participants stated they consume beef on a weekly basis both in the home or while dining out. When participants did dine out, it was usually only two to three times per month, but some dine out on a weekly basis. Most of the participants preferred filet mignon when consuming beef, but the ribeye steak and New York strip were also favorites.

Besides the cut of beef, other attributes that participants used to make a decision when ordering steak in a restaurant included the price, USDA Quality Grade (e.g. Prime, Choice, etc.), and if there was a guarantee of tenderness or not (Table 1). Traits or attributes participants considered to be not as important were factors such as the breed of the cow or the brand (e.g., Certified Angus Beef®, Sterling Silver®, etc.). The most important

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characteristics that best determined overall eating satisfaction for the participants were flavor, tenderness, and degree of doneness (Table 1). Participants considered characteristics such as accompaniments (potatoes, vegetables, salad, etc.), thickness of the steak, and portion size to be less relevant.

For the most part, the participants assumed their meat came from within the U.S. When asked what type of origin information they would like provided, 39% wanted to know state-of-origin and 38% wanted to know country-of-origin. A fairly large number wanted region-of-origin (33%) and only 17% cared to know farm-of-origin. About 24% did not care about the origin at all.

When the price of a steak from an unspecified source is $20.95, 63% of the participants indicated they would be willing to pay more for a steak that was source-verified (Table 2). About 26% would only pay the same amount for the source-verified steak, 7% would only buy it if it was priced less than the unspecified source steak, and only 3% said they would not purchase the source-verified steak.

In-restaurant Tasting

When presented with a menu with four different steak descriptions, 37% of the participants ordered the steak that named the farm-of-origin, while 31% chose the steak that listed the state-of-origin. Conversely, the steak that did not specify any origin was ordered by 18% of the participants, and only 14% ordered the steak that named the region-of-origin. In addition, the state-of-origin and farm-of-origin steaks were the most ordered regardless of price. About 2/3 of the participants preferred steaks with a more specific source-verification in the description and were willing to pay extra for steaks that had it.

About 78% or more of the participants gave the steaks they consumed high ratings (1 or 2 on a 5-point scale) on all attributes, and 73% said they would order the same steak again (Table 3). Similar to the online

Table 1. Rank of deciding factors among steak attributes for participants of the online survey.

Steak traits/attributes consumers use when making a decision among several options	Weighted Average[1]
Specific cut (e.g. T-bone, Sirloin)	1.74
Price	2.84
USDA Quality Grade (e.g. Prime)	2.98
Tenderness verification/guarantee	2.89
Grass-fed	2.98
Nutritional Information	3.28
Aged for at least 14 days	3.72
Brand (e.g. Certified Angus Beef®)	3.82
Natural label	3.56
Corn-fed or grain-fed	3.80
Certified organic	3.38
U.S. origin	3.78
Free range	3.51
Locally raised	3.75
Traceable from farm to consumer	3.79
Breed (e.g. Angus, Hereford)	4.01
Other	3.40
Factors that determine consumers' overall satisfaction with eating experience of the steak	
Flavor/Taste	1.74
Tenderness	2.19
Degree of doneness	2.72
Juiciness	3.48
Little fat trim/less waste due to fat	3.63
Aroma/Smell	4.03
Portion size	4.09
Thickness of steak	4.09
Accompaniments (e.g. salad)	4.32
Other	3.41

[1]1 = very important and 5 = not as important

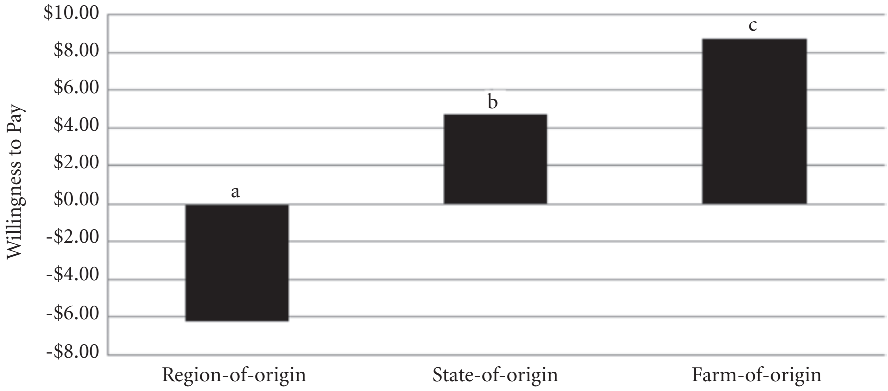
Table 2. Percentage of online survey participants willing to pay for a source-verified steak.

Statement	%
I would only pay the same price as the unspecified source steak ($20.95)	26.26
For this steak, I would pay a premium of:	
10-20 % ($23.05-$25.15)	35.94
30-40% ($27.25-$29.35)	17.71
>50% ($31.45-$41.90)	9.58
I would NOT purchase this steak	3.40
I would only purchase if priced LESS than the unspecified source steak	7.11

Table 3. In-restaurant steak tasting scores (%).

Item, %	1	2	3	4	5
Visual[1]	40.64	47.59	11.76	0.00	0.00
Aroma[1]	25.00	54.89	19.57	0.00	0.00
Flavor[1]	45.99	37.44	16.04	0.53	0.00
Juiciness[2]	34.59	49.19	15.14	1.08	0.00
Tenderness[3]	36.22	41.62	16.76	4.32	1.08
Acceptability[4]	59.24	26.63	12.50	1.63	0.00
Willingness to purchase again[5]	72.97	15.14	11.89	—	—

[1]1 = Extremely Desirable and 5 = Extremely Undesirable
[2]1 = Extremely Juicy and 5 = Extremely Dry
[3]1 = Extremely Tender and 5 = Extremely Tough
[4]1 = Extremely Acceptable and 5 = Extremely Unacceptable
[5]1 = Yes, 2 = No, 3 = Not Sure



[a]P = 0.06.
[b]P = 0.09.
[c]P < 0.01.

Figure 1. Premium or discount that restaurant consumers are willing to pay when compared to a generic, nonsource verified steak, %.

Table 4. Top states in-restaurant steak tasting participants believe grow the highest quality beef (%).

State	%
Nebraska	33.81
Texas	12.03
Iowa	11.75
Kansas	10.60
Oklahoma	4.01
Colorado	3.44
Montana	2.87

surveys, tenderness and quality grade were the main attributes that made participants decide on their steak selection (20% for both), but the specified location where cattle were raised was also a deciding factor (17%).

Participants were less likely to order the steak that only listed the Midwest as the origin. However, the participants were more likely to choose the steaks that had either the state ($P = 0.089$) or farm-of-origin ($P < 0.01$) listed. When steak price was added into the model, participants were willing to pay $4.74 more for a steak with state-of-origin specification ($P = 0.09$) and $8.75 more for a steak with farm-of-origin specification ($P = 0.001$) (Figure 1). Consumers perceived no benefit from knowing the region-of-origin specified (i.e.,Midwest); the price had to be discounted $6.20 below the price of the steak that had no origin specified in the description ($P = 0.06$) in order for region-of-origin steaks to be selected.

When asked where the best beef comes from (Table 4), 83% believed it was the Midwest, with Nebraska, Texas, and Iowa specifically named as states that grow the best beef (35%, 12%, and 12%, respectively). When asked if they would be willing to pay more for beef that is source-verified, 65% of the participants said yes. This implies that Nebraska source-verified beef products would be in high demand.

In conclusion, these data suggest consumers are interested in a source-verified beef product, and they would be willing to pay a premium for it.

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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, researchers cannot apply treatments to every member of a population; therefore, they must sample the population. The use of statistics allows researchers 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 refer to 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 Department of Animal Science 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*). Another expanding educational experience is the ***Nebraska Beef Industry Scholars Program,*** a unique four year certification program for UNL students.

Careers:

Animal Health	Education	Quality Assurance
Animal Management	Marketing	Research and Development
Banking and Finance	Meat Processing	Technical Service
Consultant	Meat Safety	Veterinary Medicine

Scholarships – Thanks to the generous contributions of our supporters listed below, each year the Animal Science Department offers scholarships to incoming freshmen and transfer students, as well as students at the sophomore, junior, and senior level within the UNL Animal Science Program. For the 2010-2011 academic year, over $33,000 in scholarships were awarded to incoming freshmen and transfer students, and over $58,000 in scholarships were awarded to upperclass UNL Animal Science students.

Elton D. & Carrie R. Aberle Animal Science Scholarship
ABS Global Scholarship
Dr. Charles H. & Beryle I. Adams Scholarship
Maurice E. Boeckenhauer Memorial Scholarship
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Frank and Mary Bruning Scholarship
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Derrick Family Scholarship
Doane Scholarship
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Feedlot Management Scholarship
Will Forbes Scholarship
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Lincoln Coca-Cola Bottling Company Scholarship
William J. and Hazel J. Loeffel Scholarship
Nebraska Cattlemen Livestock & Meat Judging Team Scholarship
Nebraska Cattlemen NCTA Transfer Scholarship
Nebraska Cattlemen New Student Scholarship
Nutrition Service Associates Scholarship
Oxbow Pet Products Scholarship
Parr Family Student Support Fund
Parr Young Senior Merit Block and Bridle Award
Eric Peterson Memorial Award
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Chris and Sarah Raun Memorial Scholarship
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