NEBRASKA

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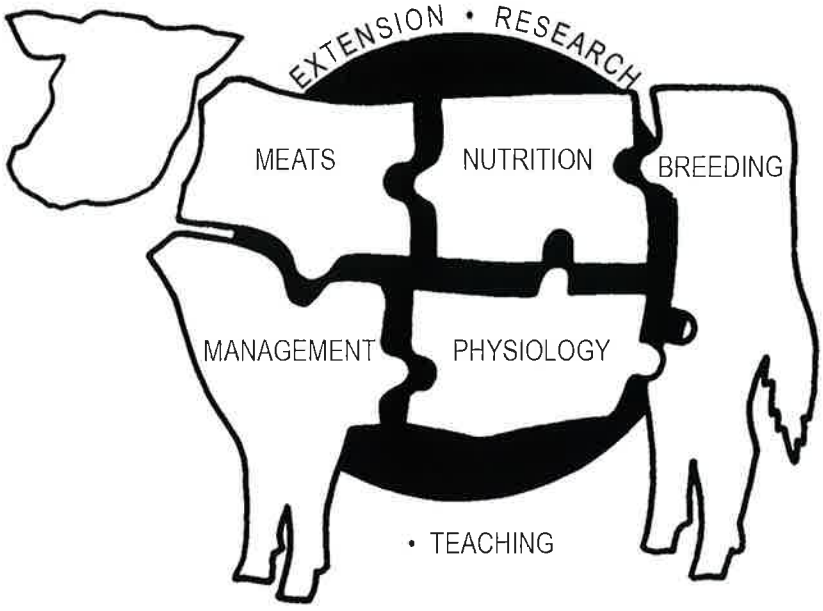

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2016 Beef Cattle Report

University of Nebraska Lincoln

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Animal Science
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Beef Products

Industry Perceptions

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

Jason M. Warner, Curtis J. Bittner, Robert G. Bondurant, Karla H. Jenkins, Rick J. Rasby, Matt K. Luebbe, Galen E. Erickson, and Terry J. Klopfenstein

Summary

Effects of wintering cow-calf pairs on cornstalks or in a drylot on cow-calf performance and reproduction in a summer-calving intensively managed cowherd were evaluated at two locations. Cow body condition score change was not different between treatments in western Nebraska, but was greater for pairs fed in a drylot in eastern Nebraska. In western Nebraska, calf gain and weights were not different between treatments, but were greater for drylot calves in eastern Nebraska. Initial data indicate that wintering pairs on cornstalks may decrease cow performance and calf gain. If reproduction is adequate and grazing is not impeded, wintering pairs on cornstalks may be viable for later-calving cowherds compared to drylot feeding.

Introduction

Data from previous studies (*2015 Nebraska Beef Cattle Report*, pp. 14–15 & 16–18) indicate that intensive management (confinement) of cowherds may be a viable alternative when forage resources for grazing are limited. Cornstalk residues represent a valuable forage resource for fall/winter grazing and may complement an intensive cow-calf production system because areas with fewer traditional forage resources also tend to favor grain crop production. Results from economic analyses of alternative cow-calf systems suggest that incorporating cornstalk grazing may decrease production costs (*2015 Nebraska Beef Cattle Report*, pp. 19–21). Gestating spring-calving cows maintain BW and BCS when grazing cornstalk residue (*Professional Animal Scientist*, 27:540–546), yet few data are available regarding a lactating female and her calf when grazing the same forage resource. Our objectives were to test a winter management system incorporating winter cornstalk grazing on cow-calf performance in a summer-calving intensively managed cow-calf production system.

Procedure

Multiparous (5.1 ± 1.4 yr old), crossbred (Red Angus × Red Poll × Tarentaise × South Devon × Devon), lactating beef cows (n = 65) with summer-born calves at side were used in an experiment conducted at both the University of Nebraska–Lincoln Agricultural Research and Development Center (ARDC) feedlot located near Mead, Neb., and the Panhandle Research and Extension Center (PHREC) feedlot at Scottsbluff, Neb. The trial was a randomized complete block design with two treatments. Cow—calf pairs within each location (n = 36 and 29 pairs at ARDC and PHREC, respectively) were blocked by cow BW (4 blocks at ARDC, 2 blocks at PHREC), stratified by calf age, and assigned randomly within strata to one of two wintering system treatments with either four (ARDC) or two (PHREC) replications (pens or paddocks) per treatment (4–8 pairs per replicate). Treatments included: 1) drylot feeding (DL) or cornstalk residue grazing (CS).

Preceding the initiation of the experiment, cows at their respective locations were managed as a single group during the summer calving season (mean calving date = July 13 and 14 at ARDC and PHREC, respectively). Post-calving, cows were limit-fed distillers grains and crop residue-based diets to meet nutrient requirements for early-lactation. At trial initiation (Nov. 6 at ARDC; Dec. 1 at PHREC) cow-calf pairs assigned to the CS treatment were transported to irrigated cornstalk fields for winter grazing. Cows and calves assigned to the DL treatment remained in drylot pens and were limit-fed a diet (Table 1) formulated to meet maintenance energy requirements for a lactating cow in early-gestation. The amount of feed offered to DL pairs increased monthly throughout the experiment to account for growth and increasing diet consumption by the calf. Within a location, all calves regardless of wintering system were weaned on a common date. At ARDC, calves were removed from their dams April 13, and this date

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

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

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

corresponded to the end of the cornstalk grazing period. At PHREC, calves were separated from cows April 2.

Stocking rate for CS pairs was determined based on corn grain yield with an assumption of 8 lb (DM) of leaf and husk available for consumption per bushel of grain yield (*2012 Nebraska Beef Cattle Report*, pp. 11–12) and estimated residue intakes by the cow and calf (*2009 Nebraska Beef Cattle Report*, pp. 13–14). At ARDC, pairs grazed a field which has been in a corn/soybean rotation for multiple years and also has three treatments applied annually: un-grazed, fall-grazed, and spring-grazed. Consequently, cows and calves grazed four paddocks initially from November through February, and were rotated to four additional paddocks to graze from March through mid-April. Pairs at PHREC grazed fields that have been in a corn/sugar beets/dry-edible beans rotation and cattle were moved to a new field in mid-Feb. Pairs at both locations were supplemented (5.2 lb DM/pair/d, range of 3.5 to 7.0 lb) with a dried distillers grains based pellet (Table 2). The supplementation rate was designed to provide an equivalent energy intake to that of the DL pairs, based on estimated residue intakes by the cow and calf (*2009 Nebraska Beef Cattle Report*, pp. 13–14) and digestibility values throughout the grazing period (*2004 Nebraska Beef Cattle Report*, pp. 13–15). The supplement was fed daily in bunks with approximately 2 feet of linear space per pair. Hay was not fed during the cornstalk grazing period except when snow impeded grazing.

Cow BW measurements were recorded over two consecutive d at trial initiation and completion to determine cow weight change throughout the winter. Body condition score was visually assessed by the same experienced technician concurrent with collecting weights. Calf BW measurements were also recorded during two consecutive d to determine gain during the winter period. Before collecting weights at trial initiation, all pairs were limit-fed for five d to minimize variation in gastrointestinal tract fill. Upon trial completion, all calves were removed from their dams, and cows and calves were limit-fed separately for a minimum of five d prior to recording weights.

Cows were exposed to Simmental × Angus bulls at a bull:cow ratio of approximately 1:10 beginning Sept. 24. The breeding season was 86 and 61 d at ARDC and PHREC, respectively. Therefore, at ARDC, the first one half of the breeding season occurred while cows were in drylot pens and the second half occurred while cows were on cornstalks. At PHREC, cows were managed in drylot pens during the entire breeding season. All bulls passed a breeding soundness examination administered by a licensed veterinarian. Cows were rectally palpated approximately 135 d after bull removal to determine pregnancy status.

Data were analyzed as a randomized complete block design with pen or paddock as the experimental unit. Because of the large difference in cornstalk grazing d, the data for ARDC and PHREC were analyzed separately. The fixed effect of wintering system was included in all analyses. As the proportion of steer and heifer calves was unequal among treatments, calf sex was initially included as a covariate for all variables tested and was ultimately removed if not significant. Block was included in all analyses as a random effect, and significance was declared at $P \leq 0.05$.

Results

At ARDC, the cornstalk grazing period was Nov. 6 to April 13 (158 d). Hay was only fed during one wk when snow prevented grazing (approx. 32 lb DM/pair/d). The corn yield at ARDC was 245 bu per acre, and assuming 15.3 lb (DM) of total leaf and husk produced per bu of grain yield, then cattle removed approximately 40.5% of available residue. At PHREC, the grazing period began Dec. 1, but cattle were removed from the field Jan. 6 due to heavy snowfall that prevented grazing. Approximately 135 lb (DM) of grass hay was fed per pair before removal from cornstalks. When transported back to drylot pens, cows and calves were fed the same diet at an equal DMI as the DL pairs. Pairs returned to cornstalks Feb. 19 and grazed without supplemental hay until Mar. 17 for a total grazing period length of 62 d. Upon completion of the cornstalk grazing period at PHREC, pairs were moved to drylot pens and fed the same ration as the DL pairs until weaning (April 2). Corn grain yields for the two fields at PHREC were 216 and 190 bu per acre, thus cattle removed an estimated 11.7% of available residue. The differences in weather conditions and subsequent grazing d observed between locations in our study demonstrate the variability that can exist in Nebraska. Clearly, the availability of cornstalk residue for grazing is affected by winter weather which may pose a risk to a cow-calf production system that is dependent on its use.

Table 2. Supplement fed to cow-calf pairs on cornstalks[a, b, c]

Ingredient, %	
Dried distillers grains plus solubles	94.51
Limestone	3.50
Pelleting binder (urea formaldehyde polymer and calcium sulfate)	1.88
Vitamin A,D,E	0.11

[a]All values presented on a DM basis.
[b]Fed at 5.2 lb per pair per d (DM).
[c]Trace mineral supplement top-dressed at time of feeding.

Pairs assigned to the DL wintering treatment were limit-fed 27.6 ± 0.5 (ARDC) or 27.3 ± 0.2 (PHREC) lb DM/pair daily on average throughout the experiment, and this amount increased monthly to account for increasing intake by the calf. At ARDC, DL cows had greater ending BW than cows that grazed cornstalks, but treatments were not different at PHREC (Table 3). However, at both locations DL cows gained more BW than cows that grazed cornstalks. Cow BCS responded in similar fashion to BW. Ending BCS was not different between CS or DL cows at PHREC, but was greater for DL than CS cows at ARDC. Cows that grazed cornstalks at ARDC lost 1.0 BCS unit, while DL cows gained 0.5 units.

Calves at ARDC were approximately 25 d younger than those at PHREC at the start of the cornstalk grazing period (Table 4). Ending calf BW was not different between treatments in western Nebraska, but was greater for DL than CS calves at ARDC. Calf gain was not different between DL and CS treatments at PHREC, while DL calves outgained those that grazed cornstalk residue in eastern Nebraska. Likewise, BW per d of age was not different between treatments at PHREC, but was greater for DL than CS calves at ARDC.

The inconsistent responses between treatments can likely be explained by the variable weather conditions observed across locations which influenced cornstalk grazing d. Any significant performance differences may not be expected between CS and DL pairs at PHREC, given the grazing period was relatively short (62 d).

Table 3. Performance of cows by location and wintering system

	ARDC[a]				PHREC[b]			
Item	CS[c]	DL[d]	SEM	*P*-value	CS[c]	DL[d]	SEM	*P*-value
Cow BW, lb								
Initial	1222	1217	80	0.83	1257	1247	137	0.69
Ending	1125	1339	64	0.03	1271	1307	145	0.34
Cow BW change, lb	-97	122	28	< 0.01	14	61	8	0.03
Cow BCS[e]								
Initial	5.6	5.6	0.4	0.88	5.3	5.3	0.5	0.87
Ending	4.6	6.0	0.2	< 0.01	5.2	5.4	0.6	0.63
Cow BCS change[e]	-1.0	0.5	0.2	< 0.01	-0.1	0.2	0.1	0.34

[a]ARDC = Agricultural Research and Development Center.
[b]PHREC = Panhandle Research and Extension Center.
[c]CS = pairs wintered on cornstalks.
[d]DL = pairs wintered in drylot.
[e]BCS on a 1 (emaciated) to 9 (obese) scale.

Table 4. Performance of calves by location and wintering system

	ARDC[a]				PHREC[b]			
Item	CS[c]	DL[d]	SEM	*P*-value	CS[c]	DL[d]	SEM	*P*-value
Initial age, d[e]	111	118	—	—	139	140	—	—
Ending age, d[f]	278	285	—	—	267	268	—	—
Calf BW, lb								
Initial	319	320	9	0.93	306	312	22	0.27
Ending	558	672	19	0.02	525	512	45	0.57
Calf ADG, lb	1.44	2.13	0.09	< 0.01	1.62	1.49	0.18	0.50
BW•d•age, lb[g]	2.01	2.36	0.07	0.04	1.96	1.91	0.16	0.64

[a]ARDC = Agricultural Research and Development Center.
[b]PHREC = Panhandle Research and Extension Center.
[c]CS = pairs wintered on cornstalks.
[d]DL = pairs wintered in drylot.
[e]Initial age = age at initiation of cornstalk grazing period.
[f]Ending age = age at collecting weights following weaning.
[g]Weight per d of age at collecting weights following weaning.

At PHREC, cows and calves were removed from corn residue fields due to snow cover after a short grazing period when digestibility of the residue was high. Improved diet quality and because pairs were fed the same diet as DL pairs after returning to pens, may have enabled cows to maintain BW and BCS. Cows that grazed cornstalks at ARDC lost BW and 1.0 BCS unit during the wintering period, while those fed a complete diet gained BW and BCS. This agrees with previous work in which lactating August-calving cows grazing cornstalks lost BW and similar amounts of body condition (*2010 Nebraska Beef Cattle Report*, pp. 5–7). The supplementation rate for CS pairs was designed to provide an equal energy intake to that of the DL pairs. Given that cows lost BW and BCS, the amount of energy provided was apparently less than originally expected. Several factors may have influenced this including an overestimation of the quality of grazed residue, residue intake, possible digestibility differences between grazed and limit-fed diets, and milk production level. These same variables may have also influenced the differences observed in BW gain between CS and DL calves at ARDC. Pregnancy rates were adequate among treatments (90–100%), but additional numbers are needed to determine real effects of wintering system on reproductive performance. Preliminary data from this ongoing study suggest that wintering summer-calving pairs on cornstalk residue as part of an intensively managed system may result in cow BW and BCS losses compared to feeding pairs in a drylot. Any negative changes in BW or BCS may be less of a hindrance on reproduction provided losses occur well after the breeding season and cows are in adequate BCS (≥ 5.0) prior to calving. Daily gains for calves wintered on cornstalks with their dams may be similar to or less than those managed in a drylot.

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How Many Clean-up Bulls Are Needed after Estrus Synchronization and Artificial Insemination?

Hazy R. Nielson and Rick N. Funston

Summary

To evaluate the ideal number of bulls to use following estrus synchronization and artificial insemination (AI), research reporting AI and final pregnancy rates and bull to female ratio in Bos taurus cattle was reviewed and summarized. Pregnancy rate means were weighted based on the number of females in each study. Final pregnancy rates for a normal bull to female ratio (1:20 to 30) in a natural service setting were 87.8%. In comparison, final pregnancy rates following estrus synchronization and AI for a normal, intermediate (1:31 to 49), and half the number of bulls (1:50 to 60) were 87.8, 82.6, and 89.2%, respectively.

Introduction

One of the benefits of estrus synchronization and AI is purchasing and maintaining fewer bulls. However, an idea has been circulating that synchronized females not becoming pregnant to AI will return to estrus at the same time and require the same number of bulls as a natural service pasture would require.

Larson et al., (*Journal of Animal Science*, 2009, 87:941–921) observed cows not conceiving to AI will return to estrus over a 12 d period following a single timed AI. The most active d had 18% of the herd in estrus, with the remainder of the distribution a bell curve (Figure 1). Each cow's estrous cycle is slightly different. Some cows have 2 follicular waves during the estrous cycle, while others have 3. This results in a natural variation in cycle length, causing the non-pregnant cows' return to estrus to vary more than may be anticipated.

No effect of bull to female ratio or number of females expressing estrus per bull on pregnancy rate was found when comparing bull to heifer ratios ranging from 1:7 to 1:51 in heifers synchronized with Synchro-Mate B (*Theriogenology*, 1990, 34(6):1069–1070). In a comparison of bull to heifer ratios ranging from 1:16 to 1:50 in herds of 100 heifers synchronized with melengestrol acetate (MGA)-PG and immediately exposed to bulls, the optimal bull to heifer ratio for synchronized heifers was 1:25 based on both biological and economic criteria (*Journal of Animal Science*, 1993, 71:291–297). If the optimal bull to heifer ratio in a synchronized natural service setting is 1:25, it can be extrapolated with a hypothetical AI pregnancy rate of 50%, the number of clean-up bulls needed is decreased by 50%.

A study comparing bull to female ratios following estrus synchronization and AI is needed. However, considering the breadth of research documenting bull to female ratios, AI pregnancy rates, and final pregnancy rates and the need for this information as soon as possible; the authors have chosen to summarize available data to provide a preliminary answer to this industry-relevant question.

Procedure

Data was collected from published studies reporting AI and final pregnancy rates, and bull to female ratio. The synchronization protocol utilized, number of females in the herd, and breeding season length were also collected. The studies collected were limited to those evaluating *Bos taurus* cattle. Of the data collected, studies were divided into bull to female ratio groups including Normal-Natural Service (NS, 1:20 to 30 bull to female ratio), and 3 groups following estrus synchronization and AI; normal (NORM, 1:20 to 30), intermediate (INT, 1:31 to 49), and half (HALF, 1:50 to 60). A summary of the mean AI and final pregnancy rates, weighted by number of females in each study, are presented.

Results

The weighted means of each bull ratio group are presented in Table 1. The final pregnancy rate of a normal bull to heifer ratio in a natural service setting was 87.8%. Pregnancy rate to AI in the NORM was 56.1% and final pregnancy rate was 87.7%. The INT AI pregnancy rate was 46.5% with a final pregnancy rate of 82.6%. Pregnancy rate to AI in the HALF was 55.6% and had a final pregnancy rate of 89.2%. Bulls turned in at half the normal bull to female ratio following estrus synchronization and AI resulted in final pregnancy rates similar to normal bull to female ratio both in a natural service situation and following estrus synchronization and AI.

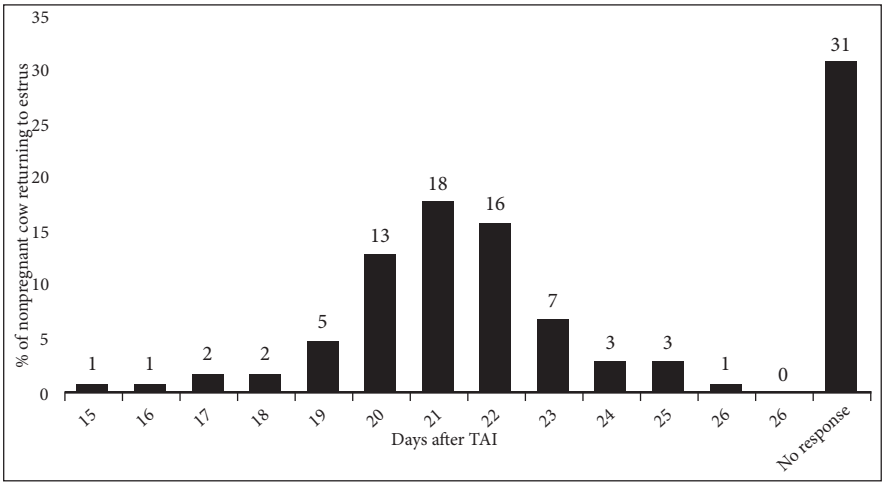

Figure 1. Distribution of estrus of nonpregnant cows following TAI (adapted from Larson et al., 2009).

Table 1. Summary of AI and final pregnancy rates of varying bull to female ratios obtained in cited studies[a]

Synchronization Protocol	AI Method[b]	Female age[c]	Number of females	Breeding Season Length	AI Preg Rate, %[d]	Final Preg Rate, %[e]	Reference
NORMAL-NS[f]							
1 shot PG	NS	cows	201	64	—	89.0	Engle et al., 2007
None	NS	cows	72	60	—	81.0	Sanson and Coombs, 2003
None	NS	cows	295	90	—	91.5	Whitworth et al., 2008
None or CIDR for 7 d	NS	cows	2,033	90–120	—	88.8	Lamb et al., 2008
None	NS	heifers	1,381	85	—	85.8	Gutierrex et al., 2015
NORMAL-NS Mean			**3,982**		**NA**	**87.8**	
NORMAL[g]							
7 day CIDR + PG (no GnRH)	HD	cows	96	30	43.1	76.4	Lake et al., 2005
16 d CIDR + GnRH (2d) + PG (1wk)	HD	heifers	65	28	40.8	72.8	Devine et al., 2015
Synchromate B	HD	cows	89	65	52.7	79.7	Fanning et al., 1995
MGA + PG	HD	cows	50	62	44.3	87.3	Berke et al., 2001
Select Synch	HD + TAI	heifers and cows	80	46	56.3	92.1	Ahola et al., 2005
Co-Synch + CIDR	TAI	cows	194	50	NR[j]	91.7	Cooke et al., 2012
Co Synch + CIDR	TAI	heifers	88	50	NR[j]	82.5	Cooke et al., 2012
Synchromate B	TAI	heifers	239	42	NR[j]	73.5	Mulliniks et al., 2013
Co Synch + CIDR	TAI	cows	188	50	47.5	97.4	Thomas et al., 2009
MGA of 14 day CIDR	TAI	heifers	1,385	50	61.5	91.5	Vraspir et al., 2013
Co-Synch + CIDR	TAI	heifers	80	53	48.0	91.5	Bryant et al., 2011
Co-Synch + CIDR	TAI	cows	102	—	41.4	70.2	Moriel et al., 2012
Norgestomate + estrodiol valerate	TAI, TAI + HD, NS	cows	150	90	52.5	88.2	Sa Filho et al., 2013
NORMAL Mean			**2,806**		**56.1**	**87.8**	
INTERMEDIATE[h]							
MGA-PG	HD	heifers	104	60	67.0	92.0	Harris et al., 2008
5 or 7 d CIDR	TAI	cows	138	40	55.8	77.5	Gunn et al., 2011
MGA-PG	HD + TAI	heifers	500	61	49.7	93.0	Funston and Meyer, 2012
2 shot PG	HD	cows	34	30	54.5	90.9	Alexander et al., 2002
8d half-cuemate	TAI	heifers	316	50	29.8	64.6	Butler et al., 2011
INTERMEDIATE Mean			**1,092**		**46.5**	**82.6**	
HALF[i]							
MGA-PG	HD	heifers	399	60	72.5	94.0	Summers et al.2014
Co Synch + CIDR	TAI	heifers	191	45	NR[10]	88.7	Mulliniks et al., 2013
MGA-PG	HD	heifers	100	60	46.0	90.0	Harris et al., 2008
MGA-PG	HD	heifers	100	60	59.0	90.0	Harris et al., 2008
MGA-PG	TAI or HD	heifers	299	60	59.0	93.0	Funston and Larson, 2011
MGA-PG	HD	heifers	1,005	60	58.7	91.0	Vraspir et al., 2013
MGA-PG	HD + TAI	cows	121	60	48.5	87.0	Post et al., 2005
MGA-PG	HD	heifers	64	29	NR[j]	82.1	Sexten et al., 2005
MGA + 2 shots EB	TAI	heifers	118	39	37.2	73.5	Baptiste et al., 2005
5 or 7 d CO synch + CIDR	TAI or HD	heifers	2,660	85	52.8	88.3	Gutierrex et al., 2014
HALF Mean			**5,057**		**55.6**	**89.2**	

[a]Studies reporting bull to female ratio, AI and final pregnancy rates evaluating *Bos Taurus* cattle were utilized.
[b]NS = natural service; HD = heat detect; TAI = time artificial insemination.
[c]Female age reported as either heifers or cows.
[d]Percentage of females that conceived to AI.
[e]Percentage of females determined pregnant at the end of the breeding season.
[f]NORMAL-NS = bull to female ratio was 1:20 to 30 in a natural service setting.
[g]NORMAL = 1:20 to 30 bull to female ratio following estrus synchronization and AI.
[h]INTERMEDIATE =1:31 to 49 bull to female ratio following estrus synchronization and AI.
[i]HALF = 1:50 to 60 bull to female ratio following estrus synchronization and AI.
[j]NR = AI pregnancy rates not reported.

A consideration to make prior to choosing a bull to female ratio is bull age. Experienced bulls are more efficient breeders, while yearling bulls are less experienced. Another consideration is pasture size and terrain; a rugged, multi-windmill pasture may demand more from a bull than a flat single-windmill pasture. In conclusion, producers utilizing estrus synchronization and AI should keep in mind the similarity between final pregnancy rates when using a 1:25 bull to female ratio and 1:50 bull to female ratio. Producers need to evaluate the cost difference of purchasing and maintaining twice as many bulls to maintain a 1:25 bull to female ratio following estrus synchronization and AI.

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Economics of Rebreeding Non-pregnant Females

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Summary

A budget analysis compared the economics of selling non-pregnant spring-calving cows immediately after pregnancy diagnosis or re-breeding non-pregnant cows to be sold as pregnant fall-calving cows in more favorable market prices. Simulation performed for the last 5 yr of market prices demonstrated the strategy is cost effective in different market scenarios, excluding the year 2012/2013. Due to drought, feed prices were the highest and cow prices the lowest of the 5 yr analyzed. Other than atypical scenarios like drought, positive economic results would be possible even at low pregnancy rates, but as the pregnancy rate increases net proceeds also increase.

Introduction

Probably no single aspect of modern beef herd management is as complicated, or has potentially greater economic impact, as the cow culling and replacement decision. Conventional wisdom has been that open cows should be sold after pregnancy detection to avoid extra feeding expenses.

Most often, these non-pregnant cows are culled and sold into the slaughter market. These sales represent, on average, 10 to 20% of total gross income for the herd (*2012 Nebraska Beef Cattle Report*, pp. 35–36). The cull cow market has traditionally been seasonal, with October and November monthly average cull cow prices being the lowest for the year. Nebraska beef production is predominantly based on a spring calving system, lending itself to November cow culling.

Keeping the non-pregnant cow to re-breed is not a common option, but the variability in cull cows and feedstuff prices suggests an alternative could exist. A study was conducted to evaluate the economics of retaining ownership and rebreeding non-pregnant spring-calving cows to be marketed as pregnant fall-calving cows.

Procedure

Animals

Spring-born, crossbred females diagnosed as non-pregnant after the regular spring breeding season were utilized over a 2 yr period at 2 locations, the Gudmundsen Sandhills Laboratory (GSL; Yr 1, n = 61; Yr 2, n = 72), Whitman, and the West Central Research and Extension Center (WCREC; Yr 2, n = 15), North Platte. The GSL females were composite Red Angus × Simmental and approximately 80% were 1 and 2 yr of age at the beginning of the study. The GSL females were exposed to a 45 d natural service spring breeding season prior to the beginning of this study. Pregnancy diagnosis was determined by ultrasound 45 days after bulls were removed. The WCREC heifers were primarily Angus and 1 yr of age. At the spring breeding season they were synchronized with a MGA-PG protocol prior to AI and following AI were placed with bulls for 60 d. Pregnancy diagnosis was performed via rectal ultrasound 45 d after bulls were removed.

Synchronization protocol and breeding

GSL

Females were synchronized with a 7 d CIDR®-PG protocol prior to a 60 d natural service breeding season beginning November 13. A 1:25 bull to cow ratio was used. Pregnancy diagnosis was determined by ultrasound 30 d after bulls were removed, 2 wk later non pregnant cows were sold. Pregnant cows were sold 2 mo after pregnancy detection at livestock auction.

WCREC

Heifers were synchronized with 7 d CO-Synch + CIDR® protocol. Estrus detection patches were used to detect standing estrus and the second GnRH injection was administered at TAI only to heifers that did not have their patches rubbed off. Heifers were AI November 11 and after AI were placed with bulls until sold at livestock auction (approximately 170 d). Pregnancy was determined by ultrasound 135 d after AI.

Diet

GSL

Hay and supplement were fed from November to February. The supplement containing 29% CP was fed in the amount of 1.2 lb/hd/d. The cows diagnosed as non-pregnant were sold March 1. Pregnant cows grazed meadow pastures (Yr 1) or were fed hay (Yr 2) until they were sold the second week of April.

WCREC

Heifers grazed winter range pastures from November to April with a self-fed cooked molasses 30% CP tub consuming approximately 0.5 lb/hd/day. The non-pregnant heifers were sold April 14 and the pregnant heifers 2 wk later.

Economic Analyses

A partial budget analysis was performed to compare economics of selling non-pregnant cows immediately after diagnosis as non-pregnant (November) or retaining ownership and re-breeding non-pregnant cows to be sold as pregnant fall-calving cows in a potentially more favorable market (April).

Hay prices ranged from $75 to $130/ton during the study, an average hay cost of $110/ton for Yr 1 and $88.21/ton for Yr 2 was assumed. Grazing meadow cost per animal was considered to be $1/d, the cost of grazing winter range per animal was also $1/d and basic management and yardage for each female was estimated at $0.30/d. Supplement ($385/ton, DM basis) was comprised of processed grain by-products, plant protein products, roughage products, calcium carbonate, molasses prod-

ucts, urea, vitamin A supplement, copper sulfate, zinc oxide, magnesium sulfate, and monensin.

Cow value at the beginning of the study (November) was calculated from the Nebraska average price reported by the USDA Agricultural Marketing Service for the corresponding date and respective average BW. Total breeding cost for GSL females included CIDR® cost at $11.25/cow, a single $PGF_{2\alpha}$ injection at $2.87/cow and labor expense of $5/cow. Breeding cost for the WCREC heifers included CIDR® cost at $11.25/heifer, a single $PGF_{2\alpha}$ injection at $2.87/heifer, GnRH injection at $2.68/injection, estrus detection aids at $1.16/patch, semen at $25/dose and technician expense of $8/heifer.

Total cost was calculated by adding the purchase price, total feeding cost, breeding expenses, and 6% annual interest rate on the purchase price. The net cost of 1 pregnant cow was calculated as the difference between total cost and cull value, divided by the number of pregnant cows. Net gain was calculated as the difference between pregnant female price and net cost.

Sensitivity Analysis

A sensitivity analysis evaluated the economics of retaining and rebreeding for the last 5 yr of market scenarios at different pregnancy rates. An analysis was performed for each location (WCREC and GSL), considering the WCREC heifers were timed AI and the GSL heifers were synchronized and placed with bulls.

Feeding was assumed to be similar for the 2 locations, hay and supplement for a 160 d period. Average hay prices for each year were obtained from the Nebraska average price reported by the USDA Agricultural Marketing Service (2010 to 2015).

Cow and heifer value in November, March, and April was calculated from the Nebraska average price reported by the USDA Agricultural Marketing Service (2010 to 2015) for the corresponding date and respective average BW. Total breeding costs were assumed to be similar each yr. Breeding expenses for GSL females included CIDR® cost, a single $PGF_{2\alpha}$ injection and labor. Breeding cost for the WCREC heifers included CIDR®, $PGF_{2\alpha}$, GnRH injection, heat detectors, semen, and technician labor.

Table 1. Reproductive performance in the re-breeding season

Description	GSL[a]	WCREC[b]
AI pregnancy rate, %	—	53.3
Overall pregnancy rate, %	86.1	80.0
Conceived in the first 21 d, %	84.4	66.6

[a]Gudmundsen Sandhills Laboratory: synchronized with 7-day CIDR®-PG protocol prior to a 60 d natural service breeding season, 1:25 bull to cow ratio was used.
[b]West Central Research and Extension Center: synchronized with 7-day CO-Synch + CIDR® protocol and timed artificial inseminated (TAI). After TAI heifers were placed with bulls for 170 days.

Table 2. Partial budget analysis of rebreeding an open female

Description	$/unit	
	GSL[a]	WCREC[b]
Cow initial value (Nov), hd	1,168.89	1,422.41
(re)Breeding expenses,[c] hd	19.12	57.63
Feeding expenses[d]	270.58	188.16
Interest (6%), hd	29.03	35.56
Total cost, hd	1,487.63	1,703.75
Cull cow value (Mar), hd	1,475.45	1,549.26
Net Cost, pregnant cow	1,502.71	1,742.38
Sale value (Apr), pregnant cow	2,023.00	2,359.19
Net gain, pregnant cow	520.29	616.81

[a]Gudmundsen Sandhills Laboratory.
[b]West Central Research and Extension Center.
[c]Breeding expenses include-GSL: cost of technician, CIDR® and $PGF2_a$ injection.—WCREC: cost of technician, semen, CIDR®, $PGF2_a$, heat detectors and GnRH injection.
[d]Feeding expenses for a period of approximately 160 days—GSL Yr 1: hay and supplement from November to February and meadow pastures from March to April.—GSL Yr 2: hay and supplement from November to February and hay from March to April.—WCREC: Winter range pastures and supplement from November to April.

Results

The overall pregnancy rate was 86.1% for GSL and 80.0% for WCREC (Table 1). A high percentage conceived in the first 21 d of the breeding season (84.4 and 66.6% for GSL and WCREC, respectively). Since they will calve sooner, it increases the likelihood these cows will adapt to the fall calving system and be more productive as fall-calving cows (2012 Nebraska Beef Cattle Report, pp. 18–19).

The partial budget analysis of re-breeding a female that would be culled is presented in Table 2. The total cost/female was $1,483.51 and $1,703.75 for GSL and WCREC, respectively. Feeding expenses were lower for WCREC heifers, as no hay and only a small amount of supplement was fed. Re-breeding expenses were lower for GSL as the cows and heifers were not AI. An important breeding expense in natural breeding systems is bull cost; nevertheless, it was not included in the breeding expenses in this study because it was assumed the operation already had bulls not in use after the spring breeding season. A different approach that could be used to calculate the bull cost is split the costs for the 2 breeding seasons, the regular spring breeding season and the re-breeding season. In this way the re-breeding season has the additional advantage of increased use of bulls, reducing the breeding costs of the regular breeding season.

Despite the differences in breeding and feeding costs between the 2 locations, the difference in the total cost between 2 locations is mainly due to the animal's initial price. WCREC heifers were all 19 mos of age and had higher market price/cwt in November compared with older females.

The best candidates for this strategy, in fact, would be young females that have more productive life remaining and the greatest potential for added value when sold later as a bred cow compared with her current value as a cull cow. Older cows have less productive life remaining and it's unlikely there would be enough extra value to capture to make the effort worthwhile.

Table 3. Sensitivity analysis of rebreeding non-pregnant females for the last 5 yr market scenarios at different pregnancy rates—GSL

Net Proceeds—$/Heifer Exposed (GSL-NSB)[a]					
Pregnancy Rate (%)	2010/2011	2011/2012	2012/2013	2013/2014	2014/2015
10	−92.16	−207.67	−802.44	63.66	−84.79
30	52.44	−55.82	−730.17	147.12	85.58
50	197.03	96.02	−657.91	230.59	255.95
70	341.62	247.86	−585.65	314.05	426.31
90	486.21	399.71	−513.38	397.51	596.68

[a]Gudmundsen Sandhills Laboratory–Natural Service Breeding: synchronized with 7-day CIDR®-PG protocol prior to a 60 d natural service breeding season, 1:25 bull to cow ratio was used. Feeding was considered to be hay and supplement for a 160 days period.

Table 4. Sensitivity analysis of rebreeding non-pregnant females for the last 5 yr market scenarios at different pregnancy rates—WCREC

Net Proceeds-$/Heifer Exposed (WCREC-TAI)[a]					
Pregnancy Rate (%)	2010/2011	2011/2012	2012/2013	2013/2014	2014/2015
10	−91.01	−206.05	−860.31	92.52	−57.27
30	35.56	−76.86	−808.62	150.11	83.81
50	162.14	52.34	−756.94	207.69	224.89
70	288.72	181.54	−705.26	265.27	365.97
90	415.29	310.73	−653.57	322.86	507.05

[a]West Central Research and Extension Center–Timed artificially inseminated: synchronized with 7-day CO-Synch + CIDR® protocol prior to fixed time artificial insemination (TAI). After TAI heifers were placed with bulls for approximately 170 d. Feeding was considered to be hay and supplement for a 160 d period.

The remaining non-pregnant females were sold in March, and they had a market price lower than the total cost for both locations (Table 2), adding to the net cost. In this way, as the percentage of open cows increase or the value of these animals decrease, the net cost/pregnant female increases.

Pregnant cows sold in April increased in value compared with November prices by approximately 73 and 66%, for GSL and WCREC heifers, respectively. The increasing cow prices from November to April and a greater market price for pregnant females resulted in a net gain of $525.13 and $616.81 per pregnant female. The higher net gain for WCREC is due to the better sale prices for bred heifers compared with older bred cows. All females at WCREC were 19 mos and only 80% were 19 mos at GSL.

The sensitivity analysis performed is presented in Tables 3 and 4 for GSL and WCREC, respectively. Considering the feed costs were the same for both locations and considering all animals 1 yr old heifers, GSL had the greatest return. However, when available, less expensive feeding strategies should be considered in order to improve economic return.

Due to differences in drugs necessary for the synchronization protocol and semen, the natural service breeding season had reduced breeding costs, raising net proceeds/heifer exposed at a given pregnancy rate. In the present study all females were sold at livestock auction and AI bred females were not priced differently compared with bull bred females. Furthermore, the USDA Agricultural Marketing Service does not provide different prices for AI and bull bred females. If the producer would have higher market prices for AI bred heifers and cows that exceed the increased AI costs, it is recommended to use AI in order to increase profits.

The strategy was not cost effective in the 2012/2013 scenario. As a result of the 2012 drought, feedstuff prices in 2012 were highest and the market prices were lowest for the last 5 yr; consequently, the production costs were greater than gross proceeds. As a result, in 2012/2013 this management practice was not profitable, regardless of pregnancy rate. With the exception of 2012/2013, the strategy appears to be cost effective even at a modest pregnancy rate. However, as the pregnancy rate increases the net proceeds also increase.

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Effect of MGA vs CIDR Estrus Synchronization on Estrus Response and Pregnancy Rates in 311 d Old Beef Heifers

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Summary

A study compared the effect of melengestrol acetate (MGA)-prostaglandin (PG) and 14-day controlled internal drug release (CIDR)-PG estrus synchronization protocols on estrus response and pregnancy rates of 311 d old heifers (n = 153). Pre-breeding BW was 50.1% of predicted mature BW. Percentage of heifers demonstrating signs of estrus was similar between synchronization treatments (CIDR vs MGA, 71.5 vs 77.4 ± 1.0%). Pregnancy rates to AI of heifers expressing estrus (n = 115) and final pregnancy rate were similar between CIDR and MGA synchronization treatments. Approximately half of these 311 d old heifers exposed to AI and bulls became pregnant.

Introduction

For optimum lifetime productivity a beef heifer should give birth to her first calf at approximately 2 yr of age (*Journal of Animal Science*, 1973, 36(1): 1–6). However, incidence of precocious puberty has been found to be higher than anticipated in several cases. In beef cattle, precocious puberty is defined as attainment of puberty before 300 d of age (*1996 Nebraska Beef Cattle Report*, pp 21–23). The heifers utilized in the current study were younger than 300 d at the initiation of the estrus synchronization protocols.

This study sought to evaluate the outcome of exposing heifers at a young age and determine if young heifers attain and maintain a pregnancy. If a pregnancy can be carried to term, will these heifers have the maturity to raise a calf? This study evaluated estrous response, reproductive performance, and subsequent calving performance of heifers exposed at 311 d of age synchronized with melengestrol acetate (MGA) or 14-d controlled internal drug release (CIDR) estrus synchronization protocols.

Procedure

Angus-based, crossbred, fall-born heifers (n = 153) from 2 locations were utilized in this study. Heifers were weaned at approximately 193 d of age (Feb 18). After weaning heifers received, on a DM basis, 8 lb of hay, 3.19 lb of dry distillers grain, 1.32 lb of cracked corn and 0.05 lb of mineral mixed in the ration (2.9% of BW) with amount increasing as heifer BW increased. At approximately 10 mo of age, group pre-breeding BW was measured and heifers were randomly assigned to 1 of 2 estrus synchronization protocols in the spring.

Estrus synchronization treatments are presented in Figure 1. Heifers in the MGA protocol received MGA for 14 d fed through the diet beginning on d 0 of the synchronization treatment period. Heifers in the CIDR treatment received the same diet as MGA heifers, on a DM basis, 10.6 lb of hay, 4.6 lb of dry distillers grain, 1.8 lb cracked corn and 0.05 lb of mineral mixed in the ration (2.8% of BW), and were implanted with a CIDR (Eazi-breed CIDR, Zoetis, Florham Park, NJ) on d 2 of the treatment period and removed on d 16. Following estrus synchronization, heifers from both treatments were combined and received a single PG (Lutalyse, Zoetis, Florham Park, NJ) injection on d 32. Heifers with activated heat detection aids (Estrotect, Rockway Inc, Spring Valley, WI) were AI 12 h following observation for 3 d. Heifers not expressing signs of estrus were not given an opportunity to become pregnant. Heifers exposed to AI (n = 115) were placed with bulls at a 1:50 bull to heifer ratio 4 d after the last d of AI for 35 d. Sixty-three d following bull removal heifers were diagnosed for pregnancy by a veterinarian. Over the winter heifers grazed deferred upland Sandhills range with supplementation of dry distillers grain beginning at 2.3 lb (DM) and increasing as heifer demand increased. Hay was provided in times of deep snow.

At calving the following data was collected (n = 58): birth date, sex of calf, calf birth BW, calving ease score, and mothering score. Calving ease was scored according to the BIF 9th Edition Guidelines (1 = no difficulty, no assistance, 2 = minor difficulty, some assistance, 3 = major difficulty 4 = ceasarian or very hard pull, 5 = abnormal presentation). A mothering

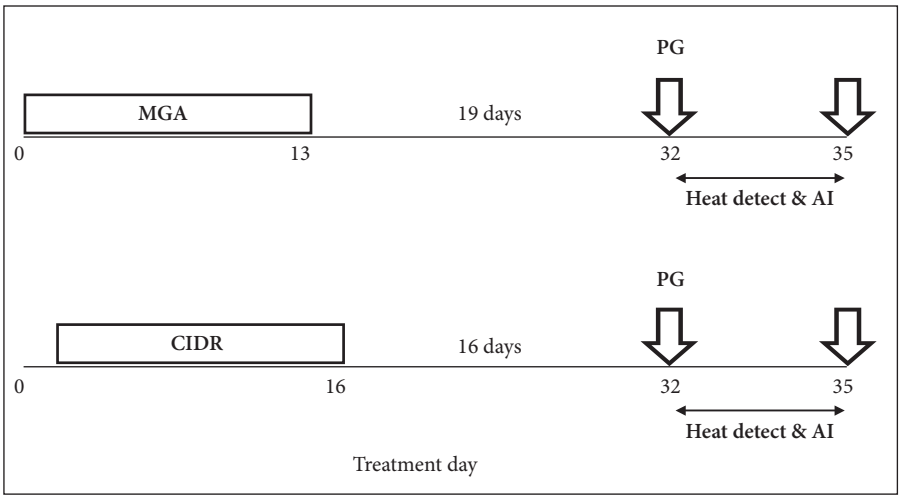

Figure 1. Treatment schedule for heifers in CIDR (n = 76) or MGA (n = 77) treatments. MGA = melengestrol acetate, CIDR = controlled internal drug release, PG = prostaglandin, GnRH = gonadotropin releasing hormone.

score was assigned to each heifer at calving. Mothering score was similar to Behavioral Pen Scores described in the BIF 9th Edition Guidelines, but takes into consideration the heifer's ability to care for her calf. The mothering score ranged from 1 to 5 wherein 1 = calm, attentive, keeps her calf with her; 2 = unremarkable, but presents no problems when moving the pair; 3 = slightly nervous or distracted; 4 = very nervous or confused, required extra time to move the pair; 5 = "crazy" or completely disinterested in the calf.

Economic Analysis

Due to the unique prices in the actual yr of this study (2014), average 5-yr price was used to conduct an economic analysis. Value of heifers was obtained from the Nebraska Weekly Cattle Auction Summary available through the USDA Agriculture Marketing Service (AMS) for the wk heifers were weaned. Feed expenses, including dry distillers grain, corn, and hay were also obtained from the AMS of USDA. Pasture rates were calculated as one half the pasture rental rates of a cow-calf pair, values obtained from the Nebraska Farm Real Estate Summary. Other expenses include interest calculated at 6.5% of the opportunity cost of the heifer, management expense valued at $\$0.50 \cdot hd^{-1} \cdot d^{-1}$, vaccinations and other miscellaneous health expenses, and breeding expenses calculated using EstruSynch estrus synchronization planner (estrussynch.com). Total cost included value of heifer, feed cost, and other expenses. Cull heifer value at the time of pregnancy diagnosis was determined via AMS and calculated by multiplying the value of a single cull heifer by 1 minus pregnancy rate (*Journal of the American Society of Farm Management and Rural Appraisers*, 1992, 56(1):61–66). The net cost of 1 pregnant heifer was calculated as the difference between total heifer cost and cull value, divided by pregnancy rate.

Statistical Analysis

All data were analyzed using the GLIMMIX procedure of SAS (SAS Institute, Inc., Cary, N.C.), accounting for origin as a random variable. Estrous response, pregnancy rate, and calf sex were analyzed using an odds ratio. Least squared means and SE of the proportion of pregnant heifers by treatment were obtained using the ILINK function.

Results

Group BW were measured at weaning and prior to breeding and are presented in Table 1. Pre-breeding BW was 50.1% of predicted mature BW. Heifer ages and estrous response are presented in Table 2. Heifer age at breeding was not different ($P = 0.12$) between MGA and CIDR treatment groups. Percentage of heifers demonstrating signs of estrus was similar ($P = 0.42$) between synchronization treatments (CIDR vs MGA, 71.5 vs 77.4 ± 1.0%). Heifers not expressing estrus were not given an opportunity to become pregnant and removed from the herd. Pregnancy results are presented in Table 3. Pregnancy rates to AI were similar ($P = 0.27$) between CIDR and MGA synchronized heifers (46.3 vs 36.1 ± 6.8%). Final pregnancy rate was also similar ($P = 0.96$) between CIDR and MGA treatments (51.0 vs 51.5 ± 7.4%). Heifer BW at pregnancy diagnosis was not different ($P = 0.45$) between CIDR and MGA treatment groups (715 vs 708 ± 7.6 lb). Calving rate was similar ($P = 0.72$) between CIDR and MGA treatments (50.9 vs 47.5 ± 6.7).

Calving data is presented in Table 4. Julian calf birth date did not differ ($P = 0.30$) between CIDR and MGA groups. Calf BW at birth was similar ($P = 0.69$) between groups as well. Calving ease score was similar ($P = 0.68$; 1.3 ± 0.2 vs 1.2 ± 0.2, CIDR vs MGA). Mothering score was also

Table 1. Measures of BW on heifers AI at 311 d of age[a]

Item	All Heifers
n	153
Weaning BW, lb	437
Pre-breeding BW, lb	602
Development ADG,[b] lb	1.40
Percent of mature BW, %	50.1

[a]Group BW of all heifers were taken and weaning and pre-breeding; group BW averages are presented here.
[b]118 d (Feb 18 to June 16).

Table 2. Effect of CIDR or MGA estrus synchronization on estrus response of 311 d old heifers

	CIDR[a]	MGA[b]	SEM	*P*-value
n	76	77		
Estrus Response, %	71.5	77.4	1.0	0.42
Age at weaning, Julian d	196	190	5	0.12
Age at breeding, Julian d	317	311	5	0.12

[a]Heifers synchronized using the 14-day CIDR-PG protocol.
[b]Heifers synchronized using the MGA-PG protocol.

Table 3. Effect of CIDR or MGA estrus synchronization on reproductive performance of 311 d old heifers

	CIDR[a]	MGA[b]	SEM	*P*-value
n	51	53		
AI pregnancy rate, %	46.3	36.1	6.8	0.27
Total pregnancy rate, %	51.0	51.5	7.4	0.96
Pregnancy diagnosis BW, lb	715	708	7.6	0.45
Calving rate,[c] %	50.9	47.5	6.7	0.72

[a]Heifers synchronized using the 14-day CIDR-PG protocol.
[b]Heifers synchronized using the MGA-PG protocol.
[c]Number of live calves born divided by number of heifers exposed to AI and bulls.

Table 4. Calving performance of heifers' exposed at 311 d old

	CIDR[a]	MGA[b]	SEM	*P*-value
n	28	30		
Birth Date, Julian d	82.8	86.0	2.2	0.30
Birth Weight, lb	74.2	74.9	1.2	0.69
Calf Sex[c]	0.43	0.45	0.09	0.88
Calving Ease Score[d]	1.3	1.2	0.2	0.68
Mothering Score[e]	2.1	2.0	0.2	0.79

[a]Heifers synchronized using the 14-day CIDR-PG protocol.
[b]Heifers synchronized using the MGA-PG protocol.
[c]Calf Sex: bull = 1; heifer = 0.
[d]1 = no difficulty, no assistance; 2 = minor difficulty, some assistance; 3 = major difficulty 4 = ceasarian or very hard pull; 5 = abnormal presentation.
[e]1 = calm, attentive, keeps her calf with her; 2 = unremarkable, but presents no problems when moving the pair; 3 = slightly nervous or distracted; 4 = very nervous or confused, required extra time to move the pair; 5 = "crazy" or completely disinterested in the calf.

Table 5. Economic Analyses using average 5-yr price for heifer development from weaning to pregnancy diagnosis

	CIDR[a]	MGA[b]	SEM	*P*-value
Value of heifer, Feb. 18, $/hd	833.50	833.50	73.54	1.00
Feed Cost, $/hd	233.46	233.46	23.15	1.00
Other expenses,[c] $/hd	260.01	248.58	4.78	0.13
Total Expenses, $/hd	1,326.97	1,315.54	91.40	0.93
Less: Value of cull heifers,[d] $/hd	532.29	526.86	70.62	0.96
Net Cost, $/hd	794.68	788.68	53.41	0.94
Net cost per pregnant heifer, $/hd	1,558.20	1,531.42	104.21	0.86

[a]Heifers synchronized using the 14-day CIDR-PG protocol.
[b]Heifers synchronized using the MGA-PG protocol.
[c]Includes interest at 6.5%, management expense, vaccine, and other miscellaneous health expenses, and breeding expense.
[d]The value of non-pregnant heifers the week of pregnancy diagnosis multiplied by (1 minus pregnancy rate).

similar ($P = 0.79$) with CIDR heifers scoring 2.1 ± 0.2 and MGA heifers scoring 2.0 ± 0.2. The heifers had little trouble calving at 1.6 yr of age and demonstrated adequate mothering skills.

Economic Analysis

Table 5 presents the economic analysis conducted using prices from the last 5 yr. Heifers began development at the same value and were developed as a single group, thus feed costs were also the same. Other expenses were numerically different due to the difference in cost associated with the less expensive MGA-PG synchronization protocol compared with the more expensive 14-day CIDR-PG protocol. Given that final pregnancy rates were not different ($P = 0.96$), value of cull heifers was also not different ($P = 0.96$). The net cost per pregnant heifer was similar ($P = 0.86$) between CIDR and MGA heifers.

Although not statistically significant, there was a numerical 10 percentage unit decrease in AI pregnancy rate in MGA compared with CIDR synchronization. Approximately half of these 311 d old heifers exposed to AI and bulls became pregnant. They went on to demonstrate adequate calving ease and mothering ability.

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Comparison of TAI at GnRH Injection and Delayed Insemination of Non-estrus Beef Heifers

Hazy R. Nielson, Dan J. Kelly, T. L. Meyer, and Rick N. Funston

Summary

Heifers were estrus synchronized utilizing the melengestrol acetate (MGA)-prostaglandin (PG) protocol. Heifers expressing estrus after synchronization were removed from the herd and AI. Heifers not expressing estrus were administered GnRH and either AI at GnRH injection or AI 19 hours following GnRH injection. Heifers AI from estrus detection had a higher pregnancy rate compared with heifers not expressing estrus. Pregnancy rates to AI did not differ between heifers AI immediately after GnRH compared to heifers AI 19 hours after the GnRH injection. There was no benefit to delayed AI of non-estrus beef heifers compared with traditional timed AI at GnRH injection.

Introduction

The utilization of estrus synchronization and fixed-time artificial insemination (FTAI) has improved AI efficiency, concentrating the labor and time requirement into a few d, making AI more feasible for producers (*Journal of Animal Science*, 2010, 88: E181–92). However an improvement in pregnancy rates typically attained when a FTAI protocol is used would increase the appeal of such protocols to producers. In a comparison of heifers synchronized and AI with either a standard FTAI protocol or a 19 h delayed AI following GnRH administration protocol, heifers on the delayed insemination protocol had significantly higher overall pregnancy rates (54 vs. 46%; *Journal of Animal Science*, 2014, 92: 4189–4197). Among heifers in estrus there was no difference in pregnancy rates between standard FTAI and delayed AI. However in heifers not having expressed estrus prior to GnRH injection there was a significant advantage to delayed AI compared with standard FTAI (49 vs 34%). Thus it was the objective of this study to determine the effect of a 19 h delayed AI following GnRH administration in non-estrus heifers as part of a hybrid estrus detection/FTAI protocol.

Procedure

Yearling, Angus-based, crossbred heifers (n = 453) were managed as a single herd at the Kelly Ranch (KR), Sutherland, NE, grazing dormant upland Sandhills range and offered 2.9 lb/d dried distillers grains. Alfalfa was offered to each heifer at 6.4 lb/d beginning 66 d prior to synchronization. As winter range availability decreased in the spring, alfalfa was offered ad libitum. Approximately 1 wk prior to estrus synchronization, a subset of heifers (n = 100) were transported to the West Central Research and Extension Center (WCREC), North Platte, NE. The balance of heifers remained at the KR (n = 353) through synchronization and AI. Heifers housed at the WCREC were placed in a drylot and fed 25.6 lb/d of a diet containing 10% corn, 71% prairie hay, 16% wet corn gluten feed, and 3% supplement.

At both locations, estrus was synchronized utilizing the MGA-PG protocol (Figure 1). At each location heifers received 0.50 mg/hd/d melengestrol acetate (MGA; Pfizer Animal Health, New York, NY) for 14 d. At WCREC, MGA pellets were mixed in the ration; at KR, MGA pellets were mixed with 4.6 lb/d ground hay and 3 lb/d wet distiller grain. Nineteen d later, on d 33 of the protocol, heifers received a PG (Lutalyse, Zoetis, Florham Park, NJ) i.m. injection and estrus detection aids were applied (Estrotect, Rockway Inc, Spring Valley, WI).

Heifers were considered to have expressed estrus when greater than 50% of the rub off coating was removed from the Estrotect. Heifers expressing estrus (n = 319) were assigned to the first treatment group, removed from the herd, and AI 12 h later (ESTRUS). Seventy-two hours following the PG injection heifers whose Estrotect patches were less than 50% activated were randomly assigned to 1 of 2 remaining treatment groups: administered GnRH (Fertagyl, Intervet/Schering-Plough Animal Health, Summit, NJ) and immediately AI (GNRH-I) or administered GnRH injection and AI 19 ± 1 h later (GNRH-D).

The day after TAI, WCREC heifers were returned to KR, where they were comingled on upland Sandhills range with KR heifers. Thirteen d following TAI 9 bulls were placed with heifers for a bull to heifer ratio of 1:50 for 42 d.

A minimum of 51 d after AI, BW was measured and AI pregnancies were detected via trans-rectal ultrasonography (Repro Scan XTC, Repro Scan, Beaverton, OR). Forty-five d following bull removal, pregnancy was again diagnosed to determine pregnancies sired by natural service.

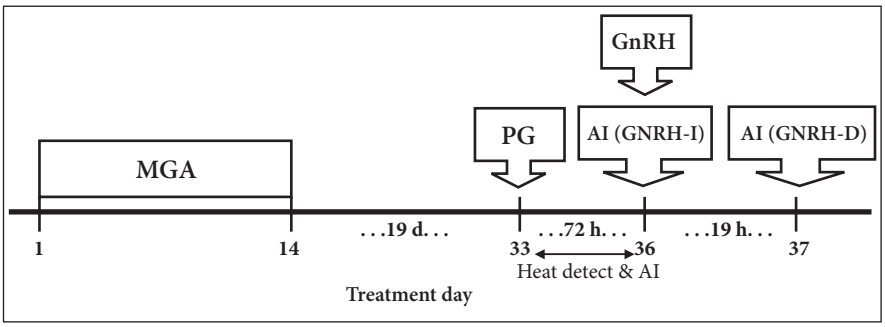

Figure 1. Modified MGA-PG estrus synchronization protocol utilized to compare AI at GnRH injection (GNRH-1) and AI 12 h following GnRH injection (GNRH-D).

Statistical Analysis

All data was analyzed using the GLIMMIX procedure of SAS (SAS Institute, Inc., Cary, N.C.), accounting for origin, pen (KR was counted as a single pen), and AI technician as random variables. Pregnancy rate was analyzed using an odds ratio. Least squared means and SE of the proportion of pregnant heifers by treatment were obtained using the ILINK function.

Results

Heifer reproductive performance is presented in Table 1. Pre-breeding BW was similar ($P = 0.58$) among ESTRUS, GNRH-I, and GNRH-D treatments (773, 764, and 770 ± 12 lb, respectively). Furthermore, there was no difference ($P = 0.46$) in BW at pregnancy diagnosis among treatments, (829, 838, and 831 ± 13 lb; ESTRUS, GNRH-I, and GNRH-D, respectively).

Heifers in the GNRH-I group had significantly ($P < 0.01$) greater ADG from pre-breeding to pregnancy diagnosis compared with heifers in the ESTRUS group (1.20 vs. 0.89 ± 0.13 lb/d). However, there was no difference in ADG either between GNRH-I and GNRH-D (1.20 vs. 0.95 ± 0.13 lb/d, $P = 0.18$) or between ESTRUS AND GNRH-D (0.89 vs. 0.95 ± 0.13 lb/d, $P = 0.80$).

Heifers expressing estrus, as determined by an activated Estrotect, represented 70% (n = 319) of the herd. The proportion of pregnant heifers was significantly affected ($P < 0.01$) by treatment. Heifers AI on estrus, had significantly higher ($P < 0.01$) AI pregnancy rates compared with heifers in both GNRH-I and GNRH-D groups (72 vs. 56, 47 ± 6%). Pregnancy rates to AI did not differ ($P = 0.56$) between GNRH-I and GNRH-D (56 vs. 47 ± 6%). Final pregnancy rates were similar ($P = 0.54$) among ESTRUS, GNRH-I, and GNRH-D heifers (92 vs 89 vs 91 ± 4%). Heifers in all groups reached a similar ($P = 0.58$) percentage of their mature BW prior to the breeding season (63 ± 1%).

Table 1. Growth and reproductive performance of heifers AI on their estrus and non-estrus heifers assigned to GNRH-I[a] or GNRH-D[b]

	ESTRUS	Non-Estrus			
Item		GNRH-I[a]	GNRH-D[b]	SEM	*P*-value
Pre-breeding BW, lb	773	764	770	12	0.58
Pregnancy Diagnosis BW, lb	829	838	831	13	0.46
Post AI ADG,[c] lb/d	0.89[e]	1.20[f]	0.95[e,f]	0.13	0.01
AI Pregnancy Rate, %	70[e]	56[f]	47[f]	6	< 0.01
Final Pregnancy Rate, %	92	89	91	4	0.54
Percent Mature BW,[d] %	63	63	63	1	0.58

[a]Non-estrus heifers were administered GnRH 72 h following $PGF_{2\alpha}$ and immediately AI.
[b]Non-estrus heifers were administered GnRH 72 h following $PGF_{2\alpha}$ and AI 19 h following.
[c]ADG from pre-breeding to pregnancy diagnosis (57 d).
[d]Percent mature BW based on 1,218 lb mature BW.
[e,f] Means in a row with different superscripts are different ($P < 0.05$).

Previous research has shown a benefit to delayed AI, suggesting a 20 h delay is advantageous because of a more favorable uterine environment. Moreover, the delay should give females more time to attain estrus, increasing the number of heifers expressing estrus at AI (*Journal of Animal Science*, 2014, 92: 1747–1752). The current study, however, did not observe any advantage to delayed AI. The results of this study found no benefit to a 19 h delayed AI.

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Effect of Dam Age on Offspring Productivity

Aline G. da Silva, Jacqueline A. Musgrave, John Nollette, Andy Applegarth, and Rick N. Funston

Summary

Records collected from 1997 to 2014 were analyzed to evaluate the effects of dam age on offspring productivity. Steer calves born from young mothers (2 and 3 yr old dams) had lighter carcasses with more carcasses grading Choice and upper 2/3 Choice. The calving performance and reproductive performance in the second breeding season for heifer calves born from first calving dams were the lowest compared with heifers born from multiparous dams. A quadratic effect of dam age on offspring performance was observed; as dam age increased, offspring performance increased, until dam age reached 7 to 8 yr and then offspring performance decreased.

Introduction

It is well accepted first calving heifers and old cows are less productive than middle age cows. Beef breed associations and the Beef Improvement Federation Guidelines (2010) recommend adjusting the birth and weaning weight of calves contingent upon dam age. However, most of the studies limit their comparisons to primiparous *vs*. multiparous females and researchers concentrate on dam performance or offspring performance only in the pre-weaning phase. Few studies have evaluated the effects of dam age on offspring productivity later in their lives, especially for heifer calves. This study evaluated the effects of dam age at calving on male calf performance from birth to slaughter and female calf productivity from birth through her second breeding season.

Procedure

Data was collected from a composite Red Angus × Simmental herd from the Gudmundsen Sandhills Laboratory (GSL), Whitman, NE from 1997 to 2014 for heifer calves (n = 1,524) and from 2003 to 2014 for steer calves (n = 1,195).

Breeding protocol

From 1997 to 2002, cows and heifers were exposed to a natural service breeding season for 60 d at a bull to female ratio of 1:25. From 2003 to 2014, females were exposed to bulls for 45 d at a bull to female ratio of 1:25 and a single injection of $PGF_{2\alpha}$ was administered i.m. 108 h after placement with bulls. Pregnancy diagnosis was performed via transrectal ultrasonography approximately 45 d after the breeding season.

Culling and replacement

Cows and heifers were culled when they failed to become pregnant; cows were also culled for advanced age or health issues. First calving heifers replaced culled cows. All replacement heifers were born and developed at GSL.

Offspring performance

HEIFER CALVES

Performance parameters evaluated included: birth weight, adjusted 205 d weaning weight, pre-breeding BW, BW and BCS at pregnancy diagnosis, BW and BCS at calving, and BW and BCS at weaning of their first calf. Reproductive performance parameters include pubertal status and pregnancy rate for their first and second breeding seasons. Pubertal status was determined by progesterone concentration measured in 2 blood samples taken 10 d apart prior to the first breeding season.

STEER CALVES

Performance parameters evaluated included: birth weight, adjusted 205 d weaning weight, BW at slaughter, HCW, ADG from birth to weaning, and ADG from weaning to slaughter. At slaughter, marbling score, fat thickness, ribeye area, and yield grade were measured.

Statistical analysis

Data were analyzed using PROC GLIMMIX of SAS 9.4 (SAS Inst., Inc., Cary, NC). The model includes the fixed effect of dam age, and random effects of yr and treatment applied to dam and offspring due to other experiments occurring simultaneously to this study. Means were adjusted using Julian birth date as a covariate. Orthogonal contrasts were used to compare primiparous and multiparous females and also to evaluate the linear and quadratic effects of dam age on offspring productivity.

Results

The results for the heifer calves are presented in Table 1. Compared with multiparous, primiparous-born heifer calves had lower birth BW, adjusted 205 d weaning weight, pre-breeding BW and pregnancy diagnosis BW ($P < 0.05$). There was a linear and quadratic relationship ($P < 0.05$) of dam age on birth BW and adjusted 205 d weaning weight. The same pattern is observed for steer calf birth BW and adjusted 205 d weaning weight ($P < 0.05$, Table 2). Final BW and HCW were greater for middle age steer calves (Table 2) (primiparous vs. multiparous contrast and quadratic effect, $P < 0.05$). As dam age increases, offspring BW at different phases also increases until the dam is 7 to 8 yr old and then decreases.

A lower percentage of heifers born from primiparous dams were pubertal prior to the breeding season compared with heifers born from multiparous dams ($P < 0.01$). There was a linear tendency ($P = 0.06$) of dam age affecting the percentage of heifers pubertal prior to the breeding season, heifers born from young dams tended to have a lower cycling rate compared with heifers from older dams, but no difference was observed on pregnancy rates in the first breeding season ($P > 0.10$).

Table 1. Effect of dam age at calving on heifer performance

Item	Dam Age									SEM	Contrast		
	2	3	4	5	6	7	8	9	10		Primiparous *vs* Multiparous	Linear	Quadratic
n	308	273	201	192	163	133	91	62	59				
Heifer Performance													
Birth BW, lb	70	76	78	78	80	80	80	78	80	2	< .01	0.06	0.05
Adj. 205d Weaning BW, lb	371	425	446	452	457	459	460	448	459	19	< .01	< .01	< .01
Birth to Weaning ADG, lb	1.44	1.69	1.79	1.82	1.84	1.85	1.86	1.80	1.85	0.09	< .01	< .01	< .01
Pre-breeding BW, lb	636	648	661	662	669	665	671	667	670	15	< .01	0.04	0.18
Weaning to Pre-breeding ADG, lb	1.12	0.92	0.87	0.85	0.85	0.83	0.84	0.83	0.82	0.07	< .01	< .01	0.13
Overall Birth to Pre-breeding ADG, lb	1.33	1.35	1.37	1.38	1.39	1.38	1.39	1.39	1.39	0.04	< .01	0.06	0.23
Heifers Pubertal, %	56	69	76	74	75	83	74	68	83	8	< .01	0.06	0.72
Pregnancy Check BW, lb	799	810	821	822	825	820	824	820	821	17	< .01	0.33	0.41
Pregnancy Check BCS	5.76	5.77	5.80	5.81	5.79	5.78	5.80	5.75	5.78	0.08	0.56	0.86	0.76
Pre-breeding to Pregnancy Check ADG, lb	1.85	1.84	1.83	1.81	1.80	1.75	1.73	1.74	1.75	0.13	0.09	0.20	0.27
Pregnancy Rate, %	86	86	86	90	84	87	87	89	77	8	0.88	0.22	0.25
Fist Calving Heifer Performance													
Calved in the first 21d, %	73	72	76	80	76	82	83	76	64	8	0.50	0.32	< .01
Assisted, %	27	24	31	24	26	24	30	31	19	6	0.78	0.52	0.28
Post-calving BW, lb	926	949	948	950	960	954	969	957	950	20	< .01	0.93	0.24
Post-Calving BCS	5.35	5.28	5.26	5.28	5.25	5.33	5.22	5.26	5.30	0.08	0.04	0.85	0.74
1st Calf Wean Cow BW, lb	914	922	926	928	946	946	948	942	935	15	0.16	0.34	0.06
1st Calf Wean Cow BCS	5.06	5.16	5.07	5.13	5.15	5.16	5.16	5.17	5.12	0.09	0.04	0.85	0.74
2nd Breeding Season Performance													
2nd Pregnancy Rate, %	58	81	85	78	82	90	83	94	87	10	0.01	0.61	0.69

Heifers born from cows 4 to 9 yr old had more calves born in the first 21 d of the calving season (quadratic effect, $P < 0.05$). Heifer calves born to multiparous cows had greater BW and BCS at calving and greater BCS when their first calf was weaned ($P < 0.05$).

Although there was no difference in the first breeding season, heifers born from 2 yr old dams had lower pregnancy rates in the second breeding season ($P = 0.01$). The improved calving performance of heifers born from multiparous dams, especially in terms of BCS at calving and weaning may have contributed to greater pregnancy rates in the second breeding season compared with heifers born from primiparous dams.

Male calves born from primiparous dams had greater marbling scores, lower fat thickness, lower percentage of carcasses grading Select, a higher percentage of carcasses grading Choice and upper 2/3 Choice, and a lower percentage of carcasses with yield grade 3 ($P < 0.05$). There was a linear effect of dam age on the percentage of carcasses grading Standard ($P < 0.05$), as dam age increased more carcasses graded Standard.

There was a quadratic effect of dam age on ribeye area and yield grade 2 ($P < 0.05$), and a quadratic tendency ($P = 0.06$) on the percentage of carcasses grading Select. As dam age increased, steers had greater ribeye area and heavier HCW until dam age was 7 to 8 yr old, and then offspring performance decreased. As a consequence, steers born to young dams produced lighter, less muscled, and more marbled carcasses; which might explain the better carcass quality grades for steers born from young mothers.

Overall effects of dam age on offspring performance are likely affected by genetics and environment. The environmental effects in turn can be divided into 2 phases: in utero and pre-weaning phase.

Epigenetic modifications caused by adverse uterine environment can affect fetal growth and subsequent calf performance, even later in life (*Annual Review of Animal Biosciences*, 1:339–363). During pregnancy,

Table 2. Effect of dam age at calving on steer performance

Item	Dam Age									SEM	Contrast		
	2	3	4	5	6	7	8	9	10		Primiparous *vs* Multiparous	Linear	Quadratic
n	268	220	217	138	130	81	49	41	41				
Steer Performance													
Birth BW, lb	75	81	82	83	84	87	87	89	89	2	< .01	< .01	0.03
Adj. 205d Weaning BW, lb	476	510	526	530	543	545	552	565	558	15	< .01	< .01	0.01
Final BW, lb	1,255	1,300	1,320	1,317	1,343	1,351	1,340	1,367	1,329	20	< .01	0.12	0.02
Over Weight, %	1	3	5	4	9	11	5	9	8	5	< .01	0.10	0.40
Pre Weaning ADG, lb	1.96	2.10	2.16	2.18	2.24	2.24	2.27	2.32	2.29	0.07	< .01	< .01	0.02
Post Weaning ADG, lb	3.42	3.38	3.41	3.40	3.40	3.45	3.42	3.51	3.38	0.11	0.97	0.98	0.31
Carcass traits													
HCW, lb	793	821	834	830	845	849	845	863	838	13	< .01	0.15	0.04
Marbling Score	548	541	544	542	526	513	509	505	516	18	< .01	0.09	0.10
Fat Thickness, inches	0.502	0.534	0.575	0.550	0.551	0.529	0.527	0.512	0.520	0.030	0.01	0.55	0.96
REA, inches^2	13.7	13.6	13.6	13.5	13.7	13.9	14.2	14.3	13.7	0.3	0.19	0.82	0.01
USDA Quality Grade													
Standard, %	3	3	3	5	6	3	2	5	9	5	0.48	0.04	0.26
Select, %	22	25	28	29	26	38	38	39	29	7	0.01	0.57	0.06
Choice, %	70	65	67	65	61	57	60	56	61	8	0.02	0.62	0.47
Upper 2/3 Choice, %	23	25	24	29	23	9	15	7	12	5	0.03	0.09	0.18
Prime, %	1	1	1	1	2	0	0	0	0	1	0.98	0.99	0.99
USDA Yield Grade													
YG 1, %	7	6	4	10	5	6	4	2	2	2	0.18	0.29	0.74
YG 2, %	49	45	43	40	45	45	56	43	29	7	0.17	0.06	0.03
YG 3, %	37	39	44	42	45	40	39	56	60	8	0.03	0.01	0.12
YG 4 and 5, %	7	10	8	7	5	9	2	0	10	5	0.97	0.96	0.14

young dams need energy and nutrients not only for fetal development, but also for their own maintenance and growth. In this high nutritional requirement scenario, it is more likely nutritional imbalances affect nutrient and energy availability for the fetus and may explain the differences in offspring performance from a fetal programing stand point.

The pre-weaning environment effect is represented basically by milk supply for the calf. Young cows (2 and 3 yr old) do not produce as much milk as middle age cows (*Journal of Animal Science*, 81:1693–1699), this might contribute to the differences in offspring performance, especially from birth to weaning.

It is hypothesized improved genetics in younger dams would result in increased performance of their offspring. However, if the dam does not provide an adequate uterine environment and/or enough milk, their calf cannot fully express their genetic potential.

The data suggest producers should select heifers born from cows 4 to 8 yr old as replacements. Heifers born from dams 3 yr old and younger are unable to express their genetics for growth and have an increased chance of failure in the first calving season and second breeding season, increasing their likelihood to be removed from the herd. Heifer progeny from dams older than 8 yr also exhibited decreased performance.

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Cows with Excess Androgen are Anovulatory and Have Differing Patterns of Progesterone Secretion

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Summary

Within the physiology herd, a group of cows that have excess androgen (androstenedione, A4) in the dominant follicle and a 17% reduction in calving rate have being identified. Thus, our objective was to determine follicular dynamics (follicle growth) and progesterone (P4) concentrations in High A4 cows to determine if they were anovulatory. High A4 cows had more persistent dominant follicles and either did not display estrus and ovulated at an inappropriate time or did not ovulate compared with Low A4 cows (Controls). Furthermore, P4 concentrations had reduced peak values and were maintained longer in High vs Low A4 cows which may contribute to their failure to ovulate.

Introduction

A major reason a cow is removed from the herd is the failure to have a calf. Within the UNL physiology herd there is a population of females, which have reduced calving rate and is associated with increases in excess androgen in the dominant follicle.

In cattle, ovarian follicles develop in a wave-like pattern referred to as follicular waves. After ovulation of the dominant follicle, a new wave is initiated with the recruitment of small follicles. A follicle is subsequently either selected to become a dominant follicle or undergoes atresia allowing for 2 or 3 follicular waves during a cow estrous cycle which on average is 21 d. Furthermore, the selected follicle which will become the dominant follicle inhibits the growth of the other small follicles. What triggers this follicle to ovulate is the drop in P4 and increases in estrogen to stimulate surges of gonadotropin hormones such as Luteinizing Hormone (LH) and Follicle Stimulating Hormone (FSH). If P4 does not drop to levels, which will allow for increases in estrogen and concomitant increases in LH and FSH, then ovulation will not occur and the follicle remaining on the ovary may become a persistent follicle. Many persistent follicles can produce excess androgen and because no ovulation occurred no corpus luteum (CL) is produced. Without the CL to regress, P4 concentrations do not change and this can affect the initiation of the next reproductive cycle. In some cases the persistent follicle luteinizes producing small amounts of P4 which may aid in the start of a new estrous cycle after it is no longer present on the ovary.

Since many cattle producers use standing heat (estrus) as a marker for when to AI their females; estrus without ovulation, ovulation without a previous standing heat or estrus, or no estrus or ovulation could impact the number of females identified to breed. In turn, this could reduce the number that get pregnant, reducing the calf crop and producer profitability.

Excess androgen has been demonstrated to affect the ability of females to ovulate; so our objectives with this experiment were to determine (1) if the cows identified as High A4 were also anovulatory (failed to ovulate), (2) if High A4 cows fail to display estrus, and (3) if ovulation occurred every time estrus was displayed.

Procedure

All procedures were approved by the Animal Care and Use Committee at the University of Nebraska-Lincoln. Non-

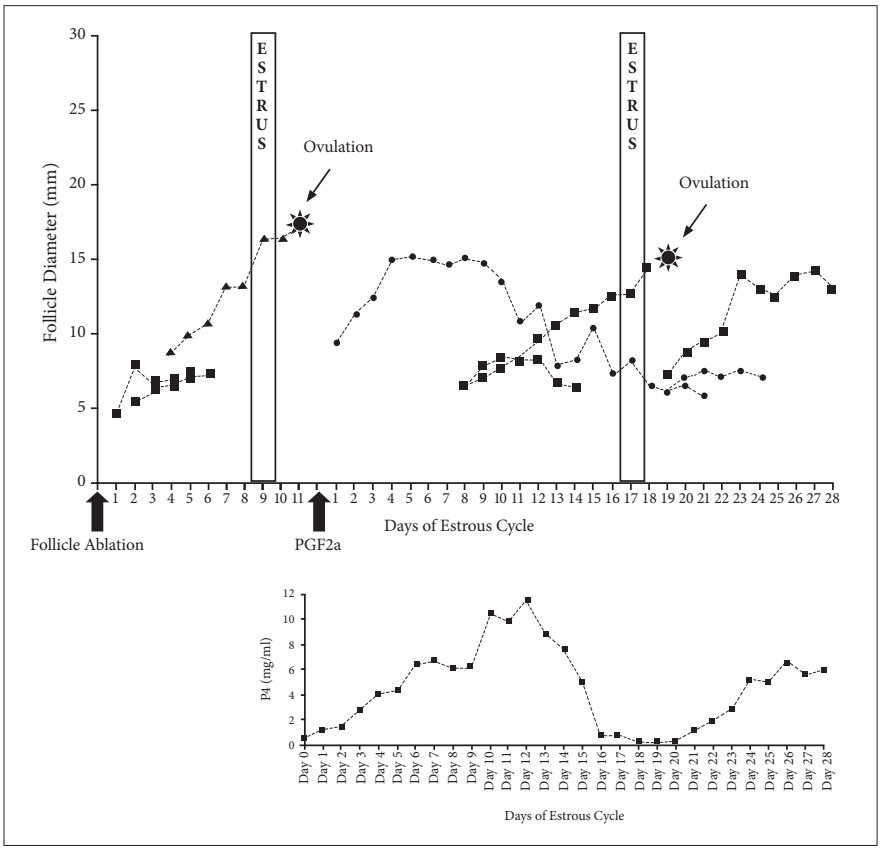

Figure 1. Diagram of follicular waves, d of ovulation and estrus after follicle ablation for Low A4 cow (ovulatory; upper diagram). Graph below shows progesterone concentrations measured daily after PGF_{2a} injection.

lactating, composite (25% MARC III [1/4 Angus, 1/4 Hereford, 1/4 Pinzgauer, 1/4 Red Poll] and 75% Red Angus) beef cows from the beef physiology herd at the University of Nebraska Agricultural Research and Development Center (ARDC), near Mead, were used in this study.

Each cow with a follicle(s) greater than 7 mm was ablated (aspirated) using a vaginal ultrasound probe with a needle to puncture the follicle and remove it from the ovary. Twelve days after the follicle ablation cows were injected with 5ml of $PGF_{2\alpha}$. Transrectal ultrasound was conducted daily with a 7mm Aloka probe starting at initial follicle ablation and was continued for 28 d. Ovulation was determined by the absence of the preovulatory follicle. Estrus was detected using Estrotec™ Heat Detector placed to their tail head. Blood samples were collected daily and P4 concentrations from blood samples were measured every day after $PGF_{2\alpha}$ treatment and are shown in Figures 1, 2 and 3.

The concentration of A4 in follicular fluid of the dominant follicle was used to classify cows into Low A4 (n = 5, control; A4 where A4 less than 20 ng/ml), and High A4 (n = 6, excess A4 where A4 greater than 40 ng/ml).

Results

Different ovulatory phenotypes were found between Low A4 and High A4 cows (Figure 1, 2, 3). Low A4 cows (ovulatory) displayed estrus and ovulated directly after estrus occurred. The day of estrus was considered when an Estrotec™ Heat Detector patch had more than 75% of its area rubbed-off. Low A4 cows also had typical P4 concentrations with a peak around d12 of the estrous cycle followed by a decrease immediately before estrus display and ovulation occurred (Figure 1). High A4 cows presented 2 different phenotypes: chronic anovulatory or cows displaying estrus, but failed to ovulate (persistent dominant follicle was present in the ovary for at least 10 d) and produced very low amounts of P4 during the entire 28 d (Figure 2); and sporadic anovulatory or cows not displaying estrus, but did ovulate during the 28 d and had greater P4 values than chronic anovulatory cows (Figure 3).

Additionally, the pattern of P4 secretion was different in High A4 cows with a

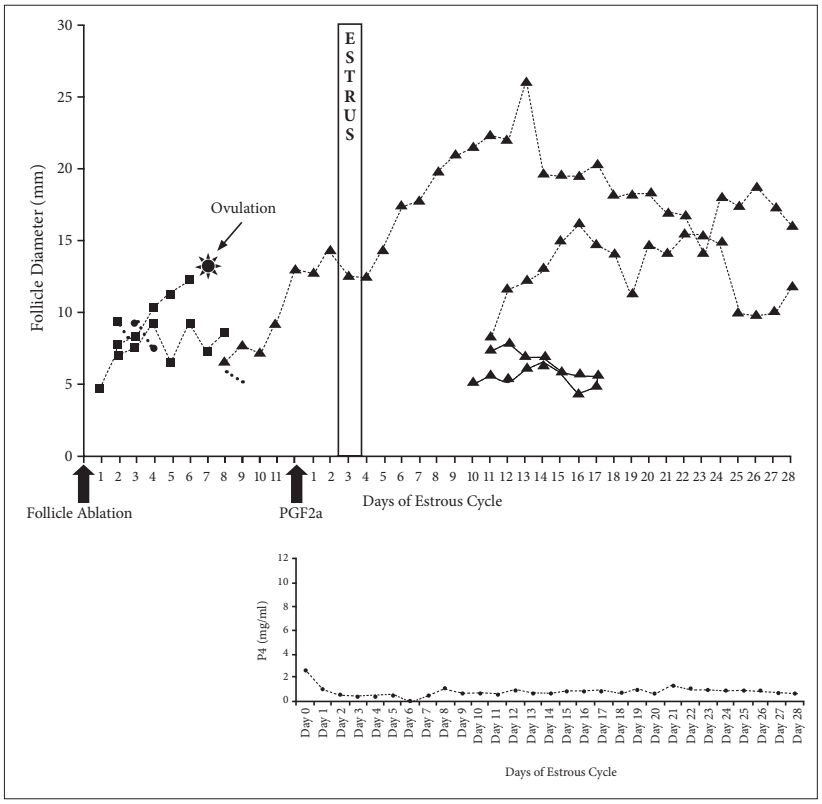

Figure 2. Diagram of follicular waves, and estrus in a High A4 cow who was classified as chronic anovulatory since estrus was detected but there was no ovulation of the dominant follicle (upper diagram), and very low progesterone concentrations since no corpora lutea was produced (graph below).

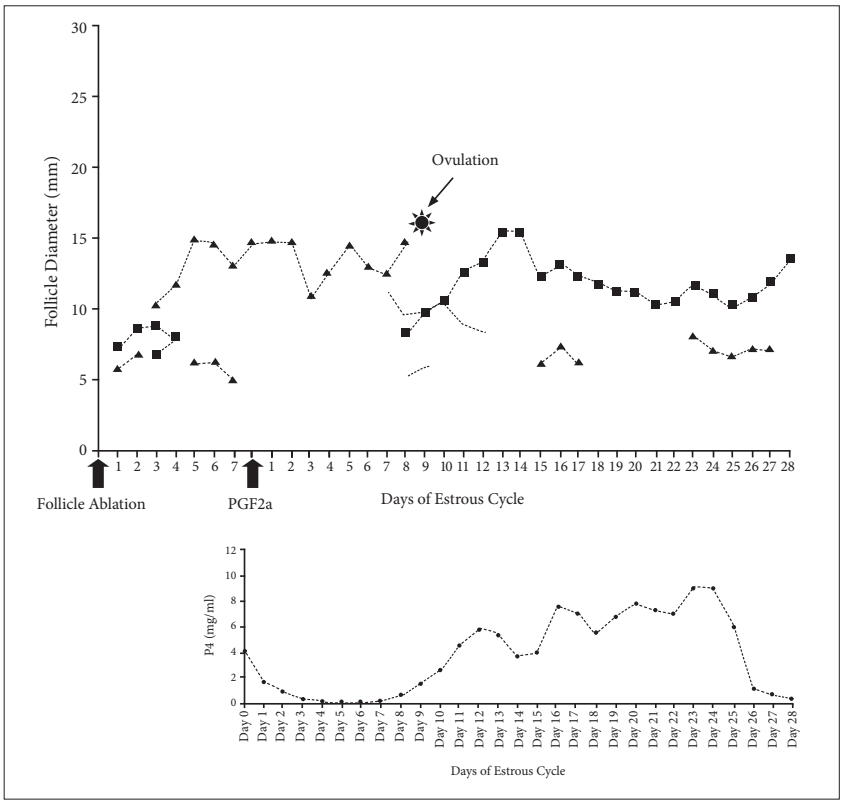

Figure 3. Follicular waves and the d of ovulation characterizing a High A4 cow who was classified as sporadic anovulatory is showed in the upper diagram, no estrus or ovulation was detected, as well as the progesterone values (graph below).

40% decrease in peak value (5.83 ng/mL) compared with to Low A4 cows (8.18 ng/mL). Furthermore, P4 in High A4 cows remained greater than 3.0 ng/ml during the time CL regression was occurring while Low A4 cows' P4 concentrations dropped at CL regression to less than 1.5 ng/ml.

Reduced peak P4 concentrations with sustained levels of P4 over a longer period of time in High A4 cows may contribute to their inability to ovulate. In addition, these differences in P4 production and maintenance may indicate granulosa and theca cells within the dominant follicle that support the egg are altered and may not be capable of producing a fully functional CL (similar to a sub-functional CL). Understanding what is different about these cows and what is impacting their ability to ovulate may lead to more efficient synchronization regimes to induce cows to display estrus and ovulate at appropriate times or ovulate at all. Alternatively, methods may be developed to identify these females to ensure they are not kept as replacement females.

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Granulosa Cell Exposure to Excess Androgens Inhibits Their Ability to Proliferate in the Cow Which May Cause or Perpetuate Androgen Excess

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Summary

Within the UNL physiology herd, a group of cows have been identified with excess androgen (androstenedione, A4) in their dominant follicle (30 fold higher than controls) and a 17% reduction in calving rate, suggesting subfertility. The objective was to identify altered granulosa cell gene expression that could be preventing these cells from converting excess androgen into estrogen. Microarray analysis suggests these granulosa cells experience inhibited proliferation resulting in a reduced total population of cells. Improved understanding of the causes of this phenotype may provide beef producers with tools to identify potentially subfertile cattle and improve reproductive efficiency.

Introduction

Profitability of a beef herd is linked to a heifer or cow's ability to become pregnant within the first 21 d of the breeding season, allowing her to maintain a 365-d calving interval and wean a marketable calf each yr (*1988 Journal of Animal Science*, Hohenboken, pp. 1885–1891). Achieving this timing is largely dependent on cows ovulating each estrous cycle, which is largely dependent on the ovarian environment. In the UNL Physiology herd a group of cows with increased androgen production have been identified (*2012 Nebraska Beef Cattle Report*, pp. 28–29). This population of cattle produces calves with greater weaning weights (26 lb heavier) but tends to have reduced pregnancy rates (17% lower) compared with cows with low androstenedione (A4) concentrations.

Most steroid hormone production (steroidogenesis) occurs in the gonad. Increased follicular androgens are associated with decreased ovulation efficiency and fertility in cattle. Ovarian steroidogenesis, the process of creating steroid hormones within the ovary, occurs within the theca and granulosa cells of the follicle. These cell layers surround the oocyte; therefore, increased concentrations of steroid hormones likely affect oocyte quality (*2014 Nebraska Beef Cattle Report*, pp. 11–13), impacting fertility rates. Site specific enzymes within the granulosa cells are responsible for the conversion of androstenedione to estrogen, thus gene expression patterns within the granulosa cells could affect these enzymes or the genes responsible for producing these enzymes resulting in altered steroid hormone concentrations, creating an adverse environment for the developing follicle and oocyte. The objective was to determine if granulosa cell gene expression or function was altered in cows classified as High A4 compared with Low A4 cows and assess how these changes impact fertility.

Procedure

Estrus was synchronized in cows utilizing a Co-Synch + CIDR protocol for timed AI, with ovariectomy performed after. Cows received a single injection (100 µg/cow, i.m.) of GnRH (Cystorelin, Merial Limited, Duluth, GA) on treatment d 0 to induce ovulation and thus, initiate a new follicular wave. Also on d 0, an intravaginal insert (controlled internal drug release device [CIDR], Zoetis, Florham Park, NJ) containing 1.38 g of progesterone (P4) was inserted. Approximately 84 h prior to ovariectomy, cows were transported to the University of Nebraska-Lincoln Animal Science building for holding and surgery. The CIDR was removed on day 7 and cows received a single injection (25 mg/cow; i.m.) of prostaglandin $F_{2\alpha}$ ($PGF_{2\alpha}$; ProstaMate, AgriLabs, St. Joseph, MO). Thirty-six h after CIDR removal and $PGF_{2\alpha}$ administration, ovaries were removed via right flank laparotomy. Following removal, ovaries were measured and dominant follicles collected. Follicular fluid was aspirated from these follicles, and granulosa cells were removed via microdissection and messenger RNA was extracted. Messenger RNA was sent to University of Nebraska Medical Center to their microarray core and placed on Affymetrix chips to determine differences in genes expressed in High A4 classified cows (n = 5; excess A4 where A4 greater than 40 ng/ml in follicular fluid) vs. Low A4 classified cows (n-4; control; A4 less than 40 ng/ml in follicular fluid of dominant follicle).

Results

Statistics were performed (Analysis of Variance) and genes increased or decreased in granulosa cells from High A4 cows vs. Low A4 cows were selected based on statistical criteria ($P < 0.005$, False Discovery Rate < 0.05, fold-change > 1.5 or < -1.5). These criteria ensure the differences in expression of selected genes are not due to random variation between measurements or sampling error. The messenger RNAs for 166 genes were decreased and 90 genes were increased in granulosa cells from High A4 cows compared with Low A4.

To determine the biological relevance of these differences in gene expression, a software package called Ingenuity Pathway Analysis was used to categorize the genes and how they may affect normal cellular functions. Overwhelmingly, the most inhibited functions in High A4 granulosa cells involve cell cycle regulation. The analysis indicated granulosa cells from the High A4 cows experienced inhibition of proliferation. The expected decrease in total numbers of granulosa cells may explain why the follicle as a whole is not efficiently converting androgens to estrogens.

The major categories of genes with decreased expression included cell cycle, cell proliferation, and cellular growth and

Table 1. Categories of genes that are either increased or decreased in granulosa cells from High A4 vs. Low A4 cows

Categories	Diseases or functions annotation	*P*-value	Predicted activation state	Number of genes
Cancer	Incidence of malignant tumor	2.50E−04	Increased	9
Cancer	Incidence of tumor	3.63E−04	Increased	12
Cell cycle	Ploidy	6.01E−05	Increased	9
Embryonic development, organismal survival	Death of embryo	3.04E−05	Increased	9
Organismal survival	Organismal death	2.43E−05	Increased	54
Cancer	Cell transformation	4.68E−04	Decreased	15
Cancer	Transformation of fibroblasts	9.56E−03	Decreased	5
Cell cycle	M phase	1.14E−16	Decreased	24
Cell cycle	Cell cycle progression	2.78E−18	Decreased	52
Cell cycle	M phase of tumor cell lines	1.12E−15	Decreased	16
Cell cycle	Mitosis	2.13E−19	Decreased	37
Cell cycle	Interphase	3.23E−07	Decreased	25
Cell cycle	Entry into mitosis	1.48E−05	Decreased	5
Cell cycle	M phase of cervical cancer cell lines	1.99E−12	Decreased	12
Cell cycle, cellular movement	Cytokinesis	1.18E−10	Decreased	16
Cell cycle, cellular movement	Cytokinesis of tumor cell lines	1.33E−11	Decreased	11
Cell death and survival	Cell survival	2.67E−03	Decreased	30
Cell death and survival	Cell viability	3.15E−03	Decreased	28
Cell death and survival	Cell viability of tumor cell lines	8.80E−04	Decreased	20
Cell death and survival	Cell viability of myeloma cell lines	9.12E−03	Decreased	4
Cellular assembly and organization	Organization of cytoskeleton	6.23E−04	Decreased	32
Cellular assembly and organization	Organization of cytoplasm	1.41E−03	Decreased	33
Cellular assembly and organization	Microtubule dynamics	3.63E−04	Decreased	29
Cellular assembly and organization	Formation of microtubules	7.77E−04	Decreased	5
Cellular growth and proliferation	Proliferation of tumor cell lines	1.76E−08	Decreased	45
Cellular growth and proliferation	Proliferation of breast cancer cell lines	2.47E−05	Decreased	16
Cellular growth and proliferation	Proliferation of fibroblasts	2.28E−03	Decreased	11
Cellular growth and proliferation	Proliferation of cells	4.70E−05	Decreased	73
DNA replication, recombination, and repair	Alignment of chromosomes	5.49E−16	Decreased	11

proliferation (Table 1). A wide variety of growth factor gene potential networks were down regulated in granulosa cells from the High A4 cows including Epidermal Growth Factor (EGF), Platelet Derived Growth Factor BB (PDGF BB), Leukocyte Inhibitory Factor (LIF), Vascular Endothelial Growth Factor A (VEGFA), and Hepatocyte Growth Factor (HGF). A major function of these factors is to stimulate growth and proliferation by regulating the cell cycle and promoting increases in cell size and number.

Understanding what is different about the granulosa cells from High A4 cows compared with Low A4 cows might allow us to develop techniques to enhance the fertility of affected cattle. This could be accomplished by treatments to increase granulosa cell proliferation survival to ensure conversion of A4 to estrogen thus preventing androgen excess. Better estrous synchronization techniques to ensure ovulation occurs in the affected females may also be developed.

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Evaluation of Different Byproduct Combinations along with Treated Corn Stover on Growing Steer Performance

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Summary

A growing study was conducted to determine the effects of maximizing the energy density of treated corn stover through feed component additions. Calves fed 46% brome hay diet with treated corn stover and varying amounts of solubles or glycerin had greater dry matter intake, but lower average daily gain compared to calves fed modified distillers grains. Calcium oxide treated corn stover treatments also had lower feed to gain and ending body weight than control calves fed distillers grains. Displacing protein as solubles or fat as glycerin in a treated corn stover feed did not provide the same feeding value as distillers grains.

Introduction

With a large supply of distillers grains plus solubles (DGS), opportunities exist for growing cattle. Utilization of increasingly available corn residue is another opportunity. A previous growing study evaluated the different components of DGS in comparison to calcium oxide (CaO) treated stover; feeding the treated stover product with isolated DGS ingredients did not provide the same performance as bran (*2016 Nebraska Beef Cattle Report*, pp. 128–31). This raises the question if other feed additives, such as solubles or glycerin, are able to increase the energy density of the stover product to be equal to DGS in growing cattle diets. The objectives of this study were to evaluate the CaO treated corn stover product compared to DGS, characterize the effects of increasing the concentration of distillers solubles level, and determine if crude glycerin could further improve growing cattle performance.

Procedure

An 81-day growing study utilized 300 yearling crossbred steers (initial BW = 684, SD = 33 lb) in a randomized block design at the University of Nebraska-Lincoln Agricultural Research and Development Center (ARDC). Steers were limit fed a 50:50 Sweet Bran® and alfalfa hay diet at 2% of BW for 5 days prior to and upon completion of the trial to reduce the effects of gut fill on weights. Two consecutive day weights were collected and averaged to determine initial BW and ending BW. Steers were poured with StandGuard® on day 0 and implanted with Ralgro® on day 1 of the trial. The steers were blocked into 1 of 2 blocks based on the first day weight. The heavy weight block had 1 replication (initial BW = 761 lb) and the light weight block had 4 replications (initial BW = 653 lb). Within a block, cattle were stratified by BW, assigned randomly to pen with 15 head per pen and five replications per treatment.

All diets had a 46% brome hay base (11% CP, 2% ether extract (EE), 77% NDF, 92% OM) and 4% supplement with 200 mg/hd/day (DM basis) Rumensin®. Treatments imposed on the remaining 50% of the diet: 1) the control diet (CON) contained 50% modified distillers grains plus solubles (MDGS); 2) product A (ProdA) consisted of 18.75% solubles, 12.50% treated stover, 18.75% high-protein distillers; 3) product B (ProdB) consisted of 30% solubles, 12.50% treated stover, 7.50% high-protein distillers; 4) product C (ProdC) consisted of 25% solubles, 5% glycerol, 12.50% treated stover, 7.50% high protein distillers. The nutrient content of each treated corn stover product is listed in Table 1. Diets were formulated to meet RDP requirements and were supplemented with urea if deficient. ProdB had 0.74% urea (DM basis) and ProdC had 1.13% urea (DM basis) added to the supplement to match ProdA RDP supply. Feed samples were analyzed each month to determine nutrient composition.

Performance data (BW, DMI, ADG, G:F) were analyzed with the MIXED procedure of SAS (SAS Institute, Inc., Cary, N.C.) with pen as the experimental unit and block treated as fixed effect. One steer died during the study of cause unrelated to the dietary treatments administered and was removed from the data set.

Results

Diets containing CaO treated stover (ProdA, ProdB, ProdC) had lower ADG than CON calves fed MDGS ($P < 0.01$). As a result, CON calves had greater ending BW ($P < 0.01$) than ProdA, ProdB, or ProdC (Table 2).

Similar ending BW was observed for all 3 treated corn stover diets ($P > 0.25$). Treatment ProdA, with more DDGS, had similar DMI to ProdC ($P = 0.12$), but lower DMI as compared to ProdB, which had 30% solubles and 7.50% DDGS ($P = 0.01$). There was no difference in ADG among the 3 products ($P \geq 0.40$). As a result, feed conversion for ProdB was poorer than ProdA. The hypothesis was that displacing DGS with solubles would improve the feeding value of the treated corn stover product. These data do not support the hypothesis. The addition of solubles may have made

Table 1. Nutrient composition of CaO treated products (DM basis)[a]

Nutrient	ProdA	ProdB	ProdC
OM, %	85.0	81.0	82.0
CP, %	27.8	25.6	24.7
NDF, %	41.8	39.5	43.2
ADF, %	28.8	27.2	30.0
EE, %	**6.67**	**6.55**	**5.51**

[a]Nutrient content of CaO treated stover products prior to inclusion in diet

Table 2. Effects of solubles and glycerin additions to CaO treated corn stover diets on cattle performance

	Treatment[a]				SEM	*P*-value
	CON	ProdA	ProdB	ProdC		
Initial BW, lb	703	704	703	705	0.90	0.30
Ending BW, lb	992[c]	954[d]	948[d]	955[d]	4.78	< 0.01
DMI, lb/d	23.5[c]	23.8[c]	25.0[d]	24.5[c,d]	0.30	0.01
ADG, lb	3.56[c]	3.08[d]	3.02[d]	3.09[d]	0.06	< 0.01
Feed:Gain[b]	6.58[c]	7.72[d]	8.30[e]	7.92[d,e]	—	< 0.01

[a]CON = 50% MDGS; ProdA = 18.75% solubles, 12.50% treated stover, 18.75% high-protein DDG; ProdB = 30% solubles, 12.50% treated corn stover, 7.50% high-protein DDG; ProdC = 25% solubles, 12.50% treated stover, 7.50% high-protein DDG, 5% glycerin; Each treatment also contained 46% brome hay and 4% supplement.
[b]Analyzed Gain:Feed, the reciprocal of F:G
[c,d,e]Means within a row with different superscripts differ ($P < 0.05$)

Table 3: Ingredient composition of diet fed to growing steers (DM basis)

Ingredient	Treatment			
	CON	ProdA	ProdB	ProdC
Brome hay	46.00	46.00	46.00	46.00
MDGS[a]	50.00	—	—	—
Solubles	—	18.75	30.00	25.00
Glycerin	—	—	—	5.00
Treated Stover	—	12.50	12.50	12.50
High-Protein DDG[b]	—	18.75	7.50	7.50
Supplement[c]			—	—
Fine ground corn	2.101	2.101	1.487	1.479
Limestone	1.424	1.424	1.300	1.130
Urea	—	—	0.740	0.918
Salt	0.300	0.300	0.300	0.300
Tallow	0.100	0.100	0.100	0.100
Pre-mix, Tr. Mineral[d]	0.050	0.050	0.050	0.050
Premix, Vitamin[e]	0.015	0.015	0.015	0.015
Rumensin[f]	0.010	0.010	0.008	0.008
Nutrient Composition				
OM, %	88.4	86.9	84.9	85.9
CP, %	22.0	19.0	20.0	20.6
NDF, %	55.5	56.4	55.2	57.1
ADF, %	30.0	36.5	35.7	36.9
Ether Extract, %	5.21	4.05	3.99	3.47
Ca, %	0.95	1.58	1.60	1.44
S, %	0.413	0.366	0.453	0.390

[a]MDGS = modified distillers grains with solubles
[b]High-protein DDG = High-protein dried distillers grain plus solubles
[c]Supplement comprised 4% of dietary DM
[d]Premix contained 10% Mg, 6% Zn, 4.5% Fe, 2% Mn, 0.5% Cu, 0.3% I, and 0.05% Co
[e]Premix contained 1,500 IU of vitamin A, 3,000 IU of vitamin D, and 3.7 IU of vitamin E·g-1
[f]Formulated to supply 200 mg/head/day

the treated corn stover more palatable, resulting in increased DMI. However, solubles did not provide comparable energy to distillers grains in these growing diets. The addition of crude glycerin in ProdC did not significantly improve performance over ProdB with more solubles. However, there was a tendency for an improvement in feed conversion, 4.6% due to replacing 5% of the solubles with glycerin (ProdC compared to ProdB; $P = 0.12$).

As DGS were displaced by CaO treated corn stover in the diet, NDF content increased 1% and 2% for ProdA and ProdC, respectively, compared to the CON diet (Table 3). As DGS were displaced with the CaO treated stover product, the CP content decreased, in addition, ProdB and ProdC had a 1% increase in CP as solubles were increased compared to ProdA. As treated stover displaced DGS, the ADF content increased in ProdA. ProdB, and ProdC compared to CON. Calcium content was greater in treated stover product diets than CON, but remained similar among treated stover products. S content increased as solubles were added to the diet, but across the diets, the S content averaged 0.41%.

Utilizing up to 30% solubles, 5% glycerin, and 12.50% CaO treated stover to displace DGS in a brome hay diet did not provide the same performance or feeding value as MDGS. Increasing the amount of solubles increased intake, but decreased efficiency. Replacing 5% of the solubles with glycerin did not improve calf performance, except for a slight tendency for improved feed conversion.

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Effects of Feeding Isolated Nutrient Components in MDGS on Growing Cattle Performance

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Summary

An experiment was conducted to evaluate the influence of individual nutrient components in distillers grains on performance of growing calves. A 40% corn control treatment was included for direct comparison to a diet containing 40% modified distillers grains. Four additional treatments were formulated to isolate the contribution of solubles, protein, fiber, and a combination of fiber and solubles on cattle performance. Average daily gains and ending BW were greater, while F:G lower for cattle fed 40% modified distillers grains compared to the corn control. We were able to determine that protein, when overfed, contributes to the higher energy value of distillers relative to corn in growing diets.

Introduction

The ethanol and beef industries have maintained a mutually beneficial relationship in the Midwest for the last decade or more. However, ethanol producers are removing a portion of the oil via centrifugation, and possibly, fiber during a secondary fermentation process. Extraction of these components changes the nutritional composition of byproducts fed to cattle. A previous growing trial compared de-oiled vs normal fat modified distiller grains plus solubles (MDGS) at 40% dietary inclusion (*2014 Nebraska Beef Cattle Report*, pp. 32–33). Only small numeric differences between de-oiled and normal fat byproducts were observed, which suggest fat content may not be the most important factor in determining the feeding value of MDGS. Therefore, it was hypothesized that other nutrients may be responsible for the improved energy value of MDGS compared to DRC. The objective of this research was to evaluate the effects of isolated nutrient components found in distillers grains on growing steer performance.

Procedure

A study conducted at the University of Nebraska–Lincoln Agricultural Research and Development Center near Mead, NE utilized 450 crossbred, steers (initial BW 655 ± 52 lbs) to determine the feeding value of isolated components in MDGS using growing calves. Prior to initiating the trial cattle were limit fed a diet of 50% alfalfa and 50% Sweet Bran® for five days at 2% of BW to reduce variation in gastrointestinal fill. Steers were weighed two consecutive days (day 0 and 1) to establish an accurate initial BW and implanted with Ralgro® on d1. Based on initial BW, steers were blocked into three BW blocks (Light, Middle, or Heavy), stratified within BW block, and assigned randomly to a pen within their BW block. Cattle were placed into 30 pens with 15 steers per pen, resulting in 5 replications per treatment and pens were assigned randomly to one of six dietary treatments.

Treatments contained equal amounts of grass hay (50%) and a meal supplement at 10% inclusion (DM basis). The six treatments consisted of 1) a 40% corn control (CON) with no MDGS 2) MDGS at 40% inclusion (MDGS), and 3) a diet (SOL) containing 15% condensed distillers solubles (CCDS), equivalent to the solubles contribution in MDGS. An additional three diets were formulated to simulate the nutrient content of each individual component of MDGS plus a combination of solubles and fiber (COMBO). The protein component diet (PROT) included 20% corn gluten meal, while the fiber component treatment included corn bran (16.4%) and germ meal (3.6%). The same ratio of corn bran and germ was used in the COMBO diet with the addition of 15% CCDS (Table 1). The COMBO treatment was included to examine any associative effects between CCDS and fiber components within MDGS. Additionally, Soypass® was included at 5% of total diet DM across all treatments (Table 1) to insure MP requirements were met. Monensin was included at 200 mg/steer daily across all six treatments. At the end of the 81 d feeding period, cattle were limit fed for 5 days prior to collecting ending BW, similar to the beginning of the trial. Ending BW was measured on two consecutive days and averaged. Animal performance was analyzed using the MIXED procedure of SAS (SAS Institute, Inc. Cary, N.C.). Pen was the experimental unit and BW block was a random effect.

Results

Numerical differences in DMI were observed (Table 2; $P = 0.06$). Intake was greater for MDGS, SOL, and COMBO compared with the fiber component diet (FIB; $P = 0.06$), while CON and PROT were intermediate. Steers fed MDGS had the greatest ADG while those on FIB had the least ($P < 0.01$). All remaining treatments (CON, SOL, PROT, COMBO) had intermediate ADG compared to MDGS and FIB ($P > 0.05$). Feed to gain conversions were improved for MDGS and PROT, intermediate for FIB, and poorer for CON, SOL, and COMBO treatments ($P < 0.02$). Ending BW was heaviest for MDGS and lightest for CON and FIB ($P < 0.01$). Cattle fed PROT, SOL, and COMBO had intermediate ending BW with PROT being greater compared to SOL or COMBO ($P < 0.01$).

In agreement with past research, data from this experiment suggest that growing calves on a roughage-based diet containing an optimum level of MDGS (40%) consistently perform better than cattle fed DRC at the same inclusion. The feeding value of MDGS in this study was 118% the value of corn, which is lower than the previously reported feeding value of distillers grains in forage diets of 136% the value of corn (*2015 Nebraska Beef Cattle Report*, pp. 34–35). When evaluating the individual nutrient components in distillers grains, only PROT resulted in feed conversions similar to MDGS and better than CON. The feeding value of corn gluten meal

Table 1. Ingredient composition of forage based component diets fed to growing steers

Ingredient[a]	Treatment					
	CON	MDGS	SOL	PROT	FIB	COMBO
Grass Hay	50	50	50	50	50	50
DRC[b]	40	—	25	20	20	5
MDGS[b]	—	40	—	—	—	—
CCDS[b]	—	—	15	—	—	15
CGM[b]	—	—	—	20	—	—
Corn bran	—	—	—	—	16.4	16.4
Germ	—	—	—	—	3.6	3.6
Supplement[c]						
Soy Pass®	5	5	5	5	5	5
FGC[d]	1.95	2.99	2.52	2.99	2.19	2.74
Limestone	1.38	1.39	1.36	1.39	1.39	1.38
Urea	1.05	—	0.49	—	0.79	0.25
Salt	0.30	0.30	0.30	0.30	0.30	0.30
Tallow	0.25	0.25	0.25	0.25	0.25	0.25
BTM[d]	0.05	0.05	0.05	0.05	0.05	0.05
Vitamin ADE	0.02	0.02	0.02	0.02	0.02	0.02
Rumensin-90®[e]	0.01	0.01	0.01	0.01	0.01	0.01
Nutrient Composition[f]						
CP, %	12.5	17.7	12.5	22.7	12.5	12.5
NDF, %	32.6	43.9	31.2	33	39.9	40.5
Fat, %	2.4	5.1	3.0	2.2	2.6	4.0
Ca, %	0.667	0.679	0.672	0.679	0.675	0.697
P, %	0.304	0.543	0.439	0.342	0.238	0.373

[a]All values represented on a % DM basis.
[b]DRC: Dry rolled corn, MDGS: Modified distillers grains, CCDS: Condensed distillers solubles, CGM: Corn gluten meal.
[c]Supplement formulated to be fed at 10% of dietary DM.
[d]FGC: Fine ground corn, BTM: Beef trace minerals
[e]Formulated to supply 200 mg/hd/d.
[f]Individual nutrients measured as % of total diet (DM).

Table 2. Effects of feeding corn, modified distillers, or protein and fiber components on growing steer performance

	Treatment[a]						SEM	*P*-value
	CON	MDGS	SOL	PROT	FIB	COMBO		
Performance								
Initial BW,lb	668	668	669	669	669	668	1.1	0.85
Ending BW,lb	937[f]	959[d]	940[ef]	950[de]	933[f]	944[ef]	6.1	< 0.01
DMI,lb	21.62[de]	21.77[d]	22.04[d]	21.18[de]	20.81[e]	21.98[d]	0.43	0.06
ADG,lb	3.32[fg]	3.58[d]	3.34[efg]	3.47[de]	3.26[g]	3.40[ef]	0.07	< 0.01
F:G, lb:lb[b]	6.48[e]	6.04[d]	6.55[e]	6.07[d]	6.35[de]	6.41[e]	0.004	0.02
Feeding Value[c]	—	118%	93%	134%	110%	103%	—	—

[a]Protein: included 20% corn gluten meal to simulate the protein component of MDGS; Fiber: contained 16.4% bran and 3.6% full-oil germ to provide similar fiber levels to those found in MDGS; Combo: consisted of 16.4% bran, 3.6% full-oil germ, and 15% condensed distillers solubles.
[b]Analyzed as G:F, the reciprocal value of F:G
[c]Calculated as the percent change in the G:F of each treatment and the control, divided by the percentage of corn replaced in each treatment.
[d–g]Means with different superscripts differ ($P < 0.05$).

in PROT was 134% the feeding value of corn and is very similar to the previously reported feeding value of 136% the value of corn. Since all diets were formulated to meet MP requirements, the response to PROT suggests that protein in MDGS, when overfed to provide energy, is important to the improved performance response of MDGS in high forage growing diets. No other nutritional component appeared to contribute toward the greater energy value of MDGS relative to corn, although FIB resulted in a feeding value that was 10% greater than corn. Replacing 20 percentage units of corn with corn bran and corn germ may have alleviated some negative associative effects between corn starch and fiber digestion. The addition of distillers solubles did not appear to contribute positively to the feeding value of distillers grains in high forage diets. Potential positive associative effects were tested between solubles and fiber in the COMBO diet, but these diets were unable to match the performance of those fed MDGS. These data suggest that the carbon skeleton of amino acids can contribute significantly to the feeding value of MDGS in high forage diets.

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Effects of Supplemental Energy and Protein Source on Performance of Steers Grazing Irrigated Corn Residue

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Summary

Steer calves grazing corn residue (86 d) were assigned to 1 of 5 treatments to evaluate the effects of protein and energy supplements on steer performance. The 5 treatments consisted of 1) un-supplemented control (NS), 2) dry rolled corn only (CRN), 3) 89% dry rolled corn/6% molasses/5% urea (C + RDP), 4) 60/40 blend of soy-pass/soybean meal (SP), and 5) dried distillers grains plus solubles (DGS). Supplements were fed to provide equal TDN intake. Average daily gain among treatments was 1.48, 1.32, 0.53, 0.31, and −0.18 lbs. for SP, DGS, C + RDP, CRN, and NS, respectively. Only steers fed SP and DGS produced over-winter gains greater than 1 lb/d, suggesting metabolizable protein requirements must be met for growing calves to utilize residue efficiently.

Introduction

Corn residue grazing, an abundant feed resource for some Nebraska beef producers, extends the grazing period, and decreases the amount of harvested feed needed per animal, which allows producers to decrease feed cost. Corn residue contains CP and energy concentrations sufficient to support mature, non-lactating, beef females (*2012 Nebraska Beef Report*, pp. 5–7); but those nutrients may not meet the requirements for growing animals. Dried distillers grains plus solubles is high in protein (30% CP), energy (104% TDN), and is a good source of rumen undegradable protein (RUP). Previous work has shown DGS to be an effective supplement to combine with corn residue grazing in order to optimize gain and improve forage intake (*2015 Nebraska Beef Report*, pp. 25–26). However, DGS price is variable and may not always be the most economical supplement choice. Therefore, the objective of this experiment was to compare DGS to alternative protein and energy supplement sources on performance of steers grazing corn residue.

Procedure

Seventy-five (7–9 mo) crossbred steer calves (initial BW = 516; SD = 3 lbs.) grazed irrigated corn residue for 86 d at the University of Nebraska–Lincoln Agricultural Research and Development Center near Mead, Nebraska. Treatments were arranged in a randomized complete block design. Steers were blocked by BW and assigned to 1 of 5 treatments (n = 15) to evaluate the effects of protein and energy supplementation on steer performance. All steers grazed residue from the same paddock throughout the study, and individual supplementation was provided daily for 1 hour from 1100 to 1200 hr via a Calan gate system. In addition to an un-supplemented control group (NS), supplements fed were 1) 60% soy-pass + 40% soybean meal (SP), 2) dried distillers grains plus solubles (DGS), 3) 89% dry rolled corn, 6% molasses, 5% urea (C + RDP), and 4) dry rolled corn only (CRN), fed at 3.50, 3.00, 4.00, and 3.75 lb DM/d, respectively. Estimated TDN values of supplement were 90% (SP), 104% (DGS), 78% (C + RDP), and 83% (CRN). Supplements were formulated to provide 3.12 lb of TDN, which is the amount of TDN provided by 3.0 lb DM of DGS. In order to provide an equal amount of TDN in each supplement, DM amounts of each supplement varied. Un-supplemented calves were sorted off prior to other treatments entering the Calan gate system. Therefore, non-supplemented steers did not have access to supplement or residue until all steers consumed their supplement. After individual supplementation, all steers were returned to the paddock to continue grazing.

Steers were limit-fed a 50:50 diet of alfalfa hay and Sweet Bran® at 2% of BW on a DM basis for 5 d before the trial. Body weight was measured on 3 consecutive days to reduce variation from gut fill. Steers were blocked by initial BW and assigned to 1 of 5 treatments. At the conclusion of the trial, steers were again limit-fed a 50:50 diet of alfalfa hay and Sweet Bran at 2% of BW on a DM basis and ending BW was measured on 3 consecutive days.

Stocking rate was calculated based on grain yield at harvest and previous research estimating the amount of residue available for grazing per bushel of grain yield. Available forage was determined by multiplying grain yield, estimated forage availability (8 lb/bu), and number of acres, to produce the total available forage in the paddock. Total available forage was then divided by the estimated DMI (10 lb) of all steers to determine the length of grazing period available in the paddock (*2015 Nebraska Beef Report*, pp. 25–26).

Supplement refusals were collected and weighed each week. Samples were analyzed for DM by drying at 60° Celsius for 48 hours in a forced air oven and weighed using a digital scale.

Results

Results from the trial are shown in Table 1. Ending BW and ADG differed ($P < 0.01$) among treatments. Average daily gain among treatments was 1.48, 1.32, 0.53, 0.31, and-0.18 lb/d for SP, DDG, C+RDP, CRN, and NS respectively. Both SP and DDG provided supplemental metabolizable protein as RUP. These data support a metabolizable protein deficiency for growing calves grazing corn residue.

It is likely that the TDN value assigned to the SP supplement may have been underestimated. When the NRC is utilized and a supplement TDN value of 95% instead of 90% is modeled for the SP supplement, the DM amount fed decreases to 3.3 lb instead of 3.5 lb, and the estimated TDN amount is 3.13 lbs. Under this scenario, a predicted ADG is 1.32 lb, equal to the actual ADG of the DGS treatment. Therefore, if a greater TDN value had been

Table 1. Comparison of ADG response to protein and energy supplements for calves grazing irrigated corn residue

	No Suppl.[a]	Corn[b]	Corn/ Urea[c]	DDGS[d]	Soypass[e]	SEM	*P*-value
Initial BW	516	516	516	516	516	3.5	0.1
Ending BW	504[h]	539[i]	559[j]	629[k]	640[l]	4.9	< 0.01
ADG	−0.18[h]	0.31[i]	0.53[j]	1.32[k]	1.48[l]	0.06	< 0.01
Suppl. DMI, lb/d[f]	—	3.75	3.23	3.0	3.5	—	—
TDN, %	—	83%	78%	104%	90%	—	—
TDN intake lb/d	—	3.11	2.52	3.12	3.15	—	—
DIP balance (g/day)	−144	−253	7	−161	−1	—	—
MP balance[g]	−19	126	93	144	258	—	—

[a]Calves did not receive suppl. throughout feeding period.
[b]Suppl. contained 3.75 lbs. DM, whole corn.
[c]Suppl. contained 4 lbs. DM, 89% whole corn, 6% molasses, 5% urea.
[d]Suppl. contained 3 lbs. DM, dried distillers grains + solubles.
[e]Suppl. contained 3.5 lbs. DM, 60% soy-pass + 40% soybean meal.
[f]Suppl. was formulated to provide 3.12 lbs. TDN intake, which is the TDN amount supplied by 3.0 lb. dried distillers grains + solubles. This formulation requires differing DM amounts.
[g]Metabolizable protein balance to achieve the observed ADG for each treatment.
[h–l] Means within a row with differing superscripts are different.

used for SP, steer performance between SP and DGS would have likely been similar.

Steers supplemented with C + RDP were the only treatment group to refuse feed each week, likely due to the high inclusion level and palatability of urea. Calves supplemented with C + RDP consumed less TDN than other treatment groups. The average daily DMI for C + RDP was 3.23 lb/d, which is 80% of the supplement offered. Differences in DMI (3.23 vs. 4.0 lb) and TDN (2.52 vs 3.11 lb) likely had an impact on performance of the C + RDP treatment group. When the NRC model is used and reflects the scenario of consuming 80% of C + RDP supplement, it projects an ADG of 1 lb/d, which is 0.5 lb above actual ADG. It is unlikely the decrease in DMI and TDN consumption accounts for the entire deficit in performance. While the NRC model did not predict a metabolizable protein deficiency at the observed 0.53 lb of ADG, it is likely that corn was not able to provide adequate metabolizable protein to achieve ADG similar to DDG, even when balanced for RDP. The CRN treatment group was further affected by a deficiency in RDP, which contributed to the reduced ADG compared to C + RDP. Additionally, a negative associative effect of starch digestion on fiber digestibility of corn residue is possible.

Supplements high in both RDP and RUP will produce greater growth response in growing cattle even when TDN is similar. This experiment supports protein supplementation (SP, DGS) being crucial for steers grazing corn residue even when TDN of high energy supplements (CRN, C + RDP) is equal. Meeting CP requirements with a combination of RDP and RUP will result in greatest growth response in steers grazing corn residue. Additionally, supplementing with corn grain, with or without urea, will produce insufficient over-winter gains, and supplements should contain protein, both RUP and RDP, at a higher level than what is supplied by corn and urea.

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Effects of Replacing a Traditional Growing Diet with a Complete Pelleted Feed on Total Tract Digestibility of Growing Diets

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Summary

A digestion study evaluated the effects of replacing traditional growing diets containing 60% untreated corn stover \or 60% alkaline treated corn stover, with one of two types of complete pelleted feeds (Pellet C or Pellet S) containing alkaline treated corn stover and dry distillers grains. Pellet C and S were harvested using different methods. Pellet S had the greatest OM and NDF digestibility, while the untreated stover had the lowest. Pellet C and the treated stover fell intermediate. Replacing a traditional growing diet with a complete pelleted feed resulted in similar or improved diet digestibility, depending on stover harvesting method.

Introduction

Increased crop production has resulted in increased corn residue available to be utilized as feed. Traditionally corn residue has been considered low quality due to its low digestibility, which varies among the different parts of the corn stover. The stalk and cob were the least digestible parts of the corn plant; however, they made up the largest portion (60.11%) of the plant DM (*2012 Nebraska Beef Report*, pp. 11–12). Advancements in corn harvesting methods have allowed producers to alter which parts of the corn stover are baled and used as feed. Corn stover harvested using a John Deere 569 round baler with the Hillco single pass round bale system (primarily husk, cob, and leaf baled) compared to traditional harvesting methods resulted in an improvement in feed efficiency (*2015 Nebraska Beef Report*, pp. 42–44). Additionally, digestibility of corn residue can be improved with processing and alkaline treatment. A previous study found that feeding a complete pelleted feed containing CaO treated corn stover and distillers by-products resulted in increased ending BW, ADG, and DMI; however, the pellet negatively impacted F:G compared to the un-pelleted diet (*2015 Nebraska Beef Cattle Report*, pp. 36–37). Therefore, the objective of this study was to evaluate the effects of corn stover harvesting method, chemical treatment, and processing on total tract digestibility of growing cattle.

Procedure

Six steers (initial BW = 788 ± 15 lb) were utilized in a 4 × 6 Latin square with four treatments fed each period (Table 1). Steers were assigned randomly to one of four treatments using a row × column transformation. The negative control (NEGCON) consisted of 60% untreated corn stover, 18% modified distillers grains plus solubles (MDGS), 18% distillers solubles, and 4% supplement. The positive control (POSCON) contained 60% CaO treated corn stover, 18% MDGS, 18% distillers solubles, and 4% supplement. The third treatment (Pellet C) contained a complete pelleted feed containing CaO treated corn stover, solubles, dry distillers grains (DDG), and supplement in the same proportion as the control diets. The fourth treatment (Pellet S) was also a complete pelleted feed containing CaO treated corn stover, solubles, DDG, and supplement in the same proportion as the control diets. The difference between pellets A and B were the harvesting method used to collect the corn stover.

The corn stover used in Pellet C was harvested using a rake and conventional baler, while the corn stover used in Pellet S was harvested using a single pass round baler pulled behind the combine (John Deere, Moline, IL; Hillco Technologies, Inc.,Nexperce, ID). Pellet C and S did not

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

Ingredient	NEGCON	POSCON	Pellet C	Pellet S
MDGS	18	18	—	—
Solubles	18	18	—	—
Corn Stover	60	—	—	—
CaO Treated Corn Stover	—	60	—	—
Pellet C[a]	—	—	100	—
Pellet S[b]	—	—	—	100
Supplement[c]	—	—	—	—
Fine Ground Corn	2.408	3.524	3.524	3.524
Limestone	1.116	—	—	—
Salt	0.300	0.300	0.300	0.300
Tallow	0.100	0.100	0.100	0.100
Beef Trace Minerals[d]	0.050	0.050	0.050	0.050
Vitamin A-D-E[e]	0.015	0.015	0.015	0.015
Rumensin-90[f]	0.011	0.011	0.011	0.011

[a]Contained corn stover harvested conventionally.
[b]Contained corn stover harvested with a Hillco single pass round bale system.
[c]Supplment supplied at 4% of dietary DM.
[d]Premix contained 10% Mg, 6% Zn, 4.5% Fe, 2% Mn, 0.5% Cu, 0.3% I, and 0.05% Co.
[e]Premix contained 1,500 IU of vitamin A, 3,000 IU of vitamin D, and 3.7 IU of vitamin E·g-1.
[f]Formulated to supply 200 mg/hd/d.

contain corn stover harvested from the same field; however, fields were in the same region. After the corn stover was harvested using the different methods, bales were taken to Pellet Technology (Gretna, NE) and processed. Both pellets C and S were produced by processing the corn stover to a smaller particle size, hydrating it with distillers solubles, treating with CaO, mixing in DDG, and pelleting the mixture. Corn stover used in the NEGCON and POSCON treatments was harvested from the same location as the stover used to produce Pellet C. The corn stover used in the POSCON and NEGCON treatments was processed through a tub grinder fitted with a 3 inch i.d. screen. The POSCON corn stover was then treated with 5% CaO (DM basis), hydrated with water (targeting 50% DM), and mixed in a Roto-Mix feed truck. The treated corn stover was then dispensed into 200 L barrels and stored for 7 d prior to feeding to ensure the treatment process was complete. Calcium oxide used to treat the corn stover in the POSCON treatment was the same CaO used to treat the stover within pellets C and S.

Each period was 14 d in length consisting of a 9-d adaptation and a 5-d collection. During the first 7 d of the adaptation phase, steers were fed *ad libitum* intake. The remaining 2 d the steers were fed 98% of *ad libitum* intake to minimize refusals. Steers remained at 98% *ad libitum* intake for the 5 d collection period. Steers were housed in individual slatted floor pens. All steers were fitted with total fecal collection bags at the start of the collection period (d 10) to measure total fecal output. Bags were emptied twice daily (0700 and 1600 h). Once the bags were emptied, feces were weighed, and both morning and afternoon collections were composited by day for each steer. Composites were made by mixing the morning and afternoon collection times in a mixer, and then sub-sampling the mixture. Two sub-samples of the fecal day composite were taken. One sub-sample was dried in a 60°C forced air oven to calculate total fecal output on a DM basis, while another sub-sample was freeze dried, and ground through a Wiley mill (1-mm screen). The freeze dried and ground day composites were composited on a dry weight basis by steer each collection period. Fecal samples were analyzed for OM and NDF to estimate total tract digestibility.

Table 2. Nutrient composition of dietary treatments[a]

	NEGCON	POSCON	Pellet C	Pellet S
DM, %	64.55	46.32	86.60	85.90
OM, %	91.36	86.40	90.47	90.28
NDF, %	61.24	55.42	48.26	48.22
CP, %	15.47	15.18	21.46	20.55

[a]DM basis

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

	NEGCON	POSCON	Pellet C	Pellet S	SEM	P-Value
DM						
Intake, lb/d	13.16	12.51	11.76	11.84	0.77	0.42
Total tract digestibility, %	64.69[c]	67.98[b]	71.87[a]	74.4[a]	1.15	< 0.01
OM						
Intake, lb/d	11.47	10.62	10.41	10.49	0.67	0.55
Total tract digestibility, %	67.58[c]	71.67[b]	73.32[ab]	75.55[a]	1.07	< 0.01
NDF						
Intake, lb/d	7.98[a]	6.89[a]	5.62[b]	5.66[b]	0.44	< 0.01
Total tract digestibility, %	54.36[b]	60.09[ab]	59.73[ab]	63.93[a]	2.24	< 0.01

[abc]Means with differing superscripts are different.

Individual ingredients were dried in 60°C forced air oven weekly to ensure that accurate DM's were used when mixing dietary treatments. Samples of individual ingredients were taken prior to mixing diets, composited by period, freeze dried, and ground through a 1-mm screen using a Wiley mill. Feed samples were analyzed for OM, CP, and NDF to calculate nutrient composition of dietary treatments (Table 2). Nutrient composition of dietary treatments and feces were used to calculate total tract digestibility of DM, OM, and NDF using the following equation: 1-((fecal output * nutrient concentration) / (feed intake * nutrient concentration)).

All data were analyzed using the MIXED procedures of SAS (SAS Inst., Inc., Cary, N.C.). Steer was the experimental unit. The model included period as a fixed effect. Steer and steer * treatment were included in the random statement. Probabilities less than or equal to alpha ($P \leq 0.05$) were considered significant.

Results

There was no significant difference ($P = 0.42$) observed for DMI between all four treatments (Table 3). The DMI response to the pelleted treatments differed from previous observations with similar products in production settings. A pellet similar to Pellet C resulted in an increased DMI compared to the un-pelleted treatment (*2015 Nebraska Beef Cattle Report*, pp. 36–37). Increased intake for pelleted diets may be attributed to a greater passage rate due to smaller particle size. The increased passage rate may result in reduced total tract digestibility. However, Pellet C and Pellet S had the greatest DMD (74.4 and 71.87%, respectively), and the NEGCON (64.69%) had the least DMD ($P < 0.01$). The POSCON fell intermediate (67.98%). Total tract digestibility of OM followed a similar pattern, with Pellet S (75.55%) having the greatest OMD and the NEGCON (67.58) having the least ($P < 0.01$). However, the POSCON treatment and Pellet C treatment had similar OM digestibilities (71.67 and 73.32%, respectively; $P = 0.22$). Similar to DMI, there was no difference observed ($P = 0.55$) for OM intake between the four treatments.

Intake of NDF was different among the four treatments ($P < 0.01$). The NEGCON and POSCON treatments consumed 7.98

and 6.89 lb of NDF/d, respectively. Both Pellet C and Pellet S treatments consumed 5.62 and 5.66 lbs of NDF/d, respectively. The lower NDF intake of the POSCON, Pellet C, and Pellet S treatments was due to lower dietary NDF (Table 2), which is a result of the CaO treatment solubilizing portions of the fiber in the corn stover. Steers on the Pellet S treatment had the greatest (63.93%) NDF digestibility, while steers on the NEGCON treatment (54.36%) had the least ($P \leq 0.01$). The POSCON and Pellet C treatments fell intermediate (60.09 and 59.73%, respectively). Chemically treating corn residue solubilizes portions of the fiber content. Consequently, solubilized fiber is not accounted for in the NDF digestibility of the POSCON, Pellet C, or Pellet S treatments. The residue in the Pellet C and POSCON treatments is the same residue in the NEGCON. Therefore, the NDF content of the untreated corn stalks was used to re-calculate dietary NDF of the POSCON and Pellet C treatments. Re-calculating dietary NDF to include the solubilized fiber resulted in increased NDF digestibility values for the POSCON and Pellet C treatments (64.0% and 67.5%, respectively).

In conclusion, replacing a traditional growing diet with a complete pelleted feed resulted in similar or improved digestibilities. Harvesting method (i.e. plants parts harvested) can also impact digestibility, as Pellet S (contained corn stover harvested with a single-pass round baler behind the combine) had greater OM and NDF digestibility compared to Pellet C (contained corn stover harvested using a rake and conventional baler).

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Effect of Pelleted Byproducts on Performance When Fed to Growing Cattle

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Summary

Heifers fed a basal diet of either low or high quality forage were supplemented with a corn residue and corn by-product pellet at 0, 0.5, or 1.0% of BW. A linear increase in final BW, ADG, and feed efficiency was observed as supplement increased for heifers fed high quality forage while a quadratic response was observed for those fed low quality forage. Increasing supplement linearly decreased daily average forage dry matter intake from 16.5 lb to 12.6 lb at 0 and 1.0% of BW, respectively. Accordingly, as supplement intake increased, total dry matter intake increased linearly from 16.5 lb to 19.5 lb at 0 and 1.0% of BW, respectively.

Introduction

During the last decade, a significant amount of grazing land has been converted into cropland due to increased grain prices. From 2007–2011, 1.3 million acres of grazing land were converted in the North Central region of the U.S. alone. As a result, there is reduced availability of traditional forages and an increased amount of corn residue available. Additionally, due to the decrease in grazing land, there has been an increase in rent prices for grazing. During the same period of time, the U.S. cow herd decreased by 2.39 million head with 1.13 million (47%) of the decrease occurring in the North Central region. With current economics pointing some producers toward expansion of the cow herd, there may be a further increase in competition and prices for grazable land. To increase production per fixed unit of land, utilizing the increased amount of corn residue and associated by-products that arise from the increase in cropland as a supplement may be beneficial. Pelleted distillers grain and treated corn stover can replace up to 20% of the corn in finishing diets containing 40% MDGS with no negative effects on performance (*2015 Nebraska Beef Report*, pp. 86–87). The objective of this study was to evaluate the effects of feeding a similar pellet as a supplement on the performance of growing cattle consuming *ad libitum* forage.

Procedure

An 84-d growing trial was conducted utilizing 300 heifers (initial BW = 615 lb; SD = 49) in a 2 × 3 factorial design. The first factor was forage quality with low quality (LQ) or high quality (HQ) forage as the basal diet. The LQ diet consisted of bromegrass hay and the HQ diet was comprised of 50% bromegrass silage, 37.5% alfalfa hay, and 12.5% sorghum silage (Table 1). The second factor was increasing levels of pellet supplement at 0, 0.5, or 1.0% of BW. The pellet consisted of 53% corn stover treated with calcium oxide, 32% dried distillers grains, 14% solubles, and 1% urea (provided by Pellet Technology, USA Gretna, Neb.). All heifers were limit fed a diet consisting of 50% alfalfa and 50% Sweet Bran for 5 days to equalize gut fill. Heifers were weighed on 2 consecutive days and the average of those 2 days was used as initial BW. Heifers were blocked by BW (n = 3) and stratified by BW within block and assigned randomly to pens using the first day weights. Treatments (n = 6) assigned randomly to pens with 5 replications per treatment, and 10 heifers per pen. The first weight block had 1 replication, the second weight block had 3 replications, and the third weight block had 1 replication. Pen was the experimental unit. Cattle were implanted with Ralgro® on d 1.

The NRC model was used to estimate initial forage intake and pens were fed *ad libitum* forage thereafter. Initial BW was used to calculate initial supplement amount and adjusted every 28 days using the NRC estimate of gain given actual forage and supplement intake. Actual supplement intake was within 0.02% of BW of targeted intake for all treatments. Ending BW was determined similarly to initial BW. Heifers were limit fed a 50% alfalfa, 50% Sweet Bran diet for 5 consecutive days and weighed 2 days thereafter. Ending BW was then calculated by averaging the 2-d weights.

Performance (BW, ADG, F:G) and intake (forage DMI and total DMI) data were analyzed using the GLIMMIX procedure of SAS (SAS Institute, Inc., Cary, N.C.) with pen as the experimental unit. Six heifers were removed from the study due to non-treatment related issues. Initial BW was used in the model as a covariate due to subtle differences across treatments but was non-significant as a covariate, and removed from subsequent analysis.

Table 1. Nutrient composition of dietary ingredients and diet

Item	DM, %	OM, % of DM	CP, % of DM	NDF, % of DM	Fat, % of DM
Ingredient					
Alfalfa	87	92	16.4	54	—
Bromegrass Hay	92	92	7.1	71	—
Bromegrass Silage	90	92	15.8	68	—
Pellet	85	85	21.2	52	3.9
Sorghum Silage	85	92	8.6	59	—
Diet					
Low Quality[a]	92	92	7.1	71	—
High Quality[b]	88	92	15.1	62	—

[a]Bromegrass hay
[b]Bromegrass silage (50%), Alfalfa (37.5%), sorghum silage (12.5%).

Table 2. Effects of supplementing growing cattle with 0, 0.5, or 1.0% (of BW) with a corn byproduct pellet with either low or high quality forage

Supplement, % BW	Low			Lin[a]	Quad[b]	High			Lin[c]	Quad[d]	SEM	*P*-Value		
	0	0.5	1.0			0	0.5	1.0				Int.[e]	Forage	Supp.
Initial BW, lb	615[fg]	612[g]	616[f]	0.54	0.02	614[fg]	616[f]	613[fg]	0.54	0.15	1.17	0.02	0.78	0.78
Ending BW, lb	670[f]	720[g]	749[h]	< 0.01	0.03	744[h]	770[i]	796[j]	< 0.01	1.00	3.69	< 0.01	< 0.01	< 0.01
ADG, lb/d	0.66[f]	1.29[g]	1.59[h]	< 0.01	< 0.01	1.55[h]	1.84[i]	2.18[j]	< 0.01	0.59	0.04	< 0.01	< 0.01	< 0.01
Forage DMI, lb/d	16.2[f]	14.5[g]	12.4[h]	< 0.01	0.57	16.8[f]	14.2[g]	12.9[h]	< 0.01	0.17	0.36	0.38	0.35	< 0.01
Total DMI, lb/d	16.2[f]	17.9[g]	19.2[h]	< 0.01	0.72	16.8[fi]	17.6[gi]	19.8[h]	< 0.01	0.13	0.36	0.40	0.31	< 0.01
F:G	24.5[f]	13.9[g]	12.1[h]	< 0.01	< 0.01	10.8[i]	9.6[j]	9.1[j]	< 0.01	0.23	—	< 0.01	< 0.01	< 0.01

[a]Linear contrasts for supplement level with low quality forage.
[b]Quadratic contrasts for supplement level with low quality forage.
[c]Linear contrasts for supplement level with high quality forage.
[d]Quadratic contrasts for supplement level with high quality forage.
[e]Forage quality by supplement level interaction.
[fghij]From the P-values, means within a row with differing superscripts are different ($P < 0.05$).

Results

A forage × supplement interaction existed for ending BW, ADG, and F:G ($P < 0.01$) (Table 2). For the HQ forage diet there was a linear increase in ending BW and ADG and a linear decrease in F:G as supplement level increased ($P < 0.01$). For the LQ forage diet, there was a quadratic response ($P \leq 0.03$) for ending BW, ADG, and F:G as supplement level increased; ending BW and ADG increased at a decreasing rate while F:G decreased at a decreasing rate. In the LQ diet, as supplement level increased from 0 to 0.5% there was a 0.63 lb increase in ADG and a 10.6 decrease in F:G. As supplement increased from 0.5 to 1%, ADG and F:G only increased and decreased by 0.30 lb and 1.8, respectively. The ADG and F:G response between 0.5 and 1% in LQ forage was similar to relative changes in HQ diet between 0.5 and 1% levels of supplementation (0.34 lb increase and 0.5 decrease for ADG and F:G, respectively). Retrospectively, the levels of RDP and MP were analyzed with the NRC model. The LQ control diet was deficient in RDP (−142 g/d) while the HQ control diet did not have the deficiency for RDP (+ 438g/d). As supplement level increased to 0.5% of BW, the LQ diet was no longer deficient in RDP. The larger increase in ADG with the LQ diet from 0 to 0.5% of BW supplementation would suggest a response to supplementing RDP, while the rate of increase from 0.05 to 1% of BW is similar to the response observed in the HQ forage diets, suggesting an energy response as supplement level increased from 0.5 to 1.0% of BW. Forage DMI and total DMI had linear responses as supplement increased, with forage DMI decreasing and total DMI increasing ($P < 0.01$). However, forage quality did not affect either forage or total DMI ($P \geq 0.35$).

Supplementing a corn residue-based pellet increased ADG and decreased F:G of growing calves fed either a low or high quality roughage diet, although there is a greater response when fed in a low quality forage diet, likely due to the addition of RDP.

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Effect of Pelleted Feed Products and Bambermycins on Performance When Fed to Cattle Grazing Residue

Cody A. Welchons, Robby G. Bondurant, F. Henry Hilscher,
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Summary

Steer calves grazing non-irrigated corn residue were supplemented with a corn residue and by-product pellet at 0.3, 0.7, or 1.1% of BW. The, pellet was formulated to deliver either 0 or 10 mg/steer daily of bambermycins (Gainpro). There was no interaction between bambermycins inclusion and level of supplementation. Likewise, there was no effect of bambermycins on ending BW or ADG. As level of supplement increased, both ending BW and ADG increased linearly.

Introduction

Due to increased conversion of pasture and range land to cropland during the last decade there is significant potential for grazing corn residue. Grazing corn residue increases grazing season length and decreases the amount of harvested forage that must be fed to cattle. Corn residue quality decreases as grazing progresses because the highly digestible portions are consumed first. Additionally, the CP content of corn residue is insufficient to meet the protein needs of a growing animal. Therefore, supplementation with protein and energy is beneficial to supplement cattle grazing residue should improve performance. Supplementation of growing cattle with pelleted distillers grains and alkaline treated corn stover has been shown to increase ADG when fed with a low quality forage source (*2016 Nebraska Beef Report*, pp. 36–37). Feed additives, such as ionophores, are also an option for increasing ADG of cattle grazing forage. Bambermycins (Gainpro®) is an antimicrobial feed additive that has been shown to increase ADG in forage diets. Feeding bambermycins has not been evaluated in steers grazing corn residue. Therefore, the objective of this study was to evaluate the effects of bambermycins inclusion and differing amounts of supplementing a corn residue and byproduct pellet on performance of growing calves grazing non-irrigated corn residue.

Procedure

An 85-d corn residue grazing trial was conducted from November 5, 2014 to January 28, 2015 at the University of Nebraska-Lincoln Agricultural Research and Development Center near Mead, NE. Sixty crossbred steers (initial BW = 560 lbs; SD = 58) were evaluated in a 2 × 3 factorial design. The first factor was inclusion of bambermycins fed at either 0 or 10 mg/steer daily. The second factor was increasing amounts of pellet supplement at 0.3, 0.7, or 1.1% of BW. The pellet contained 21% CP and consisted of 54% corn stover treated with calcium oxide, 32% dried distillers grains, and 14% solubles (provided by Pellet Technology, USA Gretna, Neb.). A second pellet contained 10% supplement as a percentage of DM to provide supplemental vitamins, minerals, and, depending on treatment, bambermycins. This pellet was fed at 1 lb of DM/steer daily with the remaining amount of supplement provided in the primary pellet. Steers were limit-fed a diet at 2% of BW consisting of 50% alfalfa and 50% Sweet Bran® for 5 days to equalize gut fill. Steers were weighed 3 consecutive days and assigned randomly to treatments after being stratified by weight. Steers were gathered daily at 1130 and individually offered supplement via Calan gates for approximately 1 hour. Following supplement consumption steers were returned to graze dryland corn residue. All steers were implanted with 36 mg of zeranol (Ralgro®) on d 1 of the experiment.

Stocking rate was calculated using estimates of residue amount and grazing efficiency from previous research (*2012 Nebraska Beef Report*, pp. 11–12). Yield (202 bu/acre), estimated forage availability (8 lb/bu), and total acres (42 acres) were multiplied to determine an estimate of total available forage for the corn field. Estimated available forage was divided by estimated DMI (10 lb/steer daily) of steers to determine the number of grazing days the field could support. Supplement amount was adjusted on d 28 and 56 by taking BW measurements and shrinking them 4% to determine interim BW.

Ending BW was determined similarly to initial BW. Steers were limit fed a 50% alfalfa 50% Sweet Bran diet at 2% of BW for 5 consecutive days and weighed 3 days thereafter. Ending BW was calculated by averaging the 3 day weights.

Performance (BW and ADG) data were analyzed using the GLIMMIX procedure of SAS (SAS Institute, Inc., Cary, N.C.) with steer as the experimental unit. One steer was removed from the study due to issues unrelated to the experiment.

Results

There was no interaction between inclusion of bambermycins and pellet supplementation for ending BW or ADG ($P > 0.82$). Similarly, there was no main effect of bambermycins inclusion on ending BW or ADG ($P > 0.90$; Table 1) when fed at 10 mg/steer daily. There was a linear increase ($P > 0.01$) for ending BW and ADG as pellet supplementation increased (Table 2). For steers receiving supplement at 0.3% of BW, ADG was essentially 0 (−0.02 lb/d) which resulted in an ending BW that was 2 lb less than the initial BW. For steers supplemented at 0.7 and 1.1% of BW, ADG was 0.62 and 1.24 lb/d, respectively. The lack of BW change in steers supplemented with pellet at 0.3% of BW would indicate steers were being fed at maintenance requirements. This result was unexpected and would suggest that calves were significantly deficient in protein and/or energy. Metabolizable protein has been shown to increase gains in steers grazing corn residue (*2016 Nebraska Beef Report*, 31–32). The increased levels of protein provided by pellet to steers fed at greater levels likely contributed to the linear response in gain. It can also be assumed that the protein and

Table 1. Main effect of Gainpro on performance of growing cattle grazing corn residue

Gainpro Inclusion	Gainpro[a]	No Gainpro	SEM	*P*-Value
Initial BW, lb	561	560	11.3	0.93
Ending BW, lb	613	612	11.6	0.91
ADG, lb/d	0.61	0.61	0.04	0.93

[a]Provided bambermycins at 10 mg/steer daily.

Table 2. Main effect of supplementation amount on performance of growing cattle grazing corn residue

Supplement[a], % BW	0.3	0.7	1.1	SEM	*P*-Value	
					Lin[b]	Quad[c]
Initial BW, lb	558	565	559	14	0.95	0.71
Ending BW, lb	556[d]	617[e]	664[f]	14	< 0.01	0.68
ADG, lb/d	−0.02[d]	0.62[e]	1.24[f]	0.05	< 0.01	0.89

[a]CaO treated corn residue (54%), dried distillers grains (32%), and solubles (14%).
[b]Linear contrasts for supplement level.
[c]Quadratic contrasts for supplement level
[def]Means within a row with differing superscripts are different ($P < 0.05$).

energy levels available to steers supplemented at 1.1% of BW did not maximize gain, as the increase in ADG was identical between supplementation amounts (ADG of 0.62 and 0.64 between 0.3 and 0.7% of BW, and 0.7 and 1.1% of BW, respectively), suggesting that the point of diminishing return has not been met. Use of a corn-residue based pellet increased performance as supplementation increased; however, due to the nutrient deficiencies inherent to corn residue, greater amounts of protein and/or energy may be beneficial for growing calves.

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Effect of Crude Glycerin Concentration on Forage Digestion Parameters in Beef Calves

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Summary

Seven ruminally and duodenally cannulated steers were used to evaluate effects of increasing concentrations of crude glycerin on digestion in high forage diets. As glycerin inclusion increased, DM, OM, and NDF intake decreased. Neither DM nor OM digestibility were affected by glycerin inclusion. While dietary NDF digestibility decreased as glycerin increased, glycerin inclusion had no effect on rate or extent of in situ NDF digestibility estimates. As glycerin inclusion increased, propionate and butyrate VFA proportions increased while acetate decreased. Decreases in acetate to propionate ratio with increasing concentrations of crude glycerin may improve F:G in forage-based diets.

Introduction

Due to expansion of the alternative fuels industry, new feedstuffs, such as crude glycerin (GLY) have become available to producers. The production of biodiesel yields GLY as a byproduct resulting from the formation of methyl esters of fatty acids from triglycerides. Data on GLY in forage-based beef cattle diets are limited. Thus, the purpose of this experiment was to evaluate increasing inclusion of GLY in a forage-based diet to evaluate its effect on total tract digestibility, rate and extent of fiber digestibility, and rumen fermentation parameters.

Procedure

This experiment utilized 7 ruminally and duodenally cannulated steers (initial BW = 800 lb) in a row by column transformation with four periods, four dietary treatments, and seven steers. Each period consisted of 9 days for adaptation and 5 days for collection. Dietary treatments (Table 1) included 0, 4, 8, and 12% diet DM inclusion of GLY. Basal diets consisted of 50% wheat straw (WS), soybean hulls (SH), 4% supplement, and soybean meal, to maintain a consistent CP concentration. Dietary GLY replaced SH in treatment diets. Diets were mixed twice weekly and stored in a cooler (32° F) throughout the experiment.

Steers were ruminally dosed with 5 g of TiO_2 twice daily at 0800 and 1600 hours from d 3 to 13. During the 5 d collection period, fecal, rumen, and duodenal samples were collected 1 h prior to feeding and at 2, 5, and 8 h post feeding. Starting on d 10 of each period, in situ bags containing ground WS or SH were incubated in the rumen for 0, 6, 12, 16, 24, 48, and 96 h to determine NDF digestion rates. Rate of NDF digestion was calculated from the log of potentially digestible fiber remaining at each time point after correcting for indigestible fiber estimated at 96 h of incubation. The rates for each time point were averaged to estimate an overall rate of the feed.

Hourly duodenal samples were freeze-dried, ground and composited by steer into a daily composite. Within each day, fecal samples were composited by steer into a daily composite, then freeze-dried. Daily composites were ground, and a steer within period fecal composite sample was made and analyzed for NDF, OM, and percent Ti. Dietary ingredients and feed refusals were analyzed for DM, OM, and NDF. Percent DM was determined using a forced air oven set at 60° C for 48 hours.

Digestibility and *in situ* extent of NDF digestion data were analyzed using the GLIMMIX procedure of SAS (SAS Institute, Inc., Cary, N.C.). *In situ* data for rate of NDF digestibility were analyzed using the MIXED procedure of SAS. Orthogonal contrasts were used to test linear and quadratic effects of GLY inclusion. Ruminal VFA data were analyzed using the MIXED procedure of SAS with time within day as the repeated measure and AR (1) as the covariance structure.

Results

Both DMI and OM intake decreased quadratically ($P = 0.04$) as GLY increased in the diet, with lowest intakes occurring at 4% GLY inclusion (Table 2). As GLY inclusion increased from 0 to 12% diet DM, NDF intake linearly decreased ($P <$

Table 1. Composition of treatment diets (% of diet DM) fed to ruminally and duodenally fistulated steers

	Dietary Treatments			
	0	4	8	12
Ingredient, %				
Wheat Straw	50.0	50.0	50.0	50.0
Soybean Hulls	38.3	33.5	28.8	24.0
Soybean Meal	7.8	8.5	9.2	10.0
Crude Glycerin	0.0	4.0	8.0	12.0
Supplement[a]	4.0	4.0	4.0	4.0
Analyzed composition, % DM				
CP	18.7	18.7	18.3	17.7
OM	90.6	90.7	90.9	91.0
NDF	70.5	68.4	65.4	62.6

[a]Supplements formulated to provide minimum of 12.5% CP, 0.70% Ca, 0.40% P, and 0.40% Na for each treatment diet.

Table 2. Effect of increasing dietary crude glycerin concentration on intake, digestibility, and rate of fiber digestion.

	Glycerin Inclusion, % Diet DM					*P*-value	
	0	4	8	12	SE	Linear	Quadratic
Intake, lb/d							
DM	19.0[a]	17.7[b]	18.3[ab]	18.8[ab]	1.1	0.79	0.04
OM	17.1[a]	16.1[b]	16.6[ab]	17.1[a]	1.0	0.96	0.04
NDF	13.5[a]	12.2[b]	12.0[b]	11.8[b]	0.8	< 0.01	0.06
Duodenal flow, lb/d							
NDF	6.25	5.76	6.00	5.35	0.52	0.10	0.82
Ruminal digestibility, %							
NDF	53.63	51.17	50.17	53.72	3.22	0.98	0.33
Fecal output, lb/d							
OM	6.59	5.87	6.38	6.72	0.52	0.83	0.24
NDF	5.06	4.55	4.88	5.38	0.45	0.58	0.20
Total apparent digestion, %							
OM	61.62	62.90	60.98	60.35	2.72	0.75	0.73
NDF	62.61	61.90	58.16	53.82	3.24	0.08	0.58
Wheat Straw Rate[c]	4.67	4.61	4.48	4.53	0.20	0.64	0.78
Extent at 24 hour, %	31.79	35.80	34.39	34.65	2.03	0.25	0.26
Extent at 48 hour, %	49.45	47.67	49.06	47.69	1.00	0.14	0.80
Extent at 96 hour, %	55.45	55.74	57.56	55.79	1.36	0.82	0.34
Soy Hulls Rate[c]	4.33	4.78	4.59	4.59	0.19	0.34	0.27
Extent at 24 hour, %	72.57	81.97	74.99	76.11	3.00	0.38	0.16
Extent at 48 hour, %	96.09	96.01	96.54	95.32	0.63	0.31	0.30
Extent at 96 hour, %	97.25	97.24	97.92	97.73	0.18	0.07	0.59

[ab]Means within rows having different superscripts differ at $P \leq 0.05$.
[c]Percent NDF digestion per h

0.01) (13.5 to 11.8 lb, respectively) because GLY displaced SH in the diet and intake decreased. Increasing glycerin inclusion tended to linearly decrease ($P = 0.10$) NDF duodenal flow and had no effect on ruminal NDF digestibility ($P \geq 0.33$). Glycerin inclusion had no effect on OM or NDF fecal output ($P \geq 0.20$). As GLY inclusion increased from 0 to 12%, total tract OM digestibility was not different ($P \geq 0.73$) while total tract NDF digestibility tended to decrease linearly ($P = 0.08$) from 62.6 % to 53.8%, respectively. However, the inclusion of GLY had no effect on in situ rate of NDF digestibility ($P \geq 0.27$) for WS or SH. Because the GLY is replacing SH which has a higher NDF digestibility than WS, the proportion of digestible dietary NDF decreases. Thus, the decrease in total tract NDF digestibility may not be a result of changes in fermentation but rather a function of the decrease in a more digestible source of NDF as GLY displaced SH.

Molar acetate proportion (Figure 1) decreased ($P < 0.01$) while molar propionate proportions (Figure 2) increased ($P < 0.01$) as dietary GLY concentration increased and as time post-feeding progressed from-1 to 8 h. Butyrate concentration increased ($P < 0.01$) at 2, 5, and 8 h post feeding for 8 and 12% GLY, while proportions were unchanged for 0 and 4% GLY (Figure 3). Subsequently, acetate to propionate ratio decreased ($P < 0.01$) as GLY inclusion increased from 0 to 12% and time from feeding increased from-1 to 8 h (Figure 4).

The inclusion of GLY in forage-based diets appears to have an effect on fiber digestion due to a decrease in total tract NDF digestibility. However, when evaluating the decrease in dietary NDF digestibility as GLY replaces SH, coupled with no decrease in *in situ* NDF digestibility, the inclusion of GLY in forage-based diets does not appear to impact NDF digestibility. Incorporating GLY in forage-based diets decreases acetate to propionate ratio, which may improve F:G.

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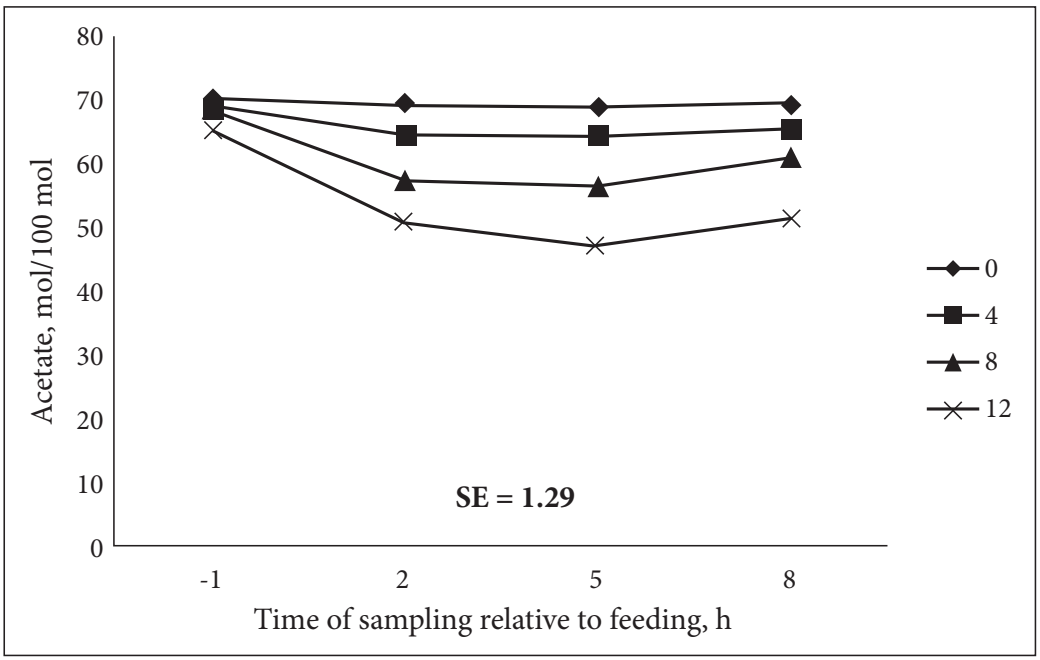

Figure 1. Ruminal acetate VFA proportions from samples collected at-1, 2, 4, and 8 h post feeding. Treatment diets consisted of 0, 4, 8, or 12% dietary crude glycerin (GLY). There was a treatment x time interaction ($P < 0.01$) for acetate VFA proportions as GLY inclusion increased. At 1 h pre-feeding, 0 and 4% GLY were similar ($P = 0.28$), while 0 and 8% GLY tended to be different ($P = 0.09$), and all were significantly different from 12% GLY ($P \leq 0.01$). Acetate VFA proportions were significantly different for all GLY concentrations at 2, 5, and 8 h post feeding ($P \leq 0.01$).

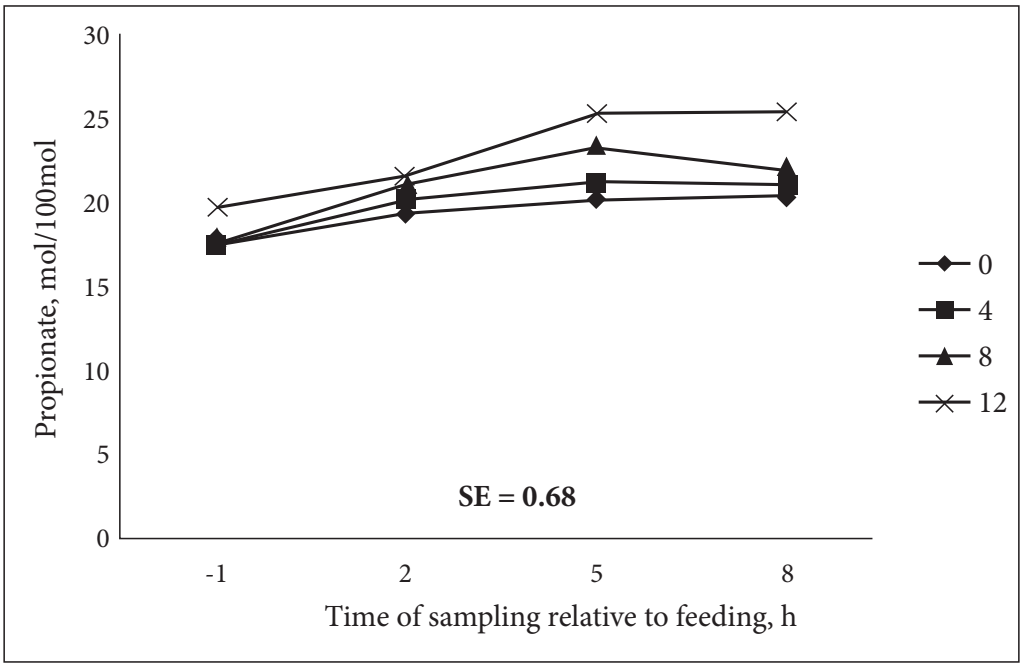

Figure 2. Ruminal propionate VFA proportions from samples collected at-1, 2, 4, and 8 h post feeding. Treatment diets consisted of 0, 4, 8, or 12% dietary crude glycerin (GLY). There was a treatment x time interaction ($P < 0.01$) for propionate VFA proportions as GLY inclusion increased. At 1 h pre-feeding, propionate VFA proportions for 0, 4 and 8% GLY were similar ($P \geq 0.52$) while all were significantly different from 12% GLY ($P \leq 0.01$). At 2 h post feeding, 0% GLY was similar to 4% GLY ($P = 0.22$) but different from 8 and 12% GLY ($P \leq 0.01$), while 4% GLY was similar to 8% GLY ($P = 0.19$) but different from 12% GLY ($P = 0.03$) and 8 and 12% GLY were similar ($P = 0.42$). At 5 h post feeding, 0% GLY was similar to 4% GLY ($P = 0.14$) but different from 8 and 12% GLY ($P \leq 0.01$), while 4, 8 and 12% GLY were significantly different ($P \leq 0.01$) from one another. At 8 h post feeding, 0% GLY was similar to 4% GLY ($P = 0.24$), but different from 8 and 12% GLY ($P \leq 0.02$), while 4% GLY was similar to 8% GLY ($P = 0.22$) but 4 and 8% GLY were different from 12% GLY ($P < 0.01$).

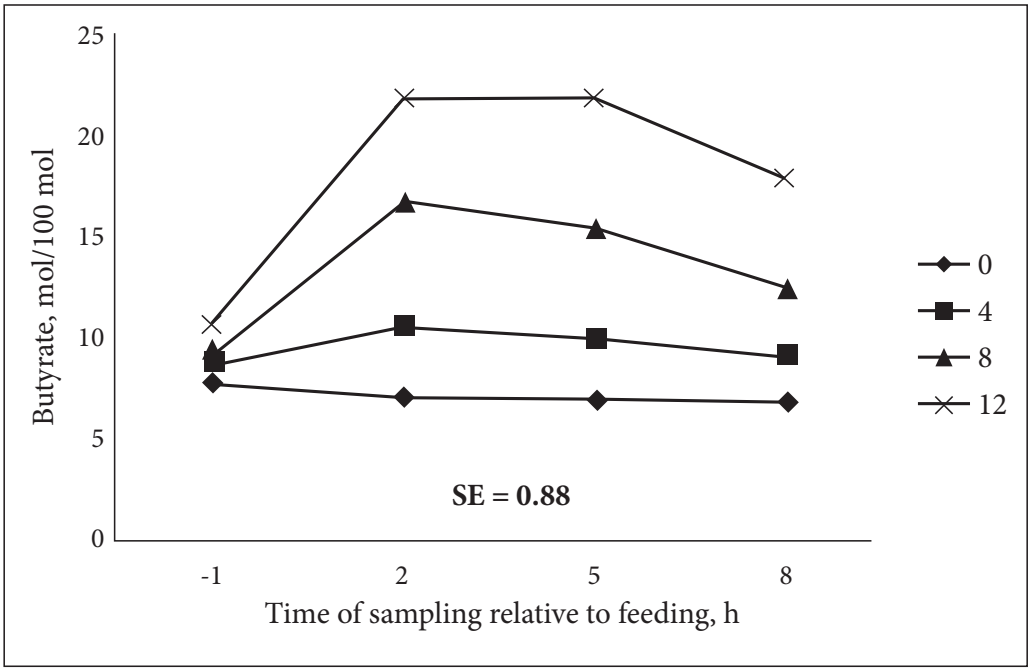

Figure 3. Ruminal butyrate VFA proportions from samples collected at-1, 2, 4, and 8 h post feeding. Treatment diets consisted of 0, 4, 8, or 12% dietary crude glycerin (GLY). There was a treatment x time interaction ($P < 0.01$) for butyrate VFA proportions as GLY inclusion increased. At 1 h pre-feeding, ruminal butyrate VFA proportions were similar between 0 and 4% GLY ($P = 0.19$), 4 and 8% GLY ($P = 0.58$), while 8% GLY tended to be different from 0% GLY ($P = 0.06$) and 12% GLY ($P = 0.10$). Butyrate VFA proportions quadratically increased ($P \leq 0.01$) as GLY concentration increased and time post feeding increased to 2, 5, and 8 h.

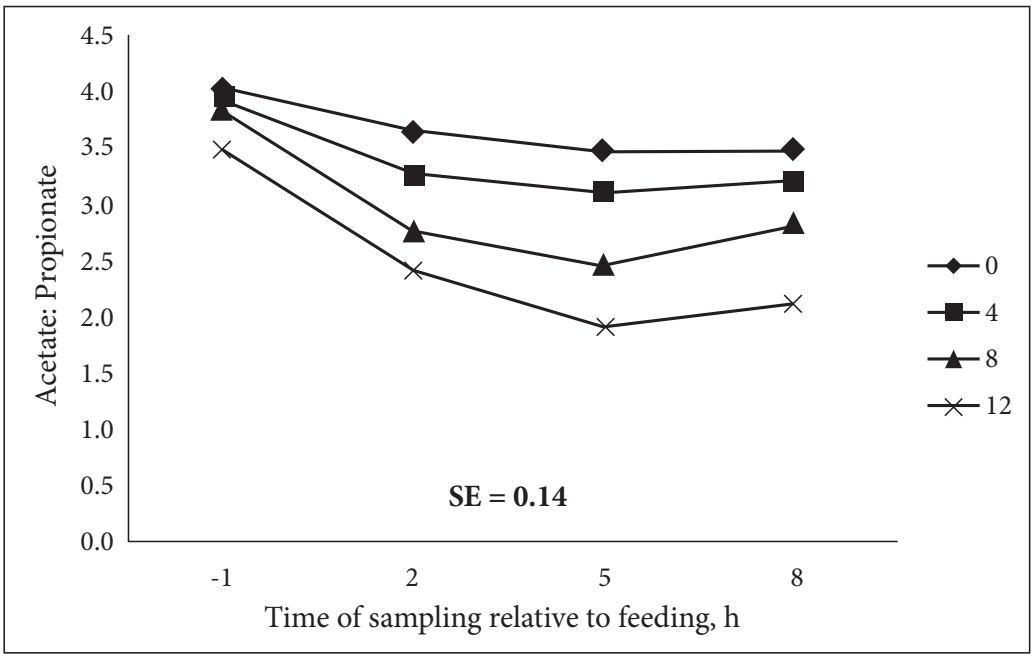

Figure 4. Ruminal acetate to propionate ratio from samples collected at-1, 2, 4, and 8 h post feeding. Treatment diets consisted of 0, 4, 8, or 12% dietary crude glycerin (GLY). There was a treatment x time interaction ($P < 0.01$) for acetate to propionate ratio as GLY inclusion increased. At 1 h pre-feeding, acetate to propionate ratio for 0, 4 and 8% GLY was similar ($P \geq 0.14$) while all were significantly different from 12% GLY ($P \leq 0.01$). Acetate to propionate ratio quadratically decreased ($P < 0.01$) as GLY concentration increased and time post feeding increased to 2, 5, and 8 h.

Impact of Crude Glycerin Supplementation on Rumen and Duodenal Microbial Populations in Forage Diets

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Summary

Seven ruminally and duodenally fistulated beef steers were fed 0%, 4%, 8%, and 12% crude glycerin in forage-based diets. Rumen and duodenal samples were used to determine the effects of crude glycerin on the prevalence of five selected species of ruminal bacteria. In the rumen, Anaerovibrio lipolytica and Selenomonas ruminantium increased while Butyrivibrio fibrosolvens, Fibrobacter succinogenes, and Megasphaera elsdenii were unaffected. In the duodenum, A. lipolytica, S. ruminantium, and B. fibrosolvens increased while F. succinogenes and M. elsdenii were unaffected. Changes in the relative abundance of microbial species may help explain animal performance responses to crude glycerin.

Introduction

In an effort to keep feed costs low, beef cattle producers often incorporate byproducts as feed ingredients into the beef cattle diet. The primary byproduct of biodiesel production is crude glycerin which has become more abundant with industry growth, at times making it a cost effective feed additive. Crude glycerin has been shown to increase performance when fed in moderate amounts. Decreases in the acetate to propionate ratio commonly reported with the addition of crude glycerin may have positive impacts on F:G. However, the impacts of crude glycerin on fiber digestion are unclear and changes in ruminal microbial populations may help understand this relationship. However changes in microbial community composition during glycerin supplementation are undocumented.

The objective of this study was to determine the effects of crude glycerin on the abundance of five species of rumen microbes that are known to influence energy metabolism and fiber digestion within the rumen. The five species investigated in this study were *Selenomonas ruminantium*, *Megasphaera elsdenii*, *Butyrivibrio fibrosolvens*, *Anaerovirbrio lipolytica*, and *Fibrobacter succinogenes*. Species were selected based on metabolic pathways and substrates utilized by these microbes. The lipid digester *A. lipolytica* was the major species of interest because of its ability to metabolize glycerol. It was hypothesized that this species would increase in abundance with increasing glycerin concentrations. Fiber digesters were included to investigate the influence of glycerin on fiber digestion.

Procedure

Seven ruminally and duodenally fistulated beef steers were used in a four diet, four period, row by column transformation with dietary treatments of 0%, 4%, 8%, and 12% glycerin. The basal diet consisted of wheat straw, soybean hulls, and soybean meal. Crude glycerin replaced soybean hulls and soybean meal increased with increasing concentration of crude glycerin to ensure sufficient nitrogen in the diet. Diets and digestion parameters from this study are reported elsewhere (*2016 Beef Report*, pp. 40–43).

Samples were collected from ruminal and duodenal cannulas 8 hours post-feeding on the last day of a 21-day period. Total DNA was extracted from rumen and duodenal samples and the microbial species abundance was quantified using quantitative realtime PCR with species-specific primers. Real-time assays were performed using the SYBR Green reporter assay and the relative fold change in the rumen and duodenum were calculated using the ΔΔ CT method relative to the control for each species. The 16S rRNA gene was used to normalize the data before fold change was calculated. Data were analyzed using

Table 1. Fold Change in Selected Ruminal Microbial Species in Response to Crude Glycerin

Species	Dietary crude glycerin inclusion				SE	*P*-value	
	0%	4%	8%	12%		linear	quadratic
A. lipolytica	1.00	3.73	15.67	13.69	0.81	< 0.01	0.18
B. fibrosolvens	1.00	0.54	1.41	0.86	0.77	0.83	0.91
M. elsdenii	1.00	1.59	5.35	2.02	1.18	0.27	0.52
F. succinogenes	1.00	1.04	3.77	1.52	0.49	0.31	0.30
S. ruminantium	1.00	1.91	18.47	21.44	1.12	< 0.01	0.74

Table 2. Fold Change in Selected Duodenal Microbial Species in Response to Crude Glycerin

Species	Dietary crude glycerin inclusion				SE	*P*-value	
	0%	4%	8%	12%		linear	quadratic
A. lipolytica	1.00	1.29	8.07	8.85	0.70	< 0.01	0.87
B. fibrosolvens	1.00	13.97	17.09	21.35	0.39	< 0.01	< 0.01
M. elsdenii	1.00	1.47	1.35	1.35	0.51	0.61	0.59
F. succinogenes	1.00	0.82	0.99	1.13	0.33	0.87	0.90
S. ruminantium	1.00	1.11	4.02	4.33	0.42	< 0.01	0.97

the mixed procedures of SAS. The model included glycerin concentration, animal, and period. Contrasts were developed to test linear and quadratic change in species abundance as glycerin inclusion increased.

Results

In the rumen, *S. ruminantium* linearly increased up to 21-fold at 12% glycerin supplementation (Table 1; $P = 0.02$) and *A. lipolytica* linearly increased up to 16-fold at 8% glycerin supplementation ($P < 0.01$). *F. succinogenes*, *B. fibrosolvens*, and *M. elsdenii* abundance did not change within the rumen ($P > 0.27$). In the duodenum, *S. ruminantium* and *A. lipolytica* linearly increased up to 4-fold (Table 2; $P < 0.001$) and up to 9-fold ($P < 0.001$) at 12% glycerin supplementation, respectively. *F. succinogenes* and *M. elsdenii* populations showed no significant change in the duodenum ($P > 0.86$). *B. fibrosolvens* increased quadratically up to 21-fold at 12% glycerin supplementation in the duodenum ($P < 0.001$).

An increase in *A. lipolytica* is indicative of an increase in propionate which could positively impact animal performance. An increase in *S. ruminantium* indicates an increase in lactate utilization within the rumen. Since there was no change in the abundance of *M. elsdeni* (a lactate utilizer), the data suggest that the primary metabolic pathway being utilized for lactate utilization is the succinate pathway. An insignificant effect on *F. succinogenes* suggests that fiber digestion is not affected or may not be negatively affected by an increase in dietary glycerin. Overall, the data suggest that crude glycerin inclusion at moderate levels in the beef cattle diet may have positive effects on feed efficiency because of the increase in propionate producing microbial species.

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Methane Production, Diet Digestibility, and VFA Profile of Growing Steers Fed High or Low Quality Forage

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Summary

A headbox calorimeter study evaluated the impacts of forage quality on methane production, diet digestibility, and VFA profile of growing steers. Daily production of methane and carbon dioxide were greater for steers fed high-quality compared to low-quality forages. There was no difference in DM or OM digestibility, likely due to dramatic intake differences, and no difference in the amount of methane produced per unit of OM digested. Methane emissions data from this study agree reasonably well with those obtained by alternate methods previously utilized by this group.

Introduction

Methane production through enteric fermentation by ruminants is a nutritional as well as an environmental concern. Forage is the primary component in diets fed to beef cattle. There is a vast array of forages available and forages vary widely in quality, often measured as differences in fiber (NDF) content. This variation in forage characteristics can have a significant impact on animal performance and CH_4 emissions due to differences in digestibility and resulting VFA profile. Therefore, the objective of this experiment was to determine the impact of forage quality in growing diets on methane production using indirect calorimetry; and to compare results with those obtained by a less intensive method described previously (*2014 Nebraska Beef Cattle Report*, pp. 29–31).

Procedure

Six intact, crossbred steers (initial BW 813 lb; SD = 37 lb) were used in a 3-period switchback designed, calorimetry study to evaluate CH_4 production by growing cattle consuming low- or high-quality forage. Steers were paired by similar BW and assigned randomly within pair to one of two treatments for three, 21-d periods, with a 4-d fecal sample collection period and two consecutive, 23-h periods in the headbox calorimeter. Two treatments were designed to be similar to a previous study (*2014 Nebraska Beef Cattle Report*, pp. 29–31): a high-quality forage diet consisting of a 60:40 sorghum silage:alfalfa hay blend with 20% MDGS (HQ) or a low quality forage diet consisting of 75% ground corn stalks and 20% MDGS (LQ), each with 5% supplement. Urea was included in the LQ diet at 1.65% and both treatments were formulated to provide 200 mg/steer daily of monensin (Rumensin, Elanco Animal Health). Nutrient composition of the HQ diet was: 14.8% CP, 50.5% NDF, and 37.1% ADF. The nutrient composition of the LQ diet was: 13.9% CP, 68.3% NDF, and 48.3% ADF. Steers were fed *ad libitum* once daily at 0800. Feed refusals were weighed back daily and on d 10–14, weighed, subsampled, and dried at 60°C for DM determination.

Apparent total tract digestibility of DM, OM, NDF, and ADF were determined through total fecal collection using fecal bags on d 12–15. Feces were weighed, mixed, and composited by day and steer for DM determination. Steer by period composites of feces, feed ingredients, and feed refusals were dried, ground, and analyzed for DM as described above. All samples were ashed at 600°C for 6 h for OM determination. In addition, NDF and ADF analyses were performed on all samples using the ANKOM system. Rumen fluid was collected on the morning of day 20, prior to feeding, and analyzed for VFA profile.

Methane emissions were measured through indirect calorimetry using headboxes constructed at the University of Nebraska-Lincoln with the guidance of the U.S. Meat Animal Research Center (Clay Center, NE). Steers were trained and acclimated to the headboxes before the initiation of the study. Only two headboxes were available, so the start day of the trial for each pair of steers was offset. Methane collections consisted of two consecutive, 23-h periods on d 20 and 21 of each period. Feed offered continued to be called and adjusted throughout all collections, with the goal of *ad libitum* access. Steers and feed were placed in the headboxes at approximately 0800 and the doors were closed and vacuum motor turned on for 15 minutes before collections commenced to allow for air equilibration. Total gas flow through the system was measured using a flowmeter and a constant, proportional sample of inlet and exhaust air was sampled and regulated using flowmeters. Gas samples were collected in methane gas collection bags and analyzed for CH_4 and CO_2 using a gas chromatograph. Steers were removed from headboxes for one hour between the two collection days to rest in their home pens and allow for cleaning and removal of refused feed.

Nutrient intake and digestibility as well as CH_4 and CO_2 production were analyzed using the MIXED procedure of SAS (SAS Inst., Cary, NC) with period and treatment as fixed effects and steer as the random effect. An α-level of $P \leq 0.10$ was considered significant.

Results

Digestibility

Intake of DM, OM, and ADF were greater for cattle fed HQ compared to LQ forage ($P \leq 0.01$, Table 1), with DMI of HQ forage being 48% greater than that of LQ forage. Intake of NDF also tended to be greater when steers consumed HQ forage ($P = 0.06$). Apparent total tract digestibility of DM tended ($P = 0.08$) to be greater for those cattle fed HQ compared to LQ forage (63.7 and 61.5% respectively). No differences were observed for OM digestibility ($P = 0.59$). Both NDF and ADF digestibilities were greater in cattle fed diets containing LQ forage compared to HQ ($P < 0.01$). As expected, cattle fed the alfalfa hay and sorghum silage blend ate more than those fed ground corn stalks. Greater intakes of

Table 1. Intake and digestibility of steers fed diets containing high or low quality forage.

Item	Treatment[a]		SEM	*P*-value
	HQ	LQ		
Intake, lb/d				
DM	21.6	14.6	0.57	< 0.01
OM	19.6	13.5	0.51	< 0.01
NDF	10.6	9.7	0.35	0.06
ADF	7.7	6.8	0.22	0.01
Apparent total tract digestibility, %				
DM	63.7	61.5	1.15	0.08
OM	66.0	66.7	1.07	0.59
NDF	54.6	64.2	1.27	< 0.01
ADF	49.5	58.7	1.49	< 0.01

[a]HQ = diets containing high-quality forage; LQ = diets containing low-quality forage.

Table 2. Methane emissions and VFA profile of steers fed diets containing high or low quality forage.

Item	Treatment[a]		SEM	*P*-value
	HQ	LQ		
Emissions				
CH_4:CO_2	0.090	0.082	0.002	0.03
CH_4, L/d	210	132	6.6	< 0.01
CH_4, L/lb OM digested	16.1	14.9	0.59	0.14
CO_2, L/d	2404	1654	76.4	< 0.01
VFA profile				
Acetate, mol %	66.3	67.6	1.02	0.22
Propionate mol %	19.5	19.8	0.95	0.82
Butyrate, mol %	10.1	8.8	0.61	0.05
Acetate: Propionate	3.4	3.5	0.22	0.94

[a]HQ = diets containing high-quality forage; LQ = diets containing low-quality forage.

DM, OM, NDF, and ADF by those steers consuming HQ forage could be attributed to the increased passage rate and reduced gut fill limitation associated with a diet that contains less NDF (50.5 vs. 68.3) and ADF (37.1 vs. 48.3) than the LQ forage. The tendency for the small increase in DM digestibility in HQ compared to LQ forage is not the magnitude of response expected. However, the large difference in DMI (48% greater for HQ) may have led to similar digestibility estimates, presumably due to a slow passage rate for LQ forage. In addition, NDF values are not ash corrected which may impact absolute values of NDF in the LQ treatment. Even so, digestibility for LQ forage was greater than anticipated. Similarly, we expected to observe a lower OM digestibility for cattle fed LQ forage, as would be indicated by performance of those fed a similar diet (*2014 Nebraska Beef Cattle Report*, pp. 29–31). The digestibility data are potentially due to the dramatic difference in DMI, especially considering that steers fed HQ forage had intakes approaching 3% of BW.

Methane Emissions and VFA Profile

Cattle consuming HQ forage had greater CH_4:CO_2 ($P = 0.03$, Table 2) than those fed LQ forage (0.090 vs. 0.083). Methane and CO_2 production (L/d) were also greater ($P < 0.01$), with cattle fed HQ forage producing 59 and 43% more than those consuming LQ forage, respectively. However, due to the 31% decrease in OM intake in LQ vs. HQ forage diets, no difference was observed for CH_4 production per lb of OM digested ($P = 0.14$). Increasing forage quality, as defined by decreasing fiber content impacts CH_4 production by decreasing acetate production, which has traditionally been associated with lower observed CH_4 production. However, we did not observe the expected differences in methane production due to forage quality. In this study, HQ forage increased both daily CH_4 production and CH_4:CO_2, the latter of which should account for differences due to DMI. It is important to remember, however, that although HQ forage results in greater daily CH_4 production, cattle fed LQ forage gain less weight, negating savings in daily CH_4 production on a weight gain basis.

Forage quality had no impact on molar proportion of acetate or propionate ($P = 0.22$ and $P = 0.82$, respectively; Table 2). Thus, A:P was not different, 3.4 vs 3.5 in HQ and LQ forage diets ($P = 0.94$). Concentration of butyrate was greater in those cattle consuming HQ forage ($P = 0.05$). An increase in total VFA concentration could be expected but total VFA production was not measured in this study, and total mM concentration of VFA is not reported as the concentration is not indicative of VFA production and sampling method used in this study is not ideal for measuring total VFA concentration due to potential saliva contamination (esophageal tubing). Additionally, no differences in VFA profile is likely due to the time of rumen fluid collection, which was in the morning prior to feeding, when VFA profile is least impacted due to diet quality.

A major objective of this work was to compare methane emissions values obtained by our system described in the *2014 Nebraska Beef Cattle Report*, pp. 29–31, with those obtained in this study using indirect calorimetry. A comparison of emissions values for cattle fed high and low-quality forage, obtained through each

system is presented in Table 3. While the absolute values may not agree, we consider the relative differences as well as the direction of change between treatments, to be in reasonable agreement. The newly developed system appears to be capable of detecting differences, at least of the magnitude displayed in this comparison, though HQ and LQ forage treatments were chosen specifically for their expected differences in CH_4 production.

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Table 3. Comparison of emissions data obtained through methods described in *2014 Nebraska Beef Cattle Report*, pp.29–31 or by calorimetry in the current study

Item	Treatment[a]	
	HQ	LQ
CH_4:CO_2		
Headbox[b]	0.090	0.082
Calan[c]	0.101[d]	0.088
CH_4, L/d		
Headbox	210	132
Calan	224–345[d]	125
CO_2, L/d		
Headbox	2404	1654
Calan	2210–3447[d]	1421
DMI, lb		
Headbox	21.6	14.6
Calan	19.6–22.7[d]	10.8

[a]HQ = diets containing high-quality forage; LQ = diets containing low-quality forage.
[b]Values obtained in current, through indirect calorimetry.
[c]Values obtained in *2014 Nebraska Beef Cattle Report*, pp. 29–31.
[d]A range is shown for values obtained in Exp. 1 because an exact diet comparison is not available. High-quality forage diets in Calan gate barn contained 0 or 40% modified distillers grains plus solubles; those in the current study contained 20%.

Effects of Protein Supplementation in Corn Silage Growing Diets Harvested at 37 or 43% DM on Cattle Growth

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Summary

A growing study evaluated the effects of harvesting drier corn silage and response to rumen undegradable protein (RUP) supplementation. Corn silage was harvested at 37 or 43% DM from the same fields and protein supplement (high in RUP) was provided at 0.0, 2.5, 5.0, 7.5 or 10.0% of diet DM. Ending BW and ADG were decreased, while F:G was increased, when steers were fed 43% DM silage compared to 37% DM silage (88% silage inclusion). Increasing supplemental RUP in the diet increased ending BW, DMI, and ADG linearly, and decreased F:G linearly. Drier silage had less energy for growing steers while supplemental RUP improved gain and efficiency in silage growing diets.

Introduction

Feeding greater inclusions of corn silage during times of increased corn prices can be an economical alternative compared to corn, although ADG and F:G are not as favorable. Feeding corn silage allows cattle feeders to take advantage of the entire corn plant at a time of maximum quality and tonnage as well as secure substantial quantities of roughage/grain inventory (*2013 Nebraska Beef Cattle Report*, pp. 74–75). Plot work suggests that as corn harvest is delayed to black layer formation, corn and whole plant yield is maximized with little effect on nutritive quality as measured in the lab (*2013 Nebraska Beef Cattle Report*, pp. 42–43; *2016 Nebraska Beef Cattle Report*, pp. 79–80).

Corn silage typically contains 6.5 to 8.5% CP, most of which is in the form of RDP and is utilized for microbial protein synthesis. Our hypothesis was that very little protein from corn silage escapes the rumen (i.e., RUP) and previous estimates of RUP of silages are likely incorrect. Inadequate supplemental RUP could result in inadequately meeting metabolizable protein requirements (NRC, 2000). Thus, source and amount of supplemental protein are important factors affecting growth because supplemental protein provides a significant amount of the total dietary protein (2014 Professional Animal Scientist, pp. 327–332). Therefore, the objectives of this experiment were to determine the effects of delaying corn silage harvest on growing steer performance while determining RUP response when growing cattle are fed corn silage-based diets.

Procedure

Corn silage harvest data were previously presented (*2016 Beef Cattle Report* pp. 146–48). Corn silage was harvested at the Agricultural Research and Development Center (ARDC) near Mead, Neb. Harvest DM was targeted to mimic traditional corn silage harvest at 37% DM or a delayed harvest at 43% DM. Corn silage harvest was initiated when the field was at approximately ¾ milkline for the 37% DM corn silage (9/4/2014), and delayed two wks coinciding with black layer formation for the 43% DM corn silage (9/16/14). Corn silage was harvested in 4 replications within field and green chop samples were taken for DM determination on a Koster tester prior to bagging. Additionally, high moisture corn and dry corn yield strips were harvested within the same field on 9/18/14 and 11/4/14, respectively. Both 37% DM and 43% DM silages were stored in sealed AgBags and after 28 d, silage was sampled for fermentation analysis and DM samples were collected weekly during feedout (Table 1).

A 78-d growing study was conducted using crossbred steers (n = 60; initial BW = 597 lb; SD = 70 lb) that were individually fed using the Calan gate system. Trial initiation occurred after 4 months of corn silage harvest. Five days before trial initiation, cattle were limit-fed a common diet of 50% alfalfa hay and 50% Sweet Bran (Cargill, Blair, Neb) at 2% of BW to reduce variation in gut fill and then weighed on

Table 1. Nutrient and fermentation analysis of 37 and 43 % DM silage

Item	37 DM		43 DM	
	Mean	C.V.[a]	Mean	C.V.[a]
DM[b]	37.3	(3.2)	42.7	(3.9)
CP	7.51	(3.6)	7.50	(1.2)
NDF, %	31.55	(17.5)	28.88	(5.7)
ADF, %	21.38	(15.8)	18.63	(17.9)
Starch, %	35.4	(16.7)	40.8	(5.0)
Sugar, %	2.6	(19.6)	2.5	(8.7)
pH	3.88	(1.3)	3.85	(1.5)
Lactic acid, %	3.11	(26.9)	4.14	(28.1)
Acetic acid, %	3.98	(21.5)	2.81	(27.1)
Propionic acid, %	0.51	(26.8)	0.28	(54.3)
Butyric acid, %	< 0.01	(0.0)	< 0.01	(0.0)
Total acids, %	7.61	(10.5)	7.22	(3.3)

[a]C.V. = coefficient of variation and is calculated by dividing the standard deviation by the mean and is expressed as a percentage.
[b]DM was calculated using weekly samples and oven dried for 48 h at 600 C.
Note: All other samples are based on monthly composites, and analyzed at Dairyland Labs (St. Cloud, MN) and Ward Labs (Kearney, NE).

3 consecutive days, with the average used as initial BW. The common growing diet consisted of either 37% DM or 43% DM corn silage at 88% of diet DM, and treatments consisted of top dressing a blend of 0/100, 25/75, 50/50, 75/25, or 100/0 combination of a RDP and RUP supplement (Table 2). This combination allowed for 0, 2.5, 5.0, 7.5, or 10 % in the form of SoyPass (50% CP; 75% RUP as % of CP) and Empyreal (Cargill, Blair, Neb; 75% CP; 65% RUP as % of CP) in the growing diet. The supplement included Rumensin and was formulated to provided 200 mg/steer daily. Steers were stratified by day-1 and day 0 BW, and assigned randomly to 1 of 10 treatments (Table 2), arranged in a 2 × 5 factorial arrangement with 5 to 8 steers per level of RUP supplementation (n = 8 for 0% RUP; n = 5 for 2.5% and 5% RUP; n = 6 for 7.5% and 10.0% RUP treatments). With a limited number of bunks, a greater number of animals were used at 0% RUP inclusion to establish the intercept for response to supplemental RUP. In addition, a greater number of steers were in the7.5% and 10% supplemental RUP source treatments to establish the maximum gain response as it was hypothesized the metabolizable protein needs would be met. Steers were implanted with Ralgro on d 0. Steers were fed ad libitum once daily at 8 am. Feed refusals were collected weekly, weighed, and then dried in a 60°C forced air oven for 48 hours to calculate an accurate DMI for individual steers. At the conclusion of the study, steers were limit-fed the same diet as prior to the start of the trial at 2% of BW for 5 days. Weights were collected for 3 consecutive days and averaged to determine an accurate ending BW.

Data were analyzed using the mixed procedure of SAS as a randomized block design in a 2 × 5 factorial arrangement testing for linear and quadratic interactions between silage DM and RUP supplementation with steer serving as the experimental unit and weight block as a fixed effect. If no interactions were detected, the main effects of silage DM and supplemental RUP were evaluated. To evaluate RUP supplementation, linear and quadratic contrasts were developed to determine the effect of increasing RUP inclusion. Significance was declared at $P \leq 0.05$.

Table 2. Diet composition (% of diet DM) fed to individually-fed growing steers for 78 d

Ingredient	Treatment[a]									
	37% DM					43% corn silage				
	0.0%	2.5%	5.0%	7.5%	10.0%	0.0%	2.5%	5.0%	7.5%	10.0%
37% DM corn silage	88.0	88.0	88.0	88.0	88.0	—	—	—	—	—
43% DM corn silage	—	—	—	—	—	88.0	88.0	88.0	88.0	88.0
RDP supplement[b]	12.0	9.0	6.0	3.0	0.0	12.0	9.0	6.0	3.0	0.0
RUP supplement[c]	0.0	3.0	6.0	9.0	12.0	0.0	3.0	6.0	9.0	12.0

[a]Treatments: Diets contained 88% of either 37 or 43% DM corn silage and formulated to contain 0, 2.5, 5.0, 7.5 or 10.0% RUP.
[b]RDP supplement: was formulated for a target inclusion level of 12% and contained 9.35% soybean hulls, 1.2% urea, 0.45% dicalcium phosphorus, 0.40% salt, 0.3% tallow, 0.21% limestone, 0.05% trace minerals, 0.015% Vitamin A-D-E as a % of total diet DM. Formulated to provide 200 mg/steer daily of Rumensin (Elanco, Greenfield, IN :DM basis)
[c]RUP supplement: was formulated for a target inclusion level of 12% and contained 6.0% SoyPass, 4.0% Empyreal (Cargill branded corn gluten meal product, Blair, Neb), 0.42% soybean hulls, 0.3% urea, 0.2% dicalcium phosphorus, 0.30% Salt, 0.3% tallow, 0.40% limestone, 0.05% trace minerals, 0.015% Vitamin A-D-E as a % of total diet DM. Formulated to provide 200 mg/steer daily of Rumensin (% of diet DM)

Table 3. Effects of delayed silage harvest on growing steer performance

Item	Treatments[a]		SEM	*P*-value
	37% DM	43% DM		
Initial BW, lb	597	597	3.8	0.92
Ending BW, lb	846	826	6.7	0.04
DMI, lb/d	18.0	17.9	0.3	0.93
ADG, lb	3.19	2.93	0.07	0.01
Feed:Gain[b]	5.63	6.11	—	< 0.01

[a]Treatments: steers were fed 88% of either 37 or 43% DM corn silage.
[b]Analyzed as gain:feed, the reciprocal of F:G.

Table 4. The effects of increased inclusion of RUP in silage based growing diets on performance of cross bred steers

Variable	Treatments[a]					SEM	Lin.	Quad.
	0.0%	2.5%	5.0%	7.5%	10.0%			
Initial BW, lb	595	597	597	596	600	5.2	0.98	0.60
Ending BW, lb	791	824	855	842	868	9.1	< 0.01	0.88
DMI, lb/d	16.9	18.3	18.9	17.4	18.4	0.5	0.05	0.84
ADG, lb	2.51	2.91	3.31	3.15	3.43	0.09	< 0.01	0.82
F:G[b]	6.74	6.26	5.71	5.52	5.35	—	< 0.01	0.57

[a]Treatments: steers were fed 88% corn silage and a combination of RDP and RUP supplements to achieve either 0, 2.5, 5.0, 7.5 or 10 % RUP in the final diet.
[b]Analyzed as gain:feed, the reciprocal of F:G.

Results

There were no linear ($P \geq 0.33$) or quadratic ($P \geq 0.36$) interactions between corn silage DM and RUP supplementation for growing performance, therefore main effects will be discussed. As DM of corn silage increased from 37 to 43% there was a significant decrease ($P = 0.04$) in ending BW (Table 3). There was no difference ($P = 0.93$) in DMI between 37 or 43% DM corn silage, and ADG was reduced ($P = 0.01$) as DM of silage increased, which led to a significant increase ($P < 0.01$) in F:G.

As supplemental RUP sources in the growing diet increased from 0 to 10%, ending BW increased linearly ($P < 0.01$), with steers receiving 10% RUP sources having the heaviest ending BW and steers receiving 0% RUP having the lowest ending BW (Table 4). There was a linear increase ($P = 0.05$) in DMI as RUP inclusion was increased in the growing diet. Daily gain was improved as RUP inclusion increased in the growing diet, with ADG increasing ($P < 0.01$) linearly from 0 to 10% RUP inclusion. With both an increase in DMI and ADG, F:G decreased ($P < 0.01$) linearly as RUP inclusion increased. This indicates that increasing RUP in silage growing diets allowed for increased gains while increasing efficiency of gain.

Feeding silage in growing diets at 88% of diet DM indicates that 37% DM silage would result in greater ADG and lower F:G compared to 43% corn silage. Increasing the amount of RUP in silage growing diets resulted in linear increases in ending BW, DMI, ADG, and F:G. These results indicate that the addition of RUP into silage diets will improve performance by supplying more metabolizable protein. While the main effect of RUP inclusion was linear, the response is diminishing with increasing RUP. Supplementing 10% RUP may be insufficient to meet the metabolizable protein requirements and even greater inclusions may improve ADG and F:G further.

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Effect of Winter Distillers Grains Supplementation Level on Spayed Heifer Performance

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Summary

The effects of winter level of supplementation were evaluated using spayed heifers grazing winter corn residue followed by brome grass and native range grazing periods and finished on a common diet. Distillers grains were supplemented during winter corn residue grazing at 3, 5, and 7 lb per heifer daily. Gain during the winter phase increased while summer phase decreased with increasing level of winter supplementation. There were no differences in feedlot performance for either year across treatments. In year 2, HCW increased from 820 to 848 and 855 lb as heifers were supplemented 3, 5, or 7 lb distillers grains.

Introduction

In previous years grain prices have increased substantially. Thus, the cost to finish beef cattle has increased as well. One way to decrease the cost of finishing is use of a long yearling system to add weight prior to feedlot entry. Previous research (*2014 Nebraska Beef Cattle Report*, pp. 39–45) has shown that spayed heifers which are supplemented only during the winter period, have similar live performance in the feedlot and have increased profit compared to those supplemented in both the winter and summer periods. The increase in profit is the result of an increase in HCW sold when heifers were fed a greater level of supplement during the winter grazing period. However, the optimal amount of winter supplementation has not been defined.

The objective of this experiment was to determine the optimal level of distillers grains supplementation during the winter grazing period by evaluating heifer performance in the winter, summer, and finishing phases in a complete long yearling system. Carcass characteristics were also evaluated to determine if level of winter supplementation had an effect specifically on HCW and thus, the potential for increased profit.

Procedure

A study was conducted over 2 consecutive years utilizing 220 crossbred spayed heifers per year. Treatments included the supplementation of modified distillers grains plus solubles (MDGS) at 3, 5, and 7 lb per heifer per day during the winter corn residue grazing phase.

Winter Phase

Heifers were purchased, received for approximately 30 d then limit fed for 5 consecutive days prior to a 2 day weight collection, with the average as initial BW. Heifers were implanted with Ralgro and backgrounded on corn residue for approximately 150 days and supplemented with 3, 5, or 7 lb of MDGS (DM basis). Heifers were surgically spayed approximately half way through the winter phase.

Summer Phase

Heifers were removed from corn residue, placed in pens and limit fed for 5 consecutive days with a 2 day weight collected to serve as the initial summer BW. Ending BW for the winter phase was calculated as the average of the 2 day weight minus 1 pound for each day heifers were fed the limit diet to correct for weight gain during those 6 days. Heifers were implanted with Revalor-G and then grazed smooth brome grass for approximately 30 days. After grazing smooth brome grass, heifers were transported to UNL Barta Brothers Ranch near Ainsworth, Neb. to graze native Sandhills range for approximately 120 days.

Finishing Phase

Upon completion of summer grazing, heifers were transported to Northeast Research and Extension Center near Concord, Neb. At the facility, heifers were limit fed for 5 consecutive days with a 2 day weight collected. The average of the 2 day weight, corrected for limit fed weight gain, served as the ending BW for the summer phase, and the initial BW for the finishing phase. Heifers were assigned randomly to pen within winter treatment, implanted with Revalor-200® on day 1, and adapted to a common finishing ration containing 23.5% dry-rolled corn, 23.5% high moisture corn, 40% Sweet Bran®, 9% hay, and 4% supplement (DM basis). In year 1 the dietary hay source was oat hay while in year 2 the source was alfalfa. The supplement was formulated to provide minimum of 13.5% CP, Ca:P of 2:1, 30 g/ton Rumensin®, and 90 mg/d Tylan®.

All data were analyzed using the GLIMMIX procedure of SAS (SAS Institute, Inc., Cary, N.C.). The 2 years of data were analyzed separately due to variation in summer gains by year. Finishing pen within winter treatment was included as the experimental unit. Orthogonal contrasts were used to test linear and quadratic effects of winter supplementation level.

Results

Winter Phase

By design, initial BW was similar for each treatment, although year 1 heifers were lighter at 499 lb compared to year 2 at 529 lb. For both years, ADG linearly increased ($P < 0.01$) as MDGS supplementation increased (Table 1). In year 1, heifers gained 1.53, 1.67, and 1.91 lb/d, while year 2 heifers gained 1.43, 1.78, and 2.06 lb/d when supplemented 3, 5, and 7 lb of MDGS (DM) daily, respectively. Subsequently, winter phase ending BW increased linearly ($P < 0.01$) as supplementation amount increased. Heifers weighed 739, 756, and 790 lb for year 1 while in year 2 heifers weighed 726, 777, and 812 lb.

Table 1. Winter, summer and total forage system performance of spayed heifers

	Treatments[a]				*P*-value	
Item,	3	5	7	SEM	Linear	Quadratic
Winter, year 1[b]						
Initial BW, lb	503	499	496	4	0.24	0.81
ADG, lb	1.53	1.67	1.91	0.03	< 0.01	0.17
Ending BW, lb	739	756	790	5	< 0.01	0.22
Winter, year 2[b]						
Initial BW, lb	528	531	529	7	0.95	0.72
ADG, lb	1.43	1.78	2.06	0.02	< 0.01	0.16
Ending BW, lb	726	777	812	8	< 0.01	0.39
Summer, year 1[c]						
ADG, lb	0.80	0.68	0.50	0.03	< 0.01	0.32
Summer, year 2[c]						
ADG, lb	1.18	1.01	0.88	0.03	< 0.01	0.64
Total forage system, year 1[d]						
ADG, lb	1.20	1.23	1.20	0.02	0.85	0.12
Ending BW, lb	865	866	874	6	0.36	0.67
Total forage system, year 2[d]						
ADG, lb	1.29	1.36	1.42	0.02	< 0.01	0.69
Ending BW, lb	915	940	954	8	< 0.01	0.59

[a]Treatments = 3, 5, or 7 lb per day supplementation of modified distillers grains plus solubles during winter corn residue grazing
[b]Winter = corn stalk residue grazing for ~ 150 days
[c]Summer = smooth brome grass grazing for 30 days followed by native range grass for ~ 120 days
[d]Total forage system = average of winter + summer grazing performance

Summer Phase

During the summer phase for both years, heifer ADG linearly decreased ($P < 0.01$) as winter supplementation increased. In year 1, summer ADG was 0.80, 0.68, and 0.50 lb/d while year 2 ADG was 1.18, 1.01, and 0.88 lb/d when MDGS was supplemented at 3, 5, and 7 lb/d in winter. During year 1 summer grazing phase, the Sandhills area was undergoing severe drought conditions, thus explaining the difference in ADG for heifers compared to year 2 when grazing conditions were less severe.

When comparing heifer performance on total forage system (average of winter and summer), there was no difference in ADG ($P = 0.12$) or ending BW ($P = 0.36$) for year 1. However, in year 2 total forage system ADG increased linearly ($P < 0.01$) as winter supplementation increased (1.29, 1.36, and 1.42 lb per day, respectively). For year 2, ending BW linearly increased ($P < 0.01$).

Finishing Phase

For year 1 heifers, there was no difference ($P \geq 0.30$) in finishing performance across treatments (Table 2). Total system ADG (average of winter, summer, and finishing) was not different among treatments ($P = 0.91$). In year 2, final BW linearly increased ($P = 0.04$) from 1301 to 1356 lb due to winter supplementation. Gain and F:G were not different ($P \geq 0.25$) during the fall finishing phase due to winter supplementation. Year 2 total system ADG linearly increased ($P = 0.02$) from 1.82 to 1.95 lb/d as MDGS supplementation increased during the previous winter.

Carcass Characteristics

There were no differences in carcass characteristics ($P \geq 0.27$) for year 1. However in year 2, HCW increased linearly ($P = 0.04$) from 820 to 855 lb as winter supplementation increased, which is similar to previous findings (*2014 Nebraska Beef Cattle Report*, pp. 39–42). It has also been shown that long yearling heifers supplemented at a higher level during winter grazing, produce additional live weight and thus increased revenue (*2014 Nebraska Beef Cattle Report*, pp. 36–38). Similar with year 1, there was no difference in LM area ($P = 0.23$) or marbling score ($P = 0.28$). Contrary to year 1, there was a linear increase ($P = 0.04$) in 12th rib back fat thickness and consequently a linear increase in calculated yield grade ($P = 0.10$) as heifers were supplemented with increasing levels of MDGS in the winter phase.

Level of winter supplementation had no effect on finishing ADG or F:G when backgrounded on summer grass without supplement prior to feedlot arrival. However, higher levels of supplementation increased total system gain when summer grazing is not limited. Supplementing heifers at 7 lb/d MDGS during winter corn residue grazing has the potential to increase HCW and profit potential if maintaining ownership through finishing.

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Table 2. Finishing performance and carcass characteristics of spayed yearling heifers

	Treatments[a]				*P*-value	
	3	5	7	SEM	Linear	Quadratic
Performance, Year 1						
Final BW, lb[b]	1329	1331	1321	14	0.69	0.71
DMI, lb/d	28.5	28.4	28.4	0.4	0.91	0.90
ADG, lb	4.11	4.13	3.96	0.10	0.30	0.44
F:G	6.95	6.88	7.18	—	0.32	0.36
Total system ADG, lb[c]	2.03	2.04	2.02	0.03	0.91	0.63
Carcass characteristics, Year 1						
HCW, lb	837	839	832	9	0.67	0.70
LM area, in^2	13.7	13.8	13.8	0.1	0.60	0.56
Fat Thickness, in	0.53	0.54	0.53	0.02	0.85	0.59
Marbling Score[d]	517	498	508	10	0.50	0.27
Calculated YG	3.1	3.2	3.1	0.1	0.51	0.59
Performance, Year 2						
Final BW, lb[b]	1301	1347	1356	18	0.04	0.42
DMI, lb/d	29.7	30.6	29.8	0.4	0.86	0.07
ADG, lb	3.06	3.22	3.19	0.10	0.36	0.44
F:G	9.80	9.62	9.43	—	0.25	0.98
Total system ADG, lb[c]	1.82	1.92	1.95	0.04	0.02	0.44
Carcass characteristics, Year 2						
HCW, lb	820	848	855	11	0.04	0.43
LM area, in^2	13.1	13.4	13.3	0.1	0.31	0.23
Fat Thickness, in	0.56	0.56	0.64	0.02	0.04	0.19
Marbling Score[d]	561	548	568	12	0.69	0.28
Calculated YG	3.3	3.3	3.6	0.1	0.10	0.29

[a]Treatments = 3, 5, or 7 lb per day supplementation of modified distillers grains plus solubles during winter corn residue grazing
[b]Final BW = carcass adjusted
[c]Total system ADG = average of winter + summer + finishing performance
[d]400 = Small00, 500 = modest00, 600 = moderate00, 700 = Slightly Abundant00, 800 = Moderately Abundant00

Utilizing Corn Residue or Fall Double Cropped Forages for Winter Backgrounding of Calves

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Summary

The impact of three backgrounding systems: grazing corn residue with distillers supplementation at 0.86% BW/d, grazing an oats-brassica forage, or feeding a grower ration in a drylot were evaluated. Calves grazing oats-brassica forage had a greater average daily gain (2.25 lb/d) during the 65 d grazing period than calves grazing corn residue (1.77 lb/d). During the entire growing period (end target weight of 800 lbs) which included 21 days of grower ration for the grazing treatments, gains of calves put directly in the drylot and fed a grower ration (3.58 lb/d) were greater than both grazing treatments and the calves grazing oats-brassica forages had greater gains (2.65 lb/d) than calves grazing corn residue (2.22 lb/d).

Introduction

In Nebraska there is significant opportunity to background spring born calves in the winter using forages produced from crop acres, including crop residues and double cropped annual forages. Calf gain response to differing levels of distillers supplementation when grazing irrigated corn residue has been well documented (*2015 Nebraska Beef Cattle Report*, pp. 25–26). On the contrary, less information is available regarding gain of calves grazing fall double cropped forages, such as oats and brassicas (turnips and radishes) planted after corn silage. Therefore, the objective of this study was to evaluate the performance and economics of backgrounding spring born calves by 1) grazing corn residue and feeding a distillers grains based supplement at 0.86% BW/d, 2) grazing an oats, turnip, radish mix double crop planted after corn silage harvest, or 3) drylotting calves on a corn silage based grower ration.

Procedure

This experiment was conducted at the Meat Animal Research Center near Clay Center, Neb., utilizing 355 spring born, MARC II composite steer calves. All calves were weaned in the third week of September and moved to the feedlot where they were fed the grower ration (Table 1). An initial BW was taken prior to feeding on November 17, 2014. Calves were stratified by BW (610 ± 1.1 lb) and genetic line on November 17, 2014 and then assigned to 1 of 3 treatments: 1) corn residue grazing with distillers supplementation (CRD), 2) oat-brassica forage grazing (OBF) or 3) consuming a grower ration in the drylot (DGR). Each treatment had 4 replicates. On November 20, 2014, calves were sorted to their assigned group and were started on their treatment.

Calves on CRD were placed in an irrigated corn field that was divided into 4 quarters with 31 acres and 30 calves per quarter. The corn yield from this field averaged 225 bu/ac. Calves were supplemented 6 days a week with 6.1 lb DM/hd of dried distillers grains mixed with limestone at 2% on DM basis. Calves on OBF were placed in an irrigated field that was planted after corn silage. The double-crop was planted on September 8, 2014 with 84 lb/ac of oats, 2 lb/ac of daikon radish, and 1.5 lb/ac of purple top turnips. Nitrogen was split applied via pivot on September 15th and 24th (48 lb of N/ac total). This field was divided into 31 acre quarters and initial forage mass was measured on November 6, 2014. Each quarter was stocked at a rate 3617 ± 21 lb DM/hd and there were 25, 30, 30, and 30 calves per quarter. Samples of the oats-brassica forage mixture were taken on November, 6th and December 9th. Samples were composited within date and sent to Dairyland Laboratories to be analyzed for nutrient composition.

Both CRD and OBF calves were given access to a free choice mineral with Rumensin (1,320 g monensin per ton). The CRD and OBF calves were removed from grazing after 64 d when the OBF biomass was 1287 ± 93 lb DM/ac. Each group was placed into a separate feedlot pen and calves were fed the grower ration (Table 1). After 6 days on the grower ration CRD and OBF calves were weighed (d 71). Calves continued to be fed the grower ration for an additional 15 days (d 86), to reach a targeted average BW of 800 lb. At which point they were implanted with Revalor®-XS (Merck Animal Health) and transitioned onto the finishing diet (Table 1).

Calves in the DGR treatment were placed in 4 feedlot pens with 30 calves per pen. They were backgrounded on the grower ration (Table 1) for 54 days, to meet a targeted average BW of 800 lb. At which point they were weighed, implanted with Revalor®-XS and transitioned onto the finishing diet.

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

Table 1. Composition of grower ration

Ingredient	DM basis, %
Corn Silage	51.0
Alfalfa Hay	25.0
WDGS[a]	20.0
Supplement[b]	4.0
Analyzed composition	
NEm, Mcal/lb	0.75
NEg, Mcal/lb	0.47

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

and water maintenance) and CRD calves were charged an additional $0.10/d for the extra labor to feed their supplement. The yardage cost for feed calves in the feedlot was charged at $0.40/d.

Results

OBF Production

Total DM yield of the oats, turnip and radish mixture was 3353 ± 140 lb/ac with 93% (3110 ± 135 lb/ac) being leaf and stem and the remaining 244 lb being tubers of the radish and turnips. Of the forage produced, the oats made up the greatest ($P < 0.01$) proportion (54.5% of DM produced), turnips were intermediate (30.5% of DM produced) and radishes produced the least amount of DM (15.0% of DM). However, the lower seed cost of the turnips resulted in a lower cost per ton of DM produced (Table 2) than both the oats and radishes. The nutrient analysis of the mix is shown in Table 3. The forage produced was high quality and appeared to maintain its quality after frost kill, although some loss of sugar did occur resulting in an increase in fiber (NDF and ADF).

Cattle Performance

Cattle performance during the grazing periods for CRD and OBF is shown in Table 4. Calves consuming OBF had a greater ($P < 0.01$) ADG (2.25 lb/d) during the grazing period than CRD calves (1.77 lb/d). At the end of the grazing period, both treatments were fed a grower ration for 15 days. When fed the grower ration they gained an average of 4.4 lb/d.

When comparing the total growing period ADG across all three treatments (Table 5), DGR calves had the greatest rate of gain (3.58 lb/d), while OBF was intermediate (2.65 lb/d), and CRD had the lowest rate of gain (2.22 lb/d). Therefore, the growing period for CRD and OBF calves was 22 days longer (86 days total) than DGR calves (54 days). The BW of OBF (838 lb) was greater at the end of the growing period than both CRD and DGR (802 vs. 803 lb for CRD and DGR, respectively).

Table 2. Forage production of oats, purple top turnip and daikon radish when planted in a mix after corn silage

	Oats	Turnip	Radish	Total
Seeding rate, lb/ac	84	1.5	2	87.5
Cost of seed, $/ac	25.2	2.7	5.0	32.9
Forage yield, lb DM/ac	1827	1023	503	3353
Forage yield, % of DM	54.50	30.50	15.00	100
Cost of seed, $/ton DM[a]	27.59	5.28	19.88	19.62

[a]Seed cost ($/ac) divided by forage produced (lb DM/ac) × 2000 lb = cost per ton of forage DM.

Table 3. Nutrient content of the forage mix containing oats, daikon radish, and purple top turnips planted September 8th and sampled on November 6th and December 9th

	November	December
DM, %	15.5	59.5
	%, DM basis	
CP	23.2	22.9
TDN	77.8	67.4
ADF	19.9	27.7
NDF	29.9	44.0
Sugar	15.8	7.9

Table 4. Growing performance of calves backgrounded by grazing corn residue plus supplemented with dry distillers at 0.86% of BW (CRD) or grazing fall planted oats and brassica forage (OBF) during the winter

Growing Phase	CRD	OBF	SEM[b]	*P*-value
Grazing Period (71 d period)[a]				
Initial BW, lb	611	609	1.4	0.28
End Grazing BW, lb	737[d]	770[c]	5.9	< 0.01
ADG, lb	1.77[d]	2.25[c]	0.084	< 0.01

[a]Grazed for 65 days on backgrounding treatment and were then feed grower ration for 6 days (d 66–71) prior to weighing (to achieve similar weighing conditions when the initial weight was recorded and to reduce weight variation due to gut fill).
[b]Standard error of the least squares mean.
[c,d]Means within row lacking common superscript differ.

Table 5. Growing performance of calves backgrounded by grazing corn residue plus supplemented with dry distillers at 0.86% of BW (CRD), grazing a fall oats and brassica forage (OBF) or fed a grower ration in drylot (DGR)

Growing Period[a]	CRD	OBF	DGR	SEM[b]	*P*-value
Initial BW, lb	611	609	610	1.4	0.51
End Growing BW, lb	802	838	803	5.3	
ADG, lb	2.22e	2.65d	3.58c	0.067	< 0.01

[a]The CRD and OBF calves grazed for 65 days and were fed grower ration for 21 days (86 d period) while DGR was fed grower ration for 54 days before being implanted and transitioned to the finishing ration.
[b]Standard error of the least squares mean.
[c,d,e]Means within a row lacking common superscript differ.

Economics

A partial budget comparison of the treatments can be found in Table 6. These comparisons do not include veterinary costs, interest, or transportation. During the growing period the cost of gain for CRD was the lowest at $0.35/lb ($P < 0.01$), while the cost of gain for DGR calves was intermediate ($0.40/lb), and OBF had the greatest cost of gain ($0.46/lb). The greater cost of the OBF than that of the CRD and DGR is the result of high forage cost which is due to the cost of inorganic nitrogen ($29.25/hd). For producers that have access to manure as a nitrogen source, and will already be applying it to crop land in the fall for next year's grain crop, no inorganic nitrogen would be needed for forage production. In this scenario (no fertilizer cost) the cost of gain for the OBF ($0.35/lb) and CRD are not different. Likewise when the seed cost is offset by payments ($20 to 30/ac) for planting these cover crops as a part of conservation stewardship program cost of gains would be competitive with CRD.

Table 6. Partial budget economic analysis1 of three backgrounding systems: grazing corn residue plus supplemented with dry distillers at 0.86% of BW (CRD), grazing a fall oats and brassica forage (OBF) or fed a grower ration in drylot (DGR)

	CRD	OBF	DGR	SEM[e]	P-value
Growing period					
Grazing period					
Feed cost[a,b], $/hd	22.97	71.89	—	—	—
Yardage[c], $/hd	12.10	6.50	—	—	—
Drylot period					
Feed cost[d], $/hd	22.70	23.45	56.06	—	—
Yardage[c], $/hd	8.40	8.40	21.60	—	—
Total cost, $/hd	66.17	110.24	77.66	—	—
Cost of gain, $/lb	0.35[h]	0.46[f]	0.40[g]	0.015	< 0.01

Note. Excludes vet cost, interest and transportation.
[a]Distillers supplement $110/ton and corn residue $0.20/hd/d.
[b]Seed plus seeding $38.90/ac ($41.58/hd) and N fertilizer $27.36/ac ($29.25/hd).
[c]Yardage: drylot $0.40/d; feeding supplement $0.10/d and checking fence, water and calves while grazing $0.10/d.
[d]Grower ration $114/ton DM.
[e]Standard error of the least squares mean.
[fgh]Means within row lacking common superscript differ.

Implications

Grazing corn residue and supplementing distillers at 0.86% BW is a cost effective way of backgrounding calves during the winter and ADG of 1.8 lb/d can be expected. When grazing oat-brassica forage, relatively high gains (2.2lb/d) can be achieved. However, the cost effectiveness is dependent on the production scenario. Producers that are already planting oats and brassicas for soil benefits as a part of a conservation stewardship program or those that typically apply manure in the fall for the next season's crop, the cost of gain is competitive with using corn residue and less expensive than feeding a grower ration. However, when both the cost of seed and 50 lb of inorganic nitrogen is included, the cost of gains is greater than both corn residue grazing or feeding a grower ration in drylot.

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Finishing Yearling Heifers Using Self-Fed Dried Distillers Grains on Pasture

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Summary

A 2-yr study compared a traditional system of grazing yearlings followed by a grain-based drylot finishing program to a system using a self-fed dried distillers grain supplement during a spring/summer/fall pasture grazing season. The self-fed (SF) heifers had greater ADG and ending BW on pasture but the traditionally managed heifers had greater final BW and HCW. At harvest, SF heifers had greater 12th rib back fat. When data were adjusted to a common empty body fat, carcass weight and marbling score were greater for traditionally managed heifers.

Introduction

Traditionally, producers select replacement heifers at weaning time. Selecting replacement heifers at weaning is based on weaning weight. Once heifers are selected as replacements, producers have management options for cull heifers. Non-selected heifers could be sold or retained into a yearling system where they graze pasture and are finished in a feedlot. With the availability of ethanol byproducts, an alternative heifer enterprise may be considered for the non-selected heifers. This experiment was conducted to determine the possibility of adding another enterprise to an existing cow/calf enterprise and establish another profit center to generate revenue. Distiller grains was selected as the feed used in the self-feeder because distiller grains are usually less expensive in the spring/summer compared to the fall/winter and distiller grains does not have a negative impact on forage digestibility. The objectives of the experiment were: 1) to compare heifer performance and carcass characteristics in two systems post-weaning, and 2) to assess the pasture use and conditions when heifers were either finished on vegetative pasture with a high energy supplement or allowed to graze summer pastures without supplementation followed by a feedlot finishing phase.

Procedure

The experiment was conducted at the University of Nebraska Barta Brothers Ranch located near Rose, NE. In a two year study, 96 crossbred yearling heifers were used: Control (CON) and Self-fed (SF) to compare a traditional yearling system of spring/summer grazing followed by a feedlot finishing period to a system where yearling heifer grazed spring/summer/fall pasture and were offered a high concentrate self-fed ration. In the spring each year, heifer calves were weighed, vaccinated for respiratory disease, implanted with Synovex-H (Pfizer Animal Health), and dewormed with Ivomec (Merial Animal Health). Once weighed, heifers were assigned randomly to treatments. All heifers had limited access to grass hay for three days before two day consecutive BW measurements were recorded and used to stratified heifers and randomly assigned them to treatments after the second weight was recorded (CON = 688 lb; SF = 677 lb). Control heifers (n = 24/yr) were provided a summer pasture with no supplement followed by a feedlot finishing period. Self-fed heifers (n = 24/yr) had ad libitum access to a dried distillers grains plus solubles (DDGS)-based concentrate that was offered in a self-feeder during the grazing season.

Both CON and SF heifers were placed on native upland Sandhills pastures of similar topography and forage composition. Control heifers had a stocking rate of 0.61 AUM/ac while SF heifers were stocked at 0.87 AUM/ac based on the assumption that the distiller grain supplement would replace one third of the grazed forage consumed. Each treatment grazed from mid-May to the end of their treatments respective grazing period. Forage stubble height was measured at the end of each grazing period.

All cattle were transported to a commercial abattoir (Tyson Fresh Meats, Dakota City, Nebraska) when 12th rib backfat was estimated to be 0.50 inches. Hot carcass weights, marbling scores, 12th rib fat depth, LM area, and KPH were recorded. Final live weight was estimated by dividing individual carcass weight by a 62% dressing percentage.

Control (Grazing Followed by Feedlot Phase)

Control heifers grazed from mid-May to mid-September annually and received a free choice mineral supplement (0.24 lb/hd/d). In September, heifers were weighed and transported to the Haskell Agricultural Laboratory (HAL) feedlot located near Concord, NE. Upon arrival heifers were vaccinated for respiratory disease, treated for internal and external parasites with Ivomec (Merial Animal Health), and re-implanted with Synovex-H (Pfizer Animal Health). Prior to collecting two day consecutive weights, cattle were limit fed grass hay for three days to minimize variation in gastrointestinal tract fill. Cattle were transitioned over a period of 21 days to a final finishing diet composed of 75.25% dry rolled corn, 18.0% corn silage, 3.5% liquid supplement, 3.25% SBM, on a DM basis.

Self-Fed (Ad libitum DDGS Based Feed during Grazing)

The SF heifers grazed from mid-May to mid-October and had ad libitum access to a dry distiller grains plus solubles (DDGS) based supplement (Table 1). Self-feeders were located near pasture water sources. This was done to reduce trampling of areas and minimize the effect of creating a blowout. The stocking rate was increased by one-third in anticipation that the DDGS would substitute for some of the grazed forage. Heifers were harvested on October 26 and October 16 for yr 1 and 2, respectively. Because 12th rib backfat

Table 1. Composition of concentrate mixture offered to Self-fed heifers

Ingredient[a]	Year1	Year 2
DDGS	75	75
Whole Shelled Corn	20	—
Soy Hull Pellet	—	20
Commercial Pellet[b]	5	5

[a]% of supplement DM basis. Supplement intake: 10.12 lb/hd/d/yr (DM basis).
[b]Contained minerals and ionophore (Bovatec).

Table 2. Performance and forage attribute of Control and Self-fed heifers

	Actual				Adjusted[a]			
Item	Control	Self-Fed	SEM	P-value	Control	Self-Fed	SEM	P-value
Initial BW, lb	688	677	19.81	0.33	688	677	19.81	0.33
Off Grass BW, lb	909	1220	21.21	0.01	909	1146	13.02	0.01
ADG	1.73	3.21	0.10	0.01	1.73	3.39	0.08	0.01
Days on Grass	128.5	169	6.75	0.01	128.5	138	8.14	0.17
Forage Appraisal, in	6.46	6.33	0.66	0.33	6.46	6.33	0.66	0.33
Days in Feedlot[b]	97.5	—	—	—	103	—	—	—

[a]Data adjusted to 28% empty body fat (Guiroy et al., 2001; Journal of Animal Science).
[b]Feedlot diet composition (DM-basis): 75% DRC, 18% corn silage, 3.5% liquid supplement, 3.25% SBM.

Table 3. Performance and carcass weight of Control and Self-fed heifers

	Actual				Adjusted[a]			
Item	Control	Self-Fed	SEM	P-value	Control	Self-Fed	SEM	P-value
HCW, lb	789	747	24.05	0.01	788	711	18.57	0.01
Final BW, lb	1256	1220	38.91	0.03	1271	1146	29.95	0.01
System ADG, lb[b]	2.53	3.21	0.21	0.01	2.52	3.39	0.09	0.01
Feedlot ADG, lb[c]	3.58	3.21	0.34	0.01	3.51	3.39	0.20	0.46
F:G Grass[d]	11.58	6.92	0.27	0.01	11.58	6.55	0.27	0.01
F:G Feedlot[e]	6.95	6.92	0.76	0.92	7.25	6.55	0.48	0.06

[a]Data adjusted to 28% empty body fat (Guiroy et al., 2001; Journal of Animal Science).
[b]Using days in system: (Control: May-December; Self-fed: May-October).
[c]Using days in system: (Control: September-December; Self-fed: May-October).
[d]Grass intake was determined using the 2000 NRC Nutrient Requirements for Beef Cattle.
[e]Feedlot DMI: 23.90 lb/d.

was significantly different from the control heifers at harvest (0.57 inches for SF and 0.42 inches for CON), performance and carcass data were adjusted using an equation to adjust data to a common empty body fat (EBF) of 28%.

Data were analyzed as a completely randomized design with the experimental unit being the pasture. Treatment was analyzed as a fixed effect and year was analyzed as a random variable.

Results

Performance

Heifer performance and days on grass or in the feedlot are presented in Table 2. The SF heifers had greater ADG while on pasture as a result of the treatment. Gain for SF heifers was 3.39 lb/d while CON heifer ADG was 1.73 lb/d during the pasture phase and 3.51 lb during the feedlot phase (2.52 lb/d; combined grazing and feedlot phases for CON heifers, Table 3). Self-fed heifers consumed on average 10.12 lb/hd/d/yr of the DDGS concentrate. There was no difference in forage appraisal between the two treatments. Self-fed heifers were harvested approximately 93 d before their CON contemporaries.

Carcass Data

Control heifers had greater F:G on grass (11.58 lb) and in the feedlot (7.25 lb) than SF heifers (6.55 lb and 6.55 lb respectively). The CON heifers produced heavier carcasses than SF heifers (788 lb vs 711 lb). A greater hot carcass weight for CON heifers resulted in final calculated live weight being greater than SF heifers (1271 lb, 1146 lb respectively; Table 3). After carcass data were adjusted to a 28% empty body fat, there were differences ($P \leq 0.01$) in USDA marbling scores, calculated yield grade, and LM area (Table 4). Control heifers had higher marbling score and had a lower calculated yield grade then SF heifers (2.85 vs 3.11 respectively). Heifers on the control treatment had larger LM area compared to SF heifers.

This experiment was conducted to determine the possibility of adding another enterprise to an existing cow/calf enterprise and establish another profit center to generate revenue. Distiller grains was selected

Table 4. Carcass characteristics of Control and Self-fed heifers while grazing pasture

	Actual				Adjusted[a]			
Item	Control	Self-Fed	SEM	P-value	Control	Self-Fed	SEM	P-value
% EBF[b]	27	29	0.34	0.01	28	28	—	—
Marbling Score[c]	457	431	9.02	0.06	464	387	9.16	0.01
YG	2.80	3.36	0.15	0.01	2.85	3.11	0.11	0.01
12th Rib Backfat, in	0.42	0.57	0.41	0.01	0.43	0.50	0.03	0.06
LM Area, in	13.03	12.21	0.24	0.01	13.14	11.60	0.33	0.01

[a]Data adjusted to a 28% empty body fat (Guiroy et al. 2001; Journal of Animal Science).
[b]Original EBF %: (Control 27.26; Self-fed: 29.01).
[c]Marbling Score 500 = Modest (Choice), 400 = Small (Choice), 300 = Slight (Select).

as the feed used in the self-feeder because distiller grains are usually less expensive in the spring/summer compared to the fall/winter and distiller grains does not have a negative impact on forage digestibility.

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Performance and Economics of Supplementing Yearlings on Smooth Bromegrass Pastures

Cody A. Welchons, Robby G. Bondurant, Terry J. Klopfenstein, Jim C. MacDonald and Andrea K. Watson

Summary

Ten years of performance data from 2005–2014 were summarized to evaluate the effects of distillers grains plus solubles supplementation or fertilization of smooth bromegrass on performance and economic profitability of yearling steers with corn priced at either $3,4, or 5/bu and DGS priced at either 95, 105, or 115% the price of corn. Steers supplemented with distillers grains on non-fertilized smooth bromegrass had greater ADG (2.37 lb/d) compared with unsupplemented steers (1.69 lb/d). Unsupplemented steers grazing fertilized and non-fertilized pasture had similar gains; however, steers grazing fertilized pasture were more profitable due to savings in land rent. Supplemented steers were more profitable than unsupplemented steers until distillers grains reached 105% the price of $5/bu corn.

Introduction

Supplementing steers grazing smooth bromegrass pastures with distillers grains plus solubles (DGS) increases ADG compared to unsupplemented cattle. Adding nitrogen fertilizer (in the form of urea) to smooth bromegrass pastures increases forage production, but does not impact forage quality, demonstrated by similar ADG of cattle (*2011 Nebraska Beef Report*, pp. 24–25). Profitability of these treatments is greatly impacted by input costs such as land rent, fertilizer price, and DGS cost (*2013 Nebraska Beef Report*, pp. 33–35). Additionally, summer grazing management strategies can affect profitability of steers if they are retained through the finishing period.

The objective of this study was to summarize 10 years of cattle performance data and evaluate the effects of DGS supplementation or nitrogen fertilization on cattle backgrounding and finishing economics.

Procedure

Performance

Four hundred and fifty yearling steers (708 lb, SD = 46) were utilized in a randomized complete block design on smooth bromegrass pastures over the course of 10 years. Each year, 45 steer calves were assigned to 1 of 3 treatments with 3 replications per treatment. Treatments consisted of bromegrass pastures fertilized with 80 lb N/acre (FERT), unfertilized pastures stocked with cattle that received DGS at 0.6% of BW (SUPP), and unfertilized pastures stocked with cattle that received no supplement (CON). The FERT and SUPP pastures were stocked at 4 AUM/acre while the CON pastures were stocked at 2.8 AUM/acre or 69% of the other 2 treatments. Five tester animals were maintained on each pasture for performance measurements; extra calves were added or removed to maintain constant grazing pressure across all treatments. Treatment pastures were divided into 6 equal paddocks and rotationally grazed for an average of 152 days per year from April to September. The grazing period was divided into 5 cycles with cycles 1 and 5 lasting 24 days and cycles 2, 3, and 4 lasting 36 days. In order to update supplement amount, BW was measured at the end of each cycle and shrunk 4% to account for gut fill. Beginning and ending BW measurements were collected on 3 consecutive days and averaged following 5 days of being limit fed a diet of 50% roughage and 50% byproduct to equalize gut fill. From 2005–2009 cattle received no implant and from 2010–2014 cattle were implanted with Revalor-G (40 mg trenbalone acetate, 8 mg estradiol).

Economics

Total costs for each system included initial animal cost, yardage, pasture rent, fertilizer, health and processing, death loss, interest, and supplement cost (Table 1).

Table 1. Economic analysis input costs

Initial Steer Cost	$210.00/cwt		
Final Grazing Value	$180.64/cwt, 963 lb; $10/cwt slide		
Final Live Value[a]	$3/bu, $145.94/cwt; $4/bu, $151.84/cwt; $5/bu, $157.74/cwt		
Grazing Yardage	[b]CON & FERT, $0.10/hd/day; SUPP, $0.20/hd/day		
Feedlot Yardage	$0.45/hd/day		
Health and processing	Grazing, $8.40/animal; Finishing, $8.40/animal		
Death loss	Grazing, 0.50%; Finishing, 0.25%		
Fertilizer	$430/ton urea plus $4/acre application fee		
Land cash rent	$31/AUM		
DGS, relative to corn price	95%	105%	115%
$3/bu corn, $124.53/ton DM	$118.30/ton DM	$130.76/ton DM	$143.21/ton DM
$4/bu corn, $166.05/ton DM	$157.75/ton DM	$174.35/ton DM	$190.96/ton DM
$5/bu corn, $207.56/ton DM	$197.18/ton DM	$217.94/ton DM	$238.69/ton DM

[a]Nine economic scenarios were compared with corn priced at $3, 4, and 5/bu and DGS priced at 95, 105, and 115% the price of corn.
[b]Treatments consisted of nonfertilized paddocks (CON), paddocks fertilized with 80 lb N/acre (FERT), and nonfertilized paddocks grazed by steers supplemented with DGS at 0.6% of BW daily.

Interest was calculated using a rate of 6% and applied to half of the initial animal cost and all of the other costs. Grazing yardage was included at $0.10/hd/day for the CON and FERT treatments to account for fence maintenance, checking on animals, and watering. Yardage was increased to $0.20/hd/day for the SUPP treatment to account for extra labor incurred due to daily supplementation. Pasture rent was charged at a rate of $31/AUM (*2014 Nebraska Farm Real Estate Report*, Department of Agricultural Economics, University of Nebraska–Lincoln). As stocking rate varied between treatments, cost of land rent also changed. For CON cattle land rent was $168.48 for the grazing period while for FERT and SUPP cattle land rent was $112.48. Urea cost $430/ton and an application fee of $4/acre was included. For the summer grazing period an $8.40/animal health and processing fee and a 0.5% death loss were charged. Initial calf price was based on a Nebraska 3 year average.

Nine economic scenarios were compared. Corn was priced at $3, 4, or 5/bu with DGS priced at 95, 105, or 115% the price of corn. When corn was $3/bu, DGS prices were $118.30, 130.76, and 143.21/ton DM, respectively for 95, 105, and 115% the price of corn. At $4/bu the DGS prices increased to $157.75, 174.35, and 190.96/ton DM and $197.18, 217.94, and 238.69/ton DM with $5/bu corn.

The effects of summer grazing system on profitability of steers through the finishing period were also evaluated. Total costs for the entire system through finishing included costs incurred during the summer grazing period, plus feedlot yardage ($0.45/hd/d), health and processing ($8.40/animal), death loss (0.25%), interest on yardage and feed, and feed cost. Feed cost during the finishing period was calculated using the same price scenarios as during the grazing season with the finishing diet consisting of 70% corn and 30% DGS. Finishing performance was based on previous research in which supplemented or unsupplemented steers grazing pastures during the summer were followed through the finishing phase(*2012 Nebraska Beef Report*, pg. 112–114). The CON and FERT steers required 126 days on feed compared to 102 days for SUPP steers due to SUPP steers weighing approximately 100 lbs more at the end of the grazing season. To

Table 2. Performance of yearling steers grazing smooth bromegrass pastures

	Treatments[a]			SEM	*P*-Value
	CON	FERT	SUPP		
Initial BW, lb	709	708	706	15.2	0.47
Ending BW, lb	963[c]	963[c]	1063[b]	15.1	< 0.01
ADG, lb/d	1.68[c]	1.70[c]	2.37[b]	0.09	< 0.01

[a]Treatments consisted of nonfertilized paddocks (CON), paddocks fertilized with 80 lb N/acre (FERT), and nonfertilized paddocks grazed by steers supplemented with DGS at 0.6% of BW daily.
[b,c]From the *P*-values, means with differing superscripts are different ($P < 0.05$).

Table 3. Profitability of yearling steers under differing summer management strategies with different corn and DGS prices

Scenario		Treatments[a]			SEM	*P*-Value
		CON	FERT	SUPP		
$3/bu corn, DGS at 95%	Revenue[b]	$1736.96[e]	$1736.96[e]	$1811.03[d]	11.72	< 0.01
	Profit[b]	$0.00[f]	$15.67[e]	$70.99[d]	26.02	< 0.01
	Breakeven[c]	$180.37	$178.74	$163.69		
$3/bu corn, DGS at 105%	Revenue	$1736.96[e]	$1736.96[e]	$1811.03[d]	11.72	< 0.01
	Profit	$0.00[f]	$15.67[e]	$65.67[d]	26.02	< 0.01
	Breakeven	$180.37	$178.74	$164.19		
$3/bu corn, DGS at 115%	Revenue	$1736.96[e]	$1736.96[e]	$1811.03[d]	11.72	< 0.01
	Profit	$0.00[f]	$15.67[e]	$60.35[d]	26.02	< 0.01
	Breakeven	$180.37	$178.74	$164.69		
$4/bu corn, DGS at 95%	Revenue	$1736.96[e]	$1736.96[e]	$1811.03[d]	11.72	< 0.01
	Profit	$0.00[f]	$15.67[e]	$54.14[d]	26.02	< 0.01
	Breakeven	$180.37	$178.74	$165.28		
$4/bu corn, DGS at 105%	Revenue	$1736.96[e]	$1736.96[e]	$1811.03[d]	11.72	< 0.01
	Profit	$0.00[f]	$15.67[e]	$47.05[d]	26.02	< 0.01
	Breakeven	$180.37	$178.74	$165.94		
$4/bu corn, DGS at 115%	Revenue	$1736.96[e]	$1736.96[e]	$1811.03[d]	11.72	< 0.01
	Profit	$0.00[f]	$15.67[e]	$39.96[d]	26.02	< 0.01
	Breakeven	$180.37	$178.74	$166.61		
$5/bu corn, DGS at 95%	Revenue	$1736.96[e]	$1736.96[e]	$1811.03[d]	11.72	< 0.01
	Profit	$0.00[f]	$15.67[e]	$37.30[d]	26.02	< 0.01
	Breakeven	$180.37	$178.74	$166.86		
$5/bu corn, DGS at 105%	Revenue	$1736.96[e]	$1736.96[e]	$1811.03[d]	11.72	< 0.01
	Profit	$0.00[e]	$15.67[d]	$28.43[d]	26.02	< 0.01
	Breakeven	$180.37	$178.74	$167.70		
$5/bu corn, DGS at 115%	Revenue	$1736.96[e]	$1736.96[e]	$1811.03[d]	11.72	< 0.01
	Profit	$0.00[e]	$15.67[d]	$19.57[d]	26.02	< 0.01
	Breakeven	$180.37	$178.74	$168.53		

[a]Treatments consisted of nonfertilized paddocks (CON), paddocks fertilized with 80 lb N/acre (FERT), and nonfertilized paddocks grazed by steers supplemented with DGS at 0.6% of BW daily.
[b]$/animal
[c]$/cwt, ending wt
[d,e,f]From the *P*-values, means within a row with differing superscripts are different ($P < 0.05$).

control for changes in cattle prices among years, price received for steers coming off grass and at the end of the finishing period were calculated so that CON cattle broke even when DGS was priced at 95% of the bushel price of corn. Therefore, grazing season profitability remained the same for the CON cattle as corn and DGS prices increased. However, system profitability decreased due to the increase in total costs as the price of DGS and corn in the finishing diet increased. To account for the greater weight of SUPP steers at the conclusion of the grazing period compared to CON and FERT steers, a price slide of $10/cwt was used. Cost of gain over the grazing season and finishing period was calculated by dividing the total costs incurred, excluding initial steer price, by total weight gained during either the grazing season or finishing period. Breakeven prices were calculated by dividing total costs by BW at the end of the grazing period or shrunk final BW. Profitability was then calculated as live animal revenue minus total costs.

Results

Performance

Steers on CON and FERT treatments gained similarly throughout the grazing season (1.68 and 1.70 lb/day, respectively; $P = 0.67$); however, fertilized pastures had greater gain per acre. Steers supplemented with DGS at 0.6% of BW had increased ADG (2.37 lb/day) compared to CON and FERT steers ($P < 0.01$; Table 2). This increase in ADG of SUPP steers throughout the grazing season led to greater ending BW compared to nonsupplemented steers (1063 vs. 963 lb, respectively). Additionally, SUPP steers had increased production per unit of land over FERT steers. While SUPP and FERT steers were stocked at the same rate, the increase in ADG of SUPP steers led to 371 lb gain/acre over the 152 d grazing season compared to 289 lb gain/acre for FERT steers over the same time period.

Economics

Over the grazing season, FERT and SUPP steers were more profitable than CON steers ($P < 0.01$; Table 3). With CON steers generating a net return of $0, FERT steers generated a net return of

Table 4. Effect of summer management strategy on retained ownership profitability of yearling steers through the finishing period

Scenario		Treatments[a]			SEM	*P*-Value
		CON	FERT	SUPP		
$3/bu corn, DGS at 95%	Revenue[b]	$2054.66	$2055.81	$2054.99	21.11	> 0.99
	Profit[b]	$0.00[e]	$16.79[e]	$56.11[d]	23.78	< 0.01
	Breakeven[c]	$145.93	$144.82	$141.97		
$3/bu corn, DGS at 105%	Revenue	$2054.66	$2055.81	$2054.99	21.11	> 0.99
	Profit	$(7.61)[e]	$9.20[e]	$44.65[d]	23.78	< 0.01
	Breakeven	$146.47	$145.36	$142.78		
$3/bu corn, DGS at 115%	Revenue	$2054.66	$2055.81	$2054.99	21.11	> 0.99
	Profit	$(15.20)[e]	$1.61[e]	$33.19[d]	23.78	< 0.01
	Breakeven	$147.01	$145.89	$143.59		
$4/bu corn, DGS at 95%	Revenue	$2137.73	$2138.92	$2138.07	21.11	> 0.99
	Profit	$0.00[e]	$16.86[e]	$55.12[d]	23.78	< 0.01
	Breakeven	$151.83	$150.71	$147.94		
$4/bu corn, DGS at 105%	Revenue	$2137.73	$2138.92	$2138.07	21.11	> 0.99
	Profit	$(10.12)[e]	$6.74[e]	$39.84[d]	23.78	< 0.01
	Breakeven	$152.55	$151.43	$149.02		
$4/bu corn, DGS at 115%	Revenue	$2137.73	$2138.92	$2138.07	21.11	> 0.99
	Profit	$(20.23)[e]	$(3.38)[e]	$24.56[d]	23.78	< 0.01
	Breakeven	$153.26	$152.15	$150.11		
$5/bu corn, DGS at 95%	Revenue	$2220.79	$2222.04	$2221.15	21.11	> 0.99
	Profit	$0.00[e]	$16.93[e]	$54.13[d]	23.78	< 0.01
	Breakeven	$157.73	$156.61	$153.91		
$5/bu corn, DGS at 105%	Revenue	$2220.79	$2222.04	$2221.15	21.11	> 0.99
	Profit	$(12.63)[e]	$4.29[e]	$35.03[d]	23.78	< 0.01
	Breakeven	$158.62	$157.51	$155.26		
$5/bu corn, DGS at 115%	Revenue	$2220.79	$2222.04	$2221.15	21.11	> 0.99
	Profit	$(25.27)[e]	$(8.36)[e]	$15.93[d]	23.78	< 0.01
	Breakeven	$159.52	$158.41	$156.62		

[a]Treatments consisted of nonfertilized paddocks (CON), paddocks fertilized with 80 lb N/acre (FERT), and nonfertilized paddocks grazed by steers supplemented with DGS at 0.6% of BW daily.
[b]$/animal
[c]$/cwt, final wt shrunk 4%
[d,e]From the *P*-values, means within a row with differing superscripts are different ($P < 0.05$).

$15.67 indicating that fertilizer costs are offset by the decrease in land rent due to increased stocking rate. As price of corn increased from $3 to $5/bu, profit of SUPP steers relative to CON steers decreased; however, even at the highest price of corn and DGS relative to corn, SUPP steers still had a $19.57 profit potential compared to CON steers. At the lowest price of DGS in this evaluation, SUPP steers had a net return of $70.99 compared to CON steers. Across all DGS prices at $3 and $4/bu corn, SUPP steers had greater profitability than FERT steers ($P < 0.01$). When corn price increased to $5/bu and DGS were priced at 105 or 115% the price of corn, SUPP steers were no longer more profitable than FERT steers with net returns of $28.43 and $19.57, respectively, compared to the $15.67 net return of FERT steers ($P > 0.07$).

Overall, for every $1/bu increase in corn price, SUPP steer profit decreased by $18.62. Within each corn price, for every 10% increase in DGS relative to corn, profit of SUPP steers decreased by $5.32, $7.09, and $8.87 per animal for $3, $4, and $5/bu corn, respectively.

When comparing the effects of summer management strategy on profitability of steers through the finishing period, CON and FERT steers were not significantly different ($P \geq 0.10$; Table 4), though FERT steers had numerically higher returns. Across all price scenarios SUPP steers were more profitable than unsupplemented steers through the finishing period ($P \leq 0.03$). Similar to the grazing season, as corn and DGS prices increased, profit of SUPP steers relative to unsupplemented steers decreased. The decrease in profit of SUPP steers relative to CON steers from the lowest corn and DGS price to the highest price was $14.88/hd. For the finishing period, as corn increased $1/bu there was a $2.30 decrease in profit of SUPP steers over CON steers and a $4.81 decrease overall. Within each corn price, for every 10% increase in DGS relative to corn, profit of SUPP steers decreased by $11.46, $15.28, and $19.10 per animal for $3, $4, and $5/bu corn, respectively.

When corn was priced at either $3 or 4/bu, it was more profitable to sell SUPP steers at the end of the grazing season rather than retaining ownership through the finishing phase. However, as corn price increased to $5/bu it became more profitable to retain ownership of SUPP steers through the finishing period. This is greatly impacted by cattle prices and price slides.

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Observations of Forage Quality and Calf Gain when Grazing Double Cropped Forage following Wheat Harvest

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Summary

A 2-year cover crop grazing study was conducted following wheat harvest to evaluate the quality and yield of a 5-way forage annual forage mix in addition to cattle performance. In 2013, gain of steer calves was 2.03 lb/day, while 2014 steer calves had gain of 1.55 lb/day. Above ground forage production was 1.08 and 1.72 tons/acre in 2013 and 2014, respectively. Daikon radish and purple top turnip (brassicas) were high in sulfur and low in fiber. Fall forage production of brassica and oat based mixes following wheat grain harvest provide 97 to 137 lb of gain per acre.

Introduction

Planting annual forages in August after wheat harvest may provide producers with an alternative grazing source for backgrounding spring born calves in the winter. The objective of this study was to determine forage production and quality of a double cropped annual forage mix (cover crops used for forage), in addition to calf growth when grazed from October to December.

Procedure

Field and planting details

Dryland wheat fields at University of Nebraska-Lincoln Agricultural Research and Development Center (ARDC) near Mead NE were planted to a 5 way annual forage mix (brassicas, oats and sorghum) on August 17, 2013 and August 15, 2014 following wheat harvest in July (Table 1). Two treatments with three replications per treatment were applied: grazed cover crops (double crop annual forage) and ungrazed cover crops. Within year, the same 5-way annual forage mix was utilized for the double cropped forage and the cover crop (Table 1). In 2013, there was no N applied to the field, and in 2014, 210 lbs N from liquid feedlot manure from a confinement barn was applied to the field.

Forage production measurements

Initial forage mass was measured in the last week of October in both years. In 2013, only above ground forage mass, which did not include any tubers, was determined. In 2014, the forage was separated by species, and the tubers (roots) of the radishes and turnips were separated from the tops such that in addition to above ground biomass, total biomass production which included the tubers of the turnips and radishes, and production of each species could be determined. To measure biomass, three randomly selected 3.28 × 2.33 ft. areas in each paddock were sampled. In 2013, calves were provided access to the entire paddock; while in 2014, calves were initially given access to half of their paddock and 22 d later (Dec. 4th) the interior fences were removed and calves were given access to the whole paddock. This was because there was concern that the calves would not completely utilize all the forage, especially the tubers.

In 2014, quality samples were collected on Nov. 25 and Dec. 17 by randomly clipping the grasses and brassica tops and pulling tubers at fifteen locations within the ungrazed paddocks. Samples were separated by species, and the radishes and turnips were separated into leaf and tuber. All samples were freeze dried. Samples were analyzed for DM in 105°C oven and CP, NDF, ADF, sulfur, and organic matter on the freeze-dried, ground samples.

Stocking rate and grazing

To determine cattle grazing groups, 2013 steer calves (initial BW= 450 ± 35 lb) and 2014 steer calves (initial BW = 585 ± 8 lb) were limit fed a 50:50 diet of alfalfa hay and Sweet Bran® for five days, and then weighed three consecutive days prior to grazing to adjust for rumen fill. On day two of weighing, calves were assigned to paddocks based on weight blocks. On day three of weighing, calves were implanted with Ralgro® in both years. In both years, grazing was initiated in Mid-November and steers were provided free choice mineral supplement (Table 2).

Table 1. Seeding rate of cover crop/double cropped annual forage by year

Forage Type	2013 Seeding Rate (% of full seeding rate)	2014 seeding rate (% of full seeding rate)
Crimson Clover	1 lb/acre (10%)	—
Daikon Radish[a]	—	3 lb/acre (30%)
Oats	15 lb/acre (13%)	15 lb/acre (13%)
Purple Top Turnip	2 lb/acre (40%)	3 lb/acre (60%)
Sorghum	1 lb/acre (3%)	5 lb/acre (17%)
Sunflower	2 lb/acre (22%)	—
Safflower[b]	—	4 lb/acre (44%)
Total	21 lb/acre (88%)	27 lb/acre (161%)

Note. Percentages indicate the percent of the full seeding rate of each species (based on the number of seeds per lb.) as compared to planting a 100% of a monoculture of that specific species
[a]Changed crimson clover to daikon radish in 2014
[b]Changed sunflower to safflower in 2014

Table 2. Composition of free choice mineral provided to cattle in 2014 (DM basis)

Guaranteed Analysis	
Calcium (Ca)	18.90–22.70%
Phosphorus (P), minimum	1.50%
Salt (NaCl)	15.70–18.90%
Magnesium (Mg), minimum	2.00%
Copper (Cu), minimum	1.000 ppm
Selenium (Se), minimum	26.40 ppm
Zinc (Zn), minimum	3.750 ppm
Vitamin A, minimum	100,000 IU/lb
Vitamin D_3, minimum	10,000 IU/lb
Vitamin E, minimum	50 IU/lb
Active Drug Ingredient	
Monensin (as Monensin Sodium)	1200 g/ton

Table 3. Calf performance and forage yield (DM-basis) of forage

Item	2013	2014
Calf performance		
Initial BW, lb	450 ± 35	585 ± 8
Ending BW, lb	555 ± 39	664 ± 30
ADG, lb/d	2.03 ± 0.40	1.55 ± 0.57
Gain per acre, lbs	97 ± 4	137 ± 6
Forage production		
Above ground biomass, tons/acre	1.08 ± 0.39	1.76 ± 0.31
Below ground biomass, tons/acre	—	0.70 ± 0.34

Note. Means reported with standard deviation

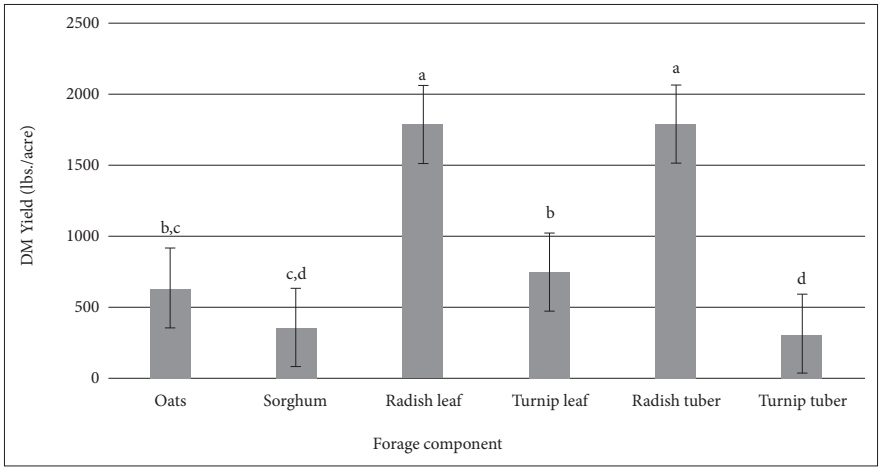

Figure 1. Total biomass yield (lb DM/acre) of forage components in October 2014 prior to start of grazing.

In 2013, the calves were stocked at 1 calf per ton of aboveground forage mass which was equal to 1 calf per acre (450 lb BW/ac). In 2014, calves were stocked 1 calf per ton of above ground biomass (excluded radish and turnip tubers), which was equal to 1.7 calves per acre (995 lb BW/ac). Calves grazed for 48 d in 2013 and 52 d in 2014. At termination of grazing, calves were brought back to the feedlot and limit fed a 50:50 alfalfa and Sweet Bran® diet for five days followed by weighing three consecutive days to determine final body weight.

Forage nutrient data were analyzed with the MIXED procedure of SAS (SAS Institute, Inc., Cary, N.C.) with sample as experimental unit.

Results

Forage production

In year 1, the aboveground forage mass was 1.01 ± 0.39 tons/acre, however; in year 2, there was a numerically greater yield at 1.76 ± 0.31 tons per acre (Table 3). However, the number of seeds per acre (as indicated by the percentage of the full seeding rate of each specific species as compared to planting 100% of a monoculture of that specific species) for the pastures was twice as much as in year 1 (Table 1). In year 2, total biomass (top growth and tubers of brassicas) was approximately 2.39 ± 0.44 tons per acre. Therefore, above ground biomass was 74% of the total biomass produced. The production of DM that each species contributed to the total biomass is shown in Figure 1. In 2014, the radish produced the most biomass accounting for 60% of the total biomass, followed by turnip at 17%, oats at 16% and sorghum at 10%. Safflower was not detectable.

Forage quality

The nutrient content of the forage mix in October of 2013 was reported in Table 4. The low ADF content observed in the 2013 mix suggests the forage was highly digestible and thus, high in energy. The 2014 nutrient analysis of the forage mix is shown in Table 4. Again, the mix had a relatively low ADF content. ADF content increases with plant maturity as more cellulose and lignin, structural plant components, are formed. Therefore, the energy content of the forage

is reduced as ADF content increases. Both the 2013 and 2014 forage were moderate in CP (12.2 and 19.6 % CP, respectively). However, the high S content of the 2014 mix may be a concern. The high S content of the mix is caused by the contribution of the leaf and tuber of the brassicas (radish and turnip; Table 5). The brassicas' leaf and tubers were significantly lower in NDF (fiber measurement correlated to intake) than the grasses (oat and sorghum). The sorghum had the greatest ADF and thus, may have contributed the least amount of energy. The ADF content of the oats and radish leaf did not differ. The ADF content of the radish tuber did not differ from the radish or turnip leaf but was greater than the turnip tuber. This may suggest the turnip tuber provides a significant amount of energy when consumed. However, the radish leaf provided significantly more protein than the other components of the mix. Given the relatively low seed cost of the brassicas, the high DM yield and the high quality of the forage; brassicas appear to be an excellent feed source for growing cattle. However, the high S and low NDF of the brassicas may be reason to include a grass in the mix to possibly reduce sulfur toxicity issues. The maximum tolerable level for dietary sulfur is 0.40% (NRC, 1996). When planting in early August, oats appear to yield more than sorghum.

Table 4. Nutrient composition of forage (DM basis) in late October prior to the start of grazing

Nutrient	2013	2014
OM, %	86.5 ± 1.78	82.0 ± 4.28
NDF, %	49.1 ± 10.4	35.0 ± 18.0
ADF, %	23.1 ± 2.28	25.1 ± 9.62
CP, %	12.2 ± 4.71	19.6 ± 4.36
S, %	0.63 ± 0.15	0.55 ± 0.25

Note. Means reported with standard deviation

Table 5. 2014 mean nutrient composition of annual forages in early December

	Oats	Sorghum	Radish Leaf	Turnip Leaf	Radish Tuber	Turnip Tuber	SEM	*P*-value
Nutrient[a]	% on DM basis							
OM, %	90.3^{b}	88.1^{c}	85.1^{d}	84.5^{d}	89.5^{b,c}	88.2^{b,c}	0.72	< 0.01
NDF, %	54.1^{c}	67.8^{b}	41.7^{d}	38.7^{d}	28.4^{e}	16.7^{f}	2.0	< 0.01
ADF,%	29.8^{c}	42.0^{b}	25.9^{c,d}	25.2^{d}	21.8^{d}	11.8^{e}	1.6	< 0.01
CP, %	14.3^{c}	15.6^{c}	25.3^{b}	17.5^{c}	14.7^{c}	15.9^{c}	1.2	< 0.01
S, %	0.19^{d}	0.21^{d}	0.71^{b}	0.62^{b,c}	0.56^{c}	0.60^{c}	0.033	< 0.01

Note. Average of samples taken on November 25th and December 17th
[a]OM (Organic Matter)-measure of the dry matter of the forage without mineral included; NDF (Neutral Detergent Fiber)-measure of the fiber negatively correlated to intake; ADF (Acid Detergent Fiber)-measure of less or indigestible fiber (cellulose and lignin) negatively correlated to energy of diet; CP (Crude Protein)-measure of the nitrogen of forage used for protein; S (Sulfur)-measure of sulfur in forage
[b,c,d,e,f]Means within a row with different superscripts differ ($P < 0.05$)

Cattle performance

The calves from year 1 had an ADG of 2.03 ± 0.40 lb/d, while the calves from year 2 had an ADG of 1.55 ± 0.57 lb/d (Table 3). However, due to the greater forage production and stocking density in year 2, gain per acre was numerically greater in year 2 (137 ± 6 lb/acre) than year 1 (97 ± 4 lb/acre).

These data suggest that there is an opportunity for forage production after wheat harvest for grazing. The brassicas (daikon radish and purple top turnip) produced high quality forage (low ADF and moderate CP). While no sulfur toxicity issues were observed in the current experiment, the high S and low NDF of brassicas may increase risk of sulfur toxicity. More research on grazing high-sulfur brassicas is needed before accurate recommendations can be developed. Grazing an annual forage mixture, consisting mainly of brassicas and oats, after summer wheat harvest provides moderate gains for growing calves for 50 d in early winter.

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Annual Forages following Irrigated Winter Wheat

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Summary

A sorghum-sudangrass hybrid, oats, and foxtail millet were compared using two planting dates and two irrigation levels in western Nebraska following irrigated winter wheat. In 2012, regardless of planting date and irrigation level, the sorghum-sudangrass hybrid produced more dry matter tons than oats and millet (2.0 vs. 1.3 and 1.2, respectively). In 2013, the sorghum-sudangrass hybrid and oats produced more dry matter tons than millet (1.0 and 1.1 vs. 0.64, respectively). The earlier forages could be planted, the more dry matter tons were produced before frost. Across planting dates and water level, crude protein was 11–16% DM and total digestible nutrients were 62–67% DM.

Introduction

Western Nebraska is a low rainfall area with annual rainfall ranging from 8 to 18 inches per year. Precipitation usually occurs in the early spring benefitting the predominately cool season grasses of this high altitude (3800–5000 ft.) area. Unfortunately, limited summer rainfall and declining quality of cool season pastures creates a challenge for producers needing a forage resource in the fall. Additionally, many areas of the High Plains are under irrigation restrictions so limited water is available for crops and forages. Planting forages after irrigated winter wheat may allow producers to use a limited amount of water to produce additional forage for fall or winter grazing, or for baling as hay. The objective of this research was to evaluate three annual forages with two planting dates and two water levels to evaluate dry matter production, digestibility, measured as total digestible nutrients (TDN), and crude protein (CP) for beef cattle.

Methods and Materials

2012

Two summer annuals (brown mid-rib sorghum-sudangrass hybrid and White Wonder foxtail millet), and one cool season annual (oats), were planted at 25, 15, and 100 lb/ac., respectively, following irrigated winter wheat harvest in 2012. In 2012 wheat harvest was early due to the extreme heat and drought and forages were planted on

Table 1. Dry matter tons produced in 2012 for sorghum-sudangrass hybrid, oats, and foxtail millet harvested 9/26/2012

	Planting Date		Irrigation Level	
	7/18/2012	8/02/2012	4”	8”
	Tons/ac		Tons/ac	
Sorghum Sudangrass[a]	2.5[b]	1.5[c]	1.3[a]	2.7[c]
Oats	1.2[c]	1.3[c]	0.85[d]	1.7[b]
Foxtail Millet	1.3[c]	1.1[c]	0.87[d]	1.5[b]

[a]Means with different superscripts within planting date differ, means with different superscripts within irrigation level differ, $P < 0.05$.

Table 2. Crude protein and total digestible nutrients for sorghum-sudangrass hybrid, oats, and foxtail millet harvested 9/26/2012

	Planting Date				Irrigation Level			
	7/18/2012		8/02/2012		4”		8”	
	CP	TDN	CP	TDN	CP	TDN	CP	TDN
Sorghum-sudangrass hybrid[a]	10.6[b]	61.8[b]	13.4[d]	64.7[c]	13.5[b]	63.9[be]	10.6[c]	62.6[b]
Oats	14.2[de]	65.0[cf]	18.3[c]	68.2[de]	16.3[d]	66.4[de]	16.2[d]	66.8[cd]
Foxtail Millet	12.9[d]	66.5[ce]	16.0[d]	67.5[ef]	14.4[bd]	68.1[cd]	14.5[bd]	65.9[de]

[a]Means with different superscripts within planting date differ, means with different superscripts within irrigation level differ, $P < 0.05$.

Table 3. Crude protein and total digestible nutrients for sorghum-sudangrass hybrid, oats, and foxtail millet planted in 2012 and harvested either 9/26/2012 or 3/5/2013

	Harvested 9/26/2012			Harvested 3/5/2013		
	% CP	% TDN	NO_3-N	CP	TDN	NO_3-N, ppm
Sorghum-sudangrass hybrid[a]	15.9[b]	63.2[b]	3320	12.0[b]	62.5	1283
Oats	20.1[c]	66.6[c]	4276	13.7[c]	64.3	1216
Foxtail Millet	18.3[c]	67.0[c]	2641	11.8[b]	62.9	1195

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

Table 4. Dry matter tons produced in 2013 for sorghum-sudangrass hybrid, oats, and foxtail millet harvested 10/8/13

	Planting Date		Irrigation Level	
	8/05/2013	8/20/2013	4”	5”
	Tons/ac		Tons/ac	
Sorghum-sudangrass hybrid[a]	1.22[b]	0.77[e]	1.04[b]	0.95[b]
Oats	1.54[c]	0.65[e]	1.12[b]	1.06[b]
Foxtail Millet	1.00[d]	0.27[f]	0.66[c]	0.61[c]

[a]Means with different superscripts within planting date differ, means with different superscripts within irrigation level differ, $P < 0.05$.

Table 5. Crude protein and total digestible nutrients for sorghum-sudangrass hybrid, oats, and foxtail millet harvested 9/26/2012

	Planting Date				Irrigation Level			
	8/05/2013		8/20/2013		4”		5”	
	CP	TDN	CP	TDN	CP	TDN	CP	TDN
Sorghum-sudangrass hybrid[a]	10.1[b]	60.3[b]	13.2[ce]	63.3[bc]	10.9[b]	60.6[b]	12.3[b]	63.0[bc]
Oats	11.1[be]	65.8[c]	19.0[d]	69.9[d]	14.8[c]	64.2[bc]	15.2[cd]	71.5[d]
Foxtail Millet	13.5[c]	63.9[c]	19.2[d]	67.2[cd]	15.6[cd]	65.1[c]	17.2[d]	66.0[c]

[a]Means with different superscripts within planting date differ, means with different superscripts within irrigation level differ, $P < 0.05$.

Table 6. Average crude protein, total digestible nutrients, and nitrate concentration for sorghum-sudangrass hybrid, oats, and foxtail millet harvested 10/8/2013, crude protein and total digestible nutrients when harvested 3/13/2014

	Harvested 10/8/2013			Harvested 3/13/2014	
	% CP	% TDN	NO3-N, ppm	% CP	%TDN
Sorghum-sudangrass hybrid[a]	11.6[b]	61.8[b]	277	10.2[b]	55.0[b]
Oats	15.0[c]	67.8[c]	91	9.2[b]	65.0[c]
Foxtail Millet	16.4[c]	65.5[c]	314	11.6[c]	58.1[d]

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

July 18th, and August 2nd. Fertilizer was broadcast supplying 50 lb. N/acre. Water was applied at two irrigation levels, 4” and 8”. Initially, the plan was to use 3” and 6” but the extreme drought conditions warranted higher levels of irrigation to compare a restriction to no restriction. Plots were harvested on September 26, 2012 for dry matter production. Subsamples of each plot were analyzed for crude protein (CP), total digestible nutrients (TDN), and NO_3-N. A subset of each plot was left standing throughout the winter and was subsampled again on March 5, 2013 and analyzed for CP, TDN, and NO_3-N. Generally, plots would not have been sampled for NO_3-N, but since 2012 was unusually hot and dry, NO_3-N accumulation was a concern.

2013

Sorghum-sudangrass hybrid, foxtail millet, and oats were planted at the same rate as in 2012, but in 2013, irrigated winter wheat was harvested in late July, and therefore, the planting dates were August 5, and 20, 2013. Additionally, Roundup Ultramax was applied to the whole plot area (32 oz/ac) on July 27, 2013 and again to the second planting date plots on August 22, 2013 to help control volunteer wheat growth. Sixty lb. of N per acre was also applied on August 22, 2013. To be consistent with 2012, 4” and 8” of irrigation were to be applied. However, due to irrigation system issues and above normal rainfall in September (8 inches), only 4” and 5” were applied. The plots were harvested on October 8, 2013 for dry matter, CP, TDN, and NO_3-N. Subsamples were left standing for subsequent CP and TDN analysis after the winter, and were harvested on March 13, 2014.

Results and Discussion

2012

The earlier planting date resulted in greater dry matter production of the sorghum-sudangrass hybrid but was not significantly different for the oats or foxtail millet ($P < 0.05$; Table 1). The 8” irrigation level significantly improved dry matter production for all three forages ($P < 0.05$; Table 1). The CP and TDN were not affected by water level within forage. However, CP and TDN were greater within forage, for the later planting date which was simply a function of less plant maturity (Table 2). All forages, when averaged across planting date and water level, had a CP value of 16–20% and a TDN level of 63–67% which would be considered a medium quality feed source for beef cattle (Table 3). The NO3-N levels were high (Table 3) (> 1500 ppm is considered unsafe for feeding even non-pregnant animals unless mixed with low nitrate feed to dilute the ppm to 1500 ppm or less) due to the drought conditions and immaturity of the forage at harvest. Results from the subsamples taken in March indicated the CP was 11–13% which is adequate to maintain rumen function (Table 3). The TDN was only slightly lower than the September harvest date indicating all three forages made an acceptable option for standing forage through the winter. The NO3-N values by March were below 1500 ppm. Therefore, nitrate toxicity while grazing the forages as standing hay in the winter would not have been an issue.

2013

The earlier planting date resulted in greater dry matter yield for all crops compared to the later planting date. The earlier planting date resulted in the greatest dry matter yield for oats followed by sorghum-sudangrass hybrid, and then foxtail millet (Table 4; $P < 0.05$). Irrigation level did not impact production within forage type. This was probably due to the rains in September and the issues with the irrigation system making the water levels only 1" different. At both irrigation levels the dry matter yield was similar for sorghum-sudangrass hybrid and oats which were greater than the foxtail millet ($P < 0.05$). The second planting date resulted in greater CP for all forages, and greater TDN for the oats, but similar TDN for the sorghum-sudangrass hybrid and foxtail millet (Table 5; $P < 0.05$). The 5" irrigation level resulted in greater TDN for the oats but similar TDN for each of the other two forages. The CP was similar within forage across irrigation treatment. The average CP and TDN regardless of planting date and irrigation level were greater for oats and foxtail millet than for sorghum-sudangrass hybrid when harvested 10/8/13 ($P < 0.05$; Table 6). The NO_3-N concentration was well below concern, most likely because 8.4 inches of rain was received in September. Therefore, NO_3-N concentration was not measured the following March as they would have been low then as well. Nitrate toxicity is generally not a problem unless the plant becomes stressed from drought or frost. Producers concerned about NO_3-N concentrations in forages or hay should send samples to a commercial laboratory for testing. Hays with nitrate toxicity potential can be blended with other hays or feedstuffs to reduce risk. The CP was greater in foxtail millet than sorghum-sudangrass hybrid and oats after the winter, while TDN was greatest for foxtail millet, oats were greater than sorghum-sudangrass hybrid ($P < 0.05$; Table 6). As in yr 1, the quality of the forages harvested in March had decreased from pre-frost levels, but values indicated they would be acceptable standing forage for fall and winter grazing.

Conclusion

Planting annual forages after irrigated winter wheat is harvested may be a beneficial way to utilize land for both crops and livestock. The earlier forages can be planted after wheat harvest, the more dry matter can be produced before frost. The window of opportunity for planting the forages appears to be fairly narrow since forages planted the third week of August produced substantially less dry matter than forages planted by the first week in August. The tradeoff for dry matter production is decrease quality. However, all forages in this two year study resulted in acceptable crude protein and digestibility for beef cattle regardless of dry matter production. Additionally, these forages could be used as standing hay for winter grazing as the quality did not drastically deteriorate throughout the winter.

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Accurate Amounts and Nutritive Values of Corn Residues

Shelby E. Gardine, Andrea K. Watson, Jana L. Harding and Terry J. Klopfenstein

Summary

It is important to have accurate data on the amounts and nutritive values of residues, especially for grazing situations. Ten plants were harvested for each field replication. Statistical analysis suggests 6 to 10 plants are needed to obtain accurate grain yields and accurate amounts of residue. Further laboratory analysis of the leaves and husks suggests that the energy and protein contents of the residue that is consumed is less than previously reported.

Introduction

Supplies of conventional forages, pasture, and hay have declined in recent years and corn residue supply has increased. It is important to the cattle industry to make efficient use of this corn residue. Extensive sampling of corn residue has been reported previously (*2012 Nebraska Beef Report*, pp. 11–12; *2015 Nebraska Beef Report*, pp. 56–58). This was done by sampling 10 plants, assuming they were representative. Further, laboratory analytical procedures have been updated. The Objective was to determine variation in individual plants and to re-evaluate energy and protein values of corn residues.

Procedure

An irrigated field in a corn, soybean rotation has been used for stalk grazing research for over 20 years (*2015 Nebraska Beef Report*, pp. 53–55). There are non-grazed areas and areas grazed in the fall and areas grazed in the spring. There are 4 field replications that contain each of these areas. In the fall of 2014, 10 consecutive corn plants were harvested from each of these field replications (3 treatments × 4 reps = 12 sampling locations). Each of the 120 corn plants, harvested above the anchor roots just before grain harvest, was

Table 1. Yield of corn grain and residue measured by clipping individual corn plants

Yield	Treatment[a]			SEM	*P*-value
	Fall Grazed	Spring Grazed	Non-grazed		
Grain, g	207.2	199.8	199.3	5.24	0.49
Husk, % of grain	5.64[c]	6.35[b]	5.56[c]	0.22	0.02
Leaf, % of grain	11.48	11.85	11.44	0.60	0.87
Sheath, % of grain	6.20	6.71	6.29	0.28	0.38

[a]Samples were collected from a field in a corn-soybean rotation. Treatments were due to timing of cattle grazing residue 2 years prior to these samples being collected. Ten plants were collected from each of 4 replications per treatment.
[b,c]Means within a row without a common superscript differ ($P < 0.05$).

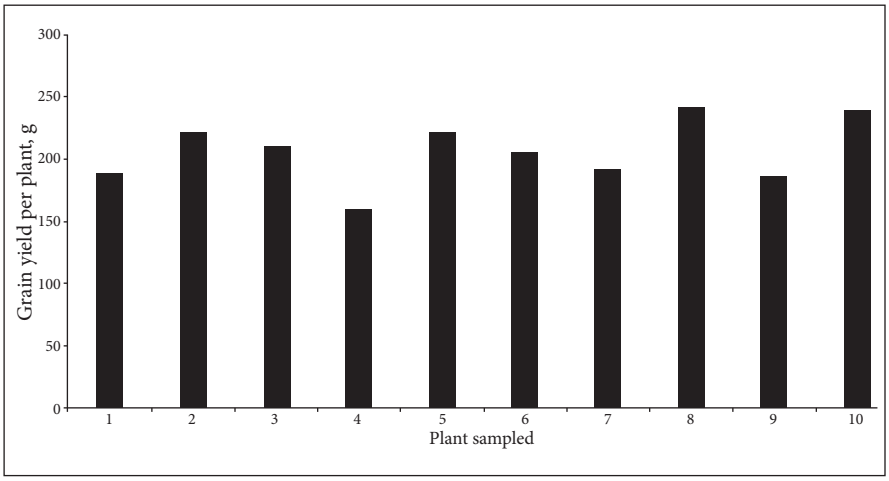

Figure 1. Grain yield measured on individual plants in replication 4 of the non-grazed treatment.

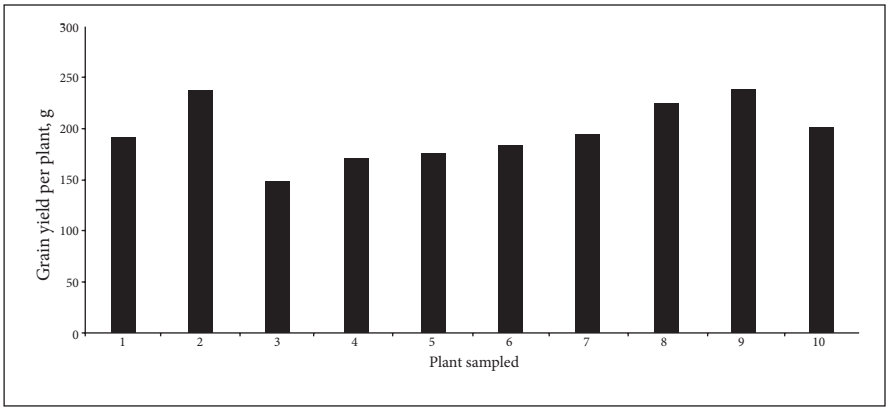

Figure 2. Grain yield measured on individual plants in replication 2 of the spring grazed treatment.

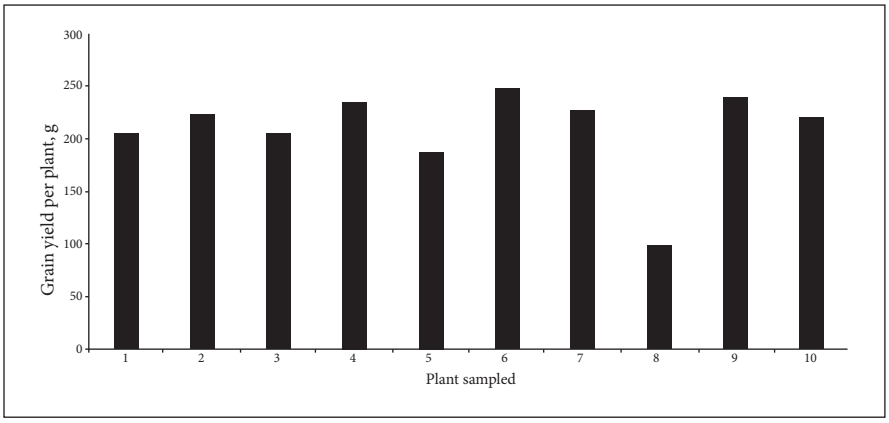

Figure 3. Grain yield measured on individual plants in replication 2 of the fall grazed treatment.

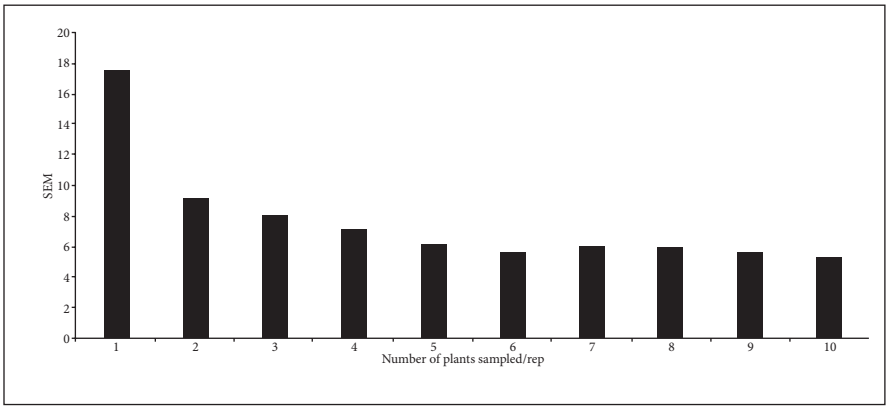

Figure 4. Standard error of the mean for grain yield (g) as the number of plants sampled per replication increased from 1 to 10.

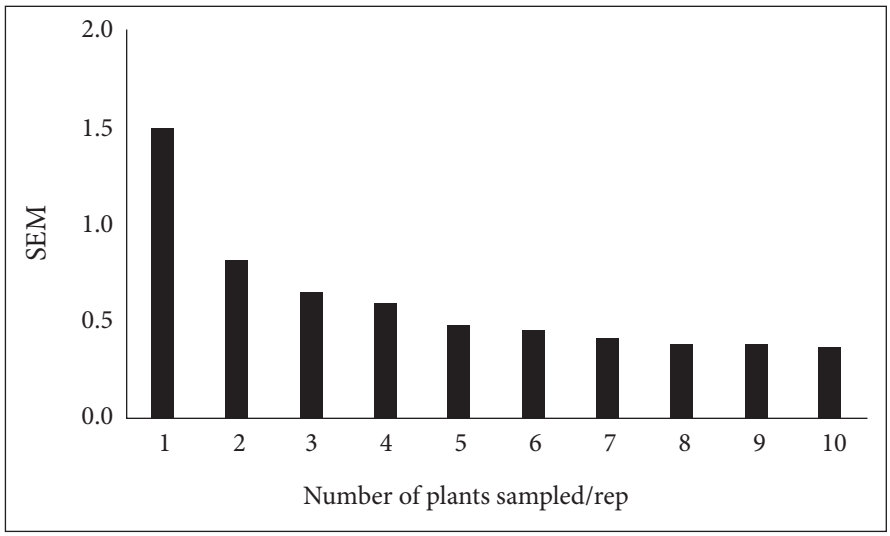

Figure 5. Standard error of the mean for residue (leaf + sheath+ husk) yield, expressed as a % of grain yield, as the number of plants sampled per replication increased from 1 to 10.

separated into grain, cob, leaf blade, leaf sheath, and husk. Each plant part was dried (60°C) and DM amounts determined.

The 10 plant parts within each replication were composited for organic matter and in vitro organic matter digestibility (IVOMD) determination. Previous samples of corn leaf and husk (*2011 Nebraska Beef Report*, pp. 33–34) were analyzed for protein degradability using in situ and mobile bag techniques. Statistical analysis was conducted using a model with 3 treatments and 4 replications, with corn plant as the experimental unit. The analysis was repeated 10 times using 1 corn plant, 2 corn plants, etc. until all 10 were included.

Results

Amount of grain per plant and the amount of residue as a percentage of grain are shown by treatment (Table 1). Grain yield was not affected by grazing treatment ($P = 0.49$). Numerically, fall grazing produced the greatest grain yield which is consistent with previous yield data (*2015 Nebraska Beef Cattle Report*, pp. 56–58). Grain yields are in grams per plant (ear). Yield of 200 grams dry matter per plant at a plant population of 36,000/ac would yield approximately 240 bu/ac. As expected, all plants were not the same. As an example figure 1 shows the grain yield per plant for rep 4 of the nongrazed area. Figure 2 shows the yield for rep 2 of spring grazed and Figure 3 shows rep 2 of fall grazed. Overall, grain yield ranged from 160 to 293 grams/plant.

The analysis of variance was conducted using 1 to 10 plants per rep. The analysis is the same as reported in Table 1. Figure 4 illustrates the change in the standard error of the mean (SEM) as additional plants were added. This suggests that 6 to 10 plants are needed to obtain sufficient statistical power when measuring grain yield.

The average amount of leaf blade, leaf sheath and husk was 23.8% of the grain. That is 15.8lb of residue dry matter/bu of corn at 15.5% moisture. Cows and (or) calves grazing corn residue consume the husk and leaf and very little of the steam and cob. Previous research has shown 15 to 16 lb of leaf and husk are produced per bu of corn, and harvest efficiency was measured at about 50%. This allows producers to estimate carrying capacity as 8 lb DM

available per bu or 1920 lb per acre at corn yield of 240 bu/ac.

The amount of leaf and husk harvested from the 10 plants is presented as a percentage of the grain. (Figure 5). The SEM declined as number of plants increased through 10. This illustrates the need to harvest a sufficient number of plants to get a representative sample of residue, probably 6 to 10 plants.

Organic matter digestibility was greatest in the husk while no difference was observed between the leaf and sheath. Grazing treatment had no effect on organic matter digestibility within the husk, leaf, or sheath. The IVOMD values are similar to previous data. However, the ash content of the leaves is very high. In previous research where samples were collected off the ground, the ash was assumed to be soil contamination. Recent results show leaves have high ash content, even with no soil contamination. The leaf blades contained 15.4% ash and the leaf sheaths 8.8%. The blades are more accessible for consumption so it is assumed more blade is consumed than sheath. The leaf material consumed may contain up to 14% ash. Ash has no energy so it is important to account for that by calculating the amount of digestible organic matter (DOM). There was no effect of grazing treatment on DOM of the plant parts. Husk had 55.6% DOM, leaf blade 40.7% DOM and leaf sheaths 38.6% DOM. The DOM equates closely to TDN. This calculation shows the leaves to have less energy than previously thought. Assuming cattle consume the leaf blade and husk in the proportions it is produced on the plant, the TDN of the consumed residue would be 45%.

Residue samples were collected at the Brule, NE site in 2009 (*2011 Nebraska Beef Report*, pp. 33–34). Crude protein was 3.75% for the husk and 5.75% for the leaf. The rumen degradable protein (RDP) contents were 2.72 and 4.43% of DM, respectively. Digestibility of the ruminally undegradable protein (RUP) was less than 25% for both plant parts. Therefore, new values have been calculated that would be appropriate for use in the NRC metabolizable protein system assuming residue consumed is 1/3 husk and 2/3 leaf. The adjusted CP is 4.25% and RDP is 90.7% of the CP.

The protein and energy values for corn residue reported herein are lower than previously reported. They do not include values for residual grain in the field that can be a source of both energy and protein. Residual corn was estimated at 0.5 bu/ac for the field sampled in 2014. A cow grazing the field for 70 days would consume about 0.3 lb corn grain DM per day. Residual corn may vary up to 2 bu/ac and if cows grazed fewer days, up to 2 ½ lb of corn could be available per day.

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Effect of Corn Residue Composition on Digestibility by Lambs

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Summary

A lamb digestion trial was conducted to determine the effect of harvest method on total tract digestibility of corn residues. Two residues were harvested using a corn head which gathered 4-rows or 8-rows of stalks with the tailings dropped on the top of the windrow. Corn husks were fed as a control. Diets contained 64.18% corn residue and 35.82% DM of Sweet Bran®, brome grass hay, and sheep mineral. There were no differences in OM, DM, or NDF digestibility between 4-row and 8-row residues. Corn husks had the greatest digestibility.

Introduction

Several harvest technologies have been developed to increase the feeding value of corn residue. One of those new technologies is the New Holland Cornrower, which pulls the recently harvested corn plant through a chute and into a series of rotating blades. After being cut the corn plant travels on a conveyor belt to the center of the combine. The residue is then funneled into a windrow and gathered into a baler. The rows of the Cornrower can be turned on and off so that as little as 2 rows of residue and as much as 8-rows of residue are gathered into the windrow. Previous *in vitro* DM digestibility experiments (*2015 Nebraska Beef Cattle Report*, pp. 62–63) found that IVOMD of 4-row residue (54.3%) was greater than 8-row residue (47.0%). In that study, 8-row residue was four percentage points higher in IVOMD than conventionally harvested corn residue (43.0%). This same IVOMD trial determined that corn husk was 72.4% digestible. The resulting hypothesis is that 4-row residue will have higher total tract DM, OM, and NDF digestibility than 8-row and that husk will have the greatest total tract digestibility. Therefore, the objective of this study was to compare the *in vivo* digestibilities of corn husk with residues harvested using a corn head that collected 4-rows, and 8-rows of stalk.

Procedure

A New Holland Cornrower was used to gather residue from 4 of the 8 rows of the corn head, or all 8-rows. Husks were obtained from seed corn harvest (Hoegemyer Hybrids). Nutrient profiles of the residues are provided in Table 1. The residues were fed to 18 crossbred wether lambs (BW 57.5 lb; SD = 9.8 lb) over three, 16 d periods. Lambs were divided into 3 blocks in a 6 × 3 row-column transformation with 6 treatments, 3 periods, and 3 independent squares (n = 9). A concentrate mixture consisting of 86.4% Sweet Bran®, 9.6% brome grass hay, and 4.0% sheep trace mineral supplement was used in all diets to supplement protein and increase palatability. Diets contained 64.18% corn residue and 35.82% DM of the concentrate mix. Residue was fed *ad libitum*; lambs consumed 1.39% BW of the residue and 0.78% BW of the concentrate mix. Lambs were fed treatment diets in a 9 d adjustment period, and total fecal collections were completed over 7 d. Feces was collected every day at 0700 and at 1600 and lambs were fed once at 0800. Each day's feed intake was recorded and refused feed was weighed and fed back to the same lamb on the following day. Feces were composited from each day of the collection period. An additional 4th period was added during which only the concentrate mix was fed. Lambs were assigned randomly to two treatments during the last period. Half of the lambs were fed 1.5% of BW while the other half were fed 2.5% of BW. Diet compositions are summarized in Table 2.

Each fecal composite was sampled and dried for 48 h in a 60oC oven to determine DM excreted. Each sample was ground through a 1-mm screen using a Wiley mill and analyzed for OM and NDF. Additionally, samples for each ingredient were taken for every period of every block and analyzed for DM, OM, and NDF. Total tract DM, OM, and NDF digestibility of the

Table 1. Nutrient composition of residue samples

	Husk	4-Row	8-Row
DM, %	92.24	90.70	91.11
OM, %	96.40	94.18	92.13
NDF, %	83.99	82.68	87.02

Table 2. Diet Composition (% of DM) fed to crossbred wether lambs

Ingredient	4-Row	8-Row	Husk	Sweet Bran/ Brome
4 Row Residue	64.18	—	—	—
8 Row Residue	—	64.18	—	—
Husk	—	—	64.18	—
Sweet Bran	29.76	29.76	29.76	86.4
Brome	3.31	3.31	3.31	9.6
Sheep Trace Mineral	2.00	2.00	2.00	2.00
Limestone	0.75	0.75	0.75	2.00

Table 3. Effects of dietary treatment on intake and total tract digestibility of DM, OM, and NDF[a]

	Husk	4-Row	8-Row	SEM	*P*-Value
DM					
Intake, %BW	1.37	1.31	1.49	0.06	0.14
Total tract digestibility, %	66.76[b]	49.89[c]	48.51[c]	2.53	< 0.01
OM					
Intake, %BW	1.36	1.29	1.47	0.06	0.14
Total tract digestibility, %	67.92[b]	52.80[c]	56.42[c]	2.37	0.03
NDF					
Intake, %BW	1.04	1.04	1.15	0.09	0.61
Total tract digestibility, %	73.89[b]	56.89[c]	57.58[c]	2.00	0.01

[a]Diets contained 64.18% residue, 29.76% Sweetbran, 3.31% bromegrass hay, and 2.75% supplement. Reported intakes and digestibities are for the residue portion only

concentrate mix fed during period 4 was determined. With these results, amount of DM, OM, and NDF of the feces in periods 1–3 from the concentrate mix was calculated. The remaining feces was from corn residue, and thus the digestibility of only the residue could be calculated. The concentrate mix had digestibility estimates of 74.8, 76.2, and 63.0% for DM, OM, and NDF, respectively.

All data were analyzed using the MIXED procedures of SAS (SAS Inst., Inc., Cary, N.C.). Lamb was the experimental unit, and the model included period as a fixed effect. Lamb and lamb*residue type were included in the random statement. Probabilities less than or equal to alpha ($P \leq 0.05$) were considered significant.

Results

All intakes and total tract digestibilities are reported for only the residue, with the concentrate mix removed (Table 3). Husks were 16.9 percentage units more digestible than 4-row and 18.25 percentage points more digestible than 8-row samples ($P < 0.01$). This demonstrates that the harvest method that increases the amount of husk should increase the digestibility. Husk had greater DM digestibility (DMD) than 4-row or 8-row residues, however there was no statistical difference in DMD between 4 and 8-row samples ($P = 0.36$).

There was a similar result for OM digestibility (OMD). Husk was the greatest OM digestibility (67.9%; $P < 0.01$), while 4-row and 8-row did not differ (52.8% and 56.42% for 4-row and 8-row, respectively; $P = 0.69$). For neutral detergent fiber, husk was 73.9% digestible while 4-row was 56.9%. The, 8-row was 57.6% digestible which is not statistically different from 4-row ($P = 0.94$). Lastly, there was no difference in intake of DM, OM, or NDF among treatments ($P > 0.14$).

The lack of difference in residue digestibility between 4-row and 8-row residues may suggest those samples did not differ in the proportion of corn plant components that were collected. However, the improved digestibility of the husk supports the hypothesis that increasing the proportion of husk in baled residues may increase digestibility.

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Effect of Corn Residue Harvest Method on In Vivo and In Vitro Digestibility

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Summary

A digestion study was conducted using 18 crossbred wether lambs to evaluate the effects of corn residue harvesting method and ensiling on the digestibility of corn residue. Husks had the greatest digestibility compared to any of the harvesting methods. No differences were observed for the digestibility of husklage, ensiled husklage, or stalklage. None of the harvest methods resulted in residue digestibilities similar to husks.

Introduction

The digestibilities of various residue components from corn differ. The husk is the most digestible while the stem is the least (*2012 Nebraska Beef Cattle Report*, pp.11–12). Advancements in residue harvesting technology now allow producers to decrease the proportion of stem in the bale compared to conventional baling. A previous evaluation of harvest methods reported improved *in vitro* digestibility estimates for residues harvested with methods that minimized the proportion of stalk (*2015 Nebraska Beef Cattle Report*, pp.62–63). Additionally, steers consuming residue harvested using new harvesting technology had improved F:G compared to steers consuming diets with conventional harvested corn residue (2015 *Nebraska Beef Cattle Report* pp. 42–44).

Digestibility estimates from *in vitro* techniques are known to be variable. However, *in vitro* estimates may be adjusted to *in vivo* values if forage samples with known *in vivo* digestibilities are included in each run as internal standards (2007 *Nebraska Beef Cattle Report* pp. 109–111). Currently, no internal standards exist for crop residues. The objectives of the current study were to determine the effects of corn residue harvest method on *in vivo* digestibility and to determine if internal standards can be used to adjust *in vitro* data to *in vivo* digestibility values for corn residues.

Procedure

A 64-d digestion study utilized 18 crossbred wethers (BW = 57.4 lb, SD = 9.9 lb) in a Latin square design with three independent squares. Wethers were blocked into three blocks based on previous DMI, and then assigned randomly to one of six treatment diets. Five of those treatments are reported here, while the remaining treatment comparisons are reported in another report (2016 *Nebraska Beef Cattle Report pp.* 74–75).

The trial was comprised of four, 16-d periods. Days 1–8 allowed for adaptation to the diet. Wethers were also allowed to adapt to the metabolism crates and fecal collection bags on day 8. Total fecal collections were performed on days 9–16. Five forage based diets were used for three of the periods, consisting of: husk, husklage, ensiled husklage, stalklage, or brome. Diet composition is shown in Table 1.

Husks were obtained from Hoegemeyer Seed. Husks were sifted through a 3 foot by 5 foot metal screen by hand to remove any remaining corn. The husklage and ensiled husklage were produced with the use of a John Deere 569 round baler that was modified with the Hillco single pass round bale system (SPRB). This modification to the baler allows for the baler to connect to the combine, where it collects the residue after it passes through the combine. The producer can harvest both corn and residue in one pass through the field. To ensile the husklage, water was added to a target DM of 35%, and the mixture was bagged in an agricultural bag for a minimum of 30 days. The residue collected was 27% leaf, 17% husk, 42% cob and 14% upper stem. In order to obtain the bales of stalklage, a New Holland Cornrower Corn Head was used. The Cornrower corn head was described in the 2015 *Nebraska Beef Cattle Report* (pp. 62–63).

The fourth period of the digestion trial consisted of a *Sweet Bran®*/ brome mixture (Table 1.).This mixture was fed to determine the amount of feces that was contributed by the *Sweet Bran®*/ brome in the treatment diets collected in the first three periods. The contribution from *Sweet Bran®*

Table 1. Composition of diets (DM basis)

Ingredient, % DM	Husk	Husklage	Ensiled Husklage	Stalklage	Brome	Sweet Bran®
Husk[a]	64.18	—	—	—	—	—
Husklage[b]	—	64.18	—	—	—	—
Ensiled Husklage[c]	—	—	64.18	—	—	—
Stalklage[d]	—	—	—	64.18	—	—
Brome hay	3.22	3.22	3.22	3.22	97.25	9.6
Sweet Bran®	29.73	29.73	29.73	29.73	—	86.4
Supplement	2.15	2.15	2.15	2.15	2.0	2.0
Limestone	0.72	0.72	0.72	0.72	0.75	2.0

[a]Husk were obtained from Hoegemeyer Seed and sifted through a screen to remove remaining grain
[b]Husklage was produced with the John Deere 569 round bailer modified with the Hillco single pass round bale system
[c]Ensiled Husklage was produced the same as the husklage, then water was added to target of 35% DM and bagged in an agricultural bag for a minimum of 30 days
[d]Stalklage was produced with the New Holland Cornrower cornhead, with all 8 rows operating

and brome to the total fecal output was then subtracted to determine the digestibility of the residue.

Fecal samples were composited on a wet basis by wether within period. Both feed and fecal samples were dried and ground through a 1-mm screen. The ground samples were then ashed. The residue left was used to calculate OM. All samples were analyzed for DM, OM, and NDF.

In vitro DM (IVOMD) and *in vitro* OM (IVOMD) digestibility estimates were performed on the residue samples. Samples were dried and ground through a 1-mm screen. Test tubes contained 0.5 grams of feed and 50 mL of inoculum. The was a combination of ruminal fluid from two donor steers that were consuming a 70:30 roughage:concentrate diet (DM basis). McDougall's buffer was mixed into the ruminal fluid at a 1:1 ratio, along with the inclusion of 1 gram of urea/L.

Inoculated tubes were incubated in a water bath to allow fermentation. To end fermentation, each test tube received 6 mL of 20% HCL and 2mL of 5% pepsin solution were added. Tubes remained in the water bath for an additional 24 hours. At the end of the 24 hours, the residue was filtered through a non-ash filter. Filters containing the residues were placed in an oven to obtain the IVDMD. After obtaining IVDMD, filters were ashed. Remaining residue allowed for calculation of IVOMD.

Data were analyzed using the MIXED procedure of SAS (SAS Institute, Inc., Cary, N.C.). For *in vivo* digestion data, the model included treatment, block, period, and wether within block as fixed effects. For *in vitro* data, the response variable was IVDMD or IVOMD, with the tube being the experimental unit. The *in vivo* digestibility estimates were regressed with *in vitro* digestibility estimates for DM and OM to determine if of *in vitro* digestibilities of residues can predict *in vivo* estimates.

Results

Nutrient composition of the feed ingredients is presented in Table 2. Dry matter and NDF intakes of the residues were not significantly different ($P \leq 0.83$, Table 3.), whereas the brome had the greatest DM and NDF intake ($P < 0.01$). The husk had the greatest digestibility of DM, OM, and NDF (68.11%, 70.49, and 75.28% respectively), compared to the other treatments ($P < 0.01$) which is consistent with previous observations. The digestibility of OM and NDF did not differ among the two residues collected using alternative harvesting methods (i.e. husklage and stalklage; $P > 0.12$). Ensiling the husklage did not significantly change DM or OM intakes compared to non-ensiled husklage ($P = 0.33$ and $P = 0.32$, respectively). The NDF digestibility of the ensiled husklage, 57.52%, tended to be less than the NDF digestibility of the husklage ($P = 0.11$). There were no significant differences between the ensiled husklage and stalklage on DM, OM, and NDF digestibilities ($P > 0.88$). While ensiling the husklage appeared to numerically increase DMI, we could not observe a difference statistically ($P = 0.33$).

The brome treatment had the greatest 7 day period DM, OM, and NDF intakes, 10.04 lb, 9.45 lb, and 7.51 lb, respectively, across all treatments ($P < 0.01$). The DM digestibility of the brome (45.11%) was similar only to the stalklage (49.37%; $P = 0.14$). The OM and NDF digestibilities of the brome treatment were the lowest, 47.77% and 46.92%, respectively, across all treatments ($P \leq 0.06$).

The IVDMD and IVOMD of each of the forages were different from other forages ($P < 0.01$; Table 4). The husk had the greatest IVDMD and IVOMD, which is consistent across many observations. The average OM digestibility was 10.8 units greater for the *in vivo* analysis than the *in vitro* analysis. A regression analysis was performed for both the DMD and OMD of the residue from both the experiments. The DMD had an $R^2 = 0.65$, (Figure 1) meaning that the *in vivo* and *in vitro* digestibilities are 65% related to each other. The OMD, (Figure 2) however, had an $R^2 = 0.88$. Ideally the relationship between *in vitro* and *in vivo*

Table 2. Nutrient composition of different corn residues (DM-basis)

Residue	DM	OM	NDF	CP
Husk	93.27	96.53	85.48	5.74
Husklage	88.54	97.37	90.82	5.95
Ensiled Husklage	36.15	96.32	84.78	7.46
Stalklage	89.80	92.28	86.74	5.48
Brome	92.78	93.60	74.35	10.89

Table 3. Effects of harvest method on intakes and in vivo digestibilities in wether lambs.

	Husk	Husklage	Ensiled Husklage	Stalklage	Brome	SEM	*P*-value
DM							
Intake, lb/period	5.55^{b}	5.74^{b}	6.59^{b}	5.78^{b}	10.04^{a}	0.62	< 0.0001
Fecal output, lb	1.92^{c}	2.65^{bc}	3.34^{b}	2.95^{b}	5.48^{a}	0.34	< 0.0001
Digestibility, %	68.11^{a}	54.07^{b}	50.90^{bc}	49.37^{cd}	45.11^{d}	2.07	< 0.0001
OM							
Intake, lb	5.36^{b}	5.55^{b}	6.38^{b}	5.32^{b}	9.45^{a}	0.58	< 0.0001
Fecal output, lb	1.72^{d}	2.43^{bc}	3.09^{b}	2.28^{cd}	4.92^{a}	0.31	< 0.0001
Digestibility, %	70.49^{a}	56.40^{b}	53.30^{b}	57.58^{b}	47.77^{c}	2.18	< 0.0001
NDF							
Intake, lb	4.68^{b}	5.13^{b}	5.54^{b}	4.99^{b}	7.51^{a}	0.50	< 0.0001
Fecal output, lb	1.24^{c}	1.95^{b}	2.46^{b}	2.12^{b}	3.98^{a}	0.26	< 0.0001
Digestibility, %	75.28^{a}	62.40^{b}	57.52^{b}	57.94^{b}	46.92^{c}	2.14	< 0.0001

$^{a\text{-}d}$Means within a row without a common superscript are different, ($P < 0.10$)

Table 4. The effect of harvest method of corn residue on IVDMD and IVOMD

	Husk	Husklage	Ensiled Husklage	Stalklage	Brome	SEM	*P*-value
IVDMD, %	61.34[a]	38.71[d]	30.43[e]	42.91[c]	46.67[b]	0.70	< 0.01
IVOMD, %	67.12[a]	43.16[d]	36.27[e]	48.08[c]	50.13[b]	0.67	< 0.01

[a-e]Means within a row without a common superscript are different, ($P < 0.01$)

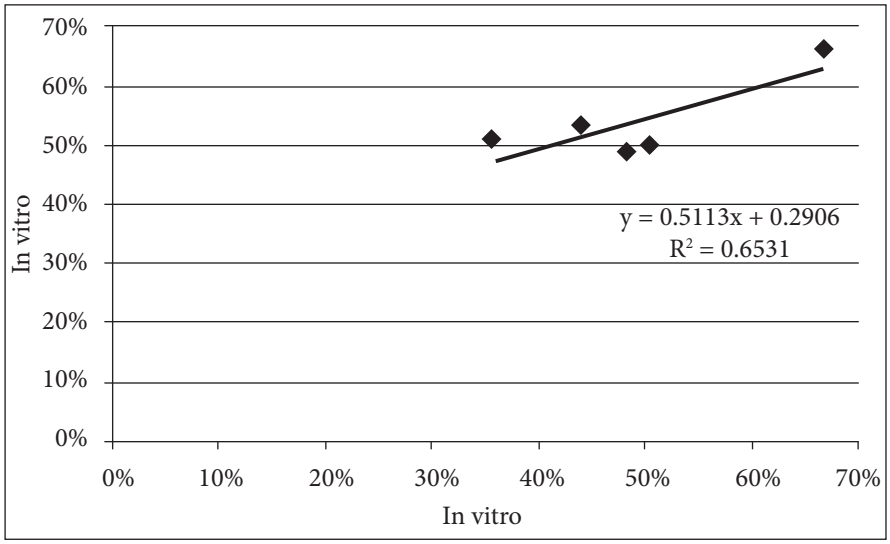

Figure 1. Regression of the dry matter digestibility of corn residue. *In vitro* vs *in vivo*

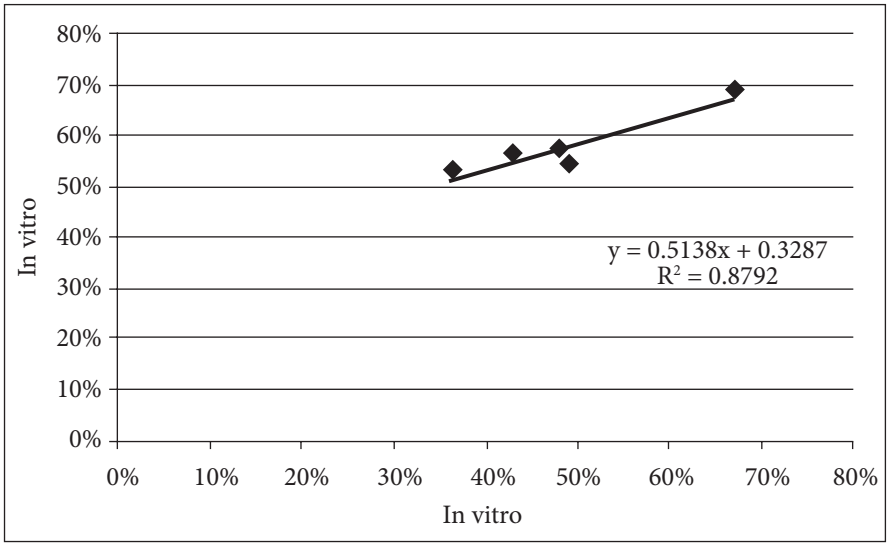

Figure 2. Regression of the organic matter digestibility of corn residue. *In vitro* vs. *in vivo*

values would have a slope of 1 and an intercept of 0. The slopes for both OM and DM were approximately 0.51 and the intercepts were approximately 0.3. These relationships suggest that *in vitro* estimates would need to be adjusted to *in vivo* values.

The methods used to harvest residue appear to influence the digestibility and quality of the residue. The differences are likely due to changing the proportion of husk, leaf, and cob compared to the proportion of stem in the bale. Since *in vitro* digestibility estimates do not accurately predict in vivo digestion values, there is a need to develop lab standards to adjust *in vitro* digestion estimates.

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Effect of Corn Plant Maturity on Yield and Nutrient Quality of Corn Plants, 2-Year Summary

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Summary

Corn plots were serially harvested over 2 years to evaluate changes in nutrient content, digestibility, and yield as plants matured from half-milk line through black layer. In yr 1 (2013), short (102 d) and normal (111 d) season hybrids were grown. Year 2 used 111 d and 112 d hybrids. Silage and grain yield increased until black layer. Silage DM increased with maturity to 42% at black layer. Percent NDF in the stover, NDF-digestibility and overall silage TDN increased quadratically as maturity increased. There is a balance between moisture content, nutrient content, and silage yield, as corn plants mature.

Introduction

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

Procedures

In the fall of 2013, two irrigated corn plots contained a 111-d maturing DEKALB variety DKC 61–16RIB and a 102-d maturing DEKALB variety DKC 52–61RIB, and fields were planted on May 1, 2013 and June 12, 2013, respectively. Both plots were sampled weekly either 6 (102 d planted late) or 7 times (111 d planted normal date) around grain maturing (before and after black layer). Sample dates were from August 22 to September 17 (111 d normal) and September 12 through October 1 (102 d early) to reflect the time from half milk line through dry grain harvest. Each sample date consisted of eight sampling replications with 10 plants in each replication.

In the fall of 2014, two hybrids, Pioneer 1151AM (111-d maturity) and Pioneer 1266AM (112-d maturity) were sampled in a dry land corner of the field and under irrigation. Sampling occurred from August 21, 2014 to October 2, 2014, with all plots sampled over the 7 week period.

In both years, plants were cut at the third node, to approximately 18 in above ground. In the fall of 2013, plants were harvested at different cutting heights and samples segregated at the lower stem at 2, 6, 12, and 18 in. heights corresponding with the nodes 1, 2, 3, and 4, respectively. For the two-year summary, data for 18 in. cutting height were used from 2013. Each week, samples were collected 20 feet past where the sampling ended the week before.

The total sample was weighed and maturity stage recorded based on the kernel. Dry matter was determined on all samples in both year 1 and 2 and used for yield calculations. The ear was weighed, and dried for a minimum of 72 hours in a 140°F oven. The last 24 hours, the grain was separated from the cob and allowed to continue to dry. After drying, grain and cobs were weighed. The remaining stover and husk were ground through a wood chipper and thoroughly mixed. Subsamples were collected from ground stover for DM analysis at 140°F for a minimum of 48 h, or freeze dried and then ground through a 2-mm screen for laboratory analysis. Ground stover samples were analyzed for concentration of NDF and in situ NDF digestibility (NDFd; 28 hour incubation). A value for stover residue digestible NDF was calculated using DM percentage, NDF, and NDFd for stover samples. Crude protein was determined on ground stover. Data from the 2 years were combined to determine the change across time for percent grain, silage yield, silage DM, grain yield, percent CP, percent cell solubles, DM NDFd, and DM NDF content. Stover digestible dry matter (DMD) was calculated as digestible NDF plus cell solubles minus 12 (metabolic loss). To calculate silage DMD, grain was assumed to have 90% DMD.

Yield and nutritive value data were analyzed using the MIXED procedure of SAS (SAS Institute, Inc., Cary N.C.). The experimental unit was classified as plot (ten corn plants) for digestibility work. Harvest timing was a fixed effect, and dry land or irrigated field and year hybrid were considered random. Differences were considered statistically significant at $P \leq 0.05$.

Results

Percent grain increased linearly as maturity increased ($P < 0.01$; Table 1) and averaged 52% grain at black layer when cut at 18 in. height above ground. Silage yield increased quadratically as maturity increased ($P < 0.01$), peaking at black layer. Grain yield also increased quadratically as maturity increased ($P = 0.02$), peaking around black layer. It is unclear why grain yield subsequently decreased after black layer. Silage DM increased linearly as maturity increased ($P < 0.01$). The silage first increased in DM slowly, until approximately a week before black layer; then DM increased at a faster rate. Silage DM was 33 to 38% at 1 to 2 weeks prior to black layer when traditionally cut for silage. However, silage DM was 42% at black layer. Crude protein had a tendency to decrease linearly with maturity in both years ($P = 0.14$). Cell solubles in the stover decreased quadratically and % NDF (DM basis) increased quadratically ($P = 0.03$) as

Table 1. Yield and nutrient characteristics of hand harvested whole plants cut at 18 in. above ground in the fall of 2013 and 2014. Data are combined for both years

	Weeks from Blacklayer								*P*-value	
	−4	−3	−2	−1	0	1	2	3	Lin.[a]	Quad.[b]
Percent Grain, %	48.8	45.2	48.9	50.9	52.3	53.5	55.2	59.4	< 0.01	0.29
Silage Yield, DM tons/ac	10.28	10.49	10.65	11.22	12.59	11.95	10.33	9.07	0.73	0.01
Silage DM, %	33.4	32.2	33.4	38.1	42.2	43.3	49.1	59.0	< 0.01	0.01
Grain Yield, bu/ac	210.8	198.5	218.4	237.8	274.5	266.6	239.8	226.4	0.03	0.02
Stover (entire plant without grain)										
Crude Protein, %	5.86	7.27	6.93	6.39	5.76	6.67	5.26	5.55	0.14	0.84
Cell Solubles, %	33.7	35.3	34.9	35.4	36.7	36.4	30.6	25.6	0.08	0.03
NDF, % of DM	66.3	64.7	65.1	64.6	63.3	63.6	69.4	74.4	0.08	0.03
NDF digestibility, %[c]	51.9	62.8	63.6	63.7	61.1	61.3	53.0	38.6	0.08	< 0.01
Digestible DM, %	56.2	63.6	63.7	64.1	62.5	62.5	55.1	42.2	0.04	< 0.01
Silage (entire plant with grain)										
Digestible DM, %	72.7	75.8	76.9	77.6	77.4	77.7	74.6	70.6	0.50	0.01
Dig DM yield, tons/acre	7.47	7.97	8.20	8.74	9.81	9.34	7.71	6.40	0.68	< 0.01

[a]*P*-value for linear response to maturity (weeks from blacklayer)
[b]*P*-value for quadratic response to maturity (weeks from blacklayer)
[c]28-h in-situ digestibility

Table 2. Effect of cutting height at harvest on yield characteristics of 111 day season corn in Exp 1

Item	Cutting Height[a]				SEM	*P*-value[b]
	2 in.	6 in.	12 in.	18 in.		linear
% DM	35.2	35.8	36.6	37.7	0.24	< 0.01
Silage Yield[c]	10.1	10.0	9.5	9.2	0.06	< 0.01
Grain %	45.2	46.2	48.1	50.2	0.32	< 0.01
NDF-dig. (stover)[d]	44.2	45.3	47.1	49.2	0.40	< 0.01
Crude Protein	7.3	7.5	7.8	8.3	0.06	< 0.01

[a]2 in.=cut at second crown root; 6 in.= cut at first node above second crown root; 12in.=cut at second node above the second crown root; 18 in.= cut at third node above second crown root
[b]Cutting Height = Lin response of cutting height
[c]Silage Yield in DM ton/ac
[d]28-h in-situ digestibility as percent of plant

Table 3. Effect of cutting height at harvest on yield characteristics of 102 day season corn in Exp. 1

Item	Cutting Height[a]				SEM	*P*-value[b]
	2 in.	6 in.	12 in.	18 in.		linear
% DM	36.0	36.5	37.4	38.2	0.25	< 0.01
Silage Yield[c]	8.6	8.6	8.4	8.2	0.08	0.37
Grain %	51.0	51.6	52.6	53.6	0.23	< 0.01
NDF-dig. (stover)[d]	36.7	37.3	38.3	39.4	0.59	< 0.01
Crude Protein	7.2	7.3	7.4	7.6	8.1	0.08

[a]2 in. = cut at second crown root; 6 in. = cut at first node above second crown root; 12in. = cut at second node above the second crown root; 18 in.= cut at third node above second crown root
[b]Cutting Height = Lin response of cutting height
[c]Silage Yield in DM ton/ac
[d]28-h in-situ digestibility as percent of plant

maturity increased. Digestibility of NDF was quadratic ($P < 0.01$) as maturity of the stover increased, with little change early, and a dramatic decrease in digestibility one week past black layer.

The DMD of the whole plant silage was estimated based on digestibility of the NDF and assuming 100% digestibility of cell solubles and 12% metabolic loss. The estimated values may not be absolute but give good relative values to predict the change in silage DMD with advancing maturity. Because NDF content increased and NDF digestibility decreased with maturity, the DMD of the stover decreased with maturity. However, because the percent grain was simultaneously increasing, the DMD of the silage did not change from the first to the last sampling time.

As cutting height increased, yield of stover decreased linearly as expected for both the 111 d hybrid (Table 2) and the 102 d hybrid (Table 3). If plants were cut higher, % DM linearly increased suggesting the bottom portions of stem are considerably lower in DM than upper portions of the plant. In addition, % grain (as a proportion of total plant corn silage) and % NDF digestibility (of stover) increased as cutting height was increased in both hybrids in year 1 (Table 2, Table 3).

Dry matter content of the silage was 35% at about 1.5 weeks prior to black layer. Silage yield increased up to black layer (42%) which means that the cost per ton of dry matter would be least at black layer. In addition, hauling dryer silage should decrease harvest, transport, and packing costs, but additional work is required on storage. The DMD of the silage (silage quality) did not change from 35 to 44% DM. These data suggest that silage should be harvested at black layer assuming steps are taken to assure adequate preservation of the drier silage.

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Effect of Harvest Method on Residue Quality

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Summary

A growing study was conducted to evaluate the effect of residue quality due to harvest method and inclusion of supplemental rumen undegradable protein on performance of growing steers. The residue harvested with an alternative method to minimize stem increased gain and improved efficiency compared to conventionally harvested corn residue. Inclusion of rumen undegradable protein increased gain and improved feed efficiency compared to diets without supplemental rumen undegradable protein.

Introduction

The use of corn residue as a roughage source has proven to be economical for producers. As the amount of corn produced has steadily increased over the past 60 years, the quantity of corn residue available has also increased. Previous research has shown that quality of the residue depends on which plant parts are harvested, with the husk having greater digestibility compared to the stalk, which is lowest in digestibility (2012 *Nebraska Beef Report*, pp. 11–12). Advancements in harvest method technology are allowing producers to harvest a bale containing less stalk than conventional baling methods. With residues being low in CP and energy, supplementation is often necessary to meet the nutrient needs of the calf to reach sufficient gains (2016 *Nebraska Beef Report*, pp. 31–32). Even with higher quality residues, metabolizable protein supplementation is still needed to achieve the desired performance of the growing calves. The objective of this trial was to determine the effect of harvest method on quality of residue in growing diets and the effect of supplemental rumen undegradable protein (RUP) to residue based growing diets.

Procedure

An 84-d growing trial was conducted utilizing 60 crossbred steers that were individually fed with the Calan gate system. Steers were limit-fed a diet of 50% alfalfa and 50% Sweet Bran® at 2% of BW for 5 days prior to start of trial to reduce variation in gut fill, then 3 consecutive day weights were collected, utilizing the average as initial BW. Steers were blocked by initial BW, and assigned randomly to 1 of 5 treatments with 12 steers per treatment in a randomized complete block design. Steers were implanted with Ralgro® on day one of the trial. Two harvest methods were utilized to obtain residue samples for the trial. The New Holland Cornrower Corn Head was used to obtain bales containing 2 or 8 rows. The Cornrower head allows the producer to adjust the number of stalks cut from 0 to 8 (8-row head) and windrows the residue (leaves and husks) on top of the stalks. Harvest method utilizing the Cornrower head was previously discussed in detail (*2015 Nebraska Beef Cattle Report*, pp. 62–63). Conventional bales were harvested in the traditional method of baling cornstalks to be used as a comparison, by raking all residue expelled through the combine and baling. The study consisted of 5 treatments. Both the 8 row and conventional corn residues were used to provide diets containing additional RUP and diets without added RUP, allowing for comparison of the effect of supplemental RUP. Due to the limited availability of 2 row corn residue bales, only a diet containing additional RUP was included to ensure RUP requirements of cattle were being met. The three harvest methods were compared using the three diets with additional RUP. Supplemental RUP was added to treatment diets through the addition of a 50:50 blend of SoyPass® and Empyreal 75® (Table 1). The 50:50 blend provided a balanced supply of amino acids in RUP. All diets were formulated to provide 200 mg/steer daily of

Table 1. Composition of growing diets (DM basis)

Ingredient, % of DM	Treatments				
	2-Row + RUP	8-Row	8-Row + RUP	Conventional	Conventional + RUP
2-Row Corn Residue	64.5	—	—	—	—
8-Row Corn Residue	—	64.5	64.5	—	—
Conventional Residue	—	—	—	64.5	64.5
Distillers Solubles	30	30	30	30	30
Supplement	5.5	5.5	5.5	5.5	5.5
Supplement Composition, %					
SoyPass®[a]	36	—	36	—	36
Empyreal 75®[b]	24	—	24	—	24
Soyhulls	—	60	—	3.0	—
Limestone	33	33	33	33	33
Tallow	2.6	2.6	2.6	2.6	2.6
Salt	2.8	2.8	2.8	2.8	2.8
Trace Minerals	1.0	1.0	1.0	1.0	1.0
Vitamin ADE	0.4	0.4	0.4	0.4	0.4
Rumensin®[c]	0.2	0.2	0.2	0.2	0.2

[a]SoyPass® is a branded soybean meal source high in RUP.
[b]Empyreal 75® is a branded corn gluten meal source high in protein.
[c]Diets were formulated to provide 200 mg/steer daily of Rumensin® at 16 lb DM consumption.

Rumensin®.

Feed samples and refusals were collected weekly, weighed, and then dried in a 140° F forced air oven for 48 hours to calculate individual DMI. At the conclusion of the trial, steers were limit fed the same diet (50% alfalfa and 50% Sweet Bran®) as the beginning limit-fed period for 5 days. Steers were weighed for 3 consecutive days with the average used to determine accurate ending BW.

Table 2. Main effects of supplemental RUP in corn residue based diets fed to growing steers[a]

	No RUP	Supplemental RUP	SE	*P*-Value
Initial BW, lb	617	618	4.9	0.91
Ending BW, lb	724	740	7.5	0.14
ADG, lb	1.27	1.45	0.07	0.08
DMI, lb/d	13.8	12.7	0.52	0.14
Feed:Gain[b]	10.50	8.65	—	0.02

[a]Interaction between residue harvest method and supplemental RUP was not statistically different ($P > 0.12$).
[b]Statistics calculated on Gain:Feed.

In Vitro *and* In Situ

An *in vitro* procedure was performed for 48 h to obtain *in vitro* organic matter digestibility (IVOMD) on the corn residues using the Tilley and Terry method with the modification of adding 1 g of urea to the buffer. Residues were filtered through non ash filters and ashed at 1112°F for 6 h.

An *in situ* study was conducted to determine the proportion of RUP in the three residue types, and the RUP digestibility of the RUP in the small intestine. Dacron bags (Ankom Technology, Fairport, NY) were filled with 1.25 g (as-is) of each corn residue. Four bags per residue were placed in mesh bags and incubated in the ventral rumen of 2 ruminally fistulated steers for 30 h. The bags were evenly divided with half being rolled and frozen until insertion in duodenum. The remaining *in situ* bags were washed and refluxed in neutral detergent solution using the ANKOM Fiber Analyzer (Ankom Technology).

In situ bags previously set aside were preincubated in a pepsin and HCL solution (1 g of pepsin/L and 0.01 *N* HCl) for 3 h at 98.6°F and agitated every 15 min to simulate abomasal digestion. Bags were inserted directly in the duodenum of 2 cows at the rate of 1 bag every 5 min for a total of 6 bags per cow. Once the bags were excreted they were rinsed and frozen until all bags were collected. Bags were washed and refluxed using the ANKOM Fiber Analyzer (Ankom Technology) and dried in a forced-air oven for 48 h at 140°F, air equilibrated for 3 h, and weighed allowing for calculation of intestinal disappearance of RUP.

Data for the performance trial were analyzed using MIXED procedures of SAS (SAS Institute, Inc., Cary, N.C.) as a randomized complete block design with animal serving as experimental unit. *In vitro* and *in situ* data were analyzed as completely randomized designs using the MIXED procedure of SAS. In both cases, residue harvest method was the treatment, and tube (*In vitro*) or steer (*In situ*) was the experimental unit.

Results

Effect of Supplemental RUP

To compare the effects of supplemental RUP to the treatments, the 8-row diets and conventional residue diets were set up as a 2 × 2 factorial. There were no interactions between conventional and 8-row residues, and dietary RUP concentration ($P > 0.12$). The addition of RUP resulted in a significant improvement in ADG ($P = 0.08$; Table 2), and F:G ($P = 0.02$) compared to the same diets without the additional RUP. Metabolizable protein has shown to be a limiting nutrient for growing steers. While the current study did not show an interaction between harvest method and supplemental RUP ($P > 0.12$), it is intriguing that steers fed residue from the conventional harvesting method responded greater to supplemental RUP (8.4% vs. 27.3% improvement in F:G for 8-row and conventional, respectively; data not shown).

Effect of Residue Harvest Method

To evaluate the effects of harvest method, comparisons were made within diets containing added RUP. Steers fed the 2-row residue diet had the greatest ADG, and consequently a greater ending BW compared to the conventionally harvested corn residue ($P < 0.10$; Table 3). There tended to be an improvement in the F:G ratio in the 2-row compared to the conventional corn residue ($P = 0.11$) resulting from the higher quality residue. The 2-row bales have a higher proportion of husk and leaf which are more digestible than stems and cobs. Results from the IVOMD show the 2-row have greater IVOMD compared to the other two residues ($P < 0.01$; Table 4). However, steers consuming the 2-row residue refused 5.0% of their daily feed compared to 1.5% refused by steers consuming conventional corn residue. Visual observations indicated that the refusals were primarily cobs. The 8-row residue diet showed no improvements over the conventional corn residue diet, which is likely due to the 8-row bales containing a similar proportion of stem as the conventional bales. IVOMD results support this conclusion showing no difference ($P > 0.05$) between the 8-row and conventional (IVOMD of 58.00% and 57.82% respectively). *In situ* results showed no difference in RUP content and RUP digestibility among the three residues (Table 5). From the results of this procedure it can be concluded that 40% and 60% should be used for RUP content (% of CP) and RUP digestibility of corn residues respectively.

These results suggest that by changing the harvest method of the residue, the quality can be improved over conventionally harvested residue. As number of rows is reduced in the bales, an increased ADG and improvement in F:G ratio was observed. However, with this reduction in rows, the yield of residue removed from the field is decreased. Based on grain yield, an estimated 4.23 tons/acre of residue is produced in the field. As the quality of the bale increased, the yield decreased down to 0.42 tons DM/acre with the 2-row bales.

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Table 3. Effects of corn residue harvest method on performance of growing steers.

					Contrasts		
	2-Row + RUP	8-Row + RUP	Conventional + RUP	SE	2-Row vs. 8-Row	Conv. vs. 2-Row	Conv. vs. 8-Row
Initial BW, lb	617	617	618	6.6	0.97	0.90	0.93
Ending BW, lb	760	744	735	10.0	0.26	0.08	0.52
ADG, lb	1.71	1.51	1.39	0.10	0.17	0.03	0.41
DMI, lb/d	13.1	13.1	12.3	0.76	1.00	0.48	0.49
Feed:Gain[a]	7.69	8.33	9.09	—	0.16	0.11	0.83

[a]Statistics calculated on Gain:Feed.

Table 4. Effect of harvest method on IVOMD

	2-Row	8-Row	Conventional	SE	*P*-value
IVOMD[a], %	61.58[e]	58.00[f]	57.82[f]	0.5	< 0.001
IVDMD[b], %	55.77[e]	50.94[f]	49.57[g]	0.3	< 0.001
DOM[c], %	60.28	55.48	54.84	—	—
Residue yield, t/ac (DM)	0.42	2.25	2.22	—	—
TDN[d], t/ac	0.25	1.25	1.22	—	—

[a]In vitro organic matter digestibility
[b]In vitro dry matter digestibility
[c]Amount of digestible organic matter as % of dry matter. Calculated as OM content × IVOMD.
[d]TDN assumed equal to DOM
[e,f,g]Means with differing superscripts are different.

Table 5. Effect of harvest method on RUP of residue.

	2-Row	8-Row	Conventional	SE	*P*-value
CP, %	6.06	7.80	7.78		
RUP (% of CP), %	35.84	40.85	44.57	12.0	0.88
RUP digestibility, %	57.96	51.78	67.36	5.8	0.35

Effects of Different Inoculum Used for *In Vitro* and *In Situ* Digestion Procedures Performed on Corn Residue Samples

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Summary

An in vitro and in situ study was conducted to assess the effects of donor diet at time of incubation on NDF digestibility of corn residue samples. Residue samples had greater NDF digestibility when animals were on a similar diet (i.e. a high corn residue diet). Digestibility of NDF was greater when time of incubation increased. The diet of the donor steer had greater impact as time of incubation increased implying that the animal's diet, and incubation time, has an impact on the true values of NDF digestibility.

Introduction

Increased corn production has resulted in increased corn residue available as a feed source for cattle. Traditionally corn residue has been viewed as a low quality forage source due to its relatively low digestibility. Parts of the corn residue have different digestibility values, with stalk and cob being the least digestible, but composing the largest portion (60.11%) of the plant (*2012 Nebraska Beef Report*, pp 11–12).

With increasing progress in corn harvesting methods there has been a shift in which parts of corn residue are being baled as feed. An improvement in feed efficiency was found when corn residue was harvested using a John Deer 569 round baler with the Hillco single pass round bale system, compared to conventional harvesting methods (*2015 Nebraska Beef Report*, pp 42–44). Further, feed efficiency was improved by harvesting 2 rows of stalks plus tailings using the Cornrower system compared to raked and baled stalks (*2016 Nebraska Beef Report* pp 81–83). This improvement in feed efficiency is attributed to a higher ratio of leaf and husk to cob and stalk in the residue. Knowing the energy value of corn residue is critical when feeding.

One of the most important feed assays to assess the energy of forages is the neutral detergent fiber digestibility (NDF digestibility). *In vitro* and *in situ* procedures are traditionally carried out using an inoculum retrieved from a donor on a 30% concentrate diet to evaluate feed. However, the diet fed to the donor may impact NDF digestibility estimates. Therefore, the objective of this study was to evaluate the effects of different donor diets on *in vitro* and *in situ* digestibility when compared to a 30% concentrate diet.

Procedure

Four ruminally canulated steers were utilized in this study comparing two forage diets. A mixed diet consisting of 70% brome and 30% dry distillers grains (DDGS) was fed to two steers and a high corn residue diet with 70% stalks and 30%

Table 1. Simple effects of incubation time and donor diet on in vitro NDF digestibility of different forages[a] (%).

Sample[c]	24 h			48 h		
	Mixed[b]	Residue	*P*-Value	Mixed	Residue	*P*-Value
2Row	41.15	40.36	0.86	57.90	57.62	0.95
4Row	33.84	33.10	0.87	47.27	48.73	0.74
6Row	37.87	35.56	0.60	48.60	51.55	0.50
8Row	36.33	35.67	0.88	47.83	49.24	0.75
Cob	40.30	38.84	0.75	49.86	53.17	0.45
Conventional	31.30	32.75	0.74	41.55	44.84	0.45
Good Brome	46.21	48.63	0.58	63.06	65.88	0.52
Husk	43.99	44.79	0.85	59.99	61.06	0.81
I-barn Hay	37.58	36.15	0.74	47.37	51.67	0.32
Leaf	36.87	41.36	0.30	48.07	51.70	0.40
Meadow Hay	47.88	41.30	0.13	53.90	58.66	0.27
Poor Brome	32.17	33.95	0.68	41.84	45.25	0.43
Prairie Hay	27.54	26.84	0.87	38.26	39.57	0.76
Stalk	34.69	36.24	0.73	43.47	44.67	0.78

[a]NDF digestibility averaged across run
[b]Mixed diet consists of 70% brome and 30% DDGS; Residue diet consists of 70% stalks and 30% Sweet Bran
[c]Sample × time × diet; [a]SEM = 3.0; *P* = 0.99; LSD = 0.04

Table 2. Main effects of diet fed to donors on in vitro NDF digestibility[a] (%).

Time (h)	Diet[b]		SEM	*P*-value[c]
	Mixed	Residue		
24	37.68	37.54	1	0.90
48	49.21	51.69	1	0.03

[a]NDF digestibility averaged across all forage samples
[b]Mixed diet consists of 70% brome and 30% DDGS; Residue diet consists of 70% stalks and 30% Sweet Bran
[c]Diet × time interaction; *P* = 0.11

Table 3. Simple effects of incubation time and donor diet on in situ NDF digestibility of different forages[a] (%)

Sample[c]	28 h			36 h			48 h		
	Mixed[b]	Residue	*P*-Value	Mixed	Residue	*P*-Value	Mixed	Residue	*P*-Value
2Row	31.04	39.21	0.02	46.73	47.90	0.74	54.44	59.76	0.13
4Row	28.08	32.02	< 0.01	40.03	39.87	0.03	47.67	49.15	< 0.01
6Row	28.68	33.72	< 0.01	42.64	42.63	0.14	49.73	50.72	< 0.01
8Row	19.20	26.33	< 0.01	35.52	39.19	< 0.01	41.95	46.31	< 0.01
Cob	15.65	21.74	< 0.01	28.65	31.02	< 0.01	37.57	40.90	< 0.01
Conv.	29.77	33.59	< 0.01	39.77	38.60	0.03	43.02	42.38	< 0.01
Husk	36.36	46.39	0.42	48.05	46.09	0.97	59.43	62.10	0.93
Leaf	42.96	46.88	0.29	53.37	52.45	0.12	54.31	57.54	0.12
Stalk	19.58	23.03	< 0.01	25.68	30.47	< 0.01	30.11	33.65	< 0.01

[a]NDF digestibility averaged across replication
[b]Mixed diet consists of 70% brome and 30% DDGS; Residue diet consists of 70% stalks and 30% Sweet Bran
[c]Sample x time x diet; [a]SEM = 2.0; *P* = 0.99; LSD = 0.04

Table 4. Main effects of diet fed to donors on in situ NDF digestibility[a] (%)

Time (h)	Diet[b]		SEM	*P*-value[c]
	Mixed	Residue		
28	27.92	33.66	2	< 0.01
36	40.00	40.91	2	0.45
48	46.47	49.17	2	0.02

[a]NDF digestibility averaged across all forage samples
[b]Mixed diet consists of 70% brome and 30% DDGS; Residue diet consists of 70% stalks and 30% Sweet Bran
[c]Diet × time interaction; *P* = 0.01

Sweet Bran was fed to the remaining two steers.

Residue samples consisting of 2-row, 4-row, 6-row, 8-row, conventional bale, leaf, husk, stalk and cob were evaluated *in situ* and *in vitro* using inoculant from both sets of steers. A New Holland Cornrower Corn Head was used to obtain bales with 2, 4, 6, and 8 rows. The Cornrower head uses an attachment to cut the stems and blow them into a windrow between the wheels of the combine. The straw spreader is disengaged, allowing for the exiting residue to fall onto the windrow of stalks. The number of rows being cut at once can be adjusted from 0 to 8. The residue exiting the combine includes all of the cobs, a majority of the husks, some leaves, and some of the upper 1/3 portion of the stems. The 8 row bale includes all of the stalk material, thus, may be equivalent to conventionally baled stalks. Conventionally baled stalks from another single field were also used.

Five chopped hays, with known in vivo NDF digestibility values were used as non-corn residue samples to compare effects of inoculum with other forage types. The hays were immature smooth bromegrass (good brome), mature smooth bromegrass (poor brome), low quality brome or immature meadow hay (meadow hay), mature brome hay used in individual feeding (mature hay), and prairie grass hay (prairie hay).The prairie hay consisted of a mixture of warm and cool season grass species. Inoculum for *in vitro NDF digestibility* was obtained by collecting whole rumen contents from each steer, with two steers per treatment, strained through 4 layers of cheesecloth. Each of the strained ruminal fluid samples were then mixed with McDougall's buffer (1:1 ratio) containing 1 g urea/L. Residue and non-residue samples of 0.5 g were weighed into a 100 mL tube where 50 mL of one of the two inoculum, was added to each tube. All 11 samples were tested with each inoculum from each individual steer, to determine the effects of each diet for each sample. This process was repeated in three runs, and steer inoculum source was the experimental unit (n = 6). Three in vitro tubes per experimental unit were averaged for digestibility estimates. Test tubes were placed in a water bath at 101°F and incubated for 24 or 48 hours. Fermentation was ended by removing tubes from the water bath and placing them in the freezer immediately. The runs were performed at one week intervals, beginning one week after donor steers started their respective diets. Tubes were later thawed in a 101°F for 10 minutes and evaluated for NDF content to estimate NDF digestibility. Tubes were poured into a 600 mL beaker and rinsed with NDF solution added up to 150 mL total volume. The beaker was brought to a boil on a hot plate and allowed to reflux for one hour. The beaker content was then filtered through Whatman 541 filter paper, rinsed with distilled water, and dried in a 100°C oven for six hours.

The NDF digestibility of the corn

residue was also determined utilizing *in situ* rumen incubation. Residue samples were weighed (1.25 g) into small (5 × 10 cm) *in situ* bags. Three bags of each sample were placed in the rumen of each of the four steers, with two steers per treatment and 81 bags per steer separated into three time points (n = 4). Individual bags were placed in a mesh zipper bags fitted with weights and incubated for 28 h, 36 h, and 48 h. After the incubation period bags were pulled from the animal and rinsed with distilled water. After rinsing the bags, Ankom analysis was conducted to analyze NDF of the remaining residue. This process was repeated with two runs performed at 48 hour intervals.

All data were analyzed using the MIXED procedures of SAS (SAS Inst., Inc., Cary, N.C.). The effects of run, diet, time, and sample were examined. Diet by time and diet by time by sample interactions were also tested.

Results

In vitro

No 3-way interaction was observed for time by sample by diet ($P = 0.99$). There are no interactions for time by sample ($P = 0.79$) or diet by sample ($P = 0.99$; Table 1). There was a tendency for an interaction for diet by time ($P = 0.11$) where diet significantly ($P = 0.03$) affected NDF digestibility at 48 h, but not at 24 h (Table 2). Both residue samples and non-residue samples were found to have greater NDF digestibility when inoculum from the residue diet was used compared to that of the mixed diet at 48 hours (Table 2). There was an effect of run ($P < 0.01$), and an effect of time ($P < 0.01$) illustrating that runs are variable. Run 1, 2, and 3 had average NDF digestibility values of 41.07%, 48.27%, and 42.74% across both diets and all samples.

In situ

No 3-way interaction was observed for time by sample by diet ($P = 0.99$; Table 3). There was an effect ($P < 0.01$) for diet across *in situ* runs. Average NDF digestibility was greater for residue samples when the donor was fed a high corn residue diet (Table 4). There was an effect of run ($P < 0.01$), and an effect of time ($P < 0.01$) again demonstrating variability between run. At 28 and 48 hours, diet impacted NDF digestibility ($P < 0.01$). However, there was no effect of diet fed to donor at 36 hours ($P = 0.45$). As expected, average NDF digestibility for all samples increased with time, regardless of diet fed to the donor steer.

As anticipated, the husk and leaf had the greatest average NDF digestibility for *in situ* (0.52, 0.45) and *in vitro* (0.50, 0.51), respectively. The stalk and cob followed with smaller average NDF digestibility for *in situ* (0.27, 0.29), respectively. Similarly stalk and cob had smaller average NDF digestibility for *in vitro* (0.40, 0.46), respectively.

This study shows that the diet of the donor animal does affect NDF digestibility estimates of corn residue samples. However, when trying to assess energy values using these techniques a set of standards should be used for adjustment.

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Effect of Safeguard® on Fecal Egg Count and Steer Performance in Newly Received Calves

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Summary

The effects of Safeguard® on fecal egg count (FEC) and performance of newly received calves in the feedlot were evaluated. Treatments were Safeguard® and Dectomax® injectable or only Dectomax® injectable. The basal diet consisted of 30% dry-rolled corn, 36% Sweet Bran® Cargill, 30% alfalfa hay, and 4% supplement. There were no differences in DMI, ADG, F:G, and initial FEC between treatments. However, FEC on d 19 was lower for animals receiving Safeguard® and Dectomax® compared to Dectomax®. The combination of Safeguard® and Dectomax® reduced FEC to very low amounts of newly received calves in the feedlot.

Introduction

Gastrointestinal parasitism is one of the most costly diseases in the US cattle industry, and has significant economic impact due to cost of treatment, prevention, and losses in beef production.

In feedlot animals, subclinical parasitism can cause inferior rates of gain and feed conversion. It is assumed that losses occur as a result of a number of factors, including the diversion of nutrients to parasite growth and reproduction, interference with nutrient absorption by reducing available surface area and direct damage to the gut lining.

The fecal egg count reduction test is a simple test recommended by the American Association of Veterinary Parasitologists to help producers verify that the dewormer they are using is effective.

Fenbendazole (Safeguard®, Merck Animal Health) and *Doramectin* (Dectomax®, Zoetis Animal Health) are indicated for use in cattle for removal and control of lungworms, stomach worms, and intestinal worms. However, interactions among these products have not been widely documented.

Procedure

The effects of Safeguard® during the receiving period on fecal egg count (FEC) and steer calf performance in the feedlot were evaluated. The experiment was conducted at the University of Nebraska–Lincoln Agricultural Research and Development Center (ARDC) near Mead, NE. Three hundred sixty-eight (BW = 584 ± 44 lb) steers were used in a completely randomized design study with 16 pens (8 replications per treatment and 23 steers per pen). Treatments were applied to steers at arrival and were a combination of Safeguard® (1 mL/110 lb of BW) and Dectomax® injectable (2.5 mL/110 lb of BW) (SG+DTX) or only Dectomax® injectable (DTX). Steers were assigned to pen based on processing order, with every other steer assigned to SG+DTX or DTX. Once a pen replicate was filled, new pen replicates were started until all steers were assigned.

The basal diet consisted of 30% dry-rolled corn, 36% Sweet Bran® Cargill, 30% alfalfa hay, and 4% supplement. On d 1, steers were ear tagged, individually weighed, vaccinated with Bovi-shield® Gold One Shot, Somubac®, and individual fecal samples were collected. On d 19, fresh fecal samples were collected off pen floor surface (10 samples/pen). Fecal samples were analyzed for FEC (eggs per 3 grams) at a commercial laboratory (Animal Production Consulting, Inc.). At the end of the receiving period (24 d), steers were limit-fed a common diet consisting of 50% Sweet Bran® and 50% alfalfa hay (DM basis) at 2% of BW for 5 d before collecting ending BW to minimize variation in gut fill. Ending BW was an average of 2 d weights. Initial BW was not shrunk because steers were weighed within 12 h of arrival and had no access to feed before weighing.

Fecal egg count and animal performance data were analyzed using the MIXED procedure of SAS (SAS Institute, Inc., Cary, N.C.) with pen as the experimental unit.

Results

There were no differences in initial BW ($P = 0.13$), ending BW ($P = 0.33$), DMI ($P = 0.41$), ADG ($P = 0.94$), and F:G ($P = 0.43$) between DTX or SG+DTX (Table 1). In relation to FEC, no significant difference was observed for initial FEC ($P = 0.45$) between treatments and averaged 16.9 eggs per 3 g

Table 1. Effects of Dectomax (DTX) or Safeguard and Dectomax (SG+DTX) on fecal egg count and steer performance of newly received beef calves in the feedlot

Item	Treatments		SEM	*P-value*
	DTX	SG+DTX		
Initial BW, lb	579	589	4.4	0.13
Ending BW, lb	655	664	6.8	0.33
DMI, lb/d	12.9	13.4	0.38	0.41
ADG, lb	3.02	3.01	0.15	0.94
Feed:Gain[a]	4.29	4.46	—	0.43
Initial FEC[b]	18.7	15.1	3.35	0.45
Ending FEC	0.50	0.06	0.13	0.03

[a]Analyzed as G:F, the reciprocal of F:G
[b]FEC: Fecal egg count (eggs per 3 grams)

of feces, which is a fairly low parasite load. However, FEC on d 19 was lower ($P = 0.03$) for animals receiving SG+DTX (FEC = 0.06 eggs per 3 g feces) compared to DTX (FEC = 0.50 eggs per 3 g feces) (Table 1).

Results indicated the combination of Safeguard® and Dectomax® reduced the FEC of newly received calves in the feedlot slightly more than Dectomax® alone, but is probably not biologically significant. The parasite load was quite low on incoming cattle. Given the slight reductions between treatments and low parasite load on arrival, no performance impacts are logical.

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Evaluation of Varying Corn Grain (and Byproduct) Inclusion in Beef Cattle Finishing Diets

Andrea K. Watson, Matt K. Luebbe and Galen E. Erickson

Summary

A pooled-analysis of UNL feedlot trials examined the impact of starch (corn grain) on cattle performance. Cattle age (calf-fed or yearling) affected DMI, ADG, and F:G, but not marbling score or fat depth. Intake, ADG, F:G, and fat depth were optimized with 50–70% corn grain in the diet. Marbling was not maximized until the diet contained > 75% corn. Removing either all the corn or all the byproduct from diets did not maximize performance. Including a minimum of 20% byproduct and 20% corn in the diet is biologically advantageous, while the remaining 60% of the diet is flexible based on economics.

Introduction

In recent years, corn grain in finishing diets has been replaced with byproducts, largely due to relatively expensive grain prices. However, this substitution varies greatly with price of distillers relative to grain. Feed byproducts from both the wet and dry corn milling industries contain low concentrations of starch (< 5%). Replacing corn with distillers grains or corn gluten feed improves performance which would suggest that some replacement of starch with non-structural fibrous byproducts benefits cattle and there is no starch "requirement." Likewise, some research has focused on replacement of corn grain with corn silage, or with alkaline-treated forages to replace relatively small proportions of grain. When grain is relatively expensive, beef cattle can be fed alternatives and small replacements of starch can be accomplished. If forages replace grain, then ADG will be reduced, and F:G increased. If distillers grains or corn gluten feed replace grain, ADG and F:G are improved. The development of the cattle feeding industry was largely driven by the availability of cheap corn (relative to other feedstuffs), which is similar to current feeding scenarios. This pooled-analysis was done to identify blends of grain and byproduct that maximize cattle performance.

Procedure

Data were collected from 19 experiments conducted during 2005–2010 at the University of Nebraska-Lincoln. The data included 678 pen means fed 111 different treatment diets with varying inclusion of corn grain. Included in the analysis were 353 pens of cattle fed some level of distillers grains plus solubles (DGS), 184 pens of cattle fed a blend of DGS and wet corn gluten feed (WCGF), and 141 pens of cattle fed no byproduct. For data analysis, pens of cattle were divided into 5 subclasses of corn inclusion in the diet; 0% corn (69 pens of cattle), 1–25.9% corn (28 pens), 26–50.9% corn (238 pens), 51–75.9% corn (250 pens), and ≥ 76% corn (93 pens), on a DM basis. Corn was processed as dry rolled corn, high moisture corn, or a blend of the two. There were 423 pens of yearling cattle and 255 pens of calf-feds. Yearlings were defined as cattle starting on feed in the spring (May) and finished the following fall, typically September. Yearlings had an average initial BW of 726 lb. Calf-feds started on feed in the fall, roughly November, and finished the following spring, approximately May. Average initial BW for calf-feds was 574 lb. Cattle performance was measured using DMI, ADG, F:G, marbling, and 12th rib fat thickness.

Within experiment, cattle were blocked by initial BW, allocated randomly to pens within block, and pens were assigned randomly to dietary treatments. In all but one experiment, cattle within an experiment were fed the same number of days and then marketed at a commercial abattoir. Hot carcass weight was recorded on day of slaughter. Fat thickness was measured after a 24 to 48-hr chill. USDA marbling score was called by a professional USDA grader. Both ADG and F:G were calculated based on hot carcass weights adjusted to a common dressing percentage of 63%. These experiments have been previously published individually as Nebraska Beef Reports (*2006* p. 51; 2007 p.33; 2007 p. 25; 2007 p. 27; 2007 p. 36; 2008 p. 36; 2008 p. 53; 2009 p. 62; 2009 p. 64; 2009 p. 66; 2009 p. 70; 2009 p. 76; 2010 p. 86; 2011 p. 48; 2011 p. 55; 2011 p. 84).

Performance data for each pen of cattle were available, thus, pen means were used in the pooled-analysis. Experiment was included in the model as a random effect and type of byproduct in the diet was included as a covariate. Corn inclusion in the diet was treated as a fixed effect. Interactions between study and corn inclusion or byproduct type were not significant ($P > 0.10$). Quadratic responses were plotted and the first derivative calculated to determine the maximum or minimum point. Age of cattle was tested to determine if calf-feds and yearlings had different responses. Factors that may have affected the results, but were not included in the statistical model; include type and amount of forage in the diet, processing of corn, implant program, and year effects.

Results

Age of cattle affected DMI, ADG, and F:G ($P < 0.01$). Marbling score and fat depth were not affected by age of cattle ($P \geq 0.18$), thus those data were combined across all pens. All cattle were fed with the goal of reaching 0.5 in of backfat. For calf-feds, DMI quadratically increased as inclusion of corn in the diet increased ($P < 0.01$; Table 1). Maximum DMI was 22.3 lb/d, corresponding with a 70% corn diet. Yearling DMI was not affected by corn inclusion ($P = 0.95$) and averaged 25.1 lb/d. Both calf-feds and yearlings had a quadratic increase in ADG as amount of corn in the diet increased ($P < 0.01$). For calf-feds, maximum ADG was 3.95 lb at 49% corn in the diet while yearlings had a maximum ADG of 3.85 lb with 44% corn in the diet.

Feed conversion was minimized with 47% corn in the diet with a conversion of 5.39 for calf-feds; F:G was optimized at 6.30 with 64% corn in the diet for yearlings. Marbling was maximized with 83% corn and a marbling score of 533 for all cattle combined. Fat thickness for all cattle was maximized at 49% corn in the diet at 0.52 in. Marbling and fat thickness change across days on feed, energy content of the diet can affect how many days on feed are required to reach a 0.5 in fat thickness endpoint.

Optimal ADG and F:G occurred when grain was included at 26 to 50% of diet DM in finishing diets, and likely reflects improved performance when some grain is replaced with distillers grains (most common substitute for corn in these studies). Complete removal of corn grain decreased ADG and increased F:G suggesting that some corn (> 25%) is beneficial. Carcass characteristics generally reflected changes in gain as cattle within experiments with different treatments were fed similar days in all but one experiment. It is unclear whether complete removal of corn hindered ADG and F:G due to less starch, or if certain nutrients in the diet became a challenge, such as sulfur or fat. The diets with the majority of the corn replaced were based on common byproducts such as distillers grains replacing corn, which dramatically increase dietary sulfur and fat. Depending on the definition of requirement, some starch may be required; however, this likely reflects no appropriate substitute (byproducts or forages) available for complete replacement of starch.

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Table 1. Finishing steer performance when fed different dietary inclusions of corn grain

	Corn grain inclusion, % of dietary DM					Peak[a]	SEM	Linear	Quad
	0	1–25.9	26–50.9	51–75.9	≥ 76				
Calf-feds									
No. of pens	26	17	57	105	50				
DMI, lb/d	18.7	20.5	21.5	22.4	22.2	70	0.75	< 0.01	< 0.01
ADG, lb	2.59	3.61	3.88	3.92	3.55	49	0.15	0.01	< 0.01
F:G[b]	7.20	5.67	5.52	5.67	6.33	47	—	0.34	< 0.01
Yearlings									
No. of pens	43	11	181	145	43				
DMI, lb/d	25.2	24.7	25.1	25.2	25.2	—	0.78	0.70	0.90
ADG, lb	3.50	3.61	3.91	3.99	3.79	44	0.16	0.07	< 0.01
F:G[b]	7.10	6.85	6.49	6.47	6.77	64	—	0.31	< 0.01
All cattle									
Marbling score[c]	462	488	511	529	532	83	10.3	< 0.01	< 0.01
12th rib fat, in	0.41	0.50	0.52	0.53	0.50	49	0.03	< 0.01	0.01

[a]Peak is the amount of corn in the diet, % of DM, at which DMI, ADG, marbling, and 12th rib fat were maximized and F:G was minimized.
[b]Analyzed as G:F, the reciprocal of F:G.
[c]Marbling score: 300 = slight, 400 = small, 500 = modest.

Carcass Gain, Efficiency, and Profitability of Steers at Extended Days on Feed

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Summary

Steers were individually fed for 22 and 44 days longer than the industry average marketing point of 0.5" backfat to determine carcass-based gain, efficiency, and deposition changes throughout the feeding period (142, 163, and 184 days on feed). Premiums and discounts for yield grade, quality grade, and overweight carcasses were applied to determine profitability. Feeding steers for 22 and 44 days longer increased carcass weight, quality grade, and yield grade 4 and 5s. Steers fed 44 days longer had increased total revenue and profit per head despite a decrease in live gain and efficiency.

Introduction

Recent increases in base carcass price of fed cattle have increased the incentive to feed cattle longer. Extending the feeding period increases the risk of receiving discounts for overweight carcasses and increased yield grades (YG) while also having increased likelihood of receiving premiums for higher quality grades (QG) due to fat deposition as cattle continue to be fed. Historically, the optimum marketing date of steers has been determined by changes in feed efficiency for live weight gain where cost of gain should not surpass breakeven live price. Since energy deposited as fat on the carcass stays with the animal through harvest, fat is transferred to hot carcass weight (HCW) and adds value to the animal (*2014 Nebraska Beef Report*, pp 92–96). If additional HCW sold, which makes up the largest portion of total revenue, coupled with QG premiums can outweigh YG discounts, profitability may increase when steers are fed longer days on feed (DOF). The objective of this experiment was to evaluate the changes in steer performance on a live-animal and carcass-basis as steers are fed beyond the industry average 0.50 inch backfat and to determine if feeding cattle longer can remain profitable based on market conditions when sold on a grid basis.

Procedure

This study was conducted at the West Central Research and Extension Center (WCREC), North Platte, Neb. Crossbred steers (n = 114, initial BW = 736 ± 65 lb) were individually fed using a GrowSafe® feeding system in an experiment to evaluate the change in carcass characteristics throughout the feeding period and the economic profit/loss realized by feeding cattle 0, 22 and 44 days longer than the industry average fat endpoint. Steers were limit fed a diet containing 55% Sweet Bran® and 45% hay for 5 consecutive d, with a 2 d weight collected. On the second d, steers were implanted with Revalor-200®, stratified by BW and assigned randomly to 1 of 3 pens. Steers were adapted to a concentrate finishing ration for 24 d and moved into GrowSafe® feeding facility to allow for individual DMI calculation.

Steers were weighed for 2 consecutive d with a 4% shrink applied to account for differences in gut fill; a constant gain (81 lb) was applied to the limit fed weight and served as initial BW at the time they entered the GrowSafe® feeding system on d 1. This was necessary because individual DMI could not be calculated until steers were placed in GrowSafe® system. Therefore, adaptation period was not included in DOF calculation. Steers within pen were assigned randomly to 3 serial harvest groups, allowing for 38 steers per harvest (1/3 of each pen). Steers were not blocked by initial BW in an attempt to simulate variation within pen, as might be observed in an industry setting. To maintain *ad libitum* intake, steers were fed twice daily a common finishing ration containing 48% dry-rolled corn, 40% Sweet Bran®, 7% prairie hay, and 5% supplement (DM basis) including Rumensin 90® (28g/ton diet DM), Tylan 40® (10g/ton diet DM), vitamins, and trace minerals. At 80 DOF, steers were re-implanted with Revalor-200® (102 d after initial implant).

Real time carcass ultrasound measurements including LM area, intra-muscular fat percentage, 12th rib fat thickness, and rump fat thickness were collected on 76 steers (2 pens) at 1, 78, and 134 DOF. Ultrasound image interpretation was conducted by The CUP Lab, Ames, IA. Steers were considered to be industry average when the group was estimated to be at 0.5" 12th rib fat thickness. The first set of calves was harvested at 142 DOF, while the second and third groups were harvested at 163 and 185 DOF, respectively. Carcass data were collected by Tyson Fresh Meats utilizing camera data.

Dressing percent for each harvest group was calculated using the total HCW sold divided by the gross live weight (no shrink). Carcass adjusted live animal performance was calculated using the calculated dressing percent of each harvest group rather than a common dressing percent. Incremental carcass-based gain and feed efficiency was calculated in an attempt to quantify performance over extended DOF on a carcass-basis using different sets of steers. Carcass-based gain and feed efficiency was calculated using the following calculations:

Carcass ADG for 163 DOF: (163 DOF average HCW − 142 DOF average HCW)/22 DOF

Carcass ADG for 185 DOF: (185 DOF average HCW − 163 DOF average HCW)/23 DOF

Carcass F:G for 163 DOF: 163 DOF carcass ADG/21.8 (average DMI from 142–163)

Carcass F:G for 185 DOF: 185 DOF carcass ADG/23.1 (average DMI from 163–185)

Economic factors were applied to the animal performance and carcass characteristics to determine total profit/loss when marketing steers at each harvest point under current market conditions (February 2015 averages). Economic prices of importance included Nebraska feeder, feed-

stuffs, 5-Area market average dressed steer, and 5-Area market average premiums and discounts applied to the carcass including HCW, QG, and YG. Yardage, vet./chute/misc, death loss, trucking and interest on cattle and feed were also included in the analysis (Table 1). Market prices were obtained from the Livestock Marketing Information Center, Lakewood, CO.

All data were analyzed using the GLIMMIX procedure of SAS (SAS Institute, Inc., Cary, N.C.). To develop 12th rib fat thickness, marbling score, and LM area data for the 2 pens of steers ultrasounded, data were analyzed separate from non-ultrasounded steers using covariate regression. Pen was included as random effect. Orthogonal contrasts were used to test linear and quadratic effects of DOF for steers.

Results

Average dressing percent at harvest was 63.54, 64.59, and 64.82% for 142, 163, and 185 DOF, respectively. Carcass adjusted final live weight increased linearly ($P < 0.01$) from 1295 to 1392 lb as steers were fed additional DOF (Table 2). Steer DMI was not different ($P = 0.59$) among DOF. Live ADG decreased linearly ($P < 0.01$) while F:G increased linearly ($P < 0.01$) as steers were fed longer. As steers were fed from 142 to 185 DOF, HCW increased linearly ($P < 0.01$) from 823 to 903 pounds, respectively. Incremental carcass ADG was 1.41 lb between days 142 and 163, and 2.13 lb between days 163 and 185. Carcass F:G was 15.38 between 142 and 163 days, and 10.87 between 163 and 185 days. Steer LM area quadratically increased ($P = 0.04$) from 13.8 to 14.5 in^2 (142 and 163 DOF, respectively) and did not change for 185 DOF at 14.3 in^2. Actual marbling score numerically increased from 475 to 506 (142 and 185 DOF, respectively) but was not significantly different ($P = 0.14$). Calculated YG and actual 12th rib fat thickness increased linearly ($P < 0.01$) as DOF increased for steers.

On d 1 when initial ultrasound was conducted, 12th rib fat thickness, marbling score, and LM area were not different ($P \geq 0.42$) among harvest groups. Steer 12th rib fat thickness increased quadratically ($P < 0.01$) from 0.19" on d 1 to 0.65" on d 185 (Figure 1). Steers ultrasounded on 134 DOF had 0.47" backfat, while those harvested at 142 DOF had an actual

Table 1. Prices used for economic analysis of steers fed increasing days on feed

Yard Information,	
Yardage, $/hd/d	0.45
Vet./Chute/Misc., per hd	15.00
Death Loss	2.0%
Trucking, $/hd	5.00
Interest on Feedlot Charges	5.0%
Interest on Calf	5.0%
Feedstuffs[a],	$/ton DM
Corn ($3.81/bu)	161.03
Ration cost	164.69
Dressed Steer, Base Choice[b]	253.00
Nebraska Feeder Calves[c],	$/cwt
500–599	279.99
600–699	245.15
700–799	219.30
800–899	199.88
900–999	186.12
1000–1099	176.60
Carcass Premiums and Discounts[d],	$/cwt
HCW,	
400–499	(25.43)
500–549	(22.82)
550–599	(2.73)
600–899	—
900–999	—
1000–1049	—
≥ 1050	(23.47)
Quality Grade,	
Prime	15.88
Choice, Upper 1/3	1.54
Choice, Middle 1/3	1.99
Choice, Bottom 1/3	—
Select	(6.08)
Standard	(17.09)
Yield Grade,	
1.00–1.99	4.59
2.00–2.49	2.25
2.50–2.99	2.13
3.00–3.49	—
3.50–3.99	—
4.00–4.99	(8.27)
≥ 5.00	(13.02)

[a]Values from the 5-Area Monthly Feedstuffs averaged for February 2015.
[b]Values from the 5-Area Weekly Dressed Steer averaged for February 2015.
[c]Values from the Nebraska Weekly Feeder Market Sales averaged for February 2015.
[d]Values from 5-Area Market Premiums and Discounts received for dressed steers averaged for February 2015.

Table 2. Feedlot and carcass performance of steers fed increasing days on feed

Live Animal Performance[a],	Days on feed				Contrasts	
	142	163	185	SE	Linear	Quadratic
Initial BW	732	739	736	11	0.79	0.75
Final BW, lb	1295	1322	1392	19	< 0.01	0.35
Live DMI, lb/d	23.8	23.5	24.1	0.5	0.59	0.31
Live ADG, lb	3.92	3.58	3.55	0.08	< 0.01	0.10
Live F:G, lb/lb	6.10	6.54	6.80	—	< 0.01	0.30
Carcass Performance,						
HCW	823	854	903	12	< 0.01	0.56
LM area, in^2	13.8	14.5	14.3	0.2	0.06	0.04
Marbling score[b]	475	476	506	15	0.14	0.42
12th rib fat thickness, in	0.49	0.58	0.69	0.04	< 0.01	0.79
Calculated YG[c]	2.89	3.05	3.56	0.16	< 0.01	0.20

[a]Live animal performance calculated using carcass adjusted final live weight: HCW divided by actual dressing percent from each serial harvest time point (64.83, 65.91. and 66.14%, respectively)
[b]200=Traces^{00}, 300 = Slight^{00}, 400 = Small^{00}, 500 = modest^{00}, 600 = moderate^{00}, 700 = Slightly Abundant^{00}, 800 = Moderately Abundant^{00}
[c]Calculated as: YG = 2.50 + (2.5 * rib fat thickness, in) − (0.35 * REA, in^2) + (0.2 * 2.5 KPH) + (0.0038 * HCW, lb)

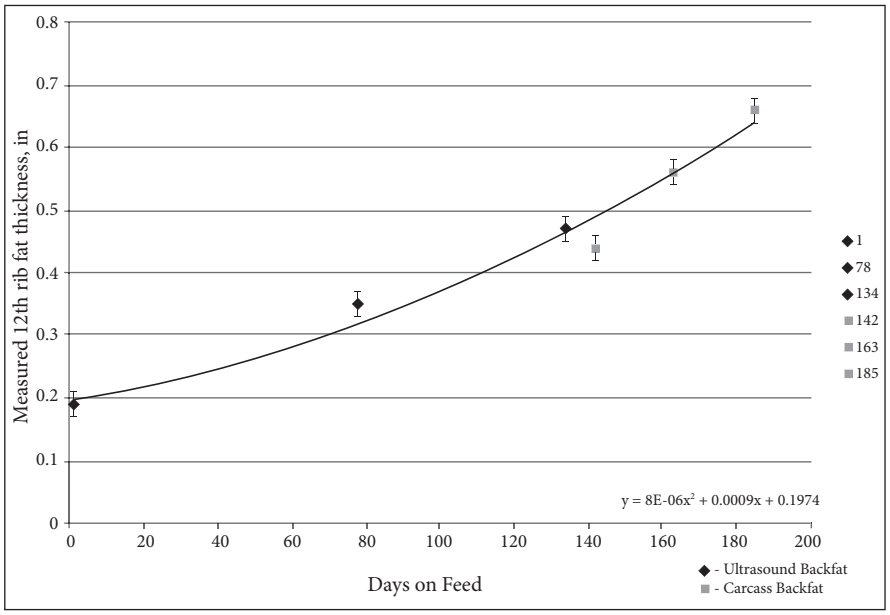

Figure 1. Measured 12th rib backfat thickness in inches throughout days on feed. Days 1, 78, and 134 were measured using real-time carcass ultrasound on 2 pens of cattle (n = 76) and averaged. Days 142, 163, and 185 were measured at time of harvest for each serial slaughter group (38 head) and averaged. Steer 12th rib backfat thickness increased quadratically ($P < 0.01$) from 0.19" at d 1 to 0.69" at 185 days on feed.

12th rib fat thickness of 0.44". This small discrepancy in fat thickness may be due to hide pulling and carcass trim at the harvest facility or the inherent differences in ultrasound and camera measurements. Marbling score increased quadratically ($P < 0.01$) from 346 at d 1 (initial ultrasound) to 526 at 185 DOF (Figure 2). Measured LM area increased quadratically ($P < 0.01$) from 10.3 in^2 (initial ultrasound) on d 1 to 14.4 in^2 as steers were fed to 185 DOF (Figure 3). The percentage of steers with final YG 5 was not different among DOF (Figure 4). The percentage steers within harvest group with final YG 4 increased linearly ($P < 0.01$) with DOF (2.63, 10.53, and 31.58%, respectively). Steers harvested at 185 DOF had 10.5% more YG 3 than 142 and 163 DOF which were not different. The percentage of steers grading choice or better was not different across DOF; however, the 185 d cattle had an increased percentage of steers grading upper 2/3 choice (Figure 5).

Total feedlot costs increased linearly ($P < 0.01$) with increasing DOF for 142, 163, and 185 ($431.36, $482.57 and $549.58, respectively). There was no difference ($P \geq 0.17$) in HCW and QG premiums and discounts however; there was a linear increase ($P < 0.01$) in YG discounts as steers were fed increasing DOF. Steers fed for 142 DOF had no HCW discount, a $1.40 and $6.23/head premium for QG and YG, respectively. However, the 163 DOF steers had no HCW discount, but $6.40 and $0.07/head discounts for QG and YG. Discounts of $6.72/head for HCW and $19.25 per head for YG were observed with a $5.12/head QG premium received for those steers fed to 185 DOF. Revenue generated from HCW linearly increased ($P < 0.01$) with increasing DOF from 142 to 185 ($2081.68 to $2283.37 per head, respectively). Similarly, total revenue including premiums and discounts linearly increased ($P < 0.01$) from $2089.41 to $2262.43 per head as DOF increased. Total profit per head increased from $18.20 to $85.74 as steers were fed from 142 to 185 DOF; however, due to variation among individuals within harvest groups, total profit per head only tended to increase ($P = 0.06$). Steers fed for 163 and 185 DOF sold 31 and 80 lb of additional HCW compared to the 142 DOF which equated to an additional $79.16 and $201.69 per head, respectively (Table 4). The incremental cost of HCW gain de-

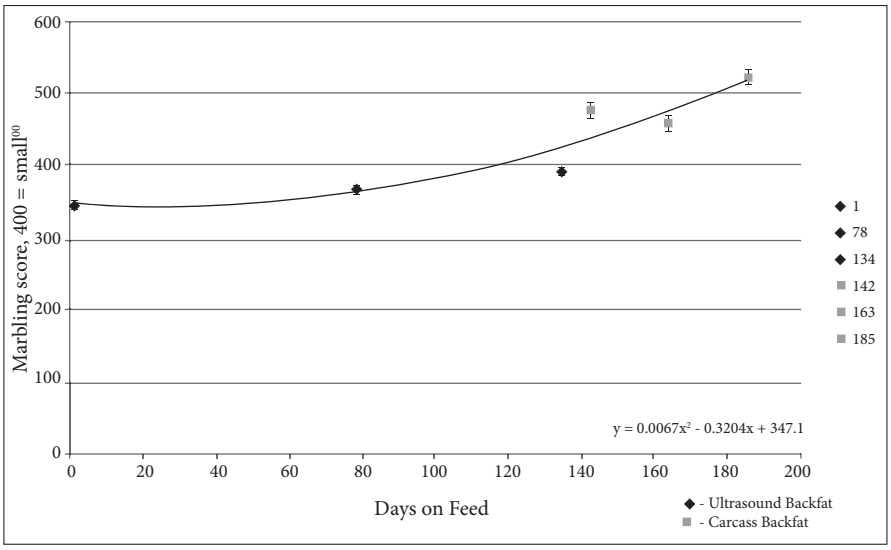

Figure 2. Marbling score of steers throughout days on feed. Days 1, 78, and 134 were measured using real-time carcass ultrasound on 2 pens of cattle (n = 76). Ultrasound measurement was evaluated as % IMF and converted to marbling score which was averaged for total group. Marbling score for days 142, 163, and 185 was calculated at time of harvest for each serial slaughter group (38 head) and averaged. Marbling score quadratically increased ($P < 0.01$) from d 1 at 346 to 526 at 185 days on feed.

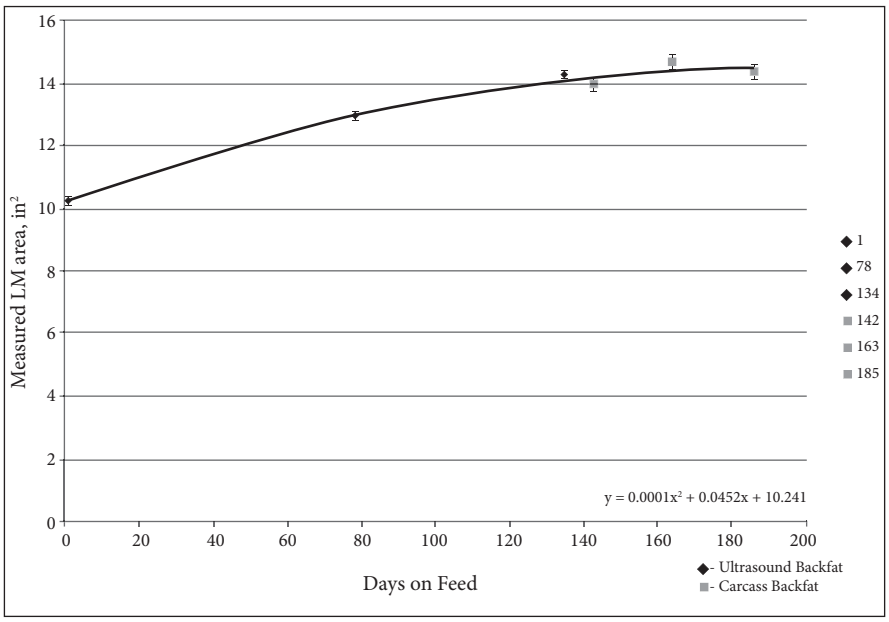

Figure 3. Measured LM area (in^2) throughout days on feed. Days 1, 78, and 134 were measured using real-time carcass ultrasound on 2 pens of cattle (n = 76) and averaged. Days 142, 163, and 185 were measured at time of harvest for each serial slaughter group (38 head) and averaged. Steer LM area increased quadratically ($P < 0.01$) from 10.3 in^2 at d 1 to 14.3 in^2 at 185 days on feed.

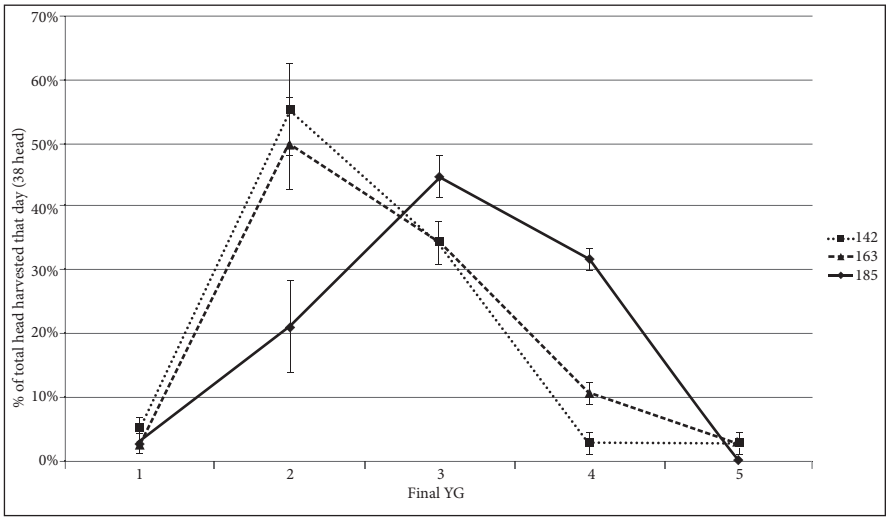

Figure 4. Percent of total steers harvested (38/day) on days 142, 163, and 185 having final yield grade (YG) 1–5. Final YG linearly increased ($P < 0.01$) with increasing days on feed from 142 to 185.

creased from $1.65 to $1.37 per lb as steers were fed an additional 22 or 23 d (142 to 163 and 163 to 185 DOF, respectively).

Although carcass adjusted live ADG decreased and live F:G became poorer with increasing DOF, steer HCW increased significantly. For steers fed longer DOF, the increase in profit despite the added total feedlot costs can be attributed to more HCW sold. Even though an increase in YG was observed, the premium received for QG coupled with the value of additional HCW in the current market equates to an increase in total revenue. When comparing economics at current market conditions, steers can be fed for 44 days longer than industry average of 0.5" backfat and increase profit per head because the cost of HCW gain is decreasing.

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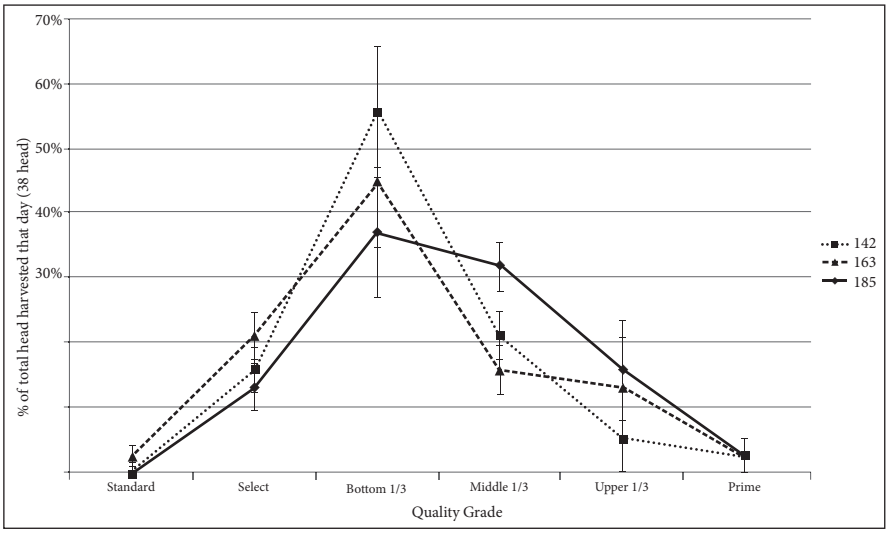

Figure 5. Percent of total steers harvested (38/day) on days 142, 163, and 185 having quality grade (QG) of standard, select, bottom 1/3, middle 1/3, upper 1/3, and prime.

Table 3. Feedlot economics for steers fed increasing days on feed

	Days on feed				Contrasts	
Inputs,	142	163	185	SE	Linear	Quadratic
Purchase Cost, $/hd[a]	1639.71	1635.83	1626.92	9.91	0.36	0.83
Feed Cost, $/hd[b]	279.27	315.48	366.66	6.54	< 0.01	0.20
Total Feedlot Costs, $/hd[c]	431.36	482.57	549.58	6.60	< 0.01	0.19
Premiums/Discounts[d],						
HCW, Average $/hd	0	0	(6.72)	3.95	0.23	0.48
Quality Grade, Average $/hd	1.40	(6.20)	5.12	5.67	0.64	0.17
Yield Grade, Average $/hd	6.23	(0.07)	(19.25)	7.10	< 0.01	0.33
Outputs,						
HCW Sold, $/hd[e]	2081.68	2160.84	2283.37	30.53	< 0.01	0.56
Total Revenue, $/hd[f]	2089.41	2154.47	2262.43	31.10	< 0.01	0.57
Total Profit, $/hd[g]	18.20	36.22	85.74	24.98	0.06	0.60

[a]Calculated using Nebraska Market sales with 100 lb weight groups multiplied by initial BW/100
[b]Calculated by: total DM feed usage multiplied by ration cost/ton DM.
[c]Total feedlot costs including feed, vet. and misc, yardage, trucking, death loss, and interest.
[d]Values from 5-Area Market premiums and discounts received for dressed steers.
[e]Calculated by: (HCW/100) * February 2015, 5-Area Market Dressed Steer Price.
[f]Calculated by: HCW sold + Premiums and Discounts received.
[g]Calculated by: Total Sold – (Purchase Cost + Total Feedlot Cost).

Table 4. Comparative feedlot economics of feeding an additional 22 or 44 days

	Days on Feed[a]	
Item,	142–163	163–185
Added Feed Cost, $/hd	36.31	51.18
Added Total Feedlot Cost, $/hd[b]	51.21	67.01
Additional HCW Sold, lbs/hd	31	49
Additional Revenue from HCW, $/hd	79.16	122.53
Total Additional Revenue, $/hd[c]	65.06	107.96
Cost of HCW Gain, $/lb[d]	1.65	1.37

[a]Values calculated per head for 22 or 44 additional days on feed, respectively.
[b]Including additional feed, vet. and misc, yardage, trucking, death loss, and interest for added days on feed.
[c]Additional $/hd received including discounts and premiums.
[d]Calculated as: Added Total Feedlot Cost / Additional HCW sold.

Effects of Feeding OmniGen-AF® on Immune Function, Performance, and Carcass Characteristics during the Feeding Period

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Summary

OmniGen-AF (Phibro Animal Health, Quincy, IL) was fed to steers to evaluate the effects on the metabolic and immune response during an immune challenge, as well as feedlot performance. The inclusion of OmniGen-AF for either the first 28 d or the entire feeding period) did not impact feedlot performance or carcass characteristics. However, within a subset of cattle receiving an immune challenge (the endotoxin lipopolysaacharide; LPS), OmniGen-AF supplementation did alter the metabolic and immune profile of steers. These results suggest that feeding of OmniGen-AF may enhance the metabolic and immune response if cattle are challenged by bovine respiratory disease.

Introduction

Within the beef industry, one of the most prevalent diseases is Bovine Respiratory Disease (BRD). The major hurdle in overcoming BRD is the multi-factorial etiology of the disease. Bovine respiratory disease is a combination of stress, viral pathogens, and bacterial pathogens that interact to cause major economic losses due to morbid cattle. A potential strategy to aid in combating BRD could be the inclusion of OmniGen-AF. OmniGen-AF is a feed additive that is composed of active dried *Saccharomyces cerevisiae* in combination with other vitamins and minerals that may have the potential to enhance the immune function of cattle. OmniGen-AF is a patented proprietary product shown to augment the innate immune function in cattle. The purpose of this study was to evaluate differences in immune response, feedlot performance, and carcass merit of newly received calf-fed steers fed OmniGen-AF.

Procedures

Three hundred and six calf-fed steers (BW 581 ± 41 lb) were utilized in a randomized block design experiment at the University of Nebraska-Lincoln Agricultural Research and Development Center (ARDC) near Mead, Neb. Steers were received over two d period at the ARDC. Upon arrival, steers were provided access to water and were processed, weighed, and allocated to treatment within 12 hours. Steers were blocked based on arrival date resulting in two blocks. Within blocks, steers were assigned randomly to 36 pens and pens assigned randomly to treatment (8–9 steers/pen and 12 pens/treatment).

Treatments diets included: Control (CON; basal receiving diet, no OmniGen-AF); basal receiving diet with OmniGen-AF supplemented at 4 g/100 cwt/hd/d for the first 28 d on feed (OG+28); or OmniGen-AF supplemented at 4 g/cwt/hd/d for the entire feeding period (OG+EFP). OmniGen-AF was supplemented daily to steers through the diet supplement for—both OmniGen treatment groups. The receiving diet was 30% alfalfa hay, 30% dry rolled corn, and 36% Sweet Bran with 4% supplement added. After the receiving period, steers were limit-fed a diet (50% alfalfa hay, 50% Sweet Bran) at 2% of BW for 5 d before weighing for ending BW to minimize gut fill variation. Ending BW for the receiving period was an average of 2 d weights collected after limit-feeding. Steers were adapted to a common finishing diet by replacing alfalfa hay at 27.5%, 20%, 12.5%, 5%, and 0% with high moisture corn at 22.5%, 30%, 37.5%, 45%, and 50% of the diet DM for steps 1 through 5 of the ration. Sweet Bran was held constant 40% while wheat straw and supplement were both held constant at 5%. During the adaptation, heifers were on step 1 for three d, step 2 for four d, step 3 for seven d, step 4 for seven d, and step 5 was the finishing ration. The final finishing diet included 50% high moisture corn, 40% Sweet Bran, 5% wheat straw, and 5% supplement. At the conclusion of the 28 d receiving period, OmniGen+28 steers were switched to the CON diet (no OmniGen-AF), while OmniGen+EFP cattle continued to receive OmniGen-AF supplement; recalculated every 30 d to supply 4 g/cwt/hd/d of BW. Also, after the 28 d receiving period, all steers were implanted with Revalor® XS (Merck). During the last 28 d of the finishing period, all cattle were supplemented Optaflexx® (Elanco) for 28 d at 300 mg/hd/d. At the end of the trial, steers were transported to Greater Omaha Pack (Omaha, Neb.). The following morning steers were harvested at which time hot carcass weights (HCW) were recorded. Following a 48 h chill, fat thickness, rib eye area (REA), and USDA marbling score were determined. Final BW, ADG, and F:G were calculated using HCW adjusted to a common (63%) dressing percentage.

To evaluate the immune response, on d 25 of the receiving period, 18 steers (nine steers from CON (n = 9), and OmniGen-AF treatment groups (n = 9; 4 from OmniGen+28 and 5 from OmniGen+EFFP) treatment groups) from block 2 were randomly selected for an immune challenge and moved into a tie stall barn. After a 3 d adjustment period, steers were fitted with indwelling jugular vein catheters for serial blood collection and indwelling rectal temperature (RT) recording devices, programed to record RT at 5-min intervals. After insertion of the jugular catheter and RT device, steers were returned to the individual tie stalls and allowed to rest for the remainder of the d.

On the following d, from 0800 to 1800 h, blood samples were collected at 30 min intervals from 2 h prior to the challenge to 8 h after the challenge. At 1000 (0 h), following the collection of the blood sample, steers were administered an i.v. bolus of

lipopolysaccharide (LPS, 0.5 µg/kg BW; *E. coli* O111:B4). At each collection point, 9 mL of blood was collected via monovette tubes for serum. After collection, blood samples were allowed to clot for 30 min at room temperature, centrifuged at 2,000 x *g* for 30 min (39.2°F) and serum was separated. Serum was collected and transferred into 1.5 mL microcentrifuge tubes and held at-112°F until analyzed for cortisol, pro-inflammatory cytokines (Tumor Necrosis Factor-α; TNF-α, Interferon-γ; IFN-γ, and Interleukin-6; IL-6), blood urea nitrogen (BUN), non-esterified fatty acids (NEFA), and glucose.

Feedlot performance data were analyzed as a randomized block design using MIXED procedures of SAS (SAS Institute, Inc., Cary, NC). Steers were blocked by arrival date and pen was the experimental unit; model included the fixed effect of treatment and block was a random effect. Immune response data were analyzed as a completely randomized design with repeated measures using the MIXED procedures of SAS; model included fixed effects of treatment and time, treatment × time was used as the error term to test whole plot effect. For both feedlot and immune data, when results of F-test were significant ($P < 0.05$), group means were compared by use of least significant difference. Pair wise differences among least squares means at various sample times were evaluated with the PDIFF option of SAS. Distribution of USDA Quality Grade data were analyzed as a randomized block design using the GLIMMIX procedure of SAS.

Results

At the conclusion of the receiving period (28 d), ending BW ($P = 0.43$), DMI ($P = 0.76$), ADG ($P = 0.32$), and F:G ($P = 0.35$) were similar between treatments. While overall rate of morbidity was low, there was a trend ($P = 0.12$) for morbidity to be decreased in OmniGen+28 and OmniGen+EFP steers when compared to CON steers. At the conclusion of the finishing period, no difference in final BW (P = 0.59), DMI ($P = 0.89$), ADG ($P = 0.66$) or F:G ($P = 0.90$) were observed across the three dietary treatments (Table 1). In regards to carcass merit, there were no differences in weight or characteristics (P > 0.31). There was no difference in the percentage of USDA Prime, USDA Choice, or USDA Select Quality Grades for all three dietary treatments. These data suggest that including OmniGen-AF during the receiving period (28 d) or for the entire feeding period does not impact feedlot performance or carcass merit of calf-fed steers.

For the LPS challenge portion of the trial, there was a dietary treatment ($P = 0.002$) and time effect ($P = < 0.001$); however, there was no dietary treatment x time interaction ($P = 0.99$) for RT. Steers within the OmniGen-AF treatment groups had a greater ($P < 0.01$) RT when compared to CON steers (102.70 ± 0.02°F vs. 102.51 ± 0.02°F, respectively). For both groups of steers, maximum RT was observed 2.5 h post LPS administration, and within 6 h, RT had returned to baseline temperatures (Figure 1.). Prior to the LPS challenge, RT was greater in the OmniGen-AF steers when compared to CON steers. Due to this difference prior to challenge, RT data were analyzed as the change in RT from baseline. As a change from baseline, RT was similar ($P = 0.49$) between the treatment groups.

For serum concentrations of cortisol, there was a dietary treatment effect ($P = 0.005$) whereby OmniGen-AF steers had decreased cortisol concentrations when compared to the CON steers (Table 2). Cortisol is the primary hormone responsible for the stress response. During an immune challenge, aside for initiating the bodies response to the stress (immune challenge) the release of cortisol also serves to prevent hyper-inflammation. There was a dietary treatment effect ($P = 0.03$) for the pro-inflammatory cytokines TNF-α

Table 1. Receiving period and overall feedlot performance and carcass merit for steers fed no OmniGen-AF (CON), OmniGen-AF during the receiving period (OmniGen+28), or OmniGen-AF for 215 d (OmniGen+EFP)

Item	Treatment groups[a]			SEM	*P-value*
	CON	OmniGen 28	OmniGenEFP		
Receiving Performance					
Initial BW, lb	571	573	577	7.0	0.82
Ending BW, lb[b]	662	670	675	8.0	0.43
DMI, lb/d	16.5	17.0	16.8	0.80	0.76
ADG, lb[c]	3.18	3.38	3.48	0.33	0.32
Feed:Gain[d]	5.53	5.00	5.24	—	0.35
Morbidity, %[e]	6.9	2.0	3.0	3.0	0.12
Feedlot Performance					
Initial BW, lb	662	670	675	6.0	0.87
Final BW, lb[f]	1431	1416	1417	11.0	0.59
DMI lb/d	21.6	21.6	21.8	0.3	0.89
ADG lb/d[g]	3.91	3.92	3.93	0.04	0.66
Feed:Gain	5.55	5.51	5.56	—	0.90
Carcass Merit					
HCW, lb	901	892	893	7.0	0.96
LM area, in^2	14.7	14.2	14.6	0.25	0.31
Calculated YG	3.1	3.3	3.1	0.14	0.52
12th rib fat, in.	0.5	0.6	0.6	0.14	0.86
Marbling[h]	503	498	508	24.0	0.96
Prime (%)	4.5	2.1	5.3	2.32	0.53
Choice (%)	76.4	76.6	81.9	4.50	0.59
Select (%)	19.1	21.3	13.8	4.22	0.41

[a]CON: No OmniGen-AF; OMN-28: OmniGen-AF during receiving, OMN-EFP: OmniGen for 215 d (the entire feeding period).
[b]Limit fed at 2% of BW for 4 d prior to single BW to determine ending BW of receiving period
[c]Calculated from ending BW of receiving period
[d]Analyzed as G:F, the reciprocal of F:G.
[e]Overall percentage of steers treated for bovine respiratory disease
[f]Calculated from carcass weight, adjusted to 63% common dressing percent.
[g]ADG for the entire feeding period (including receiving period)
[h]Marbling Score: 400 = Small, 500 = Modest, etc.

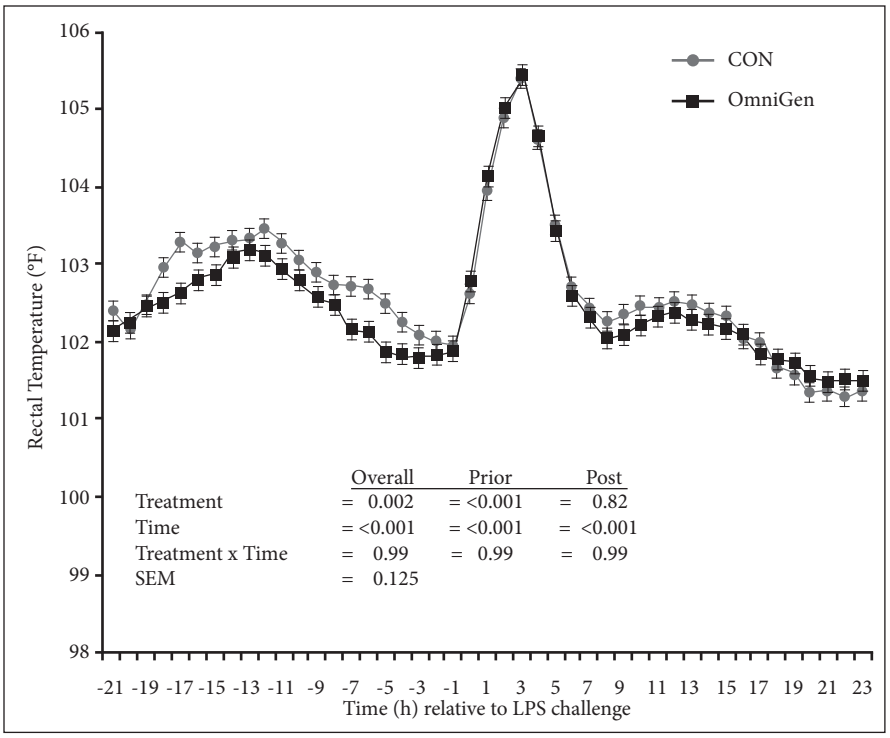

Figure 1. Rectal temperature of newly received steers supplemented OmniGen-AF at a rate of 4 g/cwt/hd/d (OmniGen) during the receiving period (28 d) or no OmniGen-AF (CON) during a lipopolysaccharide challenge

and IFN-γ (Table 2). Concentrations of TNF-α and IFN-γ were greater ($P = 0.03$) in OmniGen-AF steers when compared to the CON steers. Concentrations of IL-6 were not impacted ($P = 0.87$) by dietary treatment. Pro-inflammatory cytokines are released as a first response to an immune challenge; initiating a cascade of the immune response, such as inducing fever, inflammation, and initiating the healing of damaged tissue. The increased production of TNF-α and IFN-γ, may indicate the OmniGen-AF fed steers were able to mount a more robust pro-inflammatory response, compared to the CON steers.

Blood urea nitrogen (BUN), non-esterified fatty acids, and glucose were analyzed to evaluate metabolic alterations during the LPS challenge. Steers within the CON treatment group had greater ($P < 0.01$) concentrations of BUN and NEFA when compared to the OmniGen-AF steers (Table 2). Serum glucose concentrations were greater ($P < 0.01$) for OmniGen-AF fed steers, when compared to CON steers (76.42 ± 1.1 mg/mL vs. 72.42 ± mg/mL, respectively; Table 2). Both BUN and NEFA are indicators of energy mobilization; this increase in both BUN and NEFA may indicate a greater need for energy from CON steers to mount an immune response when compared to OmniGen-AF steers.

Overall, the results of this study indicate that the feeding of OmniGen-AF to calf-fed steers did not impact feedlot performance or carcass merit, but did alter the metabolic and immune response of calf-fed steers during an LPS challenge. While there was a decreased rate of morbidity in both treatments, the trend in decreased receiving morbidity in the OmniGen-AF fed steers may be a result of the alterations observed in the LPS challenge (decreased energy metabolism and increased pro-inflammatory cytokines). Overall, these alterations associated with OmniGen-AF feeding may allow for an enhanced metabolic and immune response of newly received cattle, which may help cattle combat BRD.

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Table 2. Endocrine, immune, and metabolic analysis of newly received steers supplemented OmniGen-AF at a rate of 4 g/cwt (OMN) during the receiving period (28 d) or no OmniGen-AF (CON) during a lipopolysaccharide challenge (LPS)

	Treatment groups[a]		SEM	Trt	Time	T × T
	CON	OmniGen				
Overall Cortisol	29.22	25.52	4.44	0.05	< 0.001	0.99
Post-LPS[b]	34.74	30.07	1.15	0.004	< 0.001	0.99
Overall TNF–α[c]	12.85	25.94	3.97	0.03	< 0.001	0.42
Post-LPS	15.71	31.04	4.88	0.03	< 0.001	0.47
Overall IFN–γ[d]	0.76	1.85	0.21	0.003	< 0.001	0.77
Post-LPS	0.93	2.12	0.26	0.007	< 0.001	0.81
Overall IL-6[e]	1877.66	1849.28	697.75	0.87	< 0.001	0.99
Overall BUN[f]	12.44	11.47	0.12	< 0.001	0.28	0.99
Overall NEFA[g]	0.21	0.10	0.01	0.002	< 0.001	0.49
Overall Glucose	72.42	76.36	1.12	0.009	< 0.001	0.19
Post-LPS	69.72	74.23	1.28	0.009	< 0.001	0.23

[a]CON = basal receiving diet (No OmniGen), OmniGen = OmniGen-AF at a rate of 4 g/cwt for 28 d. For the OmniGen treatment group; 4 steers from the OmniGen+28 group and 5 steers from the OmniGen+EFP were utilized)
[b]Treatment means after the LPS challenge (0.5–24 h)
[c]Tumor necrosis-α
[d] Interferon-γ
[e]Interleukin-6
[f]Blood urea nitrogen
[g]Non-esterified fatty acids

Yeast Supplementation Alters the Immune Response in Feedlot Steers

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Summary

Newly received steers (462 hd), were utilized to evaluate the effect of supplementation of Saccharomyces cerevisiae subspecies boulardii CNCM I-1079 yeast for a period of 32 d on performance and immune responsiveness. Treatment groups consisted of yeast supplementation of Saccharomyces cerevisiae CNCM I-1079 at either 0, 0.5, 1, 3, or 5 g/steer daily. Supplementations of Saccharomyces cerevisiae CNCM I-1079 yeast did not enhance receiving performance. However, supplementation did alter the pro-inflammatory profile of steers during an immune challenge. These results suggest yeast supplementation may provide a beneficial response for morbidity typical in newly received cattle.

Introduction

Bovine respiratory disease (BRD) is the most common disease impacting the beef industry. A possible tool to mitigate BRD is the supplementation of yeast as a probiotic. Supplementation of yeast has the potential as a probiotic in cattle due to yeast's ability to alter the innate immune response, directly interact with pathogenic bacteria within the GIT, and/or through alteration of ruminant metabolism, which in turn may influence the immune response. To further evaluate yeast supplementation as a means to improve health and performance in cattle, a receiving and immune challenge study was conducted to evaluate the effects of active dry yeast, *Saccharomyces cerevisiae* subspecies *boulardii* CNCM I-1079 (Lallemand, Inc.)

Procedures

Newly received steers (n = 462; BW 584 ± 49 lb) were stratified upon processing order at the University of Nebraska-Lincoln Agricultural Research and Development Center (ARDC) near Mead, Neb and assigned randomly to five treatment groups: yeast supplementation of *Saccharomyces cerevisiae CNCM I-1079* at 0, 0.5, 1, 3, & 5 g/steer daily. Initial BW was a single day weight collected at time of processing. For supplementation, live yeast was mixed 1:1 with a ground corn carrier and top-dressed immediately after daily delivery of feed for a period of 32 d. During the last five d of the receiving period (28–32 d), steers were limit fed at 2.0% of BW with continued yeast treatment and individually weighed on consecutive d (31 and 32 d). The average of the two consecutive d served as the ending BW for the 32 d receiving period.

To evaluate the immune response, on d 25 of the 32 d receiving period, 18 steers (six steers each from 0, 0.5g, and 5.0g treatment groups) were randomly selected for an immune challenge and moved into a tie stall barn. On d 27, steers were fitted with indwelling jugular catheters for serial blood collection and indwelling rectal temperature (RT) recording devices, programed to record RT at 5-min intervals. After insertion of the jugular catheter and RT device, steers were returned to the individual tie stalls and allowed to rest for the remainder of the d.

On d 28, blood samples were collected from 0800 to 1800 h at 30 min interval; 2 h prior to the challenge (0800–1000 h) and 8 h after the challenge (1000–1800 h) and at 24 h (1000 h) post-challenge on d 29. At 1000 (0 h), following the collection of the 0 h blood sample, steers were administered an i.v. bolus of lipopolysaccharide (LPS, 0.5 µg/kg BW; from *E. coli* O111:B4). At each sample collection point, blood was collected for serum. Serum harvested stored at -112°F until analyzed. Serum was analyzed for cortisol and pro-inflammatory cytokines (tumor necrosis factor-α, TNF-α; Interferon-γ, IFN-γ; and Interleukin–6, IL-6).

Performance data were analyzed as a randomized block design using MIXED procedures of SAS (SAS Institute, Inc., Cary, NC) with pen serving as the experimental unit. The model included the fixed effect of treatment and orthogonal contrast to test linear and quadratic effects with block as random effect. Immune response data were analyzed as a completely randomized design with repeated measures using the MIXED procedures of SAS. The model included fixed effects of treatment and time, and treatment × time was used as the error term to test whole plot effect. For

Table 1. Performance of newly received steers supplemented with *Saccharomyces cerevisiae* CNCM I-1079 yeast supplemented at 0.0, 0.5, 1.0, 3.0, and 5.0 g/steer daily for 32 d.

	CON[a]	0.5g[b]	1.0g[c]	3.0g[d]	5.0g[e]	SEM	*P*-value	Linear	Quadratic
Initial BW, lb	569	563	600	589	576	18.5	0.61	0.69	0.15
Ending BW, lb	655	664	704	688	679	26.5	0.64	0.96	0.43
Gain, lb	86	101	104	99	103	2.8	0.63	0.70	0.85
DM Offered lb/d	15.4	15.8	15.9	15.9	15.9	0.57	0.69	0.25	0.41
ADG, lb	3.3	3.2	3.2	3.1	3.2	0.10	0.47	0.36	0.78
Feed:Gain	4.93	5.09	4.87	5.05	5.01	—	0.66	0.75	0.80
Morbidity (%)	7.3[h]	18.5[fg]	10.4[gh]	15.4[fgh]	21.0[f]	3.9	0.05	0.01	0.78

[a]Control group, did not receive S*accharomyces cerevisiae*
[b]Supplemented S*accharomyces cerevisiae* at a rate of 0.5 g/hd/d
[c]Supplemented S*accharomyces cerevisiae* at a rate of 1.0 g/hd/d
[d]Supplemented S*accharomyces cerevisiae* at a rate of 3.0 g/hd/d
[e]Supplemented S*accharomyces cerevisiae* at a rate of 5.0 g/hd/d
[f,g,h]Denotes differences ($P < 0.05$) between treatment groups

both feedlot and immune response data, when results of F-test were significant ($P < 0.05$), group means were compared by use of least significant difference. Pair wise differences among least squares means at various sample times were evaluated with the Tukey-Kramer option of SAS

Results

In terms of morbidity, regardless of treatment, 14.2% of the steers were treated for respiratory diseases during the trial. The majority (75%) of cattle treated for respiratory disease occurred during the first 8 d of the study (regardless of treatment). There was a linear response ($P = 0.01$) to SC supplementation. Steers within the CON, 1.0g and 3.0g groups had a decreased ($P = 0.05$) overall rate of morbidity due to respiratory disease, when compared to the steers in the 0.5g and 5.0g treatment groups (Table 1.).

There was no treatment effect for ending BW ($P = 0.64$), DM offered ($P = 0.69$), ADG ($P = 0.47$), and F:G ratio ($P = 0.63$). There was also no difference ($P = 0.63$) in total weight gained between the five treatment groups; the average gain of treatment groups were 94 ± 8.3 lb. during the 32 d receiving period.

For the immune challenge portion of the trial, there was a difference in RT between the three treatment groups ($P = < 0.001$) prior to the LPS challenge. Prior to challenge (−4 to 0 h), 0.5g steers had a greater ($P = 0.004$) RT (102.8 +0.1°F), when compared to 5.0g (102.0 + 0.1°F) and CON steers (101.8+0.1°F; Figure 1). Due to difference in RT prior to the challenge, temperature was analyzed as the change from the average RT prior to the LPS challenge (−4 to-1 h; Figure 1). In response to the LPS challenge, RT increased in all three groups within 1 h of challenge ($P < 0.01$). The change in RT from baseline indicated a treatment effect ($P < 0.01$) but no treatment x time interaction ($P = 0.10$); CON steers had the greatest ($P < 0.01$) change in RT (2.01 ± 0.5°F) from baseline compared to 0.5g (1.51 ± 0.4°F) and 5.0g (1.19 ± 0.5°F) steers.

For serum cortisol, there was a treatment × time interaction ($P < 0.01$). Prior to the LPS challenge (−2–0 h), cortisol concentrations were similar ($P \geq 0.63$) between the treatment groups. Regardless of treatment, cortisol concentrations increased ($P < 0.01$) 0.5 h after the LPS challenge. At 0.5 h and

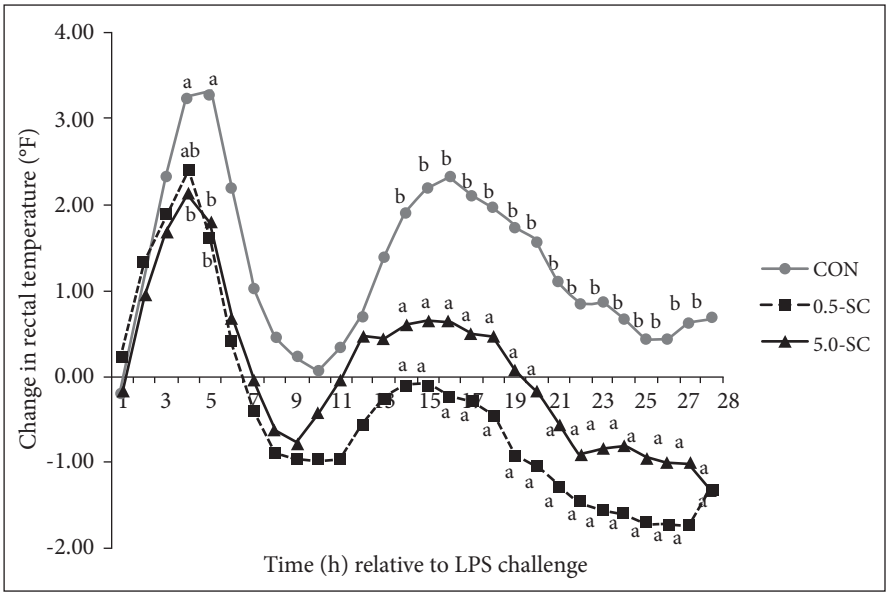

Figure 1. Change in rectal temperature (°F) from baseline (prior to challenge) during a lipopolysaccharide (LPS) challenge of newly received steers supplemented with S*accharomyces cerevisiae* CNCM I-1079 yeast supplemented at a rate of 0.0 (CON), 0.5 (0.5g), and 5.0 g/hd/d (5.0g) for a period of 32 d.

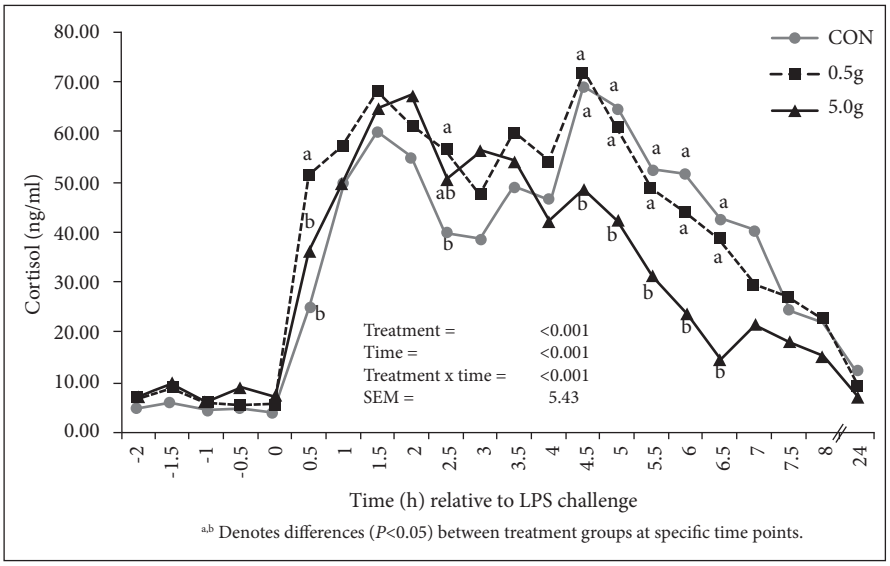

Figure 2. Cortisol concentrations during the lipopolysaccharide (LPS) challenge of newly received steers supplemented with S*accharomyces cerevisiae* CNCM I-1079 yeast supplemented at a rate of 0.0 (CON), 0.5 (0.5g), and 5.0 g/hd/d (5.0g) for a period of 32 d.

2.5 h post LPS challenge cortisol concentrations in the CON steers was less ($P < 0.01$) than steers in the 0.5g treatment group. Starting at 4.5 h and continuing until 6.5 h post LPS challenge, cortisol concentrations for steers within the 5.0g group were less than CON and 0.5g steers (Figure 2). Cortisol concentrations in all three groups returned to near baseline concentrations within 24 h of the LPS challenge.

There was a treatment effect ($P < 0.01$) for all pro-inflammatory cytokines (IFN-γ, TNF-α, and IL-6) and there was a treatment × time interaction ($P < 0.01$) for TNF-α and IL-6. Concentrations of IFN-γ were greater ($P < 0.01$) in the CON steers, when compared to the 0.5g and 5.0g. Concentrations of TNF-α increased ($P < 0.01$) in all treatment groups 1 h after the LPS challenge, and started to return to near baseline concentrations by 3 h post challenge (Figure 3). Concentrations of TNF-α in the CON steers from 1–1.5 h after the LPS challenge were greater ($P < 0.01$) than 0.5g and 5.0g

steers, and remained greater ($P = 0.001$) than the 5.0g steers until 3 h post challenge. Prior to the LPS challenge, concentrations of IL-6 were similar ($P = 0.95$) between all groups and remained similar until 1 h post LPS challenge (Figure 4). One h post challenge, IL-6 concentrations started to increase ($P < 0.01$) in all treatments, and concentrations in 5.0g steers were greater ($P = 0.05$) than CON steers, with 0.5g steers intermediate. Following the difference at 1 h post challenge, IL-6 concentrations were similar between treatments until 3.5 h post challenge. Starting at 3.5 h, concentrations of IL-6 in the 5.0g steers began to decrease and were less ($P = 0.009$) than CON and 0.5g. For the next 4.5 h (3.5–8 h post LPS challenge), concentrations of IL-6 for the 5.0g steers were less ($P = \leq 0.05$) than both the CON and 0.5g treatment groups. Twenty-four h after the LPS challenge, concentrations of IL-6 had returned to near baseline and were similar ($P \geq 0.53$) between all treatments.

While the 0.5g and 5.0g treatment groups had a greater rate of morbidity, there was no difference in performance between these two treatments and that of the CON, 1.0g, and 3.0g. The ability to maintain similar performance while having a greater rate of morbidity is supported by the LPS challenge results. Data from the LPS challenges suggest that the *Saccharomyces cerevisiae* subspecies *boulardii* CNCM I-1079 supplemented steers had a lesser response to the challenge compared to CON steers, indicated by decreased production of cytokines and decreased production of cortisol in the 5.0g supplemented steers.

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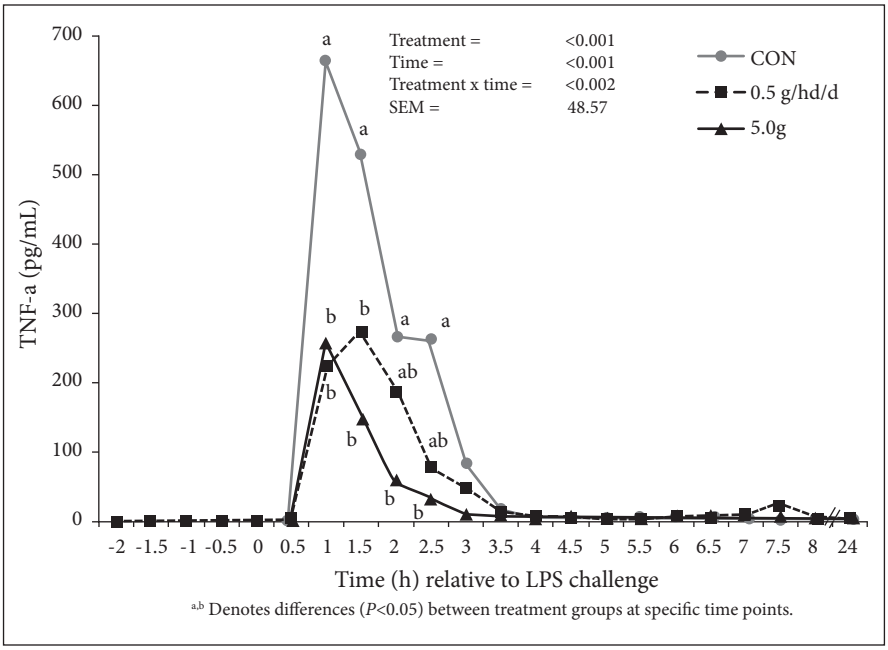

Figure 3. Tumor necrosis factor–α (TNF-α) concentrations during the lipopolysaccharide (LPS) challenge of newly received steers supplemented with *Saccharomyces cerevisiae* CNCM I-1079 yeast supplemented at a rate of 0.0 (CON), 0.5 g/hd/d (0.5g), and 5.0 g/hd/d (5.0g) for a period of 32 d.

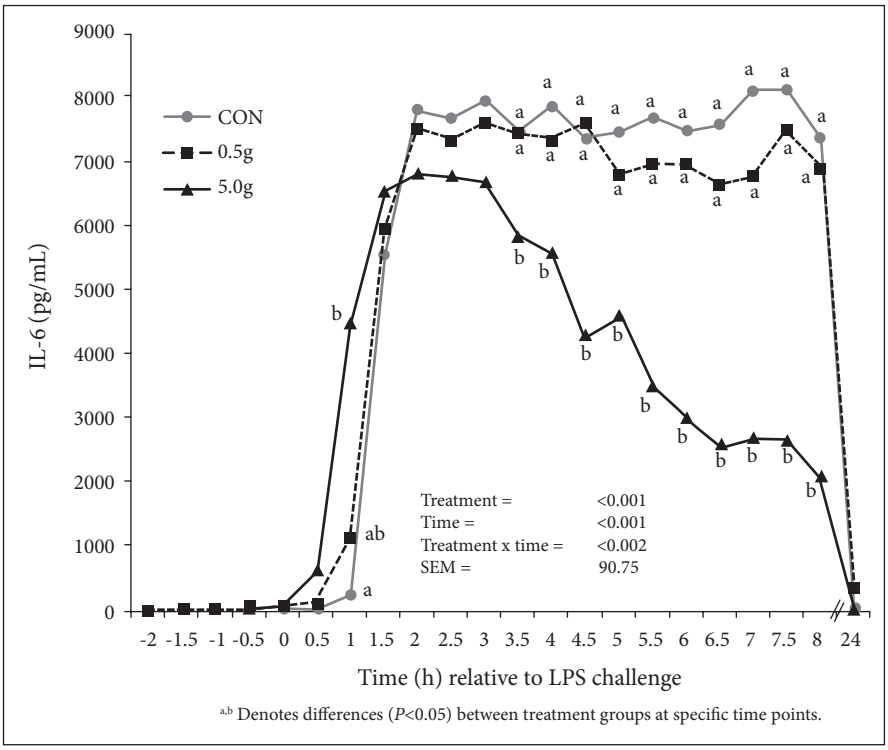

Figure 4. Interleukin–6 (IL-6) concentrations during the lipopolysaccharide (LPS) challenge of newly received steers supplemented with *Saccharomyces cerevisiae* CNCM I-1079 yeast supplemented at a rate of 0.0 (CON), 0.5 g/hd/d (0.5g), and 5.0 g/hd/d (5.0g) for a period of 32 d.

Effects of Supplementing OmniGen-AF® with or without Ractopamine Hydrochloride on Performance and Carcass Characteristics of Feedlot Steers

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Summary

An experiment was used to evaluate feeding OmniGen-AF during the last 28 or 56 days of the finishing phase in diets with or without Optaflexx. There were no differences in steer performance or carcass characteristics when OmniGen-AF was fed alone or in combination with Optaflexx. Feeding Optaflexx increased ADG, HCW, and improved F:G. Supplementation of Optaflexx also increased the rate of accretion in LM area, but decreased the accretion of intramuscular fat percentage. These data illustrate the repartitioning of nutrients between lean and fat tissues when Optaflexx is fed.

Introduction

OmniGen-AF is patented proprietary product shown to augment the immune system in ruminants. In several studies where feedlot cattle were exposed to an endotoxin challenge (lipopolysaccharide, LPS), researchers reported an ability of OmniGen-AF to prime the immune system before the LPS challenge allowing the cattle to a display stronger acute phase response to the LPS challenge while preserving energy stores in the body [Burdick Sanchez et al., 2014 J. Anim. Sci. 92(E-Suppl 2):37].

Supplementing cattle with ractopamine hydrochloride (RAC) reduces the rate at which body fat is deposited, allowing for continued increase in the proportion of muscle growth by increasing muscle fiber hypertrophy. Supplementing cattle with RAC increases ADG, HCW, and final BW as well as improves F:G, while having little to no impact on DMI, 12th rib fat thickness or marbling characteristics. Anecdotal evidence suggests feeding beta agonists may impair the immune response late in the finishing period.

There are currently no data on the combination of supplementing OmniGen-AF during the final phase of feedlot production along with the use of RAC. Thus, the objectives of this study were to evaluate the effects of feeding OmniGen-AF during the final 0, 28, or 56 days of the feedlot finishing phase with or without supplemented RAC on feedlot steer performance and carcass characteristics. In addition, change in body composition over the final 56 days was evaluated via ultrasound imaging.

Procedure

Crossbred steers (n = 336; initial BW = 658 ± 67 lb) were utilized in a feedlot finishing trial at the University of Nebraska Panhandle Research Feedlot (PREC) near Scottsbluff, Nebraska in a 3 × 2 factorial randomized block design. The first factor was the duration of OmniGen-AF (OG; Phibro Animal Health; Quincy, IL) feeding (4 g/ 100 lb BW) during the last 0, 28, or 56 days of the finishing period. The second factor was supplementation of ractopamine hydrochloride (RAC; Elanco Animal Health; Greenfield, IN) at 300 mg/ steer daily for the last 28 days of finishing or no beta agonist supplementation. Steers were limit fed a diet consisting of 45% ground alfalfa hay, 35% wet beet pulp, and 20% of wet distillers grains plus solubles (WDGS; DM basis) for a minimum of 5 d prior to the start of the experiment. Three BW measurements were recorded on d-1, 0 and 1 of the experiment, were averaged, and used as the initial BW for the experiment. Steers were blocked by initial BW into heavy, medium, and light BW blocks, stratified by BW and assigned randomly within block to pen for a total of 42 pens (8 steers/pen). Pen was assigned randomly to one of the six treatments. Steers were implanted with Revalor®-XS (Merck Animal Health) on day-1. Steers were adapted to a finishing diet using four grain adaptation diets that replaced alfalfa hay with dry-rolled corn (DRC). Adaptation diets were fed 3, 4, 7, and 7 days; respectively, and by d 22 steers were fed the common finishing diet (Table 1).

All steers were fed a supplement via micromachine to provide 360 mg/hd daily of Rumensin and 90 mg/steer daily Tylan (Elanco Animal Health). OmniGen-AF feeding (OG; 4 g/100 lb BW) was administered by topdressing beginning 56 or 28

Table 1. Diet Composition—DM basis

Ingredient	d 1–3	d 4–7	d 8–14	d 15–21	d 22+
	Step 1	Step 2	Step 3	Step 4	Finisher
Alfalfa Hay	27.5	20.0	12.5	5.0	0.0
Corn Silage	30.0	25.0	20.0	15.0	15.0
WDGS[a]	25.0	25.0	25.0	25.0	25.0
DRC[b]	11.5	24.0	36.5	49.0	54.0
Supplement[c,d]	6.0	6.0	6.0	6.0	6.0

[a]Wet distillers grains plus solubles
[b]Dry-rolled corn
[c]Liquid supplement formulated to provide a dietary DM inclusion of 10% Ca, 0.3% salt, 60 mg/kg of Fe, 40 mg/kg of Mg, 25 mg/kg of Mn, 10 mg/kg of Cu, 1 mg/kg of I, 0.15 mg/kg of Se, 1.5 IU/g of vitamin A, 0.15 IU of vitamin D, 8.81 IU/kg of vitamin E.
[d]Feed additives were provided via micromachine (Model 271 Weigh and Gain Generation 7; Animal Health International, Greely, CO) to provide 360 mg / hd / daily Rumensin® (Elanco Animal Health; DM basis) and 90 mg/ steer daily of Tylan (Elanco Animal Health). OmniGen-AF supplementation (4 g / 45.5 kg BW) was administered through topdressing the delivered finishing diet beginning 56 or 28 d prior to the targeted marketing date during the remainder of the finishing period. The topdress consisted of 50 g OmniGen-AF and 100g fine ground corn carrier (DM basis) fed to achieve 4 g OmniGen-AF / 45.5 kg steer BW.

Table 2. Effects of supplementing OmniGen-AF last 0, 28, or 56 days with or without supplementation of ractopamine hydrochloride the last 28 days of feedlot finishing period in crossbred beef steers on performance and carcass characteristics

Item	Ractopamine[a]		OG[b]			SEM	*P*-value[c]		
	NORAC	RAC	0	28	56		RAC	OG	OG × RAC
Performance									
Initial BW, lb	686	684	686	684	686	21	0.89	0.90	0.53
Interim BW, lb	1199	1185	1187	1201	1187	15	0.04	0.18	0.42
Final BW, lb[d]	1355	1378	1366	1364	1370	6	< 0.01	0.82	0.97
ADG, lb	3.87	3.98	3.92	3.91	3.94	0.06	0.02	0.89	0.99
DMI, lb/d	23.0	22.9	22.9	22.8	23.0	0.2	0.69	0.80	0.67
F:G, lb/lb	5.95	5.74	5.84	5.83	5.85	—	0.05	0.62	0.72
Carcass Characteristics									
HCW	854	868	861	859	863	7	< 0.01	0.83	0.97
LM area, in[b]	12.32	12.76	12.49	12.45	12.69	0.32	0.01	0.35	0.52
12th rib fat, in	0.52	0.58	0.53	0.56	0.54	0.03	0.42	0.10	0.55
Yield grade[e]	3.65	3.62	3.57	3.73	3.61	0.14	0.69	0.19	0.46
Marbling score[f]	454	455	449	458	457	13	0.90	0.76	0.44
Abscessed livers, %	5	8.7	7.5	5.5	7.5	0.31	0.18	0.80	0.62

[a]Steers either did not receive a beta-agonist (NORAC) or were supplemented with ractopamine hydrochloride at 300 mg/ hd / day (RAC).
[b]Steers received OmniGen-AF® supplementation for the last 0, 28, or 56 days of the finishing period.
[c]OG = main effect due to OmniGen-AF supplementation the last 0, 28, or 56 days of the finishing period; RAC = main effect due to ractopamine hydrochloride supplementation the last 0 or 28 days of the finishing period; OMNI × RAC = the interaction between OmniGen-AF supplementation and ractopamine hydrochloride supplementation.
[d]Carcass adjusted final BW, used in calculation of ADG and F:G, was calculated from HCW using a common dressing percentage of 63% to minimize errors associated with gastrointestinal tract fill.
[e]Yield grade = 2.50 + (2.5 × fat thickness, in) − (0.32 × LM area, in^2) + (0.2 × KPH, %) + (0.0038 × HCW, lb).
[f]Marbling score of 400 = small[00].

d prior to the targeted marketing date of each BW block. The topdress consisted of 50 g OG and 100g fine ground corn carrier (DM basis) fed to achieve 4 g OG/100 lb steer BW. Pens designated to receive no OG supplementation also received a topdress of fine ground corn as a control. Pens designated to treatments that received a beta agonist were supplemented RAC (300 mg/ steer daily) via micromachine beginning 28 d prior to the targeted market date of each BW block.

Initial ultrasound data were collected 56 days prior to the targeted marketing date of each BW block. Ultrasound data measurements of rump fat thickness (RUMP), 12th rib fat thickness (RIB), LM area, and intramuscular fat (IMF) were collected on each steer 56 d prior (Initial) to the targeted marketing date of each BW block and then again 1 d prior (Final) to steers being harvested. Individual steer BW was also collected at each ultrasound time point. The differences between final and initial ultrasound data were calculated to determine body composition change due to dietary treatments imposed.

Steers in the heavy and medium BW blocks were harvested on d 167 and the light BW block was harvested on d 194. Hot carcass weight, and liver scores were recorded the day of harvest. After a 48-hour chill, 12th rib fat depth, LM area, and marbling score were recorded. Carcass adjusted final BW, used in calculation of ADG and F:G, was calculated from HCW using a common dressing percentage of 63% to minimize errors associated with gastrointestinal tract fill. Yield grade was calculated as 2.50 + (2.50*fat thickness, in) + (0.2*2.5 [KPH]) + (0.0038 * HCW, lb) − (0.32 * LM area, in^2)

Data were analyzed using the Glimmix Procedure of SAS (SAS 9.3; SAS Institute, Inc., Cary, N.C.) as a randomized block design. Pen was the experimental unit and block was treated as a random effect. Model included main effects of OG and RAC, and the interaction of OG and RAC. A difference in interim body weights collected 58 days prior to harvest for steers was detected ($P = 0.04$; Table 2). Therefore, 58-day interim BW was considered a covariate according to the 3-step covariate analysis process. Main effects of OG and RAC were tested as well as the interaction of OG and RAC.

Results

There were no OG by RAC interactions observed in this study for animal performance, carcass characteristic, or ultrasound variables ($P \geq 0.22$; Table 2). Furthermore, there were no differences in any of the feedlot performance measures due to feeding OG ($P \geq 0.18$). Supplementation of RAC at 300 mg/steer daily for 28 d increased final BW by 23 lb, ADG by 0.11 lb/d, and improved F:G ($P < 0.05$). There were no differences in DMI for between treatments ($P > 0.67$), and an increase in ADG, supplementing RAC improved F:G ($P = 0.05$).

There was no effect of feeding OG on

Table 3. Effects of supplementing OmniGen-AF last 0, 28, or 56 days with or without supplemented ractopamine hydrochloride the last 28 days of feedlot finishing period in crossbred beef steers on change in body composition the last 56 days of feedlot finishing

Item	Ractopamine[a]		OG[b]			SEM	*P*-value[c]		
	NORAC	RAC	0	28	56		RAC	OG	OG X RAC
Initial ultrasound									
Rump fat, in	0.40	0.43	0.44	0.42	0.43	0.02	0.47	0.12	0.44
Rib fat, in	0.44	0.47	0.46	0.45	0.46	0.03	0.38	0.12	0.78
LM area, in	12.7	12.9	12.8	13.0	12.6	0.4	0.62	0.46	0.70
Intramuscular fat, %[d]	3.94	4.06	3.98	3.97	4.01	0.15	0.64	0.65	0.52
Final ultrasound									
Rump fat, in	0.51	0.55	0.55	0.53	0.54	0.02	0.61	0.12	0.62
Rib fat, in	0.57	0.61	0.59	0.58	0.60	0.03	0.06	0.06	0.88
LM area, in	13.6	13.8	13.8	13.9	13.6	0.3	0.08	0.48	0.94
Intramuscular fat, %[d]	4.29	4.38	4.35	4.42	4.25	0.15	0.10	0.73	0.50
Ultrasound differences[e]									
Rump fat, in	0.11	0.12	0.11	0.12	0.11	0.01	0.87	0.38	0.95
Rib fat, in	0.13	0.14	0.13	0.13	0.14	0.01	0.09	0.57	0.22
LM area, in	0.9	0.9	1.0	0.9	1.0	0.2	< 0.01	0.07	0.43
Intramuscular fat, %[d]	0.37	0.34	0.39	0.47	0.26	0.16	0.02	0.92	1.00

[1]Steers either did not receive a beta-agonist (NORAC) or were supplemented with ractopamine hydrochloride at 300 mg/ hd / day (RAC).
[2]Steers received OmniGen-AF® supplementation for the last 0, 28, or 56 days of the finishing period.
[3]OG = main effect due to OmniGen-AF supplementation the last 0, 28, or 56 days of the finishing period; RAC = main effect due to ractopamine hydrochloride supplementation the last 0 or 28 days of the finishing period; OMNI x RAC = the interaction between OmniGen-AF supplementation and ractopamine hydrochloride supplementation.
[4]Percentage of intramuscular fat (IMF) were 2.3–3.9 = Select, 4.0–5.7 = Choice–, 5.8–7.6 = Choice°, 7.7–9.7 = Choice+, and 9.9–12.3 = Prime.
[5]Ultrasound difference calculated by subtracting final ultrasound measurements from initial ultrasound measurements.

HCW, LM area, calculated yield grade, marbling score, or the percentage of abscessed livers in the present study ($P > 0.18$). However a tendency ($P = 0.10$) for OG ration addition to increase 12th rib fat thickness was observed. Carcasses from steers that received RAC were 12 lb heavier than carcasses from steers that received NORAC ($P < 0.01$). Furthermore, carcasses of steers supplemented RAC also had increased LM area compared to carcasses from steers that received NORAC ($P = 0.01$). There were no effects of RAC supplementation on 12th rib fat thickness, calculated yield grade, marbling score, or the percentage of abscessed livers ($P \geq 0.42$).

There was no effect of OG, RAC, or their interaction at the initial ultrasound period 56 days prior to harvest for RUMP, RIB, LM area, or IMF ($P > 0.11$; Table 3). Analysis of the final ultrasound time point also indicates no effect of OG or RAC on RUMP ($P = 0.12$ and 0.61, respectively). There was no effect of OG supplementation on LM area or IMF during the final ultrasound time point ($P = 0.48$ and 0.73, respectively; Table 3). Steers supplemented RAC tended to have increased RIB fat during the final ultrasound measurement compared to steers that were not supplemented RAC ($P = 0.06$). A similar tendency ($P = 0.06$) of an increase in RIB was also observed in cattle supplemented with OG during the final ultrasound period. There also tended to be an effect of RAC supplementation on LM area and IMF during the final ultrasound ($P = 0.08$ and 0.10, respectively).

Finally, when looking at the differences in the variables (RUMP, RIB, LM area, and IMF) collected via ultrasound between the two ultrasound points, no differences were observed for RUMP, RIB, and IMF in the current study due to OG supplementation ($P = 0.38$, 0.57, and 0.92, respectively). There was a tendency ($P = 0.07$) for supplementation of OG to increase the rate of LM area growth of steers. When analyzing the effects of RAC supplementation, there were effects on LM area and IMF change ($P < 0.01$ and 0.02, respectively), but no effects on RUMP ($P = 0.87$), and only a tendency for an effect on RIB to increase ($P = 0.09$) due to RAC supplementation. Steers supplemented with RAC experienced an increase in LM area ($P < 0.01$) between the two ultrasound time points compared to those not supplemented with RAC. However, the supplementation of RAC caused a decrease in IMF accumulation (increased at at slower rate) as compared steers not supplemented RAC. There was also a tendency ($P = 0.09$) for supplementation of RAC to increase the change in RIB fat in comparison to not supplementing RAC.

Feeding RAC increased steer ADG, resulting in an increased final BW, HCW, and improved F:G along with increasing LM area of carcasses. Supplementation of RAC increased the rate of accretion in steer LM area, but decreased the accretion of intramuscular fat percentage. These data would suggest that there is no interaction between OmniGen and ractopamine on steer feedlot performance or carcass characteristics.

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Effects of Shade and Feeding Zilpaterol Hydrochloride to Finishing Steers on Performance, Carcass Quality, Heat Stress, Mobility, and Body Temperature

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Summary

A finishing study evaluated the effects of shade and feeding zilpaterol hydrochloride (ZH) on performance, carcass quality, mobility, and body temperature. No effect on body temperature, or performance was observed for shaded cattle versus cattle in open pens. Feeding ZH increased HCW, LM area and decreased yield grade. Zilpaterol hydrochloride increased respiration rate but did not significantly affect body temperature or mobility. Across all treatments mobility decreased with time, therefore, cattle were least mobile at the time of harvest.

Introduction

Zilpaterol hydrochloride (ZH; Merck Animal Health; De Soto, KS.) is a β adrenergic-agonist approved for feeding to beef cattle in the United States in 2006 (FDA, 2006). Zilpaterol hydrochloride was heavily utilized in the United States feedlot industry since its release. Recently, some have raised concerns of animal welfare issues with the feeding of ZH, which resulted in it being removed from the market by the manufacturer. Performance responses from feeding ZH during the end of the finishing phase are well characterized and clearly show beneficial responses in HCW. A 33 lb increase in HCW along with increased dressing percentage and decreased USDA yield grade have been consistently observed when ZH was supplemented at the end of the feeding period (Journal of Animal Science, 93:2285–2296; PLoS ONE, 9(12):e0115904; Journal of Animal Science, 86:2005–201). However, there are few studies evaluating the effect of ZH on animal welfare issues, such as heat stress and mobility of cattle. Therefore, the objective of this study was to further investigate the impact of feeding ZH on heat stress, mobility, and body temperature, in addition to performance and carcass characteristics for steers fed in open or shaded pens.

Procedure

Four hundred and eighty crossbred beef steers (initial BW = 793 lb; S.D. = 88 lb) were fed at the US Meat Animal Research Center (USMARC) feedlot near Clay Center, Neb. Cattle were started on finishing diets on January 2, 2014. The diet consisted of 57.35% DRC, 30% WDGS, 8% alfalfa hay, 4.25% supplement, and 0.04% urea for all pens and treatments. Zilpaterol hydrochloride (Merck Animal Health; De Soto, KS) was fed through the supplement according to the label at 7.56 g/ton of diet DM and the inclusion rate was confirmed by laboratory testing. Zilpaterol hydrochloride was fed for 21 days with a 4 day (block1) or 3 d (block 2) withdrawal prior to harvest.

Cattle were implanted with a Revalor XS (200mg trenbolone acetate, 40mg estradiol; Merck Animal Health) and individual BW was collected on January 28, 2014. At this time, cattle were divided into 2 blocks based on a previous BW. The blocks were based on differences in BW and were labeled heavy (block 1) or light (block 2) and the weight difference between blocks was 116 lb (unshrunk BW). The artificial shade used during the study was comprised of poles 32.8 ft tall by 50.5 ft long that were placed in the fenceline. The north/south structures were equipped with four 50.5 ft lengths of poly snow-fence and provided 50% shade coverage. The shade structures tracked the sun during the day and offered 32.3 ft^2 of shade per animal. The other eight pens were unshaded.

The experiment was designed as a randomized block with a 2 × 2 factorial arrangement of treatments. Factors consisted of housing type (shaded or unprotected open lot pens) and the inclusion of ZH (0 or 7.56 g/ton of DM for the last 21 days of the finishing period). Cattle were blocked by initial BW and assigned randomly to pen (within housing type) and pen was assigned randomly to ZH treatment. Treatments were applied at the end of the finishing period for both blocks and staggered so that cattle could be harvested in the warmest weeks of summer (mid-July and early August).

Both blocks of cattle received a SmartStock (SmartStock; LLC. Pawnee, OK) temperature monitoring rumen bolus one d prior to the initiation of feeding ZH. The rumen boluses were set to record rumen temperature in 10 min intervals. Rumen temperatures were transmitted from the boluses to a computer via a receiver located in the animal's home pen, thus temperature recording stopped when animals left their home pens. After an adaptation period to humans prior to initiating ZH feeding, panting scores (0 = no panting, 4 = severe stress) and respiration rates were taken daily by trained individuals during the ZH feeding phase of the study starting at 1300. Respiration rates were recorded as the amount of time it took the animal to take 10 breaths and these data were then used to calculate breaths/min. Prior to ZH feeding, one-half of the cattle in each pen were selected and identified with a uniquely colored ear tag. One-half of the animals in each pen were evaluated individually on a daily basis such that each one-half of the animals in each pen were evaluated every other day. Panting scores and respiration rates were taken by a team of 2 people and the first pen observed rotated daily to minimize time of day effects.

Mobility scores were collected 10 times throughout the ZH feeding period. These scores were based on the 0 to 4 (0 = no lameness and 4 = severe lameness) Tyson mobility scoring system (Tyson Foods; Springdale, AR). The observation times included leaving their home pens, as

they were loaded on the truck leaving the feedlot, during unloading at the abattoir, and as they were moved into holding pens at the abattoir. Cattle were held at the packing plant overnight and on the day of harvest mobility scores were collected during antemortem inspection, as cattle left the holding pen, and as cattle were moved to the restrainer. Mobility scores were then compiled to create four time points; before ZH, after ZH, arrival at the abattoir, and time of harvest by the same technician at each time point.

Performance data, carcass characteristics, respiratory rate, and chute exit velocity, were analyzed using the MIXED procedure of SAS (SAS Institute, Inc. Cary, N.C.) with pen as the experimental unit. Mobility scores were analyzed using the GLIMMIX procedure of SAS (SAS Institute, Inc.) with pen as the experimental unit. The model included fixed effects of dietary treatment (fed ZH or not), time point of observation, housing type (open or shade), the interaction of dietary treatment and time, and the interaction of dietary treatment and housing type. Body temperature was analyzed using the GLIMMIX procedure of SAS (SAS Institute, Inc.) with animal as the experimental unit. The model included the fixed effects of day, dietary treatment (fed ZH or not), housing type (open or shade) and the interaction of dietary treatment and housing type and a random animal effect and residual. Body temperature measurements were characterized as average, maximum, area under the curve, and area over the curve.

Table 1. Main effects of zilpaterol hydrochloride (ZH) feeding and housing type on performance and carcass characteristics of summer fed steers

Trait	Control	Zilmax	*P*-value[a]	Open	Shade	*P*-value[b]	Interaction	SEM
Performance								
Initial BW, lb	790	794	0.37	794	788	0.24	0.72	3
Final BW, lb	1408	1417	0.43	1421	1401	0.08	0.90	7
DMI, lb/d	21.3	21.1	0.61	21.03	21.3	0.55	0.26	0.2
ADG, lb	3.41	3.43	0.56	3.45	3.39	0.10	0.68	0.03
F:G	6.29	6.17	0.44	6.17	6.29	0.39	0.53	—
Carcass Characteristic								
HCW, lb	895	926	< 0.01	917	904	0.17	0.61	6
Dressing %	63.7	65.4	< 0.01	64.5	64.6	0.78	0.29	0.2
LM area, in[b]	13.7	14.7	< 0.01	14.4	14.1	0.27	0.59	0.1
12th Rib Fat, in	0.64	0.61	0.15	0.64	0.62	0.39	0.54	0.01
Marbling[c]	476	469	0.50	472	473	0.92	0.67	7
USDA YG[d]	3.5	3.2	< 0.01	3.4	3.4	0.89	0.68	0.06
Non-performance characteristics								
Respiration, breaths/min	92.3	100.8	0.05	96.3	96.9	0.88	0.69	2.93
Panting Score[e]	0.55	0.68	0.10	0.62	0.62	0.99	0.31	0.05

[a]Main effect of ZH inclusion.
[b]Main effect of housing type.
[c]300 = slight, 400 = Small, 500 = Modest.
[d]Calculated as 2.5 + (6.35 × 12th rib fat) + (0.2 × 2.5[KPH]) + (.0017 x HCW) − (2.06 × LM Area) USDA, 1997.
[e]Panting scores based on 0–4 scale with 0 = no panting and 4 = severe distress.

Results

There were no ZH x Housing interactions ($P \geq 0.26$) observed for performance, carcass characteristics, panting scores or respiration rate (Table 1). Initial BW, final live BW, F:G, DMI, and ADG was not different between dietary treatments ($P \geq 0.37$). There was a tendency for cattle fed in open lot pens to have a greater final live BW ($P = 0.08$) and ADG ($P = 0.10$) than cattle in shaded pens; however, there was no difference in DMI or F:G between housing type ($P < 0.24$). For cattle fed ZH, HCW, dressing percent, and LM area were greater ($P < 0.01$) compared to control cattle. However, there was no difference ($P > 0.17$) between shaded and open lot cattle for HCW, dressing percent, yield grade, and LM area. Twelfth rib fat thickness and marbling score were not different ($P \geq 0.15$) between dietary treatments or housing types. Control cattle had a greater ($P < 0.01$) USDA yield grade compared to cattle fed ZH. There was no difference ($P = 0.89$) due to housing type for USDA yield grade.

There was no ZH × housing interaction ($P > 0.31$) for respiration rates or panting scores so only main effects are presented (Table 1). Cattle fed ZH had greater respiration rates ($P = 0.05$) than cattle fed the control diet. Respiration rates were not different ($P = 0.88$) due to housing type. There was a tendency ($P = 0.10$) for cattle fed ZH to have a greater panting score over the control group but panting scores were not different ($P = 0.99$) between housing types. These data are consistent with the ZH feed label (Merck Animal Health) that states increased respiration rates may be observed in conjunction with ZH feeding.

There was no ZH × housing or ZH × time interactions ($P > 0.14$) observed for mobility score. Consequently, only the main effects of dietary treatment and time for mobility are presented. There were no differences in mobility between the control cattle and ZH fed cattle for the percentage of animals scoring 0 ($P = 0.91$) or 0 and 1 ($P = 0.21$; Table 2). There was no ZH × housing or ZH × time interactions ($P > 0.48$) for chute exit velocity. Cattle fed the control diet compared to ZH were not different in chute exit velocity ($P = 0.68$; Table 2). These data are similar to findings by Bernhard et al. (Proc. 2014 Plains Nutrition Council Spring Conference, San Antonio, TX. Page 142) where it was noted that feeding ZH did not affect chute exit velocity or mobility score.

Time had a significant effect ($P < 0.01$) on overall cattle mobility with mobility being greatest earlier in the feeding period and decreasing over time up to harvest (Table 3). Additionally, time also had a significant effect ($P < 0.01$) on chute exit velocities with cattle taking more time to travel 26 feet at the end of the study as compared to the beginning of the study. Housing did not affect mobility ($P > 0.70$; data not presented). Combined, these data suggest that cattle mobility decreases as

cattle gain weight and that transport and standing on concrete at the abattoir further exacerbates mobility problems.

Body temperature data are presented in Table 4. There were ZH × housing interactions ($P < 0.01$) observed for body temperature. Feeding ZH in open and shaded pens decreased average and maximum body temperature, relative to the control group ($P < 0.01$). Cattle fed ZH in open pens had the lowest average body temperature followed by cattle fed ZH in shaded pens, control cattle in shaded pens, and control cattle in open lot pens with the greatest average body temperature ($P < 0.05$). Maximum body temperature followed this same pattern with cattle fed ZH in open lot pens having the lowest body temperature followed by cattle fed ZH in shaded pens, control cattle in shaded pens, and control cattle in open lot pens having the greatest maximum body temperature ($P < 0.05$). Area under the curve, which indicates the average magnitude of body temperature each d, also followed the same pattern as average and maximum body temperature. Area over the curve, area of body temperature greater than the average of the steer's respective home pen, did not differ ($P = 0.65$) in shaded pens when animals were fed ZH or the control diet. In shaded pens, both ZH and control had the lowest area over the curve with animals fed ZH in open lot pens intermediate and control animals in open lot pens having the greatest area over the curve ($P < 0.05$).

In the current study the use of ZH for 21 d at the end of the feeding period increased HCW, dressing percent, LM area, and decreased yield grade. Shade had little impact on cattle performance or carcass characteristics in the current trial. While respiration rates and panting scores were greater for cattle fed ZH, average and maximum body temperature for cattle fed ZH were lower than that of the control. However, it is important to note that while the differences in body temperature between treatments are statistically different, biologically the observed change in body temperatures are irrelevant. This suggests that the inclusion of ZH had little impact on the heat load experienced by the animal. Overall, no impact was observed for feeding ZH on cattle mobility, however; with time, mobility decreased for all cattle up until harvest. Based on the observations in this study we concluded that the use of ZH improved carcass weight with little impact on body temperature or mobility suggesting that animal welfare was not affected by feeding ZH during the last 21 days of the feeding period.

Table 2. Main effect of Zilpaterol Hydrochloride (ZH) on mobility score calculated as the proportion of animals in a treatment that received the score[a]

Item	Control	ZH	SEM	*P*-value
0 score, %	90.49	90.63	0.81	0.91
0 and 1 score[b], %	99.00	98.44	0.34	0.21
CEV[c]	4.94	5.02	0.15	0.68

[a]Mobility scores are based on the Tyson mobility scoring system where 0 is no lameness and 4 is non-ambulatory.
[b]The percentage of animals receiving a score of 0 or 1 added together. The percentage of animals that scored a 2 can be calculated as 100%-% of 0 and 1 scores together.
[c]CEV = Chute exit velocity reported as seconds to travel 26 ft.

Table 3. Main effect of Time on mobility score calculated as the proportion of animals in a treatment that received the score[a]

Item	Before ZH[b]	After ZH[b]	Unloading at Plant	Up to Restrainer	SEM	Interaction[c]	*P*-value[d]
0, %	95.01[g]	90.78[h]	88.42[hi]	85.56[i]	1.27	0.14	< 0.01
0 and 1[e], %	98.99[g]	99.42[g]	98.54[gh]	97.16[h]	0.61	0.49	< 0.01
CEV[f]	4.65	5.32	N/A	N/A	0.11	0.84	< 0.01

[a]Mobility scores are based on the Tyson mobility scoring system where 0 is no lameness and 4 is non-ambulatory.
[b]ZH = Zilpaterol Hydrochloride
[c]*P*-value for the time × ZH interaction.
[d]*P*-value for the effect of time on mobility.
[e]The percentage of animals receiving a score of 0 or 1 added together. The percentage of animals that scored a 2 can be calculated as 100%-% of 0 and 1 scores together.
[f]CEV = Chute exit velocity reported as seconds to travel 26 ft.
[g,h,i]Values within row with unique superscripts differ $P < 0.05$

Table 4. Simple-effect means for cattle body temperature observed during the presence of a zilpaterol hydrochloride (ZH) × housing interaction

Measurement	Open		Shade		SEM	*P*-value[a]
	Control	Zilmax	Control	Zilmax		
Average, °F	102.44[g]	102.16[d]	102.38[f]	102.35[e]	0.01	< 0.01
Max, °F	104.56[g]	104.21[d]	104.47[f]	104.30[e]	0.02	< 0.01
AOC BT[b]	340.14[f]	237.94[e]	124.49[d]	122.74[d]	2.75	< 0.01
AUC BT[c]	14752[g]	14711[d]	14743[f]	14738[e]	2	< 0.01

[a]*P*-value of the ZH × Housing type interaction.
[b]AOC = Area over the curve which indicates the area of body temperature greater than the average of the steer's respective home pen.
[c]AUC = Area under the curve which indicates the average magnitude of body temperature each d.
[d,e,f,g]Values within rows with unique superscripts differ $P < 0.05$.

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Impact of a Newly Developed Direct-Fed Microbial on Performance in Finishing Beef Steers

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Summary

An individual feeding experiment (n = 60) was conducted to evaluate the effects of feeding a direct-fed microbial (DFM) or not on performance of finishing steers fed 0 or 40% modified distillers grains (MDGS) in a 2 × 2 factorial design. Gain and F:G were improved when cattle were fed MDGS compared to the corn diet. No significant differences (P ≥ 0.23) were observed between cattle fed DFM or not for DMI and ADG. However, numeric advantages were observed for F:G when cattle were fed a DFM, with a 5% improvement in feed efficiency for steers supplemented with DFM.

Introduction

Direct-fed microbial (DFM) have been defined as single or mixed cultures of live organisms, which, when fed to animals, beneficially affect the host. Available DFM have been used to increase animal productivity and to improve health. For beef cattle, some DFM have shown improved feed efficiency and ADG; however, these responses have been variable. Some researchers suggest that feeding DFM to feedlot cattle results in a 2.5 to 5% increase in ADG and approximately 2% improvement in feed efficiency. Several dietary and management factors may have an influence on the effect of DFM's. Gain and efficiency responses to DFM have been variable, with this variation typically being attributed to differences in culture and/or dosage of DFM. A new DFM was isolated from cattle feces that may impact food safety or shedding of *E. coli* O157:H7.

Thus, the objective of this study was to determine the effect of this newly developed DFM in beef steers fed with either a dry-rolled corn-based or MDGS-based diet.

Procedure

Sixty yearling steers (initial BW = 848 lb, SD = 76 lb) were utilized in a completely randomized design experiment at the University of Nebraska–Lincoln at the Agricultural Research and Development Center (ARDC). A 2 × 2 factorial design consisting of two diets (factor 1; Table 1) with or without direct-fed microbial (DFM; factor 2) was used in this study. Yearling steers were previously trained to the Calan gates. Steers were limit-fed a common diet of 50% alfalfa hay and 50% Sweet Bran® (Cargill, Blair, Neb) at 2% of BW for 5 days prior to the start of the trial to minimize gut fill variation and then weighed on three consecutive days (d-1, 0, and 1) and the average was used to establish initial BW. On d 1, steers were implanted with Ralgro® (Merck Animal Health) and reimplanted with Revalor-S (Merck Animal Health).

Steers were housed in open front barns with 30 steers in a common pen (i.e., barn). Steers within each pen received their respective basal diet consisting of dry-rolled corn (CON) or 40% MDGS (40MDGS) treatments (Table 1). Each barn was given either no DFM or was dosed daily with DFM grown in lab. The DFM treatment was dosed based on barn to avoid any possible contamination of bunks within a barn or contamination of the housing environment with the DFM and subsequently inoculate steers not getting DFM. Steers were adapted to finishing diets using limit feeding by starting cattle on finishing diets provided at 2% of BW and increased by 0.5 lb/d (DM basis) until reaching *ad libitum* intake of finishing diets (approximately 20 days).

The DFM bacteria were isolated from cattle fecal matter which were identified on a previous study as low-shedders beef steers (2014 Nebraska Beef Report, pp.101–102) in August 2011. The bacteria were of the genera *Bacteroides* and *Anaerovibrio*. Each bacterium was grown separately in broth media (5 days at 42°C in anaerobic media). At the end of the growth period, the optical densities (OD) of the broth cultures were measured and the cells were harvested by centrifugation (3000

Table 1. Diet composition fed to finishing steers to evaluate feeding DFM in diets based on corn only or with 40% modified distillers grains (DM basis)

Ingredient[a]	Corn	MDGS
Dry-rolled corn	87	47
Modified distillers grains plus solubles	—	40
Sorghum silage	8	8
Supplement[b]		
Fine ground corn	1.670	2.885
Limestone	1.315	1.600
Urea	1.500	—
Salt	0.300	0.300
Tallow	0.125	0.125
Beef trace minerals	0.050	0.050
Rumensin-90[c]	0.016	0.016
Vitamins A-D-E	0.015	0.015
Tylan-40[c]	0.009	0.009

[a]MDGS = modified distillers grains plus solubles. Cattle with DFM were fed with 1×10^9 cells of each culture per day.
[b]Supplement formulated to be fed at 5% of dietary DM.
[c]Formulated to supply: Rumensin-90 = 375 mg/steer daily; Tylan-40 = 90 mg/steer daily

rpm, 15 min at 4°C). Subsequently, the cells were diluted with sterile 20% glycerol/anaerobe basal broth so that each culture had a cell density of 1×10^9 cells/ml (based on the OD reading of each bottle). After the dilution, the same volume of each culture was mixed in a sterile polypropylene tube and 'snap-frozen' in liquid nitrogen (thus, each tube contained 1×10^9 cells/ml of each bacterium). Frozen DFM tubes were stored at -80°C until transport in liquid nitrogen to ARDC, where they were kept in the freezer at −4°C. Samples were stored in daily aliquots (30 tubes) and transferred to the refrigerator and allowed to thaw for 24 hours prior to each feeding.

Feeds were sub-sampled and analyzed for DM content weekly. Feed refusals were weighed back, sub-sampled, and analyzed for DM content to determine DMI of each steer. Steers were fed once daily and DFM was top-dressed by emptying tubes into each individual bunk.

After 132 d, cattle were weighed and transported to a commercial abattoir (Greater Omaha Pack, Omaha, Nebraska), where HCW, and after 48 hours, LM area, marbling score, and 12th rib fat thickness were recorded. Yield grade was calculated from following formula: 2.5 + (2.5 × 12th rib fat) − (0.32 × LM area) + (0.2 × 2.5 [assumed KPH]) + (0.0038 × HCW). With the use of a common dressing percentage (62%), final BW, ADG, and F:G were calculated.

Intake, performance, and carcass characteristics were analyzed as a 2 × 2 factorial using the MIXED procedure of SAS (SAS Institute, Inc., Cary, N.C.) using $P \leq 0.05$ as the significance level for type I error. Steer was the experimental unit. Main effects of diets and DFM were tested, as well as the interaction between these factors.

Results

There were no significant interactions ($P \geq 0.23$) between the diets and DFM for DMI, ADG, fat, and USDA yield grade in this study (Table 2). However, LM area ($P = 0.09$) and marbling score ($P = 0.13$) tended to have an interaction between diet and DFM supplementation. Main effects of basal diet and DFM are presented (Table 2) and discussed.

For the main effect of basal diet, DMI was not affected ($P = 0.92$; Table 2) by whether steers were fed 40MDGS or CON. In contrast, some variables (ADG, F:G, fat, and USDA yield grade) were affected by basal diet, which were generally improved when cattle were fed with 40% MDGS compared to corn. Gain was 11.4% greater ($P < 0.01$) for steers fed 40MDGS compared to CON. Feed efficiency was improved by 10% for cattle fed 40MDGS, which agrees with previous trials. Steers fed 40MDGS had greater ($P \leq 0.04$) fat and USDA yield grade compared to steers fed the corn control diet. Research has shown that the MDGS has a greater feeding value when compared to corn, and improves ADG and F:G, which supports results from this study.

For the main effect of supplementing the DFM, no significant differences ($P \geq 0.23$) were observed for performance. However, numeric advantages were observed for DMI and F:G when cattle were fed with DFM supplementation. Steers supplemented with DFM had 4% numerically lower DMI ($P = 0.23$) compared to non-supplemented steers, but similar ADG ($P = 0.80$). While not significant statistically ($P = 0.29$), there was a 5% numerical improvement in F:G with steers supplemented with DFM having lower F:G compared to steers not receiving the DFM. Carcass characteristics were not affected ($P > 0.40$) by feeding DFM or not, except for marbling ($P = 0.10$). Steers not fed DFM had a greater marbling score than steers fed DFM. The impact on marbling is difficult to explain and likely unimportant given the relatively small number of steers on test.

Results from this study suggest DFM supplementation may improve performance of cattle, but with limited experimental units, the 5% numerical improvement in F:G was not significant. More research is needed evaluating performance. As a follow up to this experiment, 336 finishing heifers were fed the same DFM in a pen performance study, and no improvement was observed in ADG or F:G (*2016 Nebraska Beef Report*, pp. 110–11). As expected, steers fed 40% MDGS had greater ADG and lower F:G than steers fed a corn control.

Table 2. Main effects of diet or feeding a new direct-fed microbial on performance and carcass characteristics.

Item[a]	Diets		DFM		SEM	*P*-value		
	Corn	MDGS	+	−		Diet	DFM	Diet * DFM
Performance								
Initial BW, lb	852	844	846	850	12	0.74	0.89	0.93
Final BW[b], lb	1282	1323	1303	1303	13	0.14	0.98	0.75
DMI, lb/d	22.5	22.4	22.0	22.9	0.38	0.92	0.23	0.50
ADG[b], lb	3.26	3.63	3.46	3.42	0.06	< 0.01	0.80	0.71
F:G[b,c]	7.00	6.30	6.49	6.82	—	0.02	0.29	0.44
Carcass characteristics								
HCW, lb	795	820	808	808	8.4	0.14	0.98	0.75
LM area, in[b]	12.9	13.0	13.1	12.9	0.15	0.72	0.43	0.09
Marbling[d]	447	448	433	462	8.9	0.96	0.10	0.13
12th rib fat, in	0.51	0.60	0.54	0.56	0.02	0.02	0.62	0.80
USDA Yield grade	3.29	3.59	3.38	3.50	0.07	0.04	0.40	0.23

[a]Diets = main effects of diets (corn or modified distillers grains with solubles) in steers; DFM = main effects of direct-fed microbial supplementation in steers; Diets * DFM = interaction between diets and direct-fed microbial supplementation.
[b]Calculated from carcass weight, adjusted to 62% common dressing percentage.
[c]Analyzed as G:F, reported as F:G.
[d]Marbling score: 400 = Small°; 500 = modest°; etc.

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Effects of Direct-Fed Microbial Supplementation in Different Diets on Performance and Carcass Characteristics of Beef Feedlot Heifers

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Summary

The objective of this study was to evaluate performance and carcass characteristics of heifers fed a newly developed direct-fed microbial (DFM), using 336 heifers in a pen study. The experiment consisted of feeding corn (CON) or 40% modified distillers grains plus solubles (40MDGS) and presence or absence of DFM added as a top-dress. No significant differences were observed for heifer performance and carcass characteristics due to DFM. Feeding MDGS increased ADG, while reducing F:G compared to CON. The DFM developed for this study did not enhance performance as was hypothesized, while feeding MDGS did.

Introduction

The FDA defines direct-fed microbial (DFM) as "a source of live (viable) naturally-occurring microorganisms". Several mechanisms are plausible in explaining if DFM will improve performance such as: competitive exclusion of pathogenic organisms (for nutrients or site of activation in the mucosa); synthesis of bacteriocins; prevention of ruminal acidosis (altering ruminal fermentation products, reducing lactic acid) and/or activation of the immune system. For beef cattle, DFMs have been used to improve feed efficiency and daily gain. However, effects on animal performance in beef cattle are still inconsistent and dietary factors may have an influence on whether DFM affect performance. In a previous study, cattle were individually fed and supplemented a DFM developed here at UNL and steers had 4% lower DMI and 5% lower F:G when supplemented DFM, but differences were not significant (*2016 Nebraska Beef Report*, pp. 108–09). Therefore, we conducted a trial to evaluate the effect of DFM in two different diets in a larger study with more cattle to conclusively determine the impact on performance and carcass characteristics in beef feedlot heifers.

Procedure

Three hundred thirty-six heifers (initial BW = 768 lb, SD = 60 lb) were utilized in a randomized block design experiment at the University of Nebraska–Lincoln, Agricultural Research and Development Center (ARDC). A 2 × 2 factorial design consisting of two basal diets (factor 1; Table 1) with or without DFM (factor 2) was used in this study. All diets contained Rumensin (Elanco Animal Health) to supply 390 mg/heifer daily, MGA (Zoetis Animal Health) to supply 0.5 mg/heifer daily, and Tylan (Elanco Animal Health) to supply 90 mg/heifer daily. Heifers were limit-fed a 50% alfalfa hay and 50% Sweet Bran® (Cargill, Blair, Neb) diet (DM basis) at 2% of BW for five days prior to trial initiation to minimize gut fill variation. Following five days of limit feeding, heifers were weighed two consecutive days (d 0 and 1) and the average was used to establish initial BW. Heifers were blocked into four BW blocks (6 replications in each block) based on d 0 BW, and assigned randomly within strata to a total 24 pens. Pens (14 heifers/ pen) were assigned randomly to one of four treatments with six replications per treatment. On d 1, heifers were implanted with Revalor®-IH (Merck Animal Health) and were reimplanted on

Table 1. Diet composition fed to finishing heifers to evaluate feeding DFM in diets based on corn only or with 40% modified distillers grains (DM basis)

Ingredient	Basal Diets[a]	
	CON	40MDGS
Dry-rolled corn	40	20
High-moisture corn	40	20
Modified distillers grains plus solubles	0	40
Corn silage	15	15
Supplement[b]		
Fine ground corn	1.619	2.930
Limestone	1.545	1.545
Urea	1.311	—
Salt	0.300	0.300
Tallow	0.125	0.125
Beef trace minerals	0.050	0.050
Rumensin-90[c]	0.017	0.017
Vitamins A-D-E	0.015	0.015
MGA[c]	0.010	0.010
Tylan-40[c]	0.009	0.009

[a]CON=control basal diet; 40MDGS = modified distillers grains included in finishing diets. Cattle with DFM were fed with 1 × 10^9 cells of each culture per heifer daily as a top-dress.
[b]Supplement formulated to be fed at 5% of dietary DM.
[c]Formulated to supply: Rumensin-90 = 390 mg/heifer daily; MGA = 0.5 mg/heifer daily; Tylan-40 = 90 mg/heifer daily

d 78 with Revalor®-200 (Merck Animal Health). Heifers were acclimated to finishing diets (Table 1) over a 22-day period consisting of four adaptation diets. Alfalfa hay inclusion was gradually decreased from 30 to 0% while inclusion of dry-rolled corn and high-moisture corn was increased from 25 to 40% (DM basis) in corn diet. For the distillers based treatment, alfalfa hay inclusion was gradually decreased from 30 to 0% while inclusion of dry-rolled corn and high-moisture corn were increased from 5 to 20% while MDGS inclusion was constant at 40% (DM basis).

The bacteria of DFM were isolated from cattle fecal matter (*2014 Nebraska Beef Report*, pp. 101–102) in August of 2011. The bacteria were *Bacteroides* and *Anaerovibrio*. Each bacterium was grown separately in broth media (5 days at 42°C in anaerobic media). At the end of the growth period, the optical densities (OD) of the broth cultures were measured and the cells were harvested by centrifugation (3000 rpm, 15 min at 4°C). Subsequently, the cells were diluted with sterile 20% glycerol/anaerobe basal broth so that each culture had a cell density of 1×10^9 cells/ml (based on the OD reading of each bottle). After the dilution, the same volume of each culture was mixed in a sterile polypropylene tube and 'snap-frozen' in liquid nitrogen (thus, each tube contained 1×10^9 cells/ml of each bacterium). Frozen DFM tubes were stored at −80°C until transported in liquid nitrogen to ARDC near Mead, NE, where they were kept in freezer at −4°C.

Feeds were sub-sampled and analyzed for DM content weekly. Cattle were fed once daily and pens that received DFM were top-dressed by emptying DFM tubes into one gallon of water, followed by even distribution on top of feed at feeding. Tubes of DFM were thawed in the refrigerator 24 h prior to feeding.

After 135 d, cattle in the heavy block (4 pens) were harvested and after 149 d, cattle in the light and medium blocks (20 pens) were harvested. Cattle were transported to a commercial abattoir (Greater Omaha Pack, Omaha, Neb), where HCW was obtained on the day of slaughter. Following a 48-h chill, USDA marbling score, 12th rib fat thickness, and LM area were recorded. Hot carcass weight was used to calculate adjusted final BW by dividing HCW by a common dressing percentage (63%) and used to calculate ADG and feed efficiency.

Table 2. Main effects of diet or feeding a new direct-fed microbial on performance and carcass characteristics

Item[a]	Basal Diet		DFM		SEM	*P*-value		
	Corn	MDGS	−	+		Diet	DFM	Diet * DFM
Performance								
Initial BW, lb	768	769	770	768	15	0.32	0.10	0.86
Final BW,[b] lb	1230	1287	1264	1252	14	< 0.01	0.22	0.25
DMI, lb/d	24.1	25.1	24.6	24.6	0.26	< 0.01	0.98	0.27
ADG,[b] lb	3.21	3.60	3.44	3.37	0.05	< 0.01	0.25	0.25
F:G[b,c]	7.49	6.96	7.13	7.32	—	< 0.01	0.08	0.34
Carcass characteristics								
HCW, lb	775	811	797	789	8	< 0.01	0.22	0.25
LM area, in[b]	12.6	12.5	12.6	12.5	0.12	0.64	0.72	0.68
12th rib fat, in	0.60	0.67	0.64	0.63	0.013	< 0.01	0.68	0.08
Marbling[d]	555	571	560	565	4	0.06	0.53	0.71

[a]Diets = main effect of diets (Corn or MDGS) in cattle; DFM = main effect of direct-fed microbial inclusion in cattle diet; Diets*DFM = interaction between diets and direct-fed microbial inclusion.
[b]Calculated from carcass weight, adjusted to 63% common dressing percentage.
[c]Analyzed as G:F, reported as F:G.
[d]Marbling score: 400 = Small°; 500 = Modest°; etc

Performance and carcass characteristics were analyzed as a 2 × 2 factorial using the MIXED procedure of SAS (SAS Institute, Inc., Cary, N.C.) using $P \leq 0.05$ as the significance level for type I error. Pen was the experimental unit and BW block was included as a random effect. Main effects of diets and DFM were tested, as well as the interaction between these factors.

Results

There were no significant interactions ($P \geq 0.25$; Table 2) between diets and DFM for performance and HCW, LM area, and marbling, but fat depth tended to be significant ($P = 0.08$; Table 2). Given the lack of interactions, main effects of diets and DFM are presented (Table 2).

There were no significant differences in performance ($P \geq 0.08$) and carcass characteristics ($P \geq 0.22$) due to feeding DFM. Dry matter intake during the trial was similar ($P = 0.98$; Table 2) between heifers fed DFM or not. It was expected that DFM would improve F:G; however, no improvements ($P = 0.08$) were observed due to feeding this specific DFM. Actually, F:G tended ($P = 0.08$; Table 2) to be 2.6% poorer for cattle fed DFM compared to none.

For the main effect of basal diet, feeding 40MDGS increased ($P < 0.01$) DMI compared to CON. Feeding 40% MDGS increased ($P < 0.01$) ADG by 12% and decreased F:G by 7% ($P < 0.01$) compared to heifers fed corn. Hot carcass weight was 4% greater ($P < 0.01$) compared to the corn control diet. *Longissimus* muscle area was similar ($P = 0.64$) among diets, while 12th rib fat thickness was greater ($P < 0.01$) for cattle fed MDGS. Heifers fed MDGS were 11% fatter than cattle fed the corn control diet. There was a tendency ($P = 0.06$) for marbling score of heifers fed 40MDGS to be greater compared to CON.

In conclusion, the DFM developed for this study did not enhance performance, while feeding modified distillers grains compared to corn did improve performance similar to previous research.

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Impact of Inoculating Corn Silage with Buchnerii 500 on Feedlot Cattle Performance with or without Added Yeast Product at Time of Feeding

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Summary

Inoculant, Biotal® Buchneri 500, was used to evaluate effects of silage inoculant on feedlot cattle performance and the inclusion of a yeast product, Levucell-SC. Silage was fed at 15 or 40% inclusion so overall treatment structure was a 2 × 2 × 2 factorial arrangement of treatments. Numerous 3-way interactions were observed, but appear due to inconsistent patterns of treatment effects. Feeding silage at 40% increased DMI, decreased ADG, and increased F:G compared to feeding 15% silage. Inoculant or feeding Levucell-SC did not improve performance.

Introduction

Numerous studies have evaluated the effects of bacterial inoculants on silage fermentation, dry matter recovery, and aerobic stability. Fewer experiments evaluate how bacterial inoculants affect digestibility. However, very little has been done to determine if bacterial inoculants affect performance and carcass characteristics of feedlot cattle.

Most studies with yeast cultures have been completed with dairy cattle and how yeast cultures affect dairy cattle milk production and composition. Little work has been done to evaluate yeast cultures in feedlot cattle and impact on performance or carcass characteristics. The objective of our study was to evaluate the impact of using Biotal® Buchneri 500 as an inoculant with or without a yeast product (Levucell-SC) added at feeding on feedlot performance and carcass characteristics when silage was fed at 15 or 40% of diet DM.

Procedure

Corn silage from two fields under irrigation was harvested using a silage chopper on September 10, September 13, and September 14, 2013 (the break was due to rain and inability to enter the field). Two silage treatments were applied to silage at harvest in sequential loads by turning on or off the inoculator system, mixing all hybrids between the two treatments. Treatments were no inoculant (CON) or Biotal® Buchneri 500 (B500) (Lallemand Animal Nutrition) applied at 500,000 CFU/g of silage. This allowed for 100,000 CFU/g of *Pediococcus pentosaceus 12455* and 400,000 CFU/g of *Lactobacillus buchneri 40788*. Separate trucks were used to deliver each treatment of silage to avoid cross contamination, and each truck was weighed and a sample taken from each load for analysis. The silage was packed into individual bunkers, covered with silage plastic, and weighted down with tires at the end of harvest. Individual samples from each load were mixed and sampled. Half the sample was placed into a bucket of composited samples by harvest day and treatment. The remaining half of the sample was quartered and divided for DM analysis using a forced-air oven at 140°F, freeze drying for nutrient analysis, and DM analysis using toluene displacement. Density testing was completed at three points during the feeding period (May 16, 2014; July, 10, 2014; August 26, 2014), to reflect the first quarter of the bunker, middle of the bunker, and last quarter of the bunker. On d 153 post ensiling, core samples, of approximately 340 g were taken from each of the bunkers, transported to the lab, frozen and sent to DairyOne for testing of DM, VFA analysis, pH, and CP. Feeding began May 8, 2014 or 236 d post ensiling. On May 20, 2014, weekly samples were taken shortly after feeding was complete for the day. Samples were weighed, mixed and subsampled for freeze drying, toluene displacement, oven dry matters at 140°F in a forced-air oven, and compositing at the conclusion of the trial. At the end of the feeding trial, samples were composited by weeks 1–3, 4–7, 8–11, and 12–15. These composites were stored overnight in the freezer and shipped to DairyOne for silage nutrient analysis (DM, VFA analysis, pH, CP, and ammonia content).

The feeding trial was set up in a 2 × 2 × 2 factorial arrangement (Table 1), using 320 steers, beginning May 7, 2014 (d 0). The first factor was the control (no inoculant) versus silage inoculated with Biotal® Buchneri500 (B500; Lallemand Animal Nutrition). The second factor was feeding both silage types at 15% or 40% inclusion of diet DM. The final factor was adding a yeast product (Levucell SC, Lallemand Animal Nutrition) or not. Levucell SC (LEV) is a live yeast product containing *Saccharomyces cerevisiae* I-1077, and was fed at a rate of 0.5 oz/steer daily (14 g). Steers were blocked by BW into light (1), middle (2), and heavy (2) weight blocks, stratified by BW and assigned randomly to one of 40 pens, with pens assigned randomly to 1 of 8 dietary treatments. There were eight treatment diets with five replications per treatment and eight steers per pen. Steers were limit-fed at approximately 2% BW on a 50% alfalfa and 50% Sweet Bran diet for 5 d, followed by weighing two consecutive days and averaged for initial BW. Steers were implanted with Revalor-200 (Merck Animal Health) and sorted into treatment pens on May 8 (d 1). Following initial weighing, steers were adapted to treatment diets over a period of 22 days. All pens were weighed and shipped on the afternoon of September 2, 2014 and harvested in the morning on September 3, 2014. Hot carcass weight, liver scores for abscesses and kill order were recorded on the day of harvest. After a 48-h chill, fat thickness, LM area, and marbling score were measured. Dry matter intake was calculated from the amount fed and the amount of feed rejected by each pen, corrected for DM. Using the limit-fed initial BW and carcass-adjusted final BW, ADG

Table 1. Diet composition of feedlot cattle finishing trial on a DM basis

Silage Inclusion:	15				40			
Inoculant:[a]	CON	CON	B500	B500	CON	CON	B500	B500
Levucell SC:	–	+	–	+	–	+	–	+
MDGS[b]	30	30	30	30	30	30	30	30
Corn (HMC)[b]	51	51	51	51	26	26	26	26
Silage CON	15	15	0	0	40	40	0	0
Silage B500	0	0	15	15	0	0	40	40
Supplement								
Gr. Corn	1.84	1.70	1.84	1.70	1.84	1.70	1.84	1.70
Limestone	1.67	1.67	1.67	1.67	1.67	1.67	1.67	1.67
Tallow	0.30	0.10	0.30	0.10	0.30	0.10	0.30	0.10
Salt	0.10	0.30	0.10	0.30	0.10	0.30	0.10	0.30
Beef Trace Min[c]	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Vitamin A-D-E[d]	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Rumensin-90[e]	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Tylan-40[f]	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Levucell SC[g]	—	0.14	—	0.14	—	0.14	—	0.14

[a]CON = Silage with no Inoculant, B500 = Silage inoculated with Biotal® Buchneri 500
[b]MDGS = Modified distillers grains with solubles, HMC = High moisture corn
[c]Mineral Pre-mix contains: 6.0% Zn, 5.0% Fe, 4.0% Mn, 2.0% Cu, 0.29% Mg, 0.2% I, 0.05% Co.
[d]Vitamin Pre-mix contains: 30,000 IU vitamin A, 6,000 IU vitamin D, 7.5 IU vitamin E per gram.
[e]33.0 mg/hd/d
[f]90.0 mg/hd/d
[g]14.8 g/hd/d

Table 2. Change in inoculated (B500) or not (CON) silage nutrient and acid profile[a]

Treatment	% DM	pH	% Crude Protein	Lactic Acid %[b]	Acetic Acid %[b]	Propionic Acid %[b]	Butyric Acid %[b]
CON	35.5	3.88	8.9	3.98	4.03	0.64	0.01
B500	36.5	3.91	8.9	3.47	4.31	0.60	0.01

[a]DairyOne results
[b]As a percent of total dry matter

was calculated. Carcass-adjusted final BW was calculated by HCW/0.63. Dressing percent was calculated as HCW divided by final live BW (pen weight/number in pen) multiplied by 0.96.

No statistical analysis was performed on the silage nutrient data due to lack of bunker replication. Performance and carcass characteristics were analyzed using the MIXED procedures of SAS (SAS Institute, Inc., Cary, N.C.) as a randomized block design. Pen was the experimental unit and block was treated as a fixed effect. Treatments were evaluated for 3-way and 2-way interactions, and main effects.

Results

Corn Silage Composition

At the time of ensiling, DM averaged 37.8 percent. Dry matter percentage across the feeding period averaged 35.5% for CON and 36.5% for B500. After fermentation, the pH of both silages was 3.9. Percent crude protein was 8.9 percent for both silages (Table 2). Lactic acid content was greater for CON at 4.0% compared to 3.5% for B500. The acetic acid percentage was higher for B500 silage (4.31%) than CON (4.03%). Silage recovery (% of initial DM weight accounted for in DM weight) was 86.9% for CON and 85.2% for B500. The DM densities were 16.6 and 17.3 lb/ft^3 for CON and B500, respectively.

Performance

A three way interaction ($P < 0.05$) between inclusion, inoculant, and Levucell for final live BW, HCW, calculated ADG, F:G, and dressing percent (Table 3) was observed. Greater inclusion of silage (i.e., 40% vs. 15%) in the diet increased DMI ($P < 0.01$). There was no effect of silage inoculant on DMI ($P = 0.84$), and no effect of Levucell on DMI ($P = 0.90$). A 3-way interaction ($P < 0.01$) was observed for ADG and G:F between inclusion level, inoculant, and LEV. The interaction was due to CON with LEV and B500 without LEV being greatest when fed at 15%, yet the lowest when fed at 40% relative to the other combinations of treatments. In general, no consistent positive performance effects were observed where B500 silage or feeding LEV. Treatments with silage at 15% inclusion, CON with LEV and B500 without LEV, numerically had the greatest ADG. However, the previous difference was only significantly greater from those fed B500 with LEV. Within 40% silage inclusion, no treatments were significantly different from one another. A 3-way interaction was observed ($P = 0.01$) for F:G, which mimicked ADG. Feeding silage at 40% increased F:G compared to 15% silage, but main effects for B500 and LEV were non-significant.

Final live BW was numerically greatest for cattle fed CON silage at 15% inclusion with LEV. However this was not significantly different from the groups fed the CON silage at 15% without LEV, B500 at 15% without LEV, CON fed at 40% without LEV, or B500 at 40% with LEV ($P > 0.10$). Cattle fed the treatment containing CON silage fed at 40% with LEV had the numerically lowest final live BW.

Carcass Data

A three way interaction ($P < 0.05$) between inclusion, inoculant, and Levucell for HCW and dressing percentage was observed. Hot carcass weights followed a similar pattern as final live BW. Amount of silage was a significant main effect, but no other main effects or 2-way interactions were significant. In general, when

Table 3. Feedlot performance results for steers feed inoculated silage (B500) or not (CON) with Levucell (+) or not (–)

Inclusion	15				40				SEM	3-WAY	Main Effects[a]		
Incoculant	CON	CON	B500	B500	CON	CON	B500	B500					
Levucell	–	+	–	+	–	+	–	+			Incl	Inoc	Lev
Initial BW, lb	919	922	920	919	921	919	921	921	0.94	0.06	0.30	0.65	0.45
Final live BW, lb	1409^{cdef}	1433^{c}	1434^{cd}	1413^{def}	1424^{cdef}	1415^{f}	1435^{ef}	1428^{cde}	8.7	< 0.01	0.03	0.69	0.53
DMI, lb/d	26.6	27.2	27.0	26.8	28.1	27.7	27.7	27.9	0.40	0.22	< 0.01	0.84	0.90
ADG, lb	3.98^{cde}	4.17^{c}	4.17^{c}	3.94^{de}	4.00^{cde}	3.79^{e}	3.92^{c}	4.01^{cde}	0.08	< 0.01	0.02	0.85	0.50
F:G	6.71^{cde}	6.49^{c}	6.49^{c}	6.80^{def}	7.04^{efg}	7.30^{g}	7.09^{fg}	6.94^{efg}	—	0.01	< 0.01	0.60	0.42
HCW, lb	870^{cdef}	885^{c}	884^{cd}	867^{def}	872^{cdef}	856^{f}	867^{ef}	873^{cde}	5.8	< 0.01	0.03	0.66	0.53
Dressing %	61.7^{c}	61.8^{c}	61.6^{c}	61.4^{c}	61.3^{cd}	60.5^{de}	60.4^{c}	61.1^{cde}	0.27	0.03	< 0.01	0.34	0.76
LM area, in[b]	13.52	13.56	13.44	13.33	13.49	13.17	13.50	13.49	0.24	0.52	0.78	0.98	0.56
Fat Depth, in	0.61	0.57	0.57	0.59	0.58	0.56	0.54	0.53	0.027	0.45	0.12	0.18	0.54
Marbling [b]	470	457	472	471	448	448	443	469	17	0.78	0.20	0.49	0.81

[a]P-values for 3-way interaction, and main effects of silage inclusion (Incl), silage inoculate (Inoc), and feeding yeast (Lev). All 2-way interactions were not significant ($P > 0.33$).
[b]300 Slightly Abundent; 400 Small; 500; Modest
[cdefg]Numbers with differing letters are significantly different.

silage was included at 15% of the diet, cattle consuming the CON with LEV and the B500 without LEV had the greatest HCW. At 40% corn silage inclusion, steers consuming the CON without LEV diet and the B500 with LEV had numerically greatest HCW. There was a significant 3-way interaction, in addition to a main effect of silage inclusion level for dressing percent. Dressing percent was numerically greatest for the treatments with 15% inclusion CON with LEV (61.8%); however, this was not significantly different from other treatments within 15% silage inclusion ($P > 0.20$). The dressing percent in these diets averaged 61.6%. At 40% silage inclusion, CON without LEV and B500 with LEV were not significantly different from treatments with 15% inclusion ($P \geq 0.10$). Steers fed 40% silage generally had lower dressing percent, likely due to gut fill.

Conclusions

The lack of composition differences between the B500 silage and CON silage may be why the feeding trial results were similar. At 15% silage inclusion without an inoculant, feeding Levucell SC numerically improved ADG and F:G, but not statistically. When silage was inoculated with Biotal® Buchneri500, the addition of Levucell SC was not beneficial for ADG and F:G, and had lower HCW and dressing percent. At 40% silage inclusion, the opposite trend was observed. No inoculant with no Levucell SC had numerically improved performance, but not statistically. But with inoculant Buchneri500, the addition of Levucell SC numerically increased performance, but not significantly. If silage is fed at only 15% of diet DM, it is unlikely that inoculation would impact performance. A lack of major impacts of inoculation when 40% silage is fed on F:G suggests little impact would be expected. Based on density testing, and nutrient profiles, silages used in these studies were ensiled appropriately and fermentation was typical.

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Rumen Protected Amino Acids in Finishing Cattle Diets

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Summary

A 190-d calf fed finishing study, utilizing 240 steers, was conducted to determine the effects of supplementing finishing cattle with bypass amino acids (methionine and lysine) on growth performance. Three treatments (control, methionine, methionine and lysine) were evaluated with 8 pens/trt. All cattle were fed a 40% Sweet Bran, 50% high moisture corn basal diet. Supplementing with bypass amino acids did not affect live cattle performance, and only small differences in 12th rib fat and USDA marbling score were observed. Lack of any dramatic changes in performance suggests these calves were not deficient in methionine or lysine.

Introduction

Supplementing cattle with bypass protein has been shown to improve gains and feed efficiency, especially for young, rapidly growing calves. Methionine and then lysine are the first limiting amino acids in microbial protein. If specific amino acids are limiting, then increasing the amount of those amino acids available to the animal postruminally presents opportunities for increased animal growth and efficiency.

Two products coming from the corn milling industry and commonly fed to cattle are wet corn gluten feed (WCGF) and distillers grains plus solubles (DGS). These products come from the wet and dry corn milling industries, respectively, and have very different nutrient profiles. Sweet Bran®, a branded WCGF developed by Cargill, is 22% CP, of which approximately 25% is ruminal undegradable protein (RUP). Distillers grains average 30% CP, with 63% RUP (as % of CP). Finishing diets containing 20% or more DGS (DM basis) meet cattle requirements for metabolizable protein. Diets containing WCGF that are formulated to meet CP requirements may be deficient in RUP. More specifically, these diets may be deficient in lysine, the first limiting amino acid in corn protein, or methionine, the first limiting amino acid of microbial crude protein. The objective of this trial was to evaluate the effects of bypass methionine and lysine on calf performance in a finishing trial.

Procedure

The current trial evaluated growth implications of the bypass amino acid products, MetiPEARL™ and USA Lysine® of Kemin Industries, Inc. (Des Moines, Iowa) in a calf-fed finishing trial. Two hundred and forty crossbred steers with an average BW of 619 lb (SD = 20 lb) were utilized in a completely randomized treatment design to study the effects of bypass methionine and lysine on growth performance. Steers were received for a 24-d period at the University of Nebraska's Agricultural Research and Development Center (ARDC) near Mead, NE, in October, 2014. After receiving, steers were limit fed at an estimated 2% of BW a diet consisting of 50% alfalfa and 50% Sweet Bran® (DM basis) for 5 d prior to weighing. Cattle were weighed on 2 consecutive days (d 0 and 1) to establish initial BW. Steers were stratified by d 0 BW and assigned randomly to pens. Pens were assigned randomly to treatment. There were 3 treatments and 8 pens/treatment for a total of 24 pens.

Cattle were adapted to a common finishing diet consisting of 40% Sweet Bran®, 50% high moisture corn (HMC), 5% wheat straw, and 5% supplement (DM basis; Table 1). The step up period consisted of 4 diets fed over 21 d. During the adaptation, HMC was increased from 20 to 50% of diet DM while alfalfa was decreased from 30 to 0% of diet DM; all other ingredients were held constant. Supplement was formulated to provide 330 mg/steer daily of Rumensin, 90 mg/steer daily of Tylan, and 3 mg/steer daily of chromium (KemTRACE Chromium). All cattle were fed Optaflexx the last 28 d of the trial at 300 mg/steer daily. Treatments consisted of a control (CON); 8 g methionine/steer daily (26 g MetiPEARL™/steer daily; MET); and 8 g methionine and

Table 1. Composition of diets fed to cattle

Ingredient, % of diet DM	CON[a]	MET	MetLys
High moisture corn	50	50	50
Wet corn gluten feed[b]	40	40	40
Wheat straw	5	5	5
Supplement	5	5	5
Methionine[c]	—	98.1	98.1
Lysine[d]	—	—	113.9
Chromium[e]	3.0	3.0	3.0
Monensin[f]	6.2	6.2	6.2
Tylosin[g]	3.8	3.8	3.8

[a]Treatments were due to cattle diet; CON = control, MET = control diet with added bypass methionine, and MetLys = control diet with added bypass methionine and lysine.
[b]Cargill's Sweet Bran product.
[c]MetiPEARL™ (Kemin Industries, Inc., Des Moines, IA) expressed as lb/ton of supplement. Formulated to provide 26 g/steer daily of MetiPEARL™ or 8 g metabolizable methionine/steer daily.
[d]USA Lysine® (Kemin Industries, Inc.) expressed as lb/ton of supplement. Formulated to provide 28 g/steer daily of USA Lysine® or 12 g metabolizable lysine/steer daily.
[e]KemTRACE Chromium (Kemin Industries, Inc.) expressed as lb/ton of supplement. Formulated to provide 3 mg chromium/steer daily.
[f]Rumensin-90 (Elanco Animal Health, Greenfield, IN), expressed as lb/ton of supplement. Formulated to provide 330 mg/steer daily.
[g]Tylan-40 (Elanco Animal Health), expressed as lb/ton of supplement. Formulated to provide 90 mg/steer daily.

12 g lysine/steer daily (26 g MetiPEARL™ and 28 g USA Lysine®/steer daily; MetLys). Using the 1996 NRC model the CON diet was predicted to meet cattle metabolizable protein requirements (70 g/d excess), overall CP concentration was 14.7%. However, it is not clear if individual amino acid requirements are being met throughout the feeding period. All cattle were implanted with Revalor-XS on d 0.

Cattle gain was measured throughout the study by collecting pen weights (4% pencil shrink applied) 4 times throughout the trial. Weights were collected after 1 wk on the finisher d 28–29, 72 d after initiation of the trial, at initiation of feeding Optaflexx (d 162), and at termination of the study on the day that cattle were shipped to the packing plant (d 189). All steers were harvested at Greater Omaha Packing Co. (Omaha, NE) on d 190. Six animals were removed before completion of the trial due to respiratory and foot and leg issues (3 on CON; 1 on MET; and 2 on MetLys).

Performance traits measured include DMI, ADG (using limit fed initial and carcass-adjusted final BW), live final BW, and carcass traits. Interim ADG was calculated for 3 periods using limit fed initial and pen weights. On the d of slaughter, HCW was collected. Following a 48-h chill, 12th rib fat thickness, LM area, and USDA marbling score were recorded. Assuming 2.5% kidney, pelvic, and heart (KPH) fat, yield grade was calculated. A common dressing percent of 63% was used to calculate carcass-adjusted performance.

Animal performance and carcass characteristics were analyzed as a completely randomized design using the MIXED procedure of SAS (SAS Institue, Inc., Cary, N.C.). Pen was the experimental unit and animals that were removed during the experiment were not included in the analysis. Treatment was a fixed effect and differences were considered significant at $P \leq 0.05$.

Table 2. Finishing cattle performance and carcass characteristics

	Treatment[a]			SEM	*P*-value
	CON	MET	MetLys		
Performance					
Initial BW, lb	618	620	620	1	0.15
Final BW, lb[d]	1352	1360	1350	11	0.79
DMI, lb/d	22.6	22.7	22.3	0.2	0.46
d 28 ADG, lb[b]	4.36	4.22	4.20	0.09	0.41
d 72 ADG, lb	3.46	3.55	3.51	0.08	0.77
d 162 ADG, lb[c]	3.74	3.82	3.77	0.05	0.50
ADG, lb[e]	3.86	3.90	3.84	0.06	0.77
Feed:Gain	6.00	5.95	6.04	—	0.79
Carcass Characteristics					
HCW, lb	852	857	851	7	0.78
Marbling Score[f]	508[a]	465[b]	498[a]	8.5	0.01
LM area, in^2	13.2	13.5	13.3	0.2	0.33
12th-rib fat, in	0.64a	0.60b	0.60b	0.01	0.02
Calculated YG	3.70	3.50	3.50	0.07	0.08

[a]Treatments were due to cattle diet; CON = control, MET = control diet with added bypass methionine, and MetLys = control diet with added bypass methionine and lysine.
[b]Live ADG measured after 1 week on finisher diet, d 28–29. Measured by pen weighing cattle on 2 consecutive days and applying a 4% pencil shrink.
[c]Live ADG measured by pen weighing cattle on the first day of Optaflexx supplementation and applying a 4% shrink.
[d]Calculated from HCW divided by a common 63% dressing percentage.
[e]Calculated using carcass-adjusted final BW and limit fed initial BW.
[f]300 = slight, 400 = small, 500 = modest, etc.
[ab]Within a row, means without a common superscript after ($P < 0.05$).

Results

There were no differences in DMI ($P \geq 0.46$; Table 2) between the 3 treatments over the entire feeding period. Using carcass-adjusted performance, there was no difference in final BW ($P \geq 0.79$) or ADG ($P \geq 0.77$). Therefore, F:G was also unaffected by the supplementation of bypass amino acids ($P \geq 0.79$). Additionally, when evaluating animal performance using interim pen weights no differences in ADG were observed ($P \geq 0.41$).

While there was no difference in HCW ($P \geq 0.78$) nor LM area ($P \geq 0.33$), there was a notable difference in USDA marbling score ($P \leq 0.01$). When comparing the 3 treatments, CON and MetLys treatments were similar with scores of 508 and 498 respectively ($P \geq 0.05$). The difference appeared in the MET treatment which had a noticeably lower score of 465 ($P \leq 0.05$). There was also a difference found when comparing fat thickness among treatments. The CON treatment had the greatest 12th rib fat ($P = 0.02$). However, all cattle were well finished, with average fat thickness of at least 0.60 in.

In conclusion, bypass amino acid supplementation had no effect on live cattle performance. Each treatment had similar effects both on live performance and carcass characteristics, differing only slightly in 12th rib fat and USDA marbling score. Although WCGF provides less bypass protein than DGS, it appears that a 40% Sweet Bran, 50% HMC diet provides sufficient lysine, methionine and metabolizable protein to meet finishing steer requirements.

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Metabolic and Body Temperature Responses to Environmental Conditions across Seasons in Finishing Steers

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Summary

Two trials (summer and winter) were conducted with 80 steers each at the UNL ARDC near Mead, Neb. Continuous body temperature was collected throughout both trials and blood samples were taken every other week until four weeks prior to harvest. This resulted in a total of 6 collections for the summer and 8 collections for the winter. Blood measures responded differently between seasons with significant quadratic interactions between collection time and season suggesting environmental conditions affect blood metabolites.

Introduction

Environmental stress can cause substantial economic losses to producers through both losses in animal performance and mortality. Summer conditions consisting of above normal ambient temperature, relative humidity, and solar radiation coupled with low wind speeds can increase an animal's heat load resulting in reduced performance, decreased animal comfort, and death (Journal of Animal Science, 84:712–719). In addition, cold stress can result in sustained performance losses, particularly when coupled with wet and/or windy conditions. Even though environmental stress has been a researched topic for the past few decades little is known about how hot and cold environmental temperatures affect cattle metabolically, and whether significant interactions exists among seasons (hot vs cold) for various physiological parameters. Additionally, even though body temperature has been measured, measures have been recorded over only short periods of time. Therefore, the objective of the current studies was to determine the effect of season and ambient temperature on animal blood parameters in addition to body temperature measured continuously throughout the feeding period.

Procedure

Crossbred beef steers were utilized to conduct two studies (80 steers, 10 steers/pen) at the University of Nebraska Agricultural Research and Development Center research feedlot near Mead, Nebraska. Cattle in both experiments were limit fed a diet consisting of 50% Sweet Bran (Cargill, Blair, Neb) and 50% alfalfa hay at an estimated 2% of BW for five days prior to an initial BW being collected over 2 d. The first trial was conducted during the summer utilizing summer yearlings (initial BW = 1076 ± 45 lb). Cattle were started on trial May 22, 2014 and harvested on September 10, 2014 (summer). Fall yearlings (initial BW = 853 ± 35 lb) were used for the second trial and fed during the fall and winter with cattle starting on feed on September 11, 2014 and harvested on January 14, 2015 (winter). Cattle in both trials were stepped onto the finishing diet over a 21 day period by reducing alfalfa inclusion in the diet and increasing levels of HMC. Cattle in both trials were fed the same finishing diet consisting of 40% Sweet Bran (Cargill, Blair, Neb), 51% HMC, 5% wheat straw, and 4% supplement.

On the first day of both trials, blood samples were collected via jugular venous puncture from each steer to obtain a baseline measure. Blood samples were collected from every steer in two week intervals until 4 weeks prior to harvest, resulting in 6 blood collections for the summer trial and 8 collections for the winter trial. Three separate blood samples were collected from each steer during each collection. One sample was allowed to clot and was then centrifuged in the lab to separate blood cells from blood serum and samples were sent to Nebraska Lab-Link (Lincoln, Neb) for analysis. A second sample was collected using EDTA containing vacutainers and sent to Physicians Lab (Omaha, Neb) for analysis. The final sample was centrifuged in the lab and blood plasma was removed and plasma samples were sent to Commonwealth Scientific and Industrial Research Organisation (CSIRO; Queensland, Aus) for subsequent analysis.

All cattle in both trials received a SmartStock (SmartStock; LLC. Pawnee, OK) temperature monitoring rumen bolus at the initiation of the trial. These boluses transmitted each individual steer's body temperature in ten minute intervals (summer) and twenty minute intervals (winter) to a central computer where data were compiled across days. Any missing data points were removed and average body temperature was calculated for every hour creating a final data set with individual animal body temperatures every hour throughout the duration of the finishing period.

Blood data, and body temperature were correlated to environmental temperature and comprehensive climate index (CCI) using the CORR procedure of SAS (SAS Institute, Inc. Cary, N.C.) with steer as the experimental unit. Pen intakes (DM offered) were also correlated to environmental temperature and CCI using the CORR procedure of SAS (SAS Institute, Inc. Carry, N. C.) with pen as the experimental unit. Linear and quadratic relationships between blood collection time and season were analyzed using the GLIMMIX procedure of SAS with steer as the experimental unit. The model included the fixed effects of time, season, and the linear and quadratic interactions of time and season.

Results

Only blood measures that had a correlation coefficient of 0.40 or greater to at least one of the 3-d, 7-d, or 14-d average CCI or ambient temperature were chosen to be reported. Environmental temperature data for both trials related to blood collections are presented in Table 1. Bilirubin, a powerful antioxidant (The International Journal of Biochemistry & Cell Biology 34:216–220), was positively correlated ($r > 0.71$; Table 2) with CCI measured for the previous 3-d, 7-d, and 14-d averages for the

winter trial, but was negatively correlated (r < −0.13) for the previous 3-d, 7-d, and 14-d averages for the summer trial. This opposite correlations suggest that cattle physiology may react differently to hot and cold environmental temperatures. Glucose, mean corpuscular hemoglobin (MCH), mean corpuscular volume (MCV), and sodium levels were also correlated differently between the summer and winter trials. For the 7-d and 14-d average CCI and environmental temperature, glucose, MCH, and MCV levels were positively correlated (r > 0.19) for the summer trial but negatively correlated (r < −0.38) for the winter trial (Table 2). However, when correlated to the 3-d average glucose, MCH, and MCV levels were slightly negatively correlated (r < −0.08) to CCI and environmental temperature for both summer and winter trials. Sodium levels, in the summer trial, were positively correlated (r > 0.48) to the 3-d, 7-d, and 14-d average CCI and environmental temperature; however, in the winter, sodium levels were negatively correlated (r < 0.30; Table 2).

Hemoglobin and hematocrit were both negatively correlated (r > −0.35) to the 3-d, 7-d, and 14-d average CCI and environmental temperature for both summer and winter trials. This is supported by previous findings where a negative correlation between hematocrit levels and ambient temperature in dairy cattle was reported (Journal of Dairy Science 59:104–108). It has been noted that there are significant effects of ambient temperature on hemoglobin levels when dairy cows were exposed to cool, intermediate, and hot environments (Journal of Dairy Science 64:62–70). This was attributed to a decrease in cellular oxygen requirements to reduce the heat load of the animal (Journal of Dairy Science 64:62–70) supporting similar findings where it was suggested that the oxygen binding capacity of blood is decreased under heat stress (Journal of Dairy Science 59:104–108).

Season had a significant effect on all blood parameters ($P \leq 0.04$) with the exception of creatine kinase levels and blood urea nitrogen: creatine ratio ($P \geq 0.22$; Table 3). Additionally, all blood measures had a significant quadratic interaction between season and collection ($P \leq 0.03$) with the exception of CO_2 ($P = 0.67$; Table 3) which had a linear interaction ($P <$ 0.001) between season and collection. This suggests that the blood parameters changed quadratically across collection periods for both the summer and winter trials; however, the quadratic response to collection is not the same between seasons suggesting the change in these parameters is due to environmental conditions rather than an effect due to days on feed or BW.

Table 1. Environmental temperature (°F) and comprehensive climate index (CCI) averages based on blood collections

Collection[a]	Season[b]	Three Day Avg[c]		Seven Day Avg[d]		Fourteen Day Avg[e]	
		CCI	Temp[f]	CCI	Temp[f]	CCI	Temp[f]
1	S	72.36	72.18	60.36	60.97	57.07	59.34
	W	66.53	66.97	67.58	65.80	73.11	68.76
2	S	75.46	70.24	77.96	73.26	77.17	71.95
	W	66.63	64.72	68.55	66.20	64.25	62.29
3	S	81.24	81.11	74.30	74.44	72.93	71.45
	W	59.53	59.65	51.51	54.38	61.14	60.72
4	S	69.48	67.14	73.92	70.79	78.07	72.74
	W	58.82	59.28	55.12	56.37	51.60	54.05
5	S	70.42	64.96	78.35	71.42	79.84	72.59
	W	44.49	50.87	39.08	47.03	47.45	51.36
6	S	74.87	67.85	79.82	73.15	80.21	74.37
	W	14.53	23.22	9.04	20.08	15.23	26.41
7	S	—	—	—	—	—	—
	W	16.99	24.95	18.99	28.95	20.70	32.01
8	S	—	—	—	—	—	—
	W	12.42	26.55	27.35	38.43	25.27	35.55

[a]Summer collections taken every other week beginning on 5/22/2014 and ending 7/31/2014. Winter collections taken every other week beginning on 9/11/2014 and ending on 12/18/2014.
[b]Season either defined as S = Summer or W = Winter.
[c]Three days prior to blood collection weather averages correlated to blood measures.
[d]Seven days prior to blood collection weather averages correlated to blood measures.
[e]Fourteen days prior to blood collection weather averages correlated to blood measures.
collection weather averages correlated to blood measures
[f]Environmental Temperature °F

There was a sharp decrease observed for bilirubin, blood urea nitrogen (BUN), and creatine kinase during the summer between the first and second blood collection followed by a leveling off for the remaining collections during the summer (Table 3). This sharp decrease occurred during a time where the 7-d average CCI increased from 60.36 to 77.96 followed by a leveling off. The sudden decrease and then level period in these blood measures suggests steers metabolically adapt to changing temperature over time. Furthermore, during the winter trial a sharp increase in bilirubin, BUN, and creatine kinase was observed between the 5th and 6th blood collections. This sharp increase occurred during a time where the 7-d average CCI increased from 9.04 to 18.99. This sharp increase suggests that animals were adapted to very cold conditions and when conditions warmed the animal attempted to compensate thus a large increase in these blood measures was observed. Other studies have suggested that the acclimation period to environmental conditions for most cattle is between 9–14 days (Animal 4:1167–1183). This supports the findings of the current study that suggests that the levels of bilirubin, BUN, and creatine kinase leveled off in the summer trial by the 3rd blood collection which was 14 days after the spike was observed during the 2nd blood collection.

Ruminal temperature was positively correlated (r > 0.12) to the previous day average CCI and environmental temperature in the summer trial (Table 4). This suggests that the previous day environmental conditions impacted body tempera-

Table 2. Correlation between environmental temperature and the comprehensive climate index (CCI) to blood measures

Blood Measure	Season[a]	Three day[b]				Seven Day[c]				Fourteen Day[d]			
		CCI[e]	*P*-value	Temp[f]	*P*-value	CCI[e]	*P*-value	Temp[f]	*P*-value	CCI[e]	*P*-value	Temp[f]	*P*-value
Hemoglobin, g/dL	S	−0.30	< 0.01	−0.25	< 0.01	−0.30	< 0.01	−0.44	< 0.01	−0.29	< 0.01	−0.35	< 0.01
	W	−0.57	< 0.01	−0.54	< 0.01	−0.51	< 0.01	−0.49	< 0.01	−0.51	< 0.01	−0.50	< 0.01
Hematocrit, %	S	−0.30	< 0.01	−0.22	< 0.01	−0.35	< 0.01	−0.48	< 0.01	−0.34	< 0.01	−0.40	< 0.01
	W	−0.59	< 0.01	−0.57	< 0.01	−0.54	< 0.01	−0.52	< 0.01	−0.54	< 0.01	−0.54	< 0.01
MCV[g], L/cell	S	−0.17	< 0.01	−0.26	< 0.01	0.28	< 0.01	0.19	< 0.01	0.33	< 0.01	0.31	< 0.01
	W	−0.40	< 0.01	−0.40	< 0.01	−0.42	< 0.01	−0.40	< 0.01	−0.43	< 0.01	−0.42	< 0.01
MCH[h], g/cell	S	−0.14	0.01	−0.27	< 0.01	0.33	0.01	0.24	< 0.01	0.37	< 0.01	0.35	< 0.01
	W	−0.37	< 0.01	−0.37	< 0.01	−0.38	< 0.01	−0.37	< 0.01	−0.39	< 0.01	−0.38	< 0.01
Eosinophils,%	S	−0.13	0.01	−0.29	< 0.01	0.43	0.01	0.35	< 0.01	0.46	< 0.01	0.42	< 0.01
	W	−0.07	0.09	−0.06	0.12	−.077	0.05	−0.07	0.08	−0.07	0.08	−0.07	0.10
A/G, ratio	S	0.02	0.67	0.01	0.79	−0.32	< 0.01	−0.37	< 0.01	−0.42	< 0.01	−0.46	< 0.01
	W	0.30	< 0.01	0.30	< 0.01	0.39	< 0.01	0.39	< 0.01	0.31	< 0.01	0.32	< 0.01
Albumin, g/dL	S	−0.05	0.27	−0.06	0.18	−0.35	< 0.01	−0.44	< 0.01	−0.45	< 0.01	−0.50	< 0.01
	W	0.03	0.53	0.01	0.75	0.08	0.03	0.07	0.10	0.03	0.44	0.03	0.49
BC[i], ratio	S	−0.18	< 0.01	−0.04	0.36	−0.61	< 0.01	−0.69	< 0.01	−0.67	< 0.01	−0.73	< 0.01
	W	0.07	0.08	0.08	0.04	0.13	0.01	0.12	0.01	0.14	< 0.01	0.13	< 0.01
Bilirubin, mg/dL	S	−0.13	0.01	0.01	0.77	−0.32	< 0.01	−0.33	< 0.01	−0.30	< 0.01	−0.31	< 0.01
	W	0.75	< 0.01	0.73	< 0.01	0.72	< 0.01	0.71	< 0.01	0.74	< 0.01	0.73	< 0.01
BUN[j], mg/dL	S	−0.15	0.01	−0.04	0.43	−0.59	< 0.01	−0.67	< 0.01	−0.65	< 0.01	−0.69	< 0.01
	W	0.10	0.01	0.11	0.01	0.18	< 0.01	0.17	< 0.01	0.19	< 0.01	0.18	< 0.01
Creatine kinase, U/L	S	−0.12	0.01	0.04	0.35	−0.48	< 0.01	−0.49	< 0.01	−0.49	< 0.01	−0.51	< 0.01
	W	0.07	0.07	0.08	0.04	0.12	0.01	0.12	0.01	0.11	0.01	0.11	0.01
CO_2, mM/dL	S	−0.04	0.35	−0.32	< 0.01	0.64	< 0.01	0.54	< 0.01	0.66	< 0.01	0.64	< 0.01
	W	0.24	< 0.01	0.27	< 0.01	0.28	< 0.01	0.29	< 0.01	0.29	< 0.01	0.29	< 0.01
Glucose, mg/dL	S	−0.08	0.08	−0.16	< 0.01	0.35	< 0.01	0.34	< 0.01	0.41	< 0.01	0.41	< 0.01
	W	−0.37	< 0.01	−0.37	< 0.01	−0.42	< 0.01	−0.42	< 0.01	−0.42	< 0.01	−0.42	< 0.01
Sodium, mEq/L	S	0.09	0.05	−0.15	0.01	0.54	< 0.01	0.48	< 0.01	0.53	< 0.01	0.53	< 0.01
	W	−0.30	< 0.01	−0.33	< 0.01	−0.35	< 0.01	−0.37	< 0.01	−0.41	< 0.01	−0.41	< 0.01

[a]Season either defined as S = Summer or W = Winter.
[b]Three days prior to blood collection weather averages correlated to blood measures.
[c]Seven days prior to blood collection weather averages correlated to blood measures.
[d]Fourteen days prior to blood collection weather averages correlated to blood measures.
[e]From Journal of Animal Science 88:2153–2165.
[f]Temp = Environmental Temperature °F
[g]MCV = mean corpuscular volume.
[h]MCH = Mean Corpuscular Hemoglobin.
[i]BC = Blood urea nitrogen: creatine ratio.
[j]BUN = Blood Urea Nitrogen.

Table 3: Linear and Quadratic relationship between bleed date and season

Blood Measure	Season[b]	Collection[a]								*P*-value				
		1	2	3	4	5	6	7	8	SEM	S[c]	C[d]	C * S[e]	C * C * S[f]
Hemoglobin, g/dL	S	12.47	12.96	13.51	14.02	14.18	14.68	—	—	0.11	< 0.01	0.43	0.53	< 0.01
	W	14.79	13.51	12.89	13.56	13.87	14.16	13.44	11.96					
Hematocrit, %	S	34.52	35.99	37.64	39.04	39.76	40.62	—	—	0.31	< 0.01	< 0.01	0.04	< 0.01
	W	42.49	38.53	36.61	38.63	39.23	40.01	36.75	33.33					
MCV[f], L/cell	S	44.47	45.68	46.20	46.41	46.84	46.72	—	—	0.36	< 0.01	< 0.01	< 0.01	< 0.01
	W	43.25	43.35	44.63	46.33	47.34	47.41	41.54	43.22					
MCH[h], g/cell	S	16.04	16.43	16.55	16.65	16.69	16.89	—	—	0.13	< 0.01	< 0.01	< 0.01	< 0.01
	W	15.03	15.20	15.70	16.24	16.72	16.77	15.19	15.49					
Eosinophils,%	S	4.26	4.29	4.17	3.81	3.95	4.26	—	—	0.29	< 0.01	0.10	0.02	< 0.01
	W	1.63	5.43	3.06	4.93	4.95	4.40	3.28	2.97					
A/G, ratio	S	1.34	1.41	0.89	0.85	0.86	0.98	—	—	0.02	0.01	< 0.01	< 0.01	< 0.01
	W	0.91	0.94	0.80	0.80	0.86	0.93	0.95	1.02					
Albumin, g/dL	S	4.31	4.29	3.47	3.47	3.55	3.78	—	—	0.03	0.04	< 0.01	< 0.01	< 0.01
	W	3.53	3.65	3.39	3.58	3.69	3.62	3.72	3.65					
BC[i], ratio	S	17.29	13.49	8.10	8.51	9.60	9.67	—	—	0.48	0.68	0.47	< 0.01	< 0.01
	W	10.00	9.35	10.09	11.71	10.34	12.10	16.48	11.22					
Bilirubin, mg/dL	S	0.23	0.14	0.18	0.18	0.19	0.18	—	—	0.01	< 0.01	< 0.01	< 0.01	< 0.01
	W	0.21	0.17	0.10	0.05	0.03	0.04	0.24	0.22					
BUN[j], mg/dL	S	19.62	14.97	10.38	10.75	11.02	12.97	—	—	0.32	0.01	< 0.01	< 0.01	< 0.01
	W	11.22	10.22	11.41	12.81	11.87	12.87	16.32	13.46					
Creatine kinase, U/L	S	296.82	189.30	154.15	164.00	154.15	145.04	—	—	12.88	0.22	0.77	< 0.01	0.03
	W	160.08	182.84	175.37	179.74	177.85	205.99	258.41	193.23					
CO_2, mM/dL	S	24.09	27.49	26.68	28.09	28.23	29.59	—	—	0.23	< 0.01	>0.01	< 0.01	0.67
	W	26.51	27.51	27.44	25.73	25.76	27.16	29.08	26.54					
Glucose, mg/dL	S	66.51	77.52	79.75	89.30	82.64	82.75	—	—	1.42	< 0.01	< 0.01	0.67	< 0.01
	W	91.15	93.15	92.62	99.17	92.84	93.33	74.66	81.53					
Sodium, mEq/L	S	137.94	139.38	139.95	139.59	140.85	141.20	—	—	0.22	< 0.01	0.41	< 0.01	< 0.01
	W	138.52	141.13	139.19	140.97	140.73	139.27	137.92	139.21					

[a]Summer collections taken every other week beginning on 5/22/2014 and ending 7/31/2014. Winter collections taken every other week beginning on 9/11/2014 and ending on 12/18/2014.
[b]Season either defined as S = Summer or W = Winter.
[c]Effect of season.
[d]Effect of collection.
[e]Linear interaction between collection and season.
[f]Quadratic interaction between collection and season
[g]MCV = mean corpuscular volume.
[h]MCH = Mean Corpuscular Hemoglobin.
[i]BC = Blood urea nitrogen: creatine ratio.
[j]BUN = Blood Urea Nitrogen.

ture. Conversely, in the winter trial, body temperature was negatively correlated (r < −0.23) to both the previous day average CCI and environmental temperature which suggests that in the winter as environmental temperature decreases, steers are compensating and increasing body temperature. Intake was negatively correlated (r = −0.38) to the previous day average CCI and environmental temperature in the summer trial and positively correlated (r > 0.19) in the winter trial (Table 4). This relationship between DMI and environmental measures suggest that in the summer, when CCI and environmental temperature increase, the steers consumed less feed or vice-versa. In the winter, as environmental temperature changes, DMI changes in the same manner, although the relationship is not as strong in the winter as in the summer.

In the current study it appears that finishing steers have a different metabolic reaction to hot and cold conditions. Many blood measures responded differently to collection points between the seasons which suggests environment has a greater influence on these measures than days on feed or BW. Ruminal temperature and DMI appears to be related to environmental temperature which is consistent with findings in current literature (Journal of Thermal Biology 33:12–19). Ruminal temperature was positively correlated to the previous day environmental conditions in the summer suggesting that the previous day's environmental conditions can add to the potential for environmental stress. Based on the data in these 2 studies it can be concluded that hot and cold environmental conditions affect feedlot cattle differently from a metabolic standpoint. While it is still unclear what blood metabolites are the most important during times of hot and cold environmental conditions, it is evident that blood metabolites change during periods of warm and cold weather. It appears that steers have the ability to adapt to environmental conditions over time. Therefore, sudden swings in environmental conditions may subject animals to increased stress if they have not been previously acclimated.

Table 4: Correlation between previous day environmental temperature and comprehensive climate index (CCI) to animal body temperature and DMI

Measure	Season[a]	Avg. value[b]	CCI[c]	*P*-value	Temp[d]	*P*-value
Ruminal Temperature, °F	S	102.86	0.13	< 0.001	0.12	< 0.001
	W	102.35	−0.24	< 0.001	−0.23	< 0.001
DMI, lb	S	29.55	−0.38	< 0.001	−0.38	< 0.001
	W	29.86	0.19	< 0.001	0.21	< 0.001

[a]Season either defined as S = summer or W = winter.
[b]Overall average value for DMI and rumen temperature of cattle for summer and winter trials
[c]From Journal of Animal Science 88:2153–2165
[d]Temp = Correlation to daily average environmental temperature

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Impact of Feeding Distillers Grains or Isolated Components in Distillers Grains on Feedlot Performance and Carcass Traits

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Summary

Six treatments were evaluated to determine the contribution of individual components of distillers grains on finishing performance. Diets were formulated to isolate the contribution of solubles, protein, fat, and fiber compared to a diet containing 40% wet distillers grains or a corn-based control. There was a significant improvement in both feedlot and carcass performance in steers fed the 40% wet distillers grains compared to dry-rolled-corn. Numeric differences between fat, fiber, and protein treatments were observed. However, none of the four component diets alone were able to explain the energy value associated with wet distillers grains.

Introduction

The ethanol industry continues to explore removing nutrients from distillers grains. Previous research indicates that finishing diets containing distillers grains have consistently resulted in higher ADG and improved feed efficiency compared to corn-based rations (2008 *Nebraska Beef Cattle Report*, pp.35–36). However, the contribution of individual nutrients in distillers grains that improve performance of finishing cattle has not been extensively studied. Knowing how fat, fiber, and protein in distillers grains each contribute to the value would allow prediction of impact if components are removed. The objective was to determine the energy contributions for each nutrient component in wet distillers grains plus solubles by isolating protein, fat, and fiber using corn byproducts from the wet milling industry.

Procedure

A finishing experiment utilizing 264 crossbred steers (initial BW = 918 ± 51 lb) was conducted to determine the nutrient values of isolated components of WDGS. The trial was conducted at the Panhandle Research and Extension Center (PREC), near Scottsbluff, NE. Prior to initiating the study, cattle were limit fed for five days at 2% of BW to reduce variation in gastrointestinal fill. Steers were weighed two consecutive days (day 0 and 1) to establish an accurate initial BW. According to the initial BW measurement, steers were separated into four BW blocks (Light, Mid-Light, Mid-Heavy, or Heavy), stratified and assigned randomly to a pen within their BW block. Cattle were placed in 30 pens (24 pens of 9 steers per pen and 6 pens of 8 steers per pen) allowing for 5 replications per treatment. Treatments were assigned randomly to pens, all steers were adapted to one of six dietary treatments over a four step adaptation process. During the adaptation period the percentage of dry-rolled-corn (DRC) included in the diet increased while the amount of wheat straw and corn silage decreased with each step.

Treatments consisted of 1) a corn-based control with no WDGS (CON), 2) WDGS at 40% inclusion (40WDGS), and 3) a diet (SOL) containing 10% condensed distillers solubles. Condensed distillers solubles (CCDS) are a liquid by-product of the ethanol production process which contain, CP, along with yeast cells, and energy. Condensed distillers solubles are commonly added back to dry distillers grains to create

Table 1. Composition of dietary treatments fed to yearling steers

Ingredient[a]	Treatment[e,f]					
	CON	40WDGS	SOL	PROT	FAT	FIB
DRC[b]	75.5	39	68.5	55	64.3	51.5
WDGS[b]	—	40	—	—	—	—
Silage	15	15	15	15	15	15
CCDS[b]	—	—	10	10	10	10
UreaSupp[c,e]	6	—	6	—	6	4
NoUreaSupp[d,e]	—	6	—	6	—	2
SBM[b]	3.5	—	0.5	—	0.5	0.5
Germ	—	—	—	—	4.2	—
Bran	—	—	—	—	—	14
SEM[b]	—	—	—	—	—	3
CGM[b]	—	—	—	14	—	—
Nutrient Composition, %						
CP	13.4	21.7	13.2	22.3	13.4	14.2
NDF	14.7	21.8	13.8	14.1	14.6	22.1
Fat	3.0	4.9	13.4	3.2	4.8	3.3
P	0.26	0.51	0.41	0.44	0.41	0.40
K	0.61	0.95	0.81	0.78	0.80	0.79
S	0.10	0.30	0.15	0.26	0.15	0.17

[a]All values presented on a % DM basis.
[b]DRC: Dry rolled corn, WDGS: Wet distillers grains plus solubles, CCDS: condensed distillers. solubles SBM: Soybean meal, SEM: solvent extracted meal, CGM: Corn gluten meal.
[c]Supplement 137: contained 1.3% urea, 1.34% limestone, 0.3% salt, 0.2% KCL (% of diet DM).
[d]Supplement 2041: contained 0% urea, 1.40% limestone, 0.3% salt, 0% KCL (% of diet DM).
[e]Both supplements contained a trace mineral premix (30% Zn, 50% Fe, 10% Cu, 20% Mn,0.5% I, 0.1% Co, 0.1% Se) and a Vitamin ADE premix (1,000 IU if vitamin A, 125 IU of vitamin D, and 1.5 IU of vitamin E).
[f]Treatments included a corn-based diet with no added WDGS (CON), 40% WDGS with no solubles (40WDGS), 10% solubles no WDGS (SOL), protein component using 20% CGM (PROT), fat component using 4.2% full-oil germ (FAT), and a fiber component diet containing 14% bran and 3% SEM (FIB).

WDGS. In order to accurately mimic the nutrient composition of WDGS all component treatments included CCDS at 10% of the diet DM. An additional three diets were formulated on a DM basis to simulate the nutrient content of each individual component in WDGS. The first (PROT) was formulated to match protein content using 14% corn gluten meal, the second (FAT) replicated fat content utilizing 4.2% full-oil germ, and the last (FIB) isolated fiber using 14% dry corn bran and 3% solvent extracted meal. All component diets contained 15% silage, 10% CCDS and 6% liquid-based supplement on a DM basis (Table 1). Condensed distillers solubles were included at 10% DM across all component treatments (SOL, PROT, FAT, FIB). Tylosin and monensin were distributed from a micro machine; Tylan® was fed at 90 mg/steer/day, and Rumensin® at 360 mg/steer daily. The WDGS (7.9% crude fat, 32.7% crude protein) and CCDS (6.8% crude fat, 19.5% crude protein) were delivered from Bridgeport Ethanol (Bridgeport, NE) as needed.

On d 0, cattle were implanted with Revalor-XS®. On d 113 steers in the Heavy or Mid-Heavy BW blocks were shipped to Cargill Meat Solutions in Fort Morgan, Colo. for slaughter. Cattle blocked into the Light or Mid-Light BW blocks were slaughtered on day 126. Hot carcass weight and liver score were collected on d of harvest. Following a 48 hour chill USDA marbling score, LM area, and 12th rib fat thickness were recorded. Yield grade was calculated as follows: 2.50 + (2.50 * fat thickness, in) + (0.2 * 2.5 [KPH]) + (0.0038 * HCW, lb) – (0.32 * LM area, in^2). Animal performance and carcass characteristics were analyzed using the MIXED procedure of SAS (SAS Institute, Inc. Cary, N.C.). Pen was the experimental unit and BW block was a random effect. Treatment differences were declared significant at $P \leq 0.05$. One steer died from respiratory complications and one animal was removed from the PROT treatment because of respiratory-related chronic illness. Those two steers were removed from the performance data.

Table 2. Effects of individual nutritional components of WDGS on feedlot performance and carcass characteristics

	Treatment						SEM	*P*-value
	CON	40WDGS	SOL	PROT	FAT	FIB		
Performance								
Initial BW, lb	924	923	923	923	921	921	30.7	0.50
Final BW, lb[a]	1410^{gh}	1482^{f}	1403^{h}	1432^{gh}	1411^{gh}	1440^{g}	15.3	< 0.01
DMI, lb/d	27.95^{g}	28.00^{g}	27.69^{g}	28.75^{f}	28.73^{f}	28.28^{fg}	0.36	0.04
ADG, lb	4.08^{h}	4.69^{f}	4.02^{h}	4.25^{gh}	4.12^{gh}	4.34^{g}	0.13	< 0.01
F:G[b]	6.94^{gh}	6.07^{f}	7.07^{gh}	7.00^{gh}	7.09^{h}	6.62^{g}	0.005	< 0.01
Feeding Value[c]	—	136%	82%	96%	85%	118%	—	—
Carcass Characteristics								
HCW, lb	888^{gh}	934^{f}	884^{h}	902^{gh}	889^{gh}	907^{g}	9.6	< 0.01
LM area, in[b]	13.12	13.55	12.97	13.10	13.29	13.08	0.21	0.13
12th rib fat, in	0.48^{g}	0.57^{f}	0.51^{fg}	0.55^{f}	0.48^{g}	0.54^{f}	0.03	0.02
Marbling[d]	578	586	579	594	571	576	23	0.94
Liver Abscess[e]	7	3	4	6	5	4	—	—

[a]Calculated from HCW/ common dressing percentage (63%).
[b]Originally analyzed as G:F, the reciprocal value of F:G
[c]Calculated as the percent change in the G:F of each treatment and the control, divided by the percentage of corn replaced in each treatment.
[d]Marbling score: 400 = slighto, 500 = smallo, 600 = modesto
[e]Liver abscess score: total number of A or A+ liver scores per treatment (43 or 44 steers per treatment group).
[f-h]Means with different superscripts differ ($P < 0.05$).

Results

According to past research, improved ADG and feed conversions were expected to be observed in cattle fed a diet containing 40% WDGS compared to DRC at similar intakes. In this experiment the energy value of WDGS was 137% that of DRC. As predicted, data showed significant improvement in live performance for cattle fed 40WDGS compared to CON. In this trial, DMI was greater for steers fed PROT and FAT compared with CON, 40WDGS, and SOL ($P = 0.04$) with FIB being intermediate. Daily gain was greater for 40WDGS compared to all other diets ($P < 0.01$). Gains for cattle fed PROT and FAT were intermediate, while FIB was greater than both CON and SOL ($P < 0.01$). Similar to ADG, steers fed 40WDGS had improved F:G compared with all other treatments ($P < 0.01$). Steers fed FIB had improved F:G compared to FAT ($P < 0.01$), while the remaining treatments (CON, SOL, PROT) were intermediate. Final BW was heaviest for cattle fed 40WDGS and lightest for those fed SOL ($P < 0.01$). When compared to SOL, FIB had a greater final BW ($P < 0.01$), while CON, PROT, and FAT were intermediate. Marbling score and LM area were not affected by treatment ($P \geq 0.13$). Greater external fat thickness was observed from steers fed 40WDGS, PROT, and FIB compared to CON or FAT ($P = 0.02$). Similar to final BW, cattle fed 40WDGS had the heaviest hot carcass weights of all dietary treatments.

Data from this experiment did not determine a sole nutritional component that was able to account for the energy value of wet distillers grains, however, we did observe numeric improvements from the fiber component compared to protein and fat.

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Evaluation of Distillers Grains Components Singly or in Combination in a Calf Fed Feedlot Study

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Summary

A finishing study was conducted to determine the value of the fiber, protein, fat, and solubles components from wet distillers grains plus solubles (WDGS) alone or in combination for feedlot cattle in comparison to WDGS diets. The fiber portion alone did not improve F:G. When protein was included in the composite with fiber, F:G improved. With fat and solubles both added separately, F:G continued to improve. None of the components alone could make up the feeding value of WDGS, however the composite diet of fiber, protein, fat, and solubles combined matched the performance observed when WDGS is fed.

Introduction

The ethanol industry is interested in ways to make use of portions of distillers grains to sell as separate commodities or to use in other processes. Ethanol plants are able to remove portions of fiber, protein, fat, and solubles from the distillers grains to be sold separately. Previous research suggests a feed composite can mimic wet distillers grains plus solubles (WDGS) to improve feed efficiency when compared to wet corn gluten feed (WCGF), however the question remained as to what interactions of the fiber, protein and fat contributed to the feeding value of WDGS (*1997 Nebraska Cattle Beef Report*, pp. 63–64). Recent research found the fiber portion to have the closest performance to that of a DGS diet out of the individual feeding components of fiber, fat, and protein of WDGS (*2016 Nebraska Beef Cattle Report*, pp. 122–23). Therefore, the objective of this study was to determine the nutritional energy value of the fiber, protein, fat, and solubles and their interactions in WDGS in terms of their contribution to finishing performance and carcass characteristics by using composites of feed ingredients similar to nutrient composition of WDGS.

Procedure

A finishing experiment was conducted using 600 crossbred steers (initial BW = 680 ± 40 lb) in a randomized block design to evaluate the feeding value of the fiber, protein, fat, and solubles in WDGS. Steers were limit-fed to 2% BW for five days before the start of the trial. Steers were weighed on two consecutive d (0 and 1) to determine initial BW. On day 1, steers were implanted with Revalor-XS (Merck Animal Health). Steers were blocked by BW into four blocks, stratified by BW within each block and assigned randomly to pen. Pens were assigned randomly to one of ten treatments with 6 pens per treatment and ten steers per pen.

Diets were formulated to contain the same amount of the fat, fiber and protein as in WDGS. Control diet (Table 1) had a 1:1 mix of dry rolled corn (DRC):high moisture corn (HMC) with a 5% inclusion of sorghum silage and 2.5% inclusion of grass hay. The WDGS20 and WDGS40 had 20% and 40% inclusion of WDGS, respectively. The Fiber20 contained corn bran at 7% and solvent extracted germ meal at 1.5% inclusion to mimic the fiber portion of the WDGS20. In the Fiber40 diet corn bran and solvent extracted germ meal inclusion were increased to 14% and 3%, respectively to mimic the WDGS40 fiber. Protein was then added to the diet in the form of corn gluten meal at 17.5% to mimic the crude protein in WDGS40. Whole fat germ was used to mimic the fat portion at 7.5% inclusion. Solubles was added to each Fiber diet at 8% to evaluate its contribution to energy. All diets were formulated to provide 30 g/ton DM daily of Rumensin® (Elanco Animal Health) and 90 mg/steer daily of Tylan® (Elanco Animal Health).

The first two blocks were harvested on d 182 and the second two blocks were harvested on d 188 at a commercial abattoir (Greater Omaha Packing, Omaha, Neb.) with HCW taken at slaughter. Carcass 12th rib fat, LM area, and USDA marbling score were recorded after a 48-hour chill. Yield Grade was calculated using the USDA Yield Grade equation [YG = 2.5 + (2.5 × 12th Rib Fat thickness, in) − (0.32 × LM area, in^2) + (0.2 × KPH fat, %) + (0.0038 × HCW, lb)]. Final BW, ADG, and F:G were calculated using the HCW adjusted to 63% common dress.

Data were analyzed using the Mixed procedure of SAS (SAS Institute, Inc., Cary, N.C.) as a randomized block design with pen as experimental unit. Linear and quadratic simple effects were evaluated for WDGS20 and WDGS40 and for Fiber20 and Fiber40 with the control diet as a common intercept. The fiber content was also evaluated comparing WDGS20 and WDGS40 vs. Fiber20 and Fiber40. Preplanned contrasts were also used to evaluate: 1) the protein effect (Fiber40, Fiber40 Sol vs. Fiber40 CGM, Fiber40 CGM Sol), 2) the fat effect (Fiber40 CGM, Fiber40 CGM Sol vs. Fiber40 CGM Germ, Fiber40 CGM Germ Sol), and 3) the solubles effect (Fiber40, Fiber40 CGM, Fiber40 CGM Germ vs. Fiber40 Sol, Fiber40 CGM Sol, Fiber40 CGM Germ Sol). The feeding value of each diet was calculated relative to the control corn diet using the calculation: Feeding Value = ((Treatment G:F − Control G:F) / Control G:F) / inclusion rate of compared treatment.

Results

Linear and Quadratic Simple Effects: WDGS and Fiber

Final BW, HCW, DMI, and ADG increased quadratically as WDGS replaced the corn blend in the diet ($P \leq 0.02$, Table 2). Gain increased at a greater magnitude compared with DMI causing a decrease in F:G ($P = 0.02$). Yield grade increased linearly ($P = 0.03$) and had a tendency to increase quadratically ($P = 0.06$) with the inclusion of WDGS in the diet.

Table 1. Composition of dietary treatments (% of dietary DM) fed to finishing steers to evaluate components within WDGS

Ingredient	Control	WDGS20	WDGS40	Fiber20	Fiber40	Fiber Sol[b]	Fiber Protein	Fiber Protein Sol[b]	Fiber Protein Fat	Fiber Protein Fat Sol[a]
DRC[a]	43.75	33.75	23.75	39.5	35.25	31.25	26.5	22.5	24.25	20.25
HMC[a]	43.75	33.75	23.75	39.5	35.25	31.25	26.5	22.5	24.25	20.25
Sorghum Silage	4	4	4	4	4	4	4	4	4	4
Grass Hay	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
WDGS[a]	—	20	40	—	—	—	—	—	—	—
Corn Bran	—	—	—	7	14	14	14	14	14	14
SEM[a]	—	—	—	1.5	3	3	3	3	—	—
CGM[a]	—	—	—	—	—	17.5	17.5	17.5	17.5	17.5
Whole Fat Germ	—	—	—	—	—	—	—	—	7.5	7.5
CDS[a]	—	—	—	—	—	8	—	8	—	8
Urea	1.45	—	—	1.45	1.45	0.91	—	—	—	—
Supplement[c]	3.55	5	5	3.55	3.55	4.09	5	5	5	5
Analyzed Composition, % of diet										
Crude Protein	11.1	15.4	19.7	11.3	11.5	13.4	21.8	23.7	21.7	23.6
NDF	14.2	18.7	23.2	19.9	25.5	25.3	24.6	24.4	25.7	25.5
Crude Fat	4.03	5.71	7.38	3.81	3.60	3.83	3.30	3.51	6.12	6.32
Sulfur	0.12	0.23	0.35	0.13	0.14	0.20	0.30	0.36	0.30	0.36

[a]DRC = Dry Rolled Corn, HMC = High Moisture Corn, WDGS = Wet distillers grains plus solubles, SEM = Solvent extracted germ meal, CGM = Corn gluten meal, CDS = Condensed Distillers Solubles
[b]Sol = Solubles
[c]Formulated for 30 g/ton for Rumensin®, 90 mg/steer daily of Tylan®, and 300 mg/steer daily of Optaflexx the last 28d for blocks 1 and 2 and the last 35 d for blocks 3 and 4

Table 2. Linear and quadratic simple effects for increasing levels of WDGS and Fiber diets on finishing performance

	Con	WDGS20	WDGS40	Fiber20	Fiber40	SEM	Fiber Content[a]	Lin[b] WDGS	Quad[b] WDGS	Lin[b] Fiber	Quad[b] Fiber
Initial BW, lb	693	691	692	692	692	1	0.70	0.26	0.35	0.37	0.47
Final BW, lb[c]	1374	1458	1442	1384	1361	12	< 0.01	< 0.01	< 0.01	0.45	0.25
DMI, lb/day	23.0	23.6	22.6	23.0	23.3	0.2	0.82	0.26	0.02	0.44	0.68
ADG, lb	3.69	4.15	4.06	3.75	3.62	0.06	< 0.01	< 0.01	< 0.01	0.47	0.23
F:G[d]	6.25	5.68	5.57	6.15	6.44	0.002	< 0.01	< 0.01	0.02	0.15	0.07
HCW, lb	866	919	909	872	858	7.4	< 0.01	< 0.01	< 0.01	0.45	0.25
LM area, in[b]	13.5	13.5	13.5	14.1	13.7	0.18	0.02	0.74	0.91	0.46	0.04
12th Rib Fat, in	0.57	0.65	0.63	0.49	0.50	0.03	< 0.01	0.12	0.1	0.06	0.16
Marbling score[e]	494	512	507	467	471	12	< 0.01	0.45	0.45	0.19	0.29
Calculated YG[f]	3.39	3.80	3.72	3.03	3.11	.10	< 0.01	0.03	0.06	0.07	0.09

[a]Fiber content analyzed by comparing the average of WDGS20 and 40 vs average of Fiber20 and 40.
[b]Linear and quadratic simple effects term
[c]Final BW calculated from hot carcass weight adjusted to a common dressing percentage of 63%
[d]Analyzed as G:F, reciprocal of F:G
[e]Marbling score:400 = Small00
[f]Calculated YG = 2.5 + (2.5 × 12th rib fat thickness) – (0.32 × LM area in^2) + (0.2 × KPH) + (0.0038 × HCW)

Table 3. Effects of soluble, protein and fat in the diet

	Con	WDGS 20	WDGS 40	Fiber 20	Fiber 40	Fiber Sol	Fiber Protein	Fiber Protein Sol	Fiber Protein Fat	Fiber Protein Fat Sol	SEM	Solubles Effect[a]	Protein Effect[b]	Fat Effect[c]
Initial BW	693	691	692	692	692	691	690	690	692	692	1	0.99	0.26	0.05
Final BW, lb[d]	1374	1458	1442	1384	1361	1396	1417	1429	1396	1443	12	< 0.01	< 0.01	0.78
DMI, lb/day	23.0	23.6	22.6	23.0	23.3	24.2	22.9	23.2	21.8	22.5	0.2	< 0.01	< 0.01	< 0.01
ADG, lb	3.69	4.15	4.06	3.75	3.62	3.81	3.93	3.99	3.81	4.06	0.06	< 0.01	< 0.01	0.68
F:G[e]	6.25	5.68	5.57	6.15	6.44	6.35	5.82	5.82	5.71	5.54	0.002	0.19	< 0.01	< 0.01
HCW, lb	866	919	909	872	858	880	892	900	879	909	7.4	< 0.01	< 0.01	0.78
LM area, in[b]	13.5	13.5	13.5	14.1	13.7	13.8	13.7	13.6	13.4	13.6	0.18	0.57	0.43	0.41
12th Rib Fat, in	0.57	0.65	0.70	0.49	0.50	0.56	0.59	0.63	0.55	0.62	0.03	0.03	< 0.01	0.38
Marbling score[f]	494	512	507	467	471	492	473	496	467	483	12	0.05	0.80	0.44
Calculated YG[g]	3.39	3.80	3.72	3.03	3.11	3.32	3.50	3.66	3.45	3.66	0.10	0.03	< 0.01	0.76

[a]Solubles effect analyzed by comparing average of Fiber 40, Fiber Protein, and Fiber Protein Fat vs Fiber Sol, Fiber Protein Sol, Fiber Protein Fat Sol
[b]Protein effect analyzed by taking the average of Fiber 40 and Fiber Sol vs the average of Fiber Protein and Fiber Protein Sol
[c]Fat effect analyzed by comparing average of Fiber Protein and Fiber Protein Sol vs the average of Fiber Protein Fat and Fiber Protein Fat Sol
[d]Final BW calculated from hot carcass weight adjusted to a common dressing percentage of 63%
[e]Analyzed as G:F, reciprocal of F:G
[f]Marbling Score: 400 = Small00
[g]Calculated YG = 2.5 + (2.5 × 12th rib fat thickness) − (0.32 × LM area in^2) + (0.2 × KPH) + (0.0038 × HCW)

The increased performance with higher inclusion of WDGS agrees with previous research where increased levels of WDGS improved performance (*2006 Nebraska Cattle Beef Report*, pp 51–53). The LM area increased quadratically with the increased inclusion of corn bran and SEM in the Fiber diets ($P = 0.04$, Table 2). In addition, the fiber diets had a tendency to increase F:G quadratically ($P = 0.07$, Table 2) as the fiber inclusion increased.

Fiber Content vs WDGS

Feeding WDGS at 20 and 40% resulted in greater final BW, HCW, ADG, 12th rib fat, marbling score, and yield grade when compared to the cattle fed Fiber20 and Fiber40 diets ($P < 0.01$, Table 2). Due to similar DMI and greater ADG, F:G was improved for WDGS compared to feeding fiber ($P < 0.01$, Table 2). However, LM area was significantly less for the WDGS diets than for the Fiber20 and Fiber40 diets ($P = 0.02$, Table 2). When compared to the control diet, the Fiber20 diet had an increased feeding value of 119%, while the Fiber40 diet decreased to 83%. Neither diet matched the feeding value of WDGS40 at 130%, indicating the fiber portion alone of the WDGS contributes only a portion of the positive performance that we see from WDGS.

Solubles Effect

When comparing diets with and without solubles inclusion, final BW, HCW, DMI, ADG, 12th rib fat, marbling score, and yield grade all increased significantly with the inclusion of solubles ($P \leq 0.05$, Table 3), while having no effect on F:G ($P = 0.18$, Table 3) or LM area ($P = 0.57$). These data suggest the inclusion of solubles to the diet increases performance while increasing the feeding value 0% to 20%, but with no improvement in F:G, the solubles addition by itself cannot match the feeding value of WDGS at 130%.

Protein Effect

The addition of corn gluten meal to the Fiber40 and Fiber40 Sol diet significantly increased final BW, HCW, DMI, ADG, 12th rib fat, and yield grade while improving F:G ($P < 0.01$, Table 3). With the addition of corn gluten meal to the fiber diet, the feeding value increased 17% to 47%. With this increased performance and value, protein is a major part of the positive performance observed with WDGS, however, numerically WDGS still had a better feeding value at 130% compared to the protein diets that are 121% and 117%. The protein effect is when protein is fed in excess as rumen undegradable protein and used for energy.

Fat Effect

With the addition of fat to the diet, DMI decreased and F:G also decreased (improved) ($P < 0.01$, Table 3), along with increasing the feeding value an additional

2% to 8%.With the improved conversions, fat inclusion with protein and solubles in the diet shows that it is a major part of the WDGS that improves performance with a feeding value at 127% almost matching WDGS40 at 130%.

The fiber portion alone of WDGS is not responsible for its increased performance in a feedlot. Protein, fat, and solubles inclusion in the diet each further increased performance when added to the basal fiber diet. When comparing the WDGS diets to the mimicking diets, the inclusion of fiber, protein, fat, and solubles together gave the same performance as the WDGS diet at 40% inclusion. The WDGS40 diets had improved feed efficiencies compared to WDGS20. This research demonstrates that the interactions between fiber, protein, fat, and solubles in WDGS are all important, and have a similar feeding value to WDGS.

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Modifying Different Components of Distillers Grains and the Impact on Feedlot Performance

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Summary

A finishing study evaluated the effects of altering distillers grains composition on feedlot performance and carcass characteristics. Replacing dried distillers grains with isolated bran, solubles, and protein did not result in performance similar to commodity dried distillers grains. Exchanging bran for non-pelleted treated corn stover increased intake, reduced efficiency, and decreased 12th rib fat. Cattle fed pelleted treated corn stover had decreased intakes, but similar efficiency and gain as non-pelleted treated corn stover. As solubles increased and replaced protein, intakes increased quadratically and 12th rib fat linearly decreased however, all other performance and carcass characteristics were not different.

Introduction

The composition of distillers grains has potential to change as corn nutrient components are removed during ethanol production. Advancements in fermentation of fiber via secondary fermentation systems and separation of protein may change the composition of distillers grains and alter use in feedlot diets. Limited data are available characterizing the effects of feeding distillers grains from advanced ethanol production systems. Use of alternative feeds, such as corn residue, have become more common in recent years as a result of higher corn prices. Pellet Technology USA (Gretna, Neb.) has developed a proprietary pelleted feed consisting of distillers grains and treated corn stover to replace corn in finishing beef cattle diets. Pelleted distillers grains and treated corn stover can replace up to 20% of corn in the diet with 40% modified distillers grains plus solubles without affecting performance (*2015 Nebraska Beef Cattle Report*, pp. 86–87). The objectives of this study were to determine the effect of replacing isolated corn bran in distillers grains, from the dry milling industry, with calcium oxide treated corn stover and determine the effect of exchanging protein in distillers grains with isolated bran and solubles on feedlot performance and carcass traits.

Procedure

Crossbred yearling steers (n = 448; initial BW = 803; SD = 39 lb) were utilized in a randomized block design at the University of Nebraska-Lincoln Agricultural Research and Development Center feedlot located near Mead, Neb. Steers were limit-fed (2% of BW) a diet consisting of 50% Sweet Bran® (Cargill, Blair, Neb), and 50% alfalfa hay (DM basis) for five days before weighing to equalize gut fill. Steers were weighed two consecutive days (d 0 and 1) to establish initial BW. Steers were blocked by BW into three blocks, and stratified by BW within block and assigned randomly to 56 pens. Pens were assigned randomly to one of seven dietary treatments with eight replications per treatment and eight steers per pen. Two blocks contained 2 replications each and the remaining block contained 4 replications.

All byproducts replaced dry-rolled corn in the diet (Table 1). Nutrient composition for byproduct feeds are listed in Table 2. All diets contained 31.5% high-moisture corn, 5.5% alfalfa hay, 4% corn silage, 5% liquid molasses, 5% supplement formulated with 30 g/ton Rumensin® (Elanco Animal Health) and 90 mg/steer of Tylan® (Elanco Animal Health) daily. Treatments included: 1) negative control (CON) with 50% dry-rolled corn; 2) positive control (DDGS) replaced corn at 50% of diet with dried distillers grains plus solubles; 3) pelleted corn stover (PEL-STV), treated with calcium oxide, contained 18.75% solubles, 12.5% treated corn stover, and 18.75% high-protein dried distillers grains plus solubles (HPDDGS) pelleted together; 4) non-pelleted corn stover, treated with calcium oxide, contained treated corn stover, solubles, and HPDDGS (STV) at same DM inclusion as PEL-STV; 5) component (COMP) included 18.75% solubles, 12.5% isolated bran from the dry milling process and is not purified bran (contains more protein), and 18.75% HPDDGS; 6) component medium protein (COMP-MED) contained 24.4% solubles, 16.2% isolated bran, and 9.4% HPDDGS; and 7) component low protein (COMP-LOW) had 30% solubles and 20% isolated bran (DM basis). The COMP, COMP-MED, and COMP-LOW treatments were designed to determine the optimal proportion of bran, protein, and solubles in distillers grains.

Steers were implanted on d 1 with Ralgro® and re-implanted with Revalor®-200 on d 36 and 38 by implanting four replicates each day. Steers were harvested at a commercial abattoir (Greater Omaha Pack, Omaha, Neb.) on d 149 (2 reps) and d 156 (6 reps). Upon day of harvest, HCW was collected. After a 48-h chill, LM area, fat depth, and marbling scores were collected. Final BW was calculated from carcass weight, adjusted to 63% common dressing percent, for ADG and F:G.

Statistical Analysis

Performance and carcass characteristics were analyzed using the PROC MIXED procedures of SAS (SAS Institute, Inc., Cary, N.C.) with dead or chronic steers removed from analysis. One steer from COMP, one steer from COMP-MED, and three steers from COMP-LOW diets were removed from the experiment due to diagnosis of sulfur induced polioencephalomalacia by the Nebraska Veterinary Diagnostic laboratory. Pen was the experimental unit and block was treated as a fixed effect. Linear and quadratic contrasts were developed for steers fed COMP, COMP-MED, COMP-LOW to determine the impacts of removing protein from distillers grains. Additionally, pairwise comparisons were pre-planned to determine the following effects: 1) replacing corn with commodity

Table 1. Composition of dietary treatments containing modified components of distillers grains fed to steers[a]

Ingredient[b]	Treatment						
	CON[c]	DDGS	PEL-STV[d]	STV	COMP	COMP-MED	COMP-LOW
HMC	31.50	31.50	31.50	31.50	31.50	31.50	31.50
DRC	50.00	—	—	—	—	—	—
DDGS	—	50.00	—	—	—	—	—
Solubles	—	—	18.75	18.75	18.75	24.40	30.00
Treated Corn Stover[e]	—	—	12.50	12.50	—	—	—
Isolated Bran[f]	—	—	—	—	12.50	16.20	20.00
High-Protein DDGS	—	—	18.75	18.75	18.75	9.40	—
Alfalfa hay	5.50	5.50	5.50	5.50	5.50	5.50	5.50
Corn Silage	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Liquid Molasses	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Supplement	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Nutrient Composition, %							
DM	81.7	82.2	71.0	70.1	65.3	60.0	54.7
OM	94.4	92.3	91.5	91.5	91.2	90.6	89.9
CP	15.5	22.7	22.0	21.6	22.1	21.5	20.8
NDF	12.2	25.8	23.4	23.7	23.8	22.5	21.3
ADF	8.2	12.8	15.2	15.2	16.9	17.7	18.5
Fat	3.66	6.10	5.28	5.33	5.33	5.14	4.95
Ca	0.78	0.97	0.55	0.58	1.01	1.02	1.03
P	0.26	0.60	0.71	0.72	0.69	0.78	0.87
K	0.74	1.17	1.42	1.43	1.32	1.47	1.61
S	0.16	0.31	0.41	0.41	0.40	0.42	0.44

[a]All values presented on a DM basis.
[b]HMC = high-moisture corn; DRC = dry-rolled corn; DDGS = dried distillers grain plus solubles.
[c]Supplemented with urea at 1.36% of diet to meet the DIP requirement.
[d]Treated corn stover, solubles, and high-protein dried distillers grains plus solubles pelleted by Pellet Technology USA, LLC, Gretna, Neb.
[e]Corn stover treated with CaO by Pellet Technology USA, LLC, Gretna, Neb.
[f]Isolated bran is isolated from dry milling process and is not purified bran (contains more protein).

distillers grains as an internal validation (CON vs DDGS); 2) replacing distillers grains with a composite product (DDGS vs. COMP); 3) replacing isolated bran with treated corn stover (COMP vs. STV); and 4) pelleting the treated corn stover (PEL-STV vs. STV). Treatment differences were considered significant when $P \leq 0.05$ with tendencies between $P > 0.05$ and $P \leq 0.10$.

Results

Performance and carcass data are provided in Table 3 with results organized below using pre-planned contrasts.

CON vs. DDGS

Steers fed DDGS instead of CON (i.e. replacing 50% dry-rolled corn with DDGS) had increased carcass adjusted final BW (1442 vs. 1390 for DDGS and CON, respectively $P < 0.01$), increased DMI (28.4 vs. 26.2; $P < 0.01$) and increased ADG (4.17 vs. 3.83; $P < 0.01$). However, F:G was not different for CON and DDGS (6.83 vs. 6.80; $P = 0.75$). While feeding distillers grains will normally improve F:G, feeding DDGS leads to a poorer F:G compared to wet or modified distillers grains. Likewise, feeding 50% of diet DM is a high inclusion, which impacts F:G response compared to lower inclusions of distillers grains (2011 *Nebraska Beef Cattle Report*, pp. 50–52). Therefore, no difference in F:G may be due to high inclusion of DDGS. However, 50% inclusion allowed us to include individual feed ingredients at a large enough inclusion rate so that treatment differences could be detected when comparing smaller components of DDGS. Hot carcass weight was 33 lb more for steers fed DDGS ($P < 0.01$) compared to CON. There were no differences ($P = 0.34$) for LM area between CON and DDGS. Steers fed DDGS had increased 12th rib fat (0.63 vs. 0.56; $P < 0.01$) compared to CON. Marbling was not different between DDGS and CON ($P = 0.25$).

DDGS vs. COMP

Replacing DDGS with similar proportions of solubles, isolated bran, and HPDDGS (COMP) decreased final BW (1442 vs. 1373; $P < 0.01$) and decreased DMI (28.4 vs. 27.4; $P = 0.05$). Daily gain was greater for cattle fed DDGS (4.17 vs.

Table 2. Nutrient analysis for ingredients

Nutrient Composition, %	Ingredient[a]						
	DRC[b]	DDGS[b]	Pelleted Treated Corn Stover[c]	Treated Corn Stover[d]	Isolated Bran[e]	High-Protein DDGS	Solubles
DM	89.9	91.1	85.1	77.4	37.0	92.3	35.5
OM	98.4	95.0	87.1	87.1	97.6	97.2	85.3
CP	11.1	34.4	21.8	19.1	24.1	37.7	34.8
NDF	8.7	35.9	52.7	55.1	56.3	40.3	7.4
ADF	2.8	12.1	37.3	39.9	53.1	14.9	4.0
Fat	3.9	8.7	4.5	5.0	5.5	8.4	7.0
Ca	0.03	0.04	1.36	1.61	0.09	0.05	0.09
P	0.26	0.94	0.55	0.65	0.39	0.50	2.23
K	0.38	1.19	1.03	1.36	0.35	0.50	2.94
S	0.10	0.40	0.40	0.42	0.25	0.42	0.92

[a]All values presented on a DM basis.
[b]DRC = dry-rolled corn; DDGS = dried distillers grains plus solubles
[c]Pellet containing CaO treated corn stover, high-protein dried distiller grains plus solubles, and solubles produced by Pellet Technology USA, LLC, Gretna, Neb.
[d]Stover through Pellet Technology grinding process treated with CaO and water, contains corn stover, solubles, and high-protein dried distillers grains plus solubles.
[e]Isolated bran is isolated from dry milling process and is not purified bran (contains more protein).

Table 3. Effects of modifying different components of distillers grains on animal performance and carcass characteristics.

Item	Treatment[a]							SEM	*P*-value					
	CON	DDGS	PEL-STV	STV	COMP	COMP-MED	COMP-LOW		CON vs. DDGS	DDGS vs. COMP	COMP vs. STV	STV vs PEL-STV	Lin[b]	Quad[c]
Performance														
Initial BW, lb	809	810	810	810	809	809	809	2	0.65	0.65	0.52	0.74	0.11	0.43
Final BW, lb[d]	1390	1442	1359	1376	1373	1400	1386	18	< 0.01	< 0.01	0.88	0.35	0.48	0.19
DMI, lb/d	26.2	28.4	28.1	29.2	27.4	28.1	27.2	0.5	< 0.01	0.05	< 0.01	0.03	0.66	0.04
ADG, lb[d]	3.83	4.17	3.63	3.73	3.72	3.89	3.79	0.11	< 0.01	< 0.01	0.91	0.37	0.58	0.16
F:G[d,e]	6.83	6.80	7.74	7.82	7.36	7.23	7.18	—	0.75	<0.01	0.01	0.60	0.22	0.72
Carcass Traits														
HCW, lb	876	909	856	867	865	882	873	11	< 0.01	< 0.01	0.88	0.35	0.48	0.19
LM area, in[b]	13.2	13.0	13.1	13.0	12.9	13.5	13.3	0.04	0.34	0.83	0.79	0.56	0.10	0.08
12th Rib fat, in	0.56	0.63	0.53	0.54	0.60	0.56	0.54	0.01	0.01	0.02	0.02	0.73	0.02	0.67
Marbling[f]	529	511	482	511	514	512	497	16	0.25	0.82	0.82	0.07	0.28	0.67

[a]CON = 50% dry-rolled corn; DDGS = 50% dried distillers grains plus solubles; PEL-STV = pelleted 18.75% solubles, 12.5% treated corn stover, and 18.75% high-protein dried distillers grains plus solubles; STV = 18.75% solubles, 12.5% treated corn stover, and 18.75% high-protein dried distillers grains plus solubles; COMP = 18.75% solubles, 12.5% isolated bran, and 18.75% high-protein dried distillers grains plus solubles; COMP-MED = 24.4% solubles, 16.2% isolated bran, and 9.4% high-protein dried distillers grains plus solubles; COMP-LOW = 30% solubles and 20% isolated bran.
[b]Lin = *P*-value for the linear response of protein with COMP, COMP-MED, COMP-LOW.
[c]Quad = *P*-value for the quadratic response of protein with COMP, COMP-MED, COMP-LOW.
[d]Calculated from carcass weight, adjusted to 63% common dressing percent.
[e]Analyzed as G:F, the reciprocal of F:G.
[f]Marbling score: 400 = Small[00].

3.72; $P < 0.01$) compared to COMP. Steers fed DDGS had improved F:G compared to COMP (6.80 vs. 7.36; $P < 0.01$). Hot carcass weights were heavier for cattle fed DDGS compared to COMP (909 vs. 865; $P < 0.01$). There were no differences ($P = 0.83$) in LM area between DDGS and COMP. There was increased 12th rib fat (0.63 vs. 0.60; $P = 0.02$) for DDGS compared to COMP. There were no differences ($P = 0.82$) in marbling between DDGS and COMP. Combining solubles, isolated bran, and HPDDGS did not replicate performance of DDGS.

COMP vs. STV

There were no differences ($P = 0.88$) in final BW between COMP and STV. Exchanging isolated bran for non-pelleted treated corn stover increased DMI (27.4 vs. 29.2; $P < 0.01$) with no difference in ADG (3.72 vs. 3.73; $P = 0.91$) of steers, resulting in steers fed STV being 5.9% less efficient in comparison to steers fed COMP (7.82 vs. 7.36; $P < 0.01$). There was no difference ($P \geq 0.79$) in HCW and LM area between COMP and STV. However, when treated corn stover replaced isolated bran, 12th rib fat decreased (0.54 vs. 0.60; $P < 0.02$). Marbling was not different ($P = 0.82$) for COMP and STV.

PEL-STV vs. STV

There were no differences ($P = 0.35$) for final BW between PEL-STV and STV. Pelleting the treated corn stover, solubles, and high-protein distillers grains decreased DMI, with steers fed PEL-STV consuming 28.1 lb/d in comparison to 29.2 lb/d for steers fed STV ($P = 0.03$). However, there were no differences between PEL-STV and STV for ADG (3.63 vs. 3.73; $P = 0.37$) and F:G (7.74 vs. 7.82; $P = 0.60$). There were no differences ($P \geq 0.35$) in HCW, LM area, and 12th rib fat between PEL-STV and STV. Marbling had a tendency to decrease for steers fed PEL-STV compared to STV (482 vs. 511; $P = 0.07$).

Linear and Quadratic Responses for COMP, COMP-MED, and COMP-LOW

There were no differences ($P = 0.19$) for final BW between COMP, COMP-MED, and COMP-LOW. As HPDDGS was replaced with solubles and isolated bran between COMP, COMP-MED, and COMP-LOW, DMI quadratically increased ($P = 0.04$) with COMP-MED increasing and COMP-LOW decreasing, compared to COMP. There were no significant differences ($P \geq 0.16$) in ADG and F:G due to changing portion of protein. Decreasing proportions of protein did not affect F:G, perhaps due to solubles concentrations increasing with decreasing protein inclusion. There were no differences ($P = 0.19$) for HCW between COMP, COMP-MED, and COMP-LOW. Removing protein tended to increase LM area quadratically ($P = 0.08$) and linearly decrease 12th rib fat ($P = 0.02$). There were no differences ($P = 0.28$) for marbling. Displacing half the protein with solubles and isolated bran caused increased DMI and tended to increase LM area. When protein was completely displaced by a combination of solubles and isolated bran (from dry milling), DMI, ADG, and F:G were not different from COMP.

This study suggests that replacing bran normally found in distillers grains with treated corn stover increased intake, resulted in poorer feed conversions, and decreased 12th rib fat. Pelleting treated corn stover decreased intake without impacting F:G or carcass quality. Dried distillers grains increased final BW, ADG, DMI, HCW and 12th rib fat compared to corn based diets. As solubles and isolated bran (from dry milling) replaced protein, DMI quadratically increased and 12th rib fat linearly decreased. Isolated ingredients of distillers grains did not mimic performance of distillers grains suggesting some component(s) was missing.

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Evaluation of the Relative Contribution of Protein in Distillers Grains in Finishing Diets on Animal Performance

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Summary

A finishing study evaluated the relative contributions of protein from wet distillers grains plus solubles (WDGS) on feedlot performance and carcass characteristics. The protein portion of WDGS was mimicked by corn gluten meal (CGM). Increasing WDGS inclusion from 0 to 40% increased final body weight and gain, decreased intakes, and improved feed efficiency. When CGM was fed to equal protein concentration as WDGS, final body weight and gain increased, and feed efficiency improved. Adding solubles to CGM did not improve feed efficiency. The feeding value of CGM was similar to distillers grains, suggesting protein has a major role in the feeding value of distillers grains.

Introduction

As advances in technology continue in the ethanol industry, the components of distillers grains become more susceptible to change. These changes may influence the use of distillers grains in feedlot diets. Ethanol plants are able to separate a portion of the protein from distillers grains for use in alternative markets. The contributions of protein in WDGS at 40% inclusion has been examined in previous research (*2016 Nebraska Beef Cattle Report*, pp. 122–23) and reported the feeding value of CGM was 109% and WDGS was 137% relative to corn. This indicates that protein has a large role in the feeding value in WDGS at 40% inclusion rate. It is important to further investigate the relative contributions of protein on the feeding value of WDGS at other inclusion rates on feedlot performance and carcass traits.

Procedure

Crossbred calf-fed steers (n = 324; initial BW = 642; SD = 53 lb) were utilized in a randomized block design at the University of Nebraska Panhandle Research and Extension Center feedlot located near Scottsbluff, Neb. Steers were limit-fed (2% of BW) a diet consisting of 15% straw, 25% alfalfa hay, 35% corn silage, and 25% WDGS (DM basis) for five days prior to weighing to equalize gut fill. Steers were weighed two consecutive days (d 0 and 1) to establish initial BW. Steers were blocked by BW into two blocks (light and heavy) and stratified by BW within block, and assigned randomly to 36 pens.

Pens were assigned randomly to one of six dietary treatments with six replications per treatment and 9 steers per pen. Dietary treatments are provided in Table 1. In the experimental diets, the protein portion of WDGS was mimicked by CGM to provide similar protein as 20 and 40% WDGS. Diets were formulated to provide 360 mg/steer of Rumensin® (Elanco Animal Health) and 90 mg/steer of Tylan® (Elanco Animal Health) daily.

Steers were implanted on d 1 with Component TE-IS (Elanco Animal Health) and re-implanted with Component TE-S (Elanco Animal Health) on d 90. Steers were harvested at a commercial abattoir (Cargill Meat Solutions, Fort Morgan, Colo.) on d 182 (heavy block) and d 193 (light block). Hot carcass weight and liver scores were recorded on day of harvest. After a 48-h chill, LM area, marbling score, and 12th rib fat were recorded. Yield grade was calculated from the following formula: 2.5 + (2.5 × 12th rib fat) − (0.32 × LM area) + (0.2 × 2.5 [KPH]) + (0.0038 × HCW). Final BW was carcass adjusted using HCW and a common dressing percent (63%) to calculated ADG and F:G. Feeding value was calculated from the following formula: ((compared treatments

Table 1. Composition of dietary treatments containing protein components of distiller grains fed to steers[a]

Ingredient[b]	Treatment					
	CON[c]	20WDG	40WDG	20PRO	40PRO	40PRO-SOL
DRC	75.50	59.00	39.00	70.25	61.50	51.50
WDGS	—	20.00	40.00	—	—	—
Corn Silage	15.00	15.00	15.00	15.00	15.00	15.00
CGM	—	—	—	8.75	17.50	17.50
Solubles	—	—	—	—	—	10.00
SBM	3.50	—	—	—	—	—
Supplement	6.00	6.00	6.00	6.00	6.00	6.00
Nutrient Composition, %						
DM	71.5	61.1	50.8	71.1	70.8	64.3
CP	13.9	13.0	17.3	14.3	20.0	21.0
NDF	14.8	18.9	23.0	14.6	14.4	13.5
Fat	2.8	3.7	4.6	2.9	2.9	2.6
Ca	0.51	0.53	0.54	0.52	0.52	0.52
P	0.28	0.37	0.49	0.28	0.30	0.45
K	0.71	0.71	0.88	0.53	0.52	0.82
S	0.11	0.20	0.31	0.16	0.22	0.32

[a]All values presented on a DM basis.
[b]DRC = dry-rolled corn; WDGS = wet distillers grains plus solubles; CGM = corn gluten meal; SBM = soybean meal.
[c]Supplemented with urea at 1.30% of diet to meet the DIP requirement.

Table 2. Effect of protein in wet distillers grains on finishing performance and carcass characteristics

Item	Treatment[a]						SEM	*P*-value						
	CON	20WDG	40WDG	20PRO	40PRO	40 PRO-SOL		WDG Lin.[b]	WDG Quad.[c]	Protein Lin.[d]	Protein Quad.[e]	40PRO vs. 40 PRO-SOL	20WDG vs. 20PRO[f]	40WDG vs. 40PRO[f]
Performance														
Initial BW, lb	642	643	644	641	643	640	1	0.23	0.95	0.58	0.41	0.11	0.32	0.51
Final BW, lb[g]	1323	1338	1350	1314	1356	1326	10	0.06	0.86	0.02	0.04	0.04	0.09	0.65
DMI, lb/d	22.6	21.6	21.4	22.1	22.6	21.9	0.2	< 0.01	0.21	0.85	0.13	0.08	0.16	< 0.01
ADG, lb[g]	3.63	3.71	3.77	3.59	3.81	3.65	0.05	0.06	0.83	0.02	0.04	0.04	0.08	0.61
F:G[g,h]	6.22	5.83	5.67	6.17	5.92	6.00	—	< 0.01	0.12	< 0.01	0.19	0.32	< 0.01	0.01
Feeding Value	—	134	125	110	129	121	—	—	—	—	—	—	—	—
Carcass Traits														
HCW, lb	833	843	851	828	855	835	6	0.06	0.87	0.02	0.04	0.04	0.09	0.66
Dressing, %	63.5	63.3	63.6	63.1	63.5	63.0	0.2	0.64	0.21	0.95	0.12	0.06	0.64	0.69
LM area, in^2	13.5	13.6	13.8	13.3	13.8	13.5	0.2	0.26	0.62	0.24	0.10	0.21	0.32	0.95
Calculated YG	2.93	2.96	2.95	3.04	3.00	2.85	0.09	0.91	0.85	0.61	0.50	0.24	0.53	0.69
12th Rib fat, in	0.48	0.48	0.49	0.50	0.51	0.46	0.02	0.58	0.81	0.22	0.75	0.05	0.41	0.49
Marbling[i]	422	428	429	433	443	426	9	0.60	0.85	0.10	0.94	0.19	0.65	0.26
Liver abscess, %	21.2	18.5	14.8	9.3	11.3	11.8	0.5	0.41	0.89	0.19	0.27	0.94	0.17	0.60

[a]CON = 75.5% DRC; 20WDG = 20% wet distillers grains plus solubles; 40WDG = 40% wet distillers grains plus solubles; 20PRO = 8.75% corn gluten meal to mimic the protein portion of 20WDG; 40PRO = 17.5% corn gluten meal to mimic the protein portion of 40WDG; 40PRO-SOL = 17.5% corn gluten meal and 10% solubles.
[b]WDG Lin. = *P*-value for the linear response of wet distillers grains inclusion for CON, 20WDG, 40WDG.
[c]WDG Quad. = *P*-value for the quadratic response of wet distillers grain inclusion for CON, 20WDG, 40WDG.
[d]Protein Lin. = *P*-value for the linear response of corn gluten meal for CON, 20PRO, 40PRO.
[e]Protein Quad. = *P*-value for the quadratic response of corn gluten meal for CON, 20PRO, 40PRO.
[f]Comparison of the protein portion of WDGS, mimicked by corn gluten meal, and WDGS.
[g]Calculated from carcass weight, adjusted to 63% common dressing percent.
[h]Analyzed as G:F, the reciprocal of F:G.
[i]Marbling score: 400 = Small[00].

G:F-corn G:F) / corn G:F) / compared treatment's inclusion rate).

Performance and carcass characteristics were analyzed using the PROC MIXED procedure of SAS and liver abscesses were analyzed using the GLIMMIX procedure of SAS (SAS Institute, Inc., Cary, N.C.) with dead or chronic steers removed from analysis. Five steers were removed from the experiment due to injury or respiratory issues. Pen was the experimental unit and block was treated as a fixed effect. Linear and quadratic contrasts were developed to compare distillers grains level (20 vs. 40) and protein concentration. Pairwise comparisons were pre-planned to determine the addition of solubles (40PRO vs. 40PRO-SOL) and feeding value of protein from distillers grains (20WDG vs. 20PRO; 40WDG vs. 40PRO). Treatment differences were considered significant when $P \leq 0.05$ with tendencies between $P > 0.05$ and $P \leq 0.10$.

Results

Linear and Quadratic Responses for CON, 20WDG, and 40WDG

There was a tendency for a linear increase for final BW (1323 vs. 1350 for CON vs. 40WDG, respectively; $P = 0.06$) due to WDGS (Table 2). As WDGS inclusion increased from 0 to 40%, DMI decreased linearly (22.6 vs. 21.4 for CON vs. 40WDG, respectively; $P < 0.01$) with a tendency for a linear increase in ADG (3.63 vs. 3.77 for CON vs. 40WDG, respectively; $P = 0.06$). Increasing WDGS inclusion linearly decreased F:G (6.22 vs. 5.67 for CON vs. 40WDG, respectively; $P < 0.01$). Cattle fed 20WDG and 40WDG had a feeding value of 134% and 125% relative to corn, respectively. All carcass traits, except HCW ($P = 0.06$), were not impacted ($P \geq 0.21$) by WDGS inclusion.

Linear and Quadratic Responses for Protein

The protein portion of WDGS was mimicked by CGM at inclusion concentrations equal to the protein contained in 20 and 40% WDGS. Increasing protein concentrations quadratically increased ($P = 0.04$) final BW. Cattle fed 40PRO were 33

lb heavier compared to CON. There were no differences ($P \geq 0.13$) in DMI between CON, 20PRO, and 40PRO. Gain increased quadratically ($P = 0.04$) as CGM increased. Cattle fed 17.5% CGM (protein concentration equal to 40% WDGS) gained 3.81 lb/d compared to CON which gained 3.63 lb/d. As protein increased in the diet, F:G decreased linearly (6.22 vs. 5.92 for CON vs. 40PRO, respectively; $P < 0.01$). There was a quadratic increase ($P = 0.04$) for HCW with steers fed 40PRO having the greatest HCW at 855 lb compared to CON and 20PRO. There were no differences ($P = 0.12$) in dressing percent as protein increased. There tended to be a quadratic increase ($P < 0.10$) in LM area with 40PRO having the largest LM area, CON intermediate, and 20PRO with the smallest. There were no differences ($P \geq 0.22$) in calculated yield grade and 12th rib fat among CON, 20PRO, and 40PRO. Marbling tended to increase linearly ($P = 0.10$) as protein concentration increased. There were no differences ($P = 0.19$) for liver abscesses between CON, 20PRO, and 40PRO. These results indicate an energy response for CGM, not a protein response.

40PRO vs. 40PRO-SOL

The addition of 10% solubles (40PRO-SOL) decreased final BW (1326 vs. 1356; $P = 0.04$) compared to 40PRO. Dry matter intake tended to be lower ($P = 0.08$) for cattle fed 40PRO-SOL compared to 40PRO. Average daily gain decreased for 40PRO-SOL, with steers gaining 3.65 lb/d in comparison to 3.81 lb/d for steers fed 40PRO ($P = 0.08$). However, there were no differences ($P = 0.32$) in F:G between 40PRO and 40PRO-SOL. Therefore, supplementing solubles decreased ADG and DMI at a similar rate, which did not change F:G. Compared with 40PRO, feeding 40PRO-SOL decreased HCW (835 vs. 855; $P = 0.04$) and tended to decrease dressing percent (63.0% vs. 63.5%; $P = 0.06$). There were no differences ($P \geq 0.21$) in LM area and calculated yield grade between 40PRO and 40PRO-SOL. There was a decrease in 12th rib fat (0.46 vs. 0.51; $P = 0.05$) for 40PRO-SOL compared to 40PRO. There were no differences ($P \geq 0.19$) in marbling and liver abscesses between both 40PRO and 40PRO-SOL.

20WDG vs. 20PRO

Isolating the protein portion of 20% WDGS by feeding 8.75% CGM (20PRO) decreased final BW (1314 vs. 1338; $P = 0.05$) compared to 20WDG. However, there were no differences ($P = 0.16$) in DMI between 20WDG and 20PRO. Steers fed 20PRO tended to have decreased ADG (3.59 vs. 3.71; $P = 0.09$) compared to 20WDG. This resulted in steers fed 20PRO being 5.8% less efficient than steers consuming 20WDG (6.17 vs. 5.83; $P < 0.01$). The feeding value for protein was less than that of WDGS (110 vs. 134 for 20PRO vs. 20WDG, respectively) relative to corn. There was a tendency for decreased HCW ($P = 0.09$) for 20PRO compared to 20WDG. However, all carcass traits were not different ($P \geq 0.17$) between 20WDG and 20PRO.

40WDG vs. 40PRO

When comparing 40% WDGS to 40PRO, there were no differences ($P = 0.65$) in final BW, however, steers fed 40PRO consumed 1.2 lb/d more than 40WDG (22.6 vs. 21.4; $P < 0.01$). There were no differences ($P = 0.61$) for ADG between 40WDG and 40PRO. This translated into steers consuming 40WDG being lower in F:G than 40PRO (5.67 vs. 5.92; $P < 0.01$). Unlike the 20PRO vs. 20WDG comparison, the feeding value of protein was higher than WDGS (129 vs. 125 for 40PRO vs. 40WDGS, respectively). There were no differences ($P \geq 0.26$) for carcass traits between 40WDG and 40PRO.

Inclusion of 26–50.9% (DM basis) corn grain in calf-fed diets leads to improved feed conversions (*2016 Nebraska Beef Cattle Report*, pp. 89–90). The CGM diets replaced only 8.75 and 17.5% of corn compared to the WDGS diets which replaced 20 and 40%. According to Watson, higher levels of corn grain result in poorer feed conversions. This did not affect the comparison between 20WDG and 20PRO. However, this may have had an impact on F:G between the 40PRO and 40WDG comparison since 40WDG has considerably less corn grain in the diet.

This study suggests that inclusion of WDGS increased final BW, ADG, and HCW, while decreasing F:G compared to CON. Similarly, increasing protein concentration increased final BW, ADG, HCW, LM area, and marbling with improved F:G compared to CON when fed to mimic 40% WDGS. The addition of solubles to corn gluten meal decreased final BW, ADG, DMI, HCW, and marbling but did not affect F:G. The average feeding value for CGM at inclusion rates equal to the protein in WDGS at 20 and 40% was 122. Wet distillers grains plus solubles had an average feeding value of 128 at 20 and 40% inclusion rates. Suggesting, protein accounts for the majority of the feeding value response.

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Evaluating Syngenta Enhanced Feed Corn on Finishing Cattle Performance and Carcass Characteristics

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Summary

Two experiments were conducted to compare Syngenta Enhanced Feed Corn™ containing an alpha amylase enzyme trait (SYT-EFC) with commercially available corn grain without the alpha amylase enzyme trait (Conventional) for cattle performance and carcass characteristics at 2 locations. In Exp. 1, steers were fed SYT-EFC or Conventional corn with or without the addition of 25% Sweet Bran, or a BLEND (Conventional and SYT-EFC) without Sweet Bran. In Exp. 2, steers were fed SYT-EFC, Conventional, BLEND, or Conventional with an alpha amylase enzyme supplement (NZ). In Exp. 1, feed conversion improved 8.5% for SYT-EFC compared with Conventional when Sweet Bran was included in the diet. In Exp. 2, feed conversion improved 5.4% for cattle fed SYT-EFC, BLEND, and NZ compared with the Conventional corn. Feeding SYT-EFC corn containing the alpha amylase enzyme trait improves feed conversion of feedlot cattle.

Introduction

A greater extent of starch digestion is ideal to allow feedlot producers to maximize efficiency if acidosis can be controlled. The primary way to increase the extent of starch digestion for high-moisture and dry-rolled corn is to increase the rate of degradation in the rumen. Another way producers can maximize efficiency is by selecting hybrids with kernel traits that are associated with improved digestibility when fed as dry-rolled corn (*2004 Nebraska Beef Report*, pp. 54–57). Genetically modified traits producing alpha amylase enzyme in corn grain may increase starch digestion and improve the performance of finishing steers.

Therefore, the objectives of these studies were to compare 1) SYT-EFC corn (Syngenta Seeds, Inc.) containing an alpha amylase enzyme trait, alone or blended with commercially available corn grain in diets with or without Sweet Bran, 2) feeding a commercially available alpha amylase enzyme supplement on feedlot steer performance and carcass characteristics.

Procedure

Experiment 1

Three hundred crossbred steers (initial BW = 658 lb, SD = 36) were utilized in a feedlot finishing trial at the UNL Agricultural Research and Development Center (ARDC) feedlot near Mead, NE. Cattle were limit fed a diet at 2% of BW consisting of 32% corn wet distillers grains plus solubles, 32% alfalfa hay, 32% dry-rolled corn, and 4% supplement (DM basis) for 5 d prior to the start of the experiment. Two-day initial weights were recorded on d 0 and 1 which were averaged and used as the initial BW. The steers were blocked by BW into light, medium, and heavy BW blocks (n = 3, 2, and 1 pen replicates, respectively) based on d 0 BW, stratified by BW and assigned randomly to 1 of 30 pens with pens assigned randomly to 1 of 5 dietary treatments. There were 10 head/pen and 6 replications/treatment. Dietary treatments included 1) SYT-EFC corn, 2) Conventional commercial corn source (CON), 3) 50:50 blend of SYT-EFC and CON (BLEND), 4) SYT-EFC with Sweet Bran (Cargill wet milling, Blair, NE), and 5) CON with Sweet Bran in a randomized block design (Table 1). Steers were adapted to the finishing diets over a 21-d period with corn replacing alfalfa hay, while inclusion of corn silage, corn wet distillers grain plus solubles (WDGS), and supplement remained the same in all diets. In diets containing Sweet Bran, the concentration remained the same in all grain adaptation diets. Diets were formulated to meet or exceed NRC requirements for protein and minerals. The final finishing diets provided 338 mg/steer daily of Rumensin (30 g/ton of DM), and 90 mg/steer daily of Tylan (9 g/ton of DM). Steers were implanted on d 1 with Revalor-XS.

All steers were harvested at a commercial abattoir (Greater Omaha, Omaha, NE) on d 174. Final live BW were collected prior to d of slaughter and a 4% pencil shrink was applied for calculation of dressing percentage. Feed offered on d 173 was 50% of the previous day DMI and cattle were weighed at 1600 h. Steers were then shipped and held until slaughter the next day. Hot carcass weight and livers scores were recorded on the d of slaughter. Fat thickness, LM area, and USDA marbling score were recorded after a 48-h chill. Final BW, ADG, and F:G were calculated using HCW adjusted to a common 63% dressing percentage.

Performance and carcass characteristics were analyzed using the MIXED procedure of SAS (SAS Inst., Inc., Cary, N.C.). Initial BW block was included as a fixed effect and pen served as the experimental unit. Data were analyzed as a 2x2 factorial with main factors including Sweet Bran inclusion and corn trait. The model included the effects of Sweet Bran, trait, and the Sweet Bran x trait interaction. Data were also analyzed for treatments not containing Sweet Bran (SYT-EFC, BLEND, and CON) as a randomized block design using a protected F-Test.

Experiment 2

Two hundred-forty crossbred steers (initial BW = 634 lb, SD = 34) were utilized in a feedlot finishing trial at the UNL Panhandle Research and Extension Center (PHREC) feedlot near Scottsbluff, NE. Cattle limit feeding and initial BW protocols were the same as *Exp 1*. The steers were blocked by BW into light, medium, and heavy BW blocks based on d 0 BW, stratified by BW and assigned randomly to 1 of 24 pens with pens assigned randomly to 1 of 4 dietary treatments. There were 10 head per pen and 6 replications per treatment. Dietary treatments included 1) SYT-EFC, 2) CON, 3) BLEND, and 4) CON with enzyme supplement (Amaize; Alltech, Inc.) added to the diet at a rate of 5g/steer daily (NZ;

Table 1. Dietary treatments evaluating SYT-EFC corn and Conventional commercial corn with or without Sweet Bran (*Exp 1*)

Ingredient, % DM	Wet Distillers Grains plus Solubles			Sweet Bran	
	CON[a]	SYT-EFC[b]	BLEND	CON[a]	SYT-EFC
Conventional Dry Rolled Corn	68.0	—	34.0	58.0	—
SYT-EFC Dry Rolled Corn[b]	—	68.0	34.0	—	58.0
Sweet Bran	—	—	—	25.0	25.0
Wet distillers grains plus solubles	15.0	15.0	15.0	—	—
Corn silage	12.0	12.0	12.0	12.0	12.0
Meal supplement[c]	5.0	5.0	5.0	5.0	5.0
Fine ground corn	2.174	2.174	2.174	2.435	2.435
Limestone	1.6	1.6	1.6	1.6	1.6
Urea	0.6	0.6	0.6	0.4	0.4
Salt	0.3	0.3	0.3	0.3	0.3
Tallow	0.125	0.125	0.125	0.125	0.125
Trace mineral premix	0.05	0.05	0.05	0.05	0.05
Potassium chloride	0.02	0.02	0.02	—	—
Rumensin-90	0.0165	0.0165	0.0165	0.0165	0.0165
Vitamin ADE premix	0.015	0.015	0.015	0.015	0.015
Tylan-40	0.01	0.01	0.01	0.01	0.01
Nutrient Composition, %					
Starch	52.48	52.55	52.52	47.75	47.81
NDF	15.91	15.16	15.54	18.80	18.16
CP	14.15	14.22	14.18	13.45	13.51
Fat	4.07	4.01	4.04	3.19	3.13
Ca	0.63	0.67	0.65	0.61	0.64
K	0.58	0.59	0.59	0.67	0.68
P	0.40	0.39	0.39	0.46	0.44
Mg	0.20	0.20	0.20	0.23	0.23
S	0.16	0.15	0.16	0.19	0.18

[a]CON = Commercially available corn grain without the alpha amylase enzyme trait
[b]SYT-EFC = Syngenta enhanced feed corn provided by Syngenta under identity-preserved procedures. Stored, processed, and fed
separately
[c]Supplement included 30 g/ton Rumensin and 9 g/ton Tylan.

Table 2). Limit feeding, weighing, blocking, implanting, and grain adaptation procedures were the same as *Exp 1*. Steers in the heavy, middle, and light BW blocks were harvested at a commercial abattoir (Cargill Meat Solutions, Fort Morgan, CO) on days 148, 169, and 181, respectively. On the final day steers were withheld from feed and weighed at 0800 h before being shipped and slaughtered on the same day. Carcass data collection procedures and calculation of final BW were the same as *Exp. 1.*

Data were analyzed as a randomized block design with initial BW block as a fixed effect and pen as the experimental unit. Treatments were evaluated using a protected F-Test and mean separation when significant variation was observed due to treatment.

Results

Experiment 1

When data were analyzed without including Sweet Bran in the analysis there were no differences ($P \geq 0.35$) in final BW, DMI, ADG, and F:G (Table 3). Hot carcass weight, dressing %, marbling score, LM area, and incidence of liver abscesses were not impacted ($P \geq 0.12$) by dietary treatment. Fat depth was greater ($P = 0.03$) for steers fed SYT-EFC and BLEND compared with CON. Similarly, calculated yield grade was greater ($P = 0.02$) for steers fed SYT-EFC and BLEND compared with CON corn.

A tendency for a Sweet Bran X trait interaction ($P = 0.07$) for carcass adjusted final BW was observed (Table 4). In diets without Sweet Bran, cattle fed CON had numerically greater final BW. Conversely, BW was heavier for steers fed SYT-EFC in diets containing Sweet Bran. Interactions were also observed for ADG and F:G (P = 0.05 and 0.02, respectively). Cattle that were fed SYT-EFC with Sweet Bran had the greatest ADG, SYT-EFC and CON without Sweet Bran were intermediate, and CON with Sweet Bran had the lowest gains. Feed conversion was poorest for cattle fed CON with SB, intermediate for both SYT-EFC and CON in diets without Sweet Bran while cattle fed SYT-EFC with Sweet Bran were the most efficient. No interaction was observed for DMI ($P = 0.99$), however steers consuming CON tended ($P = 0.07$) to consume more DM compared with SYT-EFC. Hot carcass weights followed the same trend ($P = 0.07$) as final BW. Interactions were not observed for the remaining carcass characteristics (dressing %, marbling score, fat depth, LM area, calculated yield grade, and incidence of liver abscesses). For the main effect of trait, marbling scores, fat depth and calculated yield grade were greater ($P < 0.01$, $P = 0.01$, and $P = 0.03$, respectively) for cattle fed SYT-EFC compared with CON (Table 4).

When comparing corn processing methods or traits the response (i.e. feed conversion) may be masked by acidosis if ruminal starch fermentation is too rapid. To control acidosis, Sweet Bran or elevated concentrations of roughage are often used in the diet. In diets without Sweet Bran there was no difference between SYT-EFC and CON. However, when Sweet Bran

Table 2. Dietary treatments evaluating SYT-EFC and Conventional corn with or without added enzyme (*Exp 2*).

Ingredient	CON[a]	SYT-EFC[b]	BLEND	NZ[c]
Conventional Dry Rolled Corn	64.0	—	32.0	64.0
SYT-EFC Dry Rolled Corn[b]	—	64.0	32.0	—
WDGS	15.0	15.0	15.0	15.0
Corn silage	15.0	15.0	15.0	15.0
Liquid Supplement[d,e]	6.0	6.0	6.0	6.0
Nutrient Composition, %				
Starch	51.40	52.23	51.82	51.41
NDF	15.46	15.66	15.56	15.46
CP	12.96	13.41	13.18	12.96
Fat	3.44	3.89	3.67	3.44
Ca	0.60	0.60	0.60	0.60
K	0.55	0.53	0.54	0.55
P	0.34	0.31	0.32	0.34
Mg	0.15	0.15	0.15	0.15
S	0.15	0.15	0.15	0.15

[a]CON = Commercially available corn grain without the alpha amylase enzyme trait
[b]SYT-EFC = Syngenta enhanced feed corn provided by Syngenta under identity-preserved procedures. Stored, processed, and fed separately
[c]NZ = Conventional corn with enzyme supplement (Amaize; Alltech, Inc.) added to the diet at a rate of 5g/steer daily
[d]Liquid supplement contained; 0.6% urea, 1.6% Ca, 0.3% salt, 0.02% potassium chloride, vitamins and trace minerals.
[e]Rumensin (30 g/ton) and Tylan (9 g/ton) were added via micromachine.
[f]Enzyme added via micro-machine at the rate of 5 g/steer daily.

Table 3. Effect of corn hybrid on finishing steer performance and carcass characteristics without Sweet Bran (*Exp. 1*)

Item	Dietary Treatments[a]				
	CON	SYT-EFC	BLEND	SEM	F-Test[b]
Animal Performance					
Initial BW, lb	672	673	673	1	0.31
DMI, lb/d	23.0	22.4	23.0	0.3	0.35
Final BW, lb[c]	1296	1291	1304	11	0.71
ADG, lb[c]	3.61	3.57	3.64	0.06	0.70
F:G[c,d]	6.44	6.31	6.34	—	0.81
Carcass Characteristics					
HCW, lbs	816	814	821	7	0.73
Dressing %	62.7	62.8	62.9	0.2	0.63
Marbling Score[e]	461	489	511	17	0.13
Fat Depth, in	0.48[g]	0.55[h]	0.57[h]	0.02	0.03
LM Area, in[b]	12.9	12.5	12.3	0.18	0.12
Calculated Yield Grade[f]	3.68[g]	3.99[h]	4.10[h]	0.09	0.02
Liver Abscesses, %	8.33	5.00	5.37	—	0.73

[a]Dietary treatments: CON = Commercially available corn grain without the alpha amylase enzyme trait; SYT-EFC = Alpha amylase enzyme corn from Syngenta; BLEND = 50:50 blend of CON and SYT-EFC on a DM basis
[b]F-Test = F-test statistic for the effect of treatment.
[c]Calculated from HCW adjusted to a common 63% pressing percentage.
[d]Analyzed as G:F, the reciprocal of F:G.
[e]Marbling Score: 300=Slight[00], 400= Small[00].
[f]Calculated as 2.5 + (2.5 × 12th rib fat) + (0.2 × 2.5 [KPH]) + (0.0038 × HCW) – (0.32 × LM area).
[g,h]Means within a row with unlike superscripts differ ($P < 0.05$).

was included in the diet there was an 8.5% improvement in F:G for steers that were fed SYT-EFC (as the diet) compared to CON. Because corn trait was the only ingredient changed, when calculating feed conversion based on corn grain inclusion level there was a 14.9% improvement due to SYT-EFC compared to CON for the grain.

Experiment 2

Dry matter intakes were not different ($P = 0.80$) among treatments (Table 5). Final BW and ADG were greater ($P < 0.01$) for steers fed SYT-EFC, BLEND, and NZ compared with CON. Similarly, F:G was improved ($P < 0.01$) for steers fed SYT-EFC, BLEND, and NZ compared with CON. Hot carcass weights were greater ($P < 0.01$) for SYT-EFC, BLEND, and NZ compared with CON. Marbling score tended ($P = 0.08$) to be greatest for BLEND, intermediate for SYT-EFC and NZ, and least for CON. Ribeye area was greater ($P = 0.03$) for BLEND and NZ compared with SYT-EFC and CON. Dressing percent, fat depth, calculated yield grade and incidence of liver abscesses were not different ($P \geq 0.22$) among treatments.

In *Exp 2*, differences were observed when comparing CON with BLEND, NZ, and SYT-EFC. Comparing feed conversion of steers fed CON to SYT-EFC there was a 5.4% difference, but when accounting for concentration of corn grain in the diet, the difference for the grain itself was 8.4%. Similar improvements in F:G were also observed for steers fed BLEND and NZ. Previous research using alpha amylase supplements in feedlot finishing diets has not been consistent. Differences between the two locations and the magnitude of the response are likely due to several factors: environment, acidosis, and grain source for the conventional and/or SYT-EFC. The control and test corn hybrids used at each location were procured from different regions in the state and may have contributed to the differences we observed at each location.

These data suggest an improvement in feed conversion was observed when feeding SYT-EFC compared with Conventional corn at both locations if acidosis was controlled. Producers that can source or grow their own corn for feeding cattle may be able to take advantage of the improvement

Table 4. Effect of corn hybrid and inclusion of Sweet Bran on finishing steers performance and carcass characteristics (*Exp 1.*)

	Dietary Treatments				SEM	*P*-Value[a]		
	0% Sweet Bran		25% Sweet Bran					
	CON[b]	SYT-EFC[c]	CON[b]	SYT-EFC[c]		Trait	SB	Trait * SB
Animal Performance								
Initial BW, lb	671	673	673	674	1	0.09	0.13	0.51
DMI, lb/d	23.0	22.4	23.3	22.7	0.3	0.07	0.36	0.99
Final BW, lb[d]	1295	1290	1278	1317	11	0.14	0.68	0.07
ADG, lb[d]	3.60[hi]	3.57[hi]	3.49[i]	3.72[h]	0.06	0.15	0.74	0.05
F:G[d,e]	6.44[ij]	6.31[hi]	6.71[j]	6.13[h]	—	< 0.01	0.68	0.02
Carcass Characteristics								
HCW, lb	816	813	805	829	7	0.14	0.72	0.07
Dressing %	62.7	62.8	62.8	63.1	0.2	0.48	0.39	0.79
Marbling Score[f]	456	484	443	488	11	< 0.01	0.68	0.43
Fat Depth, in	0.48	0.56	0.48	0.53	0.02	0.01	0.56	0.41
Ribeye Area, in[b]	12.9	12.5	12.8	13.0	0.2	0.53	0.34	0.20
Calculated Yield Grade[g]	3.67	3.98	3.67	3.83	0.10	0.03	0.46	0.45
Liver Abscesses, %	8.96	5.63	11.12	5.63	—	0.23	0.77	0.77

[a]Trait = *P*-value for the main effect of corn trait, SB = *P*-value for the main effect of Sweet Bran inclusion, Trait * SB = *P*-value for the interaction between corn trait and Sweet Bran inclusion.
[b]CON = Commercially available corn grain without the alpha amylase enzyme trait
[c]SYT-EFC corn provided by Syngenta under identity-preserved procedures. Stored, processed, and fed separately.
[d]Calculated from HCW adjusted to a common 63% pressing percentage.
[e]Analyzed as G:F, the reciprocal of F:G.
[f]Marbling Score: 300=Slight[00], 400= Small[00].
[g]Calculated as 2.5 + (2.5 × 12th rib fat) + (0.2 × 2.5 [KPH]) + (0.0038 × HCW) – (0.32 × LM area).
[h,i,j]Means within a row with unlike superscripts differ ($P < 0.05$).

in feed conversion by feeding the Syngenta Enhanced Feed Corn which contains the alpha amylase enzyme trait.

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Table 5. Effect of corn hybrid and inclusion of an alpha amylase enzyme supplement on finishing steer performance and carcass characteristics (*Exp 2*)

Item	Dietary Treatment[a]				SEM	F-Test[b]
	CON	SYT-EFC	BLEND	NZ		
Animal Performance						
Initial BW, lb	646	649	647	647	1	0.38
DMI, lb/d	23.6	23.8	23.5	23.4	0.3	0.80
Final BW, lb[c]	1257[g]	1301[h]	1299[h]	1299[h]	7	< 0.01
ADG, lb[c]	3.71[g]	3.94[h]	3.93[h]	3.93[h]	0.04	< 0.01
F:G[c,d]	6.53[h]	6.18[g]	6.07[g]	6.07[g]	—	0.03
Carcass Characteristics						
HCW, lbs	792[g]	820[h]	818[h]	818[b]	5	< 0.01
Dressing %	62.7	63.2	63.3	63.2	0.3	0.58
Marbling Score[e]	451[g]	468[gh]	481[h]	468[gh]	8	0.08
Fat Depth, in	0.57	0.60	0.61	0.60	0.01	0.22
Ribeye Area, in[b]	12.1[g]	12.1[g]	12.4[h]	12.4[h]	0.1	0.03
Calculated Yield Grade[f]	3.47	3.64	3.55	3.55	0.07	0.35
Liver Abscesses, %	3.33	5.00	0	5.33	—	0.41

[a]CON = Commercially available corn grain without the alpha amylase enzyme trait, SYT-EFC = Alpha amylase enzyme corn from Syngenta, BLEND = 50:50 blend of SYT-EFC and CON on a DM basis, NZ = Inclusion of a commercially available alpha amylase enzyme supplement in CON based diets.
[b]F-Test = F-test statistic for the effect of treatment.
[c]Calculated from HCW adjusted to a common 63% pressing percentage.
[d]Analyzed as G:F, the reciprocal of F:G.
[e]Marbling Score: 300 = Slight[00], 400 = Small[00].
[f]Calculated as 2.5 + (2.5 × 12th rib fat) + (0.2 × 2.5 [KPH]) + (0.0038 × HCW) – (0.32 × LM area).
[g,h]Means within a row with unlike superscripts differ ($P < 0.05$).

Site and Extent of Digestion of Finishing Diets Containing Syngenta Enhanced Feed Corn

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Summary

Four ruminally and duodenally fistulated steers were utilized to evaluate the effects of Syngenta Enhanced Feed Corn™ containing an alpha amylase enzyme trait (SYT-EFC) compared to the isoline parental control corn without the alpha amylase enzyme trait (Negative Isoline) on site and extent of digestion in finishing diets. Cattle fed SYT-EFC dry rolled corn had numerically greater postruminal starch digestibility, excreted lower fecal starch, and had greater total tract starch digestibility compared to cattle fed Negative Isoline corn. These data would suggest that cattle are able to utilize more starch from corn containing the SYT-EFC trait, which has resulted in greater gains and efficiencies.

Introduction

Additional growth technologies are needed by the beef industry to improve feed conversion. Three experiments have been conducted to evaluate the effect of feeding SYT-EFC on finishing cattle performance (*2016 Nebraska Beef Report* pp. 135; *2016 Nebraska Beef Report* pp. 143). When cattle were fed SYT-EFC dry rolled corn with byproducts; feeding value increased by 101 to 115% over the control. With the data from the finishing trials, the hypothesis of this digestion experiment was that more starch is being digested by cattle fed SYT-EFC corn compared to corn without the alpha amylase enzyme trait. Therefore, the objective of this trial was to evaluate the effect of feeding SYT-EFC corn containing the alpha amylase enzyme trait on site and extent of digestion and ruminal metabolism characteristics.

Procedure

A metabolism experiment was conducted to evaluate the effects of feeding SYT-EFC dry rolled corn (Syngenta Seeds, Inc.) on site and extent of digestion in finishing diets. The corn utilized in this trial was grown at the UNL Agricultural Research and Development Center (ARDC) near Mead, NE and contained the alpha amylase enzyme trait (SYT-EFC) or was the near isoline, parental corn hybrid that did not contain the trait (Negative Isoline, NEG). The trial utilized 4 ruminally and duodenally cannulated steers in a 4 steer, 6 period row-column transformation design. Steers were assigned randomly to treatments by utilizing a row by column random number arrangement. Dietary treatments (Table 1) were designed in a 2 × 2 + 1 factorial arrangement. The first factor was corn trait, which consisted of SYT-EFC or Negative Isoline corn. The second factor consisted of byproduct type, being either modified distillers grains plus solubles (MDGS) or sweet bran (SB). Lastly, the plus one treatment consisted of a 50:50 blend of SYT-EFC and NEG corn with MDGS (BLEND). All diets contained 360 mg/steer daily of Rumensin (30 g/ton of DM) and 90 mg/steer daily of tylosin (9 g/ton of DM).

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

Ingredient, % of DM	MDGS[a]			Sweet Bran	
	NEG[b]	SYT-EFC[b]	Blend	NEG[b]	SYT-EFC[b]
SYT-EFC DRC[c]	—	65	32.5	—	55
Negative Isoline DRC[c]	65	—	32.5	55	—
MDGS[a]	15	15	15	—	—
Sweet Bran	—	—	—	25	25
Corn Silage	15	15	15	15	15
Supplement[d]	5	5	5	5	5
Fine ground corn	2.11	2.11	2.11	2.76	2.76
Limestone	1.67	1.67	1.67	1.63	1.63
Urea	0.63	0.63	0.63	0.10	0.10
Salt	0.3	0.3	0.3	0.3	0.3
Tallow	0.125	0.125	0.125	0.125	0.125
Trace mineral premix	0.05	0.05	0.05	0.05	0.05
Potassium chloride	0.064	0.064	0.064	—	—
Rumensin-90	0.0165	0.0165	0.0165	0.0165	0.0165
Vitamin ADE premix	0.015	0.015	0.015	0.015	0.015
Tylan-40	0.01	0.01	0.01	0.01	0.01
Analyzed Composition, %					
OM	95.8	95.5	95.6	95.1	94.8
CP	15.5	15.4	15.4	14.7	14.7
Starch	54.5	52.4	53.5	50.7	48.9

[a]MDGS = Modified distillers grains plus solubles
[b]NEG = Negative Isoline, the isoline parental control corn without the alpha amylase enzyme trait; SYT-EFC = Corn containing the alpha amylase enzyme trait
[c]DRC = Dry rolled corn
[d]Formulated to contain 360 mg/steer daily of Rumensin and 90 mg/steer daily of Tylan

Table 2. Effects of corn trait and byproduct type in finishing diets on nutrient intake, flow, and digestion

Item	Dietary Treatments												
	MDGS[a]			Sweet Bran			2 × 2[b]				Contrasts[c]		
	NEG[d]	SYT-EFC[d]	Blend	NEG[d]	SYT-EFC[d]	SEM	F-Test[e]	Trait	Byproduct	Int.	SYT-EFC vs. NEG	NEG vs. Blend	SYT-EFC vs. Blend
Intake, lb/d													
DM	16.7	17.2	18.1	19.6	17.6	1.4	0.12	0.33	0.04	0.09	0.59	0.28	0.50
OM	15.9	16.5	17.3	18.6	16.7	1.3	0.13	0.36	0.05	0.08	0.54	0.27	0.52
Starch	8.8	9.4	9.7	9.7	8.9	0.7	0.40	0.87	0.60	0.09	0.28	0.19	0.65
Ruminal Digestibility, %													
Apparent OM	50.29	54.99	49.65	55.54	53.98	2.82	0.30	0.48	0.36	.017	0.16	0.87	0.17
True OM[f]	56.02	59.71	56.43	61.82	59.76	2.60	0.31	0.68	0.19	0.18	0.22	0.91	0.35
Apparent Starch	77.21	82.80	74.56	79.82	77.43	3.40	0.33	0.54	0.60	0.14	0.16	0.57	0.08
True Starch[g]	77.62	83.11	75.03	80.37	78.97	3.39	0.37	0.43	0.79	0.20	0.16	0.57	0.08
Postruminal Digestibility, % Entering													
OM	52.99	58.06	58.95	47.90	61.02	6.08	0.32	0.08	0.83	0.40	0.46	0.49	0.91
Starch	55.63	61.50	75.25	51.89	72.50	10.67	0.25	0.11	0.65	0.35	0.61	0.18	0.31
Fecal Output, lb/d													
OM	3.43	3.19	3.41	4.31	2.95	0.23	0.18	0.05	0.42	0.16	0.65	0.96	0.71
Starch	0.804[hi]	0.679[ij]	0.662[ij]	1.06[h]	0.477[j]	0.088	0.06	0.01	0.82	0.08	0.48	0.45	0.93
Total-Tract Digestibility, %													
DM	75.39	79.32	78.79	75.96	81.41	2.71	0.29	0.05	0.55	0.72	0.21	0.38	0.88
OM	76.38	80.68	79.92	77.11	82.47	2.64	0.26	0.04	0.56	0.80	0.17	0.35	0.83
Starch	90.41[ij]	92.79[hij]	93.67[hi]	89.69[j]	94.72[h]	1.94	0.09	0.02	0.66	0.33	0.24	0.19	0.70

[a]MDGS = Modified distillers grains plus solubles
[b]2 × 2 = Treatments MDGS NEG, MDGS E, SB NEG, and SB E are treatments within the 2x2 factorial
[c]SYT-EFC vs. NEG = MDGS SYT-EFC vs. NEG; NEG vs. Blend = MDGS NEG vs. MDGS Blend; SYT-EFC vs. Blend = MDGS SYT-EFC vs. MDGS Blend
[d]NEG = Negative Isoline, the isoline parental control corn without the alpha amylase enzyme trait; SYT-EFC = Corn containing the alpha amylase enzyme trait
[e]F-Test = F-Test statistic for the effect of treatment
[f]True OM = Corrected for microbial OM reaching the duodenum
[g]True Starch = Corrected for microbial starch
[h,i,j]Means within a row with unlike superscripts differ ($P \leq 0.10$)

Steers were fed once daily at 0800 h and had ad libitum access to feed and water. Cattle were housed in individual, rubber slatted pens in a temperature controlled room. Ingredient samples were taken during the collection period at time of mixing, composited by period, and ground through a 1-mm screen of a Willey Mill. Period duration was 21-d with a 16-d adaptation phase and 5-d collection period. Beginning on d 10 of each period, titanium dioxide was dosed intraruminally at 0800 and 1600 h to provide a total of 10 g/d. Fecal and duodenal samples were collected 4 times/d at 0700, 1100, 1500, and 1900 h on d 17–20. Fecal samples were composited by day, freeze dried, ground through a Wiley Mill using a 1 mm screen, and composited by animal within period. Duodenal samples were freeze dried, ground as described previously, and composited by animal within period. Fecal and duodenal samples were analyzed for titanium dioxide to determine nutrient digestibility and duodenal flow. Feed ingredients, fecal, and duodenal samples were also analyzed for DM, OM, total starch, and CP.

On d 21, whole rumen contents were collected, fixed with formalin, and stored frozen at −4°C. At the conclusion of the trial, whole rumen contents were blended, strained through 3 layers of cheesecloth, centrifuged to isolate bacteria, and freeze dried. Bacteria isolates and duodenal contents were analyzed for purine concentration to determine microbial flow. Along with whole rumen contents, rumen fluid samples were collected using the suction-strainer technique on d 21. Rumen fluid samples were collected 5 times/d at 0700, 1000, 1300, 1600, and 1900 h. Samples were stored frozen until analyzed for ruminal volatile fatty acid (VFA) concentration. Ruminal pH was measured continuously from d 17 to 21 with submersible wireless pH probes. Measurements for pH included average ruminal pH, minimum and maximum pH, magnitude of change, variance, and time and area below 5.6.

All data were analyzed using the MIXED procedure of SAS with steer within

Table 3. Effects of corn trait and byproduct type in finishing diets on ruminal pH

Item	Dietary Treatments												
	MDGS[a]			Sweet Bran				2 × 2[b]			Contrasts[c]		
	NEG[d]	SYT-EFC[d]	Blend	NEG[d]	SYT-EFC[d]	SEM	F-Test[e]	Trait	Byproduct	Int.	SYT-EFC vs. NEG	NEG vs. Blend	SYT-EFC vs. Blend
Average pH	5.59	5.65	5.60	5.62	5.58	0.14	0.99	0.94	0.82	0.67	0.69	0.95	0.76
Maximum pH	6.47	6.47	6.52	6.42	6.38	0.09	0.70	0.87	0.24	0.59	0.94	0.59	0.64
Minimum pH	4.97	4.93	4.89	4.97	4.97	0.10	0.95	0.80	0.85	0.79	0.71	0.53	0.78
pH magnitude	1.51	1.53	1.63	1.45	1.40	0.09	0.45	0.98	0.20	0.44	0.86	0.35	0.44
pH variance[f]	0.150[mn]	0.153[mn]	0.207[n]	0.133[m]	0.099[m]	0.026	0.08	0.49	0.06	0.19	0.93	0.11	0.13
Time < 5.6, min/d[g]	802	790	803	777	750	174	0.99	0.93	0.91	0.99	0.96	0.99	0.95
Area <5.6, min/d[h]	289	287	290	247	300	104	0.99	0.80	0.97	0.85	0.99	0.99	0.98
Time < 5.3, min/d[i]	623	526	451	424	451	139	0.74	0.30	0.12	0.65	0.58	0.35	0.69
Area < 5.3, min/d[j]	143	109	82	86	117	49.6	0.85	0.30	0.19	0.47	0.60	0.38	0.70
Time < 5.0, min/d[k]	205	120	102	125	222	78.4	0.66	0.24	0.54	0.13	0.42	0.36	0.87
Area < 5.0, min/d[l]	23.6	13.5	8.2	16.3	34.0	15.4	0.76	0.22	0.59	0.31	0.64	0.51	0.82

[a]MDGS = Modified distillers grains plus solubles
[b]2 × 2 = Treatments MDGS NEG, MDGS E, SB NEG, and SB E are treatments within the 2x2 factorial
[c]SYT-EFC vs. NEG = MDGS SYT-EFC vs. NEG; NEG vs. Blend = MDGS NEG vs. MDGS Blend; SYT-EFC vs. Blend = MDGS SYT-EFC vs. MDGS Blend
[d]NEG = Negative Isoline, the isoline parental control corn without the alpha amylase enzyme trait; SYT-EFC = Corn containing the alpha amylase enzyme trait
[e]F-Test = F-Test statistic for the effect of treatment
[f]Variance of daily ruminal pH
[g]Time < 5.6 = Minutes that ruminal pH was below 5.6
[h]Area < 5.6 = Ruminal pH units below 5.6 by minute
[i]Time < 5.3 = Minutes that ruminal pH was below 5.6
[j]Area < 5.3 = Ruminal pH units below 5.3 by minute
[k]Time < 5.0 = Minutes that ruminal pH was below 5.0
[l]Area < 5.0 = Ruminal pH units below 5.0 by minute
[m,n]Means within a row with unlike superscripts differ ($P \leq 0.10$)

period as the experimental unit. Treatment and period were included in the model as fixed effects while steer was treated as a random effect for all analyses. The main effect of corn trait, byproduct type, and the interaction between corn trait and byproduct type were analyzed. An F-test was utilized to compare the means of all five treatments. Lastly, 3 pre-planned contrasts were used to evaluate the effect of corn trait when fed with MDGS. Treatment differences were considered significant at $P < 0.10$.

Results

Intake and Digestion

A corn trait by byproduct type interaction was observed for DMI, OMI, and starch intake ($P = 0.09$, 0.08, and 0.09; respectively; Table 2). Steers that consumed MDGS with SYT-EFC had greater DM, OM, and starch intakes than steers fed MDGS with NEG corn. However, the opposite was true when steers were fed Sweet Bran. Intakes were greater for steers fed Sweet Bran with NEG corn compared to SYT-EFC. No interactions for ruminal apparent OM, true OM, apparent starch or true starch digestibility ($P \geq 0.14$) were observed. There were no differences for the main effect of corn trait ($P \geq 0.43$) or byproduct type ($P \geq 0.19$) for ruminal apparent OM, true OM, apparent starch or true starch digestibility. There were no interactions observed for postruminal OM and starch digestion ($P \geq 0.35$). The main effect of corn trait was significant ($P = 0.08$) for postruminal OM digestibility and tended ($P = 0.11$) to be significant for postruminal starch digestion. There appears to be a biological difference between cattle fed SYT-EFC compared to NEG corn. Cattle that were fed SYT-EFC corn had a postruminal starch digestibility of 67.00% compared to 53.76% for cattle fed NEG corn. An interaction was observed for starch output ($P = 0.08$) with steers fed NEG with Sweet Bran having the greatest fecal starch excreted, NEG and SYT-EFC with MDGS were intermediate, and SYT-EFC with Sweet Bran had the lowest. Cattle that were fed SYT-EFC corn had less starch excreted in the feces compared to cattle fed NEG corn ($P = 0.01$). This resulted in cattle that were fed SYT-EFC corn having a greater total tract starch digestibility compared to steers fed NEG corn, 93.8% and 90.1%, respectively ($P = 0.02$). No interactions were observed for total tract DM or OM digestibility ($P \geq 0.72$). The main effect of trait was significant for total tract DM ($P = 0.05$) and OM ($P = 0.04$) digestibility with steers fed SYT-EFC having greater DM and OM digestibilities compared to NEG corn.

When comparing only the three diets that contain MDGS, there were no differences ($P \geq 0.19$) in DMI, OMI, or starch intake among steers fed SYT-EFC, NEG or BLEND (Table 2). However, cattle that were

Table 4. Effects of corn trait and byproduct type in finishing diets on volatile fatty acid profile

Item	Dietary Treatments[a]					SEM	F-Test[b]	2 × 2[c]			Contrasts[d]		
	MDGS NEG	MDGS EFC	MDGS Blend	SB NEG	SB EFC			Trait	Byproduct	Int.	EFC vs. NEG	NEG vs. Blend	EFC vs. Blend
Acetate, mol/100 mol	49.4	48.7	48.4	47.9	50.0	1.5	0.77	0.84	0.93	0.27	0.65	0.54	0.88
Propionate, mol/100 mol	35.6	37.0	36.8	37.5	33.8	2.1	0.59	0.60	0.63	0.13	0.58	0.63	0.94
Butyrate, mol/100 mol	10.2	10.0	10.7	10.0	10.8	0.8	0.91	0.59	0.86	0.37	0.85	0.69	0.55
Acetate:-Propionate	1.58	1.45	1.43	1.36	1.60	0.12	0.33	0.79	0.88	0.04	0.33	0.26	0.87
Total, mM	102.2[e]	107.1[e]	119.2[ef]	135.0[f]	106.0[e]	11.6	0.03	0.08	0.02	0.02	0.66	0.14	0.29

[a]MDGS NEG = Modified distillers grains plus solubles with parental Negative Isoline hybrid , MDGS EFC = Modified distillers grains plus solubles with SYT-EFC hybrid, MDGS Blend = Modified distillers grains plus solubles with 50:50 blend of EFC and NEG hybrids, SB NEG = Sweet Bran with parental Negative Isoline hybrid, SB EFC = Sweet Bran with SYT-EFC hybrid
[b]F-Test = F-Test statistic for the effect of treatment
[c]2 × 2 = Treatments MDGS NEG, MDGS E, SB NEG, and SB E are treatments within the 2x2 factorial
[d]EFC vs. NEG = MDGS EFC vs. MDGS NEG; NEG vs. Blend = MDGS NEG vs. MDGS Blend; EFC vs. Blend = MDGS EFC vs. MDGS Blend
[e,f]Means within a row with unlike superscripts differ ($P \leq 0.10$)

fed NEG corn had numerically lower DMI, OMI, and starch intake compared to SYT-EFC and BLEND. There were no differences ($P \geq 0.16$) for ruminal apparent and true OM among the three treatments. A tendency ($P = 0.16$) was observed for steers fed SYT-EFC to have greater ruminal apparent and true starch digestibilities compared to NEG. However, steers fed SYT-EFC corn did have greater ruminal apparent and true starch digestibilities compared to BLEND (P = 0.08). No differences were observed for OM and starch postruminal digestibilities ($P \geq 0.18$) or the amount of fecal OM and starch excreted ($P \geq 0.45$) for all three treatments. Although not significant, a numerical increase in postruminal starch digestion was observed for cattle fed SYT-EFC and BLEND compared to NEG corn. Fecal starch output followed a similar trend, with cattle fed SYT-EFC and BLEND having lower fecal starch than NEG corn. Among the three treatments, DM, OM, and starch total tract digestibilities were not different (P ≥ 0.17). However, cattle fed SYT-EFC with MDGS had numerically greater DM, OM, and starch total tract digestibility than NEG.

Ruminal pH

There were no interactions ($P \geq 0.44$), effect of corn trait ($P \geq 0.80$), or effect of byproduct ($P \geq 0.20$) observed for average, maximum, minimum, or magnitude of pH change (Table 3). There were no interactions ($P \geq 0.13$), effect of trait ($P \geq 0.22$) or effect of byproduct ($P \geq 0.12$) observed for time and area below 5.6, 5.3, or 5.0. No differences were observed among the 3 treatments that contained MDGS for all ruminal pH characteristics ($P \geq 0.11$).

VFA Concentration

There were no interactions ($P \geq 0.13$), effect of corn trait ($P \geq 0.59$), or effect of byproduct ($P \geq 0.63$) observed for the ruminal VFA proportions of acetate, propionate, and butyrate (Table 4). An interaction was observed ($P = 0.04$) for the acetate to propionate (A:P) ratio. Steers fed SYT-EFC with MDGS had a lower A:P ratio compared to NEG with MDGS (1.45 and 1.58, respectively). Conversely, cattle that were fed Sweet Bran with SYT-EFC had a higher A:P ratio compared to NEG with Sweet Bran (1.60 and 1.36, respectively). One explanation for the interaction could be that when SYT-EFC corn is fed with MDGS a slight shift in propionate production from acetate occurs. Whereas, when SYT-EFC is fed with Sweet Bran starch digestion bypasses the rumen and is utilized in the intestine. No differences were observed among the three treatments that contained MDGS for all VFA characteristics ($P \geq 0.14$).

These data suggest that cattle fed SYT-EFC corn have increased postruminal and total tract starch digestion compared to cattle fed Negative Isoline corn. When steers utilize an energy source to a greater extent it will result in increased gains and efficiencies which corresponds with our finishing data. Syngenta Enhanced Feed Corn would be best suited for producers who have the ability to manage the source (hybrid) of corn fed to their cattle.

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Evaluating Syngenta Enhanced Feed Corn Processed as Dry-Rolled or High-Moisture Corn on Cattle Performance and Carcass Characteristics

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Summary

A finishing trial was conducted as a 2x2x2 factorial to determine the effect of Syngenta Enhanced Feed Corn™ containing an alpha amylase enzyme trait (SYT-EFC) compared with the parental isoline control corn without the amylase enzyme trait (Negative Isoline) on cattle performance and carcass characteristics. The two types of corn grain were processed as either dry-rolled corn (DRC) or high-moisture corn (HMC) and fed with either 18% modified distillers grains plus solubles (MDGS) or 35% Sweet Bran. Cattle fed SYT-EFC DRC with MDGS had a 3.9% improvement in feed conversion compared to Negative Isoline DRC. However, this difference was 2.1% when processed as HMC. Cattle fed SYT-EFC DRC with Sweet Bran had a 1.5% improvement in feed conversion compared to Negative Isoline. However, when processed as HMC a decrease of 2.1% was observed. Feeding SYT-EFC corn that has been processed as DRC improves feed conversion in finishing diets.

Introduction

For cattle to maximize feed conversion, starch digestion must be optimized. The degree of corn processing, different corn hybrids, and kernel characteristics have been reported to improve animal performance and digestibility (Theurer, 1986; Harrelson et al., 2009; Jaeger et al., 2006). Two finishing trials have been conducted to compare feeding SYT-EFC corn grain (Syngenta Seeds, Inc.) containing an alpha amylase enzyme trait and a commercially available corn grain without the alpha amylase enzyme trait on animal performance and carcass characteristics (*2016 Nebraska Beef Report* pp. 135). In those experiments, feeding SYT-EFC corn improved F:G when fed as DRC. The objective of this study was to compare SYT-EFC corn to an isoline parental corn without the alpha amylase enzyme trait (Negative Isoline) fed as either DRC or HMC with Sweet Bran or MDGS on cattle performance and carcass characteristics.

Procedure

A 173-d finishing trial was conducted utilizing 384 crossbred steers (initial BW = 685, SD = 46 lb) in a randomized block design, with a 2×2×2 factorial arrangement of treatments. Steers were limit fed a diet at 2% BW consisting of 47.5% alfalfa hay, 47.5% Sweet Bran (Cargill; Blair, NE), and 5% supplement (DM basis) for 5 d prior to the initiation of the experiment. Two-day initial weights were recorded on d 0 and 1 and averaged to determine initial BW. Along with measuring initial BW on d 1, steers were implanted with Revalor-XS. The steers were blocked by BW into light and heavy BW blocks (n =4 and 2 pen replicates, respectively) based on d 0 BW, stratified by BW and assigned randomly to pen. Pens were assigned randomly to 1 of 8 dietary treatments with 8 steers/pen and 6 replications/treatment.

Dietary treatments (Table 1) were arranged in a 2×2×2 factorial with factors including corn processing method (DRC or HMC), corn trait [SYT-EFC or Negative Isoline (NEG)], and byproduct type (MDGS or Sweet Bran). The byproducts utilized in this trial were provided as either a protein source (18% MDGS) or as a means of acidosis control (35% Sweet Bran). Steers were adapted to the finishing diets over a 21-d period with corn replacing alfalfa hay, while inclusion of sorghum silage, Sweet Bran or MDGS, and supplement remained the same in all diets. Diets were formulated to meet or exceed NRC requirements for MP and minerals. The final finishing diets provided 330 mg/steer daily of Rumensin (30 g/ton of DM; Elanco Animal Health, Greenfield, IN), and 90 mg/steer daily of Tylan (8.18 g/ton of DM; Elanco Animal Health, Greenfield, IN).

All steers were harvested on d 174 at a commercial abattoir (Greater Omaha, Omaha, NE). Feed offered on d 173 was 50% of the previous day DMI. Steers were removed from pens and weighed by pen at 1600 h. Steers were shipped to the commercial abattoir and held until the next d for slaughter. Hot carcass weights and livers scores were recorded on the d of slaughter with 12th rib fat thickness, LM area, and USDA marbling score being recorded after a 48-h chill. Yield grade was calculated using the USDA YG equation [YG = 2.5 + 2.5 (fat thickness, in)–0.32 (LM area, in^2) + 0.2 (KPH fat, %) + 0.0038 (HCW, lb)]. Final BW, ADG, and F:G were calculated using HCW adjusted to a common 63% dressing percentage.

Performance and carcass characteristics were analyzed using the MIXED procedure of SAS (SAS Institute, Inc., Cary, N.C.). Pen was used as the experimental unit and BW block was included as a fixed effect. Data were analyzed as a 2×2×2 factorial with main factors including corn processing, corn trait, and byproduct type. The model included the main effects with all 2-way and 3-way interaction terms.

Results

No 3-way interactions were observed *(P* ≥ 0.21; Table 2) between corn processing, corn trait, and byproduct type for all performance and carcass data. However, cattle fed SYT-EFC DRC with MDGS had a 3.9% improvement in feed conversion compared to NEG DRC. When fed as HMC, feed conversion between SYT-EFC and NEG with MDGS differed by 2.1%. Cattle fed SYT-EFC DRC with Sweet Bran had a 1.5%

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

Ingredient, % DM	SYT-EFC[a]				Negative Isoline			
	MDGS[b]		Sweet Bran		MDGS[b]		Sweet Bran	
SYT-EFC DRC	69.5	—	52.5		—	—	—	—
SYT-EFC HMC	—	69.5	—	52.5	—	—	—	—
Negative Isoline DRC	—	—	—	—	69.5	-	52.5	—
Negative Isoline HMC	—	—	—	—	—	69.5	-	52.5
Sweet Bran	—	—	35.0	35.0	—	—	35.0	35.0
MDGS[1]	18.0	18.0	—	—	18.0	18.0	—	—
Sorghum Silage	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Meal Supplement[c]	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Fine ground corn	2.223	2.223	2.806	2.806	2.223	2.223	2.806	2.806
Limestone	1.710	1.710	1.677	1.677	1.710	1.710	1.677	1.677
Urea	0.55	0.55	—	—	0.55	0.55	—	—
Salt	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Tallow	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125
Trace mineral premix	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Rumensin-90	0.0165	0.0165	0.0165	0.0165	0.0165	0.0165	0.0165	0.0165
Vitamin ADE premix	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015
Tylan-40	0.0102	0.0102	0.0102	0.0102	0.0102	0.0102	0.0102	0.0102
Analyzed Nutrient Composition, %								
Starch	47.56	49.08	39.06	40.21	47.14	48.74	38.74	39.95
CP	13.5	13.4	13.7	13.7	13.6	13.4	13.9	13.7
Fat	4.35	4.98	3.19	3.66	4.35	5.19	3.19	3.82
NDF	15.5	14.9	20.0	19.5	16.2	15.4	20.5	19.9
S	0.22	0.22	0.21	0.16	0.22	0.21	0.21	0.21
P	0.38	0.39	0.53	0.53	0.34	0.35	0.50	0.51
K	0.47	0.48	0.68	0.68	0.45	0.45	0.66	0.66
Mg	0.17	0.17	0.24	0.24	0.16	0.16	0.23	0.23

[a]SYT-EFC = Syngenta enhanced feed corn containing the alpha amylase enzyme trait provided by Syngenta under identity-preserved procedures, stored, processed as dry rolled corn (DRC) or high moisture corn (HMC), and fed separately.
[b]MDGS = Modified distillers grains plus solubles
[c]Supplement included 30 g/ton Rumensin and 9 g/ton Tylan

improvement in feed conversion compared to NEG corn. However, when processed as HMC, feed conversion was decreased by 2.1% for cattle fed SYT-EFC compared to NEG corn with Sweet Bran.

There were no byproduct x trait interactions ($P \geq 0.36$) for final BW, DMI, or ADG (Table 2). The main effect of corn trait was not significantly different ($P \geq 0.21$) for all performance measurements. However, a tendency for a byproduct x trait interaction ($P = 0.13$) for feed conversion was observed. Regardless of corn processing, cattle that were fed SYT-EFC corn with MDGS had a 3.0% improvement in feed conversion compared to cattle fed NEG corn. When accounting for concentration of corn grain in the diet, the difference for the grain was 4.3%. However, feed conversions were reduced by less than 1% for cattle fed SYT-EFC compared to NEG corn with Sweet Bran. A tendency for a byproduct x trait interaction for LM area and calculated YG ($P = 0.12$ and $P = 0.12$, respectively) were observed. Cattle that were fed MDGS had a greater magnitude of difference between SYT-EFC and NEG corn for LM area and calculated yield grade than cattle fed Sweet Bran.

A corn processing x corn trait interaction was observed for final BW and ADG ($P = 0.02$ and $P = 0.04$, respectively; Table 3). Cattle that consumed SYT-EFC corn that was processed as DRC had the greatest final BW and ADG with NEG HMC being intermediate and NEG DRC and SYT-EFC HMC being the lowest. A corn processing x corn trait interaction was not observed for DMI ($P = 0.43$). However, cattle fed HMC had lower DMI than cattle fed DRC ($P < 0.01$). This reduction in DMI in cattle fed HMC resulted in those steers having lower F:G ($P < 0.01$) compared to cattle fed DRC. Biologically, there appears to be a tendency ($P = 0.15$) for a corn processing x corn trait interaction for feed conversion. Steers that were fed SYT-EFC DRC had better conversions than steers fed NEG DRC. In contrast, cattle that were fed either type of HMC were not different. An explanation for lack of efficiency improvement for SYT-EFC when processed as HMC is that ruminal starch digestion of HMC is so rapid that the alpha amylase enzyme trait may not be utilized. A tendency for a corn processing x corn trait interaction occurred for HCW ($P = 0.08$), marbling score ($P = 0.09$), and 12th rib fat thickness ($P = 0.07$). Steers that were fed SYT-EFC DRC had greater HCW and marbling score compared to NEG DRC. However, HCW and marbling scores were lower for steers fed SYT-EFC HMC compared to NEG HMC. Based on 12th rib fat thickness, cattle fed SYT-EFC DRC were leaner compared to NEG DRC however, the opposite was true for steers fed SYT-EFC and NEG as HMC. No corn processing x corn trait interactions were observed for LM area or calculated yield grade ($P = 0.45$ and $P = 0.30$, respectively).

These data would suggest an improvement was observed when feeding SYT-EFC corn when processed as DRC compared to Negative Isoline. When processed as HMC, corn grain containing the alpha amylase enzyme trait did not improve ADG or feed conversions most likely because starch digestion is already rapid and complete with HMC. When fed with MDGS, SYT-EFC DRC had a slight improvement in feed conversion compared to Negative Isoline,

Table 2: Effects of processed hybrid corn with MDGS or Sweet Bran on finishing cattle performance

	DRC[a]				HMC[a]					*P*-values					
	MDGS[b]		Sweet Bran		MDGS[b]		Sweet Bran								
	SYT-EFC	NEG[c]	SYT-EFC	NEG[c]	SYT-EFC	NEG[c]	SYT-EFC	NEG[c]	SEM	Process	By product	Trait	P*T[d]	B*T[e]	P*B[f]	P*B*T[g]
Performance																
Initial BW, lb	700	698	700	700	699	698	698	699	1.45	0.31	0.60	0.78	0.39	0.21	0.54	0.71
Final BW, lb[h]	1439	1419	1462	1446	1430	1435	1432	1459	10.3	0.71	0.01	0.90	0.02	0.38	0.44	0.52
DMI, lb/d	23.3	23.7	24.2	23.9	21.6	22.1	22.5	22.9	0.31	< 0.01	< 0.01	0.23	0.43	0.36	0.56	0.41
ADG, lb[h]	4.27	4.18	4.43	4.31	4.22	4.23	4.24	4.41	0.07	0.64	0.01	0.87	0.04	0.51	0.66	0.34
F:G[h]	5.45	5.67	5.46	5.54	5.11	5.22	5.30	5.19	—	< 0.01	0.83	0.21	0.15	0.13	0.28	0.74
Carcass Characteristics																
HCW, lb	903	896	921	912	902	903	904	920	29.1	0.82	0.01	0.97	0.08	0.44	0.40	0.36
Marbling[i]	490	492	520	493	486	495	500	520	15.2	0.84	0.03	0.89	0.09	0.55	0.85	0.21
LM area, in^2	14.4	13.9	14.3	14.1	14.4	14.0	13.9	14.2	0.29	0.69	0.66	0.19	0.45	0.12	0.43	0.39
Fat Depth, in	0.54	0.59	0.55	0.58	0.58	0.59	0.62	0.58	0.03	0.12	0.61	0.36	0.07	0.17	0.65	0.60
Cal. YG[j]	3.18	3.42	3.29	3.41	3.24	3.43	3.53	3.40	0.12	0.31	0.21	0.17	0.30	0.12	0.57	0.52

[a]DRC = Dry rolled corn; HMC = High moisture corn
[b]MDGS = Modified distillers grains plus solubles
[c]NEG = Negative Isoline, parental isoline control corn without the amylase enzyme trait
[d]P*T = *P*-value for the interaction of corn processing by corn trait
[e]B*T = *P*-value for the interaction of byproduct by corn trait
[f]P*B = *P*-value for the interaction of corn processing by byproduct
[g]P*B*T = *P*-value for the interaction of corn processing by byproduct type by corn trait
[h]Calculated from HCW adjusted to a common 63% dressing percentage.
[i]Marbling Score: 400 = Small[00]; 500 = Modest[00]
[j]Calculated as 2.5 + (2.5 × 12th rib fat) + (0.2 × 2.5 [KPH]) + (0.0038 × HCW)–(0.32 × LM area)

Table 3: Effects of SYT-EFC corn trait and corn processing on finishing cattle performance

	DRC[a]		HMC[a]		SEM	*P*-Values		
	SYT-EFC[b]	NEG[c]	SYT-EFC[b]	NEG[c]		Processing[d]	Trait[e]	P*T[f]
Performance								
Initial BW, lb	700	699	698	699	1.03	0.31	0.78	0.39
Final BW, lb[g]	1451[k]	1433[j]	1431[j]	1447[k]	7.35	0.71	0.90	0.02
DMI, lb/d	23.7	23.8	22.1	22.5	0.22	< 0.01	0.23	0.43
ADG, lb[g]	4.36[k]	4.25[jk]	4.23[j]	4.33[jk]	0.05	0.64	0.87	0.04
F:G[g]	5.43	5.60	5.22	5.20	-	< 0.01	0.21	0.15
Carcass Characteristics								
HCW, lb	912	904	903	911	28.8	0.82	0.97	0.08
Marbling[h]	505	492	493	507	13.0	0.84	0.89	0.09
LM area, in^2	14.3	14.0	14.2	14.1	0.25	0.69	0.19	0.45
Fat Depth, in	0.55	0.59	0.60	0.58	0.02	0.12	0.36	0.07
Cal. YG[i]	3.24	3.41	3.39	3.41	0.10	0.31	0.17	0.30

[a]DRC = Dry rolled corn; HMC = High moisture corn
[b]SYT-EFC = Syngenta enhanced feed corn containing the alpha amylase enzyme trait
[c]NEG = Negative Isoline, parental isoline control corn without the amylase enzyme trait
[d]Processing = *P*-value for the main effect of corn processing
[e]Trait = *P*—value for the main effect of trait
[f]P*T = *P*-value for the interaction between corn processing and corn trait
[g]Calculated from HCW adjusted to a common 63% dressing percentage
[h]Marbling Score: 400 = Small[00]; 500 = Modest[00]
[i]Calculated as 2.5+ (2.5 × 12th rib fat) + (0.2 × 2.5 [KPH]) + (0.0038 × HCW)–(0.32 × LM area)
[j,k]Means within a row with unlike superscripts differ ($P < 0.05$)

whereas there was no difference in feed conversion when fed with Sweet Bran.

Results from this trial along with data from a current study (*2016 Nebraska Beef Report*, pp 135), suggest that cattle producers who utilize the Syngenta Enhanced Feed Corn hybrid with the alpha amylase enzyme trait can expect to see an improvement in feed conversion compared to corn that does not contain the alpha amylase enzyme trait if that corn is processed and fed as DRC. However, the results have been variable when DRC has been fed with Sweet Bran or distillers grains plus solubles.

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The Effect of Delayed Corn Silage Harvest on Corn Silage Yield and Finishing Performance in Yearling Steers

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Summary

A finishing experiment evaluated the effects of harvesting drier corn silage on performance. Factors were corn silage DM (37 or 43%) and inclusion in the finishing diet (15 or 45%). As corn silage inclusion increased, DMI did not differ, ADG decreased, and F:G increased. As DM of corn silage was increased, no differences in DMI, ADG, or F:G were observed at either 15 or 45% inclusion. Ensiling drier silage increased tonnage with no negative impact on performance.

Introduction

Increased corn silage inclusion during times of increased corn prices can be an economical alternative compared to corn, although ADG and F:G are not as favorable (2015 Nebraska Beef Cattle Report, pp. 66–67). Feeding corn silage allows cattle feeders to take advantage of the entire corn plant at a time of maximum quality (approximately 35% DM) and tonnage as well as secure substantial quantities of roughage/grain inventory (2013 Nebraska Beef Cattle Report, pp. 74–75). Inclusion of distillers grains with elevated concentrations of corn silage has been shown to be an economical alternative compared to corn in times of high prices, with less depression in performance compared to adding greater concentrations of silage without distillers grains (2014 Nebraska Beef Cattle Report, pp. 88–89). Additionally, as corn harvest was delayed to black layer formation, corn and whole plant yield were maximized with little effect on nutritive quality based on hand harvested plot work (*2013 Nebraska Beef Report, pp. 42–43*; 2016 *Nebraska Beef Report*, pp. 79–80). Therefore the objectives of this experiment were to determine the effects of delaying corn silage harvest on yearling steer feedlot performance and carcass characteristics when feeding traditional levels and elevated concentrations of corn silage in diets containing 40% distillers grains.

Procedure

Corn silage was harvested at the Agricultural Research and Development Center (ARDC) near Mead, Neb. Harvest DM was targeted to mimic traditional corn silage harvest at 37% DM or a delayed harvest at 43% DM. Corn silage harvest initiation was determined when the field was at approximately ¾ milkline for the 37% DM corn silage (9/4/2014), and delayed two wks coinciding with black layer formation for the 43% DM corn silage (9/16/14). Corn silage was harvested in 4 replications within a single field and green chop samples were taken for DM determination on a Koster tester prior to bagging. Additionally, high moisture corn and dry corn yield strips were harvested within the same field on 9/18/14 and 11/4/14, respectively. Both, 37% DM and 43% DM silages were stored in sealed AgBags® and after 28 d, silage was sampled for fermentation analysis and DM (forced air oven at 140°F) were collected weekly (Table 1).

Crossbred yearling steers (n=180; initial BW = 943 lb ± 86 lb) were sorted into 3 BW blocks and assigned randomly to one of 20 pens (9 steers/pen). Treatments were designed as a 2 × 2 factorial arrangement that consisted of harvested corn silage DM (37% DM or 43% DM) and inclusion of corn silage in the finishing diet (15% or 45% DM basis; Table 2). Corn silage fed at 45% of diet DM in the finishing diet replaced high moisture corn compared to 15% silage treatments. All steers were fed a supplement formulated for 30 g/ton Rumensin® (DM basis) and a targeted intake of 90 mg/steer daily of Tylan®. Steers were implanted with Revalor-200® on d 1. Steers were fed for an average of 108 d before harvest. Prior to shipping to a commercial abattoir, pens of steers were weighed on

Table 1. Nutrient and fermentation analysis of 37 and 43% DM silage

Item	37% DM		43% DM	
	Mean	C.V.[a]	Mean	C.V.[a]
DM[b]	37.3	(3.2)	42.7	(3.9)
CP	7.51	(3.6)	7.50	(1.2)
NDF,%	31.6	(17.5)	28.9	(5.7)
ADF,%	21.4	(15.8)	18.6	(17.9)
Starch,%	35.4	(16.7)	40.8	(5.0)
Sugar,%	2.6	(19.6)	2.5	(8.7)
pH	3.88	(1.3)	3.85	(1.5)
Lactic acid,%	3.11	(26.9)	4.14	(28.1)
Acetic acid,%	3.98	(21.5)	2.81	(27.1)
Propionic acid,%	0.51	(26.8)	0.28	(54.3)
Butyric acid,%	< 0.01	(0.0)	< 0.01	(0.0)
Total acids,%	7.61	(10.5)	7.22	(3.3)

[a]C.V. = coefficient of variation and is calculated by dividing the standard deviation by the mean and is expressed as a percentage.
[b]DM was calculated using weekly samples and oven dried for 48 h at 60° C.
Note: All other samples are based on monthly composites of weekly samples taken during the finishing trial, and analyzed at Dairyland Labs (St. Cloud, MN) and Ward Labs (Kearney, NE).

a platform scale. A 4% pencil shrink was applied to this weight for final live BW and calculation of dressing percentage. Steers were weighed the afternoon prior to evening shipping, and harvested the following morning. The day of harvest, HCW were recorded, and carcass adjusted final BW were calculated from HCW adjusted to a common dressing percentage (63%), and used to determine ADG and F:G. Marbling score, 12th rib fat thickness, and LM area were recorded after a 48-h chill.

Data were analyzed using the GLIMMIX procedure of SAS as a randomized block design with pen as the experimental unit and block as a fixed effect. Silage harvest data were analyzed as a completely randomized block with field as block and silage strips serving as the experimental unit. Feedlot performance data were analyzed as a randomized block design with BW sort as block and pen serving as the experimental unit. Initial BW was significantly different between silage DM treatments, therefore initial BW was included as a covariate.

Results

There was a significant increase ($P < 0.01$) in yield of DM tons per acre comparing 37% DM to 43% DM corn silage with yields of 9.55 and 10.07 t/ac (DM), respectively. There was no difference in yield between high moisture corn and dry corn grain with 259 and 263 bu/acre yields, respectively. These data suggest that grain and silage yield was maximized when delaying corn silage harvest until black layer formation as high-moisture corn was harvested 3 d after the 43% DM silage was harvested. No further yield increase for grain was observed between this time point and dry grain harvest.

There were no interactions between corn silage DM and concentration of corn silage inclusion ($P \geq 0.47$) for feedlot performance or carcass characteristics, therefore, main effects will be discussed (Table 3). As concentration of corn silage in the finishing diet increased from 15 to 45%, ADG decreased ($P = 0.04$), while DMI did not differ ($P = 0.17$) and this in turn led to an increase in F:G ($P < 0.01$). Carcass-adjusted final BW and HCW were lower ($P \leq 0.04$) for steers fed 45% corn silage compared to 15%. Dressing percentage

Table 2. Diet composition (% of diet DM) of finishing diets fed to yearlings with varying silage DM and varying inclusion.

	Treatment[a]			
	15% corn silage		45% corn silage	
	37% DM	43% DM	37% DM	43% DM
High moisture corn	41.0	41.0	11.0	11.0
Modified distillers grains plus solubles	40.0	40.0	40.0	40.0
37% DM corn silage	15.0	—	45.0	—
43% DM corn silage	—	15.0	—	45.0
Supplement[b]	4.0	4.0	4.0	4.0

[a]Treatments: 15% silage 37% DM = 15% inclusion of 37% DM silage, 15% silage 43% DM = 15% inclusion of 43% DM silage, 45% silage 37% DM = 45% inclusion of 37% DM silage, 45% silage 43% DM = 45% inclusion of 43% DM silage; all diets contained 40% MDGS.
[b]Supplement consisted of 1.8% Fine ground corn, 1.71% limestone, 0.10% tallow, 0.30% salt, 0.05% trace mineral package, 0.015% Vitamin A-D-E package as percentages of the final diet. It was also formulated for 30 g/ton Rumensin® (DM basis) and a targeted intake of 90 mg/steer daily of Tylan®.

Table 3. The effects of delayed silage harvest and increased inclusion concentrations of silage on feedlot performance and carcass characteristics on cross bred yearling steers

Variable	Treatments[a]					*P*-value		
	15% corn silage		45% corn silage					
	37% DM	43% DM	37% DM	43% DM	SEM	Int.[b]	Concentration[c]	DM[d]
Feedlot performance								
Initial BW, lb	938	942	938	942	1.1	0.77	0.87	< 0.01
Final BW[e], lb	1353	1375	1325	1334	17.4	0.69	0.04	0.49
DMI, lbs	27.8	29.0	28.7	29.6	0.8	0.77	0.17	0.19
ADG, lb	3.89	4.05	3.61	3.69	0.21	0.75	0.04	0.55
Feed:Gain[f]	7.16	7.15	7.96	8.02	—	0.76	< 0.01	0.94
Live Final BW, lb	1393	1425	1387	1405	24.4	0.75	0.54	0.41
Carcass characteristics								
HCW, lb	853	866	835	841	14.5	0.69	0.04	0.49
Dressing percentage,%	61.1	60.8	60.2	59.8	0.56	0.93	0.06	0.62
LM area, in^2	13.07	12.81	13.14	12.92	0.21	0.86	0.54	0.23
12th-rib fat, in	0.52	0.55	0.51	0.51	0.04	0.51	0.28	0.65
Marbling score[g]	516	498	491	493	21.4	0.49	0.31	0.70

[a]Treatments: 15% silage 37% DM = 15% inclusion of 37% DM silage, 15% silage 43% DM = 15% inclusion of 43% DM silage, 45% silage 37% DM = 45% inclusion of 37% DM silage, 45% silage 43% DM = 45% inclusion of 43% DM silage; all diets contained 40% MDGS
[b] Silage Concentration × Silage DM interaction
[c] Fixed effect of silage concentration
[d] Fixed effect of silage DM
[e] Final BW, were calculated based on HCW / common dressing percent of 63%
[f] F:G was analyzed as gain to feed.
[g] Marbling score 400 = small[00], 500 = modest[00]
[h,i,j]Means with different superscripts differ ($P < 0.05$).

tended to decrease ($P = 0.06$) as concentration of corn silage was increased from 15 to 45% in the finishing diet. There were no differences ($P \geq 0.31$) in LM area, 12th rib fat, and marbling score as concentration of corn silage inclusion increased.

As DM of corn silage increased from 37 to 43% due to delaying harvest, there were no differences ($P = 0.94$) in F:G. While not significant, DMI ($P = 0.19$) and ADG ($P = 0.55$) did increase numerically as DM of corn silage was increased from 37 to 43%. Additionally, there were no differences ($P \geq 0.68$) in carcass adjusted final BW or HCW as corn silage DM was increased. No differences ($P \geq 0.23$) in dressing percent, LM area, 12th rib fat, or marbling scores were observed as DM of corn silage was increased. While increasing the concentration of corn silage from 15 to 45% in place of corn in finishing diets reduces performance, delaying corn harvest and ensiling drier silage may be economical due to increased corn silage tonnage, cheaper handling costs, and no negative impact on performance when fed at either 15 or 45% of finishing diets.

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Use of Dietary Nitrate or Sulfate for Mitigation of Methane Production by Finishing Steers

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Summary

A finishing study was conducted to evaluate the effects of dietary nitrate and sulfate on methane production in finishing cattle. Both nitrate and sulfate addition decreased DMI and ADG. In diets with no sulfate, addition of nitrate had no impact on emissions, but nitrate and sulfate in combination decreased CH_4:CO_2. However, neither nitrate nor sulfate had any further impact on methane production. Effect of these compounds may be diet dependent and in this study had little impact on CH_4 emissions in finishing cattle.

Introduction

Methane production through enteric fermentation in ruminants is a nutritional as well as an environmental concern, as the loss of carbon as methane (CH_4) is an energetic loss to the animal that can negatively impact the environment. Nitrates and sulfates have potential as methane mitigating dietary additives, as they act as H+ sinks within the rumen. Use of nitrate may be logical in low-protein diets, and both nitrate and sulfate have been studied for their methane reducing capability in forage-based diets. The objective of this study was to determine whether nitrate and/or sulfate may be effective as a methane mitigation strategy in finishing diets.

Procedure

A 131-day finishing study was conducted using 60 crossbred steers (initial BW = 918 lb; SD = 79 lb) that were individually fed using the Calan gate system. Five days before trial initiation, cattle were limit fed a common diet of 50% alfalfa hay and 50% Sweet Bran® at 2% of BW to reduce variation in gut fill and then weighed on three consecutive days, with the average used as initial BW. Steers were stratified by initial BW from d-1 and d 0, and assigned randomly to one of four treatments (Table 1), with 15 steers per treatment. Treatments were arranged as a 2 × 2 factorial design, with steers receiving either 0 or 2.0% nitrate (diet DM) and either 0 or 0.54% sulfate (diet DM). Nitrate was supplied as calcium nitrate (Calcinit, YaraLiva, Oslo, Norway), replacing urea and limestone; sulfate was supplied as calcium sulfate, replacing a portion of limestone. Cattle were adapted gradually to nitrate over a 25-day period and one steer died due to nitrate toxicity during the trial. Steers were implanted with Revalor-200 on d 1. On day 131, cattle were transported to a commercial abattoir (Greater Omaha Packing, Omaha, Neb.) to be harvested. Hot carcass weight (HCW) and liver abscess scores were collected on day of slaughter. Following a 48-hour chill, 12th-rib fat thickness, LM area, and USDA marbling score were recorded. Carcass adjusted final BW, ADG, and F:G were calculated using HCW and a common 63% dressing percentage.

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

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

Performance and calculated emissions data were analyzed as a 2 × 2 factorial treat-

Table 1. Composition of finishing diets 0 or 2.0% nitrate and 0 or 0.54% sulfate (Exp. 3)

Ingredient	−Nitrate[a]		+Nitrate[a]	
	−Sulf[b]	+Sulf[b]	−Sulf[b]	+Sulf[b]
Dry-rolled corn	35.75	35.75	35.75	35.75
High-moisture corn	35.75	35.75	35.75	35.75
MDGS[c]	10	10	10	10
Alfalfa hay	7.5	7.5	7.5	7.5
Molasses	5	5	5	5
Supplement[d]				
$(CaNO_3)_2$	—	—	2.650	2.650
$CaSO_4$	—	0.770	—	0.770
Urea	0.750	0.750	—	—

[a]-Nitrate = diet containing 0 added nitrate; +Nitrate = diet containing
[b]-Sulf = diet containing 0.54% dietary sulfate; +Sulf = diet containing no added sulfate.
[c]MDGS = modified distillers grains plus solubles.
[d]Supplement formulated to be fed at 6% diet DM and contained Rumensin and Tylan.

ment design using the MIXED procedure of SAS (SAS Institute Inc., Cary, N.C.) with steer as the experimental unit. Methane to carbon dioxide ratio was analyzed using the Autoregressive-1 covariance structure with sampling point as the repeated measure.

Results

Performance

A tendency for a nitrate × sulfate interaction was observed for F:G ($P = 0.09$, Table 2). In diets with no sulfate, the addition of nitrate had no impact on efficiency, but in diets containing both sulfate and nitrate, F:G was decreased. Inclusion of nitrate (NO_3) and sulfate (SO_4) both decreased DMI ($P < 0.01$) and nitrate decreased ADG ($P < 0.01$), while sulfate tended to decrease ADG ($P = 0.07$). Increasing levels up to 2.4% dietary NO_3 (compared to the current study feeding 2.0% dietary NO_3) caused a decrease in DMI but no impact on ADG (2014, *J. Anim. Sci*. 92:5032). Previous work on sulfur at UNL has found that decreased DMI is one of the first signs of sulfur toxicity (*2011 Beef Report*, pp. 68–69; *2011 Beef Report*, pp. 62–64), but that should not have been an issue in the current study as diets were formulated to contain no more than 0.40% total dietary sulfur. These results are also in contrast to previous work which evaluated the interaction between NO_3 and SO_4 (both fed at 2.6% diet DM), where the additives had no deleterious effects on DMI or ADG (2010, *J. Dairy Sci* 93:5856).

The consequence of the depression in DM and ADG due to nitrate was observed in carcass traits, as cattle consuming NO_3 had decreased final BW and HCW ($P = 0.02$) and 12th rib fat thickness and marbling score ($P = 0.03$). Consumption of NO_3 resulted in a 10.4% decrease in ADG with 4.2% lighter carcasses. Sulfate had no effect on carcass characteristics ($P > 0.13$).

Emissions

A tendency for a nitrate × sulfate interaction was observed for CH_4:CO_2 ($P = 0.03$, Table 3). In diets with no sulfate, addition of nitrate had no impact on emissions, but nitrate and sulfate in combination decreased CH_4:CO_2. A tendency for nitrate × sulfate interaction was also observed for L CH_4/kg DMI ($P = 0.09$), in which addition of sulfate in diets with no nitrate had no effect, but nitrate and sulfate together decreased CH_4 production per unit of DMI. No other effects of nitrate or sulfate on CH_4 emissions were observed ($P > 0.14$). These data do not agree with the dramatic depression in CH4 production seen when 2.6% NO_3 and SO_4 were fed to sheep consuming a forage-based diet. In that study, NO_3 and SO_4 decreased CH4 production by 32 and 16%, respectively, and by 47% in combination compared to the control. Contrastingly, in another study feeding a high-concentrate finishing diet, 2.15% dietary nitrate had no impact on CH_4 production. These data, combined with the current study, suggest that the response to NO_3 may be diet-dependent and may be a more promising mitigation strategy in forage-based diets. This is logical considering that the best opportunity for utilizing nitrate as a H+ sink mitigation strategy would be in naturally low-protein diets.

Table 2. Effect of dietary nitrate and sulfate on performance and carcass characteristics of finishing steers

Item	-Nitrate[a]		+Nitrate[a]		SEM	*P*-value[b]		
	−Sulf[c]	+Sulf[c]	−Sulf[c]	+Sulf[c]		Nit	Sulf	Int
Performance								
Initial BW, lb	924	919	915	910	22.9	0.68	0.87	0.97
Final BW, lb[d]	1407	1349	1327	1314	25.4	0.02	0.16	0.40
DMI, lb	26.5	24.9	22.9	21.2	0.4	< 0.01	< 0.01	0.82
ADG, lb	3.68	3.28	3.15	3.09	0.13	< 0.01	0.07	0.21
G:F	0.139[gh]	0.131[h]	0.137[gh]	0.145[g]	0.004	0.17	0.99	0.09
Carcass Characteristics								
HCW, lb	886	851	835	829	16.1	0.02	0.16	0.40
LM area, in[b]	13.5	13.1	12.9	13.2	0.3	0.40	0.83	0.24
12th rib fat, in.	0.55	0.50	0.43	0.44	0.04	0.03	0.60	0.43
Calculated YG[e]	3.40	3.28	3.14	3.03	0.17	0.12	0.50	0.97
Marbling score[f]	496	448	435	425	19.6	0.03	0.13	0.31

[a]–Nitrate = diet containing 0 added nitrate; +Nitrate = diet containing 2.0% dietary nitrate.
[b]*P*-value: Nit = main effect of nitrate, Sulf = main effect of sulfate, Int = effect of interaction between nitrate and sulfate.
[c]+Sulf = diet containing 0.54% dietary sulfate; −Sulf = diet containing no added sulfate.
[d]Calculated as HCW/common dress (63%).
[e]Yield grade (YG) = 2.5 + (6.35 × fat thickness, cm) + (0.2 × 2.5% KPH) + (0.0017 × HCW, kg) − (2.06 × LM area, cm^2) (Boggs and Merkel, 1993).
[f]Marbling score: 400 = Small[00].
[g,h]Means in a row with different superscripts differ ($P < 0.05$)

Table 3. Effect of dietary nitrate and sulfate on methane production and VFA profile of finishing steers

Item	−Nitrate[a]		+Nitrate[b]		SEM	*P*-value[b]		
	−Sulf[c]	+Sulf[c]	−Sulf[c]	+Sulf[c]		Nit	Sulf	Int
CH_4:CO_2	0.044[ef]	0.051[e]	0.047[ef]	0.040[f]	0.003	0.14	0.95	0.03
L CH_4/d[d]	206	230	205	194	17.9	0.27	0.72	0.30
L CO_2/d[d]	4591	4569	4554	4572	199.7	0.93	0.99	0.91
L CH_4/lb DMI[4]	8.21[ef]	8.75[ef]	9.53[e]	8.03[f]	0.65	0.42	0.61	0.09
L CH_4/lb ADG[d]	58.4	66.6	72.3	64.1	7.08	0.99	0.39	0.22

[a]–Nitrate = diet containing 0 added nitrate; +Nitrate = diet containing 2.0% dietary nitrate.
[b]*P*-value: Nit = main effect of nitrate, Sulf = main effect of sulfate, Int = effect of interaction between nitrate and sulfate.
[c]+Sulf = diet containing 0.54% dietary sulfate; −Sulf = diet containing no added sulfate.
[d]Values were calculated using equation of Madsen et al., 2010.
[e,f] Means in a row with different superscripts are different ($P < 0.10$).

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

Allison L. Knoell, Christopher L. Anderson, Anna C. Pesta, Galen E. Erickson, Terry J. Klopfenstein, and Samodha C. Fernando

Summary

To understand the relationships between diet, microbial community, and methane production cattle were esophageally tubed when fed a common diet and again during feeding of six treatment diets. Microbial community analysis via 16S tag sequencing, displayed structuring of microbial communities (Bacteria and Archaea) by diet. This study demonstrates that the diets tested altered the microbial community from the common diet but had no effect ($P > 0.05$) between dietary treatments used in the study. While the microbial community changed from the common diet to the treatments was observed, an alteration in microbial community or methane production was not observed due to fat source.

Introduction

Rumen microbes ferment low quality, cellulose rich feeds and provide the ruminant animal with energy. Products of the fermentation process consist of volatile fatty acids, which are used for energy by the animal, and methane, an unusable form of energy that is expired by the ruminant animal.

Methane is produced by a group of organisms that inhabit the rumen known as methanogens that belong to the kingdom Archaea. Little is known about this group of microorganisms but their end-product of fermentation (i.e., methane) does contribute to atmospheric greenhouse gas emissions.

The microbial community within the rumen is dictated by the composition of the diet and changes in dietary factors lead to changes in the microbial community. Thus, dietary intervention can be used to reduce methane from cattle by changing the rumen microbial community composition. Dietary intervention strategies for mitigation of methane are being explored (*2015 Nebraska Beef Cattle Report*, pp. 105–107). Understanding the relationship between diet, methane, and microbial community will help identify microbial species associated with methane and to develop new intervention strategies for methane mitigation. The purpose of this study was to identify the effect of fat source on microbial community composition, and to understand how fat source affects methane emissions in finishing cattle.

Procedure

A 125-d finishing study was conducted during the summer of 2013 to identify the effect of fat source on methane production and microbial community composition. Rumen samples were collected by esophageal tubing from 60 steers on a common diet containing 50% alfalfa and 50% Sweet Bran®. The cattle were then assigned randomly to one of six treatments diets (10 steers/treatment). Treatments consisted of a corn-based control with no added fat, 50% modified distillers grains plus solubles (MDGS), and two additional corn-based diets with either 3% corn oil or 3% tallow. These four diets all contained monensin (Rumensin, Elanco Animal Health) at 30 g/ton (DM basis). Two additional treatments that include a corn control and 50% MDGS without monensin (*2015 Beef Cattle Report*, pp. 105–107) were included to test for the effect of monensin. The animals were esophageally tubed to evaluate microbial community composition. The rumen samples were collected and placed in liquid Nitrogen to snap freeze the rumen sample instantly and inhibit continued microbial growth. Microbial DNA was extracted and purified from all rumen samples utilizing the MoBio PowerMag Soil DNA Isolation Kit (Carlsbad, California). The V3 hypervariable region of the 16S rRNA gene from the rumen eubacterial community and the V6 region of the 16S rRNA gene from the rumen archaea communities were amplified using the polymerase chain reaction (PCR). Following PCR, the resulting amplicons were sequenced using the Ion Torrent Personal Genome Machine (PGM). The sequence reads generated were analyzed using published Bioinformatic pipelines UPARSE (http://drive5.com/uparse/, Edgar, 2013) and QIIME (qiime.org/). Statistical analysis was performed using the phantom package within Matlab.

Results

The common diet was used as a baseline for comparison of methane and microbial community composition on the treatment diets. When animals are shifted from the common diet to treatment diets, microbial communities changed displaying that diet influences rumen microbial community composition. However there was no shift in the bacterial and archaeal community due to fat source. (Figure 1 and 2).

The diets utilized in this study displayed no change in microbial community structure due to oil and fat additions. These diets did not provide an opportunity to control the microbial community composition to reduce methane emissions in cattle. However, continued research is needed to find other dietary factors that may impact methane production negatively in the finishing phase and aid in developing management based mitigation strategies without impacting animal performance.

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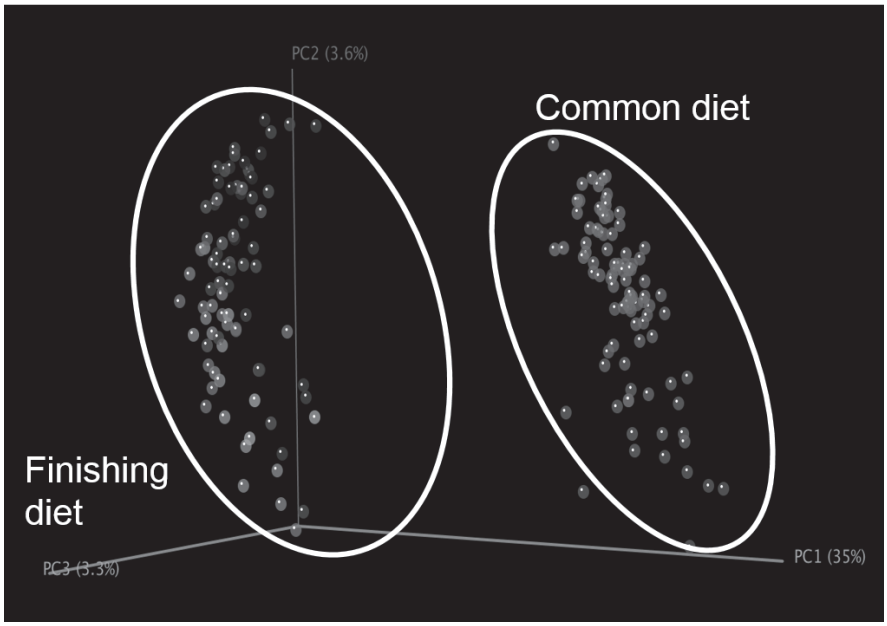


Figure 1. Bacterial community composition—shift from common to treatment diets but no dietary shift due to fat source with finishing treatment diets.

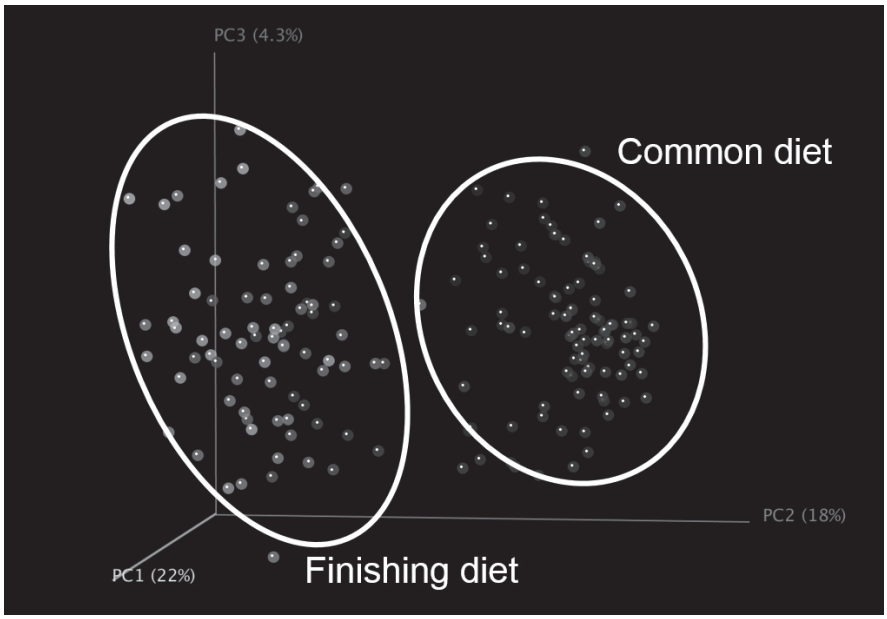


Figure 2. Archaeal community composition—shift from common to treatment diets but no dietary shift due to fat source with finishing treatment diets.

Effect of Feeding De-oiled Dry Distillers Grains Plus Solubles on Beef Oxidation, Color and Tenderness

Keni E. Z. Nubiato, Katherine I. Domenech, Galen E. Erickson and Chris R. Calkins

Summary

Cattle fed a de-oiled dry distillers grains plus solubles (DDGS) diet (50% DM basis) were compared to cattle fed a corn-based control diet to determine effects on discoloration, oxidation, color, and tenderness of beef aged for 2, 8, 14 and 21 days. Dietary treatment had no effect on tenderness. From the fourth day of retail display, beef from animals fed de-oiled DDGS had greater lipid oxidation and greater percentages of discoloration. The de-oiled DDGS treatment also showed greater discoloration after 21 days of aging. While feeding de-oiled DDGS did not impact lipid oxidation at 2, 8 and 14 days of aging, at 21 days of aging, meat from cattle fed de-oiled DDGS had greater oxidation in comparison to a corn-based diet.

Introduction

Color is the first aspect taken into consideration by consumers while purchasing meat. Lipid oxidation of meat causes unwanted off-flavors that are typically accompanied with brown discoloration, affecting the purchasing decision. Following the aging process, lipid oxidation occurs more readily, exacerbating potential issues to consumers.

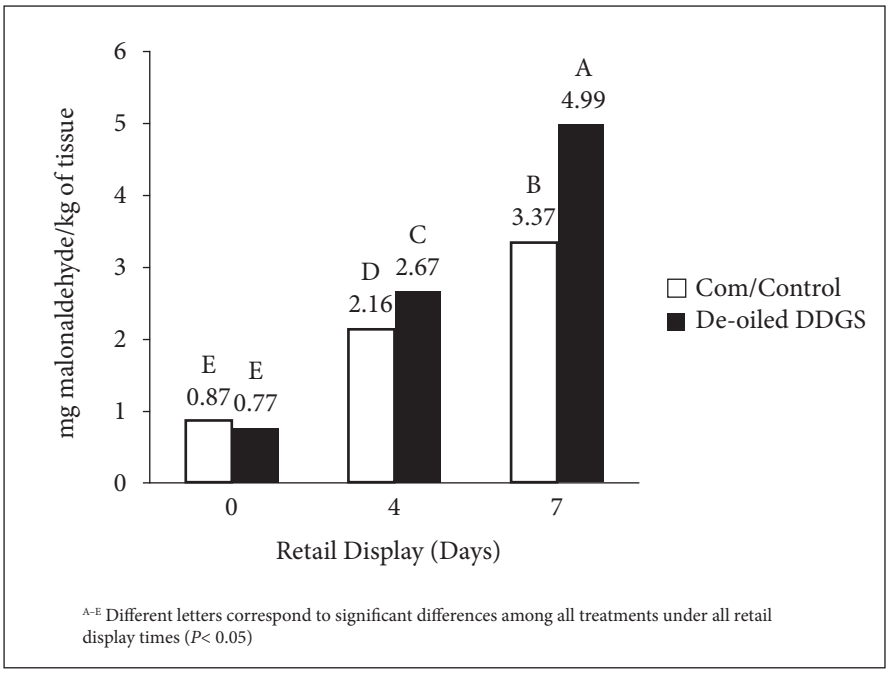
In an effort to maximize revenues of by-products, the ethanol industry is currently extracting a fraction of the oil found in distillers grains and has generated de-oiled distillers available for cattle feed. A previous study at the University of Nebraska-Lincoln evaluated the effects of de-oiled wet distillers grians plus solubles (WDGS) versus a traditional full-fat WDGS diet and a corn-based diet on lipid oxidation and beef shelf-life. With prolonged aging, de-oiled WDGS reduced lipid oxidation (2014 Nebraska Beef Cattle Report, pp. 114–115). It is unknown whether dry distillers grains plus solubles (DDGS) would also decrease lipid oxidation in comparison to a corn-based diet. Thus, the objective of this research was to determine the effect of feeding de-oiled DDGS on retail shelf-life, oxidation, color and tenderness after aging compared to a corn-based diet.

Procedure

Steers (n = 48) were fed one of two dietary treatments: a corn-based control diet (50% dry-rolled corn, DM basis) and a 50% dietary inclusion (DM basis) of de-oiled DDGS (dietary formulations can be found in the 2016 Nebraska Beef Cattle Report, pp. 128–31) After slaughter, the strip loins from the right and left sides of the carcasses were collected. Vacuum sealed loins were aged for 2, 8, 14 and 21 days (33°F). At two days of aging part of the loins were fabricated into 1-inch steaks for visual discoloration, color and tenderness and ½-inch steaks for thiobarbituric acid reactive substances (TBARS), a measure of lipid oxidation. The remaining portions of the loins were vacuum sealed and aged for to 8, 14 or 21 days at which point the fabrication process was repeated. At all aging periods, the steaks were placed in foam trays and overwrapped with oxygen permeable film and placed in retail display (37°F) for seven days. At the same time, objective color measurements were collected each day for all seven days. Steaks at day 0 of retail display were immediately vacuum packed and stored in an ultra-low freezer (−112°F) until analysis.

Visual Discoloration (discoloration score, %)

Visual discoloration was assessed daily for all samples placed in retail display. A trained panel of 6 people evaluated the percentage of discoloration, where 0% meant no discoloration and 100% meant complete discoloration.



A-E Different letters correspond to significant differences among all treatments under all retail display times ($P < 0.05$)

Figure 1. Lipid oxidation (TBARS) interaction of dietary treatment and retail display days from strip steaks placed under retail conditions (P < 0.0001).

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

Objective color measurements were collected each day for seven days with a Minolta Chromameter CR-400 (Minolta Camera Company, Osaka, Japan) with an 8 mm diameter illumination area, illuminant D65 and 2° standard observer, L* (brightness), a* (redness) and b* (blue to yellow).

Lipid Oxidation (TBARS)

Frozen samples were cut into small pieces, with no subcutaneous fat, and frozen in liquid nitrogen. Then, the pieces were powdered in a blender and 5 g of powdered sample was weighed to conduct the TBARS protocol.

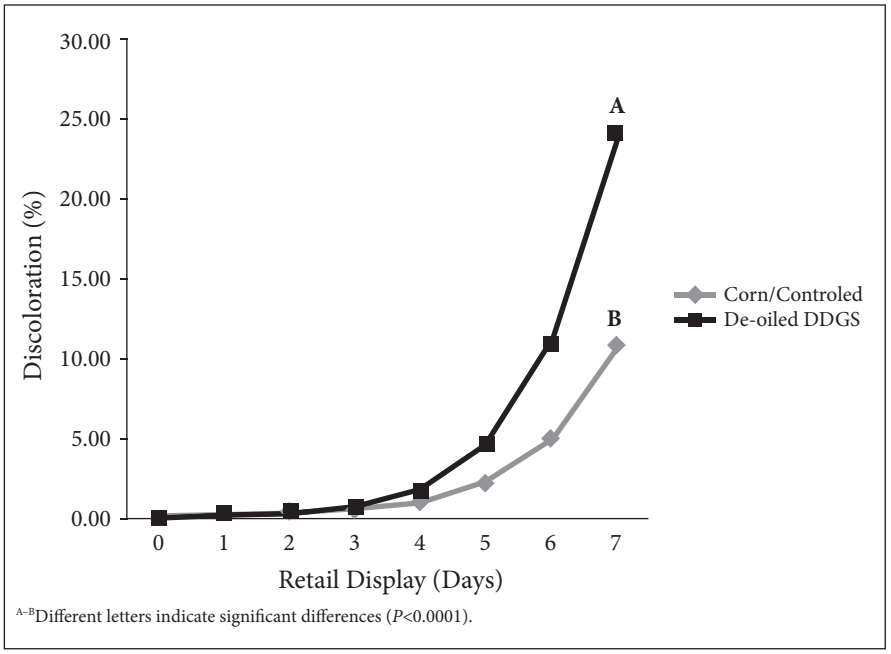
Tenderness (Warner-Bratzler Shear Force—WBSF)

The frozen steaks were defrosted for 24 hours (33°F) and a thermocouple was placed in the geometric center of each steak. The steaks were grilled on Hamilton Beach grills until they reached an internal temperature of 160°F (grilled on one side until 95°F and turned to finish grilling). The grilled steaks were placed on plastic trays and covered with plastic film and kept in a cooler for 24 hours (33°F). Then, six cores were taken on parallel direction to the muscle fiber of each steak and sheared to determine tenderness.

Statistical analysis was performed using the Proc Glimmix procedure in SAS (SAS Institute, Inc., Cary, N.C.) to test the effects of dietary treatment, aging period, and days of retail display and their interactions. Repeated measures were used to analyze the discoloration and color data and all means were separated with the LS MEANS statement and the TUKEY adjustment with an 0.05 alpha level.

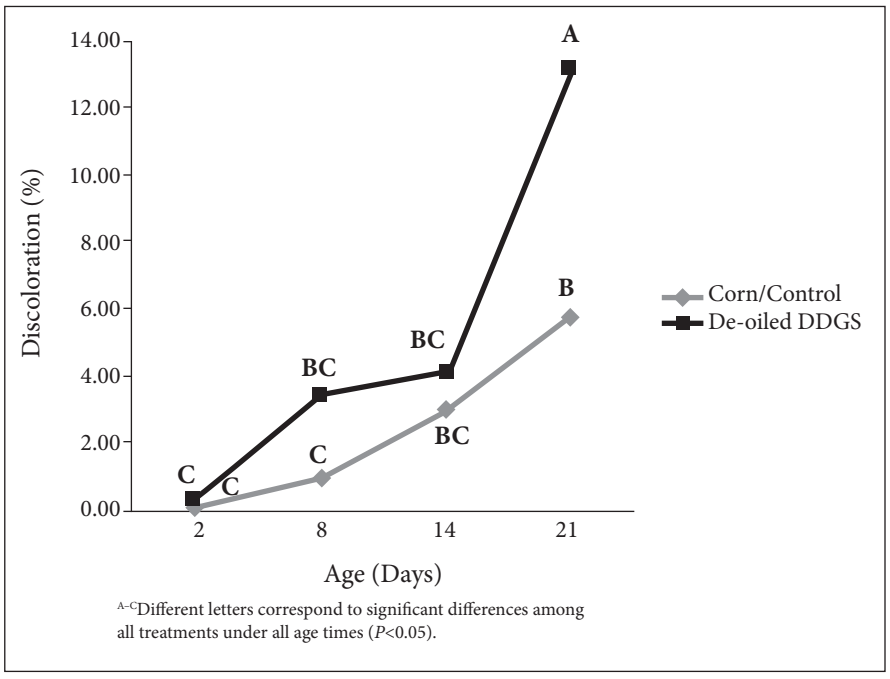
Results

For all variables analyzed, there were significant aging by retail display interactions ($P < 0.05$) meaning that as retail display time progressed at different aging time points, responses varied according to dietary treatments. A significant retail display by treatment interaction was found for TBARS, a*, b*, and discoloration. These interactions between retail display and



[A–B]Different letters indicate significant differences ($P<0.0001$).

Figure 2. Discoloration (%) of strip loin steaks (L. dorsi) placed under retail display according to dietary treatment and retail display days across all aging times.



[A–C]Different letters correspond to significant differences among all treatments under all age times ($P<0.05$).

Figure 3. Discoloration (%) of strip loin steaks (L. dorsi) placed under retail display according to dietary treatment and aging period.

dietary treatment indicate that samples did not have similar responses at different aging time points and the most relevant interactions are discussed below. Tenderness was not affected due to dietary treatment nor were there any interactions of treatment by aging or treatment by retail display affecting meat tenderness ($P > 0.05$).

On days 4 and 7 of retail display, meat from cattle finished with de-oiled DDGS showed greater oxidation, characterized by greater TBARS values (Figure 1). This difference in oxidation level was not observed at day 0 of retail display. In general, meat from animals fed with de-oiled DDGS showed higher concentrations of malonaldehyde mg / kg of tissue versus meat from cattle finished on the corn-based diet (2.81 vs. 2.14, respectively; $P < 0.0001$).

Similar to the increase in lipid oxidation, steaks from cattle fed de-oiled DDGS discolored at a greater rate and extent (Figure 2). In agreement with these results, samples from cattle fed de-oiled DDGS treatment also had steaks with greater visual discoloration and lower objective color scores (L *, a * and b *; data not shown).

There was a significant interaction between days of aging and dietary treatment, where at 2, 8, and 14 days of aging, discoloration was not different due to diet but at 21 days of aging steaks from cattle fed de-oiled DDGS presented greater discoloration than steaks from cattle fed the corn control treatment (Figure 3).

Feeding de-oiled DDGS resulted in increased oxidation and discoloration of strip steaks under prolonged aging when compared to steaks from cattle on a corn-based control diet. Removal of fat in DDGS does not appear to aleviate concerns over the retail shelf-life or lipid oxidation of beef.

Acknowledgement

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Beef Fatty Acid Profiles from Steers Finished with De-oiled Dry Distillers Grains Plus Solubles vs. a Corn-Based Diet

Katherine I. Domenech, Keni E. Z. Nubito, Galen E. Erickson and Chris R. Calkins

Summary

A total of 128 steers were fed one of two finishing diets: 50% de-oiled dry distillers grains plus solubles (DDGS) or a corn-based control diet. Carcasses (n = 48) were selected to evaluate the effect of diet on the fatty acid profile of strip loin steaks. The C15:0, C16:1, C17:0, and C17:1 were greater for beef from steers finished on the corn-based control diet while the C18:1T, C18:2, C20:3ω6, total trans, ω6 and polyunsaturated fatty acids (PUFA) were greater in beef from cattle finished on 50% de-oiled DDGS. These findings confirm that feeding distillers grains plus solubles (be it wet or dry) increases the amount of PUFA's in meat.

Introduction

The constant evolution of the ethanol industry to maximize by-products results in numerous modified versions of distillers grains available for cattle that merit evaluation in terms of cattle performance and meat quality. Recently, ethanol plants have been extracting soluble fats found in distillers grains by centrifugation for other uses (2011 *Nebraska Beef Cattle Report*, pp. 96–99). Previous research evaluated the impact of feeding de-oiled wet distillers grains plus solubles (WDGS) vs. full-fat WDGS or a corn-based control diet and have determined that the reduction in soluble fat of the feed decreases the total polyunsaturated fatty acid content of beef compared to the full-fat WDGS (2014 *Nebraska Beef Cattle Report*, pp. 116–118). The objective of this study is to determine if there are any meaningful changes in beef fatty acid profiles associated with feeding de-oiled dry distillers grains compared to a corn-based control diet.

Procedure

A total of 128 crossbred steers were fed one of two dietary treatments with eight replications per treatment. Steers were sorted based on initial body weight and grouped eight to a pen. Steers received an initial implant with Ralgro® followed by a Revalor®200 implant. All diets were formulated on a dry matter basis using high-moisture corn (31.5%), alfalfa hay (5.5%), corn silage (4%), molasses (5%), and supplement (5%) containing Rumensin® (30 g/ton) and Tylan® (90 mg/steer/day). Feeding treatments were 50% dry-rolled corn or 50% de-oiled dry distillers grains plus solubles (DDGS; DM basis). After harvest, 24 USDA low Choice carcasses were selected within each treatment (n = 48) and strip loins were obtained. Vacuum sealed loins were transported on the day of collection (2 day post-mortem) to the Loeffel Meat Laboratory where ½-inch steaks were fabricated, immediately vacuum packed, and stored in an ultralow-freezer (−112°F) for fatty acid determination and proximate analysis.

Fatty acid profile

Frozen samples were diced into small pieces, with no subcutaneous fat, and flash frozen in liquid nitrogen. The frozen pieces were powdered in a metal cup blender and 1 g of powdered sample was weighed out to conduct fatty acid determination by gas chromatography. The chromatography was done using a Chromopack CP-Sil (0.25 mm × 100 m) column with an injector temperature of 518°F and a detector temperature of 572°F. The head pressure was set at 40 psi with a flow rate of 1.0 ml/min and a temperature programing system was used. The fatty acids were identified by their retention times in relation to known standards and the percent of fatty acid was determined by the peak area under the curve in the chromatograph.

Proximate analysis

Fat was extracted with ether following the Soxhlet extraction procedure. Moisture and ash were determined by using the LECO thermogravimetric analyzer. Fat, moisture and ash percentages were added and subtracted from 100% to determine the amount of protein by difference. Fat content determined with proximate analysis was used to convert fatty acid composition from a percentage basis to mg/100 g tissue for each individual sample.

Statistical analysis

Data were analyzed using the PROC GLIMMIX procedure in SAS (SAS Inst., Inc., Cary, N.C.) where the effect of dietary treatment was evaluated and mean separation was done with the LSMEANS statement with the LINES option and TUKEY adjustment with an alpha level of 0.05. Tendencies were considered with an alpha of 0.10.

Results

The proximate analysis data (not shown) reflected that there were no differences in moisture ($P = 0.78$), fat ($P = 0.34$), protein ($P = 0.10$), or ash ($P = 0.27$) content in the beef from the two dietary treatments. The overall averages for the nutritional constituents were: 72.08% moisture, 7.31% fat, 19.31% protein, and 1.31% ash.

Table 1 provides the fatty acid profiles of each dietary treatment. Differences ($P < 0.05$) were found in the C15:0, C16:1, C17:0, C17:1, C18:1T, C18:2, C20:3ω6, as well as total trans, ω6, and polyunsaturated fatty acids (PUFA).

No differences were seen in the amounts of monounsaturated fatty acids (MUFA), saturated fatty acids (SFA), unsaturated fatty acids (UFA), SFA:UFA relation, ω3, ω6:ω3 relation, or the total amount of fatty acids.

The shorter carbon chain fatty acids (C15:0, C16:1, C17:0, and C17:1) were

Table 1. Fatty acid[a] composition of beef from cattle finished on de-oiled DDGS vs. a corn-based control diet (L. dorsi)

Fatty acid	De-oiled DDGS	Corn Control	*SEM*	*P*-value
C4:0	4.59	25.41	20.78	0.3551
C10:0	5.53	4.79	0.73	0.3273
C12:0	5.28	4.93	0.69	0.6221
C14:0	179.94	187.25	12.93	0.5751
C14:1	45.24	46.01	3.84	0.8425
C15:0	30.58[c]	37.68[b]	2.48	0.0066
C15:1	37.96	38.55	2.31	0.8006
C16:0	1736.43	1841.70	103.22	0.3139
C16:1T	22.54	22.87	1.86	0.8574
C16:1	175.89[c]	216.31[b]	13.01	0.0035
C17:0	83.12[c]	116.92[b]	8.36	0.0002
C17:1	56.57[c]	90.51[b]	5.47	< 0.0001
C18:0	1044.80	1033.62	72.97	0.8790
C18:1T	191.80[b]	128.91[c]	18.03	0.0012
C18:1	2647.65	2920.66	145.55	0.0680
C18:1V	514.33	452.46	38.91	0.1197
C18:2TT	12.28	11.56	3.6962	0.8488
C19:0	9.08	9.12	1.2582	0.9730
C18:2	389.39[b]	194.79[c]	14.74	< 0.0001
C18:3ω6	7.87	6.31	0.75	0.0538
C18:3ω3	30.75	26.12	4.23	0.2811
C20:1	15.09	17.48	3.71	0.5273
C20:3ω6	18.77[b]	15.48[c]	1.14	0.0064
C20:4ω6	55.15	50.76	3.62	0.2317
C22:4	10.86	11.17	0.82	0.7067
C22:5	9.84	10.79	1.11	0.4055
Total	**7281.87**	**7461.55**	**358.63**	**0.6191**
Other	66.04	67.03	6.36	0.8768
SFA	3081.63	3231.64	185.24	0.4228
UFA	4200.25	4229.91	192.46	0.8783
SFA:UFA	0.73	0.76	0.03	0.2282
MUFA	3676.23	3904.54	178.11	0.2073
PUFA	509.37[b]	304.57[c]	21.49	< 0.0001
Trans	210.13[b]	152.86[c]	20.26	0.0073
ω6	77.07[b]	67.70[c]	4.59	0.0480
ω3	30.75	26.12	4.23	0.2811
ω6:ω3	3.00	3.97	0.82	0.2431

[a]Amount (mg/100g tissue) of fatty acid in powdered loin sample determined by gas chromatography
[bc]Means in the same row with different superscripts are different ($P < 0.05$)

found to be greater for beef from steers finished on the corn-based control diet in comparison to those finished with 50% de-oiled DDGS. A previous study evaluating de-oiled wet distillers grains plus solubles (WDGS) vs. a corn-based control diet also observed greater C16:1 content in the corn-based control diet; however, no differences in C15:0, C17:0, and C 17:1 had been noted due to the feeding of de-oiled WDGS.

Longer chain fatty acids on the other hand (C18:1T, C18:2, C20:3ω6), were found to be in greater amounts in beef from cattle finished on 50% de-oiled DDGS. The most notable difference was seen with C18:2 where beef from cattle finished on 50% de-oiled DDGS had double the amount of C18:2 than the cattle on the control diet (389.39 mg/100 g tissue vs. 194.79 mg/100 g tissue, respectively). The increase in C18:1T and C18:2 had also been reported previously with finishing diets containing 50 and 65% de-oiled WDGS.

Additionally, beef from cattle finished with de-oiled DDGS also presented greater total trans (210.13 mg/100 g tissue vs. 152.86 mg/100 g tissue), ω6 (77.07 mg/100 g tissue vs. 67.70 mg/100 g tissue) and PUFA (509.37 mg/100 g tissue vs. 304.57 mg/100 g tissue) content in comparison to the control diet.

Although not statistically significant, C18:1 tended ($P = 0.0680$) to be greater for the control fed cattle (2920.66 mg/100g tissue vs. 2647.65 mg/100 g tissue) while C18:3ω6 tended ($P = 0.0538$) to be greater for the cattle finished on DDGS (7.87 mg/100 g tissue vs. 6.31 mg/100 g tissue).

These findings confirm that feeding distillers grains plus solubles, be it wet or dry, increase the amount of PUFA's in meat. Even considering the fact that de-oiled distillers grains are effective at reducing the PUFA content of muscle in relation or full-fat distillers grains, the increase in PUFA content associated with the use of distillers grains supports the use of pre or post-mortem antioxidants to counteract potential detrimental effects of lipid oxidation on beef shelf-life.

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Effect of Feeding Dried De-oiled Distillers Grains and Addition of Postmortem Antioxidants on Ground Beef Shelf Life

Jenae C. Martin, Brandy D. Cleveland, Tommi F. Jones, James C. MacDonald and Gary A. Sullivan

Summary

Ground beef patties from cattle fed either corn based diets with no distillers grains (control) or dried, de-oiled distillers grains (DDDG) during the finishing phase were compared to analyze color stability during retail display. As display time increased, patties with added antioxidant had less discoloration than those without antioxidant. Patties from cattle fed DDDG had the greatest discoloration when no antioxidant was included. Both raw and cooked ground beef from cattle fed DDDG had increased lipid oxidation towards the end of display than beef from corn-finished cattle. Furthermore, corn-finished cattle had lower concentrations of C18:2 in both composite and subcutaneous fat samples. Finishing cattle on DDDG resulted in reduced shelf life in raw and cooked ground beef. The addition of antioxidants to raw ground beef improved color stability regardless of diet.

Introduction

As processing of distillers grains evolves, reevaluation of the effects on shelf life is necessary. In an effort to maximize value during ethanol processing, some processors have begun removing oil by centrifugation (30–40% of total oil content, DM basis). Dried de-oiled distillers grains are one current form of ethanol co-products for feeding cattle. Cattle fed ethanol co-products have an increase in concentrations of polyunsaturated fatty acids (PUFA; *2015 Nebraska Beef Cattle Report, pp. 122–123*). The increase in PUFA may cause greater susceptibility to lipid oxidation and decreased shelf life, as lipid oxidation occurs most readily in polyunsaturated fatty acids. Raw ground beef patties from cattle fed ethanol co-products has been shown to discolor at a greater rate (*2014 Nebraska Beef Cattle Report. pp. 105–106*). Lipid oxidation and off-flavor development after cooking is accelerated due to the release of iron, free and heme-bound, from myoglobin during cooking. Lipid oxidation has been related to reduced shelf life and decreased overall desirability of the product because of evidence of "warmed over" or "rancid" flavors. The addition of plant extracts, such as cherry, rosemary and green tea, to fresh meats is becoming increasingly popular in meat processing as a natural antioxidant to increase shelf life of meat products. Previous studies have shown the effectiveness of natural plant extracts reducing lipid oxidation in cooked beef links from cattle fed distillers grains (*2015 Nebraska Beef Cattle Report, pp. 122–123*) but have none have investigated the impacts in raw ground beef. Therefore, the objective of this study was to evaluate the impact of feeding dried de-oiled distillers grains during the finishing phase on raw and cooked ground beef and determine the impact of added antioxidants on shelf life of raw ground beef.

Procedure

Cattle (n = 96) were randomly assigned to one of two finishing diets; corn (control) or dried, deoiled distillers grains (DDDG, 50% DM Basis). Cattle were harvested at a commercial abattoir. Forty-eight h postharvest, 7 USDA Choice beef shoulder clods from each dietary treatment group were collected from the right side of carcasses and vacuum packaged. On d 14 postmortem, lean, subcutaneous fat, and ground composite samples were collected from each shoulder clod for fatty acid composition and proximate composition. Each shoulder clod was independently ground. Twelve 4 oz patties (hand operated hamburger press) per shoulder clod were overwrapped with permeable oxygen wrap and placed under simulated retail display for 7 d. Six patties contained 0.2% cherry, rosemary, and green tea natural plant extract (ARGT 101 Dry, Kemin Industries, Des Moines, IA) and six had no added antioxidant. During retail display, percent discoloration (7 person panel) and objective color (L* a* b*) were evaluated on d 0, 1, 2, 3, 4, 5, 6, and 7. Samples under retail display were collected at d 0, 1, 2, 3, 5 and 7 for thiobarbituric acid reactive substances (TBARS) analysis.

For the cooked portion of the study, a 5 lb sample from each shoulder clod and non-meat ingredients (0.75% salt, 0.25% phosphate) were mixed for 1 min and

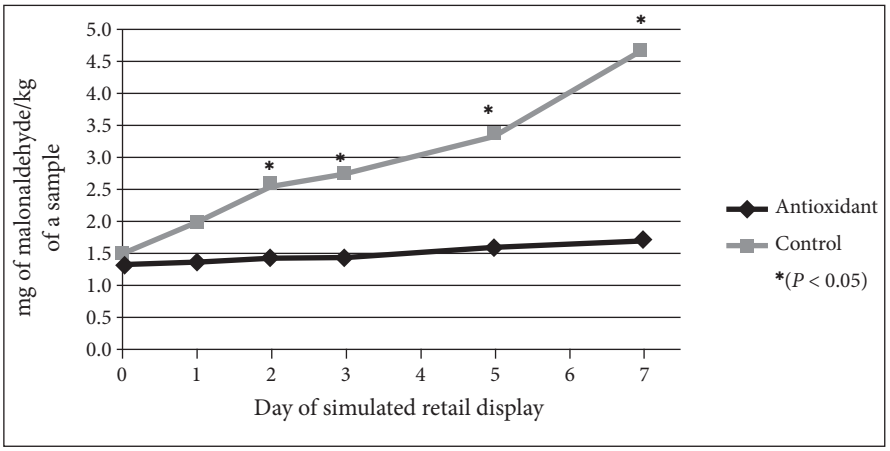

Figure 1. Effect of addition of antioxidant (0.0 or 0.2% added rosemary, green tea, and cherry natural plant extract) on the lipid oxidation (mg of malonaldehyde/kg of sample) in raw ground beef patties throughout simulated retail display. SE=0.22

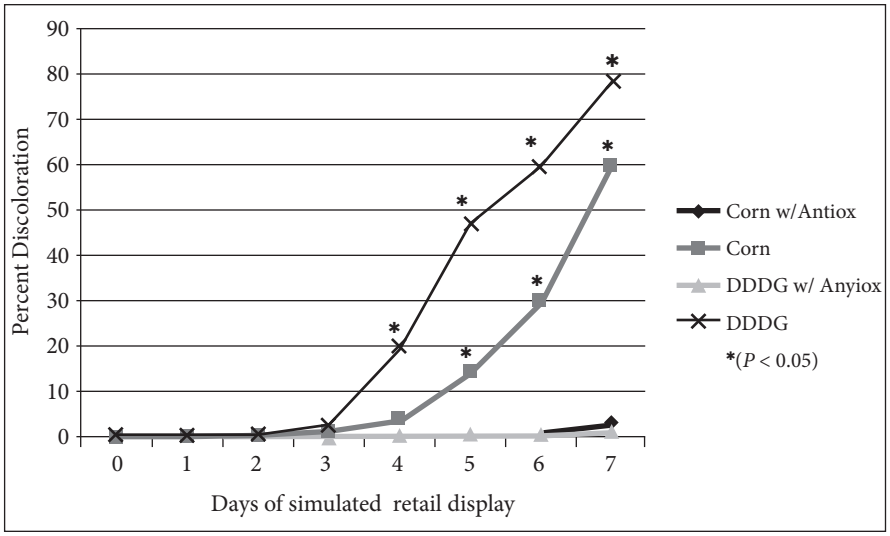

Figure 2. Effect of dried de-oiled distillers grains (DDDG) inclusion (0% or 50% DM basis) and the addition of antioxidant (0.0 or 0.2% added rosemary, green tea, and cherry natural plant extract) on the percent discoloration in raw ground beef patties throughout simulated retail display. SE=4.47

Table 1. Effects of feeding deoiled distillers grain (DDDG) during finishing and adding antioxidants, rosemary, green tea, and cherry natural plant extract, to ground beef on redness (a*) of raw beef patties during retail display.

Day	Diet			
	Corn		DDDG	
	Antioxidant			
	Yes	No	Yes	No
0	26.09[a]	26.39[a]	25.96[a]	27.70[a]
1	22.00[bc]	21.25[bcde]	21.51[bcd]	22.73[b]
2	21.00[bcde]	21.09[bcde]	21.75[bc]	20.83[cde]
3	21.19[bcde]	19.72[ef]	21.31[bcde]	18.74[fg]
4	20.98[bcde]	17.54[g]	20.64[cde]	15.24[h]
5	20.47[cdef]	15.04[h]	20.28[cdef]	12.30[i]
6	19.79[ef]	12.51[i]	20.09[def]	9.62[j]
7	17.88[g]	9.59[j]	19.01[fg]	7.78[k]

[a-k]Means within the table lacking a common superscript are significantly different ($P \leq 0.05$)

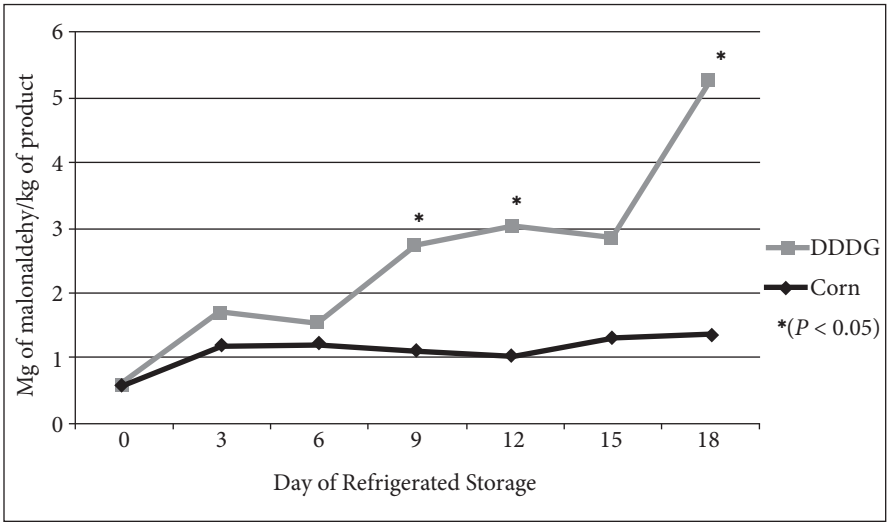

Figure 3. Effect of finishing diet of dried de-oiled distillers grain (DDDG, 50% DM Basis) or corn (0% DDDG) on lipid oxidation (mg of malonaldehyde/kg of sample) in cooked beef links throughout refrigerated storage. SE=0.54

stuffed into skinless links using a piston stuffer. Links were placed in foil trays and cooked to an internal temperature of 160 °F. Links were placed in zip- top bags and placed in dark refrigerated storage. Lipid oxidation was evaluated on d 0, 3, 6, 9, 12, 15, and 18 of refrigerated storage for TBARS analysis. Data were analyzed by treatment (diet for cooked links and diet, antioxidant, and diet × antioxidant interaction for raw patties) with repeated measures (day) utilizing the PROC GLIMMIX procedures of SAS.

Results

For raw patty TBARS, there was an antioxidant × day interaction ($P \leq 0.001$; Figure 1), patties with antioxidant addition had lower TBARS concentrations on d 2, 3, 5 and 7 ($P \leq 0.001$) than patties with no antioxidant inclusion. No dietary effects were observed ($P = 0.925$). Percent discoloration had an antioxidant × diet × day interaction (P=0.008; Figure 2) where patties with antioxidant had less discoloration than those without antioxidant. Patties from cattle fed DDDG had greater discoloration when no antioxidants were added. An antioxidant × diet × day interaction ($P = 0.036$) was observed for a* (redness; Table 1). Patties with antioxidant had higher a* values than those without antioxidant, and patties with no antioxidant inclusion from cattle fed DDDG had lower a* values than patties from cattle fed corn on day 4 and beyond. Patties from treatments that retained greater redness also had less discoloration. For b* values (yellowness), main effects were observed for both antioxidant and time (P= 0.009 and 0.017, respectively; data not shown), where b* values linearly decreased over time. The inclusion of antioxidants resulted in patties with greater b* values.

For fatty acid composition (Table 2), C18:2 was significantly greater in composite and fat samples from DDDG than the corn control ($P < 0.0001$). Additionally, cattle finished on DDDG had higher polyunsaturated fatty acids (PUFA) than cattle finished on corn in composite samples ($P = 0.043$). For lipid oxidation in cooked links, a treatment × day interaction was observed ($P = 0.007$; Figure 3), where cattle fed DDDG had greater TBARS concentrations on d 9, 12 and 18 ($P = 0.042$, 0.013 and < 0.0001, respectively), with a tendency to

have greater TBARS values on d 15 (P = 0.055). Therefore, raw patties from cattle finished on DDDG were more discolored over time than patties from cattle finished on corn, and the addition of antioxidants masked any dietary effects. Cooked links from cattle finished on DDDG were more oxidized with extended refrigerated storage than links from cattle finished on corn. Moreover, subcutaneous fat and composite samples from cattle finished on DDDG had higher concentrations of C18:2.

Feeding deoiled distillers grain during finishing resulted raw ground beef that was more discolored and less red and cooked ground beef links with greater lipid oxidation. The addition of antioxidant, rosemary, green tea, and cherry natural plant extract, resulted in in raw ground with improved color stability and less lipid oxidation.

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Table 2. Effect of feeding dried de-oiled distillers grains on fatty acid composition (mg/100g raw sample) on shoulder clod composite, lean and subcutaneous fat samples

Composite	Corn[d]	DDDG[e]	P value
C15:0 (mg/100g)	110.3[f]	84.7[g]	0.010
C16:1 (mg/100g)	662.6[f]	522.1[g]	0.005
C17:0 (mg/100g)	314.4[f]	210.4[g]	0.004
C17:1 (mg/100g)	289.2[f]	160.1[g]	< 0.001
C18:1T (mg/100g)	391.6[g]	608.4[f]	< 0.001
C18:1V (mg/100g)	373.9[f]	247.6[g]	0.003
C18:2 (mg/100g)	443.8[g]	940.9[f]	< 0.001
C20:2 (mg/100g)	5.9[g]	12.8[f]	0.001
C18:3w3 (mg/100g)	20.0[g]	32.1[f]	0.006
PUFA[a] (mg/100g)	1521.0[g]	1929.0[f]	0.044
Lean	Corn[d]	DDDG[e]	P value
C14:1 (mg/100g)	84.4[f]	34.1[g]	0.025
C17:0 (mg/100g)	120.2[f]	46.0[g]	0.048
C19:0 (mg/100g)	6.4	5.2	0.100
SFA[b] (mg/100g)	3257	1666	0.087
Fat	Corn[d]	DDDG[e]	P value
C15:0 (mg/100g)	558.5[f]	452.0[g]	0.026
C16:1 (mg/100g)	4690[f]	3503[g]	0.050
C17:0 (mg/100g)	1365[f]	1049[f]	0.061
C17:1 (mg/100g)	1812[f]	1009[g]	0.002
C18:0 (mg/100g)	8018[g]	10348[f]	0.045
C18:1T (mg/100g)	1777[g]	3220[f]	0.001
C18:1V (mg/100g)	2397[f]	1494[g]	0.018
C18:2 (mg/100g)	1225[g]	3883[f]	< 0.001
C19:0 (mg/100g)	123.0[g]	193.7[f]	0.001
C20:1 (mg/100g)	650.8[g]	816.5[f]	0.036
C22:0 (mg/100g)	49.5[g]	84.1[f]	0.016
C18:3w3 (mg/100g)	79.0[g]	167.3[f]	< 0.001
SFA[b] (mg/100g)	34932	38829	0.097
UFA[c] (mg/100g)	63461	59296	0.106

[a]Polyunsaturated Fatty Acids:
[b]Saturated Fatty Acids:
[c]Unsaturated Fatty Acids:
[d]Corn control diet
[e]Dried De-oiled Distillers Grain Diet
[f-g]Means within a row lacking common a superscript are significantly different (P ≤ 0.05)

Impact of Supplementing Cattle with OmniGen-AF at the Receiving or Finishing Phase on Beef Shelf-Life

Katherine I. Domenech, Michael D. Chao, Joe Buntyn, Ty Schmidt and Chris R. Calkins

Summary

A patented proprietary product, OmniGen-AF, was evaluated to extend beef steak shelf-life at 8, 22 and 29 days of aging. The three treatment groups included a control group with no supplementation, OmniGen-AF supplementation for28 d after receiving, and supplementation for 210 d during finishing. The inclusion of OmniGen-AF had no effect on tenderness or visual discoloration under retail display conditions and minimal effects on fatty acid composition. Although color stability seemed to be unaffected by the supplementation, feeding OmniGen-AF throughout the entire feeding period tended to decrease oxidation. Supplementing cattle with a greater concentration of OmniGen-AF or increasing the antioxidant components in the feed supplement could be explored to further maximize beef shelf-life following long periods of aging.

Introduction

Supplements used in beef rations for finishing cattle balance nutrients that are essential for proper nutrition and performance. OmniGen-AF (Phibro Animal Health, Quincy, IL) is a patented proprietary product shown to augment the innate immune function in cattle. Supplementing cattle with OmniGen-AF also poses a potential opportunity for the incorporation of antioxidants via phenolic-rich compounds that might extend beef shelf-life by slowing the development of brown color during retail display. The extension of beef shelf-life ultimately benefits the beef industry as a whole as it promotes greater color and lipid stability with greater aging times. These have proven to be strong drivers for consumer purchasing decisions. Thus, the objective of this research was to assess the impact of feeding OmniGen-AF on beef shelf-life.

Procedure

A total of 288 steers were sorted into three treatment groups (96 hd/treatment): a control group that received no OmniGen-AF supplementation and two groups supplemented with OmniGen-AF either at receiving (first 28 d at the feedlot) or all through finishing (210 d). At both the receiving and finishing phases, OmniGen-AF was top dressed at 4 g/100lb BW/hd/d. Cattle were sorted 8 hd/pen for a total of 12 pens/treatment. After harvest, 24 USDA low Choice carcasses were selected within each dietary treatment (n = 72) and strip loins from the left and right sides were obtained. Vacuum packaged loins were aged 8, 22 and 29 days (33°F). At 8 days of aging, part of the left loins were fabricated into 1-inch steaks for visual discoloration and tenderness and ½-inch steaks for thiobarbituric acid reactive substances (TBARS) was used as a measure of oxidation. The remaining portions of the loins were vacuum packaged and aged up to 22 days at which point the fabrication process was repeated. The remaining commercially vacuum packaged strip loins (right sides) were kept intact until 29 days of aging at which time the same fabrication strategy was followed. At all aging periods the steaks were placed in Styrofoam trays, overwrapped with oxygen-permeable film, and placed in retail display conditions (36°F) for 4 and 7 days. Steaks at day 0 of retail display were immediately vacuum packed and stored in an ultra-low freezer (−112°F) until analysis.

Tenderness (Warner-Bratzler Shear Force—WBSF)

The 1-inch frozen steaks were thawed for 24 hours (33°F) and a thermocouple was placed in the geometric center. The steaks were grilled on Hamilton Beach electric grills until they reached an internal temperature of 160°F (cooked on one side until 95°F and flipped once to finish cooking). The cooked steaks were placed on trays, covered with plastic film, and kept in a cooler for 24 hours (33°F). Six cores were taken parallel to the muscle fiber orientation of each steak and sheared to determine tenderness.

Visual discoloration (discoloration score)

Visual discoloration was assessed daily for all samples placed in retail display. The steaks were evaluated on a percent scale where 0% meant no discoloration and 100% meant complete discoloration.

Objective color (L, a*, b* scores)*

During retail display, objective color was assessed daily with a Minolta Colorimeter (CR-400, Minolta Camera Company, Osaka, Japan). The D65 illuminant setting was used with an 8 mm illumination area and a 2° standard observer. Values of L* (scale from 0 = black to 100 = white), a*(positive values = red to negative values = green), and b* (positive values = yellow to negative values = blue) were recorded with an average of six readings per samples.

Lipid oxidation (TBARS)

Frozen samples were diced into small pieces, with no subcutaneous fat, and flash frozen in liquid nitrogen. The frozen pieces were powdered in a Waring metal cup blender and 5 g of powdered sample was weighed to conduct the TBARS protocol.

Fatty acid profile

Frozen samples were diced into small pieces, with no subcutaneous fat, and flash frozen in liquid nitrogen. These were then powdered in a metal cup blender and 1 g of powdered sample was weighed out to conduct fatty acid determination by gas chromatography. The chromatography was done using a Chromopack CP-Sil (0.25 mm × 100 m) column with an injector temperature of 518°F and a detector temperature of

572°F. The head pressure was set at 40 psi with a flow rate of 1.0 ml/min and a temperature programing system was used. The fatty acids were identified by their retention times in relation to known standards and the percent of fatty acid was determined by the peak area in the chromatograph.

Statistical analysis

The Proc Glimmix procedure in SAS (SAS Inst., Inc., Cary, N.C.) was used to determine the effects of dietary treatment, aging period, retail display and their interactions. Repeated measures were used to analyze discoloration and objective color data. All means were separated with the LS MEANS statement and the TUKEY adjustment with an alpha of 0.05 and tendencies were considered at an alpha level of 0.10.

Results

There were no differences in tenderness (data not shown) due to dietary treatments ($P = 0.31$). As expected, tenderness did improve as aging and retail display time progressed ($P < 0.0001$). In terms of discoloration, there was a significant age by retail display interaction where at 4 days of retail display samples aged for 22 days had a greater discoloration in relation to samples aged for 8 and 29 days. Usually, prolonged aging periods will result in greater discoloration. However, beginning at 4 days of retail display, samples with the longest aging period (29 day age) were less discolored than those at 22 day age, but not different to samples aged for 8 days (Figure 1). This could be due to the fabrication of the samples where at 8 days of aging one side of the loins were fabricated and the remaining portion of the loins were re-vacuum packaged and fabricated on day 22 of aging. Samples for 29 days of age remained intact under commercial vacuum packaging until the day of fabrication. Light, oxygen, and residual oxygen exposure in the loin portions that were re-packaged and fabricated for 22 days of age could explain the increased discoloration in comparison to loins that remained under commercial packaging for a longer aging period.

The discoloration data coincided with the objective L*, a*, and b* color data that also suggested that samples aged for 22 days were lighter (greater L*) and less red (lower a*) than samples aged for 8 or 29 days (data not shown).

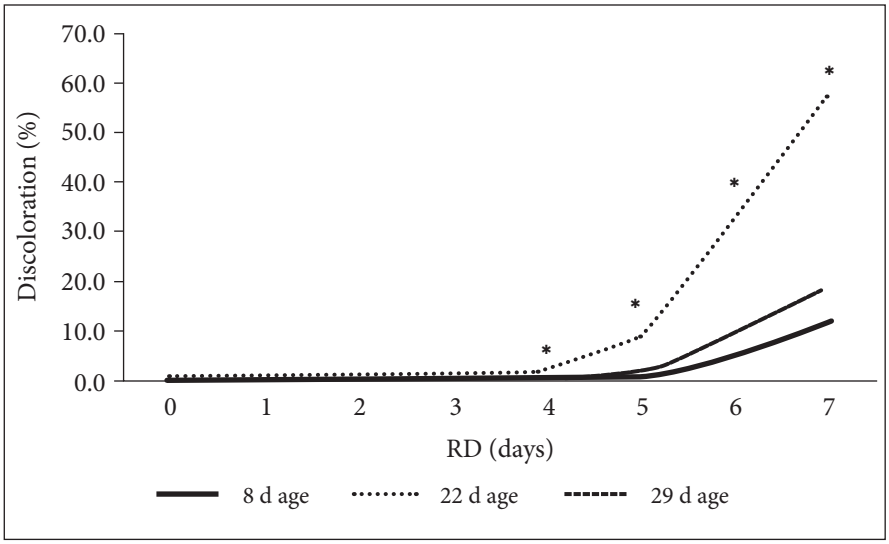

Figure 1. Percent discoloration of beef strip steaks in retail display as impacted by day of aging by day of retail display interaction ($P < 0.0001$)
*Indicate differences ($P < 0.05$)

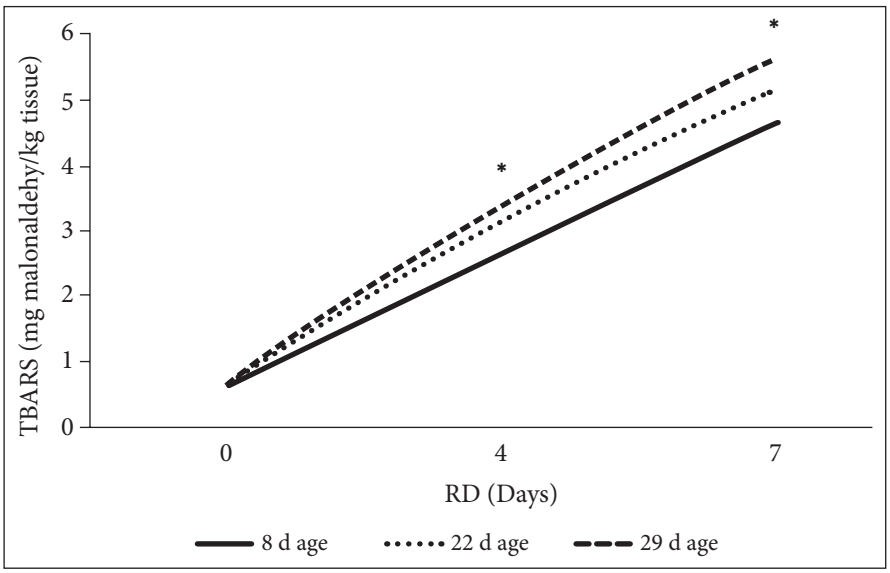

Figure 2. Lipid oxidation (TBARS) tendency of an age by retail display interaction from strip steaks placed under retail conditions ($P = 0.10$)
*Indicate differences ($P < 0.05$)

Oxidation measured via TBARS did not confirm greater lipid oxidation at 22 days of aging over samples aged for 29 days. A tendency ($P = 0.10$) for an age by retail display interaction was observed (Figure 2). At 0 days of retail display there were no differences according to aging periods but at 4 and 7 days of retail display there was a gradual but significant increase in oxidation from 8 to 22 to 29 days of age (2.66, 3.02, 3.26 mg malonaldehyde/kg tissue, respectively). In general, as retail display progressed, TBARS values increased from 0.66 mg malonaldehyde/kg tissue at day 0 of retail display to 3.09 and 5.19 mg malonaldehyde/kg tissue at days 4 and 7 of retail display respectively. Treatment was not involved in any interactions; however, there was a tendency ($P = 0.10$; Figure 3) for cattle receiving OmniGen-AF during the finishing phase to have a less lipid oxidation in comparison to those receiving the

supplementation at the receiving phase or those never being supplemented (2.80 vs. 3.07 and 3.06 mg malonaldehyde/kg tissue, respectively).

Dietary supplementation altered the proportion of palmitic acid (16:0), linoelaidic acid (18:2TT), saturated fatty acids (SFA) as well as the ratio of saturated and unsaturated fatty acids (SFA:UFA; Table 1). On a percentage basis, palmitic acid (16:0), total saturated fatty acids, and the ratio of saturated and unsaturated fatty acids were found to be greater in cattle supplemented with OmniGen-AF at the receiving phase, lowest for cattle having OmniGen-AF supplementation all through the finishing phase, and intermediate for cattle on the control diet with no OmniGen-AF supplementation (Table 1). Linoelaidic acid (18:2TT) however, was found to be greater in the non-supplemented control group (0.21%), intermediate in the receiving phase supplemented group (0.15%), and lowest for the finishing phase supplemented group (0.13%).

According to these data, the inclusion of OmniGen-AF had no effect on color stability under retail display conditions. However, cattle supplemented throughout the finishing phase tended to have greater lipid stability in relation to cattle only supplemented at the receiving phase or cattle that were never supplemented. Hence, supplementation with OmniGen-AF poses potential benefits with longer exposure times in terms of retarding lipid oxidation and thus extending beef shelf-life. Future research can explore the potential benefits of supplementing cattle with a greater concentration of OmniGen-AF or potentially increasing the antioxidant components in the feed supplement to maximize shelf-life of beef aged for long periods of time.

Acknowledgement

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Michael D. Chao, graduate student

Joe Buntyn, graduate student

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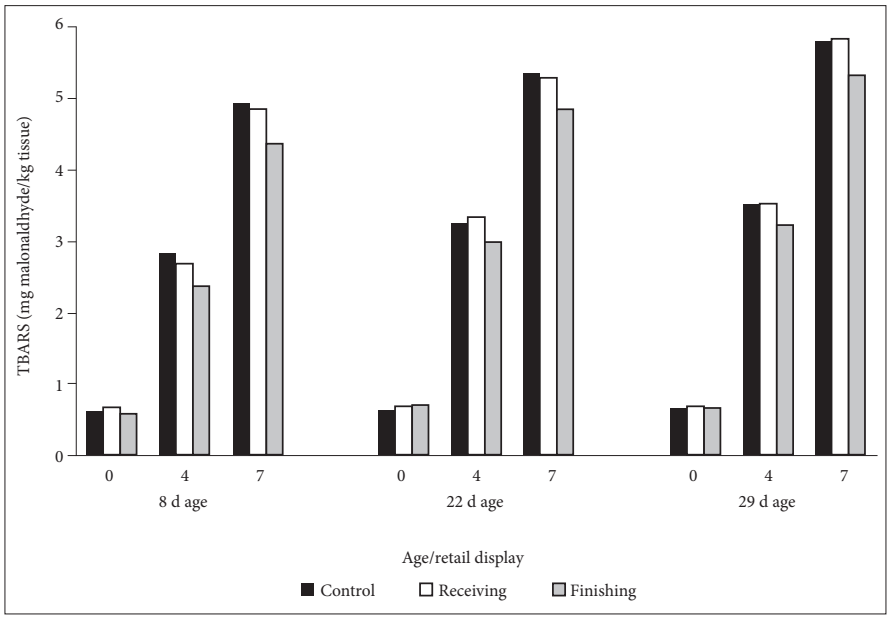

Figure 3. Lipid oxidation (TBARS) dietary treatment tendency for decreased lipid oxidation with cattle supplemented with OmniGen-AF through the finishing phase ($P = 0.10$)

Table 1. Fatty acid changes due to dietary treatment on a percentage basis

Fatty Acid (%)[a]	Dietary Treatment[b]			*P*-value
	Control	OmniGen-AF at Receiving	OmniGen-AF at Finishing	
16:0 (Palmitic)	24.17[ef]	24.64[e]	23.62[f]	0.05
18:2TT (Linoelaidic)	0.21[e]	0.15[ef]	0.13[f]	0.02
SFA[c]	41.92[ef]	43.01[e]	41.56[f]	0.04
SFA:UFA[d]	0.74[ef]	0.77[e]	0.73[f]	0.04

[a]Fatty acids reported as percent of the total fatty acids identified via gas chromatography
[b]Control: no OmniGen-AF supplementation / OmniGen-AF at Receiving: first 28 d at the feedlot / OmniGen-AF at Finishing: all 210 d at the feedlot. OmniGen-AF was top dressed at 4 g/100lb BW/hd/d.
[c]SFA = Saturated fatty acids (Account for the sum of all saturated fatty acids identified)
[d]SFA:UFA = Saturated fatty acids : Unsaturated fatty acids (Ratio of the sum of all saturated and unsaturated fatty acids identified)
[e-f]Different letters indicate differences within each row ($P < 0.05$)

Effect of Feeding Distillers Grains and Supplementing with Dietary Antioxidants on Ground Beef Shelf Life and Fatty Acid Profile

Brandy D. Cleveland and Gary A. Sullivan

Summary

Ground beef from cattle fed corn-based diets with no wet distillers grains, wet distillers grains plus solubles, wet distillers grains + 1000 IU/hd/d vitamin E, wet distillers grains + 150 ppm/hd/d, Ethoxyquin/TBHQ (Agrado Plus, Novus International, St. Louis, MO), or wet distillers grains + 500 IU/hd/d vitamin E + 150 ppm/hd/d Ethoxyquin/TBHQ during the finishing phase were compared to analyze lipid oxidation and fatty acid composition. All ground beef lipid oxidation (raw or cooked) increased over time. Raw beef samples from cattle supplemented vitamin E sustained lower TBARS values than corn after 2 d of simulated retail display. An increase in PUFA and C18:2 was observed in lean and composite fatty acids in WDGS versus corn finished cattle. The potential susceptibility to oxidation found by feeding distillers grains was counteracted by supplementation of Vitamin E in the diet.

Introduction

From each 56 lb. bushel of corn used in dry-mill ethanol production, about 17 lb. of distillers grains (DGS) is available for livestock feed and beef cattle account for nearly half of this consumption. As a result of the rapid growth of the ethanol industry, many cattle producers include ethanol by-products in cattle diets. Previous research has reported that steaks from cattle fed wet distillers grains plus solubles (WDGS) have increased concentrations of poly-unsaturated fatty acids (PUFA), and have decreased oxidative stability. Grinding of beef products disrupts the membranes that contain greater concentrations of PUFA and allows increased exposure to oxygen, thus increasing the rate of lipid oxidation. Furthermore, cooking beef increases lipid oxidation by release of free and heme iron from myoglobin. In turn, this decreases overall desirability by increasing "warmed over" or "rancid" flavors. Therefore, the objective of this trial was to evaluate the effect of feeding distillers grains and the addition of dietary antioxidants during the finishing phase on ground beef lipid oxidation and fatty acid composition.

Procedure

Cattle (n = 100) were randomly assigned to one of five finishing diets: corn-based diet with no WDGS (CON), WDGS (30% DM Basis), WDGS + 1000 IU/hd/d vitamin E (WDGSE), WDGS + 150 ppm/hd/d Agrado Plus (WDGSA), or WDGS + 500 IU/hd/d vitamin E + 150 ppm/hd/d Agrado Plus (WDGSAE). At the conclusion of the finishing phase, cattle were harvested at commercial abattoir. Forty-eight h post-harvest, seven USDA Choice beef shoulder clods from each dietary treatment group were collected from the right side of carcasses, vacuum packaged, and shipped to the University of Nebraska Loeffel Meat Laboratory. On d 14, subcutaneous fat, lean and ground composite samples were collected from each shoulder clod for fatty acid analysis. Shoulder clods were independently ground. From each shoulder clod, 4 oz. patties using a manual, single-patty press were formed to evaluate raw ground beef. A piston stuffer with a Colosimo press attachment was used to make skinless links to evaluate cooked ground beef products. Three raw beef patties from each shoulder clod were over-wrapped with oxygen permeable PVC film and placed under simulated retail display for 7 d at 37°F. During raw patty retail display, thiobarbituric reactive substances (TBARS) were evaluated as a measure of oxidation on d 0, 1, 2, 3, 5 and 7 using ½ of a beef patty per day of evaluation. For skinless links manufacture, beef was mixed with 0.75% salt and 0.25% sodium phosphate and cooked to an internal temperature of 160°F. Cooked beef links were placed in zip-top bags under refrigerated and frozen conditions. Refrigerated cooked links were analyzed for TBARS every 3 days beginning at d 0, and frozen links were evaluated every 28 d until 252 d of storage. Data were analyzed by treatment with repeated measures (day) utilizing the PROC GLIMMIX procedures of SAS.

Results

All fatty acid data are reported in Table 1. There was a treatment effect ($P \leq 0.03$) for the lean portions for C10:0, C17:0, C17:1, C18:1, C18:2 and PUFA. With the exception of C10:0, beef from the WDGS group possessed greater fatty acids (C17:0, C17:1, C18:1, C18:2 and PUFA). The lowest concentrations fatty acids concentrations were observed in beef from the control group.

A treatment effect ($P \leq 0.01$) was observed for fatty acid concentrations (C15:0, C16:0, C17:0, C17:1 and C18:2) within the subcutaneous fat samples. Subcutaneous fat from CON beef had lower ($P \leq 0.01$) concentrations of C15:0 and C17:1 compared to all other treatment groups. For C16:0, corn had greater ($P \leq 0.01$) concentrations than beef from WDGSE and WDGSAE; WDGSA and WDGS were intermediate. The CON group had lower ($P \leq 0.01$) concentrations of C17:0 than WDGS, WDGSE and WDGSAE. WDGS and WDGSE beef had greater ($P = 0.01$) concentrations of C18:2 than CON with WDGSA and WDGSAE similar to all treatments.

For the composite (ground) samples, a treatment effect ($P \leq 0.03$) was observed for C15:0, C16:1, C17:0, C17:1, C18:0, C18:1T, C18:2, C20:3ω6, UFA, SFA:UFA and PUFA. Fatty acid C15:0 and SFA:UFA in ground beef from a CON were lower ($P \leq 0.01$) than all other dietary treatments. Control ground beef samples also had lower ($P \leq 0.02$) concentrations of C17:0, C20:3ω6 and PUFA than WDGS finished cattle; the remaining treatment groups were similar. For C17:1, C18:1T and UFA, CON ground beef had lower ($P \leq 0.02$) concentrations than WDGS and WDGSE, with cattle supplemented Agrado having intermediate

Table 1. Effect of including wet distillers grain and supplementing with vitamin E and/or Agrado Plus during finishing on fatty acid composition (mg/100g raw sample) of beef shoulder clod composite, lean tissue and subcutaneous fat samples

Composite	Corn[d]	WDGS[e]	WDGSE[f]	WDGSA[g]	WDGSAE[h]	P-value
C15:0 (mg/100g)	81.01^{k}	146.40^{j}	131.17^{j}	126.24^{j}	124.21^{j}	0.001
C16:1 (mg/100g)	718.66^{j}	572.96^{jk}	547.91^{k}	599.76^{jk}	516.59^{k}	0.01
C17:0 (mg/100g)	283.23^{k}	503.02^{j}	468.45^{jk}	389.71^{jk}	429.57^{jk}	0.014
C17:1 (mg/100g)	221.62^{k}	337.27^{j}	329.73^{j}	298.64^{jk}	310.38^{jk}	0.022
C18:0 (mg/100g)	3013^{jk}	3741^{j}	3524^{jk}	3001^{jk}	2655^{k}	0.027
C18:1T (mg/100g)	606^{k}	1183^{j}	1098^{j}	888^{jk}	943^{jk}	0.003
C18:2 (mg/100g)	618^{l}	1209^{j}	1029^{jk}	944^{jk}	932^{k}	< 0.001
C20:3w6 (mg/100g)	19.15^{k}	25.69^{j}	25.23^{jk}	24.78^{jk}	21.88^{jk}	0.022
UFA (mg/100g)[a]	2956^{k}	4190^{j}	3937^{j}	3557^{jk}	3446^{jk}	0.007
SFA:UFA (mg/100g)[b]	2.92^{k}	2.33^{k}	2.30^{k}	2.35^{k}	2.20^{k}	< 0.001
PUFA (mg/100g)[c]	1569^{k}	2241^{j}	1973^{jk}	1963^{jk}	1875^{jk}	0.003
Lean	**Corn[d]**	**WDGS[e]**	**WDGSE[f]**	**WDGSA[g]**	**WDGSAE[h]**	**P-value**
C10:0 (mg/100g)	2.44^{jk}	2.75^{jk}	4.52^{j}	3.92^{jk}	2.17^{k}	0.019
C17:0 (mg/100g)	39.58^{k}	158.56^{k}	133.14^{jk}	127.68^{jk}	103.00^{jk}	0.035
C17:1 (mg/100g)	40.84^{k}	164.38^{j}	82.31^{jk}	139.53^{jk}	105.12^{jk}	0.013
C18:1 (mg/100g)	1505^{k}	3269^{j}	2069^{jk}	3116^{jk}	2186^{jk}	0.032
C18:2 (mg/100g)	197.40^{k}	490.97^{j}	374.56^{jk}	388.21^{jk}	330.40^{jk}	0.014
PUFA (mg/100g)[c]	242.86^{k}	603.25^{j}	458.07^{jk}	489.24^{jk}	474.71^{jk}	0.043
Fat	**Corn[d]**	**WDGS[e]**	**WDGSE[f]**	**WDGSA[g]**	**WDGSAE[h]**	**P-value**
C15:0 (mg/100g)	469.14^{k}	818.29^{j}	742.71^{j}	741.33^{j}	930.83^{j}	< 0.001
C16:0 (mg/100g)	22946^{j}	20799^{jk}	20175^{k}	21704^{jk}	19482^{k}	0.002
C17:0 (mg/100g)	1148^{k}	2334^{j}	2358^{j}	1838^{jk}	2638^{j}	< 0.001
C17:1 (mg/100g)	1535^{k}	2549^{j}	2389^{j}	2336^{j}	3005^{j}	< 0.001
C18:2 (mg/100g)	1837^{k}	3351^{j}	3320^{j}	2714^{jk}	2818^{jk}	0.013

[a]Unsaturated Fatty Acids: C14:1, C15:1, C16:1T, C16:1, C17:1, C18:1T, C18:1, C18:1V, C18:2TT, C18:2, C18:3ω3, C18:3ω6, C20:1, C20:3, C20:3ω6, C20:4, C20:5, C22:1, C22:4, C22:5.
[b]Saturated Fatty Acid to Unsaturated Fatty Acid Ratio.
[c]Polyunsaturated Fatty Acids: C18:2TT, C18:2, C18:3ω3, C18:3ω6, C20:1, C20:3, C20:3ω6, C20:4, C20:5, C22:1, C22:4, C22:5.
[d]Corn control finishing diet.
[e]Wet distillers grains at 30% DM inclusion.
[f]Wet distillers grains + 1000 IU/hd/d vitamin E.
[g]Wet distillers grains + 150 ppm/hd/d Agrado Plus.
[h]Wet distillers grains + 500 IU/hd/d vitamin E + 150 ppm/hd/d Agrado Plus.
[j-l]Means within a row without a common superscript are significantly different (P ≤ 0.05)

values. WDGSAE had lower ($P \leq 0.03$) concentrations of C18:0 than WDGS; WDGSA, WDGSE and CON values were intermediate. For C18:2, CON had the lowest ($P \leq 0.01$) concentrations than all dietary treatments, followed by WDGSAE. Ground beef from WDGS had the highest ($P \leq 0.01$) C18:2 concentrations, when compared to CON, WDGSE, WDGSA, and WDGSAE. Fatty acid C16:1 was the only fatty acid where higher ($P = 0.01$) concentrations were observed in CON ground beef than WDGS and WDGSE, with WDGSA and WDGSAE ground beef being intermediate.

A day x dietary treatment effect ($P = 0.03$) was observed for oxidation of raw patties. On 2–7 d of simulated retail display, the CON had higher ($P \leq 0.01$) TBARS values than the patties from WDGSE and WDGSAE treatment groups. On d 3 and 5, the CON patties were more ($P \leq 0.01$) oxidized than all other dietary treatments. On d 7 of simulated retail display, beef from WDGS displayed greater ($P \leq 0.01$) TBARS values than WDGSAE (Table 2). Beef from cattle fed all diets, with the exception of WDGSAE, displayed an increase in TBARS concentrations from 5–7 d (Table 2). The inclusion of vitamin E resulted in less ($P \leq 0.01$) lipid oxidation in patties than the patties from CON on d 2, 3, 5, and 7 (Table 2). A day of storage effect ($P = 0.01$, Table 3) was observed for lipid oxidation in cooked beef links in refrigerated storage where TBARS concentrations increased over time. A trend ($P = 0.10$) for dietary effect was observed, beef links from WDGSA beef tended to have higher TBARS values than the treatments groups. Regardless of treatment, frozen beef links had greater ($P \leq 0.01$) oxidation as d in storage increased (Figure 1). Treatment has no effects (P = 0.13) on TBAR concentrations.

An increase in C18:2 (linoleic acid) and PUFA was observed for all treatment groups containing WDGS in lean and ground samples. This did not directly related to amount of lipid oxidation in samples as TBARS concentrations patties from CON samples were among the most oxidized. A trend ($P = 0.10$) for refrigerated in cooked beef links suggests that cattle fed WDGSA had greater lipid oxidation than other dietary treatments and may be due to heating causing ethoxyquin to become oxidized, and acting as a pro-oxidant. These

dietary effects did not carry through to the frozen links, however, suggesting that frozen storage may reduce the pro-oxidant effect. Therefore, vitamin E supplementation may counteract against the susceptibility to oxidation found by feeding distillers grains in both cooked and raw ground beef.

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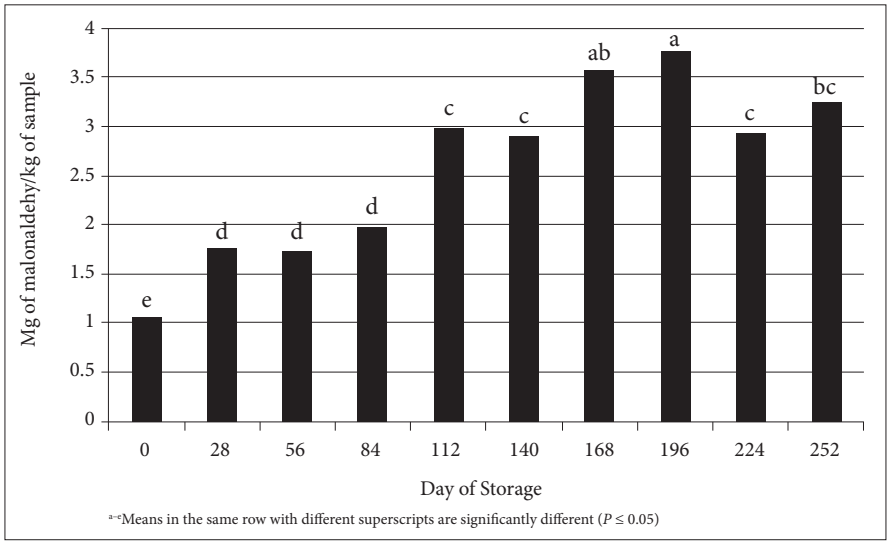

Figure 1. Effect of storage time on lipid oxidation (mg of malonaldehyde/kg of product) in frozen ready-to-eat beef links

Table 2. Interaction effects of dietary treatment and day of storage (P = 0.03) on lipid oxidation in raw ground beef patties from cattle fed finishing diets containing wet distillers grain and supplemented with vitamin E and/or Agrado Plus

Day[a]	Dietary Treatment				
	Corn[b]	WDGS[c]	WDGSE[d]	WDGSA[e]	WDGSAE[f]
0	1.6^{mn}	1.75^{lmn}	1.41^{n}	1.58^{mn}	1.51^{mn}
1	2.26^{klm}	1.45^{mn}	1.66^{lmn}	1.94^{lmn}	1.94^{lmn}
2	2.97^{jk}	2.16^{klm}	1.78^{lmn}	2.01^{klmn}	1.72^{lmn}
3	3.52^{ji}	2.35^{kl}	1.95^{lmn}	2.29^{kl}	1.88^{lmn}
5	4.51^{hi}	3.02^{jk}	2.28^{klm}	2.92^{jk}	2.12^{klmn}
7	5.94^{g}	5.24^{gh}	3.69^{hij}	4.58^{ghi}	3.21^{ijk}

[a]All values are reported as mg of malonaldehyde/kg of sample
[b]Corn control finishing diet
[c]Wet distillers grains at 30% DM inclusion
[d]Wet distillers grains + 1000 IU/hd/d vitamin E
[e]Wet distillers grains + 150 ppm/hd/d Agrado Plus
[f]Wet distillers grains + 500 IU/hd/d vitamin E + 150 ppm/hd/d Agrado Plus
[g-n]Means within the table without a common superscript are significantly different ($P \leq 0.05$)

Table 3. Effect of days of refrigerated storage on lipid oxidation in cooked beef links

Day	Thiobarbituric Acid Reactive Substances[a]
0	1.05^{g}
3	2.12^{f}
6	2.74^{de}
9	2.51^{ef}
12	3.79^{cd}
15	4.17^{bc}
18	4.88^{b}

[a]mg of malonaldehyde/kg of sample
[b-g]Means in the same column without a common superscript are significantly different ($P \leq 0.05$)

Effects of Dietary Antioxidant Supplementation on Cattle Finished with 30% Wet Distillers Grains Plus Solubles on Fatty Acid Profiles and Display Life

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Summary

Steers were finished on either 0% wet distillers grains plus solubles or 30% wet distillers grains plus solubles with four antioxidant treatments to evaluate the effects of finishing diets containing wet distillers grains plus solubles, vitamin E and Agrado Plus on beef fatty acid profiles, discoloration and lipid oxidation of retail-displayed beef. The inclusion of 30% wet distillers grains plus solubles increased total polyunsaturated fatty acids of beef, but did not promote discoloration or lipid oxidation compared to the 0% wet distillers grains plus solubles diet. In both diets, feeding vitamin E alone or vitamin E+ Agrado Plus was effective in reducing lipid oxidation and maintaining color stability, while supplementing Agrado Plus alone had minimal effects in improving lipid and color stability.

Introduction

Feeding wet distillers grains plus solubles (WDGS) in beef feedlot diets increases muscle tissue polyunsaturated fatty acids (PUFA) concentration (2008 *Nebraska Beef Cattle Report*, pp.120–121) and decreases beef display life, while feeding antioxidants like vitamin E (E; 2009 *Nebraska Beef Cattle Report*, pp.116–117) and Agrado Plus (AG; Novus International; 2011 *Nebraska Beef Cattle Report*, pp.103–104) have been shown to mitigate such effects. Vitamin E is a well-studied fat soluble antioxidant that has been reported to improve marketability of fresh meat products through delaying lipid and muscle pigment oxidation. Furthermore, AG is a mixture of synthetic antioxidants ethoxyquin and tertiary butylhydroquinone (TBHQ) and has been used in the industry as a dietary lipid preservative. Research has shown that E is stabilized when AG is added to the feed, which may create an additive antioxidant effect when the two antioxidants are fed in combination. However, there are no available data on the synergistic relationship that E and AG may have in regard to beef quality. Therefore, it is important to investigate the effects of WDGS and the combination of E and AG on muscle tissue fatty acids and redox potential to understand the overall changes of beef shelf-life resulting from diet modifications.

Procedure

One hundred and sixty Continental x British steers were blocked by BW, stratified by BW within each block, and assigned randomly to pens within block. Pens were randomly assigned to one of the eight treatments with two pens/treatment and 10 head/pen. Cattle were fed for 106 d on a corn-based diet with 0% WDGS or 30% WDGS (DM basis) with four dietary antioxidant treatments (control; E at 1,000 IU/hd/d; AG at 215 ppm of feed; a combination of E at 500 IU/hd/d and AG at 215 ppm of feed). It is important to note that although 0% WDGS-control, 0% WDGS+AG, 30% WDGS-control and 30% WDGS+AG treatments were not supplemented with additional E, 50 IU/hd/d of E was included in the mineral premix for all dietary treatments. For ease of comprehension, 0% WDGS-control, 0% WDGS+AG, 30% WDGS-control and 30% WDGS+AG treatments are referred as dietary treatments without additional E supplementation throughout this paper.

Ten strip loins (*Longissimus lumborum*) from each treatment (n = 80) were collected and aged for 2, 7, or 14 d. Steaks were removed from each loin at each aging period and placed under retail display conditions (36 ± 4°F, and exposed to continuous 1,000–1,800 lux warm white fluorescent lighting) for 0, 4, and 7 d. One steak was designated to evaluate daily objective color (a*-redness) and subjective discoloration scores (0% = no discoloration to 100% = full discoloration) during the 7 d retail display period. Steak samples designated for lipid oxidation (via thiobarbituric acid reactive substances assay [TBA]) were obtained on d 0, 4 and 7 of retail display for each aging period. Muscle tissue fatty acid profiles (via gas chromatography), E and ethoxyquin analyses (via high performance liquid chromatography) were obtained on d 0 of retail display after 14 d of aging. At the end of the allotted treatments, all samples were vacuum packaged and frozen at −112°F until analyzed.

Data were analyzed using the GLIMMIX procedure of SAS (version 9.2, Cary, NC, 2009). Data for TBA were analyzed as a split-split plot design with dietary treatments as the whole-plot, aging period as the split-plot and retail display time as the split-split plot. Color data were analyzed as a split-split-plot repeated measures design with dietary treatments as the whole-plot, aging period as the sub-plot and retail display d as the repeated measures. The E and ethoxyquin concentrations and fatty acid profiles were analyzed as a completely randomized design. Separation of means was conducted using LSMEANS procedure with PDIFF or SLICEDIFF options at $P \leq 0.05$.

Results

Feeding WDGS decreased ($P \leq 0.05$) the fatty acid proportions of 14:0, 14:1 and 16:1, but increased ($P \leq 0.05$) 15:0, 17:0, 17:1, 18:1 trans, 18:2, 20:1 and total PUFA in muscle when compared to the fatty acid profiles of steers fed 0% WDGS (Table 1). It is well known that the majority of the unsaturated fatty acids (UFA) are fermented and biohydrogenated to saturated fatty acids (SFA) in the rumen. However, WDGS has 3x the amount of PUFA compared to corn, which leads to greater absorption of

Table 1. Fatty acid profiles of strip steaks from steers fed a corn-based diet with 0% wet distillers grains plus solubles (WDGS) or 30% WDGS supplemented with or without vitamin E (E) or Agrado (AG) or a combination of E and AG

Fatty Acids, %	0% WDGS	0% WDGS+E	0% WDGS+AG	0% WDGS+E+AG	30% WDGS	30% WDGS+E	30% WDGS+AG	30% WDGS+E+AG	*P*-value
C14:0	2.00^{bcd}	2.34^{bc}	2.23^{bcd}	2.39^{b}	1.83^{cd}	1.73^{d}	2.01^{bcd}	1.73^{d}	≤ 0.01
C14:1	0.61^{bcd}	0.66^{bc}	0.60^{bcd}	0.68^{b}	0.45^{cd}	0.42^{d}	0.60^{bcd}	0.51^{bcd}	≤ 0.01
C15:0	0.42^{cd}	0.37^{d}	0.42^{cd}	0.47^{bcd}	0.60^{b}	0.52^{bcd}	0.59^{b}	0.53^{bc}	≤ 0.01
C15:1	0.67	0.63	0.56	0.62	0.52	0.52	0.53	0.59	0.25
C16:0	24.73	23.34	22.34	23.43	21.64	22.24	20.98	22.84	0.54
C16:1	2.17^{bc}	2.43^{bc}	2.69^{b}	2.73^{b}	1.91^{c}	2.01^{c}	2.25^{bc}	1.88^{c}	0.02
C17:0	1.48^{de}	1.27^{e}	1.42^{de}	1.65^{bcd}	2.43^{b}	2.14^{bcd}	1.93^{bcde}	2.28^{bc}	≤ 0.01
C17:1	1.01^{bc}	0.90^{c}	1.08^{bc}	1.16^{bc}	1.48^{b}	1.35^{bc}	1.51^{b}	1.33^{bc}	≤ 0.01
C18:0	14.95	13.82	13.15	14.25	15.33	16.76	13.12	15.19	0.37
C18:1T	2.02^{ed}	1.44^{e}	2.05^{cde}	1.85^{e}	3.50^{b}	3.25^{b}	3.03^{bcd}	3.15^{bc}	≤ 0.01
C18:1	32.36	34.52	36.23	34.17	33.14	34.29	34.63	31.47	0.84
C18:1V	1.07	1.22	1.44	1.27	1.09	1.04	1.25	1.16	0.19
C18:2	3.58^{cd}	3.09^{d}	3.39^{d}	3.60^{cd}	5.48^{b}	4.77^{bc}	4.87^{bc}	4.88^{bc}	≤ 0.01
C18:3	0.21	0.19	0.2	0.2	0.25	0.28	0.21	0.25	0.1
C20:1	0.49^{bc}	0.41^{bc}	0.43^{bc}	0.38^{c}	0.54^{bc}	0.59^{b}	0.64^{b}	0.50^{bc}	≤ 0.01
C20:3	0.27	0.25	0.26	0.28	0.24	0.24	0.23	0.27	0.63
C20:4	0.75	0.73	0.71	0.8	0.63	0.66	0.71	0.73	0.66
C22:5	0.29	0.22	0.2	0.21	0.17	0.17	0.18	0.22	0.06
SFA[a]	43.5	41.06	39.55	42.19	39.17	43.38	38.51	42.51	0.57
MUFA[a]	41.38	41.86	45.15	43.12	45.51	42.98	43.93	39.22	0.71
PUFA[a]	4.60^{c}	4.09^{c}	4.65^{c}	4.92^{bc}	6.58^{b}	5.68^{bc}	5.89^{bc}	5.85^{bc}	≤ 0.01

[a]SFA = saturated fatty acids, MUFA = monounsaturated fatty acids, and PUFA = polyunsaturated fatty acids
[b–e]Within a row, means without a common superscript differ at $P \leq 0.05$.

PUFA in the duodenum, thus increased the deposition of PUFA in muscle tissue.

Least square means of a* and discoloration at d 7 of retail display are separated and ranked in Table 2. Although only steaks from 0% WDGS+E+AG and 30% WDGS+E+AG treatments had greater ($P \leq 0.05$) a* values compared to the steaks without E treatments, the trend that separated out the ones with E treatments and the ones without E treatments were evident on d 6 of retail display (data not shown). On d 7 of the retail display, all steaks from steers supplemented with E or the combination of E and AG had greater ($P \leq 0.05$) a* values than the steaks without E treatments with one exception. The a* values from 30% WDGS+AG treatments

Table 2. Ranking of objective redness (a*) and discoloration (average of all three aging periods) of strip steaks (*m. longissimus lumborum*) from steers fed a corn-based diet with 0% wet distillers grains plus solubles (WDGS) or 30% WDGS supplemented with or without vitamin E (E) or Agrado (AG) or a combination of E and AG after 7 d of retail display

Dietary treatments	a*	Dietary treatments	Discoloration, %
30% WDGS+E+AG	21.30^{a}	30% WDGS+E+AG	2.01^{b}
0% WDGS+E+AG	20.94^{a}	0% WDGS+E+AG	2.11^{b}
30% WDGS+E	20.69^{ab}	0% WDGS+E	2.29^{b}
0% WDGS+E	20.69^{ab}	30% WDGS+E	2.37^{b}
30% WDGS+AG	20.59^{ab}	30% WDGS+AG	3.92^{c}
0% WDGS+AG	19.89^{bc}	0% WDGS+AG	4.59^{ac}
0% WDGS	19.66^{c}	30% WDGS	4.68^{ac}
30% WDGS	19.37^{c}	0% WDGS	5.71^{a}
P-value	≤ 0.01	*P*-value	≤ 0.01

[a–c]Within a column, means without a common superscript differ at $P \leq 0.05$.

Table 3. Lipid oxidation value (TBA; malonaldehyde mg/kg of meat; average of all three aging periods), vitamin E (E; ug/g) and ethoxyquin (ug/100 g) concentrations of strip steaks (*m. longissimus lumborum*) from steers fed a corn-based diet with 0% wet distillers grains plus solubles (WDGS) or 30% WDGS supplemented with or without vitamin E (E) or Agrado (AG) or a combination of E and AG

	0% WDGS	0% WDGS+E	0% WDGS+AG	0% WDGS+E+AG	30% WDGS	30% WDGS+E	30% WDGS+AG	30% WDGS+E+AG	*P*-value
TBA									≤ 0.01
d 0	1.83^{a}	1.22^{ab}	1.17^{ab}	0.99^{b}	0.88^{b}	1.19^{ab}	1.19^{ab}	1.11^{ab}	
d 4	3.51^{a}	1.97^{bc}	2.36^{c}	1.36^{b}	1.73^{bc}	1.66^{bc}	1.82^{bc}	1.50^{b}	
d 7	5.04^{a}	2.45^{b}	3.71^{c}	1.65^{b}	2.99^{bc}	2.17^{b}	2.78^{b}	1.82^{b}	
Vitamin E	2.95^{cd}	5.20^{a}	2.18^{d}	4.49^{ab}	2.68^{cd}	5.09^{a}	3.67^{bc}	4.56^{ab}	≤ 0.01
Ethoxy-quin	0.04^{b}	0.00^{b}	0.32^{a}	0.36^{a}	0.08^{b}	0.00^{b}	0.29^{a}	0.31^{a}	≤ 0.01

$^{a-d}$Within a row, means without a common superscript differ at $P \leq 0.05$.

were greater ($P \leq 0.05$) compared to the a* values from the rest of the steaks without E treatment after 7 d of the retail display.

For discoloration, the trend that separated out the steaks from E treatments and the steaks from treatments without E could clearly be seen on d 6 of retail display. At d 7 of the retail display period, all steaks from steers supplemented with E or the combination of E and AG were less discolored ($P \leq 0.01$) than steaks from steers not supplemented with E. The E+AG and E supplementation alone were effective in this study to maintain both a* values and discoloration scores in steaks from steers fed 0% WDGS or 30% WDGS diets. Reduction in steak discoloration rates due to AG supplementation was only observed when steers were on 30% WDGS diets.

A reduction in oxidation rates due to E and/or AG supplementation was observed at all three retail display periods only when steers were fed the 0% WDGS diets ($P \leq 0.01$; Table 3). The effect of E, AG or the combination of E and AG in reducing lipid oxidation for beef steaks from 30% WDGS treatment is likely diminished because of the already low level of lipid oxidation of the control diet. Comparing diet effects without any antioxidant supplementation, steaks from steers fed 0% WDGS had greater lipid oxidation values compared to steaks from steers fed 30% WDGS ($P \leq 0.01$). Feeding 30% WDGS did not increase lipid oxidation values compared to feeding 0% WDGS. Feeding WDGS may cause a vitamin E-sparing effect by synthesizing sulfur-containing antioxidant peptides and thus reducing lipid oxidation.

Finally, E supplementation increased ($P \leq 0.01$) muscle tissue E concentrations compared to muscle tissue from steers without E supplementation (Table 3). It is interesting to note that 30% WDGS+AG samples had greater ($P \leq 0.05$) muscle tissue E concentrations compared to samples from 0% WDGS+AG, which demonstrated a minor E-sparing effect. Diets with AG supplementation also increased ($P \leq 0.05$) muscle tissue ethoxyquin concentrations compared to diets without AG supplementation (Table 3). These results suggest that increased PUFA content in muscle tissue does not promote lipid oxidation and discoloration, and discoloration and lipid oxidation can be effectively suppressed by the combination of E+AG or E supplementation alone, while supplementing AG alone had minimal effects in improving lipid and color stability.

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Feeding Vitamin E May Reverse Sarcoplasmic Reticulum Membrane Instability Caused by Feeding Wet Distillers Grains Plus Solubles to Cattle

Michael D. Chao, Katherine I. Domenech and Chris R. Calkins

Summary

Steers were finished on either 0% or 30% wet distillers grains plus solubles with four antioxidant treatments (control; vitamin E; Agrado; vitamin E + Agrado). Feeding wet distillers grains plus solubles increased polyunsaturated fatty acids contents in SR membrane and altered sarcoplasmic reticulum phospholipid profiles. Steaks from steers fed wet distillers grains plus solubles also had more protein degradation. Supplementing vitamin E reversed the alteration of sarcoplasmic reticulum phospholipid profiles and prevented the accelerated protein degradation resulted from feeding wet distillers grains plus solubles. These findings suggest that feeding wet distillers grains plus solubles in the finishing diet may accelerate beef tenderization, while supplementing vitamin E may inhibit this distillers grains-induced beef tenderization effect.

Introduction

Muscle is an elegant biological system with mechanisms in place to control calcium for contraction and relaxation. After rigor, calcium ions slowly diffuse from the sarcoplasmic reticulum (SR) to the cytoplasm where the ions activate the calcium-dependent proteolytic enzymes (the calpain system) and enhance tenderness. Research results from our lab (2012 *Nebraska Beef Cattle Report*, pp. 124–126; 2015 *Nebraska Beef Cattle Report*, pp. 117–119) showed that beef from cattle fed high concentration of WDGS is more tender than beef from cattle not fed WDGS or WDGS with dietary antioxidants. Our hypothesis is that including WDGS in feedlot diets increases PUFA concentration in the SR membrane, making the membrane more prone to oxidation. Such membrane integrity alterations may result in more rapid calcium leakage post-rigor and thus improve tenderness through greater activation of the calcium-dependent proteolytic enzyme. Antioxidants may preserve membrane integrity and inhibit this WDGS-accelerated tenderization process. Feeding WDGS and different antioxidants provides an excellent model to generate samples with varying degrees of SR membrane oxidation capacity to explore this proposed mechanism of beef tenderization.

Procedure

One hundred and sixty Continental x British steers were blocked by BW, stratified by BW within each block, and assigned randomly to pens within block. Pens were randomly assigned to one of the eight treatments with two pens/treatment and 10 heads/pen. Cattle were fed for 106 d on a corn-based diet with 0% WDGS or 30% WDGS (DM basis) with four dietary antioxidant treatments (control; E at 1,000 IU/hd/d; AG at 215 ppm of feed; a combination of E at 500 IU/hd/d and AG at 215 ppm of feed). It is important to note that although 0% WDGS-control, 0% WDGS+AG, 30% WDGS-control and 30% WDGS+AG treatments were not supplemented with additional E, 50 IU hd/d of E was included in the mineral premix for all dietary treatments. For ease of comprehension, 0% WDGS-control, 0% WDGS+AG, 30% WDGS-control and 30% WDGS+AG refer to dietary treatments without additional E supplementation throughout this paper.

Ten strip loins (*Longissimus lumborum*) from each treatment (n=80) were collected and aged for 2, 7, or 14 d. Steaks were removed from each loin at each aging period and placed under retail display conditions (36 ± 4°F, and exposed to continuous 1,000–1,800 lux warm white fluorescence lighting). On d 0 and 7 of retail display for each aging period, steak samples were obtained for tenderness assessment (via Warner Bratzler Shear Force [WBSF]), free calcium concentrations (via inductively coupled plasma spectroscopy) and proteolysis (via immunoblotting to quantify troponin-T degradation). Steak samples for SR membrane fatty acid (via gas chromatography), total lipid, neutral lipid and phospholipid profiles (via thin-layer chromatography) were obtained at d 0 of retail display after 14 d of aging.

Data were analyzed using the GLIMMIX procedure of SAS (version 9.2, Cary, NC, 2009). Data for WBSF, free calcium concentration and proteolysis were analyzed as a split-split plot design with dietary treatments as the whole-plot, aging period as the split-plot and retail display time as the split-split plot. Sarcomere length, SR fatty acid, total lipid, neutral lipid and phospholipid profiles were analyzed as a completely randomized design. Separation of means was conducted using LSMEANS procedure with PDIFF or SLICEDIFF options at $P \leq 0.05$.

Results

Fatty acid analysis revealed distinct differences among fatty acid profiles of SR membrane from cattle fed different diets. Feeding 30% WDGS decreased ($P \leq 0.05$) the proportions of the fatty acids 16:0, 16:1, 18:0, 18:1V and total saturated fatty acids. There was also a tendency ($P \leq 0.10$) to decrease 18:1 and total monounsaturated fatty acids. However, feeding 30% WDGS increased ($P \leq 0.05$) 15:0, 17:0, 18:1 trans, 18:2 and total PUFA in the SR membrane (Table 1). The increase in PUFA content of the SR membrane supports the hypothesis that feeding WDGS may impair SR membrane integrity and thus accelerate free calcium release.

Furthermore, steaks from steers fed 30% WDGS-control had more ($P \leq 0.05$)

Table 1. Fatty acid profiles (%) of sarcoplasmic reticulum membranes from strip loins from steers fed a corn-based diet with 0% wet distillers grains plus solubles (WDGS) or 30% WDGS supplemented with or without vitamin E (E) or Agrado (AG) or a combination of E and AG

Fatty Acids	Dietary treatments								*P*-value
	0% WDGS	0% WDGS+E	0% WDGS+AG	0% WDGS+E+AG	30% WDGS	30% WDGS+E	30% WDGS+AG	30% WDGS+E+AG	
14:0	0.66^{ab}	0.69^{ab}	1.25^{a}	1.30^{a}	0.89^{ab}	1.05^{ab}	0.59^{ab}	0.45^{b}	≤ 0.01
15:0	0.30^{ab}	0.25^{b}	0.39^{ab}	0.42^{ab}	0.47^{a}	0.43^{ab}	0.41^{ab}	0.33^{ab}	≤ 0.01
16:0	20.52^{abc}	18.71^{bc}	21.98^{ab}	22.14^{a}	20.65^{abc}	19.83^{abc}	19.26^{abc}	17.84^{c}	≤ 0.01
16:1	2.23^{abc}	2.10^{bc}	3.03^{a}	2.81^{ab}	1.76^{c}	2.01^{bc}	1.81^{c}	1.70^{c}	≤ 0.01
17:0	0.89^{b}	0.83^{b}	1.03^{ab}	0.98^{ab}	1.36^{a}	1.24^{ab}	1.15^{ab}	1.09^{ab}	≤ 0.01
17:1	0.92	0.84	1.09	1.08	1.20	1.21	1.12	1.06	0.14
18:0	10.22	10.79	10.62	9.41	9.86	10.13	9.43	9.30	0.09
18:1T	1.90^{bcd}	1.43^{d}	2.03^{abcd}	1.71^{cd}	2.77^{ab}	2.79^{a}	2.29^{abc}	2.42^{abc}	≤ 0.01
18:1	30.45	32.08	35.60	31.55	26.45	31.15	27.68	27.31	0.06
18:1V	2.17^{ab}	2.14^{ab}	2.38^{a}	2.27^{ab}	2.05^{ab}	2.07^{ab}	1.99b	2.03^{b}	0.01
18:2	13.82^{ab}	11.58^{b}	11.12^{b}	13.81^{ab}	19.54^{a}	15.66^{ab}	17.55^{a}	18.61^{a}	≤ 0.01
20:1	0.52	0.49	0.46	0.55	0.41	0.41	0.47	0.42	0.23
20:3	1.16	1.17	1.01	1.26	1.04	0.94	1.21	1.09	0.74
20:4	4.55	3.99	3.30	4.61	3.78	3.51	4.51	4.05	0.56
20:5	0.43	0.47	0.38	0.44	0.35	0.35	0.46	0.39	0.75
22:4	0.56	0.51	0.41	0.49	0.44	0.37	0.58	0.49	0.34
22:5	1.08	0.93	0.72	0.98	0.80	0.69	1.03	0.85	0.23
SFA	32.60^{abc}	31.15^{abc}	35.16^{a}	34.26^{ab}	33.24^{ab}	32.68^{abc}	30.78^{bc}	28.90^{c}	≤ 0.01
MUFA	38.31	39.16	44.69	40.28	34.85	39.84	35.39	34.99	0.09
PUFA	21.60^{ab}	18.56^{ab}	16.78^{b}	21.59^{ab}	25.91^{a}	21.45^{ab}	25.14^{a}	25.39^{a}	0.03

Note: SFA = saturated fatty acids, MUFA = monounsaturated fatty acids, and PUFA = polyunsaturated fatty acids
[a-d]Within a row, means without a common superscript differ at $P \leq 0.05$

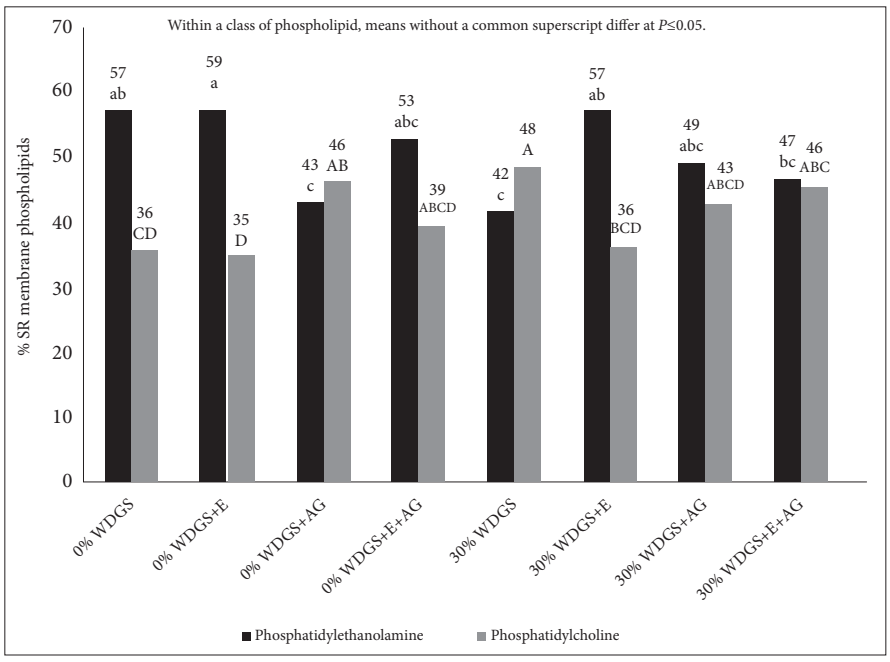

Figure 1. Phospholipid profile of sarcoplasmic reticulum membrane from strip loins from steers fed a corn-based diet with 0% wet distillers grains plus solubles (WDGS) or 30% WDGS supplemented with or without vitamin E (E) or Agrado (AG) or a combination of E and AG.

phosphatidylcholine in the SR membrane, but less ($P \leq 0.05$) phosphatidylethanolamine compared to steaks from steers fed 0% WDGS-control or 30% WDGS supplemented with E. It is interesting to note that supplementing AG in the 0% WDGS diet also created similar effects as the 30% WDGS diet for SR membrane phospholipid profile (Figure 1). Many studies have demonstrated that the conversion of phosphatidylethanolamine to phosphatidylcholine is an indicator of oxidative stress. It is possible that feeding a diet high in PUFA like WDGS might have induced oxidative stress in the SR, while supplementing E likely alleviated such stress on the SR. Furthermore, AG may have failed to act as an antioxidant, but transitioned into pro-oxidants, which stimulated the SR oxidative stress observed in this study.

At 2 d postmortem, steaks from steers fed 30% WDGS had more muscle protein degradation compared to steaks from steers fed 0% WDGS without any antioxidant

supplementation or either diet supplemented with E only. What is even more interesting is that AG in the 0% WDGS diet again created similar effects as the 30% WDGS diet, which not only failed to hold back proteolysis, but accelerated proteolysis (Figure 2). It is also worth noting that the least square means for troponin-T degradation at 2 d aging is highly correlated with the least square means for SR membrane phosphatidylcholine ($R^2 = 0.90$) and phosphatidylethanolamine ($R^2 = 0.88$) of the treatments (Figure 3). Based on these results, it is reasonable to suspect that SR oxidative stress may play a significant role in controlling rate of early postmortem protein degradation.

Finally, there were no differences in tenderness ($P > 0.10$) or free calcium concentrations ($P > 0.10$) among steaks from steer in any of the treatments, aging or display periods. It is likely that such subtle differences in tenderness can only be detected using extremely sensitive methodologies like protein degradation. These findings suggest that the WDGS-induced tenderness observed in this study may not be caused by lipid oxidation of SR membrane as proposed in our hypothesis. Evidence suggests that feeding WDGS in the finishing diet may induce SR oxidative stress, and such oxidative stress may hamper the ability of SR to effectively sequester free calcium early postmortem, leaving more free calcium behind in the cytoplasm. The free calcium interacts with the calcium-dependent proteinase and accelerates early postmortem protein degradation. Vitamin E appears to alleviate, while AG stimulates, oxidative stress.

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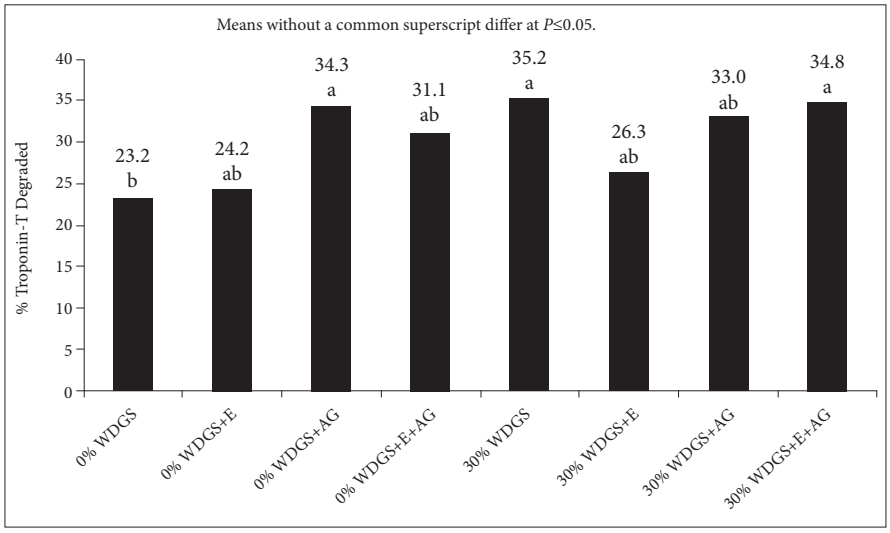

Figure 2. Protein degradation (Measured by troponin-T degradation) of strip loins (aged for 2 d) from steers fed a corn-based diet with 0% wet distillers grains plus solubles (WDGS) or 30% WDGS supplemented with or without vitamin E (E) or Agrado (AG) or a combination of E and AG.

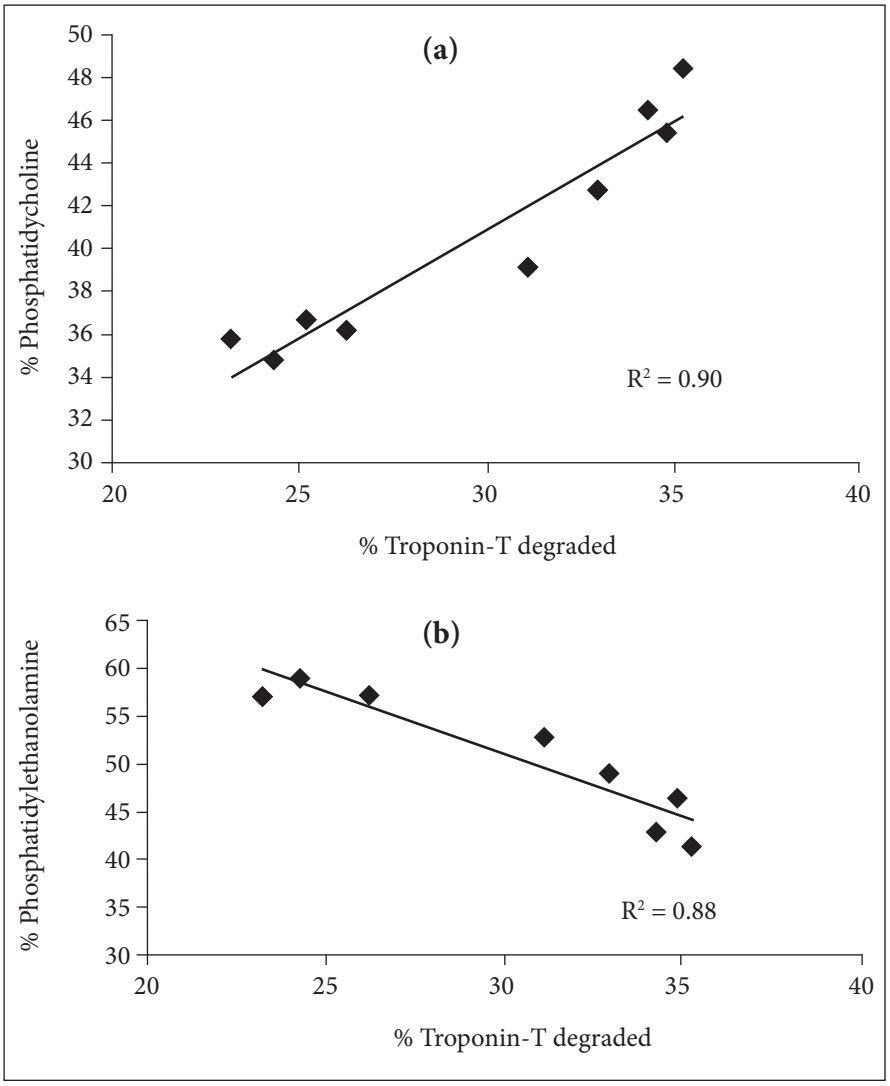

Figure 3. Relationship of the LS means of protein degradation (Measured by troponin-T degradation) of muscle aged for 2 d with a) LS means of phosphatidylcholine and b) LS means of phosphatidylethanolamine in total sarcoplasmic reticulum (SR) membrane phospholipid.

Student Perceptions and Knowledge of the Feedlot Industry and the Feedyard Management Specialization Internship

Rachel A. Oglesbee, Meredith L. Bremer, Kari L. Lewis, Dennis Brink,
Terry J. Klopfenstein, Jim C. MacDonald, and Galen E. Erickson

Summary

A survey was developed for seniors in the undergraduate feedlot management class (ASCI 457) at UNL to gauge interest in feedlot management as a profession and familiarity with the Feedyard Management Internship Program. The survey found that students feel the internship is beneficial for a future in production agriculture. The internship increases confidence of employment and management skills once participation is complete along with gaining experience. The number of positions available and the average salary of feedlot managers are underestimated by students. Recruiting efforts appear to be informing students of the program.

Introduction

The University of Nebraska–Lincoln Feedyard Management Specialization Internship has been offered the past 26 years to students following completion of their B.S. degree. Students interested in feedyard management or related fields are the target for completing the internship program. The internship starts with six weeks of coursework focusing on feedlot nutrition, health, personnel management, economics, and nutrient management. During those six weeks, guest speakers are invited to talk with students about the beef industry and these topics. Following the first six weeks of class, interns are placed in his or her individual feedlot for four and a half months to get hands-on experience of all sectors of the feedlot. Finally, they return for two weeks for a wrap-up session to share their experiences. The internship is set up to connect young people in the industry with potential jobs along with gaining a unique experience while obtaining an education of the industry.

A survey was given to the senior feedlot management class (ASCI 457) at the University of Nebraska–Lincoln with the purpose of determining student perceptions of a career in the field of feedyard management and to gauge the success of recruitment efforts on awareness and participation in the feedyard management internship.

Procedure

Surveys were administered to senior (undergraduate) feedlot management class (ASCI 457) at UNL in the fall the past 4 years (from 2011 through 2014). For each year, there were 22, 17, 33, and 43 participants, respectively. Participation in the survey was voluntary and anonymous. The survey had 26 multiple choice and short answer questions to gain knowledge of interest in the internship, interest in feedyard management, and effectiveness of recruiting. Results were summarized by year and all four years were assembled together per question.

Results

Many of the students taking the Feedlot Management class at UNL have a background with beef cattle varying from a 4H project to a family owned business. The majority of the students (51–63%) have plans to go into production agriculture or a related industry once their education is complete. Although feedlot management was one of the career choices, many students had other interests even though they were enrolled in the senior management class focused on feedlots.

When choosing a career, the students responded that feedlot management would be appealing if a defined work schedule were set (question 6), personal interests were met, they had experience with the job and the job offered adequate compensation (question 4). Over half of the students said they feel $30,000–$40,000 would be an acceptable wage when entering a mid-level management position at the feedlot. They also underestimated the average salary of a feedlot manager, where the average is over $71,000 according to the 2010 survey conducted by the Department of Agriculture Economics (http://agecon.unl.edu/resources). Students were not well aware of the availability of feedlot management positions, and underestimated the potential for careers within feedlot management. The internship is one way to connect students to these potential jobs while gaining experience. Once the student completes the internship, he or she often has the option to stay on with that feedlot for full-time employment.

When asked about managing financial risk at the feedlot, many of the students felt neither prepared nor unprepared (score of 3) or felt poorly prepared to complete that task. Interestingly, students perceived that they were prepared to manage the cattle at the production site. When female students were asked about their comfort working in a male dominant field, almost all felt comfortable. In the feedlot internship, students are taught about both personnel and financial risk to prepare them for what they will encounter in the feedlot. Instructors attempt to help students understand common practices in a feedlot today.

From 2011 to 2014, an increasing number of students said they were planning on participating in the internship. Those not interested said personal interests and applicability to their future career were the main reasons for not participating or planning to participate. The internship is set up to accommodate students. Location must be agreed upon, and the feedyard is selected based on the student's interests.

Upon graduation from UNL, most students felt they would not be prepared to take over a feedlot management position; however, the opposite response was made when asked if they felt they would be prepared after completing the internship. Students were confident in full-time employment after graduation, but feel they would be more confident if they completed the internship before full-time employment.

The survey found that 50 to 70% of the students made their post graduation plans before their senior year (as a junior in college or earlier). This says that recruiting efforts need to be geared towards underclassmen to inform them of the internship before plans are made. From 2011 to 2014, increasing numbers of students were knowledgeable of the feedlot internship, showing that more recent recruiting efforts over the past 4 years has been successful at informing students of the internship.

The internship increases confidence of employment and management skills once completed. Students also value gaining experience and feel experience is important before taking a full-time job. The number of positions available and the average salary of feedlot managers are underestimated by students, yet students feel pay is one of their top priorities for job selection. Recruiting efforts appear to be effective for informing students of the program; however, raising awareness needs to be focused on underclassmen.

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Table 1. Feedyard Management Specialization internship survey results

	2014	2013	2012	2011
1.Plans following graduation Production Agriculture	63%	59%	61%	51%
Cow-Calf	63%	57%	55%	68%
Feedlot	37%	39%	45%	26%
Non-Beef Cattle	0%	4%	0%	6%
Continue Education	16%	5%	9%	29%
Industry Related	21%	36%	24%	15%
Other	0%	0%	6%	5%
2. Time of making post-graduation plans				
Junior Year	27%	28%	41%	30%
Prior to entering college	18%	6%	18%	18%
Freshmen or Sophomore Year	36%	25%	6%	39%
Senior Year	18%	41%	35%	14%
3. Strength of considering feedlot management (1 = least amount)				
1	5%	0%	0%	5%
2	18%	9%	24%	23%
3	25%	45%	18%	23%
4	25%	30%	29%	11%
5	27%	15%	29%	18%
4. Factors in choosing a career (average ranking)				
Personal Interests	2	1	1	1
Pay	6	2 & 3	2	2 & 3
Experience with potential job	1	2 & 3	3	5
Benefits (health insurance, medical, vacation, etc.)	4	4	4	4
Located in Nebraska	12	5	5	2 & 3
Upward mobility in the company	7	6	6	8
Schedule (hours, weekends off, vacation, etc)	5	7	7	7
Company culture (coworkers, language, etc.)	9	8	8	6
Company perks (company vehicle, etc.)	10	9	9	9
Housing availability	3	10	10	11
Work environment (weather exposure, dust conditions, etc.)	11	11	11	10
Proximity to a major city	8	12	12	12

Table 1. Feedyard Management Specialization internship survey results (*continued*)

	2014	2013	2012	2011
5. Acceptable starting wage for mid-level feedlot management position (actual average salary for mid-level management position is $40,000–$58,000).				
< $20,000	0%	0%	0%	0%
$20,000–$20,000	18%	9%	6%	19%
$30,000–$40,000	52%	58%	59%	62%
$40,000–$50,000	27%	33%	29%	19%
> $60,000	2%	0%	6%	0%
6. Would a clearly defined work schedule increase attractiveness of a Feedlot Manager?				
Yes	77%	58%	71%	61%
No	23%	42%	29%	39%
7. Students' perception of availability of feedlot manager positions (1 = extremely unavailable)				
1	7%	0%	0%	5%
2	25%	35%	32%	38%
3	52%	35%	58%	48%
4	11%	24%	5%	10%
5	5%	6%	5%	0%
8. Feel comfortable and adequately trained to manage the financial risk of a feedlot using futures and options (1 = not at all).				
1	22%	9%	12%	5%
2	25%	38%	35%	23%
3	25%	25%	35%	59%
4	17%	22%	6%	5%
5	11%	6%	12%	9%
9. Feel comfortable managing other people's cattle, capital and risk at custom feeding operation (1 = not at all)				
1	11%	3%	6%	9%
2	6%	16%	24%	23%
3	33%	47%	29%	50%
4	36%	28%	12%	14%
5	14%	6%	29%	5%
10. Estimate of average Nebraska Feedlot Manager salary per year (actual average feedlot manager salary is $71,217)				
< $40,000	2%	3%	6%	10%
$40,000–$50,000	26%	24%	17%	33%
$50,000–$60,000	35%	27%	44%	48%
$60,000–$70,000	30%	33%	33%	10%
> $70,000	7%	12%	0%	0%
11. Beef Cattle Background				
Grew up with family involvement in feedlot industry	10%	12%	15%	15%
Grew up with family involvement in cow/calf industry	25%	29%	29%	32%
4-H background	22%	27%	21%	29%
FFA background	16%	16%	17%	17%
No family involvement growing up, but 4-H/FFA background	0%	0%	0%	0%
Experience working in feedlot or cow/calf (not family related)	15%	13%	15%	7%
Very limited	2%	3%	4%	0%

Table 1. Feedyard Management Specialization internship survey results (*continued*)

	2014	2013	2012	2011
12. Knowledge of UNL Feedyard Management Internship (1 = no knowledge).				
1	9%	13%	12%	50%
2	35%	32%	53%	32%
3	30%	26%	12%	18%
4	16%	29%	18%	0%
5	9%	0%	6%	0%
13. Students planning to enter Feedyard Management Internship				
Yes	26%	10%	35%	10%
No	74%	90%	65%	90%
14. Benefit of UNL Feedyard Management Internship to future career (1 = not at all).				
1	12%	10%	0%	29%
2	9%	24%	6%	29%
3	21%	29%	24%	24%
4	23%	10%	29%	10%
5	35%	29%	41%	10%
15. Why student does not plan on completing Feedyard Management internship				
Not applicable to future career	26%	30%	50%	40%
Too time consuming	3%	13%	17%	0%
No desire to take an additional class	26%	9%	17%	8%
Intern wages are prohibitively low	9%	0%	0%	3%
Personal (time away from family, significant other, etc.)	15%	22%	8%	15%
Other	21%	26%	8%	35%
16. Students' belief they are adequately trained upon UNL graduation to begin a Feedlot Manager career without internship				
Yes	37%	74%	71%	68%
No	63%	26%	29%	32%
17. Students' belief they would be adequately trained upon Feedlot Management internship completion to begin a Feedlot Manager career				
Yes	90%	86%	86%	81%
No	10%	14%	14%	19%
18. Student's perception of full-time employment upon graduation (1 = No chance, 5 = Definite employment)				
1	0%	0%	0%	0%
2	5%	0%	0%	0%
3	23%	25%	18%	11%
4	23%	31%	29%	26%
5	50%	44%	53%	63%
19. Student's perception of full-time employment upon UNL Feedlot Management internship completion (1 = No chance, 5 = Definite employment)				
1	0%	0%	0%	0%
2	0%	3%	0%	0%
3	8%	9%	6%	13%
4	36%	24%	38%	31%
5	56%	64%	56%	56%

Producer Concerns and Perceptions Regarding the Effect of Methane on Cattle Production and the Environment

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Summary

Knowledge of producer concerns and perceptions on methane production from cattle and its impact on the environment is unknown. Therefore, the objectives of this survey were to determine what producers know about methane production by cattle and to determine if different age groups, regions of Nebraska, and production size/type affects producer opinions on enteric methane production and climate change. Producers felt that methane production has little impact on animal performance but were not very confident in their knowledge. Most producers received information related to animal agriculture from veterinarians; therefore, veterinarians should continue to be a major target for extension efforts.

Introduction

Recently the environmental impact of beef cattle production and associated methane emissions has been a topic of interest. Methane is a greenhouse gas, with a global warming potential 25 times that of CO_2 (Livestock Science, 130:47–56). Ruminants account for 97% of the total methane produced by domesticated animals and 75% of the methane produced by ruminants is produced by cattle. Estimates suggest that 15–25% of the methane released into the atmosphere comes from domesticated ruminants (Tellus, 38B:271–284). The effect of livestock production on the environment is thought to be a topic that many producers overlook. However, with an increase in social media and popular press addressing climate change and methane issues, this may not be true. Therefore, the objective of this survey was to determine what producers know about methane production by cattle and how it affects the environment in addition to determining if producer age groups, regions of Nebraska, or production size/type affects producer opinions on climate change and methane.

Procedure

This survey was conducted by the Nebraska Agricultural Statistics Service who utilized their cow/calf and feedlot database from the 2007 census to determine operation size and the total number of operations in Nebraska. The feedlot operations were selected from the population for sampling first and were then removed from the sampling population prior to sampling beef cow operations. The sample was taken in this manner to eliminate duplication. This resulted in an overall sampling of 3337 randomly selected producers being surveyed.

The survey consisted of 24 multiple-choice and agree/disagree questions regarding the operation (area of Nebraska, operation size/type), producer (age, gender, years in production), and perceptions/knowledge about methane production and climate change. To analyze producer perceptions and knowledge about methane production and climate change, responses were coded numerically. Responses for the agree/disagree questions were coded on a 5-point Likert scale as 1 = Strongly Disagree to 5 = Strongly Agree. Responses for questions regarding confidence level were coded using a four point scale as 1 = "not at all confident", 2 = "not very confident", 3 = "somewhat confident" and 4 = "very confident".

The surveys were first analyzed for completeness to determine if they were valid. After the valid surveys were identified, they were analyzed using SPSS (IBM Corp; Armonk, NY). To determine if data were normally distributed the Kolomogrov-Smirnov test of normality was performed. Data were not normally distributed, so non-parametric tests were utilized for comparisons and correlations. The survey responses were grouped and analyzed for differences by area of Nebraska as marked by the producer (western, central and eastern) and age of producer (25–49, 50–59, 60–69 and 70+). A non-parametric correlation analysis was also performed to determine if producer responses to the question "I am concerned about climate change" were associated with how they responded to other questions in the survey.

Results

Survey return rate was 22% with 725 surveys returned out of the 3337 sent out. Survey responses related to producer concerns about the effects of methane production by cattle on the environment and climate change were significantly different by area within the state of Nebraska (western, central and eastern; Table 1). Producers in western NE disagreed more based on the Likert scale ($P < 0.05$) regarding concern about methane production on the environment compared to eastern NE, with responses of central NE producers being intermediate to western and eastern NE. Producers in western Nebraska also disagreed more based on the Likert scale ($P < 0.05$) regarding concern about climate

Table 1. Concern about climate change by area of Nebraska

Question	Area of Nebraska		
	Western (n = 191)	Central (n = 373)	Eastern (n = 151)
I am concerned with the effects of methane production on the environment	2.30 ± 0.99[a]	2.41 ± 1.0[ab]	2.63 ± 0.95[b]
I am concerned about climate change	2.55 ± 1.10[a]	2.79 ± 1.20[b]	2.86 ± 1.10[b]

Note. Five point Likert scale was used with question with 1 = Strongly Disagree to 5 = Strongly Agree
[ab]Values within the same row with unique superscripts differ $P < 0.05$

Table 2. Response based on age of producer

Question	Producer Age			
	25–49 (n = 129)	50–59 (n = 251)	60–69 (n = 219)	70+ (n = 114)
Methane production impacts animal performance[a]	2.86 ± 0.99[e]	2.72 ± 0.86[ef]	2.66 ± 0.88[ef]	2.47 ± 0.90[f]
Cattle diet influences methane production[a]	3.64 ± 0.88[e]	3.45 ± 0.91[ef]	3.36 ± 0.89[f]	2.93 ± 1.12[g]
Concerned with the effects of methane production on the environment[a]	2.53 ± 1.00	2.50 ± 0.98	2.36 ± 1.02	2.30 ± 0.96
I am likely to adopt management practices that research has shown to improve animal performance[a]	3.67 ± 0.94[e]	3.76 ± 0.96[e]	3.66 ± 0.91[e]	3.16 ± 1.12[f]
I am concerned about climate change[a]	3.08 ± 1.12[e]	2.82 ± 1.12[ef]	2.59 ± 1.21[fg]	2.44 ± 1.11[g]
The industry should take steps to limit greenhouse gas emissions[a]	2.97 ± 1.03[e]	2.78 ± 1.04[ef]	2.61 ± 1.11[fg]	2.45 ± 1.07[g]
The government should take steps to limit greenhouse gas emissions[a]	2.19 ± 1.21	2.18 ± 1.1[e]	2.10 ± 1.09	1.96 ± 1.09
Rank you perception of the impact cattle have on the environment[b]	4.14 ± 0.98[e]	3.83 ± 1.17[e]	3.74 ± 1.28[e]	3.01 ± 1.62[f]
Confidence in knowledge of methane production in cattle[c]	2.53 ± 0.73	2.51 ± 0.76	2.60 ± 0.82	2.74 ± 0.86
How often did you attend extension meetings in the past three years[d]	2.43 ± 1.51	2.48 ± 1.36	2.47 ± 1.45	2.37 ± 1.47

[a]Five point Likert scale was used with questions with 1 = Strongly Disagree to 5 = Strongly Agree
[b]Five point scale was used with 1 = Negative Impact to 5 = Positive Impact
[c]Four point scale was used with 1 = Not confident at all to 5 = Very Confident
[d]Five point scale was used with 1 = Never attended a meeting to 5 = Attended a meeting more than five times
[e–g]Values within rows with unique superscript differ $P < 0.05$

change compared to both central and eastern NE.

Most producers either strongly disagreed to disagreed (39%) or were neutral (33%) with the statement "I am concerned about climate change". Responses to questions on methane production by cattle and its effect on the environment, separated by age of producer are presented in Table 2. Younger producers were more neutral about the statement that methane production impacts animal performance ($P < 0.05$) than older producers who were more likely to disagree with this statement. Eighty-four percent of the population sampled fell within the disagree/neutral category, suggesting that current research on methane production in beef cattle has not been well translated to producers. Younger producers agreed with the statement that cattle diet influences methane production to a greater extent than older producers ($P < 0.05$) who tended to slightly disagree with this statement.

Producers in the youngest three age groups tended to agree concerning the likelihood of adopting new management practices that research has shown to improve animal performance. Although approximately 60% of the entire sample agreed or strongly agreed with this statement; producers over 70 years of age were closer to neutral ($P < 0.05$) compared to other age groups. This could potentially suggest that older producers are reluctant to adopt new management strategies for various reasons. The responses between producer age groups for the statement "government should take steps to limit greenhouse gas emissions" were not different ($P > 0.05$). About 63% of respondents disagreed or strongly disagreed with the statement that the government should take steps to limit greenhouse gas emissions, with another 25% neither agreeing nor disagreeing.

There was no difference between age groups for the statement "I am concerned about the effects of methane production on the environment" ($P > 0.05$) with 50% selecting disagree or strongly disagree and 37% neither agreeing nor disagreeing to the statement, suggesting that producers are not very concerned about cattle methane production and its contribution to climate change. Younger producers were generally more neutral about the statement "I am concerned about climate change" than were older producers, with statistically significant differences ($P < 0.05$) existing for producers in the youngest and oldest age categories. Producers under 70 years of age felt that cattle have a positive impact on the environment while producers older than 70 years of age were of the opinion that cattle have neither a positive nor negative impact ($P < 0.05$). Across age groups, no significant differences were detected in producer confidence in their knowledge about methane production in cattle ($P > 0.05$). Approximately 44% fell into the not at all to not very confident category, with 45% somewhat confident, and only 11% very confident. Given these low confidence levels regarding knowledge of methane production, this suggests a need for more education to be targeted in this area for producers.

Extension meeting attendance was not different ($P > 0.05$) across age groups with about 50% of producers attending one to three meetings in the past three years (Table 3). Even though the percent of producers never attending an extension meeting was higher than desired, 63% of producers attended at least one meeting in the past three years, which suggests some extension education is being provided to the majority of producers in Nebraska. Frequency of attending extension meetings was positively associated with likelihood to adopt management practices that research has shown to improve animal performance ($P < 0.01$), perception that cattle diet influences methane production, ($P < 0.05$), confidence in knowledge of methane production and management practices that impact methane production in cattle ($P <$

Table 3. Extension meeting attendance

Number of extension meetings attended in past three years (% of producers within age category)	Producer Age			
	25–49 (n = 129)	50–59 (n = 251)	60–69 (n = 219)	70+ (n = 114)
Never	38.8	31.5	37.8	45.5
Once	23.3	25.9	18.0	8.2
Twice	11.6	17.5	18.0	23.6
Three Times	8.5	13.1	12.4	9.1
More than Three Times	17.8	12.0	13.8	13.6

Table 4. Where producer obtain information about animal agriculture by age

Where producers go for animal information (% of producers within age category)	Producer Age			
	25–49 (n = 129)	50–59 (n = 251)	60–69 (n = 219)	70+ (n = 114)
Federal Government	0.8	0.8	0.0	0.9
State Government	2.4	0.4	0.9	1.8
University of Nebraska	14.2	18.5	18.4	11.9
Veterinarian	51.2	43.0	43.8	52.3
Other	31.5	38.6	36.9	33.0

Table 5. Correlations between the question "I am Concerned about climate change" and answers to other survey questions

Positively Associated	R-value	Negatively Associated	R-value
Methane production impacts animal performance.*[a]	r = 0.294	On a scale from one to five, rank your perception of the impact cattle have on the environment.[b]	r = 0.154
Cattle diet influences methane production.*[a]	r = 0.197	Please indicate how confident you are in your knowledge of methane production of cattle.*[c]	r = 0.290
I am concerned with the effects of methane production on the environment.*[a]	r = 0.546	Please indicate how confident you are in your knowledge of management practices that impact methane production in cattle.*[c]	r = 0.274
I am likely to adopt management practices that research has shown improve animal performance.*[a]	r = 0.148	Please indicate how confident you are in your knowledge of climate change?*[c]	r = 0.310
I should take steps to limit greenhouse gas emissions.*[a]	r = 0.711	Which of the following describes your current age?*[d]	r = 0.181
The industry should take steps to limit greenhouse gas emissions.*[a]	r = 0.690		
The government should take steps to limit greenhouse gas emissions.*[a]	r = 0.564		

*correlation is significant $P < 0.01$
[a]Five point Likert scale was used with questions with 1 = Strongly Disagree to 5 = Strongly Agree
[b]Five point scale was used with 1 = Negative Impact to 5 = Positive Impact
[c]Four point scale was used with 1 = Not confident at all to 5 = Very Confident
[d]Age range options were 25 or younger, 26–29, 30–39, 40–49, 50–59, 60–69, 70–79 and 80 or older

0.01), and confidence in knowledge of climate change ($P < 0.01$). These positive associations provide evidence that extension meeting attendance increased the knowledge level of producers, or at least producer perception of their knowledge level on methane production, cattle performance, and climate change.

About 45% of respondents, regardless of age, obtain information about animal agriculture from their veterinarian (Table 4), stressing the importance of sharing current research with veterinarians so they can pass it on to producers. The second most popular source of information fell into the "other" category (36%). If producers marked the other category, they were asked to comment on where they received their information. The other category consisted of magazines (n = 41) followed by consultants (n = 21), friends, family and neighbors (n = 8), feed companies/representatives (n = 6) and the internet (n = 5). The University of Nebraska–Lincoln (UNL) was responsible for getting information directly to about 16% of producers and state and federal government provided 2% of producers with information.

Correlations between how producers responded to the statement "I am concerned about climate change" and their responses to other questions in the survey are presented in Table 5. There was a positive association ($r = 0.711$, $P < 0.01$) between how producers answered if they were concerned about climate change and the question "I should take steps to limit greenhouse gas emissions". This suggests that producers who were concerned about climate change were also likely to consider taking steps to limit greenhouse gas emissions and vice versa. There were also positive correlations ($P < 0.01$) between concern about climate change and agreement that the industry ($r = 0.690$) and government ($r = 0.564$) should take steps to limit greenhouse gas emissions, as well as concern with the effects of methane on the environment (r = 0.546). Producer age, however, was negatively associated ($P < 0.01$) with being concerned about climate change ($r = 0.181$) suggesting that older producers tend to be less concerned about climate change than younger producers. There were also negative associations ($P < 0.01$) between producer confidence in their knowledge of methane production in cattle

and climate change ($r > 0.29$). This suggests that producers who are unconcerned with climate change also tend to be confident in their knowledge about methane production and climate change.

The survey results show that methane production by cattle and climate change are not major concerns for producers. Producers feel methane production has little impact on animal performance but are not very confident in their knowledge on this subject suggesting universities and extension needs to find more effective methods of reaching producers with the results of current research. Most producers received information related to animal agriculture from veterinarians; therefore, veterinarians should continue to be a major target for extension efforts

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Statistics Used in the Nebraska Beef Report and Their Purpose

The purpose of beef cattle and beef product research at University of Nebraska–Lincoln is to provide reference information that represents the various populations (cows, calves, heifers, feeders, carcasses, retail products, etc.) of beef production. Obviously, the researcher cannot apply treatments to every member of a population; therefore, he/she must sample the population. The use of statistics allows the researcher and readers of the *Nebraska Beef Report* the opportunity to evaluate separation of random (chance) occurrences and real biological effects of a treatment. Following is a brief description of the major statistics used in the beef report. For a more detailed description of the expectations of authors and parameters used in animal science see *Journal of Animal Science Style and Form* at: http://jas.fass.org/misc/ifora.shtml.

— **Mean**—Data for individual experimental units (cows, steers, steaks) exposed to the same treatment are generally averaged and reported in the text, tables and figures. The statistical term representing the average of a group of data points is mean.

— **Variability**—The inconsistency among the individual experimental units used to calculate a mean for the item measured is the variance. For example, if the ADG for *all* the steers used to calculate the mean for a treatment is 3.5 lb then the variance is zero. But, this situation never happens! However, if ADG for individual steers used to calculate the mean for a treatment range from 1.0 lb to 5.0 lb, then the variance is large. The variance may be reported as standard deviation (square root of the variance) or as standard error of the mean. The standard error is the standard deviation of the mean as if we had done repeated samplings of data to calculate multiple means for a given treatment. In most cases treatment means and their measure of variability will be expressed as follows: 3.5 ± 0.15. This would be a mean of 3.5 followed by the standard error of the mean of 0.15. A helpful step combining both the mean and the variability from an experiment to conclude whether the treatment results in a real biological effect is to calculate a 95% confidence interval. This interval would be twice the standard error added to and subtracted from the mean. In the example above, this interval is 3.2–3.8 lb. If in an experiment, these intervals calculated for treatments of interest overlap, the experiment does not provide satisfactory evidence to conclude that treatments effects are different.

— ***P* Value**—Probability (*P* Value) refers to the likelihood the observed differences among treatment means are due to chance. For example, if the author reports $P \leq 0.05$ as the significance level for a test of the differences between treatments as they affect ADG, the reader may conclude there is less than a 5% chance the differences observed between the means are a random occurrence and the treatments do not affect ADG. Hence we conclude that, because this probability of chance occurrence is small, there must be difference between the treatments in their effect on ADG. It is generally accepted among researchers when *P* values are less than or equal to 0.05, observed differences are deemed due to important treatment effects. Authors occasionally conclude that an effect is significant, hence real, if P values are between 0.05 and 0.10. Further, some authors may include a statement indicating there was a "tendency" or "trend" in the data. Authors often use these statements when *P* values are between 0.10 and 0.15, because they are not confident the differences among treatment means are real treatment effects. With *P* values of 0.10 and 0.15 the chance random sampling caused the observed differences is 1 in 10 and 1 in 6.7, respectively.

—**Linear & Quadratic Contrasts**—Some articles contain linear (L) and quadratic (Q) responses to treatments. These parameters are used when the research involves increasing amounts of a factor as treatments. Examples are increasing amounts of a ration ingredient (corn, by-product, or feed additive) or increasing amounts of a nutrient (protein, calcium, or vitamin E). The L and Q contrasts provide information regarding the shape of the response. Linear indicates a straight line response and quadratic indicates a curved response. P-values for these contrasts have the same interpretation as described above.

—**Correlation (r)**—Correlation indicates amount of linear relationship of two measurements. The correlation coefficient can range from B1 to 1. Values near zero indicate a weak relationship, values near 1 indicate a strong positive relationship, and a value of B1 indicates a strong negative relationship.

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