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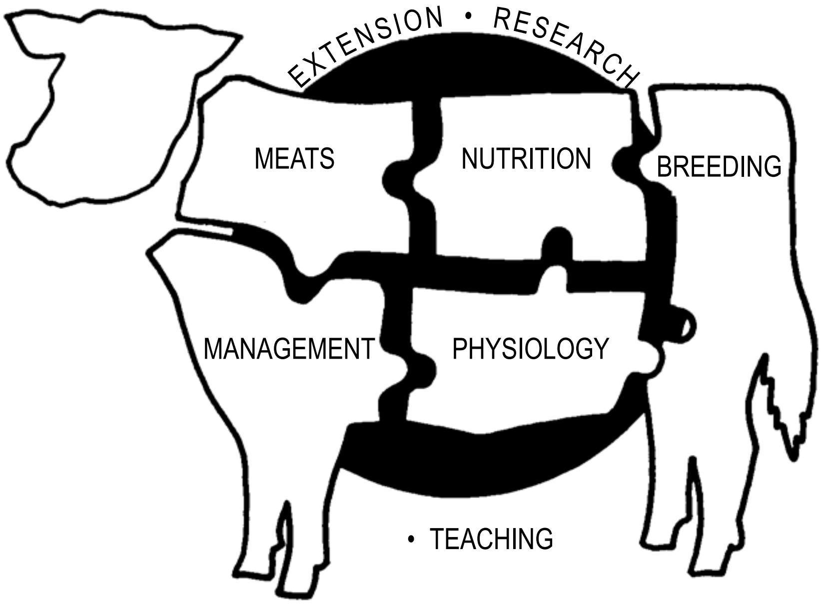

Agricultural Research Division
University of Nebraska Extension
Institute of Agriculture and Natural Resources
University of Nebraska–Lincoln

NEBRASKA

2012 Beef Cattle Report

IANR

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Table of Contents 2012 Nebraska Beef Cattle Report

Cow/Calf

Growing

Finishing

Beef Products

Supplementing Gestating Beef Cows Grazing Cornstalk Residue

Jason M. Warner
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Summary

A 5-year study evaluated the effects of protein supplementation to beef cows grazing cornstalks in late gestation on both cow and calf weight, and the reproductive performance of heifer progeny. Supplementation improved cow BCS at the end of cornstalk grazing. Calf weight, cow pregnancy rates, and reproductive traits of subsequent heifer progeny were not impacted by supplementation. Supplementing mid- to late-gestation beef cows grazing cornstalks has minimal impact on cow performance or fetal programming of heifer progeny.

Introduction

Corn residue CP levels are reported from 3.3 to 5.5%, which does not meet the requirements of a mid- to late-gestation beef female. Supplementation may be necessary when grazing low-quality forages. Prior research suggests supplementation of the dam during late gestation impacts fetal development and subsequent reproductive efficiency of the female progeny (*2006 Nebraska Beef Cattle Report*, p. 10). Therefore, the objectives of this study were to evaluate the effects of supplementing cows grazing cornstalk residue in late gestation on both cow and calf performance and the reproductive performance of heifer progeny.

Procedure

Cow and Calf Management

Multiparous, crossbred (Simmental x Angus), spring-calving beef cows (n = 832) were used in a 5-year experiment conducted at the University of Nebraska–Lincoln (UNL), Dalbey-Halleck Research Unit near Virginia, Neb. Cows were blocked annually by age, BCS, BW, and calving date and assigned randomly to one of two treatments: 1) supplemented (SUPP) with protein/energy via a range cube (Table 1) that was two-third dried distillers grains (DDG) while grazing cornstalk residue during the last trimester of pregnancy, or 2) not supplemented (CON). Data are reported as pooled across all years for 2005 (158 head), 2006 (165 head), 2007 (172 head), 2008 (166 head), and 2009 (171 head).

Changes in BW and BCS were used as predictors of nutritional status and recorded three times annually: October, February, and May (months represent weaning/stalks initial weight; off-stalks weight/pre-calving; and pre-breeding, respectively). BCS was assigned independently by two technicians and averaged. Cows were weighed once, without restriction of feed or water, in October, and 2-day weights and BCS were collected in February. BW and BCS were recorded 10 days apart in May prior to breeding.

Corn eardrop was estimated in each field prior to grazing in two 178 acre, irrigated corn fields located on the same section of land near Pickerell, Neb. Eardrop was similar for each field each year and averaged 1.0 bu/ac. An equation (*2004 Nebraska Beef Cattle Report*, p. 13) was used to determine grazing days and the amount of supplement fed. SUPP cows began receiving supplement 20 days after the start of grazing (Nov. 1), and cows were fed 2.2 lb/head/day (DM) on average for the entire period.

(Continued on next page)

Table 1. Dried distillers grains cube ingredients and nutrient composition.

Item	Year 1[a]	Years 2 and 3[b]	Year 4[c]	Year 5[d]
Dried distillers grains, %	65.0	65.0	65.0	65.0
Field peas, %	—	22.5	15.5	—
Wheat midds, %	16.5	5.5	12.5	13.0
Malt sprouts, %	—	—	—	15.0
Non-fat dried milk, %	11.4	—	—	—
Molasses, %	3.6	5.0	5.0	5.0
Calcium carbonate, %	2.0	2.0	2.0	2.0
Lignin sulfonate, %	1.5	—	—	—
Nutrient composition[e]				
Crude Protein, %	25.0	24.1	23.5	24.5
Crude Fat, %	7.1	6.7	7.0	7.5
Crude Fiber, %	9.0	7.2	6.5	7.82
Calcium, %	1.00	0.98	0.97	0.97
Phosphorus, %	0.75	0.66	0.69	0.73
Potassium, %	0.80	0.82	0.82	0.71

[a]Supplemented for the 2004-2005 grazing period.
[b]Supplemented for the 2005-2006 and 2006-2007 grazing period periods, respectively.
[c]Supplemented for the 2007-2008 cornstalk grazing period.
[d]Supplemented for the 2008-2009 cornstalk grazing period.
[e]% of DM.

Cows were supplemented three times per week until the end of stalk grazing (Feb. 1). After cornstalks, groups were managed separately until the start of calving (March 1), at which time they were combined and managed together on dormant pasture and fed a diet of smooth bromegrass and alfalfa hay. Cows and calves grazed cool- and warm-season pastures from approximately April 15 to Oct. 15 (weaning).

Blood samples were drawn twice 10 days apart immediately before breeding to determine cyclicity status. Serum progesterone (P_4) concentrations $\geq$ 1 ng/ml were used to establish if a cow had resumed normal estrous cycles. Cows were exposed to Simmental x Angus bulls at a bull:cow ratio of 1:25 for 60 days beginning May 23. Pregnancy was diagnosed via rectal palpation 90 days after bull removal.

Heifer Management

Weaned heifer progeny (n = 306) grazed dormant pasture for 60 days, and were then placed in a drylot from Jan. 1 until the end of May. Heifers were fed smooth bromegrass hay ad libitum and DDG at 0.6% BW daily (DM). Initial and final BCS were collected and BW was recorded every 14 days until breeding. Blood samples were drawn 14 days apart beginning in December to determine attainment of puberty. Serum P_4 concentrations $\geq$ 1 ng/ml for two consecutive sampling dates were used to establish if a heifer reached puberty.

Estrus was synchronized using two injections of prostaglandin $F_{2\alpha}$ (PGF) administered 14 days apart. Estrus detection was performed for five days following the second PGF injection, and heifers observed in estrus were bred by AI 12 hours later. Heifers were exposed to Angus bulls for 45 days beginning 10 days after the final AI. Heifers grazed cool- and warm-season pastures from the time of bull exposure until the end of the growing season. AI conception and pregnancy rates were determined via ultrasound 45 days post AI. A second ultrasound was performed 45 days after bull removal to establish final pregnancy rates.

Table 2. Effects of late gestation supplementation on cow and calf performance.

	Treatment			
Item	SUPP[a]	CON[b]	SEM	*P*-Value
Oct. BW, lb	1263	1265	23.5	0.79
Feb. BW, lb	1351	1327	16.5	0.19
May BW, lb	1247	1243	9.7	0.75
Change in BW, Oct.-Feb., lb	89	62	15.0	0.20
Change in BW, Feb.-May, lb	-112	-81	12.3	0.14
BCS, Oct.	5.4	5.4	0.09	0.89
BCS, Feb.	5.6[d]	5.4[e]	0.08	0.02
BCS, May	5.4	5.3	0.07	0.32
Change in BCS, Oct.-Feb.	0.19[d]	0.03[e]	0.05	0.03
Change in BCS, Feb.-May	-0.14	-0.11	0.09	0.72
Cyclic, %	76	71	0.05	0.46
Pregnancy rate, %	94	91	0.02	0.18
Calving interval, day	367	366	1.6	0.80
Calf birth weight, lb[c]	86	85	1.0	0.27
Calf weaning wt, lb[c]	552	548	11.4	0.35

[a]SUPP = cows supplemented 2.2 lb/head/day (DM basis) while grazing cornstalks.
[b]CON = cows not supplemented while grazing cornstalks.
[c]Actual weights including both steer and heifer progeny.
[d-e]Within a row, means without common superscripts differ at $P \leq 0.05$.

Table 3. Effects of dam supplementation on performance of heifer progeny.

	Treatment			
Item	SUPP[a]	CON[b]	SEM	*P*-Value
Initial BW, lb	612	609	22.4	0.79
Final BW, lb	770	774	25.3	0.60
Initial BCS	5.3	5.3	0.07	0.93
Final BCS	5.4	5.4	0.10	0.48
ADG, lb/day	0.97	1.01	0.09	0.20

[a]SUPP = heifers born of cows supplemented while grazing cornstalks.
[b]CON = heifers born of cows not supplemented while grazing cornstalks.

Table 4. Effects of dam supplementation on heifer reproductive performance.

	Treatment			
Item	SUPP[a]	CON[b]	SEM	*P*-Value
Age at puberty, day	343	336	10.8	0.23
Estrus response, %	84	78	0.31	0.39
Time of estrus, hour[c]	71	76	3.36	0.14
A.I. conception rate, %[d]	56	61	0.08	0.69
A.I. pregnancy rate, %[e]	46	47	0.08	0.93
Overall pregnancy rate, %	75	78	0.57	0.64

[a]SUPP = heifers born of cows supplemented while grazing cornstalks.
[b]CON = heifers born of cows not supplemented while grazing cornstalks.
[c]Time elapsed between second PGF injection and observed standing estrus.
[d]Proportion of heifers detected in estrus that conceived to AI service.
[e]Percentage of total group of heifers that conceived to AI service.

Statistical Analysis

Performance data and age at puberty were normally distributed and analyzed using PROC MIXED of SAS (SAS Inst., Inc., Cary, N.C.). Estrous synchronization response, conception rate to AI, pregnancy rates, and percentage of cows cyclic prior to breeding were binomially distributed and analyzed using PROC GLIMMIX of SAS (SAS Inst., Inc., Cary, N.C.). The model for all analyses included the fixed supplementation treatment effect. Because treatments were applied on a field basis, the experimental unit was field and the appropriate error term to test for differences between treatments was year by treatment.

Results

Cow and Calf Performance

Cow performance data are summarized in Table 2. Cow BW was similar at initiation and end of cornstalk grazing. Additionally, cow BW was not different at the start of the breeding season. No significant ($P = 0.14$) change in cow BW between groups occurred from either weaning to pre-calving or from pre-calving to pre-breeding. Interestingly, SUPP cows lost more weight than CON cows (-112 lb vs. -81 lb, respectively) from pre-calving to pre-breeding. BCS between groups was similar at weaning and pre-breeding. BCS was greater ($P = 0.02$) for SUPP cows at pre-calving. As expected, the change in BCS while on cornstalks was greater ($P = 0.03$) for SUPP than CON cows (0.19 vs. 0.03, respectively). However, these differences in BCS are so small that they likely have no biological significance. Calf birth and weaning weights were not affected by dam treatment. Calving interval, percentage of cows cyclic prior to breeding, and final pregnancy rates were not influenced by supplementation (Table 2).

Heifer Performance and Reproduction

Supplementation had no effect ($P = 0.20$) on heifer initial or final BW, initial or final BCS, or ADG (Table 3). Age at puberty was not influenced by dam supplementation (Table 4). Neither the percentage of heifers responding to synchronization nor the hours from the last PGF injection to estrus were different ($P = 0.14$). No differences were found in either AI conception or pregnancy rate, or final pregnancy rates. Our results agree with previous data suggesting there is no fetal programming effect on reproduction for cows supplemented protein during mid- to late-gestation when wintered on cornstalks (*2011 Nebraska Beef Cattle Report*, p. 5).

Conclusions

Supplementing cows grazing cornstalks in mid- to late-gestation did not improve cow reproduction or calf performance. Furthermore, supplementation did not affect growth or reproduction of heifer progeny. Results imply protein supplementation is not necessary for cows grazing cornstalks, given they begin the grazing period in adequate BCS (≥ 5).

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Effect of Corn Stalk Grazing and Baling on Cattle Performance and Irrigation Needs

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Terry J. Klopfenstein
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Summary

The effects of removing corn residue by grazing and baling on continuous corn production were investigated. Initial data showed a trend toward keeping more water in the soil in the treatment with the most residue left on the field (no grazing or baling), but there was no effect of either grazing or baling on subsequent corn yield. Water conservation resulting from maintaining residue on the field may help reduce pumping costs or increase yields when water is limited. However, this benefit is likely to be outweighed by feed cost savings or grazing rental income, and good cow performance.

Introduction

With high feed costs, the availability of ethanol co-products, and the potential for the bio-energy industry's use of corn residue as an input, residue removal is expected to increase. The goal of this study is to quantify the impacts from corn residue removal by grazing and baling. Specific objectives are to quantify effects of corn residue removal by grazing and baling on the performance of cattle, the water balance of the production system, and subsequent grain yield.

Procedure

One full center pivot (126 acres) under continuous corn management near Brule, Neb., was utilized. The pivot-irrigated field consists of loam, silt loam, and sandy loam soils, depending on the location within the field. The Brule area receives approximately 18.7 inches of precipitation annually. The study is in its third year and will be continued for several more years.

The impacts of corn residue removal are being investigated by applying the following treatments: 1) no residue removal, 2) light grazing (stocking rate of 1 AUM per acre), 3) heavy grazing (stocking rate of 2 AUM per acre), and 4) residue removal by baling (Figure 1). Treatments are replicated two times, for a total of eight pie-shaped paddocks fenced during the grazing season to maintain cows within the paddocks. Each paddock receives the same treatment each year.

Cattle were randomly assigned to each grazing treatment and BW and BCS were measured upon entry and exit from the paddock. Cattle entered the paddocks about mid-November and exited in January. Grazing treatments were achieved by placing twice as many cattle in the 2 AUM/acre treatment compared to the 1 AUM/acre treatment, and holding the number of acres and grazing days constant between the two grazing treatments.

In each of the eight paddocks, residue cover was measured several times a year using the line-transect method (USDA, Natural Resources Conservation Service. 2002. National Agronomy Manual, 3rd ed. Washington, D.C.). Soil water content was also measured several times a year, using the neutron scattering method. A neutron probe was used to measure soil water content at six depths, down to 6 feet deep. Corn grain yield was measured using a combine yield monitor. The corn crop was fully irrigated and no-till management is being practiced throughout this ongoing study.

Results

Initial BCS was similar for both grazing treatments (5.5 for both light and heavy grazing treatments), but the heavy grazing cattle lost 0.4 BCS units resulting in a final BCS of 5.5 and 5.1 ($P < 0.05$) for the light and heavy grazing treatments, respectively. The results demonstrate the importance of properly managing stocking rate when grazing corn residue. Because there are large differences in the nutrient content of the different parts of a corn plant (husks are better than leaves which are better than cobs and stems, *2004 Nebraska Beef Cattle Report*, p. 13), and because cattle preferentially select the more nutrient-dense parts first, stocking rate affects cattle performance.

Table 1. Mass of residue removed by baling.

	Residue mass	
Year	Tons/acre	lb/acre
2008/2009	2.29	4578
2009/2010	0.68	1366
2010/2011	1.96	3917

Area baled = 31.4 acres.

Baling removed approximately 2 tons/acre of corn residue in the first and third year of the study (Table 1). Much less was removed the second year. This may be due to less production of corn biomass in 2009 because of extensive damage from hail.

Residue cover was lowest on the baled treatment and greatest on the control (no removal) treatment (Table 2). Reasons for the decrease in residue cover between spring and summer in both 2009 and 2010 include 1) residue disturbance by the planting operation in May, 2) disturbance by an anhydrous application in June, and 3) some residue decomposition due to weather between spring and summer. In November 2010 there was no significant difference in residue cover among the four removal treatments, because this measurement was taken just after harvest and before grazing or baling. Not much residue disappeared between November 2010 and April 2011 in the control treatment.

For reducing evaporation of water from the soil, residue cover in a corn-

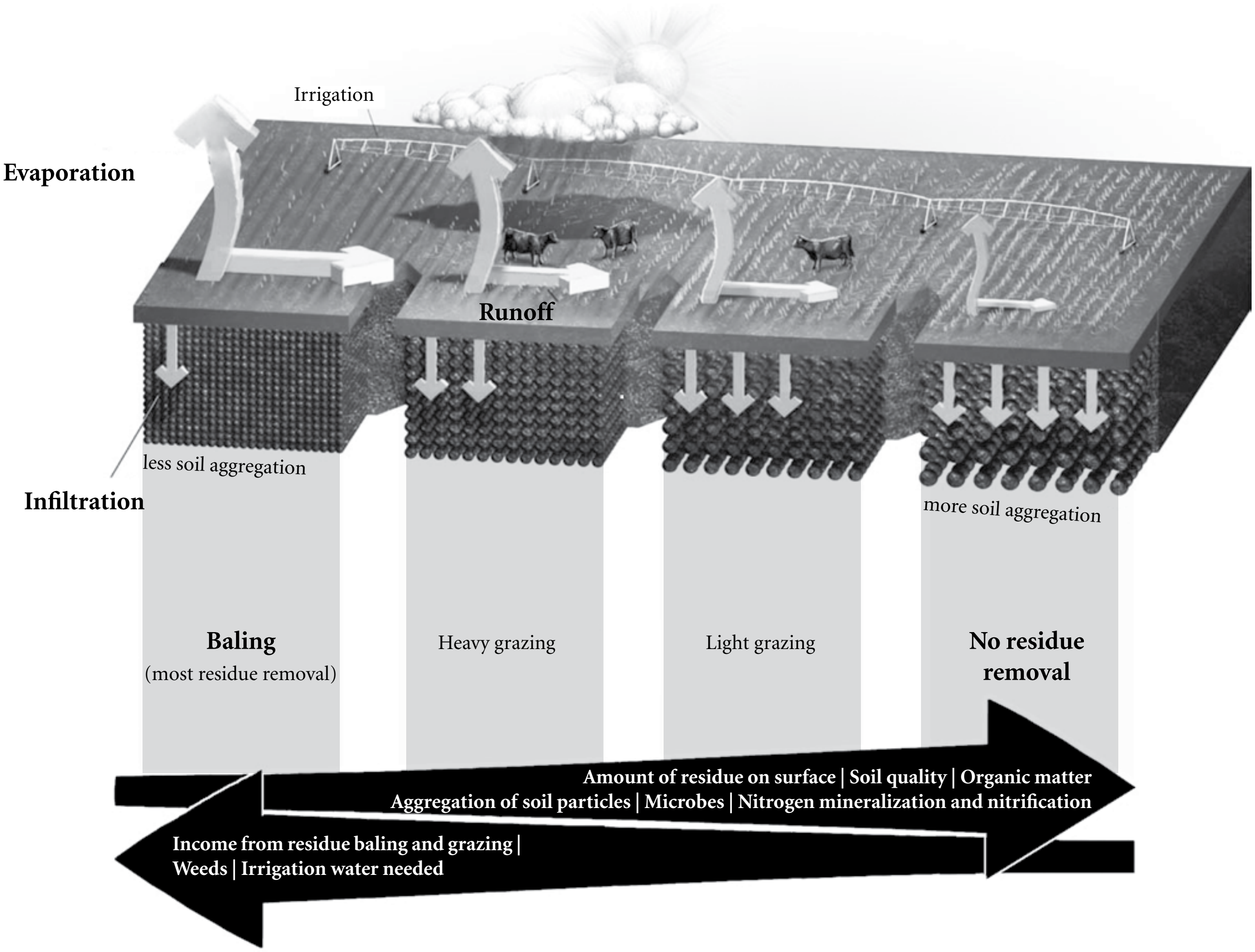

Figure 1. Depiction of the four treatments of the field study near Brule, Neb. Corn residue is removed by baling or grazing. Expected effects of residue removal are indicated in the figure. These effects include greater evaporation and runoff of water with increased residue removal. Other anticipated effects are: removing no or little residue increases carbon sequestration; baling removes nutrients from the field resulting in increased fertilization cost; cattle eat grain that is left in the field after harvest, reducing the amount of volunteer corn the following growing season; and more residue left on the surface can make planting of the next crop more challenging.

Table 2. Percent residue cover on the four residue removal treatments.

Date[a]	Baling[b]	Heavy grazing[b]	Light grazing[b]	No removal	*P*-value	MSE
April 14, 2009	30[a]	55[ab]	61[b]	79[b]	0.04	73
July 8, 2009	20[a]	38[b]	50[bc]	54[c]	0.02	22
April 30, 2010	53[a]	60[a]	80[b]	90[b]	0.01	15
Aug. 4, 2010	27[a]	44[ab]	47[ab]	67[b]	0.07	79
Nov. 2 2010	84	88	82	89	0.11	4
April 11, 2011	41[a]	76[b]	78[b]	88[b]	0.04	82

[a]For each date, different letters represent statistically significant differences between treatments at the 0.05 probability level.
[b]Baling and grazing treatments were applied in the winters of 2008/2009, 2009/2010, and 2010/2011.

field matters most in late spring and early summer when potential evaporation is high (warm, sunny weather) and the crop canopy is not yet closed. The baled treatment (with the least residue cover) lost 4.3 inches of water in the top 6 feet of soil between April 5 and Aug. 4, 2010. The heavy grazing, the light grazing, and the no removal treatments lost 2.9, 1.4, and 1.4 inches, respectively. However, there is variability in soil composition and topography on this pivot, which makes it more difficult to know whether detected differences were caused by this variability or by the residue removal treatments.

Yield differences were not evident among the four residue removal treatments in either 2009 or 2010. Two likely reasons for this include 1) the corn crop was fully irrigated, so it is unlikely it suffered from water stress, including the corn crop in the treatment with the least residue (the baled treatment); 2) it is expected that more than two years are needed to create sufficient differences in soil quality to cause yield differences.

Results from a related residue removal study at North Platte are more conclusive. This four-year study showed a water savings of 2.5 – 5.5 inches/year in plots where residue was left in place compared to plots

(Continued on next page)

with a residue cover of 5% or less. Residue grazing, and even baling, will not remove this much residue (Table 2). However, grazing and baling do remove residue, and some effect on water can be expected, albeit less than found in the North Platte study.

The economic benefits of the water savings discussed in this report can be estimated. Less irrigation water needs to be pumped when water is saved through leaving more residue on the field. This translates into a savings in pumping cost. For example, when pumping 1 inch of water less on a 130-acre field, the pumping cost savings is $1,632 for a dynamic pumping lift of 200 feet, a pump discharge pressure of 50 psi, and diesel at $3.50 per gallon. A calculator was developed to make the above calculations using one's own input data. It is available at *http://water.unl.edu/web/cropswater/reduce-need* (scroll down to the bottom of the page to access the calculator).

When water is limited, economic benefits from water savings due to residue cover can be expected in the form of higher yields. For example, corn yield may be 25 bu/ac higher when residue remains undisturbed compared to complete removal, as was the case in 2007 in the North Platte study. Again, baling and especially (light) grazing remove much less residue than was removed in the North Platte study. Thus, the yield penalty with limited water would be less when baling and especially when grazing. If the yield penalty were only 5 bu/ac, for corn at $4.00/bu, this would be $20/acre and $2,600 for a 130-acre field.

The benefits associated with retaining residue on the field need to be weighed against the benefits associated with using the residue. In our study near Brule we removed about 2 tons/acre in baled cornstalks. At $50/ton this represents a gross income of $13,000 for a 130-acre field. Obviously there are costs associated with baling but the income may be enough to offset the increased irrigation costs (or the decreased yield) caused by residue removal. Another consideration is the value of grazed cornstalks. Because cornstalks are such an inexpensive feed for wintering cattle, it is conceivable to save as much as $1/ cow/day if the cow grazes cornstalks compared to feeding in a drylot. A 130-acre pivot would be expected to maintain 100 cows for about two months. At a savings of $1/ cow/ day, that represents a savings of $6,000.

The decision about how to manage corn residue is complex and involves factors not discussed in this report. For example, baling results in nutrients contained in the residue being taken off the field with the residue. The cost of replacing these nutrients is discussed in NebGuide G1846, *Harvesting Crop Residues*. Other factors include soil compaction, soil particle aggregation, erosion by wind and water, weed pressure, volunteer corn, and agronomic practices such as planting. Each effect of removing residue, discussed in Figure 1, has its own associated economics. Some are more easily quantified than others, and continued research and analysis are needed.

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Nutritive Value and Amount of Corn Plant Parts

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Summary

Corn plants were separated into seven different plant parts and analyzed for digestibility. Digestibility of the different parts of the plant ranged from 33.85% to 59.03%. The amount of highly digestible residue averaged 13.4 lb/bu of grain. Digestibility and amount of residue has considerable impact on the stocking rate and performance of cattle on cornstalks. Subsequent crop yields were not affected by grazing.

Introduction

Several studies have shown the quality and amount of corn residue available for cattle to graze (*2004 Nebraska Beef Cattle Report*, p. 13; *Journal of Animal Science*, 69:1741; *Journal of Animal Science* 67:597); however, most of this work was done on older hybrids and smaller yields than typical today, and some of the plant parts have not been analyzed (e.g., shanks and leaf sheath)(*Journal of Animal Science*, 69:1741). Our objective was to determine the digestibility values of the parts of the corn plant and determine if there is a change in the digestibility from the top to the bottom of the stem. A second objective was to determine the amount of residue available and if it was affected by grazing treatment. A third objective was to determine if subsequent crop grain yields have changed due to numerous years of grazing of the corn residue in both fall and spring.

Procedure

This study utilized a corn field at the Agricultural Research and Development Center (ARDC) near Mead, Neb., that has been in a corn/soybean rotation for several years and is irrigated by a linear move irrigation system. The field has three treatments that have been maintained for 13 years, a fall grazed, spring grazed, and an ungrazed section. On Oct. 2 we collected 10 consecutive complete plants from 24 locations; eight from each of the three treatments. The plants were separated into grain, cobs, shanks, husks, leaf blades, leaf sheaths, and stems. Stems were measured individually and then divided into top 1/3 and bottom 2/3. All of the samples were dried in a 60°C oven, weighed, and analyzed for IVDMD (48 hours). Soybean yields the subsequent growing season and corn yields the next growing season were measured with the yield monitor on the combine.

Table 1. Plant part IVDMD, % of total plant DM, and lb DM/bu grain.

Plant Part	IVDMD	SEM	% of Plant DM	SEM	lb/bu[1]	SEM
Top 1/3 stalk	37.57%	0.80	3.60%	0.001	1.21	0.06
Bottom 2/3 Stalk	33.85%	1.74	41.83%	0.007	14.12	0.60
Leaf	45.70%	0.74	18.72%	0.003	6.30	0.25
Leaf sheath	38.56%	0.71	12.60%	0.004	4.23	0.15
Husk	59.03%	0.76	7.48%	0.002	2.51	0.08
Shank	49.75%	1.16	1.09%	0.001	.37	0.03
Cob	34.94%	0.68	14.68%	0.003	4.93	0.11

[1]15.5% moisture corn grain.

Results

Digestibility, percentage of the plant, and plant part per bushel are listed in Table 1, and there were no differences due to grazing treatments. Previous studies (*Journal of Animal Science* 69:1741; 2004 Nebraska Beef Cattle Report , p. 13) reported digestibilities for leaf, husk, and cob similar to the current study values but were higher than our values for stem. The stem was similar in digestibility throughout the plant with the top only slightly more digestible, however there was a considerable difference in the digestibility of the leaf sheath compared to the leaf blade. It is interesting to note that even though the shank makes up a very small proportion of the plant, it is one of the more highly digestible parts, ranking intermediate between leaf and husk. Others (*Journal of Animal Science* 67:597; *2004 Nebraska Beef Cattle Report* p. 13) found that the percentage of leaf, husk, stem, and cob relative to the total plant varied some from the current study values, suggesting changes in plant proportions may be changing as hybrids and yields change. Part of this difference in leaf may be due to a hail storm in late September that damaged primarily the upper leaves and upper stem.

Depending on the particular parts cattle eat, the amount per bushel available to them can range from 8.80 lb to 13.42 lb (Table 2). Post-grazing observations suggest most or all of the stem is on the ground, but it is very hard to determine if the cattle were eating the upper 1/3 of the stem. The leaf sheath remains on the stalk at times, and is removed from the stem at other times. This suggests at least some of the leaf sheath is being consumed, and the amount probably depends on how tightly the leaf sheath is attached to the stem and if it comes off when the animal is eating the leaf blade. It is also difficult to determine

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Table 2. Digestible plant parts, lb DM/bu[1].

Plant Parts	lb/bu
Leaf and husk	8.80
Leaf, leaf sheath, and husk	13.04
Leaf, leaf sheath, shank, and husk	13.40

[1]15.5% moisture grain.

if the shank is being eaten or not. There is very little found on the ground but occasionally it is found still attached to the cob. This suggests that, similar to the leaf sheath, whether it is consumed is probably due to how it is attached to the plant part cattle are selecting.

Past research and current observations show that cattle consume primarily the husk and leaf blade. These parts are the most digestible, apparently most palatable, and most readily available for consumption. Of course residual corn is readily consumed, but with hybrids that resist insects and diseases, and with efficient combines, residual grain is less than measured previously.

Because the husk is the most digestible plant part, cattle performance is better when more husk is being consumed than leaf. Further, as grazing continues or stocking rate is increased, more leaf blade is consumed and eventually some leaf sheath, cob, and upper stem are consumed. This lowers the digestibility of the diet and animal performance declines. Therefore, there is an interaction between quantity and quality. The greater the utilization of corn residue by increasing stocking rate or length of grazing, the lower the quality of the diet and animal performance.

The best indicator of residue (leaf plus husk) available is grain yield because cattlemen know the grain yield before determining stocking rate. Our data suggests the yield of leaf and husk per bushel may have declined in the past 15 to 20 years. Samples collected in 2009 (*2010 Nebraska Beef Cattle Report* p. 22) showed a range from 13.1 to 19.4 lb of leaf plus husk (average = 15.5) for 12 hybrids grown in Western Nebraska.

Table 3. Soybean yield; bu/ac at 15.5% moisture[1].

Year	Fall Grazed	Spring Grazed	Ungrazed
2004	56.76	58.67	56.95
2005	68.45	67.35	65.66
2006	68.85	67.76	67.56
2007	64.93	64.07	63.81
2008	68.75	65.78	63.38
2009	74.13	71.61	71.09
2010	54.80	53.23	53.13

[1]SEM =4.34; P=0.35.

Table 4. Corn yields; bu/ac at 15.5% moisture[1].

Year	Fall Grazed	Spring Grazed	Ungrazed
2004	179.30	181.01	184.55
2005	184.54	186.27	185.83
2006	198.97	198.93	194.88
2007	202.85	194.64	196.81
2008	189.58	189.55	187.23
2009	261.03	255.61	255.51
2010	237.03	238.75	232.31

[1]SEM=10.95; P=0.30.

This suggests that hybrid differences and perhaps the amount of leaf and husk per bushel is declining slightly with increasing corn yields. Harvest efficiency by cattle may be 50% on average but may be as high as 70% with heavy stocking. While it is very difficult to estimate, 8 lb/bu of consumable leaf and husk is still a relatively good estimate to use to calculate stocking rate. The interaction of stocking rate and diet quality can be illustrated as follows. If the stocking rate is set so that 6 lb/bu of residue is consumed and we assume 80% of husk is consumed, then the IVDMD of the diet would be about 52%. If stocking rate were higher so that 10 lb/bu were harvested, then IVDMD would be 49.4%. Further, if we assume 1.5% of the corn grain is left in the field, then the respective diet IVDMD (or TDN) values would be 56 and 52%.

Fall, spring, and ungrazed corn residue treatments have been maintained for 13 years in this corn-soybean rotation. Tables 3 and 4 show soybean and corn yields from 2004 to 2010. The soybean yields were actually numerically greater from the plots grazed the year before but were not statistically different. Spring grazing had no negative effect on the subsequent soybean yield even though spring grazing increases the amount of mud and potential compaction compared to the fall grazing. Corn yields the second year after grazing showed similar results. This suggests that cattle grazing corn residue have no effect on the subsequent yields in irrigated fields.

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Wheat Straw, Distillers Grains, and Beet Pulp for Late Gestation Beef Cows

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Summary

The feeding value of a mixture of 30:70 wet distillers grains:wheat straw or 20:20:60 wet distillers grains:beet pulp:wheat straw (DM) for late gestation beef cows was estimated. In Experiment 1, cows limit fed distillers grains and wheat straw gained as much weight and body condition as cows limit fed alfalfa hay. In Experiment 2, cows fed wet distillers grains and wheat straw or wet distillers grains, beet pulp, and wheat straw gained more weight and improved body condition compared with cows fed alfalfa hay. The results of these experiments indicate cows in late gestation will maintain body condition when limit fed by-products and crop residues to meet their energy requirements.

Introduction

In western Nebraska cows may be fed hay three to six months out of the year until green grass becomes available. Hay is often expensive and during years with drought, hail, insect, or fire damage can be in short supply. Alternative feeds can be economically important to the region. Wheat straw is typically abundant in western Nebraska, but digestible energy and palatability are low. Wet distillers grains (WDGS) and beet pulp, by-products of the ethanol and sugar industries, respectively, are highly digestible, nutrient dense, and palatable. Therefore, the objective of this study was to determine if late gestation cows could maintain body condition when limit fed by-products and crop residue.

Procedure

Experiment 1

Three months prior to the initiation of the experiment, WDGS and ground wheat straw were mixed in a 30:70 ratio (DM) and water was added to reduce the mixture DM under 50% to aid packing and storage. The mixture was stored in a commercial agricultural bag.

Late gestation multiparous cows (n = 40) were stratified by weight and BCS and assigned randomly to one of eight confinement pens (five cows/pen). Pens were assigned randomly to one of two treatments. The two dietary treatments included either ground alfalfa hay (HAY), or a 30:70 WDGS:straw (WDGS) blend (DM). Diets were formulated to provide 11 Mcal/day to meet the energy needs of the cows. All cows were limit fed rather than allowed *ad libitum* access. Cows received 20.0 lb DM of HAY or 18.3 lb DM WDGS daily and fed for 77 days. Cows on the WDGS treatment also received 0.3 lb/day limestone to increase the Ca:P ratio to 1.2:1. Cows were limit fed alfalfa hay at 2% BW for five days prior to the initiation of the experiment and prior to collecting end BW and BCS to minimize gut fill effects. The experiment was terminated two weeks before calving. Initial and ending BW, BW change, BCS, BCS change, and calf birth weight were determined.

Experiment 2

Fifty-seven late gestation multiparous cows were stratified by weight and BCS and assigned randomly to one of 12 confinement pens (5 cows/pen in three replications, and 4 cows/pen in the one replication). Pens were assigned randomly to treatments. The three dietary treatments (DM) were: 1) ground alfalfa hay (HAY), 2) 30:70 WDGS:wheat straw (WDGS), and a 20:20:60 WDGS:beet pulp:wheat straw diet (PULP). All diets were mixed and fed fresh daily for 84 days. Diets were limit fed to supply 11 Mcal/day. Cows on HAY were fed 17.2 lb DM/day, cows fed WDGS received 18.7 lb DM/day and cows fed PULP were fed 18.6 lb DM/day. The cows fed either WDGS or PULP diets were supplemented with 0.3 lb/day limestone to increase the Ca:P ratio to 1.2:1. Limit feeding and data collection was the same as Experiment 1. The experiment was terminated 4 weeks before calving. Initial and ending BW, BW change, BCS, BCS change, and calf birth weight were determined.

Ingredient samples were composited weekly and analyzed by a commercial laboratory in both experiments (Table 1).

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Table 1. Nutrient composition of the diets (Experiment 1 and 2)[1].

	Exp. 1		Exp. 2		
Item	HAY	WDGS	HAY	WDGS	PULP
DMI, lb/day	20	18.3	17	18.7	18.6
CP, % DM	18.7	11.5	16.7	11.7	10.4
TDN, % DM	57.0	60.0	57.0	60.0	60.0
ADF,% DM	39.2	40.9	38.9	37.3	37.0

[1]HAY = alfalfa hay, WDGS= 30:70 WDGS:wheat straw, PULP = 20:20:60 WDGS:beet pulp:wheat straw.

Results

Experiment 1

Initial and final BW, initial and final BCS, BCS change, and calf birth weight were not different ($P \geq 0.53$) among cows fed the two diets (Table 2). Cows receiving WDGS gained more ($P < 0.01$) weight (167 lb) compared with cows fed HAY (144 lb). These results are similar to previous data (*2009 Nebraska Beef Cattle Report*, pp. 11-12). In the previous study nonpregnant, nonlactating cows limit fed a 41:59 ratio of WDGS:ground cornstalks had greater final BW than cows limit fed that same ratio of condensed solubles and cornstalks or cows fed brome hay, stalks, and haylage *ad libitum*. These results suggest a 30:70 WDGS:ground wheat straw blend, mixed and stored for later use, can maintain BW and BCS of gestating beef cows when limit fed.

Table 2. Animal performance in Experiment 1[1].

Item	HAY	WDGS	*P* value
Initial Weight, lb	1094	1089	0.86
Initial BCS	5.5	5.4	0.74
Final Weight, lb	1238	1256	0.53
Final BCS	5.8	5.8	1.00
Change in Weight, lb	+144	+167	0.01
Change in BCS	+0.34	+0.39	0.66
Calf Birth Weight, lb	81.8	81.6	0.96

[1]HAY = alfalfa hay, WDGS= 30:70 WDGS:wheat straw, PULP = 20:20:60 WDGS:beet pulp:wheat straw.

Experiment 2

In Experiment 2, the alfalfa was not as high in digestible energy as initially estimated, so although the diets were calculated to contain the same energy level, the alfalfa diet contained less energy than expected. Cows on the alfalfa treatment gained less (66 lb; $P < 0.0001$) compared with cows fed WDGS and PULP (147 and 162 lb, respectively; Table 3). Body condition scores were not different at the initiation of the trial. Similarly, cows fed HAY had a lower ($P < 0.0001$) BCS of 5.3 while the cows receiving WDGS and PULP averaged 5.7 and 5.8, respectively. The two groups fed combinations of by-products and wheat straw mixed fresh daily maintained BCS while the cows receiving HAY lost 0.4 of a condition score. These results indicate cows in late gestation will maintain BW and BCS when limit fed WDGS and beet pulp mixed with wheat straw to meet their energy requirements.

Table 3. Animal performance in Experiment 2[1].

Item	HAY	WDGS	PULP	SE
Initial BW, lb	1094	1113	1083	33
Initial BCS	5.7	5.8	5.8	0.1
Final Weight, lb	1160[a]	1259[b]	1245[b]	32
Final BCS	5.3a	5.7[b]	5.8[b]	0.1
Change in BW, lb	+66[a]	+147[b]	+162[b]	12
Change in BCS	-0.44[a]	-0.08[b]	+0.02[b]	0.11

[a,b]Means within rows differ $P < 0.003$.
[1]HAY = alfalfa hay, WDGS= 30:70 WDGS:wheat straw, PULP = 20:20:60 WDGS:beet pulp:wheat straw.

These two experiments suggest by-products and crop residues can be limit fed as an alternative to hay to maintain gestating beef cows when by-products and residues can be obtained more economically than hay.

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Influence of Weaning Date and Prepartum Nutrition on Cow-Calf Productivity

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Summary

October weaned cows had greater average BCS and BW compared to December weaned cows; however, the level of supplementation on winter range did not impact BCS or BW. Subsequent pregnancy rates (96.5% - 98.5%) were not influenced by weaning date or any winter treatments. Steer progeny showed no differences in feedlot entry BW, final BW, DMI, ADG, or carcass characteristics; and there were no differences in percentage cycling before breeding or in pregnancy rates of heifer progeny.

Introduction

Dormant forage does not meet the high nutrient demands of the pregnant cow in the last trimester of pregnancy. Research has determined that only 0.31 lb DM/animal/day of supplemental ruminally degradable protein is necessary to maintain BCS of gestating cows grazing winter range (*1996 Nebraska Beef Cattle Report,* p. 14). Supplementation of 1.0 lb DM/animal/day (42% CP) increased BCS and percentage of live calves at weaning compared to cows not receiving supplemental protein, but had little impact on pregnancy rate (*2006 Nebraska Beef Cattle Report,* p. 7). Adjusting the weaning date of a spring calving system may also help maintain cow BCS on winter range (*2002 Nebraska Beef Cattle Report,* p. 3). However, in that study, researchers were unable to detect a difference in pregnancy rates, possibly because cows were not weaned late enough in the year.

The objectives of the current study were to evaluate long-term effects of prepartum protein supplement and weaning date, and the potential interactions, on cow reproduction, heifer progeny growth and reproduction, and steer progeny growth, feedlot performance, and carcass characteristics.

Procedure

Cow-calf Management

Two years of an ongoing three-year trial used crossbred, March calving cows and calves at University of Nebraska–Lincoln Gudmundsen Sandhills Laboratory. Cows were stratified by age and assigned to the following treatments: 1) cows were weaned in early October (N) or early December (L); 2) between approximately Dec. 1 to Feb. 28, cows received the equivalent of 0.0, 1.0, 2.0 lb DM/animal/day of a protein supplement (Table 1) on dormant upland range (WR), or corn residue grazing with no supplement (CR). Supplement was delivered three times/week on a pasture (88 acre) basis. After the December weaning each year, dams were relocated to dormant upland range pastures, or transported to corn residue fields. Cows were managed together for calving and fed *ad libitum* hay. After calving, all cows were fed 1.0 lb DM/animal/day of protein supplement before turn-out to pastures. At the time of breeding, cows were relocated to upland range pastures and managed as a common group until subsequent December weaning. Estrous was synchronized and cows were artificially inseminated (6 days) with semen from the same two bulls each year, and then placed with bulls for 45 days. Cows were removed from the study only if reproductive failure, calf death, or injury occurred. Replacement females were stratified by age and allotted randomly to treatment of removed cows. No further treatments were imposed on heifer or steer calves. October weaned calves were relocated to cool season meadows and supplemented to gain the equivalent of nonweaned contemporaries until the December wean date. Data reported for cows and calves were collected in 2009 (n = 144) and 2010 (n = 161).

Table 1. Composition and nutrient analysis of supplement[1].

Item	DM, %
Ingredient	
Dried distillers grains with solubles	62.0
Wheat middlings	11.0
Cottonseed meal	9.0
Dried corn gluten feed	5.0
Molasses	5.0
Calcium carbonate	3.0
Trace minerals and vitamins	3.0
Urea	2.0
Nutrient	
CP	31.6
Undegradable intake protein, % CP	47.6
TDN	89.4

[1]formulated inclusion of 80 mg/animal/day monensin.

Heifer Management

After December weaning, October and December weaned heifers were relocated to subirrigated meadows and fed 1.0 lb DM/animal/day of supplement (Table 1) as a common group. At the time of breeding, heifers were moved to upland range pastures to graze for the remainder of the year. Blood samples were collected twice, 10 days apart prior to placement with bulls. Heifers were considered cycling if blood serum progesterone concentrations were > 1 ng/mL. Estrus was synchronized 108 hours after bulls were initially placed with heifers for 45 days. Data reported for heifer growth and reproduction were collected in 2010 (n = 68).

Steer Management

After December weaning, October and December weaned steers were fed *ad libitum* hay in a dry lot for approximately 14 days as a common group. Steers were then transported to the feedlot at West Central Research and

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Table 2. Effects of winter wean date and winter grazing treatment during the last third of gestation on cow body condition score (BCS), BW, pregnancy rate, and calf BW.

	October[1]				December[2]				P-value[3]		
Item	WR0	WR1	WR2	CR	WR0	WR1	WR2	CR	Wean	Winter	W x W
Cow BCS											
October	5.1	5.2	5.1	5.2	5.3	5.2	5.1	5.4	0.15	0.13	0.15
December	5.1	5.3	5.2	5.3	4.9	4.7	4.9	4.8	< 0.01	0.90	0.13
Pre-calve	4.6	5.1	5.2	5.5	4.6	4.7	5.2	5.4	0.01	< 0.01	0.16
Pre-breed	4.9	5.1	5.1	5.3	5.0	4.9	5.1	5.2	0.82	< 0.01	0.06
Cow BW											
October, lb	1075	1101	1066	1112	1075	1051	1070	1104	0.30	0.15	0.43
December, lb	1049	1068	1026	1071	987	960	987	1007	< 0.01	0.33	0.33
Pre-calve, lb	1055	1108	1123	1216	1020	1020	1104	1161	< 0.01	< 0.01	0.44
Pre-breed, lb	963	1026	998	1057	971	945	1004	1046	0.24	< 0.01	0.18
Pregnancy rate, %	96.1	99.0	98.0	96.9	96.9	98.0	99.0	97.9	0.77	0.52	0.88
Calf BW											
Birth, lb	75^{bc}	79^{ab}	79^{a}	77^{abc}	71^{d}	73^{cd}	79^{ab}	79^{ab}	0.02	< 0.01	0.03
October, lb	434	480	474	489	425	445	478	472	0.01	< 0.01	0.10
December, lb	502^{b}	542^{a}	531^{a}	551^{a}	452^{c}	467^{c}	502^{b}	493^{b}	< 0.01	< 0.01	0.03

[abcd]Within a row, means without a common superscript differ (*P* < 0.05).
[1]dams weaned in October: grazed winter range without supplement (WR0); grazed winter range and received 1.0 lb DM/animal daily 32% CP supplement (WR1); grazed winter range and received 2.0 lb DM/animal daily 32% CP supplement (WR2); grazed corn residue without supplement (CR).
[2]Dams weaned in December: grazed winter range without supplement (WR0); grazed winter range and received 1.0 lb DM/animal daily 32% CP supplement (WR1); grazed winter range and received 2.0 lb DM/animal daily 32% CP supplement (WR2); grazed corn residue without supplement (CR).
[3]Wean = weaning date main effect; Winter = winter grazing treatment main effect; W x W = wean date x winter grazing treatment interaction.

Extension Center, where they were limit fed 5 days at 2.0% BW, weighed two days consecutively, and adapted to a common finishing diet fed for 176 days. Steers were assigned to one of eight pens based on weaning date and winter grazing treatment of the dam. Synovex S was administered at feedlot entry, followed by Revalor S approximately 100 days before harvest. Dry matter intake and F:G of treatment group within pen was adjusted by % BW DMI of feedlot pen. Data reported steer progeny growth and carcass characteristics were collected in 2010 (n = 64).

The experiment was completely randomized with treatments arranged in an unstructured 2x4 factorial design. Winter treatments were applied on a pasture basis, and both October and December weaned dams were maintained in a single pasture; pasture or cornstalk residue was not limiting at anytime. Therefore, each group of weaned cows within pasture served as the experimental unit; pasture was replicated three times within the year. Data were analyzed with the GLIMMIX procedure of SAS (SAS Inst., Inc., Cary, N.C.). Model fixed effects included weaning date, winter grazing treatment, and weaning date x winter grazing treatment interaction. Year was considered a random effect for cow and calf variables. Probability values less than 0.05 were considered significant.

Results

The interaction between weaning date and winter grazing treatment was not significant for variables measured in the dams. Effects of weaning date and winter grazing treatment for dams are reported in Table 2. Body condition of cows was not different at the time of October weaning. However, N dams maintained BCS until the time of December weaning; whereas L cows lost BCS during that time. A similar pattern was observed with cow BW. October weaned dams had lower BW and BCS (*P* = 0.02) before calving, but were not different from L dams at the time of breeding. Thus, subsequent pregnancy rates for cows were similar among weaning treatments. Prior to calving and breeding, CR cows had the greatest (*P* < 0.01) BCS and BW. However, subsequent pregnancy rates were not different, regardless of winter grazing treatments applied during the third trimester of gestation.

An interaction (*P* = 0.03) for effects of weaning date and winter grazing treatment occurred for calf birth BW and calf BW in December. Progeny born to N dams receiving 2.0 lb supplement on WR had the heaviest (*P* < 0.01) birth BW, except when compared to contemporaries born to WR dams receiving 1.0 lb supplement. Whereas progeny born to L dams on WR without supplementation had the lightest birth BW (*P* < 0.01), except when compared to progeny born to L dams receiving 1.0 lb supplement on WR. In October, progeny born to N dams had greater (*P* = 0.02) BW than progeny born to L dams. Cows grazing WR without supplement had the lightest (*P* < 0.01) calves in October, when all other winter grazing treatments were similar.

An interaction (*P* < 0.01) for effects of weaning date and winter grazing treatment was found for steer progeny F:G in the feedlot (Table 3). Steer progeny were similar in feedlot entry BW, final BW, feedlot DMI, feedlot

Table 3. Effects of wean date and winter grazing treatment during the last third of gestation of dams on progeny growth and performance.

Item	October[1]				December[2]				*P*-value[3]		
	WR0	WR1	WR2	CR	WR0	WR1	WR2	CR	Wean	Winter	W x W
Steer progeny											
Initial BW, lb	482	562	507	551	529	488	522	518	0.56	0.76	0.20
DMI, lb/day	21.6	23.8	22.9	24.0	25.1	22.9	24.7	24.0	0.19	0.91	0.24
ADG, lb	3.39	3.52	3.63	3.68	3.44	3.63	3.83	3.72	0.47	0.34	0.97
F:G	6.33	6.76	6.29	6.58	7.35	6.29	6.41	6.41	0.36	0.14	< 0.01
HCW, lb	740	806	786	819	773	773	822	806	0.85	0.51	0.74
LM, in^2	13.05	13.44	13.48	14.03	13.36	13.06	13.38	13.13	0.48	0.88	0.70
FT, in	0.55	0.57	0.56	0.63	0.44	0.56	0.65	0.64	0.91	0.14	0.45
MB	506	536	483	486	488	533	501	526	0.54	0.46	0.67
YG	2.56	2.58	2.52	2.58	2.00	2.52	2.70	2.78	0.75	0.48	0.48
Heifer progeny											
December BW, lb	454	502	544	511	434	458	463	487	< 0.01	0.04	0.41
Pre-breed BW, lb	604	656	676	681	562	601	604	610	< 0.01	0.04	0.88
Post-wean ADG, lb	0.95	0.97	0.81	1.06	0.79	0.91	0.88	0.77	0.07	0.77	0.22
Pregnancy BW, lb	747	789	804	817	709	756	681	762	< 0.01	0.12	0.31
Summer ADG, lb	1.04	0.95	0.93	0.99	1.06	1.04	0.53	1.10	0.74	0.21	0.40
Pregnancy BCS	5.7	5.8	5.8	5.8	5.6	5.9	5.3	6.0	0.39	0.19	0.23
Cycling rate, %	27.3	45.5	57.1	55.6	50.0	0.0	37.5	28.6	0.97	0.96	0.43
Pregnancy rate, %	63.6	63.6	85.7	66.7	58.3	100.0	57.1	83.3	0.98	0.79	0.64

[abcd]Within a row, means without a common superscript differ ($P < 0.05$).
[1]Dams weaned in October: grazed winter range without supplement (WR0); grazed winter range and received 1.0 lb DM/animal daily 32% CP supplement (WR1); grazed winter range and received 2.0 lb DM/animal daily 32% CP supplement (WR2); grazed corn residue without supplement (CR).
[2]Dams weaned in December: grazed winter range without supplement (WR0); grazed winter range and received 1.0 lb DM/animal daily 32% CP supplement (WR1); grazed winter range and received 2.0 lb DM/animal daily 32% CP supplement (WR2); grazed corn residue without supplement (CR).
[3]Wean = weaning date main effect; Winter = winter grazing treatment main effect; W x W = wean date x winter grazing treatment interaction.
[4]Small^{00} = 400.
[5]Calculated from December weaning date to subsequent average breeding date (161 days).
[6]Calculated from average breeding date to subsequent October weaning date (139 days).
[7]Considered cycling if blood serum progesterone concentrations were > 1 ng/mL.

ADG, and carcass characteristics. Previous data (*2009 Nebraska Beef Cattle Report,* p. 5) reported steers born to protein supplemented dams on winter range to have greater final BW, MB, and percentage Choice or greater than nonsupplemented cows. Numerically these data agree with previously reported data.

December and pre-breeding BW of heifers born to N dams were greater ($P < 0.01$) than L heifers. However, there were no differences in percentage cycling before breeding or pregnancy rates. Level of supplement provided to dams had no effect on post-weaning heifer ADG or reproduction. Earlier research (*2009 Nebraska Beef Cattle Report,* p. 5) found a trend for heifers born to dams receiving 1.0 lb DM/animal/day supplemental protein to have greater pregnancy rates than nonsupplemented dams, when three years of data were evaluated. A similar numerical trend was observed in these data. Statistical contradictions may be due to lack of power in one year of data.

Cows weaned in December had decreased BW and BCS with similar pregnancy rates compared to cows weaned in October. Winter grazing management of cows in the third trimester of pregnancy had minimal impact on pregnancy rates. One year of progeny data indicate that weaning date, level of supplementation, and any corresponding interactions may have minimal effect on steer and heifer calves.

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Effect of Calving Period on Heifer Progeny

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Summary

Records from 1997 through 2009 were used to determine the effect of calving date on ADG, reproduction, and first-calf characteristics in spring born heifer calves at University of Nebraska–Lincoln Gudmundsen Sandhills Laboratory. Heifers were classified as born in the first, second, or third 21-day period of the calving season. Heifer calves born during the first 21 days had greater weaning, pre-breeding, and pre-calving BW; greater percent cycling before breeding, and pregnancy rates compared to heifers born in the third period. First-calf progeny had earlier birth date and greater weaning BW. Calving period of heifer progeny impacts development and first-calf characteristics.

Introduction

Research from the 1960s through 1980s indicated puberty occurs at a genetically predetermined size, and only when heifers reach their target weight can high pregnancy rates be obtained. Guidelines were established indicating replacement heifers should achieve 60 to 65% of expected mature BW by breeding. Substantial changes in the economy and cattle genetics have occurred, indicating traditional approaches should be re-evaluated.

More recent research demonstrated feeding replacement heifers to traditional target weights increases costs relative to more extensive development systems developing heifers to 51 to 57% of mature BW (*2010 Nebraska Beef Cattle Report,* pp. 7-10; *2008 Nebraska Beef Cattle Report,* pp. 5-7).

Table 1. Effect of calving period on ADG, reproduction, and first-calf characteristics of heifer progeny.

	Calving period[1]				
Item	1	2	3	SEM	*P*
n	651	304	64		
Birth Date, julian day	77[a]	93[b]	113[c]	2.02	<0.001
Calf birth BW, lb	79[a]	82[b]	84[b]	1.52	<0.001
Calf weaning BW, lb	483[a]	470[b]	434[c]	10.80	0.03
Preweaning ADG, lb/day	1.83	1.83	1.90	0.09	0.10
Pre-breeding ADG, lb/day	0.86	0.90	0.90	0.07	0.07
Pre-breeding BW, lb	653[a]	644[b]	608[c]	9.22	<0.001
Cycling beginning of breeding, %	70[a]	58[b]	39[c]	9.35	<0.001
Breeding ADG, lb/day	1.59[a]	1.63[ab]	1.70[b]	0.09	0.03
Pregnancy diagnosis BW, lb	822[a]	818[a]	789[b]	11.75	<0.001
Pregnancy rate, %	90[a]	86[a]	78[b]	5.62	0.02
Pre-calving BW, lb	946	948	922	14.66	0.06
First-calf birth date, julian day	68[a]	73[b]	75[b]	2.03	<0.001
Calved in first 21 d, %	81[a]	69[b]	65[b]	8.41	<0.01
First-calf birth BW, lb	79[a]	82[b]	84[b]	1.52	<0.001
Assisted births, %	23	29	33	8.37	0.26
Dystocia score[2]	1.29	1.40	1.34	0.11	0.18
Cow weaning BW, lb	924	930	930	17.00	0.68
Calf weaning BW, lb	425	417	410	11.40	0.10
Pregnancy rate after first calf, %	93	90	84	6.61	0.20

[1]1 = calved in the first 21 days, 2 = calved in the second 21 days, 3 = calved in the third 21 days of the spring calving period.
[2]Scoring system 1 to 5: 1 = no assistance; 2 = easy pull; 3 = mechanical pull; 4 = hard mechanical pull; and 5 = Caesarean section.
[abc]Means without a common superscript differ ($P \leq 0.05$).

The majority of heifer development research has focused on the post-weaning phase. Numerous studies suggest the preweaning growth phase exerts a greater influence on puberty in beef heifers than post-weaning growth (Patterson et al., *Journal of Animal Science*, 1992, 70:4018).

Thus, data from 13 production years were summarized to determine the effect of time of calving on subsequent pre- and post-weaning ADG and BW and impact on reproduction and first-calf characteristics in beef heifers.

Procedure

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

Data were collected from the University of Nebraska–Lincoln Gudmundsen Sandhills Laboratory herd between 1997 and 2009. As varying nutritional and breeding treatments were applied to yearling heifers during breeding, 2 year-old cows were removed from this analysis. The breeding season began on approximately June 15. Heifers were classified as born in the first, second, or third 21-day period of the calving season within year.

Continuous data were analyzed using the MIXED procedure of SAS and binomial data with the GLIMMIX procedure. The model included the fixed effect of period the calf was born. The model also included the random effect of year and any treatments imposed on each particular herd within year.

Results

Data demonstrating the effect of calving period on subsequent pre-and post-weaning ADG and BW and impact on reproduction and first-calf characteristics are presented in Table 1.

Heifer calves born in the first calving period were 16 days older than those in the second, and 36 days older than those in the third period ($P < 0.01$). Calf birth BW was lower ($P < 0.01$) for heifers born in the first period.

As the time of calving became more advanced, calf ADG from birth to weaning tended ($P = 0.10$) to be lowest for heifers born in the first calving period. Regardless of greater birth BW and preweaning ADG, heifer calf weaning BW decreased ($P = 0.03$) with advancing calving period. Calf ADG from weaning to pre-breeding tended ($P = 0.07$) to be least for heifers born in the first period; however, pre-breeding BW was greatest ($P < 0.01$) for calves born in the first period. Heifer ADG from the beginning of the breeding season to pregnancy diagnosis was greater ($P = 0.03$) for heifers born in the third vs. first calving period. The percentage of heifers cycling at the beginning of the breeding season decreased ($P < 0.01$) with advancing calving date (70, 58, and 39%, respectively), and 45 day pregnancy rates were lowest ($P = 0.02$) for heifers born in the third calving period (90, 86, and 78%, respectively).

Heifers born later in the calving season appear to have greater pre- and post-weaning ADG and lower fertility. This is in contrast to data indicating preweaning growth exerts a greater influence on puberty than post-weaning growth (Patterson et al., *Journal of Animal Science*, 1992, 70:4018). In the current data set it appears neither pre- nor post-weaning growth influenced percent cycling before the breeding season or pregnancy rates. Considerable change in beef cattle genetics has likely occurred since these observations were made, and perhaps age rather than rate of gain is more important in determining when an animal reaches puberty and conceives. Research from our group would certainly support the theory that rate of gain prior to breeding has minimal impact on heifer pregnancy rate (*2010 Nebraska Beef Cattle Report,* pp. 7-10; *2008 Nebraska Beef Cattle Report,* pp. 5-7).

Birth date of the heifer's first calf and birth BW decreased ($P < 0.01$) if the heifer was born in the first calving period. Also, more ($P < 0.01$) calves were born in the first 21 days of the calving season if the heifer herself was born in the first calving period. Regardless of greater dam weight at calving and lower birth BW for heifers calving that were born in the first period, calving assistance and dystocia score were similar ($P \geq 0.18$). First-calf progeny had the greatest ($P \leq 0.10$) weaning BW if born to a heifer born in the first calving period. Cow BW at weaning her first calf, and pregnancy rate after the first calf, were similar ($P \geq 0.10$).

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Evaluating Conventional and Sexed Semen in a Commercial Beef Heifer Program

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Summary

Heifers (n = 500) were fed 0.5 mg/day of melengestrol acetate for 14 days, and 19 days later, administered $PGF_{2\alpha}$. Following $PGF_{2\alpha}$, heifers were detected for estrus and artificially inseminated (AI) approximately 18-24 hours later. Three days following $PGF_{2\alpha}$, heifers not detected in estrus were given GnRH and AI. Heifers were AI with one of two sires, either conventional or sexed semen, creating four possibilities for AI sire. Pregnancy rate was greater for conventional than sexed semen. In addition, more heifers detected in estrus were pregnant than heifers time AI. Further research is needed to establish the optimum estrus synchronization program with sexed semen.

Introduction

Sex-sorting sperm relies on the fact the bovine X chromosome has 3.8% more DNA than the Y chromosome. This principle enables sperm to be sorted using a flow cytometer. However, the process damages sperm and reduces fertility when compared to conventional semen (Tubman et al., *Journal of Animal Science,* 2004, 82:1029-1036).

Protocols for artificially inseminated (AI) with sexed semen have been similar to those utilized with conventional semen without modification. Objectives of this study were to evaluate the use of sexed semen compared to conventional semen in a commercial heifer development program with a slightly modified, commonly used synchronization system for beef heifers.

Procedure

Yearling heifers (n = 500) were managed together at the Kelly Ranch (KR), Sutherland, Neb. Approximately one week prior to initiation of synchronization, a subset (n = 100) of heifers was randomly sorted and transported to the University of Nebraska West Central Research and Extension Center (WCREC), North Platte, Neb.; the balance of heifers (n = 400) remained at the KR.

Heifers at the KR grazed dormant upland Sandhills range receiving 2.8 lb/day (DM) dried distillers grains. Sixty-six days before initiation of synchronization, each heifer also began receiving 6.4 lb/day (DM) alfalfa. Alfalfa was fed *ad libitum* beginning the end of March through early April due to decreasing winter range.

Heifers at WCREC were placed in a drylot and fed 18.1 lb/day (DM) of a diet consisting of 10% corn, 71% prairie hay, 16% wet corn gluten feed, and 3% heifer supplement. Heifer BW was measured (648 lb) upon arrival to WCREC.

Beginning April 8, heifers at both locations were fed 0.5 mg/day melengestrol acetate (MGA) per animal for 14 days. At WCREC, MGA pellet was added as part of the complete diet; at the KR, MGA pellet was mixed with 4.6 lb/day ground hay and 1.8 lb/day wet distillers grains (DM). Prostaglandin $F_{2\alpha}$ (PGF) was administered intramuscular (i.m.). Nineteen days later, heat detection patches were placed on tail heads. In addition, BW was measured (719 lb) for heifers at WCREC.

Following PGF injection, heifers were detected for estrus by one of two methods: visual observation of standing estrus or activated heat detection patches. Three people detected estrus at the KR, while two detected estrus at WCREC during daylight hours. Heifers were AI approximately 18-24 hours following detection of standing estrus to place insemination closer to ovulation, due to sperm damage in the sex-sorting process. Heifers detected in estrus before 0800 were AI late the same day. Heifers detected between 0800 and 1400 were AI early the next morning. Heifers detected between 1400 and the end of the day were AI early afternoon the next day.

Three days following PGF injection, heifers with activated Estrotect patches and observed in standing estrus prior to 0800 were sorted for breeding late the same day. Heifers detected the previous morning and early afternoon were AI early morning on day 3. Heifers detected in estrus late on day 2 were inseminated early afternoon of day 3. Following the early afternoon AI, heifers not detected in estrus were given a GnRH injection i.m. and AI (mass bred, MB). Following MB, heifers detected the morning of day 3 were inseminated as late as possible with consideration given to the number of heifers to inseminate and remaining daylight.

Heifers were AI with one of two sires, either conventional or sexed semen, creating four possibilities for AI sire. At each AI session, heifers were divided evenly to receive either sexed or conventional semen from the same sires. Six AI technicians were used at the KR and two at WCREC.

The sexed semen was sorted at 90% purity for heifer calf pregnancies. Each sexed semen straw contained 2×10^6 sperm.

The day after MB, heifers at WCREC were transported back to the KR. Heifers were managed as one group, grazing upland Sandhills range. Clean-up sires (n = 12) were turned in with heifers 12 days after MB, at a ratio of 1 bull to 42 heifers.

Fifty-five days after MB, BW was measured (805 lb), and pregnancy was detected via transrectal ultrasonography. Heifers were identified as pregnant by AI, bull, or open and sorted accordingly. Nonpregnant heifers (n = 124) and heifers pregnant

Table 1. Pregnancy rates by sire for conventional and sexed semen.

	Conventional Semen	Sexed Semen	SE	*P* value
Both sires, % pregnant	58.4[a]	41.0[b]	4.2	<0.01
Sire 1, % pregnant	59.4[a]	36.1[b]	5.4	<0.01
Sire 2, % pregnant	57.5[a]	46.2[b]	5.6	<0.01

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

Table 2. Pregnancy rates by insemination time for conventional and sexed semen.

	AM[1]	EPM[2]	LPM[3]	MB[4]	SE	*P* value
Overall	64.2[a]	55.9[a]	57.0[a]	24.0[b]	6.8	<0.01
Conventional	69.6[a]	59.9[a]	68.0[a]	34.9[b]	7.0	<0.01
Sexed	58.4[a]	51.9[a]	45.3[a]	15.8[b]	9.0	<0.01

[1]Heifers detected in estrus between 0800 and 1400 hours were AI early the next morning.
[2]Heifers detected in estrus between 1400 hours and the end of the day were AI early afternoon the next day.
[3]Heifers detected in estrus before 0800 hours were AI late the same day.
[4]Heifers not detected in estrus were given a GnRH injection and mass AI.
[a,b]Row means without a common superscript differ ($P < 0.05$).

Table 3. Various costs for AI with conventional semen, sexed semen, and natural service in a commercial beef heifer development program.

	Conventional Semen	Sexed Semen	Natural Service
Semen cost/straw, $	14.00	45.00	—
Semen cost/AI pregnancy, $	24.39	109.22	—
Breeding system cost per pregnant heifer, $	68.66	111.47	63.39
Pregnant heifer net cost, $	1,264.00	1,308.00	1,259.00

by bull (n = 247) were maintained with bulls for an additional 18 days and checked for pregnancy via ultrasound approximately 60 days later. Data were analyzed using PROC GLIMMIX of SAS (SAS Inst., Inc., Cary, N.C.).

Results

The subset of heifers at WCREC had an ADG of 1.70 lb during the 45 day period at WCREC. This same group of heifers weighed 816 lb at the time of ultrasound, for an ADG of 1.65 lb from AI to first pregnancy detection. Location did not affect ($P = 0.28$) pregnancy rates.

There was no ($P > 0.10$) sire × type of semen (conventional or sexed) interaction; therefore, sires were combined for analysis. Pregnancy rate was greater ($P < 0.01$) for heifers AI with conventional than sexed semen (58 vs. 41%, Table 1). These results agree with previous research indicating pregnancy rates using sexed semen are generally 70-90% of conventional semen (Seidel, *Journal of Animal Science,* 2010, 88:E-Supplement 2 (Abstract), p. 783) with quality of herd management playing a key role (Garner and Seidel, *Theriogenology,* 2008, 69:886-895).

More ($P < 0.01$) heifers detected in standing estrus were pregnant (56% or greater, Table 2) than heifers MB (24%). A review by Seidel (Theriogenology, 2003, 59:585-598) indicated most inseminations with sexed semen have been conducted at 12 or 24 hours after observed standing estrus, and fertility with timed AI was markedly lower. Work conducted at Colorado State University found pregnancy rates in lactating cows from insemination 6-14 hours after estrus detection were similar to inseminations 21-26 hours after estrus detection, recommending detection of estrus and once a day breeding using sexed semen. Pregnancy rates using sexed semen were not statistically ($P > 0.10$) different between sires or technicians; however, there was a 10% numerical difference between sires. Other studies have reported a difference in fertility rates among bulls when using sexed semen (Doyle et al., Proceedings, Western Section American Society of Animal Science, 1999, 50:203-205). Overall pregnancy rate (including natural service) was 93%.

Breeding costs based on breeding system were highest numerically for AI with sexed semen (Table 3), due to lower pregnancy rates and greater semen costs ($14 for conventional vs. $45 for sexed). A portion of the pregnant heifers (n = 417) were marketed following the breeding season. Heifers pregnant by AI were sold at $1,344/animal and heifers pregnant by natural service sold at an average of $1,238/animal. Gender difference for replacement heifers AI with sexed semen was not considered as all AI pregnant heifers sold for the same price.

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Late Gestation Supplementation Impacts Primiparous Beef Heifers and Progeny

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Summary

A two-year study utilizing primiparous heifers evaluated the influence of rumen undegradable protein (RUP) supplement level on heifer and progeny performance. Heifers were individually fed meadow hay and no supplement (CON), 1.8 lb/day (DM) dried distillers based (HIGH) supplement, or 1.8 lb/day (DM) dried corn gluten feed based (LOW) supplement during late gestation. Heifers from HIGH and LOW groups had greater final BW, DMI, ADG, and G:F compared to CON heifers. Calves from HIGH dams had greater pre-breeding BW and LOW calves had greater weaning BW compared to CON calves. Feedlot initial BW was greater for HIGH and LOW calves compared to CON calves. However, final BW and carcass characteristics were similar among treatments. Providing RUP supplementation during late gestation increased heifer final BW and ADG. Calves from supplemented dams had increased pre-breeding, weaning, and initial feedlot BW compared to CON calves.

Introduction

Past research indicates late gestation protein supplementation influences multiparous cow progeny performance, carcass quality, and health (*2006 Nebraska Beef Cattle Report*, pp. 7-9; *Journal of Animal Science,* 2009, 87: 1147-1155). These results support the fetal programming hypothesis, which suggests that maternal environment during gestation can influence progeny postnatal growth and health. The objective of the current study was to evaluate the effects of RUP supplementation levels on primiparous heifer production and subsequent progeny growth, feed efficiency, and carcass quality.

Procedure

Primiparous Heifer Management

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

Pregnant heifers were placed in a Calan Broadbent individual feeding system and acclimated for approximately 25 days prior to the beginning of supplementation. Heifers were fed meadow hay (Year 1 = 11.3% CP, DM; Year 2 = 8.0% CP, DM) from early November to mid February (Year 1 = 84 days; Year 2 = 80 days) and provided no supplement (CON; Year 1 = 12; Year 2 = 13), 1.8 lb/day (DM) of a dried distillers grain based supplement (HIGH; Year 1 = 13; Year 2 = 14) or 1.8 lb/day (DM) of a dried corn gluten feed based supplement (LOW; Year 1 = 13; Year 2 = 13). Supplements were designed to be isonitrogenous (29% CP, DM), isocaloric, but differ in RUP with HIGH (59 % RUP) having greater levels of RUP than LOW (34% RUP). After the individual feeding period, heifers were placed in a drylot for calving. All heifers were artificially inseminated (AI) using a fixed-timed AI protocol, and pairs were moved 27 miles to a commercial ranch in the Nebraska Sandhills for summer grazing. A single bull was placed with heifers approximately 10 days after AI for 60 days.

Calf Feedlot Management

Prior to weaning, steers and heifers were returned to the West Central Research and Extension Center (WCREC), grouped separately and limit fed a starter diet for 5 days at 2.0% BW prior to determining initial BW. Implants were administered providing 20 mg of estradiol benzoate and 200 mg progesterone (Synovex S) to steers and 20 mg of estradiol benzoate and 200 mg testosterone to heifers (Synovex H). Calves were transitioned to a common finishing diet of 48% dry-rolled corn, 40% corn gluten feed, 7% prairie hay, and 5% supplement (DM) over a 21-day period. Approximately 100 days prior to slaughter, calves were implanted with 28 mg estradiol benzoate and 200 mg trenbolone acetate (Synovex Plus). Calves were slaughtered at a commercial abattoir 189 days after feedlot entry with HCW and carcass data collected after a 24-hour chill.

Calf DMI was calculated using a modified DMI prediction equation established by Tedeschi et al. (*Journal of Animal Science,* 2006, 84: 767-777) where DMI = (4.18 + (0.898 x ADG) + (0.0006 x (MBW$^{0.75}$) + (0.019 x EBF)) ÷ 0.4536 where EBF represents empty body fat percentage. Empty body fat percentage was calculated using the equation developed by Guiroy et al. (*Journal of Animal Science,* 2001, 79: 1983-1995) where EBF = 17.76107 + (11.8908 x 12th rib fat depth) + (0.0088 X HCW) + (0.81855 x [(marbling score/100) + 1] – (0.4356 x longissimus muscle area).

Statistical Analysis

Heifers were offered hay and supplement on an individual basis (Year 1 = 38; Year 2 = 40), therefore animal was considered the experimental unit and supplement the treatment. Data were analyzed using PROC MIXED and PROC GLIMMIX of SAS (SAS Inst., Inc., Cary, N.C.) with a $P \leq 0.05$ considered significant. The statistical model for heifers included treatment as the fixed effect with pen and year as random effects. The statistical model for calves included dam treatment as the fixed effect with sex included as a covariate and sire included as a random effect. Year was included in the calf analysis for birth weight and pre-breeding calf BW.

Results

Primiparous Heifer Production

Primiparous heifer performance data are reported in Table 1. Heifers in the HIGH and LOW groups had greater

Table 1. Effects of supplementation on primiparous heifer performance and progeny calf body weights.

Item	Treatment[1] CON	HIGH	LOW	SEM	*P*-value
n	25	27	26		
Initial age, day	617	617	621	17	0.72
Initial BW, lb	993	983	986	34	0.73
Final BW, lb	1089	1122	1122	11	0.05
Pre-breeding BW, lb	958	977	986	16	0.28
ADG, lb	1.19[a]	1.71[b]	1.67[b]	0.47	< 0.01
DMI, lb/day	19.81[a]	20.83[b]	20.71[a,b]	1.53	0.04
NE DMI, lb/day	10.40[a]	11.41[b]	11.35[b]	0.21	< 0.01
RFI[2]	-0.439	-0.038	-0.067	0.07	< 0.01
G:F	0.062[a]	0.084[b]	0.083[b]	0.029	< 0.01
Calving date, Julian day	59	59	60	1.23	0.57
Gestation length, day	277	276	277	1.01	0.88
Calf birth BW, lb	73	71	73	2.75	0.79
Calving ease	1.48	1.40	1.49	0.19	0.92
Calf vigor	1.40	1.56	1.77	0.28	0.55
Pre-breeding calf BW, lb	223[a]	240[b]	239[a,b]	5.06	0.03
Weaning BW, lb[3]	525[a]	561[a,b]	575[b]	14	0.04

[1]Primiparous heifers individually fed meadow hay and no supplement (CON), 1.8 lb/day (DM) distillers grain based supplement (HIGH), or 1.8 lb/day (DM) dried corn gluten feed based supplement (LOW) during late gestation.
[2]RFI calculated based on NE DMI.
[3]Calf weaning BW based on Year 1 data only.
[a,b]Means without a common superscript differ ($P \leq 0.05$).

Table 2. Effect of supplementation on primiparous heifer progeny feedlot performance and carcass characteristics.

Item	Treatment[1] CON	HIGH	LOW	SEM	P-value
n	10	11	12		
Initial BW, lb	560[a]	602[b]	606[b]	14	0.04
Reimplant BW, lb	875	893	903	22	0.51
Final live BW, lb	1329	1319	1340	27	0.84
End BW, lb[2]	1305	1303	1330	32	0.72
ADG					
Initial to re-implant, lb/day	3.99	3.67	3.77	0.16	0.20
Re-implant to slaughter, lb/day	3.89	3.78	3.86	0.16	0.88
Total ADG, lb/day	3.94	3.71	3.83	0.13	0.44
DMI[3]	18.50	18.05	18.25	0.28	0.48
G:F	0.212	0.205	0.209	0.0004	0.37
RFI	0.009	0.006	-0.014	0.01	0.23
HCW, lb	822	821	838	20.05	0.72
Empty body fat, %[4]	29.11	28.93	28.09	0.68	0.49
Marbling score[5]	727	680	663	26.55	0.21
12-th rib fat, in	0.80	0.79	0.72	0.05	0.49
LM area, in^2	13.55	13.89	14.11	0.37	0.56
Yield grade	3.62	3.57	3.39	0.20	0.66
Quality grade, % Sm[6] or greater	100.0	100.0	100.0	—	1.00
Quality grade, % Md[7] or greater	91.0	67.7	60.7	15	0.27

[1]Dams individually fed meadow hay and no supplement (CON), 1.8 lb/d (DM) distillers grain based supplement (HIGH), or 1.8 lb/d (DM) dried corn gluten feed based supplement (LOW) during late gestation.
[2]Calculated from hot carcass weight and adjusted to a common dressing percent (63.0%).
[3]DMI calculated using a modified prediction formula presented by Tedeschi et al. (2006) where DMI = (4.18 + (0.0898 x ADG) + (0.0006 x ($MBW^{0.75}$) + (0.019 x EBF)) ÷ 0.4536.
[4]EBF calculated using the prediction formula presented by Guiroy et al. (2001) where EBF = 17.76107 + (11.8908 x 12th rib fat depth) + (0.0088 X HCW) + (0.81855 x [(marbling score/100) + 1] – (0.4356 x LM area).
[5]Where 500 = $small^0$.
[6]Sm = small quality grade, USDA low Choice.
[7]Md = modest quality grade, USDA average Choice.
[a,b]Means without a common superscript differ ($P \leq 0.05$).

($P = 0.05$) final BW compared to CON heifers; however, pre-breeding BW was similar for all groups. Average daily gain, DMI, DMI based on feed NE, and G:F were greater ($P < 0.05$) for HIGH and LOW heifers compared to CON heifers. However, CON heifers had improved ($P < 0.01$) RFI compared to HIGH and LOW heifers.

Calf Production

Calf BW at pre-breeding was greater ($P = 0.03$) for calves from HIGH dams compared to calves from CON dams (Table 1). Preliminary data for calf weaning BW (Table 1) suggest greater ($P = 0.04$) BW for calves from LOW dams compared to calves from CON dams, while calves from HIGH dams only tend ($P = 0.10$) to differ from CON calves. Preliminary data for calf feedlot performance and carcass data are reported in Table 2. Initial feedlot BW was 46 and 42 lb greater ($P = 0.04$) for calves from LOW and HIGH dams compared to calves from CON dams; however, at re-implant there was no difference in BW among treatments. Preliminary data suggests no differences in feedlot performance or carcass characteristic among treatments.

There was no difference in primiparous heifer performance when comparing the two levels of RUP supplemented during late gestation. However, HIGH and LOW heifers had increased final BW, ADG, and G:F compared to CON heifers. Calves from LOW dams had greater weaning BW, and calves from both supplemented groups had greater initial feedlot BW compared to calves from CON dams. These data suggest fetal programming effects on calf BW from primiparous heifers fed protein supplement during late gestation.

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Nutritional Regime and Antral Follicle Count Impact Reproductive Characteristics in Heifers

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Summary

Developing heifers were offered either a modified distillers (MOD), distillers based (DDG), or corn gluten feed based (CGF) supplement while grazing pastures during development. Prior to breeding, antral follicle count (AFC), uterine horn diameter (UHD), ovarian area, and reproductive tract score (RTS) were determined via rectal ultrasonography to examine the effect of protein supplement on heifer reproductive characteristics. Heifers developed on MOD diets had greater RTS, ovarian area, and total AFC compared to DDG and CGF heifers. Small and medium follicle counts had a positive correlation with total AFC. Heifers developed on DDG and CGF had greater overall pregnancy rates compared to MOD heifers. We also conclude that there is a positive relationship between AFC and small and medium follicle counts.

Introduction

Producer profitability is related to cow longevity, with failure to become pregnant a primary reason why cows are removed from the herd (Cushman et al., *Journal of Animal Science.* 2009 87: 1971-1980). Many producers provide protein supplementation to heifers developed on dormant winter range or pasture to improve reproductive success. Previous research indicates developing heifers on dried distillers grains does not reduce reproductive success. However, reproductive tract characteristics were not measured (2007 *Nebraska Beef Cattle Report*, pp. 5-6). Measures such as antral follicle count (AFC), reproductive tract score (RTS), and uterine horn diameter (UHD) have shown to be effective prediction tools for fertility. Cushman et al. (*Journal of Animal Science,* 2009, 87: 1971 - 1980) reported increased pregnancy rates in heifers classified as high AFC compared to low. The objective of the current study was to determine if protein supplementation during development and AFCs influence heifer reproductive characteristics and success.

Procedure

Heifers from two herds at the University of Nebraska–Lincoln Agricultural Research and Development Center were used. Heifers (Angus and Angus x Simmental hybrids) from the teaching herd (n = 56) were fed 3.5 lb/day (32% CP, DM) of a modified dried distillers grain (MOD) supplement from weaning (mid September) through May. MARC III (1/4 Angus, 1/4 Hereford, 1/4 Red Poll, 1/4 Pinzgauer) x Red Angus heifers from the physiology herd (n = 173) were randomly assigned to 1 of 2 groups and fed supplements similar to that reported by Martin et al. (2007 *Nebraska Beef Cattle Report,* pp. 5-6). Heifers received either a dried distillers grain based (DDG) or corn gluten feed based supplement (CGF) offered at 0.59% (27% CP, DM) and 0.78% BW (20% CP, DM), respectively, from mid-November through May. Supplements fed to the physiology herd heifers (DDG and CGF) were formulated to be isocaloric but differed in rumen undegradable protein. All heifers were fed ad libitum meadow hay through winter while grazing dormant pasture.

Prior to breeding, heifers underwent transrectal ultrasonography. A single technician scanned each ovary using an Aloka-500 linear array transrectal probe (7.5-MHZ transducer, Aloka Ultrasound, Wallingford, Conn.) and counted small (3-5 mm), medium (6-10 mm), and large (> 10 mm) follicles to determine AFC. Uterine horn diameter, presence of CL, and ovarian length and height were also determined. Each heifer received a RTS based on the methods reported by Martin et al. (*Journal of Animal Science,* 1992, 70: 4006-40017) as described in Table 1.

Estrus was synchronized with two injections of prostaglandin $F_{2\alpha}$ administered 14 days apart. Estrous detection was performed 5 days following the second injection. Heifers observed in estrous were artificially inseminated approximately 12 hours after initial estrous detection. Approximately 10 days after estrous detection was performed, heifers were placed with fertile bulls for 45 days. Conception rates for both AI and total pregnancy rates were performed via rectal palpation approximately 45 days following AI and bull removal, respectively.

Statistical analysis was performed using the MIXED and GLIMMIX procedures of SAS (SAS Inst., Inc., Cary, N.C.) with a $P \leq 0.05$ considered significant. The model included heifer treatment as a classification effect, total AFC as a covariate, and year as a random variable. Initial analysis included breed; however, it was not significant and was removed from the model.

Results

Heifer performance data are reported in Table 2. Heifers fed MOD supplement had greater ($P < 0.05$) RTS, total AFC, larger ovaries, and a greater proportion of heifers with a CL present when compared to both CGF and DDG supplemented heifers.

Table 1. Explanation of reproductive tract scores[1].

RTS	Uterine Horns	Approximate Size of Ovaries: Length, mm	Height, mm	Width, mm	Ovarian Structures
1	Immature, < 20 mm in diameter, no tone	15	10	8	No palpable follicles
2	20 to 25 mm in diameter, no tone	18	12	10	8 mm follicles
3	25 to 30 mm in diameter, slight tone	22	15	10	8-10 mm follicles
4	30 mm in diameter, good tone	30	16	12	> 10 mm follicles, CL possible
5	> 30 mm in diameter, good tone, erect	> 32	20	15	> 10 mm follicles; CL present

[1]Adapted from Martin et al. (*Journal of Animal Science,* 1992, 70: 4006 – 4017).

Table 2. Effect of protein supplementation and antral follicle count on developing heifers.

	Treatment[1]				*P*-value	
Item	CGF	DDG	MOD	SEM	Treatment	Total AFC
No. of heifers	87	86	56			
Initial age, day	391	389	412	16	< 0.01	0.29
RTS	4.09	4.28	4.4	0.13	0.03	0.15
Ovarian area, mm^2	32.10	34.57	42.28	1.19	< 0.01	< 0.01
Small follicles[2]	26.46	26.23	26.40	0.20	0.53	< 0.01
Medium follicles	1.41	1.18	1.40	0.16	0.32	0.01
Large follicles	0.99	1.48	1.07	0.16	0.01	0.03
Total AFC[3]	23.09	23.29	32.52	1.94	< 0.01	—
UHD, cm^2	16.76	15.28	12.35	0.48	< 0.01	0.10
CL present, %	9.24	8.17	42.05	5	< 0.01	0.51
AI bred, %	38.73	57.09	43.72	7	0.06	0.18
Total pregnant, %	92.08	90.49	77.43	6	0.03	0.10

[1]Heifers were fed meadow hay and supplemented from November to pre-breeding with 0.78% BW corn gluten feed based supplement (CGF), 0.59% BW distillers based supplement, or 3 lb/day modified distillers grain supplement (MOD).
[2]Small follicle statistical model includes heifer treatment as a classification effect and total AFC as a covariate
[3]Total AFC statistical model does not include total AFC as a covariate.

There were no differences in small or medium follicles among treatments; however, there was a positive correlation for small follicle numbers with total AFC [AFC = 2.41 + (1.0016 x small follicles); $P < 0.01$, $r^2 = 0.97$]. Heifers supplemented with DDG had a greater ($P = 0.01$) number of large follicles compared to CGF heifers.

Uterine horn diameter was larger ($P = 0.02$) for CGF heifers compared to DDG and MOD supplemented heifers, and DDG heifers had a larger ($P < 0.01$) UHD compared to MOD.

The percent of heifers AI pregnant was greater ($P = 0.05$) for DDG heifers compared to CGF. However there was no difference in total pregnancy rate for CGF and DDG heifers. Differences in AI pregnancy rates for DDG and CGF heifers are similar to those previously reported (Martin et al., 2007 *Nebraska Beef Cattle Report*, pp. 5-6). Both CGF and DDG had increased total pregnancy rates compared to MOD heifers. Although AI pregnancy rates were greater for DDG heifers compared to CGF, reproductive tract characteristics were similar suggesting more research is needed to understand the hormonal or mechanistic actions allowing for improved AI conception rates in DDG fed heifers. These findings also suggest a correlation between small and medium follicle numbers and total AFC.

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Vascular Endothelial Growth Factor A (VEGFA) in Ovulatory Follicles

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Summary

Granulosa cells express vascular endothelial growth factor A (VEGFA), and VEGFA mRNA levels increase as bovine follicles reach preovulatory status. To further evaluate the role of VEGFA isoforms in follicular development, cows were either synchronized with a modified Co-Synch protocol (CIDR) or treated with melengestrol acetate (MGA) with subsequent aspiration of the dominant follicles. Higher mRNA levels for the antiangiogenic isoform, VEGFA_164B, along with AMH and CARTPT in E2-inactive follicles suggest that these factors are markers for unhealthy, atretic follicles. In contrast, higher mRNA levels for the proangiogenic isoform, VEGFA_164, in E2-active follicles indicate that this isoform may help predict healthy ovulatory follicles.

Introduction

Several factors are important for dominant follicle development. Granulosa cells express vascular endothelial growth factor A (VEGFA) and its receptors even though they are avascular follicular cells and *VEGFA* mRNA levels increase as bovine follicles reach preovulatory status. Follicular fluid anti-Müllerian hormone (AMH) levels decrease during antral follicle growth but then increase during early atresia of large follicles while granulosa cell expression of CART prepropeptide (CARTPT) is greater in estrogen (E2)-inactive follicles than E2-active follicles. The current study evaluated granulosa cell expression of *VEGFA_164* (proangiogenic) and *VEGFA_164B* (antiangiogenic) in dominant follicles in comparison with *AMH* and *CARTPT* expression.

Procedure

All procedures were approved by the University of Nebraska–Lincoln Institutional Animal Care and Use Committee. Nonlactating beef cows that were 75% MARC III (1/4 Angus, 1/4 Hereford, 1/4 Pinzgauer, 1/4 Red Poll) and 25% Red Angus/European Composite background crossbreds with an average age of 7.5 ± 2.7 years and weight of 1,200 lb were used in this study. Cows in the first treatment group (CIDR) were synchronized with the Co-Synch + CIDR timed artificial insemination (AI) protocol, except follicle aspiration was performed after synchronization rather than timed AI. The second group of cows was treated with melengestrol acetate (MGA) for 14 days and received three injections of ProstaMate (day 0, 7, and 14) to eliminate any luteal tissue prior to follicle aspiration. Aspiration of dominant follicles was performed transvaginally with the use of caudal epidural anesthesia and an endovaginal ultrasound transducer with an attached needle guide.

Follicular fluid E2 and progesterone (P4) levels were measured to determine E2-activity for each follicle. Total RNA was extracted from granulosa cells for quantitative RT-PCR to evaluate mRNA abundance for *VEGFA_164*, *VEGFA_164B*, *AMH*, and *CARTPT*. The constitutively expressed gene, glyceraldehyde-3-phosphate dehydrogenase (*GAPDH*), was used as a control for RNA amplification. Data were analyzed by one-way ANOVA using JMP software, and differences were considered to be statistically significant at $P < 0.05$ unless otherwise stated.

Results

Using E2:P4 ratios, follicles were classified as E2-active (E2:P4 > 1; healthy) or E2-inactive (E2:P4 ≤ 1; atretic). In the CIDR group, mRNA levels for both *AMH* ($P = 0.0015$) and *CARTPT* ($P = 0.0004$) were greater in aspirated granulosa cells from E2-inactive follicles versus E2-active follicles (Figure 1C-D). Although *VEGFA_164B* mRNA levels were higher in E2-inactive follicles, and *VEGFA_164* was more abundant in E2-active follicles, these differences were not significant (Figure 1A-B). For the MGA-treated cows, mRNA levels for *VEGFA_164B* ($P < 0.0001$), *AMH* ($P = 0.007$), and *CARTPT* ($P = 0.0009$) were more abundant in E2-inactive follicles compared to E2-active follicles (Figure 1B-D). In addition, mRNA levels for *VEGFA_164* ($P = 0.02$) were greater in E2-active follicles than E2-inactive follicles (Figure 1A).

Evaluation of E2-active follicles between CIDR and MGA-treated cows did not reveal differences in mRNA levels for *VEGFA_164*, *VEGFA_164B*, or *AMH* and although *CARTPT* ($P = 0.11$) levels were higher in follicles from MGA cows; this difference was not significant (Figure 1A-D). For E2-inactive follicles, mRNA levels for *VEGFA_164* ($P = 0.04$) were more abundant in follicles from CIDR cows than MGA-treated cows (Figure 1A). Although not significant, mRNA levels for *VEGFA_164B* were higher in follicles from MGA-treated cows than CIDR cows (Figure 1B). No differences were seen in mRNA levels

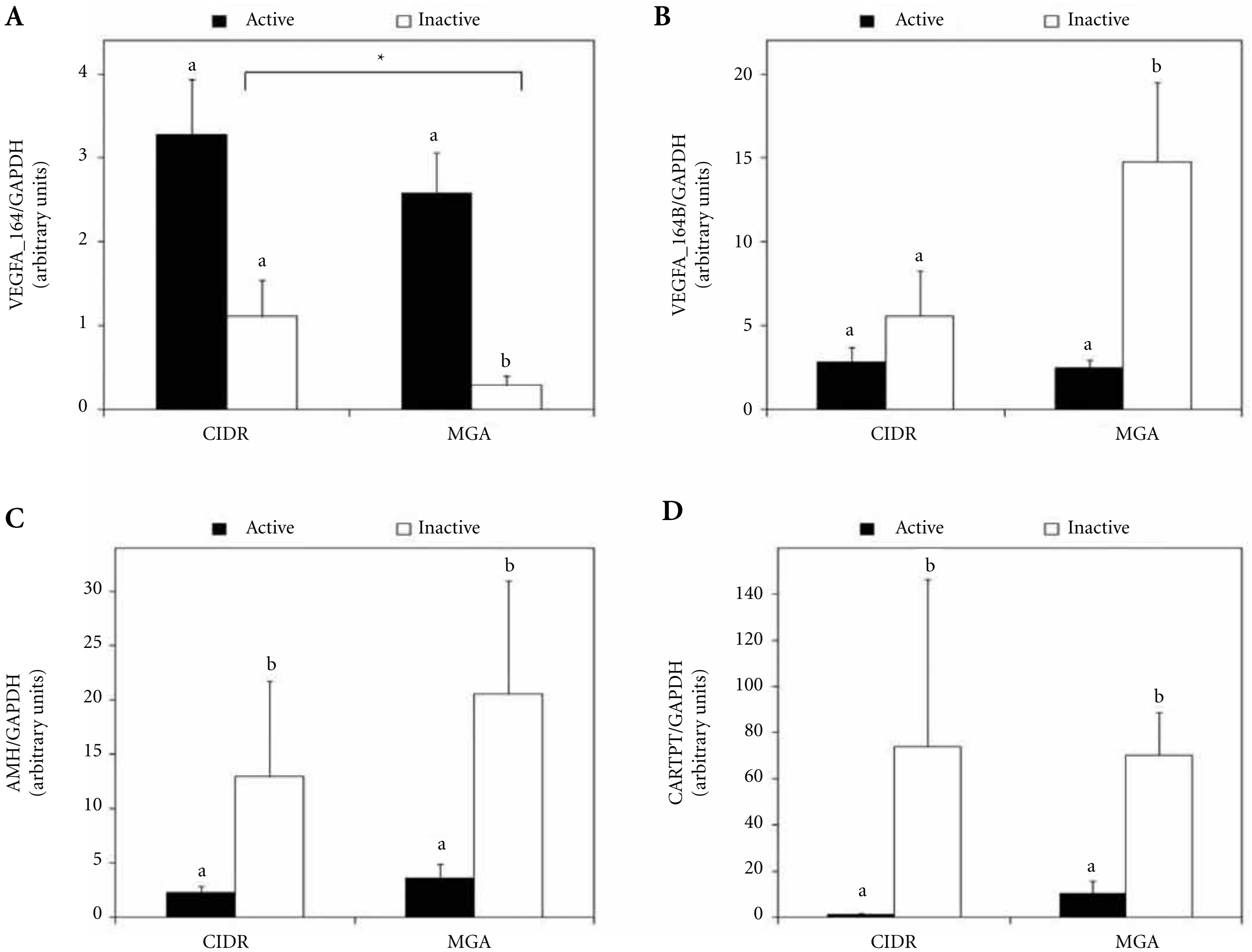

Figure 1. Granulosa cell quantitative RT-PCR results for *VEGFA_164* (A), *VEGFA_164B* (B), *AMH* (C), and *CARTPT* (D) for E2-active and E2-inactive dominant follicles from CIDR and MGA-treated cows. The mean ± SEM normalized values are presented. Different letters represent a statistically significant difference in means between E2-active and E2-inactive follicles for each treatment group ($P < 0.05$). Asterisks represent a statistically significant difference in means between CIDR and MGA-treated cows for each follicle type ($P < 0.05$).

between the two treatment groups for either *AMH* or *CARTPT* (Figure 1C-D).

Increased expression of *AMH* and *CARTPT* in E2-inactive follicles supports previous evidence that these factors are markers for unhealthy, atretic antral follicles. For *VEGFA*, higher levels of the antiangiogenic isoform (*VEGFA_164B*) were present in E2-inactive follicles and higher levels of the proangiogenic isoform (*VEGFA_164*) were present in E2-active follicles. Furthermore, *VEGFA_164* was more abundant in E2-inactive follicles from CIDR cows while *VEGFA_164B* was more abundant in E2-inactive follicles from MGA-treated cows. Treatment with MGA has been shown to promote the development of persistent dominant follicles and is associated with decreased ooctye viability. These data suggest that expression patterns for *VEGFA* isoforms may be used to predict the health status of dominant follicles.

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Oocyte mRNA and Follicle Androgen Levels Associated with Fertility

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Summary

The environment that the oocyte develops in (follicle) and the mRNA that is produced (mRNA abundance) during development were examined. Androgen levels within the follicle were higher in heifers (≤ 2 years) that never established a pregnancy compared to cows that stayed in the herd at least 3 years and had at least one successful pregnancy. These high androgen levels were associated with increased abundance of several candidate mRNAs in the cumulus-oocyte complex (COC), which includes the oocyte and somatic cells immediately surrounding the oocyte, isolated from the dominant follicle. The data suggest that androgen levels represent a marker for oocyte quality which could be used to select for females to retain in the herd.

Introduction

One factor contributing to early embryonic loss in beef heifers and cows is oocyte quality which is established during growth and maturation of the oocyte. Specifically, DNA content is reduced and mRNAs, proteins, and energy sources are synthesized and stored for use by the developing embryo. These factors determine if the oocyte will be competent for fertilization and the establishment of a successful pregnancy. Somatic cells of the follicle produce androgens and estrogen which regulate growth, maturation, and ovulation of the oocyte. However, the specific role of these hormones on each component of oocyte quality has not been defined. The goal of the current study was to determine the impact of androgen levels on oocyte mRNA abundance.

Procedure

All procedures were approved by the University of Nebraska–Lincoln Institutional Animal Care and Use Committee. Beef cows ranging in age from 1.5 to 11 years were synchronized and ovariectomies performed as previously described (*2011 Nebraska Beef Cattle Report,* pp. 13-15) to obtain follicular fluid and the COC from dominant follicles. The criteria for classification as a dominant follicle were (1) the largest follicle on the ovary and (2) an estrogen-to-progesterone ratio > 1.0. Follicular fluid was assayed for androstenedione levels. Total RNA was collected from individual COCs (Ambion) and subjected to linear amplification (Nugen). Quantitative, real-time polymerase chain reaction (qPCR) was conducted to determine the mRNA abundance of maternal effect genes.

Results

Heifers that do not establish a successful pregnancy (low reproductive longevity, LRL) have fewer antral follicles and reduced ovarian weight than cows that stay in the herd 3-6 years (moderate reproductive longevity, MRL), or greater than 6 years (high reproductive longevity, HRL) (*2010 Nebraska Beef Cattle Report,* pp. 16-18; *2011 Nebraska Beef Cattle Report,* pp. 13-15). To determine differences in ovarian function between LRL, MRL, and HRL heifers and cows, follicular fluid and COCs were collected from the dominant ovarian follicle. Follicular fluid collected from the dominant follicle of LRL heifers had significantly higher levels of androstenedione compared to MRL or HRL cows (Figure 1). Androstenedione is an important precursor of the female sex steroid estrogen. In women, high circulating or follicular levels of androgens are associated with reduced fertility.

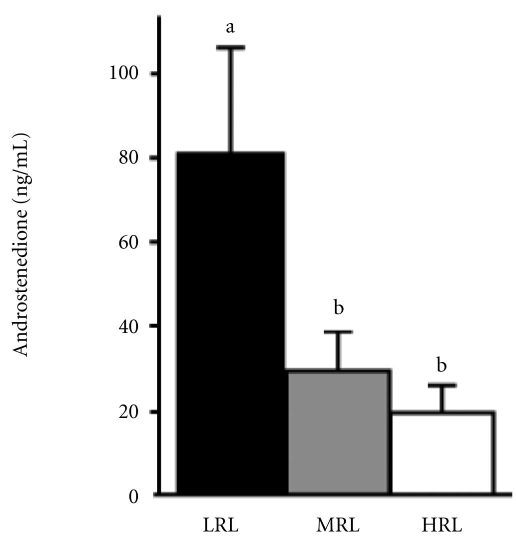

Figure 1. Androstenedione levels were measured in follicular fluid isolated from the dominant follicle on the ovary. Levels were significantly higher in heifers (≤ 2 years; LRL) compared to cows with moderate (>2, <6; MRL) or high (≥ 6 years; HRL) reproductive longevity. Statistical significance ($P < 0.05$) was determined using one-way ANOVA and is indicated by different letters.

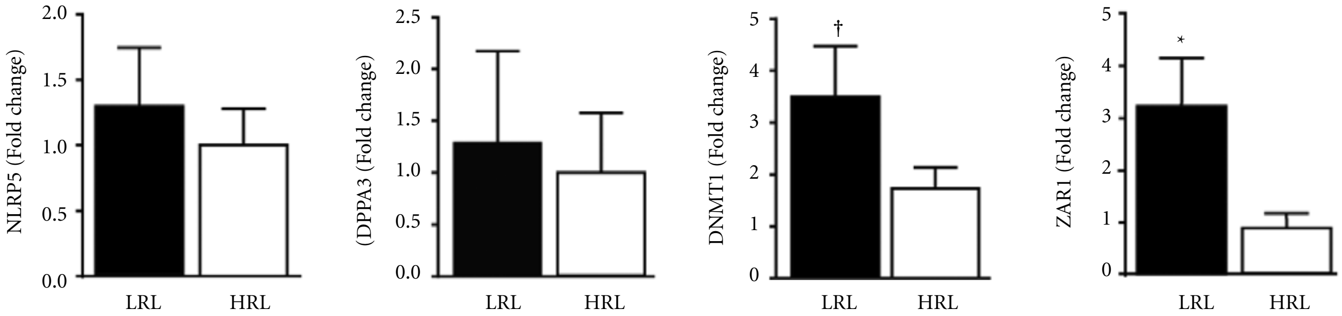

Figure 2. Total RNA from individual COCs was isolated and subjected to linear amplification. The resulting cDNA was used to carry out qPCR using primers directed against maternal effect genes (NLRP5, DPPA3, DNMT1, and ZAR1). The abundance of each specific mRNA was normalized for the housekeeping gene RPL15 and compared to the mean normalized abundance in HRL cows (fold change). Student's t-test was used to identify significant ($P < 0.05$, *) or a trend ($P < 0.1$, †) for differences in mRNA abundance.

Thus, abnormal regulation of androgen production or its conversion to estrogen by the somatic cells of the follicle may contribute to reduced fertility of LRL heifers.

In rodent and human models, high or low levels of specific mRNAs stored in the oocyte are detrimental to the ability of the oocyte to be fertilized or undergo early embryonic development. The abundance of DNMT1 and ZAR1 mRNAs, which are maternal effect genes, was increased in the COCs of LRL compared to HRL cows (Figure 2). Maternal effect genes are stored during oocyte growth and are used during early embryonic development. Thus, these data indicate that mRNA storage in the oocyte may be altered in LRL heifers, which likely results in reduced oocyte quality.

Implications

The data suggest that high follicular androgen levels alter oocyte mRNA abundance and therefore may contribute to poor oocyte quality associated with pregnancy loss. Understanding how androgen levels are regulated and the impact of altered oocyte mRNA accumulation on embryonic development may be used to reverse the negative effects of a poor follicular environment on pregnancy rates in heifers and cows or to select for heifers to retain in the herd.

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The Simmental Breed: Population Structure and Generation Interval Trends

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Summary

Pedigree data from the American Simmental Association from 1986-2008 were used to analyze the pedigree structure and changes in generation intervals over time within the Simmental breed. The number of breeders that accounted for 10% of sires of sires (SS), sires of dams (SD), dams of sires (DS), and dams of dams (DD) were 3, 5, 5, and 16, respectively. States with the greatest influence on the four pathways of selection (SS, SD, DS, and DD) included Montana, South Dakota, Kansas, and Texas. In general, generation intervals for the four pathways decreased by year of birth over the time span of the data analyzed, albeit numerically slight. Average generation intervals for sires and dams also decreased by year of birth, while animals increased slightly.

Introduction

The fundamental breeding pyramid that is evident in other species by design is less clear in beef cattle. Although not clearly delineated, nucleus and multiplier levels of the beef seedstock industry do exist. The identification of producers within each segment is beneficial, especially within the nucleus level, as this is where the accumulation of breeding value occurs before dissemination to commercial herds. Generation interval (GI) is a key component to the overall rate of genetic change. Estimating trends in GI helps to benchmark progress and identify areas for improvement prior to implementation of genomic selection. The objective of the current study was to determine the population structure of the Simmental breed, contributions by breeders and states to the four pathways of selection (grandparents), and changes in GI over time.

Procedure

Pedigree data were obtained from the American Simmental Association from animals born between 1986 and 2008. For computational ease, data were edited such that only three years per decade were used. The pedigree file utilized for analysis included 652,249 animals from 19,097 breeders. Population structure was determined by analyzing four pathways of selection including sires of sires (SS), sires of dams (SD), dams of sires (DS), and dams of dams (DD). Breeders with the greatest contribution to a particular pathway were accumulated until they accounted for 10, 25, 50, 75, or 100% of animals in the pathway. States or provinces with breeders that contributed the greatest to each pathway were also determined based on the percentage of animals in a particular pathway that originated from a specific state or province. The average generation interval, or the average age of parents when the animal is born, of animals, sires, dams, SS, SD, DS, and DD were calculated and averaged by the animal's year of birth.

Results

The number of breeders that accounted for 10, 25, 50, 75 and 100% of total animals in the four individual pathways is depicted in Table 1. The five states with breeders contributing the greatest to each pathway are reported in Table 2. Trends in sire and dam GI show an overall decrease, with the slope being more dramatic in sires than in dams. Unexpectedly, animal GI increased slightly since 1997 (Figure 1). The difference between the birth year with the greatest mean GI and the least mean GI (RANGE) for sires, dams, and animals were 0.47, 0.22, and 0.24 years, respectively. GI measurements were associated with considerable variation as the mean standard deviations pooled across years for GI of sires, dams, and animals were 2.1, 2.4, and 1.9 years, respectively. Across the four pathways,

Table 1. Number of breeders accounting for 10, 25, 50, 75, and 100% of animals in a pathway.

	SS[a]	SD	DS	DD
10%	3	5	5	16
25%	9	19	22	81
50%	29	81	100	361
75%	102	369	419	1,360
100%	3,466	8,169	7,179	15,291

[a]SS=sire of sire; SD=sire of dam; DS=dam of sire; DD=dam of dam.

Table 2. The top five states (percentage) for each pathway of selection.

SS[a]	SD	DS	DD
Montana (14.6)	Montana (12.1)	Montana (16.9)	Texas (11.8)
South Dakota (7.9)	Texas (8.2)	South Dakota (9.4)	South Dakota (8.7)
Texas (6.5)	Kansas (7.7)	Texas (9.1)	Montana (8.6)
Kansas (6.4)	South Dakota (6.7)	Kansas (6.7)	North Dakota (7.4)
North Dakota (6.4)	Nebraska (5.6)	North Dakota (5.5)	Kansas (6.6)

[a]SS=sire of sire; SD=sire of dam; DS=dam of sire; DD=dam of dam.

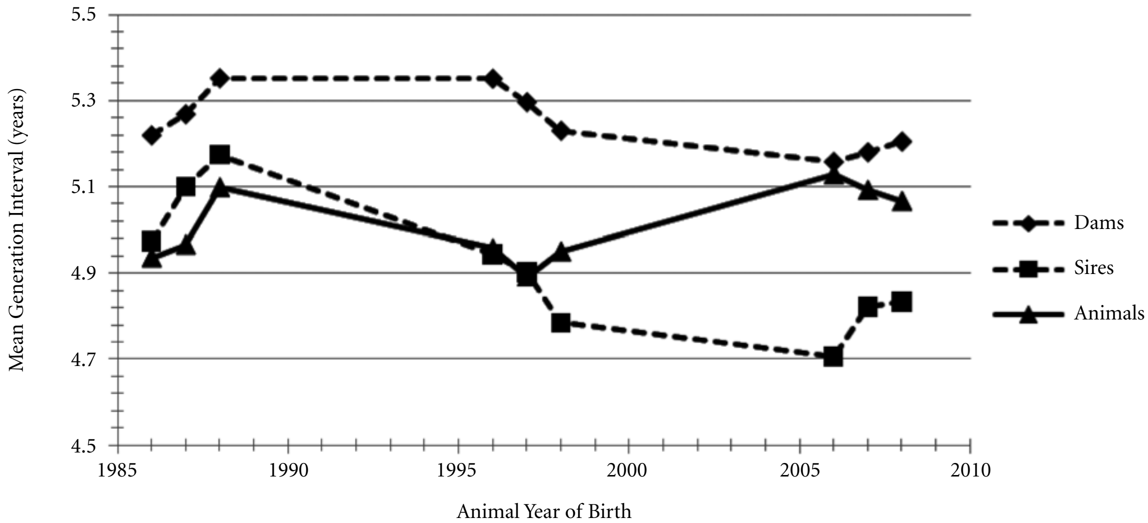

Figure 1. Mean generation interval for animals, sires, and dams by year of birth.

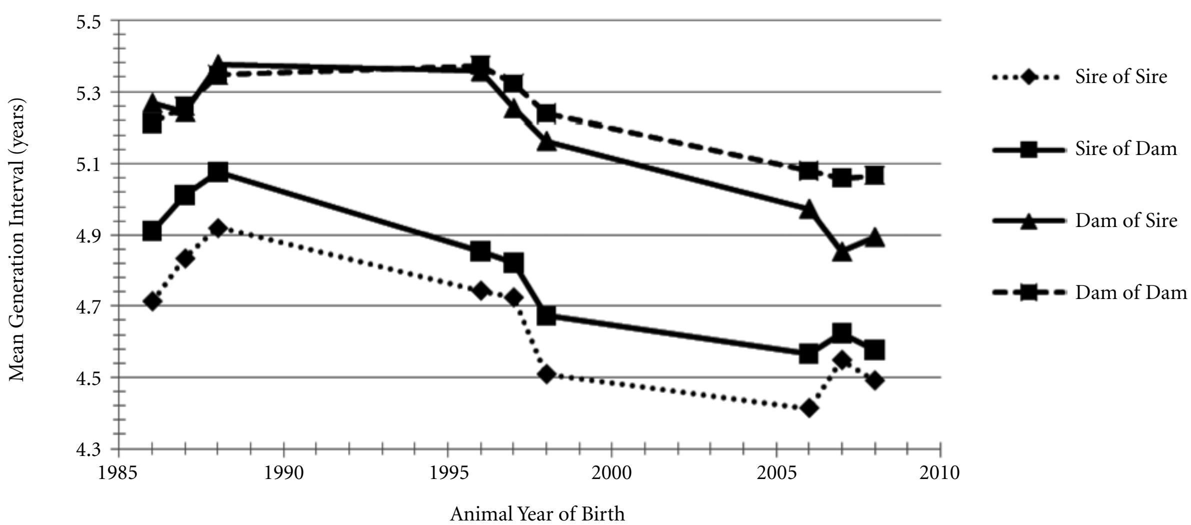

Figure 2. Mean generation interval for the four pathways of selection by year of birth.

GI shows a decreasing trend overall (Figure 2). As expected, SS generation intervals were the shortest and DD generation intervals were the longest. RANGE for SS, SD, DS, and DD were 0.51, 0.51, 0.52, and 0.31 years, respectively. The mean standard deviations pooled across years for GI were 2.0, 2.1, 2.2, and 2.3 years for SS, SD, DS, and DD, respectively.

Implications

There is a clear delineation of the Simmental breed into nucleus and multiplier levels, and genetic change is controlled by a small number of breeders. The GI for SS was the lowest of the four pathways and illustrates the importance of sire selection within nucleus herds. Although modest improvement has been made, there is room for improvement in GI within the Simmental breed, either via reproductive or genomic technologies.

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Association of Myostatin on Performance and Carcass Traits in Crossbred Cattle

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Summary

Calf-fed steers and yearling heifers genotyped as homozygous active, heterozygous, or homozygous inactive for myostatin were used to evaluate performance and carcass traits from Piedmontese influenced cattle. Homozygous inactive steers had similar ADG, lower DMI and lower F:G when compared to steers influenced by active myostatin. Steers and heifers with inactive myostatin showed similar trends in carcass traits producing larger LM area, greater dressing percentages and leaner carcasses. Similar ADG, lower DMI, and improved F:G were observed for homozygous inactive compared to homozygous active steers. Cattle with inactive myostatin require more days on feed than homozygous active cattle to reach similar live BW and 12th rib fat endpoints.

Introduction

Mutations within the myostatin gene produce inactive myostatin that leads to the overgrowth of muscle tissue associated with the double-muscling phenotype found in Piedmontese cattle. Cattle with inactive myostatin have shown increased muscle mass due to an increase in muscle fiber numbers without increasing fat deposition. Cattle associated with the double-muscled phenotype have greater muscle mass with leaner carcasses, lower DMI, and improved F:G (*Journal of Animal Science*, 76:468). The objective of this study was to investigate the potential association of inactive myostatin from Piedmontese influence on performance and carcass traits in crossbred cattle.

Procedure

The current study included two groups, crossbred calf-fed steers (n = 59; 609 ± 61 lb) and yearling heifers (n = 60; 869 ± 60 lb). Cattle genotypes were confirmed by DNA test results as homozygous active (ACTIVE), heterozygous (HET), or homozygous inactive (INACTIVE) for myostatin. Calf-fed steers included 19 ACTIVE, 28 HET, and 12 INACTIVE. Yearling heifers included 25 ACTIVE, 26 HET, and 9 INACTIVE.

Calf-fed steers and yearling heifers were trained and fed individually using Calan electronic gates located at the University of Nebraska–Lincoln Agricultural Research and Development Center Research Feedlot. Feed refusals were collected 1-2 days each week and DM of refused feed was determined for individual total DMI. Steers and heifers were adapted to a common finishing diet that consisted of 52% high moisture: dry-rolled corn blend, 35% wet distillers grains plus solubles, 8% hay, and 5% supplement (DM) for 190 days and 114 days, respectively. Cattle received no implants or feed additives as part of the market protocol for the all natural program.

Cattle were limit fed a common diet with a 1:1 ratio of alfalfa hay and wet corn gluten feed and 5 % supplement (DM) at 2 % BW for 5 days followed by a collection of 3 consecutive days weight average to minimize variation in gut fill. Cattle were weighed and serially scanned via a certified ultrasound technician at 28-day intervals for LM area, 12th rib fat thickness, rump fat thickness, and intramuscular fat percentage. Intermediate BW were shrunk 4% to account for gut fill. After a 60-hour chill, USDA marbling, 12th rib fat thickness, LM area and estimated KPH were collected. Yield grade was calculated with LM area, HCW, 12th rib fat thickness, and estimated KPH data. Individual animal final BW were calculated on 1) a two consecutive day live weight average shrunk 4% prior to slaughter, and 2) a carcass adjusted at 63% HCW. Average daily gain and F:G were determined on both a live final BW and carcass adjusted final BW.

Within sex, individual animal performance and ultrasound data were used to determine the group means of age, BW, ultrasound 12th rib fat and rump fat measurements collected prior to slaughter. Serial BW and ultrasound data were used to develop within genotype class regression equations to adjust individual animals to group means (common end points). Performance, carcass, and adjusted traits were analyzed using the MIXED procedure of SAS (Version 9.2, SAS Inst., Inc., Cary, N.C.). Steer age was significantly different ($P = 0.05$) and was used as a covariate in the MIXED procedure of SAS in analysis of unadjusted performance and carcass data.

Results

Steers

A linear decrease in age, initial BW, live final BW, and DMI were observed with increased number of inactive myostatin alleles($P \leq 0.05$; Table 1). Live final BW calculated ADG tended to linearly decrease ($P = 0.12$) with increased number of inactive myostatin alleles. However, feed conversion decreased linearly ($P < 0.01$) such that INACTIVE steers had significantly lower F:G when compared to steers with active myostatin. Dressing percentage

Table 1. Steers performance and carcass traits.

Performance traits	Myostatin[1] ACTIVE	HET	INACTIVE	SEM	Linear	Quadratic
Age, day	448[a]	445[ab]	436[b]	5	0.05	0.50
Initial BW, lb	636[a]	618[a]	546[b]	20	< 0.01	0.16
DMI, lb/day	18.30[a]	16.76[a]	14.74[b]	0.75	< 0.01	0.74
Live BW avg.						
Final BW, lb	1136[a]	1085[a]	998[b]	32	< 0.01	0.59
ADG, lb/day	2.63	2.45	2.38	0.11	0.12	0.66
F:G	6.99[a]	6.85[a]	6.22[b]	0.18	0.01	0.18
Carcass adjusted BW						
Final BW, lb	1098	1063	1042	32	0.22	0.84
ADG, lb/day	2.43	2.34	2.61	0.12	0.29	0.16
F:G	7.57[a]	7.25[a]	5.58[b]	0.30	< 0.01	0.03
Carcass traits						
HCW, lb	692	670	657	20	0.22	0.84
Dress, %	60.9[b]	61.7[b]	65.9[a]	0.75	< 0.01	0.04
Marbling[2]	473[a]	415[b]	225[c]	21	< 0.01	< 0.01
LM area, in^2	11.6[b]	13.1[a]	13.7[a]	0.34	< 0.01	0.22
12th rib Fat, in	0.42[a]	0.27[b]	0.14[c]	0.05	< 0.01	0.89
CYG[3]	2.90[a]	1.96[b]	1.29[c]	0.23	< 0.01	0.56
					Chi-square	
Liver, %	32.2	47.5	20.3	—	0.11	

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

[1]Myostatin: homozygous active (ACTIVE), heterozygous (HET), homozygous inactive (INACTIVE).

[2]Marbling score: 400 = select high, 300 = select low, 200 = standard.

[3]Calculated Yield Grade = 2.5 + (2.5*12th rib fat, in.) + (0.0038*HCW, lb.) – (0.32*LM area, in.^{2}) + + (0.2*estimated KPH, %) ·

Table 2. Steer traits adjusted to common endpoints.

Traits	Endpoint[2]	Myostatin[1] ACTIVE	HET	INACTIVE	SEM	Linear	Quadratic
LM area, in^2	live BW	12.03[c]	13.24[b]	16.07[a]	0.29	< 0.01	< 0.01
12th rib Fat, in	live BW	0.36[a]	0.28[b]	0.15[c]	0.02	< 0.01	0.35
Live BW, lb	age	1098[a]	1074[a]	990[b]	22	< 0.01	0.17
Age, day	live BW	425[b]	433[b]	465[a]	8	< 0.01	0.09
Age, day	rib fat	407[c]	454[b]	592[a]	10	< 0.01	< 0.01

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

[1]Myostatin: homozygous active (ACTIVE), heterozygous (HET), homozygous inactive (INACTIVE).

[2]Common endpoint based on group means: age 436 days; live BW 1063 lb; and rib fat 0.29 in.

increased quadratically ($P = 0.04$), and LM area linearly increased ($P < 0.01$) with INACTIVE steers being greatest. A linear ($P < 0.01$) and quadratic decrease ($P < 0.01$) was observed for 12th rib fat and marbling, respectively, with INACTIVE having leaner carcasses compared to HET and ACTIVE steers. There was no difference (P = 0.22) in hot carcass weight between genotypes (P = 0.22). Therefore, final BW was not different ($P = 0.22$) when adjusted to 63% HCW. There was no statistical difference ($P = 0.29$) among genotypes with carcass adjusted ADG; however, INACTIVE steers had numerically greater ADG than both HET and ACTIVE. Carcass adjusted F:G decreased quadratically ($P = 0.03$) where INACTIVE steers had the lowest feed conversion. There was no significant difference ($P = 0.11$) in liver abscesses between genotypes; however, 51% of steers had liver abscesses, which is not uncommon with all natural programs.

Live BW adjusted to common age decreased linearly ($P < 0.01$) with inactive myostatin allele presence with no difference between ACTIVE and HET steers (Table 2). A quadratic increase ($P < 0.01$) was observed in LM area adjusted to a common live BW where INACTIVE had larger LM area than ACTIVE with HET steers intermediate. Fat depth decreased linearly ($P < 0.01$) with INACTIVE steers being leaner at common live BW than ACTIVE with HET steers intermediate. Homozygous inactive steers require an average of 36 more days than HET and ACTIVE steers to reach a common live BW. Age adjusted to a common 12th rib fat quadratically increased ($P < 0.01$) with increasing copies of inactive myostatin alleles.

Heifers

There was no significant difference ($P = 0.48$) in age between heifers differing in myostatin genotype (Table 3). Initial BW, live final BW, DMI, and ADG linearly decreased ($P < 0.01$) as number of inactive myostatin alleles increased. Feed conversion increased ($P = 0.03$) where INACTIVE heifers had the greatest F:G. Dressing percentage and LM area increased quadratically ($P < 0.02$) with increased number of inactive myostatin alleles. A linear and quadratic decrease ($P < 0.03$) in 12th rib fat and marbling, respectively, were observed, with INACTIVE heifers being leaner than HET and ACTIVE heifers. There was no difference ($P = 0.40$) in carcass adjusted final BW, since no difference was observed ($P = 0.40$) in HCW between all genotypes. Carcass adjusted ADG did not differ ($P = 0.12$) between genotypes where INACTIVE heifers now had numerically greater ADG than both HET and ACTIVE. Carcass adjusted feed conversion decreased linearly ($P < 0.02$) where INACTIVE heifers showed the lowest F:G. On an all- natural program, heifers had 30% liver abscesses; however, there was no significant difference ($P = 0.90$) among genotypes.

Live BW adjusted to age decreased linearly ($P < 0.01$) with the presence of inactive myostatin alleles (Table 4). A quadratic response ($P < 0.01$) was observed whereby age adjusted LM

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increased from ACTIVE to INACTIVE. At a common weight, 12th rib fat linearly decreased ($P < 0.01$) with inactive myostatin. Age increased linearly ($P < 0.01$) and quadratically ($P = 0.05$) when adjusted to live BW and 12th ribfat, respectively, among heifers with increased presence of inactive myostatin alleles.

In conclusion, INACTIVE steers had similar gains, lower DMI and improved F:G when compared to steers with active myostatin allele(s). Observed data for steers and heifers suggested that INACTIVE animals had lighter initial and live final BW than ACTIVE. Homozygous inactive steers and heifers require more days on feed to reach a common live BW and 12th rib fat thickness than homozygous active steers and heifers. On a carcass adjusted final BW basis, homozygous inactive steers and heifers had improved F:G when compared to HET and ACTIVE steers and heifers. Steers and heifers with inactive myostatin allele presence had similar trends in carcass traits producing larger LM area, leaner carcasses, with greater dressing percentages, and producing similar HCW.

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Table 3. Heifer performance and carcass traits.

	Myostatin[1]					
Performance traits	ACTIVE	HET	INACTIVE	SEM	Linear	Quadratic
Age, day	595	591	591	5	0.48	0.60
Initial BW, lb	892[a]	861[ab]	829[b]	19	< 0.01	0.95
DMI, lb/day	20.05[a]	19.12[a]	16.51[b]	0.75	< 0.01	0.74
Live BW avg.						
Final BW, lb	1149[a]	1100[b]	1020[c]	26	< 0.01	0.49
ADG, lb/day	2.25[a]	2.09[a]	1.68[b]	0.13	< 0.01	0.24
F:G	8.93[a]	9.17[ab]	10.0[b]	0.472	0.03	0.45
Carcass adjusted BW						
Final BW, lb	1135	1107	1107	18	0.40	0.52
ADG, lb/day	2.16	2.16	2.44	0.15	0.12	0.28
F:G	10.13[a]	9.23[ab]	6.92[b]	1.10	0.02	0.44
Carcass traits						
HCW, lb	716	697	698	18	0.40	0.52
Dress, %	62.4[b]	63.4[b]	68.4[a]	0.69	< 0.01	< 0.01
Marbling[2]	421[a]	380[a]	219[b]	33	< 0.01	0.03
LM area, in^2	13.1[c]	14.1[b]	16.4[a]	0.32	< 0.01	0.02
12th rib Fat, in	0.42[a]	0.31[b]	0.16[c]	0.05	< 0.01	0.64
CYG[3]	2.49[a]	1.79[b]	0.64[c]	0.19	< 0.01	0.15
					Chi-square	
Liver, %	32.0	26.9	33.3	—	0.90	

[a,b,c] Means without a common superscript differ ($P < 0.05$).
[1]Myostatin: homozygous active (ACTIVE), heterozygous (HET), homozygous inactive (INACTIVE).
[2]Marbling score: 400 = select high, 300 = select low, 200 = standard.
[3]Calculated Yield Grade = 2.5 + (2.5*12th rib fat, in.) + (0.0038*HCW, lb.) – (0.32*LM area, in.^{2}) + + (0.2*estimated KPH, %) ·

Table 4. Heifer traits adjusted to common endpoints.

		Myostatin[1]					
Traits	Endpoint[2]	ACTIVE	HET	INACTIVE	SEM	Linear	Quadratic
LM area, in^2	age	14.02[c]	14.69[b]	17.12[a]	0.40	< 0.01	< 0.01
12th rib Fat, in	live BW	0.41[a]	0.29[b]	0.18[c]	0.04	< 0.01	0.83
Live BW, lb	age	1115[a]	1069[b]	997[c]	25	< 0.01	0.52
Age, day	live BW	579[b]	587[b]	605[a]	6	< 0.01	0.32
Age, day	rib fat	568[c]	596[b]	652[a]	9	< 0.01	0.05

[a,b,c] Means without a common superscript differ ($P < 0.05$).
[1]Myostatin: homozygous active (ACTIVE), heterozygous (HET), homozygous inactive (INACTIVE).
[2]Common endpoint based on group means: age 584 d; live BW 1077 lb; and rib fat 0.33 in.

Economic Analysis of Keeping a Nonpregnant Cow

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Summary

Abnormally large numbers of nonpregnant cows in cow-calf herds may be caused by diseases like trichomoniasis or a culmination of environmental factors such as heat stress during breeding and abnormally cold winters and wet spring conditions. Typically, producers sell nonpregnant females and replace them with bred heifers or cows. The five-year cash flow budgets developed in this study suggest that in some circumstances it is economically feasible to keep a nonpregnant cow.

Introduction

Sales of cull cows represent 10-20% of total gross income for the herd on average. While culling a nonpregnant cow is still an appropriate option and may be economically optimal in many cases (e.g., at high cull cow prices or for older, less productive cows), it has not been confirmed to be the best economic strategy in all situations. The variability in cattle prices and changing spreads between cull and bred stock values suggest other possible alternatives could exist. In certain circumstances, based on input and cattle prices, it is worth determining the economic feasibility of retaining a nonpregnant cow in the herd and re-breeding her the following year instead of replacing her with a new bred heifer or cow. The objectives of this analysis were to determine the feasibility of keeping a nonpregnant cow in comparison to three other common alternatives.

Procedures

Five-year discounted cash flow budgets were used to determine the feasibility of keeping nonpregnant cows. Budgets were created to calculate the annual costs of retaining replacement heifers within the herd, purchasing bred heifers, or purchasing cows to replace culled, nonpregnant cows. The budgets for retained nonpregnant cows reflected lower annual cow carrying costs (feed expenses plus operating costs) due to lower nutrient requirements.

The five-year discounted cash flow budgets are based on a case study herd of 100 cows. Each class of cattle (cows, heifers, steer calves, heifer calves) were assigned budgeted costs as well as income. Cattle prices from December 2010 to February 2011 used in this analysis are from USDA AMS for either the Burwell, Nebraska Livestock Market (bred cow and heifer prices) or from the Nebraska Combined 7-Auction Weighted Average price (cull cow and feeder calf prices) and are shown in Table 1.

Four alternatives for a nonpregnant cow are analyzed to compare annual cash flow values as well as the Total Five-Year Discounted Cash Flow Values. The four alternatives are as follows:

Alternative 1: Retain Heifers — The producer elects to cull all nonpregnant females and retain heifers from the mature cow herd's calf crop. It is assumed there is a normal 20% replacement level and a 2% death loss in the 100-head case study; therefore, 22 heifers are retained in a normal year. Certain cow herd inventory implications arise when the nonpregnant rate rises above the number of available heifers and cow herd inventories cannot be held at the target herd size of 100 head in the immediate years following a high nonpregnant cow rate. An additional assumption for this alternative is that the producer would normally retain 22 heifers waiting to enter the herd from the previous year that were not affected by any increases in nonpregnant cow rates.

Alternative 2: Purchase Bred Heifers — The producer elects to cull all nonpregnant females and replace them with purchased pregnant heifers.

Alternative 3: Purchase Bred Cows — Similar to purchasing bred heifers, the producer culls all nonpregnant cows and replaces them with purchased pregnant cows.

Alternative 4: Keep Nonpregnant Cows — The producer culls the normal rate (20%) and purchases pregnant cows as replacement. However, when nonpregnant cow rates rise above the normal cull rate, the producer keeps the additional nonpregnant cows for an entire year. In the second year of the analysis, the cow is re-bred and in the third year of this analysis, she has a calf.

Table 1. Winter 2011 prices.

550 lb Steer Calf ($/cwt)	$151.76
500 lb Heifer Calf ($/cwt)	136.26
650 lb Cull Heifer ($/cwt)	125.45
Cull Cow Value ($/cwt)	62.63
Purchase Price of Bred Heifer ($/head)	1385.00
Purchase Price of Bred Cow ($/head)	1310.00

Results

Table 2 reports the total five-year discounted cash flow value for each alternative evaluated for the five-year case study. All annual cash flow values are discounted at a rate of 5% to derive the totals. Alternative 1, retaining heifers, resulted in the highest cash returns followed by purchasing cows (Alternative 3) and keeping the nonpregnant cows (Alternative 4). Purchasing heifers (Alternative 2) resulted in the lowest-return alternative. Alternative 4 does not result in the lowest return and profits are possible when implementing this alternative.

Alternative 1 has implications at a high nonpregnant cow rate. At the 100% nonpregnant rate, the total five-year discounted cash flow value is the highest nonpregnant cow rate cash flow value. The influx of cash in

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Year 1 from culling the entire herd of nonpregnant cows is not re-invested quickly if retained heifers are used as the alternative. With the assumption that the normal replacement heifers are available in Year 1, even in the event of the rest of the cow herd being nonpregnant, the producer still has 22 first-calf heifers available to rebuild a herd. By Year 5, the ending year of this case study, the producer has yet to return to target herd size of 100.

Table 2 shows profitable levels throughout many of the nonpregnant cow rates. This is to be expected with the profitability of the cow-calf sector using price levels in the winter of 2011 time period. Furthermore, the relatively high cull cow values listed in Table 1 are a major contributor to the profit potentials in this case-study cow herd. Table 2 also illustrates the return potential of keeping a nonpregnant cow (Alternative 4) could be attractive in many instances. In our analysis, keeping the nonpregnant cow is always more profitable than purchasing a bred heifer at all nonpregnant cow rates.

Table 3 shows the ranking of each alternative's total five-year discounted cash flow values under different cull cow prices and nonpregnant cow rates (similar rankings are grouped by shaded areas). Recall the order from Table 2 that shows Alternative 1 being the highest return alternative, followed by Alternative 3, Alternative 4, and lastly Alternative 2. By using Table 1 prices and an analysis similar to that reported in Table 2, Table 3 shows this result is consistent throughout many of the cull cow value and nonpregnant rates analyzed. However, when cull cow values drop below $40/cwt and nonpregnant cow rates rise above 30%, keeping a nonpregnant cow becomes second in the ranking order. When cull cow prices rise above $76/cwt and high nonpregnant cow rates rise, it becomes advantageous to cull the nonpregnant cow and replace with either retained heifers, purchased cows, or purchased heifers. This would suggest that producers should elect to take advantage of elevated cull cow values if he or she is experiencing high nonpregnant cow rates.

The higher valued classes of cattle used in this analysis (Winter 2011 prices) show potential of keeping a nonpregnant cow out of production for an entire year. While the total five-year discounted Cash flow values prove a deterministic answer, Table 3 shows an important ranking system to assist in a producer's decision. Facing high nonpregnant cow rates can be economically devastating to a cow herd, however the previous data suggest that options are available, and keeping a nonpregnant cow could potentially be considered.

Table 2. Total five-year discounted cash flow values for each alternative at differing nonpregnant cow rates.

	Nonpregnant cow rate				
	0%	25%	50%	75%	100%
Alternative 1- Retain Heifer	36,234.57	30,198.65	28,449.62	17,345.51	35,665.57
Alternative 2- Purchase Heifer	10,939.99	4,280.55	(8,759.38)	(21,557.99)	(33,338.49)
Alternative 3- Purchase Cows	30,001.33	28,802.65	21,580.22	14,357.79	7,135.37
Alternative 4- Keep Nonpregnant Cows	30,001.33	27,659.10	14,204.57	746.24	(11,956.38)

Table 3. Ranking of alternatives (highest return first) at differing nonpregnant cow percentages and cull cow values, winter 2011 prices.

			Nonpregnant Cow Percentage (Year 1)										
	$head	$/cwt	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Cull Cow Value	$300	$24	1,3,4,2	1,3,4,2	1,3,4,2	1,4,3,2	1,4,3,2	1,4,3,2	1,4,3,2	1,4,3,2	1,4,3,2	1,4,3,2	1,4,3,2
	350	28	1,3,4,2	1,3,4,2	1,3,4,2	1,4,3,2	1,4,3,2	1,4,3,2	1,4,3,2	1,4,3,2	1,4,3,2	1,4,3,2	1,4,3,2
	400	32	1,3,4,2	1,3,4,2	1,3,4,2	1,4,3,2	1,4,3,2	1,4,3,2	1,4,3,2	1,4,3,2	1,4,3,2	1,4,3,2	1,4,3,2
	450	36	1,3,4,2	1,3,4,2	1,3,4,2	1,4,3,2	1,4,3,2	1,4,3,2	1,4,3,2	1,4,3,2	1,4,3,2	1,4,3,2	1,4,3,2
	500	40	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,4,3,2	1,4,3,2	1,4,3,2	1,4,3,2	1,4,3,2	1,4,3,2	1,4,3,2
	550	44	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2
	600	48	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2
	650	52	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2
	700	56	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2
	750	60	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2
	800	64	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2
	850	68	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2
	900	72	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2
	950	76	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,2,4	1,3,2,4
	1000	80	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,2,4	1,3,2,4	1,3,2,4
	1050	84	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,2,4	1,3,2,4	1,3,2,4	1,3,2,4
	1100	88	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,2,4	1,3,2,4	1,3,2,4	1,3,2,4
	1150	92	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,2,4	1,3,2,4	1,3,2,4	1,3,2,4
	1200	96	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,4,2	1,3,2,4	1,3,2,4	1,3,2,4	1,3,2,4	1,3,2,4

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Effect of Post-Weaning Heifer Development System on Average Daily Gain, Reproduction, and Adaptation to Corn Residue During First Pregnancy

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Summary

A three-year study evaluated post-weaning winter grazing system management on primiparous heifers at two locations. Weaned heifers were assigned to a development system: (1) graze corn residue then winter range, (2) graze winter range, or (3) graze winter range then placed in drylot. A combination of artificial insemination (AI) and natural mating was used at time of breeding based on location. Pregnant heifers were assigned to one of three corn residue fields in late gestation based on previous heifer development. Weaned heifers developed on corn residue had similar BW and ADG during winter grazing and after breeding, compared to heifers developed on winter range. The effect of post-weaning management on reproductive performance was similar for all heifer treatments. Heifers developed on winter range or drylot had similar ADG compared to heifers developed on corn residue, during late gestation.

Introduction

Developing replacement heifers on low quality dormant forage, such as corn residue or winter range, is less expensive than feeding harvested forage. Dormant winter forage is reduced in nutrient quality, and cattle developed on dormant forage tend to have reduced performance and BW. Fernandez-Rivera and Klopfenstein (*Journal of Animal Science*, 1989, 67:590-596) determined that naïve cattle require an acclimation period for grazing corn residue (CR). Objectives of this experiment were to evaluate the effect of winter grazing system on heifer ADG and reproductive performance, and to determine the effects of winter development system on subsequent adaptation to corn residue during late gestation.

Procedure

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

Red Angus x Simmental composite heifer calves (n = 287) were blocked by weight (486 ± 8 lb) and randomly assigned one of two winter development systems, (1) graze CR for 75 days, followed by WR for 105 days, or (2) graze winter range (WR) continuously for approximately 180 days. Heifers assigned to CR were transported to a corn field, whereas WR heifers were maintained at the UNL Gudmundsen Sandhills Laboratory (GSL) near Whitman, Neb. Both treatment groups were offered 1 lb/day of a supplement (28% CP) during winter grazing. After winter treatment all heifers were managed similarly on WR and mixed upland pastures at GSL for 100 days prior to breeding. Estrus was synchronized with a single 5 ml injection of $PGF_{2\alpha}$ administered 108 hours after bulls were exposed to heifers. Bulls remained (1 bull to 25 heifers) with heifers for 45 days. Heifers remained on Sandhills upland range through final pregnancy diagnosis in September.

A subset of pregnant heifers (n = 148) were blocked by weight and assigned to one of three CR fields based on previous development: a naïve group composed of only WR heifers (859 ± 16 lb; n = 51), a group previously developed on CR after weaning (860 ± 16 lb; n = 50), and a mixture of the two development systems with half of the heifers having previous CR grazing experience, and the other heifers being naïve (849 ± 16 lb; n = 47) to CR grazing. All three groups were supplemented the equivalent of 1 lb/day (28% CP) three times weekly while grazing CR. Pregnant heifers grazed CR approximately 75 days, based on CR availability over three years. In addition, weaned, angus cross heifers (n = 159) from the UNL West Central Research and Extension Center (WCREC), North Platte, Neb., grazed (1) CR and WR or (2) grazed WR and then placed in a drylot (DL) during winter development. Heifers were fed MGA to synchronize estrus, followed by AI and bull exposure for 60 days. A subset of pregnant heifers were blocked by weight and assigned to one of three CR fields during mid to late gestation, based on previous winter development: DL heifers naïve to grazing CR (995 ± 19 lb; n = 53), heifers previously developed on CR (992 ± 19 lb; n = 52), and a mixture of heifers from each development system (982 ± 19 lb; n = 54). The same three CR fields were used for GSL and WCREC heifers during late gestation. Heifers grazed CR for approximately 76 days prior to calving based on CR availability. Data were analyzed using the MIXED and GLIMMIX procedures of SAS (SAS Inst., Inc., Cary, N.C.) with year being the experimental unit and development system as the fixed effect.

Results

Heifers from GSL had similar ADG and BW during post-weaning winter development (Table 1). Percent cycling before breeding and pregnancy rate was similar for WR and CR heifers ($P \geq 0.31$). Previous research

(Continued on next page)

recommended a target weight of 65% mature weight for successful breeding of beef heifers; however, more recent research has demonstrated that heifers developed to 55% of mature BW experienced successful pregnancy rates (Martin et al., *Journal of Animal Science,* 2008, 86:451-459). Thus, utilizing dormant winter forages to develop heifers may reduce BW at time of breeding without negatively affecting pregnancy rates. Heifers developed on WR had similar ADG compared to CR heifers, when grazing CR in late gestation (Table 2). Post-weaning WCREC heifer data are reported in the *2012 Beef Cattle Report*, pp. 39-40. Although not statistically significant, ADG for pregnant heifers developed on CR was increased twofold, compared to naïve heifers previously developed in DL (Table 3). Developing heifers on CR does not negatively impact reproductive efficiency when compared to WR or traditional DL heifer development. By extending winter grazing for weaned heifers, producers can reduce harvested feed inputs without impacting ADG or BW prior to first parturition.

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Table 1. Effect of winter heifer development on ADG and reproduction in beef replacement heifers.

	Treatment[1]			
	CR	WR	SEM	*P*-value
n	144	143		
Initial BW, lb	485	489	9	0.56
Dec. – Feb. ADG[2], lb	0.49	0.67	0.13	0.21
BW after winter grazing, lb	526	544	12	0.11
Prebreeding BW, lb	608	619	8	0.36
Feb. – April ADG[3], lb	1.02	0.83	0.15	0.14
Breeding BW, lb	637	643	6	0.40
April – May ADG[4], lb	1.16	1.05	0.10	0.18
Final Pregnancy BW, lb	788	796	5	0.38
June – Sept. ADG[5], lb	1.63	1.64	0.15	0.84
Cycling, %	52	46	6	0.31
Pregnant, %	85	86	2	0.80
Pregnant BCS	5.8	5.8	0.02	0.46

[1]CR = heifers developed on corn residue; WR= heifers developed on winter range.
[2]ADG while grazing CR or WR.
[3]ADG between winter development and prebreeding.
[4]ADG between prebreeding and breeding.
[5]ADG between breeding and pregnancy diagnosis.

Table 2. Effect of weaned heifer development system on ADG while grazing corn residue (CR) during late gestation.

	Treatment[1]				
	WR	CR	MIX	SEM	*P*-value
n	51	50	47		
Initial BW, lb	859	860	849	16	0.75
Final BW, lb	919	933	909	20	0.41
ADG, lb	0.80	0.94	0.78	0.22	0.41
BCS	5.1	5.3	5.2	0.10	0.24

[1]WR = heifers grazed winter range that were naïve to grazing CR; CR = heifers who had previously grazed corn residue; MIX = mixture of heifers from CR and WR treatments.

Table 3. Effect of weaned heifer development system on ADG while grazing corn residue (CR) during late gestation.

	Treatment[1]				
	DL	CR	MIX	SEM	*P*-value
n	53	52	54		
Initial BW, lb	975	964	980	19	0.81
Final BW, lb	995	1004	1004	30	0.94
ADG, lb	0.26	0.53	0.26	0.33	0.42

[1]DL = heifers developed in drylot that were naïve to grazing CR; CR = heifers who had previously grazed corn residue; MIX = mixture of heifers from CR and DL.

Impact of Post-Weaning Beef Heifer Development System on Average Daily Gain, Reproduction, and Feed Efficiency

Stetson P. Weber
Adam F. Summers
T.L. Meyer
Rick N. Funston[1]

Summary

This experiment evaluated the impact of post-weaning heifer development system on ADG, reproduction, and subsequent feed efficiency during late gestation. Shortly after weaning, heifers were developed on one of two winter grazing systems: corn residue (CR) followed by winter range, or winter range followed by drylot (DL). Heifer BW was greater for DL heifers prior to breeding, at breeding, and prior to first parturition. There were no differences in reproductive performance despite CR heifers having lower BW at breeding. Feed efficiency was similar during late gestation between CR and DL heifers. Extending winter grazing decreased BW without impacting reproductive performance.

Introduction

Increasing harvested feed costs have producers seeking alternative resources for heifer development. Heifers developed on corn residue exhibited lower percentage cycling before breeding, compared to drylot (Funston, et al., *Journal of Animal Science*, 2011, 89:1595-1602). Heifers grazing corn residue gain less during winter months but compensate during the summer months (*2008 Nebraska Beef Cattle Report*, pp. 8-10). Jenkins et al. (*Animal Production*, 1986, 43:245-254) suggested that lighter cows have reduced liver mass, and cows with improved G:F were reported to have smaller liver mass (DiCostanzo, et al., *Journal of Animal Science*, 1991, 69:1337-1348). The objective of the current study was to evaluate effects of winter development system on reproductive performance and feed efficiency in beef heifers.

Procedure

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

The effect of post-weaning heifer development system on reproductive performance and feed efficiency was evaluated in a three-year study conducted at the University of Nebraska–Lincoln West Central Research and Extension Center (WCREC), North Platte, Neb. After a receiving period, weaned heifers (n = 299) were blocked by weight and randomly assigned to one of two developmental treatments: (1) graze corn residue (CR) followed by winter range (WR); or (2) graze WR and then fed in drylot (DL). Heifers assigned to CR initially grazed WR for 40 days, and then grazed CR for 75 days, followed by grazing WR for 65 days. Heifers received 1 lb/day protein cube (28% CP) for the duration of CR and WR grazing. Heifers developed in DL grazed WR for 95 days, with the same daily supplement as CR heifers, then entered the DL for 85 days and were offered a diet formulated to allow heifers to reach 65% of mature BW (1,250 lb) at start of breeding. Prior to breeding, CR and DL heifers were managed together 40 days in DL with a common diet. Preceding estrus synchronization, individual blood samples were collected 10 days apart to determine pubertal status. Melengestrol acetate/prostaglandin was used to synchronize estrus followed by 5 day heat detection and AI. Heifers were exposed to bulls (1 bull to 50 heifers) 10 days following the last AI for 60 days. Transrectal ultrasonography was used to determined both AI conception rate 45 days after AI. Final pregnancy rate was determined 45 days after bull removal. Heifers were managed together during and after breeding on mixed upland grasses for the summer months.

A subset of pregnant heifers (n = 118) were used to measure individual ADG and DMI, to determine feed efficiency during late gestation. Only heifers that conceived AI were utilized to reduce variation in stage of gestation. Each year (Year 1 = 40; Year 2 = 38, Year 3 = 40) heifers were stratified by weight and winter development system (CR (959 ± 6 lb) or DL (985 ± 6 lb)) into pens and individually fed in a Calan Broadbent feeding system. In Year 1, heifer diets contained 90% grass hay (11 % CP; DM) and 10% supplement composed of wet distillers grains plus solubles/straw mixture (21.8 % CP; DM). Years 2 and 3, heifers received *ad libitum* grass hay and: no supplement; a distillers grain based supplement; or a dried corn gluten feed supplement. Supplements were formulated to be isonitrogenous (29% CP, DM) and isocaloric, but differed in undegradable intake protein. Individual feeding started with a 25-day training period, followed by an approximately 80-day trial. Feed offered was recorded daily and feed refusals were measured and recorded weekly, with BW recorded every 14 days. Data were analyzed using the MIXED and GLIMMIX procedures of SAS (SAS Inst., Inc., Cary, N.C.) with development system as the fixed effect and year as the random effect.

Results

Winter development system did not affect BW ($P = 0.38$) or ADG ($P = 0.47$) during winter treatment (Table 1). However, DL heifer BW was greater ($P < 0.01$) after the DL period, compared to CR heifers beginning in

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April and continued to be greater ($P = 0.05$) until final pregnancy was determined. Heifers developed on CR had lower ($P = 0.02$) BW at time of breeding with similar ($P \geq 0.43$) percent cycling, AI conception, AI pregnancy, and overall pregnancy rates compared to DL heifers. These findings agree with research conducted by Freetly et al. (*Journal of Animal Science*, 2001, 79:819-826) indicating reduction of harvested feeds can impact ADG without impacting subsequent reproductive performance. Heifers developed on CR had similar ($P \geq 0.32$) DMI, ADG, G:F, and residual feed intake compared to DL heifers, during individual 80 day feeding trial (Table 2). Heifers developed on CR had lower ($P = 0.03$) BW prior to calving. Although heifers developed on CR had reduced BW at the start of the breeding season and prior to calving, CR heifers had similar reproductive performance, feed efficiency, and ADG during late gestation.

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Table 1. Effect of winter heifer development on ADG and reproductive performance.

	Treatment[1]			
	DL	CR	SEM	*P*-value
n	150	149		
Initial BW, lb	546	543	10	0.81
Dec – Feb ADG[2], lb	0.42	0.22	0.28	0.47
BW after winter grazing, lb	590	566	32	0.38
Prebreeding BW, lb	737	640	23	< 0.01
Feb – April ADG[3], lb	2.27	1.14	0.23	0.07
Breeding BW, lb	773	691	20	0.02
April – May ADG[4], lb	1.09	1.54	0.22	0.29
First ultrasound BW, lb	824	772	26	0.04
June – July ADG[5], lb	1.04	1.67	0.19	0.08
Final pregnancy BW, lb	940	897	17	0.05
July – Sept ADG[6], lb	1.68	1.83	0.19	0.08
Cycling %	68	52	12	0.43
Synchronization %	89	91	3	0.60
Conceived to AI %	67	71	6	0.66
Pregnant to AI %	60	65	6	0.58
Pregnant %	93	93	2	0.86

[1]DL = heifers grazed winter range then fed in drylot; CR = heifers grazed corn residue then grazed winter range.
[2]ADG while grazing CR or grazing WR.
[3]ADG between winter development and prebreeding.
[4]ADG between prebreeding and breeding.
[5] ADG between breeding and first ultrasound.
[6]ADG between first ultrasound and final pregnancy diagnosis.

Table 2. Effect of winter heifer development on ADG and feed efficiency during late gestation.

	Treatment[1]			
	DL	CR	SEM	*P*-value
n	58	60		
Initial BW, lb	986	959	6	< 0.01
Final BW, lb	1107	1085	7	0.03
ADG, lb	1.5	1.6	0.05	0.52
DMI, lb	23.0	22.7	0.24	0.42
RFI[2], lb	-0.64	-0.59	0.08	0.76
G:F	0.069	0.072	0.00	0.32

[1]DL = heifers grazed winter range then fed in drylot; CR = heifers grazed corn residue then grazed winter range.
[2]Residual Feed Intake = predicted DMI – actual DMI.

Heifer Development: Think Profit, Not Just Cost or Revenues

Matthew C. Stockton
Roger K. Wilson
Rick N. Funston[1]

Summary

Recent research on the economics of optimal beef replacement heifer size development reinforced the established economic principle that revenue or cost optimization are not equal to profit optimization. A modified profit function was used to analyze simulated results which demonstrated the differences among the three measures. In the case of optimizing pregnancy rates, a heifer must be heavier to optimize productivity as measured by revenue verses profit. Similarly in the case of cost minimization, the reduction in developmental expenses results in less profit except in the case where the economically optimal sized heifer equals that of the size chosen to cost minimize.

Introduction

Research at the University of Nebraska–Lincoln Gudmundsen Sandhills Laboratory (GSL), challenged the conventional wisdom that 65% of mature body weight for virgin heifers is necessary to achieve optimal pregnancy rates. The findings showed no statistically significant difference in pregnancy rates among groups developed to varying percents of mature body weight prior to first breeding, concluding that feed cost savings for heifer development regimes has an economic advantage.

The data from the above studies were reanalyzed in this study which captured the biological and economic information in a simulation model that was used to estimate profitability differences among individual heifers. This methodology used a Modified Profit Function (MPF) to determine differences among animals. A Maturity Index (MI), as described in the *2009 Nebraska Beef Cattle Report*, was a key component of the process. The MI measured several factors in addition to the heifer's weight at prebreeding. These other factors contributed to maturity and thus pregnancy rate, dystocia, and cost of development, as well as revenue factors such as calf size and individual size.

Procedures

Interrelationships among animal characteristics and production were established using regression analysis and a loss function criteria. The loss function was helpful in identifying appropriate variables to include in the statistical models. Once created, the biological and economic interrelationships were used to evaluate the economic performance of 39,168 individual heifer simulations. These simulations used the production of heifers with the feasible trait combinations. These production results were used to calculate Total Applicable Cost (TAC), Total Applicable Revenue (TAR), and their associated Profitability Score (PS), identified here as the results of the MPF. The MPF considered only those revenues and costs that change as MI varies, including cost differences resulting from heifer size, feed cost and intake, and dystocia. Revenue differences included the sale of the animals or their offspring during their lifetime. These sale points include cull animals, weaned calves, and pregnant retained cows. These values were sensitive to the timing of that sale, which was dependent on pregnancy status.

Results

The general results of the simulation are summarized using TAR, TAC, and PS in three separate regression analysis, a meta analysis. In all three models, the MI scores are used as the independent variables. The resulting relationships are graphed in

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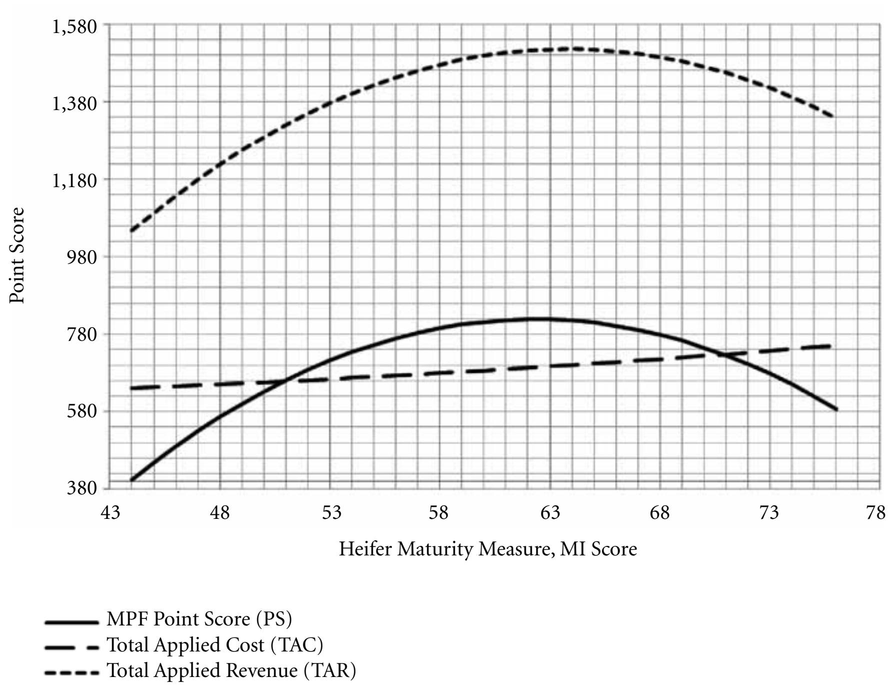

Figure 1. Modified Profit Function (MPF) Profitability Score (PS), Total Applied Revenue (TAR), and Total Applied Cost (TAC).

Figure 1. This graphic gives an overall picture of the effect that MI had on each of the three dependent variables.

The optimal MI score for PS and TAR were 62.29 and 63.80, respectively. Note that TAR was maximized at an MI greater than the PS. This point illustrated what economic theory suggests: Revenue maximization was not the same as profit maximization. As heifers approached higher maturity levels two things occurred: costs per unit increased while revenue per unit was nearly constant, resulting in costs increasing at a faster rate than revenue. At some point prior to maximum revenue, the added costs become greater than revenues, and profits decreased.

The TAC relationship was one of continual increase over the relevant range of MI's, unlike the PS and TAR, these costs were continually increasing at an accelerating rate.

Simulations were completed using the prices for three different time periods. The results were consistent for all three periods. While the actual MI of the optimal PS and TAR varied slightly in magnitude for all periods, the MI for the optimal PS was always less than the MI for the optimal TAR.

Conclusions

Any program for developing replacement females that focuses on increasing revenue or decreasing cost may not necessarily result in increased profitability. Before adopting any new program, producers should closely study all the impacts of their regime on profit. Cost reduction only increases profit when the resulting revenues remain unchanged or decline less than the cost savings. In the same way, production increases will raise revenues but only result in higher profits when the costs associated with obtaining the increased production are less than the increased revenues.

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Beef Heifer Development and Profitability

Matthew C. Stockton
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Summary

The determination of the ideal breeding size of beef replacement females is traditionally centered on maximizing pregnancy rate. Relevant physical and economic relationships were combined into a bioeconomic systems model that identified key profit factors. This system-wide approach encapsulated the physical relationships with relevant costs and revenues, including annual and seasonal variations and measures relative to profitability through the application of an incomplete or modified profit function. Optimal outcomes were relative to heifer size and management regime.

Introduction

Researchers at the University of Nebraska–Lincoln have addressed the issue of heifer development cost (Funston and Deutscher, *Journal of Animal Science*, 2004, 82:3094-3099; Martin et al., *Journal of Animal Science,* 2008, 86:451-459). These experiments challenged conventional wisdom that heifers must reach 65% of mature body weight for optimal pregnancy. This work is a continuation of that work and provides an economic focus.

Procedure

This work was undertaken to provide economic interpretation of the biological results by: 1) building mathematical constructs that were representative of the biological system; 2) identifying the pertinent cost and revenues; 3) combining costs, revenues, and biology into a systems model; and 4) using the model to evaluate the economic outcomes of heifer development strategies.

Data from the above cited experiments were combined and reanalyzed using economic methodologies. This work translated the biological information from the scientific investigations into a series of mathematical equations integrated into an economic model The overall frame work of the system was designed to measure relative profitability through the application of a Modified Profit Function (MPF). The MPF captured only those dollar values which related to heifer maturity differences.

Individual animal profitability was mathematically simulated from the interrelationships derived from the many biological performance and economically relevant variables identified using Ordinary Least Squares (OLS) and Profit regression techniques with a loss function criteria.

Only relationships whose coefficients were statistically significant at the 95% confidence level and identified as most efficient by the Akaike Loss Criteria (AIC) were included in the analysis.

Price information was obtained from publications from the United States Department of Agriculture, Livestock Marketing Information Center, and Cattle-Fax.

Profitability was measured via a Modified Profit Function (MPF). The MPF used five revenue and three cost sources that captured profitability differences among heifers at varying maturity levels. A Maturity Index (MI) was developed that used information collected before first breeding, described in the *2009 Nebraska Beef Cattle Report,* p. 15.

The MI score was a prediction of an individual animal's pre-breeding weight as a percentage of her actual mature body weight. The MI was made up of nine coefficient estimates that represented six factors. These six included: heifer's age in days, her pre-breeding weight in pounds at the start of the breeding period, her birth weight in pounds, her dam's age, and the level of development nutrition. These six factors were economically relevant and key contributors to the physical performance of the heifers up through and including the weaning of their first calves. The six factors, nine coefficient estimates, and their relationships to the MI are enumerated in equation 1.

Equation 1

$$MI = \underset{(<0.01)}{43.351} + \underset{(<0.01)}{0.03109}Wt_{Pb} - \underset{(<0.01)}{0.1419}Wt_{Birth} + \underset{(<0.01)}{0.000089}Age^2_{Heifer} - \underset{(<0.01)}{0.01272}Wt_{Dam}$$

$$+ \underset{(<0.03)}{1.756}Age_{Dam} - \underset{(<0.03)}{0.1448}Age^2_{Dam} + \underset{(<0.01)}{4.888}T1 + \underset{(<0.01)}{2.645}T2 + \underset{(<0.01)}{2.588}T3$$

Where: MI – Maturity index
Wt_{Pb} – Pre breeding weight
Wt_{Birth} – Birth weight
Age^2_{Heifer} – Pre breeding Age, (in days)
Wt_{Dam} – Mature weight of the heifer's Dam
Age_{Dam} – Dam's age in years when the heifer was born
Age^2_{Dam} – Dam's age in years squared when the heifer was born
T1 – Dummy/Indicator variable for the feed treatment group resulting in a traditional group average pre-breeding weight of 58% of herd average
T2 – Dummy/Indicator variable for the feed treatment group resulting in a traditional group average pre-breeding weight of 53% of herd average
T3 - Dummy/Indicator variable for the feed treatment group resulting in a traditional group average pre-breeding weight of 56% of herd average

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To facilitate the estimation of the regression equation, it was necessary to omit the fourth feed treatment. This omission resulted in this treatment being the basis from which all other treatments were measured, reflected in their coefficient estimates and statistical significance. This omitted group had the lowest nutritional rate and resulted in a traditional group average pre-breeding weight of 51% of herd average. The four feed treatments were utilized to produce different pre-breeding weights. The full description of the methodology can be found in the original papers.

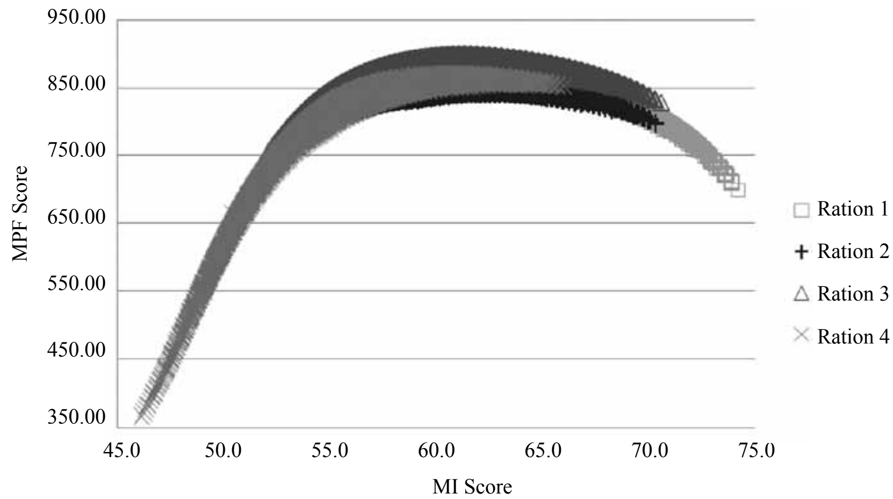

Figure 1. The 2003 Modified Profit Function (MPF) scores for all feasible Maturity Index (MI) scores for all feed treatment levels.

Results

The economically optimal MI score was 61.3, representing a prediction that the optimal heifer was of 61.3% (714 lb) of her mature weight and 456 days of age. This heifer was developed on the feed regime that produced an average heifer weight of 53% of the herd's average mature weight, was born to a 5-year-old dam with a mature weight of 1,420 lb. Given the amount of variation within a herd of cattle, accumulating a group of heifers with these exact characteristics would be unrealistic, making the application of this one statistic of little or no value.

A total of 39,168 different MI combinations were considered. This number of combinations represented the set of feasible outcomes for cows in the University of Nebraska–Lincoln Gudmundsen Sandhills Laboratory cow herd. A full description of this set of variables is available on request from the authors. Figure 1 illustrates the modified profits from all 39,168 combinations of heifer type. Results are graphed by ration which is representative of feed treatment. The first ration, ration 1, is the highest level of nutrition; ration 3 was the second highest; ration 2 the third highest; and ration 4 the least nutritious. The level of nutrition corresponds exactly with each treatment group's average percent mature body weight. The highest level of nutrition resulted in heifers having the highest average mature weight. The different shades on the graph illustrate the range and effects that nutrition has on MI and MPF scores. The wide range in results demonstrates how the different physical characteristics of heifers with varying nutrition regimes altered MI and profitability. Most strikingly is the fact that MIs with like values don't necessarily result in like profitability. The same MI can be achieved using different combinations of the six factors.

Conclusions

Individuals in a population have a significant impact on determining a system's economic optimum. The original work this analysis is based on demonstrated that differences in pregnancy rates of randomized groups were difficult to identify with small changes in nutrition. However, differences among individuals within groups were found to be statistically significant.

From the feed treatment effects on animals of various characteristics, some powerful conclusions can be drawn. Heifers from larger dams developed with the lowest level of nutrition, which are younger at pre-breeding, were restricted in profitability. Conversely, higher levels of nutrition negatively impacted profitability of older heifers from smaller dams.

The MI was valuable in predicting physical factors of production performance but was an unsatisfactory predictor of profitability. This was true because MI scores relied on six factors that had differing costs and influence on productivity and profitability.

Important points to consider are: 1) specific combinations of heifer age and potential size change the nutritional regimes needed to optimize their profitability; 2) the more homogeneous the group of heifers with respect to the critical variables identified here, the higher the profitability potential from appropriate management regimes; 3) potential loss is greater for large heifers fed lower rates of nutrition than for small heifers fed higher rates of nutrition; 4) large heifers require more days of age and higher levels of nutrition to optimize profitability; 5) when managed correctly, heifers from larger dams are more profitable than those from smaller dams, given historical information used and the range of the study.

Wide variations in animal characteristics in a homogenously managed group can cause large disparity in individual animal profitability. When managing in groups, decision makers should either select like animals that match the management regime, or the management regimes should be adjusted to match the animals selected.

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Research Results are Dependent on Accurate Cattle Weights

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Summary

The goal of limit feeding is to reduce variability in rumen fill at weighing. The amount of rumen fill varies by diet. Cattle included in this study were grazing cornstalks, smooth bromegrass pasture, or in a drylot and fed a forage and modified distillers grains (MDGS) mix. Cattle were limit fed for at least three days and then weighed on two or three consecutive days to obtain a beginning BW. Full weights of individuals were +99 to -86 lb compared to their limit fed weights. The correlation between two-day weights after limit feeding were greater than 0.9, and greater than correlation between full and limit fed weights. We conclude that limit-fed weights are more accurate than full weights.

Introduction

Since the 1920s, researchers have recognized the importance of accurate cattle weights and have debated the best method of obtaining accurate weights. For all research trials conducted at UNL's ARDC Research Feedlot a standard protocol is followed to obtain beginning and ending BW on all animals. Cattle are penned for at least three days while being limit fed at an estimated 2% of BW before being weighed on 2 or 3 consecutive days to obtain an average beginning BW. For growing studies, cattle are again limit fed at 2% of BW for at least three days at the conclusion of the trial and then weighed on two or three consecutive days to obtain an average ending BW. For finishing trials, ending BW is determined by carcass weight at the packing plant (no gut fill variation). There are three main sources of variation in cattle weights on different days: changes in the cattle, changes in environmental conditions, and residual or technique error (*Journal of Animal Science*, 6:237). We have implemented this protocol for many years to improve accuracy of weights, but have never verified differences in BW due to a limit feeding period. Therefore, the objective of this study was to document the differences in limit fed weights and full weights.

Procedure

In October 2009, 1-day full weights were taken on 45 steer calves (715 lb) that had grazed smooth bromegrass pasture for 165 days. Cattle were pulled from pasture at 6 a.m., moved approximately ½ mile to the handling facility and penned for one hour while being weighed. They were then moved less than ¼ mile to feedlot pens to be limit fed for seven days, and weights were taken on two consecutive days. The limit fed weights were taken at 6:30 a.m., and cattle were back in their pens by 7:30 a.m. In February 2011, 258 steer calves (668 lb) were weighed after grazing cornstalks for approximately 90 days. Cattle were pulled from the cornstalk field at 7 a.m., moved approximately one mile on foot to the handling facility, and full weights were taken between 8 and 10:30 a.m. They were then penned ¼ mile from the handling facility with 20 steers per pen, to be limit fed for six days. For the limit fed weights, cattle were weighed at 7 a.m., and returned to pens by 9 a.m. In April 2011, 509 steer calves (743 lb) were weighed after a growing study with diets consisting of choice between 60% grass hay 40% alfalfa mix or 70% straw/cornstalks 30% MDGS mix. These cattle were penned less than ¼ mile from the handling facility and were limit fed for 5 days in the same pens they were in for the growing study. For both the full and two-day limit fed weights, cattle were pulled from pens at 7:30 a.m., weighed, and returned to their pens by 10 a.m. Finally, in May 2011, 257 heifer calves (620 lb) were weighed after grazing smooth bromegrass pasture for 20 days. For the full weight, cattle were pulled from pasture at 7 a.m., moved ½ mile to the handling facility, and weighing was done by 10:30 a.m. They were then put in one pen ¼ mile from the handling facility to be limit fed for 7 days. Limit fed weights were taken at 8 a.m., and cattle were back in the pen by 11 a.m. On the first day of limit fed weights, heifers were also branded while in the chute.

Results

For steers grazing cornstalks, full weights off cornstalks averaged 27.5 lb less than limit fed weights. Full weights were between -86 lb to +17 lb compared to the average of the two day limit fed weights. The difference between the two day limit fed weights was -50 to +32 lb. Full weights averaged 37 lb greater than the average of the two day limit fed weights for steers on pasture. The weight change between the limit fed and full weight was +1 to +99 lb. The difference between the two day limit fed weights was -6 to +50 lb. Full weights of heifers grazing smooth bromegrass pastures averaged 10.2 lb greater than limit fed weights. The difference between the average of the two day limit fed weights and full weight was -35 to +45 lb. The difference between the two day limit fed weights was -22 to +28 lb. Full weights for steers on the growing study averaged 34 lb greater than limit fed weights. Weight change between the average of the two day limit fed weight and full weight was -85 to + 97 lb. Differences between the two day limit fed weights were -48 to + 34 lb.

Plotting the full weight, limit fed weight, and the two-day weights shows the correlation between the weights (Figures 1 and 2 and Table 1). In every weighing situation, correlation between the two day weights was

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Table 1. Characteristics of regression between limit fed and full cattle weights.

		Regression of full to limit fed weight			Regression of two day limit fed weights		
Trial[1]	No. of Cattle	R^2	Equation	Avg Difference (lb)[2]	R^2	Equation	Avg Difference[3] (lb)
A	45	0.941	1.03x – 67.5	+ 37.0	0.973	0.98x + 6.36	18.4
B	258	0.751	0.88x + 103	- 27.5	0.913	0.94x + 38.5	8.55
C	509	0.859	0.94x + 15	+ 34.0	0.927	0.93x + 49.4	9.84
D	257	0.977	1.01x – 9.63	+ 10.2	0.986	1.01x – 4.32	8.28

[1]A= steers grazing smooth bromegrass pasture October 2009.
B= steers grazing cornstalks February 2011.
C= steers on forage based growing study April 2011.
D= heifers grazing smooth bromegrass May 2011.
[2]Positive number indicates full weight greater than limit fed weight, negative number indicates limit fed weight greater than full weight.
[3]Absolute difference.

greater than the correlation between the full and limit fed weights with r^2 values greater than 0.9 for each of the two-day weights.

These data show how crucial accurate weights are to measurement of absolute amounts and variation in ADG estimates. If cattle had been weighed off cornstalks and put directly on smooth bromegrass without limit fed weights, ADG would have been misrepresented for each portion of the system. Limit fed cornstalk weights resulted in ADG 0.31 lb/day greater than full weights indicated. Limit fed weights for steers after grazing smooth bromegrass for 165 days resulted in ADG 0.22 lb/day less than full weights indicated. Limit fed weights for heifers grazing smooth bromegrass for 20 days resulted in ADG of 0.51 lb/day less than full weights indicated. Relying on full weights would have shown ADG to be 0.65 lb/day greater than limit fed ADG for the growing study.

Weights taken on consecutive days while cattle were limit fed were highly correlated and less variable than full weights. Using this method allows us to more accurately weigh cattle and identify small statistical differences between treatments.

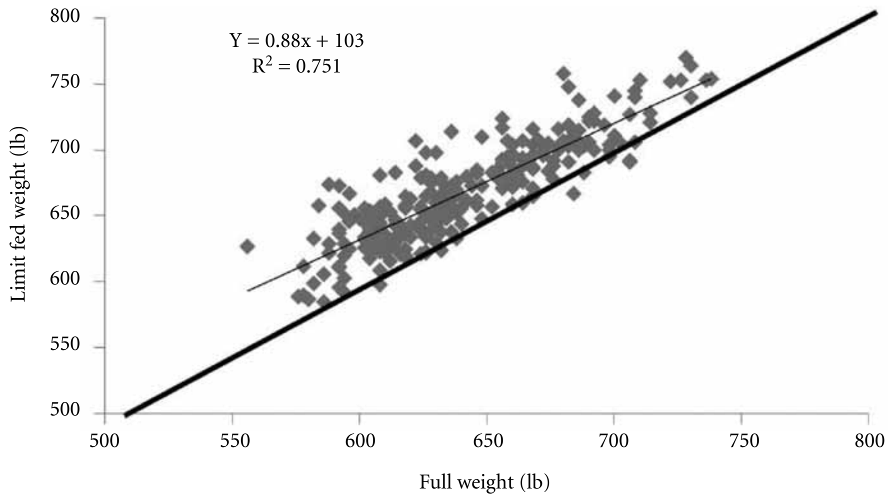

Figure 1. Regression of full to two-day average limit fed weight for cattle grazing cornstalks.

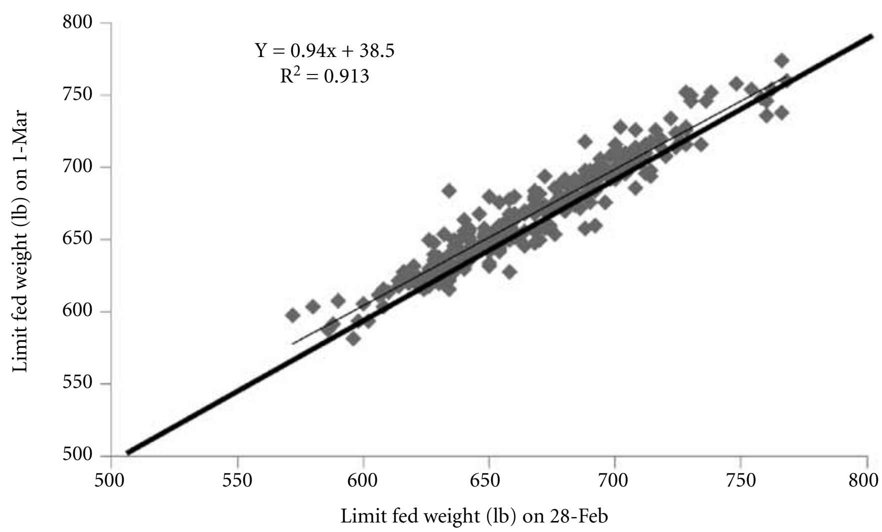

Figure 2. Regression of two day limit fed weights for cattle grazing cornstalks.

[1]Andrea K. Watson, research technician; Brandon L. Nuttelman, research technician; Terry J. Klopfenstein, professor; Galen E. Erickson, professor; Cody Schneider, research technician, University of Nebraska–Lincoln Department of Animal Science, Lincoln, Neb.

Forage Availability and Quality of No-till Forage Crops for Grazing Cattle

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Matt K. Luebbe
Drew J. Lyon[1]

Summary

No-till forage crops were planted to determine forage quantity and quality for grazing cattle. Seven combinations were evaluated using different mixtures containing forage peas, oats, winter triticale, turnips, radishes, clover, vetch, and sunflower. The cover crops were planted April 9 and sampled three times (day 54, 70, and 86 after planting) to determine forage mass and nutrient content. Mixtures containing forage peas and oats yielded the greatest quantity of DM/acre. The NDF and CP content of the mixtures are comparable to native range during the growing season. When used in place of fallow in crop rotations, grazing cover crops may provide an alternative to native range.

Introduction

Forage crops can enhance the sustainability of a cattle operation by providing a grazing alternative to native range to prevent overgrazing range resources. Multispecies crops typically include legumes, annual grasses, and deep rooted species such as brassicas (turnips and radishes). Multispecies forage crops are becoming popular in no-till farming operations as an alternative to fallow. However, the expense of planting these crops warrants evaluation. Estimates of forage quality and quantity are needed to determine appropriate stocking rates for grazing cattle. The objective of this study was to determine the quantity and quality of no-till forage crops in a dryland cropping system for cattle grazing in a semiarid region.

Procedure

Seven combinations of forage crops were planted April 9, 2010, at the High Plains Ag Lab in Sidney, Neb., at a planting depth of 2 in using a no-till drill. The cover crops were replicated using four plots/treatment. Treatments (TRT) included 1) forage peas; 2) forage peas and oats; 3) forage peas, winter triticale, turnips, radishes, clover, vetch, sunflower; 4) forage peas, oats, turnips, radishes, clover, vetch, sunflower; 5) forage peas, winter triticale, grazing brassica hybrid mix, clover, vetch, sunflower; 6) forage peas, oats, grazing brassica hybrid mix, clover, vetch, sunflower; and 7) winter triticale (Table 1). To determine the nutrient composition and quantity of biomass for each combination, two clip samples per plot (8/TRT) were collected using a 2.7 ft^2 quadrat at 16-day intervals on June 1, June 16, and July 2, 2010. A portion of these samples were dried in a 105° F forced-air oven and weighed to determine the quantity of DM/acre. The remaining portion of the samples was freeze-dried and ground in a Wiley mill to pass through a 1-mm screen for laboratory analysis. Concentration of NDF, ADF, and CP was quantified, and IVDMD was estimated using a 48-hour *in-vitro* incubation.

Forage mass data were analyzed using the MIXED procedure of SAS (SAS Inst., Inc., Cary, N.C.), with plot as the experimental unit and sampling date as a repeated measure. The CORR procedure of SAS was used to determine the correlation between seeding rate (lb of seed/acre) and forage yield (DM/acre).

Results

Forage Yield

During the second week of May the nighttime low temperature was in the low 20s. These lower temperatures, coupled with a planting depth greater than 1 in, may have contributed to limited forage production by the brassicas, clovers, vetch, and sunflowers as their seeds are smaller compared with the other species evaluated. Forage mass (tons DM/acre) was greatest for the forage pea and oat combinations (TRT 2, 4, 6) at

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Table 1. Forage crop mixtures and planting rates[1].

Forage Crop	Treatment 1	Treatment 2	Treatment 3	Treatment 4	Treatment 5	Treatment 6	Treatment 7
Forage Peas	120	80	40	40	40	40	
Oats		40		40		40	
Winter Triticale			50		50		65
Turnips			1	1			
Yellow Sweet Clover			1	1	1	1	
Sunflower			1.5	1.5	1.5	1.5	
Medium Red Clover			1	1	1	1	
Vetch			4	4	4	4	
Oilseed Radish			2.5	2.5			
Brassica Hybrid[2]					3.75	3.75	

[1]All values are in pounds per acre.
[2]Brassica Hybrid mix was 37.85% Hunter hybrid brassica, 25.84% Rangi rape, 18.94% Winfred hybrid brassica, and 17.17% Turnip.

Table 2. Nutrient composition and IVDMD of forage crop mixtures during three sampling dates.[1]

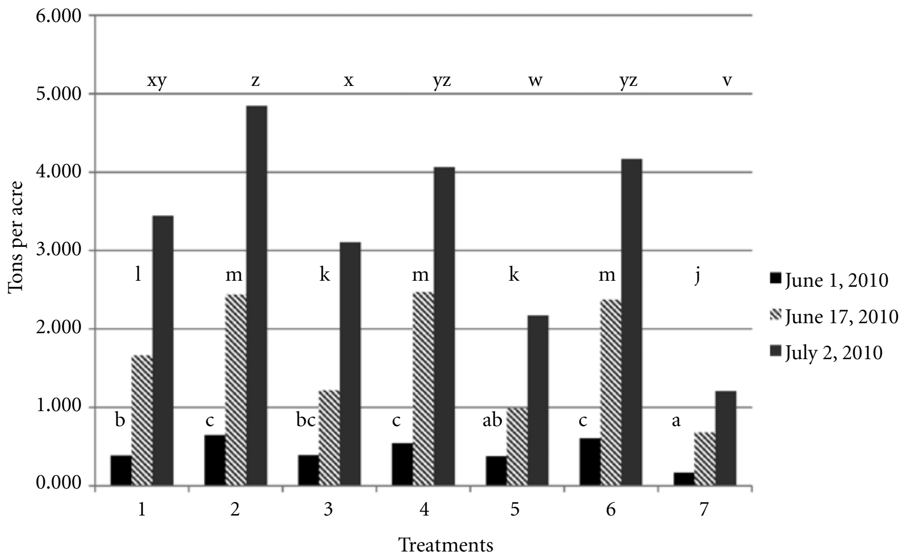
	June 1, 2010				June 17, 2010				July 2, 2010			
	IVDMD, %	CP, %	NDF, %	ADF, %	IVDMD, %	CP, %	NDF, %	ADF, %	IVDMD, %	CP, %	NDF, %	ADF, %
Treatment 1	84.4	25.3	23.3	16.2	74.3	20	37.8	29.0	72.7	17.1	38.0	29.9
Treatment 2	82.5	25.8	30.6	17.3	78.1	17.2	42.7	27.1	65.2	8.1	62.4	37.9
Treatment 3	80.4	27.3	31.0	14.8	77.3	20.5	36.4	25.9	71.7	14.6	43.1	31.6
Treatment 4	82.5	25	29.3	18.0	77.1	13.2	42.4	26.7	59.8	7.7	63.2	38.3
Treatment 5	80.6	29	35.7	14.9	76.4	19.6	38.1	28.8	71.1	13.7	44.2	26.2
Treatment 6	83.4	25.1	33.6	30.5	78.8	14.6	43.9	19.1	59.0	7.5	62.2	41.2
Treatment 7	81.8	29.9	37.1	15.9	78.2	22.1	44.2	24.9	73.4	12.8	50.8	28.9

[1]Values reported on a 100% DM basis.

all three collection times (Figure 1; $P < 0.05$). Forage mass was the least for the triticale (TRT 7) at each collection ($P < 0.05$). The triticale used in the current experiment was a winter triticale hybrid, and it remained in a vegetative state throughout the growing season. However, the estimate of forage production on June 1 for the forage peas (TRT 1) was not different ($P > 0.10$) when compared with combinations containing triticale (TRT 3, 5). On June 17, forage mass of the peas was intermediate compared with the mixtures containing both peas and oats (TRT 2, 4, 6) and the treatments containing peas and triticale (TRT 3 and 5; $P < 0.05$). By July 2, the mixtures containing forage peas in combination with oats (TRT 2, 4, and 6) produced the greatest quantity of forage ($P < 0.05$) and the combinations containing oats (TRT 4, 6) were similar to the forage peas alone (TRT 1). Although there were differences in the seeding rates (lb of seed/acre) among mixtures evaluated, there was no correlation between seeding rate (r = 0.26; $P = 0.25$) and forage yield.

Forage Quality

The IVDMD of all mixtures was greater than 80% during the first sampling on June 1, and greater than 74% during the second sampling on June 17 (Table 2). Digestibility estimated during the last clipping (July 2) ranged from 71 to 73% for the forage peas (TRT 1) and the combinations containing winter triticale (TRT 3, 5, and 7). The IVDMD of the mixtures containing oats was lower and ranged from 59 to 65% (treatments



[abc]Means with unlike superscripts are different ($P < 0.05$) during the first clipping (June 1, 2010).
[jklm]Means with unlike superscripts are different ($P < 0.05$) during the second clipping (June 17, 2010).
[vwxyz]Means with unlike superscripts are different ($P < 0.05$) during the third clipping (July 2, 2010).

Figure 1. Forage production of no-till forage crops for grazing cattle.

2, 4, 6). The lower digestibility corresponds with the increased forage production. The NDF and ADF values increased, while concentration of CP and IVDMD decreased, which supports the conclusion that increased forage production results in higher fiber and, therefore, lower quality. The CP concentration for forage peas and oats decreased from June 1 (25-26%) to July 2 (7.5-8%). The CP concentration for mixtures containing triticale did not decrease to the same extent as other mixtures because it remained in a vegetative state throughout the growing season.

Based on the forage crop combinations evaluated in this study, mixtures containing forage peas and oats resulted in the greatest DM yield. If the forage is grazed early in the season, it may be possible to maintain acceptable animal performance based on the NDF and CP composition of the forage. When used in place of fallow in crop rotations, grazing cover crops may provide an alternative to native range. Additional data are being collected to determine diet selection of cover crops compared with native range.

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Strategies of Supplementing Dried Distillers Grains to Yearling Steers on Smooth Bromegrass Pastures

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Summary

Steers supplemented with dried distillers grains with solubles (DDGS) daily on nonfertilized smooth bromegrass pastures gained 0.55 lb/day more than cattle on nonsupplemented treatments. Steers supplemented at 0.6% BW DDGS gained 2.59 lb/day compared to 2.36 lb/day for steers fed a similar total amount of DDGS at increasing levels over the growing season.

Introduction

Over the grazing season, in five previous years of research on smooth bromegrass pastures, forage quality and cattle ADG declined, but cattle ADG response to DDGS supplementation increased quadratically (*2011 Nebraska Beef Cattle Report*, p. 24). Therefore, feeding lower levels of DDGS, to meet steer MP requirements, early in the grazing season and increasing to greater levels later in the season should increase ADG of grazing steers. The objective of the current study was to determine effects of supplementing strategies of DDGS to yearling steers as the forage quality of smooth bromegrass declines over the grazing season.

Procedure

Seventy-five yearling steers (647 ± 13 lb) were used to evaluate dried distillers grains with solubles (DDGS) supplementation strategies on cattle ADG and pasture production. Steers were stratified by BW and assigned to five smooth bromegrass (SBG) pastures at the University of Nebraska–Lincoln Agriculture Research and Development Center. Three of the five SBG pastures were grazed in 2010 for the sixth consecutive year as part of a long-term study. In 2010, two brome pastures were added for increased replication and addition of the strategic supplementation treatment. Three treatments were applied within four SBG pastures (block) with three treatment paddocks (experimental unit) per pasture for a total of four replications per treatment. Treatments included were 1) brome paddocks fertilized in early spring with 80 lb N/acre stocked at 4 AUM/acre (FERT); 2) nonfertilized brome paddocks stocked at 4 AUM/acre supplemented with DDGS (DM) at 0.6% of BW daily (SUPP); 3) nonfertilized brome paddocks stocked at 2.76 AUM/acre (CONT) or 69% stocking rate of FERT and SUPP; and 4) a nonfertilized pasture with three replication paddocks stocked at 4 AUM/acre strategically supplemented with DDGS (DM) at incremental levels (STRAT). Incremental levels of DDGS were based on declining forage quality with smooth bromegrass maturation. At the start of the grazing season, steers on strategic supplementation received 2.0 lb/day DDGS (DM) to meet MP requirements; thereafter, supplement incrementally increased to 7.15 lbs/day/head (Table 1). Steers supplemented on SUPP treatment received 0.6 % BW supplement based on cycle BW taken throughout trial. The STRAT and SUPP treatments were designed to receive the same overall average amount of DDGS over the grazing season through adjustment of cycle 5 STRAT supplement to meet overall average of SUPP (Table 1).

Treatment paddocks were equally divided into six strips that were rotationally grazed. The grazing season was from April 20 through Sept. 14, 2010, divided into five cycles. Cycles 1 and 5 were 24 days in length and cycles 2, 3, and 4 were 36 days in length. Similar grazing pressure among treatment paddocks was maintained over the grazing season with the use of put-and-take yearling steers. Initial and final BW were taken on three consecutive days after a limit fed period. During the limit fed period, steers were fed at 2% BW for five days to reduce variation due to gut fill. Steers were implanted with Revalor®-G on Day 1 of the grazing season. Interim BW were measured early morning at the start of each cycle and pencil shrunk 4% to account for gut fill. Pasture quality was determined using ruminally fistulated animals to collect diet samples during each cycle at the mid-point of grazing rotations. Samples were analyzed for forage CP and IVDMD.

Cattle performance and diet samples were analyzed using the MIXED procedure of SAS (Version 9.2, SAS Inst., Inc., Cary, N.C.) in a randomized complete block design with block treated as a random effect. Model effects were treatment, cycle, and treatment by cycle interaction. Treatment paddock was the experimental unit.

Results

Ending BW and ADG were different among treatments ($P < 0.01$; Table 2). Steers supplemented with DDGS daily on nonfertilized smooth bromegrass

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Table 1. DDGS supplementation.

Cycle	SUPP (lb DM/head/day)	STRAT (lb DM/head/day)
1	3.88	2.0
2	4.24	3.5
3	4.82	5.0
4	5.42	6.5
5	5.77	7.15
Average over grazing season	4.83	4.83

pastures gained an average of 2.48 lb/day compared to the 1.93 lb/day of steers on the nonsupplemented treatments. At the end of the grazing season, the greater ADG of supplemented steers resulted in an 81 lb increase in ending BW over control and fertilized treatment steers. The increase in ADG of supplemented steers can be attributed to the UIP and energy provided by the DDGS (*2006 Nebraska Beef Cattle Report*, p. 27). Steers supplemented with DDGS at 0.6% BW daily gained 0.23 lb/day over steers supplemented strategically over the growing season. Steers in both SUPP and STRAT treatments received an average of 4.83 lb/day of DDGS (DM).

Average daily gains were measured and summarized for yearling steers on treatments supplemented with DDGS or nonsupplemented, grazing smooth bromegrass pastures for six consecutive years from 2005 through 2009 and year 2010 (Table 3). Average daily gains were greater for 2010 treatment steers; however, similar differences in ADG of steers on supplement at 0.6 % BW and nonsupplement treatments were measured with only a 0.03 lb and 0.05 lb ADG difference between cycles 1 and 2; and cycles 3, 4, and 5, respectively. Strategically supplemented steers performed better than nonsupplemented steers; however, STRAT gained less than steers on SUPP treatment for the 2010 grazing season.

Over the grazing season, the lower steer ADG measured in cycle 3, 4, and 5 correspond with the decline in forage digestibility ($P < 0.01$, Figure 1). IVDMD of pasture diet samples did not differ between treatments ($P = 0.19$). In cycle 1, CP of pasture diet samples was highest for FERT and SUPP pastures at 21.3 and 19.7 %, respectively, when compared to CONT at 14.8 % (Figure 1). There was a CP cycle by treatment interaction ($P < 0.01$); at cycle 2, all treatments had similar CP amounts at 15.2 %. As IVDMD and ADG declined over the growing season, cattle ADG response to DDGS supplementation increased (*2011 Nebraska Beef Cattle Report*, p. 24). As in previous research, forage quality and cattle ADG in the 2010 grazing season declined with an increased ADG response to DDGS supplementation. The strategic supplementation of increasing DDGS over the grazing season did not perform better than DDGS supplementation at 0.6 % BW.

Table 2. 2010 pasture performance of steers grazing smooth bromegrass.

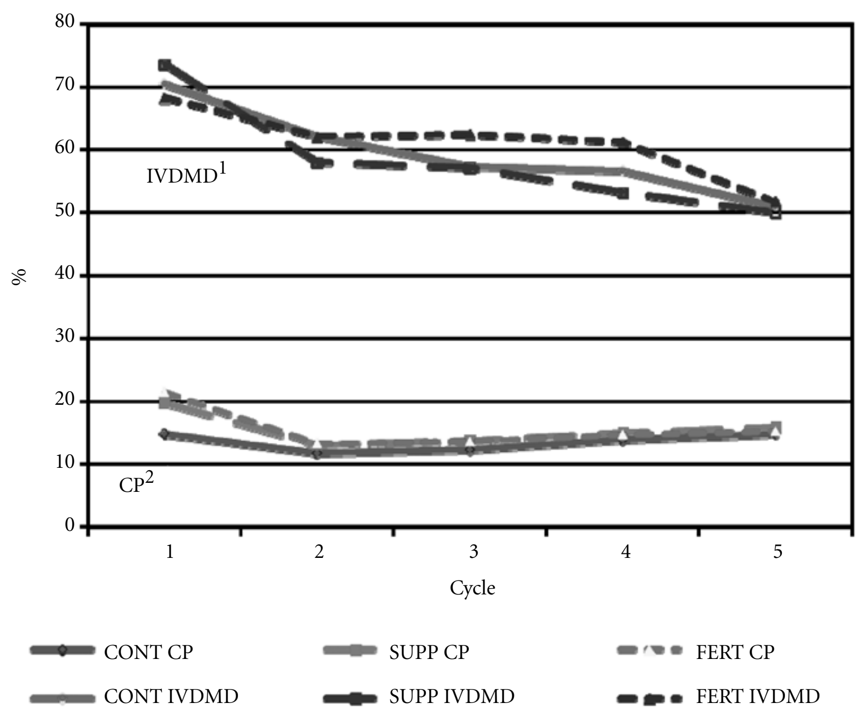
	CONT	FERT	SUPP	STRAT	SEM	*P*-value
Days	147	147	147	147		
Initial BW, lb	649	645	648	640	2.7	0.14
Ending BW, lb	959[a]	933[a]	1048[c]	1006[b]	12.3	< 0.01
ADG, lb/day	2.00[a]	1.86[a]	2.59[c]	2.36[b]	0.077	< 0.01

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

Table 3. Nonsupplemented vs. supplement strategies cattle ADG.

	Cycle 1 and 2		Cycle 3, 4, and 5	
	ADG, lb	Difference[3]	ADG, lb	Difference[3]
Nonsupplemented[1]	2.09	0.40	1.17	0.85
Supplemented,[1] 0.6% BW	2.49		2.02	
Nonsupplemented[2]	2.60	0.37	1.65	0.90
Supplemented,[2] 0.6% BW	2.97		2.55	
Supplemented,[2] strategy	2.71	0.11	2.33	0.68

[1]2005-2009 cattle ADG.
[2]2010 cattle ADG.
[3]Difference between nonsupplemented and supplemented cattle ADG.



[1]Trt*Cycle $P = 0.17$, Trt $P = 0.19$, Cycle $P < 0.01$, Quad P = 0.02,Quart $P < 0.01$[a]
[2]Trt*Cycle $P < 0.01$, Trt $P < 0.01$, Cycle $P < 0.01$

Figure 1. *In vitro* dry matter digestibility (IVDMD) and crude protein (CP) content of 2010 SBG pastures over grazing season

[1]Stephanie K. Pruitt, graduate student; Kelsey M. Rolfe, Brandon Nuttelman, William A. Griffin, research technicians; Terry J. Klopfenstein, Galen E. Erickson, professors, University of Nebraska–Lincoln (UNL) Department of Animal Science; Walter H. Schacht, professor, UNL Department of Agronomy and Horticulture.

Comparison of Feeding Dry Distillers Grains in a Bunk or on the Ground to Cattle Grazing Subirrigated Meadow

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Jerry D. Volesky[1]

Summary

The objective of this study was to compare feeding dry distillers grains with solubles (DDGS) in a bunk or on the ground to cattle grazing subirrigated meadow. Steers fed in a bunk had greater ADG than steers fed on the ground (1.19 vs. 0.92 lb). The NRC (1996) was used to retrospectively calculate the DDGS intake difference between treatments. For steers fed in a bunk, a reduction in DDGS intake between 0.8 and 0.9 lb/day would have resulted in a 0.27 lb/day reduction in ADG, which means 36-41% of the DDGS fed on the ground was wasted. At $200 (DMB) per ton for DDGS, the cost of the wasted distillers grains was between $0.08 and $0.09 per day.

Introduction

In a summary of 14 grazing trials, DDGS increased ending BW and ADG. In addition, DDGS supplementation decreased forage intake; however, total intake for cattle fed supplement increased with increased DDGS levels (2009 *Nebraska Beef Cattle Report*, pp. 37-39). Feeding DDGS on the ground may result in higher waste levels when compared to feeding it in a bunk, but may increase its use in practical grazing situations and increase profitability. Therefore, the objective of this study was to compare feeding DDGS in a bunk or on the ground to grazing cattle.

Procedure

One hundred fourteen, March-born steer calves (615 ± 64 lb BW) were assigned to one of two feeding treatments: DDGS fed in a bunk or on the ground. Six pastures were used and pasture served as the experimental unit. Steers were fed the daily equivalent of 2.0 lb/steer (DM) and supplement was delivered three days/week.

The experiment was conducted at the University of Nebraska–Lincoln (UNL), Gudmundsen Sandhills Laboratory near Whitman, Neb., according to protocol approved by the UNL Animal Care and Use Committee. Calves grazed subirrigated meadow dominated by cool-season grasses, sedges, and rushes. The study site had been hayed the previous summer so cattle grazed regrowth.

The experiment was conducted for 72 days from March 10 to May 20, 2010. Steers continuously grazed the same pasture throughout the experiment. Steer BW was recorded on two consecutive days at the initiation and completion of the feeding period. Steers were not limit fed prior to weighing.

After completion of the feeding period, soil samples were collected from three sites where DDGS was fed on the ground and three control sites. Soil sample cores represented the top 8 inches of soil which is the standard sampling depth used by agronomists. At each site, six samples were collected and composited into one. Samples were analyzed for pH, OM, nitrate, phosphorus, sulfate, and potassium.

Results

No differences were seen in soil components between DDGS and control sites ($P > 0.3$), (Table 1). A visible difference between fed and control areas was apparent. Grass was slightly greener in fed areas compared to control areas. Samples included soil from a depth of 8 inches, this may have diluted the soil components compared to those present at a shallower depth.

Steers fed in a bunk had greater ADG than steers fed on the ground (1.19 vs. 0.92 lb; $P < 0.001$), (Table 2). The NRC (1996) was used to retrospectively calculate the DDGS intake difference between treatments. For steers fed in a bunk, a reduction in DDGS intake between 0.8 and 0.9 lb/day would have resulted in a 0.27 lb/day reduction in ADG. This is the equivalent of 36-41% waste. At $200 (DM) per ton for DDGS, the cost of the wasted DDGS was between $0.08 and $0.09/day. In comparison, steers fed wet distillers grains with solubles (WDGS) on the ground were reported to have a 13% waste over those fed in a bunk (2010 *Nebraska Beef Cattle Report*, pp. 19-20). Part of this difference might be explained through ground conditions. The WDGS were fed on upland range from October to December, whereas the current study was conducted on subirrigated meadow from March to May. Subirrigated meadow is characterized by dense plant growth. DDGS particles are small, so those particles in contact with the ground may have become unavailable to the animal because of the density of plant growth.

The most profitable choice of DDGS feeding method depends on the production goal of the feeding period. If least cost to achieve a specified rate of gain is the production goal, then feeding on the ground would have been the most profitable choice. An example situation where least cost of gain would be desirable is if a contract had been made to deliver cattle of a specified weight at a specified time, or if a relatively low ADG was desired during a backgrounding phase in order to take advantage of compensatory gain on summer pasture. In our experiment we estimated the cost associated with feeding in a bunk, which includes bunk purchase and delivery and a three year bunk life span, to be $0.16/(steer · day). The value of the wasted DDGS was

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about $0.09, so if about 40% additional DDGS was fed on the ground, the cost to gain 1.1 lb/day would be $0.07 less than feeding in a bunk. This strategy would be appropriate if a set ADG was desired and BW gain above that rate was of no value. On the other hand, if the goal is to maximize profitability of the DDGS feeding period, and ownership of the cattle would not be retained beyond that period, then feeding in a bunk would have been the most profitable. If the cost of gain is less than the breakeven price, profitability is maximized when gain is maximized. If additional DDGS is fed, less waste would occur if fed in a bunk; therefore, more weight would be gained by the animal and as long as the cost of feeding in a bunk ($0.16/d) doesn't increase, the cost of gain above the breakeven price profitability at any given level of DDGS feeding would be greater if fed in a bunk. In this experiment, the cost of gain when DDGS was fed in a bunk was less than the breakeven price of the steers and therefore profit was greater in steers fed in a bunk.

Table 1. Soil nutrient characteristics (0-8 in) on sites following feeding of DDGS and on adjacent control sites.

	Ground	Bunk	SE	P-value
pH	7.6	7.7	0.3	0.82
OM	3.0	3.1	0.2	0.86
Nitrate-N (ppm)	5.2	3.5	1.3	0.41
Nitrate-N (lb/ac)	12.3	8.7	3.1	0.45
P Bicarb (ppm)	7.0	5.7	0.8	0.33
P Bicarb (lb/ac)	14.0	11.3	1.7	0.33
Sulfate-S (ppm)	23.3	24.0	7.6	0.95
K (ppm)	87.7	83.3	8.7	0.74

Table 2. Performance of steers fed DDGS on the ground or in a bunk.

	Bunk	Ground	SE	P-value
Initial BW (lb)	615	615	7.9	0.89
Ending BW (lb)	701	681	9.0	0.12
ADG (lb/d)	1.19	0.92	0.04	<0.001

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Byproducts with Low Quality Forage to Grazing Cattle

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Summary

Sixteen cows grazing smooth bromegrass pasture were unsupplemented or supplemented a 35:65 Synergy:straw mixture. Grazed forage intake was replaced about 50% with supplementation, with no differences in cow performance. In a second experiment conducted over two summers, yearling steers grazing native range were fed a mixture of 70:30 or 60:40 hay:WDGS or 60:40 straw:WDGS. During the first year, all steers fed byproduct-forage mixtures had greater ADG than control steers. During the second year, steers supplemented with byproduct-hay mixtures had similar gains as control while steers supplemented byproduct-straw mixtures gained less. Supplementing WDGS and low quality forage reduced forage intake by 17 to 22% in Experiment 2.

Introduction

Crop residues on farms with cool-season pastures are economical sources of fiber to feed during the summer to replace grass consumption. To complement this, purchasing and/or storing byproducts, such as wet distillers grains plus solubles (WDGS), during summer also may be economical for producers. Mixing WDGS with low quality forages has been shown to increase the palatability of the forage; and the bulk from the forage may potentially have a fill effect that will reduce grazed forage intake. This was illustrated when 1.0 lb of native range was replaced for every 1.0 lb of 70:30 straw:WDGS and fed to cow-calf pairs (*2010 Nebraska Beef Cattle Report,* p. 19). The objective of the following experiments was to determine the effect of supplementing low quality forage-byproduct mixtures to cattle grazing either smooth brome pasture or native Sandhills range on forage intake.

Procedure

Experiment 1

Nonpregnant, nonlactating cows (n=16, initial BW = 1,270 lb) grazed smooth bromegrass pastures at the University of Nebraska–Lincoln Agricultural Research and Development Center near Mead, Neb., for 138 days from late April to mid September. Cows were limit fed at 2% of BW for five days prior to and at the conclusion of the grazing period to minimize variation due to gut fill. Initial and final BW was an average of three consecutive day weights. Cows were assigned randomly to one of two treatments, with four cows/paddock and two replications. Treatments consisted of: 1) 1.8 ac/cow with no supplementation (CON); or 2) 0.9 ac/cow with supplementation (SUP). Supplementation consisted of a 35% synergy (40% WCGF and 60% MDGS) and 65% wheat straw mixture (DM basis), which was fed daily in feed bunks. An ensiled mixture (46.6% DM) was fed from late April to mid-August (111 days), and a fresh mixture (30.7% DM; mixed at feeding time) from mid-August to mid-September (27 days). Cows were supplemented at 0.56% of BW at experiment initiation, with supplementation level increasing throughout the grazing period to achieve 2.25% of BW at trial conclusion. It was expected that grazed forage intake would be greatest early in the growing season and would decline as cool-season grass matured. Therefore, supplement intake was lower at initiation and increased as forage quality declined. Predicted total DMI was calculated using 2.12% of BW (*2009 Nebraska Beef Cattle Report*, p. 13) and the number of days to change BCS with the NRC.

Experiment 2

Forty yearling steers (712 ± 33 lb in 2009 and 721 ± 33 lb in 2010) were stratified by BW and assigned randomly to treatment paddocks, using five steers/treatment in each of two blocks. Experimental unit was a set of five paddocks consisting of mostly warm season grasses that were assigned to a treatment within a block and rotationally grazed once during the experimental period of 68 days from June 18 to August 26 in 2009 and from June 17 to August 25 in 2010 at the University of Nebraska–Lincoln Gudmundsen Sandhills Laboratory located near Whitman, Neb. The first paddock was grazed for 12 days, and the remaining four paddocks were grazed for 14 days. Treatments were: 1) control (CON) at the recommended stocking rate (0.68 AUM/ac), 2) double stocked (1.3 AUM/ac supplemented with a mixture consisting of 60: 40 straw:WDGS (STRAW)), 3) double stocked supplemented with 60: 40 hay:WDGS (LOW), and 4) double stocked consuming a supplement made of 70: 30 hay:WDGS (HIGH). Cattle were supplemented daily with a targeted intake of 1.15% BW on a DM basis, representing 50% of their daily intake. Mixtures (50% DM) were ensiled 30 days prior to trial initiation. Beginning and ending BW were measured on three consecutive days after a five-day limit fed period to reduce fill effects. Esophageally fistulated cows were used to determine forage quality (IVODMD, CP, NDF). Standing crop and forage utilization were determined by clipping five 0.25 m^2 quadrats post-grazing. Pre-graze forage availability was calculated by adding an estimated amount of forage intake to the amount of forage remaining in the control paddocks at the end of the grazing period.

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Results

Experiment 1

Initial and final BW and ADG (Table 1) were not different between treatments ($P > 0.35$). In this experiment, the Synergy:straw mixture reduced intake of smooth brome by 48%. Supplement at about 12 lb/DM/day replaced grazed forage at nearly a 1:1 ratio.

Synergy and straw mixed fresh (at feeding time) may be as palatable as ensiled material. As days of the experiment progressed, it appeared that the ensiled material was not getting fed fast enough, and quality deteriorated in the bag. The fresh mixture was then fed. It appeared to have the same or better palatability as the higher quality ensiled mixture fed early in the grazing period. Mixture with a moisture content greater than 50% enhanced palatability, with optimum moisture content at 65 to 70%. Additionally, it may be necessary to feed a greater proportion of byproducts (up to 50%) to encourage cows to eat the supplement mixture early in the grazing season.

Table 1. Performance cows grazing smooth bromegrass pasture and supplemented a byproduct:forage mixture.

Variable	CON[1]	SUP[2]	SEM	*P*-value
Initial BW, lb	1268	1273	2.9	0.35
Ending BW, lb	1566	1587	26.3	0.62
ADG, lb/day	2.16	2.28	0.2	0.68
Forage intake, lb	26.5	13.8	—	—
Supplement, lb	—	12.1	—	—

[1]Cattle grazed at recommended stocking rate and received no supplementation.
[2]Cattle grazed at double the recommended stocking rate and received 50% of estimated daily intake of 35:65 synergy:wheat straw mixture.

Table 2. Performance of yearling steers grazing native range and supplemented a byproduct:forage mixture.

	Treatment					
	CON[1]	HIGH[2]	LOW[3]	STRAW[4]	SEM	*P*-value
Initial BW, lb	721	719	725	712	6.42	0.92
Ending BW, lb	798[a]	792[a]	816[a]	782[b]	12.05	0.02
ADG, lb/day (2009)	1.06[a]	1.12[a]	1.41[b]	1.39[b]	0.07	0.03
ADG, lb/day (2010)	1.17[a]	1.01[a]	1.23[a]	0.71[b]	0.04	<0.01
Forage intake, lb[5]	17.4[a]	13.7[b]	13.6[b]	14.3[b]	0.31	0.03
Supplement intake, lb[6]	—	7.39	7.37	6.17	0.2	0.17
Total DM intake, lb[7]	17.4	21.1	20.9	20.5	0.46	0.10

[1]CON (Control) = Cattle grazed at the recommended stocking rate (0.68 AUM/ac).
[2]HIGH=Cattle grazed at double the recommended stocking rate (1.3 AUM/ac) and supplemented with 70: 30 grass hay:WDGS at estimated 50% of daily DM intake.
[3]LOW=Cattle grazed at double the recommended stocking rate and supplemented with 60:40 grass hay:WDGS at estimated 50% of daily DM intake.
[4]STRAW=cattle grazed at double the recommended stocking rate and supplemented with 60:40 wheat straw:WDGS at estimated 50% of daily DM intake.
[5]Average amount of range forage intake.
[6]Average amount of supplement intake during the experimental period.
[7]Amount of total DM intake. Calculated by adding forage intake and supplement intake.
[a,b]Different letters represent differences between treatments ($P < 0.05$).

Experiment 2

Final BW was greater ($P = 0.02$; Table 2) for the CON, HIGH, and LOW treatments compared to the STRAW group. In 2009 there was greater ADG (P=0.03) for supplemented steers consuming a 40:60 WDGS: low quality forage mix, compared to the CON and HIGH (30:70 WDGS: grass hay). In 2010, steers on CON, HIGH, and LOW treatments achieved the same gains, while those consuming the 30:70 WDGS:straw mix were significantly lower ($P < 0.01$), most likely due to lower intake of the supplement. Supplementation with low-quality harvested forage and WDGS reduced intake of range forage by 17.8, 21.6, and 22.2% for the STRAW, LOW, and HIGH treatments respectively, compared to the CON. In general, doubling the stocking rate for supplemented treatments did not negatively affect performance. Supplementing a byproduct and low-quality forage mixture can replace forage intake without sacrificing animal performance.

Utilizing mixtures of low-quality forage and ethanol byproducts to reduce pasture intake was more successful on bromegrass pasture in Eastern Nebraska than on upland range in the Sandhills. Overgrazing in the Sandhills because of lower grazed forage replacement by the mixtures would likely have greater consequences long-term on range/pasture condition than similar overgrazing of brome pasture. Furthermore, crop residues for making the byproduct:residue mixtures are more readily available at minimal cost on farms with cool-season grass pastures.

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Effects of Forage Type, Storage Method, and Moisture Level in Crop Residues Mixed with Modified Distillers Grains

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Summary

Two growing experiments compared effects of feeding a diet consisting of cornstalks or wheat straw and modified distillers grains when ensiled or mixed fresh daily. Wheat-straw based diets also were compared at different moisture levels (50% and 70%) when ensiled and mixed daily. In Experiment 1, steers fed ensiled diets had greater DMI compared to diets mixed daily. Moisture level and crop residue type had no effect on steer performance. In Experiment 2, steers were offered the supplements and a hay mix to determine palatability and forage replacement. Moisture level had no effect, cornstalks were consumed better than wheat straw, and steers fed freshly mixed diets gained more and were more efficient than those fed ensiled mixes.

Introduction

Ensiling cornstalks (*2009 Nebraska Beef Cattle Report*, pp. 30-32) or wheat straw (*2010 Nebraska Beef Cattle Report,* pp. 42-43) with WDGS in silo bags resulted in greater ADG and G:F compared to diets mixed fresh daily. A mix of wheat straw and WDGS reduced grazed forage intake without affecting growing steer performance (*2008 Nebraska Beef Cattle Report*, pp. 29-31). By using cornstalks or wheat straw in combination with readily available ethanol byproducts, grazed forage intake may be reduced and growing performance enhanced.

The objectives of these experiments were to 1) evaluate storage method, moisture level, and forage type in crop residue and MDGS diets on growing steer performance; and 2) evaluate growing steer performance and replacement of forage with supplement blends of crop residue and MDGS.

Procedure

Experiment 1

Sixty crossbred steers (initial BW = 636 ± 22 lb) were used in a completely randomized design experiment. Steers were received at the University of Nebraska–Lincoln Agricultural Development and Research Center (ARDC), Mead, Neb., during the fall of 2010. Steers were weighed and vaccinated (Bovi-Shield Gold® 5, Somubac®, Dectomax®) on arrival, revaccinated after 14 days (Bovi-Shield Gold 5, Pinkeye, Vision® 7-Somnus) and trained to use individual Calan gates. Prior to initiation of the trial, steers were limit fed a diet of 50% alfalfa hay and 50% wet corn gluten feed at 2% of BW to minimize variation in gastrointestinal fill. Following the limit feeding period, steers were weighed on three consecutive days, with the average BW from day -1 and 0 used to assign steers randomly to treatments. Ten steers were assigned to one of six treatments in two separate 2 x 2 factorials. Forage type (cornstalks or wheat straw) and storage method (ensiled or nonensiled) were compared in the first factorial. Water was added at the time of ensiling or immediately prior to feeding to reach 70% moisture. The second factorial compared wheat straw storage method (ensiled or nonensiled) and moisture level (50% or 70%). Ensiled treatments were mixed 30 days prior to the initiation of the trial and stored in silo bags. Nonensiled treatments were mixed fresh daily using the same source of forage as their ensiled counterparts. Ensiled and nonensiled blends contained 30% MDGS and 70% crop residue on a DM basis.

Steers were individually fed their respective diets *ad libitum* for 84 days using Calan gates. Feed was adjusted daily based on individual intakes. Feed refusals were collected daily and feed samples were collected weekly. Steers were limit fed for five days at trial completion and weighed three consecutive days to obtain ending BW.

Experiment 2

Five hundred and ten crossbred steers (initial BW = 696 ± 50 lb) were used in a randomized complete block design experiment to compare forage replacement and growing performance. Steers were received at ARDC during the fall of 2010. Steers were weighed and vaccinated (Bovi-Shield Gold 5, Somubac, Dectomax) on arrival, revaccinated after 14 days (Bovi-Shield Gold 5, Pinkeye, Vision 7-Somnus), and placed onto bromegrass pastures for 30 days. After receiving, steers grazed corn residues and were supplemented with wet corn gluten feed for 90 days. In February 2011, steers were moved to pens and were limit-fed a diet consisting of 50% alfalfa hay and 50% wet corn gluten feed at 2% BW to minimize the effect of gastrointestinal fill prior to initiation of the trial. Following the 5 day limit-feeding period, steers were weighed on two consecutive days, with day 0 weights used to block by BW, stratify within block, and assign

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randomly to pen.

Treatments were supplements containing 70% crop residue and 30% MDGS (DM). The treatments were arranged in two separate 2 x 2 factorials, comparing type of crop residue (cornstalks and wheat straw) and storage method (ensiled or mixed fresh). The second factorial compared storage method and moisture content of the diet (50% or 70%). Four pens were used as a control group and were only offered the 60% grass hay:40% alfalfa hay forage diet. Steers were offered supplements *ad libitum* at 0700 hours. At 1200 hours, prior to feeding the basal forage diet, bunks were evaluated based on supplement intake and adjustments for the subsequent day's supplement offering were made. The basal diet was offered at 1300 hours and adjustments to each afternoon's feeding were made prior to the 0700 hours feeding of the residue and MDGS supplement. Feed refusals were weighed and removed at the time of each bunk evaluation. Steers were limit fed for five days at trial completion and weighed on two consecutive days for ending BW.

Table 1. Effects of forage type and storage method on growing steer performance in Experiment 1.

	Cornstalks		Wheat Straw				*P*-Value	
	Fresh	Ensiled	Fresh	Ensiled	SE	Trt	Forage	Trt*Forage
Initial BW, lb	635	637	634	638	7	0.83	0.91	0.99
Ending BW, lb	734	729	714	747	11	0.20	0.92	0.08
ADG, lb	1.18[ab]	1.10[ab]	0.94[a]	1.31[b]	0.09	0.10	0.82	0.02
DMI, lb/day	10.2	11.3	11.1	12.1	0.5	0.03	0.08	0.89
F:G	8.62[a]	10.31[bc]	11.90[c]	9.26[ab]	0.69	0.76	0.14	<0.01

[abc]Means without common superscript differ ($P \leq 0.05$).

Table 2. Effects of moisture level and storage method on growing steer performance in Experiment 1.

	70% Moisture		50% Moisture				*P*-Value	
	Fresh	Ensiled	Fresh	Ensiled	SE	Trt	Moisture	Trt*Moisture
Initial BW, lb	635	637	634	638	7	0.66	0.97	0.83
Ending BW, lb	714	747	721	733	7	0.03	0.74	0.29
ADG, lb	0.94	1.31	1.05	1.13	0.09	0.01	0.69	0.10
DMI, lb/day	11.1	12.1	11.3	11.6	0.4	0.12	0.75	0.43
F:G	11.76	9.26	10.87	10.31	0.66	0.03	0.76	0.16

Results

Experiment 1

Interactions were observed between residue type and storage method for ADG ($P = 0.02$, Table 1) and F:G ($P < 0.01$). Steers offered ensiled wheat straw and MDGS mixes had greater DMI and ADG than steers fed diets mixed fresh daily, suggesting an increase in palatability and fiber digestion. However, the positive effect ensiling had on intake of wheat straw was not observed in diets containing cornstalks. Steers fed diets containing cornstalks mixed fresh daily had lower F:G than those fed ensiled cornstalk mixes, but steers fed fresh wheat straw blends gained less and had greater F:G than their counterparts fed ensiled wheat straw blends.

In diets containing only wheat straw, no interactions ($P \geq 0.05$, Table 2) were observed between storage method and moisture level, so only main effects are presented. Steers fed ensiled diets had greater ending BW ($P = 0.03$) and ADG ($P = 0.01$), and gained more efficiently ($P = 0.03$) than those fed diets mixed fresh daily. The improvements in gain and efficiency of steers fed ensiled diets are in agreement with previous studies (*2009 Nebraska Beef Cattle Report,* pp. 30-32; *2010 Nebraska Beef Cattle Report,* pp. 42-43). Performance was not different between steers fed diets at 50% and 70% moisture.

Experiment 2

This experiment was designed to test the palatability of MDGS and crop residue mixes, therefore, DMI of the supplements relative to the hay was the important factor. An interaction was observed for supplement (MDGS, residue mix) DMI ($P < 0.01$, Table 3) and percentage of total DMI ($P < 0.01$) when comparing storage type and forage. Intakes were lower for steers fed ensiled wheat straw than fresh wheat straw and both cornstalk blends resulting in a lower percentage of forage replacement for the ensiled wheat straw blend.

Interactions between supplement DMI ($P < 0.01$, Table 4), forage DMI ($P = 0.01$) total DMI ($P = 0.01$), and percentage of total DMI ($P < 0.01$) were found when moisture level and storage type were analyzed. Steers fed the 70% fresh supplement consumed more pounds of supplement daily, resulting in the greatest percentage of total DMI. Steers offered the 70% ensiled supplement had lower supplement intakes and consequently had the lowest percentage of forage

Table 3. Growing steer performance when offered fresh or ensiled supplements containing cornstalks or wheat straw and MDGS in Experiment 2.

		Cornstalks		Wheat Straw				*P*-Value	
	CON	Fresh	Ensiled	Fresh	Ensiled	SE	Trt	Forage	Trt*Forage
Initial BW, lb	701	697	698	698	697	22	0.99	0.99	0.97
Ending BW, lb	731	755	741	760	729	17	0.18	0.83	0.61
Supplement DMI, lb/day	—	5.3[a]	5.3[a]	4.5[a]	1.4[b]	0.3	<0.01	<0.01	<0.01
Forage DMI, lb/day	—	10.5[ab]	9.7[a]	11.2[b]	12.6[c]	0.5	0.50	<0.01	0.03
Total DMI, lb/day	15.5	15.7	15.1	15.7	13.9	0.03	<0.01	0.10	0.09
Percent	100	33.7[a]	35.4[ab]	29.0[b]	9.6[c]	2.0	<0.01	<0.01	<0.01
ADG, lb	0.59	1.12	0.82	1.20	0.60	0.14	<0.01	0.63	0.32
F:G	27.03	14.08	18.52	13.16	23.26	1.69	0.01	0.71	0.36

[abc]Means without common superscript differ ($P \leq 0.05$).

Table 4. Growing steer performance when offered fresh or ensiled supplements at differing moisture levels containing wheat straw and MDGS in Experiment 2.

		70% Moisture		50% Moisture				*P*-Value	
	CON	Fresh	Ensiled	Fresh	Ensiled	SE	Trt	Moisture	Trt*Moisture
Initial BW, lb	701	698	697	698	699	23	0.99	0.97	0.96
Ending BW, lb	731	760	729	751	740	17	0.21	0.96	0.55
Supplement DMI, lb/day	—	4.5[a]	1.4[b]	3.4[c]	3.6[c]	0.3	<0.01	0.06	<0.01
Forage DMI, lb/day	—	11.2[a]	12.6[b]	12.0[ab]	11.5[a]	0.3	0.19	0.58	0.01
Total DMI lb/day	15.5	15.7[a]	13.9[b]	15.4[a]	15.0[a]	0.3	<0.01	0.14	0.01
Percent	100	29.0[a]	9.6[b]	22.2[c]	23.7[ac]	1.8	<0.01	0.06	<0.01
ADG, lb	0.59	1.20	0.60	1.03	0.77	0.14	0.01	0.99	0.25
F:G	27.03	13.16	23.26	14.93	19.61	2.70	0.02	0.97	0.36

[abc]Means without common superscript differ ($P \leq 0.05$).

replacement. Slow rates of feeding contributed to spoilage within silo bags, which may have negatively affected the palatability of the 70% ensiled wheat and MDGS blend. There were no interactions when comparing F:G. The main effects of both ADG ($P = 0.01$) and F:G ($P = 0.02$) showed an advantage of diets mixed fresh daily over ensiled diets, which contradicts the results of Experiment 1 and previous studies. However, this experiment presented steers with a choice between supplemented treatment and a basal forage diet rather than offering only the crop residue and MDGS blend. Increased palatability of fresh diets resulted in greater intakes of supplemented blends and a subsequent increase in amount of MDGS consumed.

With the exception of the 70% moisture ensiled wheat straw supplement, steers showed improved ADG and lower F:G than steers fed the control diet, while effectively replacing 22% to 35% of forage intake. It should be noted that the decreased intakes of the 70% ensiled wheat straw supplement may be attributed to spoilage within the silo bag due to slow rates of feeding. These data suggest that MDGS mixed fresh daily with cornstalks will not only increase growing steer performance relative to a forage only situation, but the supplement can replace a greater proportion of hay, which was used as a proxy for grazed forage in this experiment.

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Effect of Storage Method on Nutrient Composition and Dry Matter Loss of Wet Distillers Grains

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Summary

Storage of distillers grains plus solubles was studied using 55-gallon barrels to mimic bunker storage. Six different cover treatments were evaluated when wet distillers grains plus solubles (WDGS) and straw were stored, or modified distillers grains plus solubles (MDGS) alone was stored for 60 days in 55-gallon barrels. Covering with plastic minimized spoilage (8%), and plastic or solubles as cover decreased DM loss (3-5%). Barrels filled with WDGS alone and uncovered were evaluated over 140 days of storage. With time, DM loss increased from 5 to 22%, while spoilage increased from 6 to 12%.

Introduction

Storing wet corn byproducts for long periods of time is difficult, especially when the most common storage method is a bunker. It is common for producers to mix WDGS with low-quality forage to help bulk up the byproduct so it packs into the bunker, minimizing the amount of air penetrating the mixture. As previous research shows, the spoilage process results in loss of DM at the surface of the bunker (*2010 Nebraska Beef Cattle Report,* p. 21). Another study illustrated that during the spoilage process, WDGS decreased in fat and increased in NDF, CP, pH, and ash (*2011 Nebraska Beef Cattle Report*, p. 18). Several cover treatments can be utilized to minimize the amount of surface exposed to oxygen. Therefore, Experiment 1 compares six different cover treatments and distillers: forage mixes, and Experiment 2 compares length of storage on nutrient loss when WDGS are left uncovered.

Procedure

Experiment 1

To replicate bunker storage, 55-gallon barrels were packed with one of two treatments: 70% WDGS and 30% straw mixture (DM) or straight MDGS (46% DM). Barrels were filled to approximately the same weight (300 lb) and packed to similar heights. All barrels were stored in a barn, subject to ambient temperature but not precipitation, for approximately 60 days. Table 1 describes the covers assigned randomly to each of the three replicates per treatment.

After 60 days of storage, each barrel was opened by carefully removing the solubles layer (if applied), the spoiled portion, and then the nonspoiled portion. When salt was used as a cover it was collected and analyzed as part of the spoiled layer. As in previous research, it was assumed that all of the spoilage occurred from the top down as it was exposed to the air. The spoilage was determined by appearance and texture. As each layer (solubles layer if applied, spoiled layer, and nonspoiled portion) was removed, representative samples were collected and analyzed for pH, fat, neutral detergent fiber (NDF), ash and OM, and CP. Nutrient analyses for both the spoiled and nonspoiled layers, along with nutrient analysis of the original WDGS sample, were used to determine the nutrient losses illustrated in Tables 2 and 3. In the calculations, the spoiled layer is included in the recovered DM etc., assuming that it would be fed. Therefore, if the spoiled layer were discarded, the loss would be the total of DM loss plus spoilage amount. Data were analyzed using the mixed procedures of SAS (SAS Inst., Inc., Cary, N.C.) using barrel as the experimental unit.

Experiment 2

Similar to Experiment 1, 55-gallon barrels were filled with WDGS to approximately the same weight (300 lb) and packed to similar heights. All barrels were stored in a barn, subject to ambient temperature but not precipitation, for 7, 14, 28, 56, 84,

Table 1. Cover treatments (Experiment 1).

WDGS : Straw	
Open	Barrels were left uncovered.
Plastic	6 mil plastic covering the surface of the mixture weighted down with sand and the edges were sealed with tape. This treatment would be comparable to plastic and tires in a bunker setting.
Salt	Salt was sprinkled over the surface of the mixture at a rate of 1 lb/ft^2 (2.76 lb total).
DS[1]	DS were poured over the surface of the mixture to make a 3-in layer (45 lb as-is).
DS[1] + Salt	DS and salt added at rates previously discussed and mixed together before application.
DS[1] + Straw	DS and straw (60:40 blend) added over the surface to make a 3-in layer (25 lb as-is).
MDGS	
Open	Barrels left uncovered and stored.
Plastic	6 mil plastic covering the surface of the mixture weighted down with sand and the edges sealed with tape. This treatment would be comparable to plastic and tires in a bunker setting.

[1]Distillers Solubles — thin stillage taken off during the milling process.

Table 2. Effects of different cover treatments on nutrient losses and pH of WDGS plus straw (Experiment 1).

	WDGS+ Straw (Open)	WDGS + Straw (Plastic)	WDGS + Straw (Salt)	WDGS + Straw (Solubles)	WDGS + Straw (Solubles + Salt)	WDGS + Straw (Solubles + Straw)	*P*-Value
DM Loss, %	8.1^{a,d}	3.5^{b}	7.3^{a,b,d}	5.2^{a,b}	-1.6^{c}	11.05^{d}	<0.01
Spoil, %	19.0^{a}	7.8^{b}	23.4^{c}	17.8^{a,d}	15.0^{d}	17.2^{a,d}	<0.01
Non-Spoil, %	81.0^{a}	92.2^{b}	76.6^{c}	82.2^{a,d}	85.0^{d}	82.8^{a,d}	<0.01
OM Loss, %	9.08^{a}	3.89^{b}	9.47^{a}	13.59^{c}	7.82^{a}	19.54^{d}	<0.01
Fat Loss, %	17.33^{a}	4.80^{b}	21.75^{c}	24.70^{d}	4.88^{b}	28.93^{e}	<0.01
NDF Loss, %	4.85^{a}	2.47^{a}	5.20^{a}	7.63^{a}	6.05^{a}	15.55^{b}	<0.01
Non-spoiled pH after[1]	4.33^{a}	4.03^{b}	4.33^{a}	4.03^{b,d}	4.03^{b}	4.31^{a}	<0.01
Spoiled pH after2	6.72^{a}	6.77^{a}	7.11^{a}	6.88^{a}	6.11^{b}	6.82^{a}	<0.01
Nutrient recovery for covers							
OM recovered, %	—	—	—	43.15	59.51	32.41	0.44
Fat recovered, %	—	—	—	12.10^{a}	96.13^{b}	7.11^{a}	<0.01

^{a,b,c} means with different superscripts are different ($P < 0.05$).
[1]Nonspoiled layer of WDGS after storage, original pH was 4.42.
[2]Spoiled layer of WDGS after storage, original pH was 4.42.

Table 3. Nutrient losses of modified distillers grains plus solubles alone stored with no cover (Open) or with plastic covering (Plastic) in Experiment 1.

	MDGS (Open)	MDGS (Plastic)	*P*-Value
DM Loss, %	12.2	2.8	<0.01
Spoil, %	38.7	4.6	<0.01
Non-Spoil, %	61.3	95.4	<0.01
OM Loss, %	12.49	2.92	<0.01
Fat Loss, %	24.03	3.89	<0.01
NDF Loss, %	5.77	2.25	0.17
Non-spoiled pH[1]	4.27	4.31	0.60
Spoiled pH after[2]	6.70	6.82	0.77

[1]Nonspoiled layer of MDGS after storage, original pH was 4.63.
[2]Spoiled layer of MDGS, original pH of 4.63.

112, and 140 days, with two barrels weighed and sampled on each of these days. The two layers, spoiled and non-spoiled, were measured, separated, weighed, and sampled. The spoiled and non-spoiled samples were then analyzed for DM, ash and OM, fat, NDF, CP, and pH. Losses illustrated in Table 4 were calculated the same as described in Experiment 1. Data were analyzed using the Mixed procedure of SAS using barrel as the experimental unit.

Results

Experiment 1

There was an interaction ($P < 0.01$) between the cover treatment and amount of spoilage, DM loss, organic matter loss, fat loss, and pH for the WDGS: straw mixture and straight MDGS (Tables 2 and 3). The height of material in the barrels was just over 2 ft. If the material was stored in a bunker at a height of 10 ft, the losses would be proportionally less, about 20% as much of 1.6% DM loss and 3.8% spoilage for the open (noncovered) bunker. Spoilage caused a loss in DM, fat, and OM. Also, pH increased in the spoiled portion. The greatest loss in fat resulted when solubles and solubles + straw were used as covers. Microbes causing the spoilage are utilizing fat in the distillers for an energy source. Therefore, there is less fat available for the animals' use when they are fed the distillers: forage combination. Using plastic as a cover resulted in the least amount of fat loss for both the WDGS:straw mixture and the MDGS. The other treatments fell intermediate in terms of fat loss during the spoilage process.

Barrels using plastic and distillers solubles + salt as covers had the least amount of DM, OM, and fat lost because both covers (plastic and solubles + salt) resulted in the least amount of spoilage out of the six cover treatments. There were no interactions between NDF content and the type of cover used. The spoilage process also caused the pH of the original mixtures to increase from an initial pH of 4.42 to 6.77 with a plastic cover, and 6.11 with a solubles + salt cover. The greatest increase in pH numerically was when salt was used as a cover (4.42 to 7.11).

Covers like plastic and solubles + salt resulted in less spoilage, thus decreasing nutritional losses for the treatments. The barrels left uncovered resulted in the greatest amount of spoilage, which caused greater nutritional losses for the distillers products. The plastic and solubles + salt covers reduced the amount of air that reached the surface of the mix, allowing the distillers to retain original feeding value. However, up to 80% of the solubles can be lost when used as a cover, which is decreased when mixed with salt. Mixing solubles with straw, then using that mixture as a cover did not dramatically increase recovery of the cover for feeding. It was difficult to separate the cover from the mixtures below the cover, which is important to note.

Experiment 2

An interaction between the number of days the WDGS was stored and the amount of DM, OM, and NDF recovered (Table 4) was observed. The spoilage caused a loss of DM,

(Continued on next page)

Table 4. Nutrient losses (expressed as a % of the original amount of nutrient) of wet distillers grains plus solubles stored uncovered over time (140 days) in Experiment 2.

	Day 7	Day 14	Day 28	Day 56	Day 84	Day 112	Day 140	SEM	*P*-Value
DM Loss, %	$8.6^{a,b}$	5.0^{a}	6.6^{a}	$17.3^{b,c}$	$17.6^{b,c}$	22.4^{c}	21.1^{c}	2.05	<0.01
Spoil, %	6.4	6.0	5.8	5.8	9.6	12.5	11.7	1.76	0.10
Non-Spoil, %	93.7	94.1	94.2	94.2	90.4	87.6	88.3	1.76	0.10
OM Loss, %	$8.80^{a,b}$	4.85^{a}	6.35^{a}	$18.15^{b,c}$	$18.75^{b,c}$	23.90^{c}	22.60^{c}	2.25	<0.01
Fat Loss[3], %	3.15	-0.75	-2.70	5.75	3.35	5.10	2.70	3.67	0.67
NDF Loss[3], %	$1.20^{a,b}$	-12.60^{b}	$0.50^{a,b}$	$17.60^{b,c}$	$16.75^{b,c}$	$21.45^{b,c}$	27.10^{c}	4.82	<0.01
CP Loss[3], %	3.95	-2.60	-5.80	0.80	1.15	8.20	-7.05	3.06	0.08
Nonspoiled pH after[1]	3.67^{a}	$3.87^{a,b}$	$3.93^{a,b,c}$	4.26^{c}	$4.22^{c,b}$	$4.09^{c,b}$	$4.12^{c,b}$	0.07	<0.01
Spoiled pH after$_1$	4.78^{a}	6.18^{b}	6.50^{c}	$6.60^{c,d}$	6.43^{c}	$6.55^{c,d}$	6.72^{d}	0.05	<0.01

[a,b,c] means with different superscripts are different ($P < 0.05$).
[1]Nonspoiled layer of WDGS pH after storage, original pH was 3.7.
[2]Spoiled layer of WDGS pH after storage, original pH was 3.7.
[3]Negative numbers indicate an increase in that nutrient.

organic matter, and NDF. Spoilage also increased the pH of the WDGS from 3.95 on the day it was placed in the barrel to 6.72 on day 140 ($P < 0.01$). The nonspoiled layer increased from 3.95 to 4.12 on day 140 ($P < 0.01$). There was no statistical effect on CP; however, CP increased numerically from day 7 to 140. Days 7, 14, and 28 showed the least amount of DM loss, averaging a loss of 6.73% DM ($P < 0.01$). Numerically, days 112 and 140 showed the greatest loss of DM (22.4% and 21.1%), while days 56 and 84 fell intermediate ($P < 0.01$). Conversely, when looking at spoilage with time, there appeared to be no statistical difference ($P = 0.10$), but numerically the amount of spoilage over time increased from day 7 to 140 (6.35-11.70%). Since WDGS cannot be "stacked" in a bunker, the 2 ft height in the barrels may represent the height if stored in a bunker, and losses would be similar between the bunker and barrels.

Over time the amount of OM lost do to spoilage increased from 4.85% on day 14 to 22.60% on day 140 ($P < 0.01$). However, there was no statistical effect of time on the amount of fat lost ($P = 0.67$), indicating that the amount of fat lost due to spoilage didn't depend on the length of time the WDGS was stored.

In conclusion, the storage time for WDGS had no effect on the amount of fat lost. However, the longer WDGS was stored the greater affected the loss of DM, organic matter, and NDF.

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Spoilage of Wet Distillers Grains Plus Solubles and Feed Value

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Summary

Performance of growing or finishing steers fed wet distillers grains plus solubles (WDGS) from a silo bag (nonspoiled) or bunker (spoiled) was studied. Spoiled WDGS lost DM, as well as decreased in fat, NDF, and CP. Even though DM was lost, and composition of the spoiled WDGS changed, the spoiled WDGS had no effect on finishing cattle performance, but it did affect DMI of the growing steers consuming high forage diets.

Introduction

The top of a WDGS pile starts spoiling in a few days. Since WDGS is delivered in semitruck load quantities, it is often impractical for smaller livestock operations that cannot utilize large quantities of WDGS within a few days to purchase WDGS. The most common method of storage is in a bunker, which leaves the WDGS exposed to oxygen, causing the WDGS to spoil. Previous research illustrated WDGS decreased in fat and increased in NDF, CP, pH, and ash during the spoilage process (*2011 Nebraska Beef Cattle Report,* p. 18), indicating WDGS is losing feeding value. Most producers don't separate the spoiled from the unspoiled WDGS, so this could affect cattle performance. Therefore, the objective of these two studies was to determine the effects of spoiled WDGS on 1) feedlot performance and 2) growing performance.

Procedure

Experiment 1

A 130 day finishing experiment was conducted using 60 individually fed steers (878 ± 15.3 lb). Five days prior to the start of the experiment, steers were limit fed to minimize variation in initial BW, then weighed for three consecutive days. Animal served as the experimental unit (20 steers per treatment).

The three treatments included a dry-rolled corn based diet (control) and two diets containing 40% WDGS replacing DRC (Table 1). The WDGS was split equally between semi load into either an uncovered bunker (spoiled WDGS) or into a silo bag and stored anaerobically (nonspoiled WDGS). Storage was initiated on June 2, 2010, 38 days prior to experiment (started July 10, 2010) to allow for spoilage. WDGS from the same semi load was also placed into barrels for 140 days to mimic the WDGS being stored in the bunker. The spoiled and nonspoiled layers were measured and analyzed for ash. A relationship was found between percentage spoiled and the % ash (combining both spoiled and nonspoiled ash content) in the barrels. A regression equation was then used (% spoilage = (0.1002 * % ash of bunker WDGS) + 0.0639) to calculate the amount of spoilage in the bunker. Feed refusals were weighed and sampled twice per week. They were then analyzed for DM and used to calculate accurate DMI for each steer.

Samples of WDGS (from both storage methods) were collected daily after allowing the WDGS to mix alone in the truck prior to diet mixing to ensure accurate sampling occurred throughout. Daily samples of WDGS were composited by week for nutrient analysis. Weekly composites were analyzed for DM, ash, fat, NDF, CP, and pH. An overall composite of the bagged and bunkered WDGS was analyzed for mycotoxins (Romer Labs; Union, Mo.).

All steers were slaughtered on day 130 at Greater Omaha (Omaha, Neb). Carcass characteristics consisting of hot carcass weight (HCW), liver abscesses, USDA marbling score, 12th rib fat thickness, and LM area were collected. For USDA calculated YG, KPH fat was assumed to be 2.5%. Hot carcass weights were used to calculate adjusted final BW by dividing HCW by a common dressing percentage (63%). Yield grade was calculated using the equation: USDA YG = 2.5 + 2.5(12th rib fat thickness, in) – 0.32(LM area, in^2) + 0.2(KPH fat, %) + 0.0038 (HCW, lb). Steer performance and carcass characteristics were analyzed using the Mixed procedure of SAS (SAS Inst., Inc., Cary, N.C.).

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Table 1. Dietary treatments (% of diet DM) fed to finishing steers evaluating spoilage of stored wet distillers grains plus solubles for Experiment 1.

Ingredient	Control	Spoiled	Nonspoiled
Dry-rolled Corn	82.5	47.5	47.5
WDGS, Bag[1]	—	—	40.0
WDGS, Bunker[2]	—	40.0	—
Alfalfa Hay	7.5	7.5	7.5
Supplement[3]	5.0	5.0	5.0

[1]Bagged wet distillers grains plus solubles stored anaerobically to minimize spoilage (nonspoiled).
[2]Bunker wet distillers grains plus solubles that was allowed to have more spoilage occurring during storage prior to and during feeding (Spoiled).
[3]Formulated to contain 59% fine ground corn, 30% limestone, 6% salt, 2.50% tallow, 0.32% thiamine, 1% vitamin pre-mix, 0.38% Rumensin-80, 0.19% Tylan-40.

Experiment 2

An 84 day growing experiment was conducted using 60 individually fed steers (730 ± 0.46 lb). Steers were limit fed for five days and then weighed three consecutive days to obtain initial BW. Animal served as the experimental unit, and there were 15 steers per treatment. The four treatments were designed as a 2x2 factorial. Similar to Experiment 1, WDGS was stored in a bunker (spoiled) or silo bag (nonspoiled). The other factor was WDGS stored either way was fed at 15% or 40% (Table 2). The treatments with 15% WDGS were formulated to meet the protein needs of the steers. The 40% inclusion treatments were formulated to meet the protein needs of steers and provide additional energy. The WDGS was purchased from an ethanol plant and split equally within semi load into either an uncovered bunker (spoiled WDGS) or into a silo bag and stored anaerobically (nonspoiled WDGS). Storage was initiated five months prior to starting the experiment (March 24, 2011) to allow for spoilage to start occurring throughout the winter months. Feed refusals were weighed and sampled twice per week and analyzed for DM to calculate accurate DMI for each steer.

Sampling, compositing, and analyses are described in Experiment 1. Weighing and statistical analyses were as described in Experiment 1, also.

Table 2. Dietary treatments fed to growing steers where 15 or 40% wet distillers grains were fed that had spoiled (Bunker) or not (Bag) for Experiment 2.

Ingredient[1]	15% Bunker[3]	40% Bunker[4]	15% Bag[3]	40% Bag[4]
WDGS, Bag	—	—	15.0	40.0
WDGS, Bunker	15.0	40.0	—	—
CRP Hay[2]	81.0	57.0	81.0	57.0
Supplement	4.0	3.0	4.0	3.0

[1]Inclusion on a DM basis.
[2]Low quality grass hay with a 48% TDN, 72.7% NDF, and 5.3% CP.
[3]Supplement formulated to contain 28.5% fine ground corn, 23.0% limestone, 37.5% urea, 7.5% salt, 1.88% tallow, 1.25% trace minerals, 0.38% vitamin pre-mix.
[4]Supplement formulated to contain 44.67% fine ground corn, 40.67% limestone, 10.0 salt, 2.5% tallow, 1.67% trace minerals, 0.50% vitamin pre-mix.

Table 3. Weekly nutrient composition of spoiled and nonspoiled WDGS in Experiment 1.

Nutrient	Bunker	Bagged	Calculated Loss[1]
DM, %	35.2	33.4	12.3
Ash, %	6.4	5.6	—
Fat, %	14.1	14.8	16.0
NDF, %	33.3	31.7	8.0
CP,%	30.8	30.8	12.2
pH	4.8	4.2	—

[1]Calculated using (1-((ash initial/ash final)*(nutrient final/nutrient initial).

Table 4. Performance and carcass characteristics for steers fed wet distillers grains that had spoilage or not compared to a corn control diet in Experiment 1.

Variable	Control	Nonspoiled[4]	Spoiled[5]	SEM	*P*-Values
Initial BW, lb	871	885	879	15.3	0.81
Final BW, lb[1]	1211[a]	1269[b]	1291[b]	22.5	0.04
DMI, lb/day	22.36	21.73	22.42	0.48	0.54
ADG, lb	2.61[a]	2.95[b]	3.18[b]	0.14	0.02
F:G[2]	8.54[a]	7.39[b]	7.13[b]	0.34	0.01
HCW, lb	763[a]	800[b]	814[b]	14.2	0.04
LM Area, in[2]	12.5	13.1	12.8	0.3	0.35
Fat, in	0.46	0.47	0.48	0.03	0.86
Marbling[3]	522.5	526.5	505.7	14.6	0.57
YG	3.03	3.01	3.16	0.13	0.67

[1]Final BW was calculated by taking HCW*0.63 dressing percentage.
[2]Analyzed as G:F, the reciprocal of F:G.
[3]Marbling score 400 = slight (Select); 500 = small (Choice-); 600 = modest marbling (Choice).
[4]WDGS stored in a silo bag.
[5]WDGS stored in a bunker.
[a, b, c]Means with different superscripts within a row are different ($P < 0.05$).

Results

Experiment 1

Steers fed the spoiled treatment (bunkered WDGS) consumed WDGS that contained 7% spoilage on average. No measurable amounts of mycotoxins in either spoiled or nonspoiled WDGS were detected. Nutrient analysis of the spoiled and nonspoiled WDGS indicated spoiled WDGS was 0.7% lower in fat content throughout the feeding period compared to the nonspoiled WDGS. Spoiled WDGS was higher in DM, ash, NDF, pH, and no change in CP was observed throughout the 130 day feeding period. Ash was used as a marker to calculate the overall loss of DM of the spoiled WDGS from the day (June 2, 2010) it was stored in the bunker (Table 3). The calculated loss indicated spoiled WDGS lost 12.3% DM. Also, the spoiled WDGS lost 16% fat, 8% NDF, and 12.3% CP. It is evident that the spoiled WDGS changed in composition compared to the initial WDGS purchased on June 2 because 16% fat was lost compared to 12.3% DM; however, there was no effect on performance (Table 4).

Despite nutrient losses, feeding the control, nonspoiled WDGS, or spoiled WDGS treatments did not affect DMI (Table 4). No differences in ADG, final BW, or F:G were observed between nonspoiled and spoiled WDGS. However, both WDGS treatments were greater ($P \leq 0.04$) in ADG, final BW, and lower in F:G compared to the control. Even though the spoiled

Table 5. Weekly nutrient composition of spoiled and nonspoiled WDGS in Experiment 2.

Nutrient	Spoiled[2]	Nonspoiled[3]	Calculated Loss[1]
DM, %	37.0	35.1	6.0
Ash, %	5.8	5.2	—
Fat, %	12.8	11.2	-2.6
NDF, %	35.1	34.9	10.3
CP,%	35.2	33.1	4.9
pH	4.8	4.0	—

[1]Calculated using (1-((ash initial/ash final)*(nutrient final/nutrient initial).
[2]WDGS stored in the bunker.
[3]WDGS stored in the silo bag.
Negative losses indicate an increase in that nutrient.

Table 6. Performance characteristics of growing steers Experiment 2.

	15%		40%		*P*-value		
Variable	S[1]	NS[2]	S[1]	NS[2]	Interaction	Level	Source
Initial BW, lb	730	730	730	729	0.94	1.0	1.0
Ending BW, lb	785	793	831	835	0.83	<0.01	0.56
DMI, lb	15.0	16.5	17.6	19.1	0.94	<0.01	<0.01
ADG, lb	0.66	0.75	1.20	1.26	0.71	<0.01	0.13
F:G	24.4	23.0	14.9	15.3	0.42	<0.01	0.67

[1]WDGS stored in the bunker (spoiled).
[2]WDGS stored in the silo bag (nonspoiled).

WDGS changed in composition from the initiation of the trial to the end; it is evident that the spoilage occurring when WDGS was stored in a bunker had no effect on the performance of finishing steers.

Experiment 2

Steers receiving the spoiled treatments consumed WDGS that contained 7% spoilage on average. Mycotoxins were not observed in either spoiled or nonspoiled WDGS. Nutrient analysis of the spoiled and nonspoiled WDGS indicated spoiled WDGS were higher in fat content throughout the feeding period compared to the nonspoiled WDGS. Spoiled WDGS were higher in DM, ash, NDF, pH, and CP throughout the 84 day feeding period. Ash was used as a marker to calculate the overall loss of DM from the spoiled WDGS from the day (October 26, 2010) it was stored in the bunker (Table 5). There was a 6.0% DM loss for the spoiled WDGS. Also, the spoiled WDGS lost 10.3% NDF and 4.9% CP. The spoiled WDGS increased 2.6% fat, indicating that the fat was becoming more concentrated in the spoiled layer due to other nutrient losses. The effects of spoilage of WDGS on performance were different in the growing experiment compared to the finishing experiment (Table 6).

There was no interaction (Table 6) between level of WDGS (15% or 40%) and source of WDGS (bag or bunk). The diets containing 40% WDGS performed better in ending BW, DMI, ADG, and F:G ($P < 0.01$) compared with steers fed 15% WDGS. Feeding spoiled WDGS decreased DMI ($P < 0.01$) across both levels of dietary WDGS compared to nonspoiled WDGS. The diets containing spoiled WDGS had statistically similar ending BW, ADG, and F:G compared to diets with nonspoiled WDGS. Numerically, the steers fed 15% spoiled WDGS in the diet had lower ending BW, lower ADG ($P = 0.14$ for main effect of ADG between source of WDGS), and greater F:G than nonspoiled WDGS. There were no differences for ending BW, ADG, or F:G between the 40% spoiled and 40% nonspoiled diets. Therefore, there was no overall effect of source (spoiled or nonspoiled) on ending BW, ADG, or F:G. However, spoiled WDGS did affect intakes of growing steers.

In conclusion, the spoilage process that occurs when WDGS is stored in a bunker causes a loss of DM and nutrients, with decreases in % fat and small increases in ash content (i.e., lower OM). However, feeding spoiled WDGS did not affect finishing performance. Feeding spoiled WDGS to growing steers did decrease DMI, but had little impact on ADG and no effect on F:G.

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Increasing Levels of Condensed Distillers Solubles and Finishing Performance

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Summary

Effects of adding 0, 9, 18, 27, or 36% condensed corn distillers solubles (CDS) to finishing diets containing a blend of dry-rolled and high-moisture corn and no other byproducts, were evaluated. As CDS replaced corn, DMI decreased linearly, while ADG and F:G increased quadratically. Feeding up to 36% CDS may effectively reduce dietary inclusion of corn, while improving ADG and F:G in finishing diets, with calculated maximal ADG at 20.8 and best F:G at 32.5% inclusion of CDS (DM).

Introduction

Condensed distillers solubles (CDS) is typically blended with the distillers grains fraction to produce wet, modified, or dry distillers grain plus solubles. The amount of CDS added to the grains is mostly dependent upon the ethanol plant's capacity to store the liquid CDS. When supply of CDS exceeds storage availability, CDS is available to producers as a relatively inexpensive, yet energy-dense feed ingredient.

Limited data are available on feeding CDS in finishing diets, especially at relatively high levels (above 10% of diet DM). However, previous research on both the addition of CDS to diets containing wet corn gluten feed (*2009 Nebraska Beef Cattle Report*, pp. 64-65), and on increasing the CDS to grains ratio in wet distillers grains with solubles (*2009 Nebraska Beef Cattle Report,* pp. 59-61) has found no negative impacts of CDS on cattle performance. Therefore, the objective of the current study was to determine the effects of feeding high levels of CDS on finishing performance and carcass characteristics in a corn-based diet as the sole byproduct.

Procedure

A 132-day finishing study was conducted using 250 crossbred, yearling steers (BW = 783 ± 40 lb). Cattle were received in the fall and placed on a common diet of soybean hulls and wet corn gluten feed. Steers were limit fed at 2.0% of BW for five days prior to trial initiation and then weighed on two consecutive days (days 0 and 1) to establish initial BW. Cattle were blocked by day 0 BW, stratified by BW within block, and assigned randomly to pen. Pens were assigned randomly to one of five treatments with 10 steers per pen and five pens per treatment.

Five treatments (Table 1) consisted of: 0, 9, 18, 27, or 36% condensed corn distillers solubles (CDS), which replaced both urea and a 1:1 blend of dry-rolled corn (DRC) and high-moisture corn (HMC). The CDS (Nebraska Energy LLC., Aurora, Neb., and Southwest Iowa Renewable Energy, Council Bluffs, Iowa.) used in this study contained 30.0% DM, 21.9% CP, 18.6% fat, and 1.1% sulfur. Urea decreased from 1.58% in the 0% CDS diet to 0.35% in the 36% CDS diet. Soypass™ was included in all diets, replacing corn from day 1 to day 40 to meet the metabolizable protein requirement of those steers. All diets contained 7.5% alfalfa hay and 5% dry supplement, which was formulated to provide 345 mg/steer Rumensin®, 90 mg/steer Tylan®, and 130 mg/steer thiamine daily. Dietary fat increased from 3.7 to 9.0%, whereas dietary sulfur increased from 0.12 to 0.48%, as CDS increased.

Steers were implanted on day 1 with Revalor-S (Intervet, Millsboro, Del.). All animals were harvested on day 133 at Greater Omaha Pack (Omaha, Neb.), at which time hot carcass weights (HCW) and liver scores were recorded. Fat thickness, loin muscle area, and USDA marbling score were recorded after a 48-hour chill. Yield grade was calculated using HCW, fat thickness, LM area, and an assumed 2% kidney, pelvic, and heart fat. Final BW, ADG, and F:G were calculated using hot carcass weight adjusted to a common (63%) dressing percentage.

Performance and carcass data were analyzed using the MIXED procedure of SAS (SAS Inst., Inc., Cary, N.C.) as a randomized complete block design

Table 1. Diet composition and analysis for diets containing 0% to 36% CDS (DM).[1, 2]

	CDS, % Diet DM				
Item	0	9	18	27	36
Ingredient, %					
DRC	43.75	39.25	34.75	30.25	25.75
HMC	43.75	39.25	34.75	30.25	25.75
CDS	—	9.0	18.0	27.0	36.0
Alfalfa Hay	7.5	7.5	7.5	7.5	7.5
Urea[3]	1.58	1.28	0.96	0.65	0.35
Supplement[4]	3.42	3.72	4.04	4.35	4.65
Analyzed Composition, %					
Crude Protein	13.6	13.9	14.1	14.4	14.7
Fat	3.7	5.0	6.4	7.7	9.0
Sulfur	0.12	0.21	0.30	0.39	0.48

[1] All values expressed on a DM basis.
[2] CDS = dry milling corn condensed distillers solubles; DRC = dry-rolled corn; HMC = high-moisture corn.
[3] Urea replaced fine ground corn in supplement.
[4] Soypass was fed for days 1-40.

Table 2. Effect of CDS inclusion on cattle performance and carcass characteristics.

Item	CDS, % Diet DM					SEM	*P*-value	
	0	9	18	27	36		Lin.[1]	Quad.[2]
Performance								
Initial BW, lb	779	780	779	781	781	1.2	0.24	0.85
Final BW, lb	1231	1280	1287	1271	1261	12.8	0.22	0.01
DMI, lb/day	22.7	22.8	22.7	22.1	21.2	0.36	<0.01	0.07
ADG, lb	3.42	3.78	3.84	3.71	3.64	0.10	0.25	0.01
F:G	6.62	6.02	5.92	5.95	5.81	0.11	<0.01	0.02
Live final BW, lb	1274	1328	1309	1293	1283	25.2	0.82	0.16
Carcass Characteristics								
HCW, lb	776	806	810	801	794	8.0	0.22	<0.01
Dressing %	60.9	61.3	61.9	61.9	61.9	0.4	0.04	0.35
LM area, in^2	12.3	12.6	12.8	12.4	12.5	0.21	0.76	0.29
12^{th} rib fat, in	0.52	0.57	0.52	0.55	0.53	0.02	0.98	0.60
Calculated YG	3.37	3.44	3.30	3.42	3.35	0.08	0.80	0.94
Marbling Score[3]	564	555	553	563	557	12.4	0.86	0.71

[1]Lin. = *P*-value for the linear response to CDS inclusion.
[2]Quad. = *P*-value for the quadratic response to CDS inclusion.
[3]Marbling Score: 500 = Small00, 600 = Modest00.

with pen as the experimental unit. Weight block was included as a random effect. Orthogonal contrasts were used to test the effects of CDS inclusion level.

Results

As CDS inclusion increased, DMI decreased linearly ($P < 0.01$), while ADG increased quadratically ($P = 0.01$; Table 2), with maximum ADG calculated at 20.8% CDS using the first derivative of the quadratic response. Feed:gain also decreased quadratically ($P < 0.01$) as CDS inclusion increased. The lowest F:G was calculated at 32.5% CDS, at which steers were 12% more efficient than those fed 0% CDS. Relative feeding values were also calculated for each CDS inclusion versus 0% CDS by dividing the difference in G:F by the G:F of 0% CDS, then by the decimal percentage inclusion of CDS. Relative feeding values were 210, 166, 142, and 139% of corn for 9, 18, 27, and 36% CDS, respectively. These improvements in ADG and F:G are presumably partially due to the high fat level, and thus high energy density of the diets, as CDS inclusion increases. Previous studies have shown that dietary fat levels of up to 7% in finishing diets have positive impacts on performance. The results of the current study confirm this, and suggest even up to 9% dietary fat may be acceptable, when this fat is supplied by CDS. It also has been suggested that there is a higher tolerance for fat from CDS, relative to other fat sources (*2010 Nebraska Beef Cattle Report,* p. 74). It is interesting to note that since F:G plateaus at the highest inclusions of CDS, perhaps even higher levels could be acceptable or economical. The limiting factor to inclusions higher than 36% CDS would likely be challenges in the physical handling properties of the diet, dietary fat, and/or dietary sulfur. The dietary sulfur level of 0.48% in the diet containing 36% CDS appears to have had no negative impact on performance, and no cases of polioencephalomalacia were reported.

Final BW and HCW increased quadratically as CDS inclusion increased, with steers fed 18% CDS having 34 lb heavier HCW than those fed 0% CDS. No other differences were observed for carcass characteristics, as steers in all treatments were finished to a similar endpoint.

Feeding up to 36% CDS may effectively reduce dietary inclusion of corn, while improving gain and gain efficiency in finishing diets. Maximal animal performance was observed between 20.8 and 32.5% inclusion of CDS (DM).

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Feeding Condensed Distillers Solubles in Finishing Diets Containing WDGS or Synergy

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Summary

Effects of adding 0, 7, 14, or 21% condensed distillers solubles (CDS) to diets containing either 20% modified distillers grains (MDGS) or 20% Synergy (a combination of modified distillers grains and wet corn gluten feed) were evaluated. A byproduct by CDS level interaction was observed for final BW, hot carcass weight, and ADG. Cattle fed Synergy had greater DMI than cattle fed MDGS. In MDGS diets at 14% CDS and in Synergy diets at 21% CDS, ADG was maximized. Increasing CDS level in both types of diets improved F:G linearly.

Introduction

Previous research (*2012 Nebraska Beef Cattle Report,* pp. 64-65) indicates that up to 36% inclusion of condensed distillers solubles (CDS) can replace a portion of corn in the diet while improving finishing performance. However, these data were collected for diets in which CDS was the sole byproduct in corn-based diets. The majority of finishing rations used today contain either distillers grains or wet corn gluten feed to replace a portion of corn. Adding high levels of CDS to finishing diets, in addition to another byproduct, has not been studied. Thus, the objective of the current study was to evaluate adding increasing levels of CDS to diets that contain MDGS or Synergy.

Procedure

A 180 day finishing study was conducted using 400 crossbred steer calves (BW = 748 ± 33 lb) in a randomized complete block design, with a 2 × 4 factorial arrangement of treatments. Steers were limit fed at 2.0% of BW for five days prior to trial initiation and then weighed on two consecutive days (day 0 and 1) to establish an initial BW. Cattle were blocked by day 0 BW, stratified by BW within block, and assigned randomly to pen. Pens were assigned randomly to one of eight treatments with 10 steers per pen and five pens per treatment.

Dietary treatments (Table 1) consisted of 20% MDGS (ADM, Columbus, Neb.) or Synergy (a combination of modified distillers grains and wet corn gluten feed; ADM, Columbus, Neb.) and 0, 7, 14, or 21% condensed corn distillers solubles (CDS), which replaced urea and a 1:1 blend of dry-rolled corn (DRC) and high-moisture corn (HMC). The CDS (BioFuel Ethanol Energy Corp., Wood River, Neb.) used in this study contained 35.0% DM and 18.6% ether extract. All diets contained 6% wheat straw and 5% dry supplement, which was formulated to provide 338 mg/steer daily Rumensin®, 90 mg/steer daily Tylan®, and 130 mg/steer daily thiamine. Dietary fat increased from 4.6 to 8.8% as CDS inclusion increased from 0 to 21%.

Steers were implanted on day 1 with Revalor®-IS and reimplanted on day 83 with Revalor®-S (Intervet, Millsboro, Del.). All animals were harvested on day 181 at Greater Omaha Pack (Omaha, Neb.), at which time hot carcass weights (HCW) and liver scores were recorded. Fat thickness, loin muscle LM area, and USDA marbling score were recorded after a 48 hour chill. Yield grade was calculated using HCW, fat thickness, LM area, and an assumed 2% KPH. Final BW, ADG, and F:G were calculated using HCW adjusted to a common (63%) dressing percentage.

Performance and carcass data were analyzed as a 2 × 4 factorial using the MIXED procedure of SAS (SAS Inst., Inc., Cary, N.C.) as a randomized complete block design with pen as the experimental unit. Weight block was included as a random effect.

Table 1. Diet composition for diets containing CDS with either MDGS or Synergy.[1,2]

	CDS Inclusion, %			
Ingredient, %	0	7	14	21
MDGS Diets				
DRC	34.5	31.0	27.5	24.0
HMC	34.5	31.0	27.5	24.0
MDGS	20.0	20.0	20.0	20.0
CDS	—	7.0	14.0	21.0
Straw	6.0	6.0	6.0	6.0
Supplement	5.0	5.0	5.0	5.0
Analyzed Composition				
Ether Extract	5.1	6.3	7.6	8.8
Synergy Diets				
DRC	34.5	31.0	27.5	24.0
HMC	34.5	31.0	27.5	24.0
Synergy	20.0	20.0	20.0	20.0
CDS	—	7.0	14.0	21.0
Straw	6.0	6.0	6.0	6.0
Supplement	5.0	5.0	5.0	5.0
Analyzed Composition				
Ether Extract	4.6	5.8	7.1	8.3

[1] All values expressed on a DM basis.
[2] CDS = condensed distillers solubles; MDGS = modified distillers grains; DRC = dry-rolled corn; HMC = high-moisture corn.

Table 2. Effects of CDS inclusion on performance and carcass characteristics.

	20% MDGS				20% Synergy				*P*-value	
CDS level:	0	7	14	21	0	7	14	21	Bypr[1]	Int[2]
Performance										
Initial BW, lb	767	766	767	766	768	767	768	766	0.57	0.98
Final BW, lb[3,4]	1441	1456	1504	1476	1470	1478	1473	1498	0.27	0.09
DMI, lb/day	24.2	23.8	25.2	23.4	24.8	24.6	24.7	24.3	0.06	0.16
ADG, lb[4]	3.74	3.83	4.10	3.94	3.89	3.95	3.91	4.07	0.31	0.08
Feed:Gain[5]	6.45	6.17	6.13	5.92	6.37	6.25	6.29	5.95	0.48	0.67
Carcass Characteristics										
HCW, lb[4]	908	917	948	930	926	931	928	944	0.27	0.09
LM area, in^2	13.6	13.8	13.7	13.8	13.9	14.0	14.0	14.0	0.12	0.99
12th rib fat, in	0.52	0.57	0.59	0.59	0.55	0.57	0.56	0.59	0.95	0.64
Calculated YG	3.39	3.49	3.71	3.60	3.47	3.50	3.46	3.60	0.58	0.46
Marbling score[6]	583	570	570	567	583	586	561	580	0.52	0.70

[1]Bypr = Main effect of byproduct type.
[2]Int = Effect of byproduct type and CDS level interaction.
[3]Calculated from hot carcass weight, adjusted to a common 63% dressing percentage.
[4]Quadratic effect of CDS within MDGS diets ($P = 0.10$).
[5]Linear main effect of CDS ($P < 0.01$).
[6]500 = $Small^0$; 600 = $Modest^0$.

Orthogonal contrasts were used to test the effect of CDS inclusion level within each byproduct type when an interaction occurred, or for the main effect of CDS when no interaction was observed. Treatment differences were considered significant at $P \leq 0.10$.

Results

Significant byproduct type by CDS level interactions were observed for final BW, HCW, and ADG ($P < 0.10$). Byproduct type affected DMI only, as cattle fed Synergy consumed 1.9% more DM than cattle fed MDGS ($P = 0.06$). Addition of CDS to the diet impacted DMI, ADG, F:G, final BW, and HCW ($P < 0.05$) (Table 2). A cubic response in DMI to increasing CDS level was observed ($P = 0.01$) in both MDGS and Synergy diets. A quadratic response was observed for ADG as CDS increased ($P = 0.09$) in diets containing MDGS, with ADG being maximized at 14% CDS and then decreasing slightly at 21% CDS. As level of CDS increased in Synergy diets, ADG increased numerically. This lack of significant ADG response to CDS in Synergy diets is consistent with previous research (*2009 Nebraska Beef Cattle Report*, p. 64) in which addition of 20% CDS to a diet containing 35% WCGF had no significant impacts on ADG. A linear improvement in F:G ($P < 0.01$) due to increasing CDS level was observed regardless of byproduct type, as cattle fed 21% CDS were approximately 8% more efficient than those receiving no CDS. Final BW and HCW responded quadratically to increasing CDS level in MDGS diets ($P = 0.10$); increasing with CDS levels up to 14%, then decreasing slightly when 21% CDS was added. No effect on final BW or HCW due to CDS was observed in Synergy diets. No differences due to either byproduct type or CDS level were observed for LM area, 12th rib fat thickness, calculated YG, or marbling score.

Previous research (*2012 Nebraska Beef Cattle Report,* pp. 64-65) showed improved performance in cattle fed diets containing up to 9% dietary fat, when supplied by CDS as the only byproduct ingredient. In the current study, when 8.8% dietary fat was supplied by a combination of CDS and MDGS, ADG, final BW, and HCW were slightly lower than diets containing CDS and Synergy (8.3% fat). Even so, F:G continued to improve with addition of CDS up to 21% in both types of diets, suggesting that the upper threshold for adding dietary fat from CDS and either MDGS or Synergy has not been reached.

Condensed distillers solubles can effectively be fed in combination with other byproducts as a partial replacement for dry-rolled and high-moisture corn. Average daily gain was maximized in MDGS diets at 14% CDS. However, feed conversion continued to improve up to 21% CDS in both diets, so inclusions of at least 21% CDS may be optimal, regardless of byproduct type.

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Metabolism of Finishing Diets Containing Condensed Distillers Solubles and WDGS

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Summary

A metabolism study was conducted to evaluate the effects of feeding wet distillers grains (WDGS) and condensed distillers solubles (CDS), both separately and in combination, on the metabolism characteristics of feedlot steers. Diet had no impact on nutrient digestibility. Average ruminal pH was lower for steers fed CDS than for those fed WDGS alone, and steers fed WDGS spent less time below pH 5.6 than steers fed diets with no WDGS. Inclusion of CDS decreased ruminal acetate concentration and acetate to propionate ratio compared to diets with less or no CDS.

Introduction

Previous research (*2012 Nebraska Beef Cattle Report,* pp. 64-65) indicates that relatively high levels of condensed distillers solubles (CDS) can replace a portion of corn in the diet while improving finishing performance. Additionally, distillers solubles are higher in fat, lower in protein, and competitively priced. Thus, the opportunity may exist to include CDS alone or in combination with wet distillers grain plus solubles (WDGS) in feedlot diets. Limited data have been collected on the metabolic characteristics of diets containing blends of WDGS and CDS, but previous research has shown that steers fed CDS have lower ruminal pH and greater DM digestibility than steers fed corn. Therefore, the current study was conducted to determine effects of feeding WDGS and CDS, both separately and in combination, on metabolism characteristics of steers on finishing diets.

Table 1. Dietary treatments utilizing combinations of WDGS and CDS (DM basis).

	Treatment[1]				
Ingredient, %	CON	20WDGS	27CDS	LoMix	HiMix
Dry-rolled corn	43.75	33.75	30.25	29.5	25.25
High-moisture corn	43.75	33.75	30.25	29.5	25.25
WDGS	—	20.0	—	20.0	20.0
CDS	—	—	27.0	8.5	17.0
Alfalfa Hay	7.5	7.5	7.5	7.5	7.5
Supplement	5.0	5.0	5.0	5.0	5.0
Diet					
Fat, %	4.1	5.3	7.4	6.3	7.4
NDF, %	15.3	19.5	14.2	19.2	18.9

[1]CON = corn-based control; 20WDGS = 20% wet distillers grains diet; 27CDS = 27% condensed distillers solubles diet; LoMix = 20% WDGS plus 8.5% CDS; HiMix = 20% WDGS plus 17% CDS.

Procedure

Five ruminally cannulated steers were utilized in a 5 × 5 Latin Square designed study. Steers were assigned randomly to one of five treatments (Table 1). The control (CON) diet was a dry-rolled and high-moisture corn-based diet with no byproduct. One diet contained 20% WDGS (20WDGS). Another diet contained 27% CDS (27CDS), a level found to be near the optimum inclusion in diets containing no other byproducts (*2012 Nebraska Beef Cattle Report,* pp. 64-65). The final two diets were blends of 20% WDGS and either 8.5% CDS (LoMix), or 17% CDS (HiMix). The level of CDS in HiMix blend was chosen so that CDS and HiMix diets would be isofat, with dietary fat at 7.4% of diet DM. All diets contained 7.5% alfalfa hay and Rumensin®, thiamine, and Tylan® at 300, 130, and 90 mg per steer daily, respectively.

Steers were housed in individual, slatted floor pens and fed once daily at *ad libitum* intake. The CDS fed for the entire trial were from a single load (BioFuel Ethanol Energy Corp., Wood River, Neb.) and were 36% DM, 16.6% fat, and 7.9% NDF. The WDGS used in the trial (Abengoa Bioenergy, York, Neb.) were 35% DM, 10.6% fat, and 33% NDF.

Period length was 18 days with a 13-day adaptation period. Chromic oxide (7.5 g/dose) was dosed intraruminally at 0700 and 1700 hours on days 10 to 18. Fecal grab samples were collected at 0700, 1200, and 1700 hours on days 14 to 18, composited by steer and period and used for calculation of fecal output. Fecal samples and diet ingredients were analyzed to determine intake of DM, organic matter (OM), NDF, and fat. Fecal samples were analyzed for chromium to determine DM excretion, and from this, nutrient digestibility could be calculated. Rumen fluid samples were collected at 0, 3, 6, 9, 12, and 15 hours post-feeding on day 18 and analyzed for volatile fatty acid profile. Wireless pH probes (Dascor, Inc., Escondido, Calif.) collected pH measurements continuously for the entire period, with the last 7 days used for rumen pH analysis.

Ruminal pH data were analyzed as a crossover design using the GLIMMIX procedure of SAS (SAS Inst., Inc., Cary, N.C.) , and the compound symmetry covariance structure was used with day as a repeated measure. The MIXED procedure was used to analyze intake, digestibility, and VFA profile. An unstructured covariance structure was used for VFA analysis with time as a repeated measure. Steer

Table 2. Effects of dietary treatment on intake and total tract digestibility of DM, organic matter, fat, and NDF.

Item	CON	20WDGS	27CDS	LoMix	HiMix	SEM	*P*-value
	Treatment[1]						
DM							
Intake, lb/day	27.5	26.3	25.1	27.8	28.8	2.6	0.87
Total tract digestibility, %	79.6	79.4	79.0	78.2	81.9	3.0	0.90
OM							
Intake, lb/day	25.7	24.2	23.0	25.4	26.4	2.4	0.87
Total tract digestibility, %	80.5	80.3	80.4	79.1	82.9	2.9	0.89
NDF							
Intake, lb/day	4.2[b,c]	5.1[b]	3.6[a,c]	5.3[b]	5.4[b]	0.4	0.02
Total tract digestibility, %	50.6	53.8	49.7	54.7	62.3	7.6	0.71
Fat							
Intake, lb/day	1.1a	1.4[a]	1.9[b]	1.8[b]	2.1[b]	0.1	<0.01
Total tract digestibility, %	89.0	86.9	88.1	79.0	89.5	4.4	0.46

[1]CON = corn-based control; 20WDGS = 20% wet distillers grains diet; 27CDS = 27% condensed distillers solubles diet; LoMix = 20% WDGS plus 8.5% CDS; HiMix = 20% WDGS plus 17% CDS.

Table 3. Effects of dietary treatment on ruminal pH parameters.

Item	CON	20WDGS	27CDS	LoMix	HiMix	SEM	*P*-value
	Treatment[1]						
Average pH	5.26[a]	5.55[b]	5.34[a,c]	5.48[b,c]	5.31[a,c]	0.13	0.04
Maximum pH	6.06	6.22	6.10	6.33	6.13	0.13	0.34
Minimum pH	4.79	5.02	4.89	4.93	4.83	0.12	0.16
pH change	1.33	1.25	1.27	1.45	1.27	0.11	0.66
pH variance	0.099	0.071	0.078	0.100	0.074	0.015	0.43
Time < 5.6, min/day	1153[a]	885[b,c]	1170[a]	878[b,c]	1080[a,c]	120	0.02
Area < 5.6, min/day	667[b,c]	329[a]	488[a,c]	356[a]	508[a,c]	133	0.06

[1]CON = corn-based control; 20WDGS = 20% wet distillers grains diet; 27CDS = 27% condensed distillers solubles diet; LoMix = 20% WDGS plus 8.5% CDS; HiMix = 20% WDGS plus 17% CDS.

Table 4. Effects of dietary treatment on rumen volatile fatty acid parameters.

Item	CON	20WDGS	27CDS	LoMix	HiMix	SEM	*P*-value
	Treatment[1]						
Total, mM	116.0	115.8	124.7	108.5	117.6	7.7	0.70
Acetate, mol/100 mol	50.9[a]	51.3[a]	47.0[b,c]	53.4[a]	49.7[a,c]	1.6	0.09
Propionate, mol/100 mol	33.9	35.5	36.9	28.8	36.8	3.0	0.31
Butyrate, mol/100 mol	9.7	8.8	8.8	11.9	11.5	2.2	0.78
Acetate:Propionate	1.66	1.79	1.39	1.91	1.34	0.22	0.32

[1]CON = corn-based control; 20WDGS = 20% wet distillers grains diet; 27CDS = 27% condensed distillers solubles diet; LoMix = 20% WDGS plus 8.5% CDS; HiMix = 20% WDGS plus 17% CDS

was treated as a random effect for all analyses. Treatment differences were considered significant at $P \leq 0.10$.

Results

No differences due to treatment were observed for DMI or OM intake; however, intakes were numerically highest for steers fed HiMix and lowest for steers fed 27CDS. Intake of NDF was greater for steers fed diets containing WDGS than for steers fed CON and 27CDS diets ($P = 0.02$), due to the higher NDF content in WDGS. Similarly, fat intake was higher for steers fed diets containing CDS than for steers fed CON and 20WDGS diets, due to the high fat content of CDS. Treatment had no effect on digestibility of DM, OM, NDF, or fat (Table 2).

Average ruminal pH was lower for steers fed diets containing CDS than for steers fed WDGS alone ($P = 0.04$). Likewise, steers fed diets not containing WDGS spent a greater amount of time below pH 5.6 than steers whose diets included WDGS (Table 3). Ruminal concentration of acetate was lower for steers fed higher levels of CDS (27CDS and HiMix) than for steers fed WDGS only. While concentration of propionate was not impacted by diet, acetate to propionate ratio was numerically lower for steers fed diets with the highest CDS inclusions (27CDS and HiMix), indicating a slight shift away from acetate production (Table 4).

These data suggest that feeding a combination of 20% WDGS and up to 17% CDS, or 27% CDS alone, has no impact on digestibility of the ration and is a viable option to replace a portion of dry-rolled and high-moisture corn in finishing diets.

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Wet Distillers Grains and Ratios of Steam-Flaked and Dry-Rolled Corn

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Summary

Feeding different ratios of dry-rolled corn (DRC) and steam-flaked corn (SFC) in diets that contain 0 or 35% wet distillers grains plus solubles (WDGS) was evaluated. As SFC replaced DRC in diets containing no WDGS, F:G improved. Varying SFC and DRC ratio in diets containing 35% WDGS did not impact F:G. Feeding WDGS increased hot carcass weight, and fat depth while feeding different ratios of corn impacted marbling deposition. Wet distillers grains appears to reduce the positive impacts of feeding SFC in finishing diets when included at 35% of diet DM.

Introduction

Numerous studies have examined effects of feeding wet distillers grains plus solubles (WDGS) in combination with steam-flaked corn (SFC). Results from one of those studies indicated an interaction between SFC and WDGS (2007 *Nebraska Beef Cattle Report*, pp. 33).

Few data exist examining effects of feeding combinations of corn processed by different methods fed with WDGS. Therefore, the objective of the current study was to determine effects of feeding different ratios of dry-rolled corn (DRC) and SFC in diets that contain 35% (DM) WDGS on finishing performance and carcass characteristics.

Procedure

Yearling British x Continental steers (n = 480; initial BW = 779±51 lb) were used in an experiment conducted at the University of Nebraska–Lincoln (UNL) Panhandle research feedlot. Prior to the start of the experiment, cattle were given Bovi-Shield® Gold, Vision® 7, Safe-Guard®, Revalor® XS, and an electronic and visual ID. Cattle were limit fed (2% of BW) a 50% forage, 50% WDGS diet for a total of five days before the initiation of the trial. Steers were individually weighed two consecutive days (day 0 and day 1) after the limit feeding period to obtain an initial BW. Cattle were stratified by BW within three weight block (light, medium, and heavy) and assigned randomly to 40 pens (12 steers/pen). Dietary treatments (n = 10; four replications) were assigned randomly to pens within BW block. Treatments were ratio of SFC:DRC (SFC:DRC 0:100, 25:75, 50:50, 75:25, 100:0, % of corn DM) with or without 35% (DM) WDGS. Cattle were individually weighed at the end of the trial. Carcass adjusted performance was calculated using carcass weights adjusted to a common dressing percentage of 63%. Cattle were on feed for 160 days.

Incremental percentages of corn

Table 1. Experimental diets (DM basis).

	SFC:DRC									
	0 WDGS					35% WDGS				
Ingredients	100:0	75:25	50:50	25:75	0:100	100:0	75:25	50:50	25:75	0:100
DRC[1]	—	20.4	40.7	61.1	81.47	—	12.1	24.3	36.4	48.5
SFC[2]	81.47	61.1	40.7	20.4	—	48.5	36.4	24.3	12.1	—
WDGS[3]	—	—	—	—	—	35	35	35	35	35
Corn Silage	7	7	7	7	7	7	7	7	7	7
Alfalfa	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
Urea	1.07	1.07	1.07	1.07	1.07	—	—	—	—	—
SBM	2.03	2.03	2.03	2.03	2.03	—	—	—	—	—
Supp.[4]	6	6	6	6	6	6	6	6	6	6
Lab Analyzed Nutrient Composition										
CP %	12.3	12.2	12.2	12.2	12.2	16.1	16.1	16.1	16.1	16.1
NDF %	12.6	12.3	12.0	11.8	11.5	22.6	22.4	22.3	22.1	21.6
Fat %	2.8	2.8	2.9	2.9	3.0	5.6	5.6	5.6	5.7	5.7
Starch %	61.5	61.5	61.4	61.4	61.3	37.6	37.6	37.7	37.6	37.5
S %	0.12	0.13	0.13	0.13	0.13	0.26	0.26	0.26	0.27	0.27
Formulated Nutrient Composition										
Ca %	0.61	0.61	0.61	0.61	0.61	0.68	0.68	0.68	0.68	0.68
P %	0.29	0.29	0.29	0.29	0.29	0.47	0.47	0.47	0.47	0.47
K %	0.65	0.65	0.65	0.65	0.65	0.73	0.73	0.73	0.73	0.73

[1]DRC=dry-rolled corn.
[2]SFC=steam-flaked corn.
[3]WDGS=wet distillers grains plus solubles.
[4]Formulated to provide 30 g/ton Rumensin and 90 mg/steer/day Tylan®.

Table 2. Effect of corn processing ratio and wet distillers grains with solubles (WDGS) on finishing performance.

	0 WDGS					35 WDGS					*P*-value		
Item	0:100	25:75	50:50	75:25	100:0	0:100	25:75	50:50	75:25	100:0	W x R	WDGS	SFC:DRC[1]
Carcass Adjusted Data													
Initial BW, lb	778	776	781	780	779	783	774	779	781	778	0.80	0.89	0.45
Final BW, lb	1392	1405	1404	1424	1397	1483	1443	1466	1463	1450	0.17	<0.01	0.37
DMI, lb/day	25.3	24.8	23.7	24.1	23.0	25.9	25.2	25.6	25.4	24.4	0.15	<0.01	<0.01
ADG, lb/day	4.30	4.40	4.37	4.50	4.33	4.90	4.68	4.79	4.77	4.70	0.13	<0.01	0.43
F:G	5.88	5.62	5.43	5.35	5.29	5.29	5.41	5.35	5.32	5.18	0.03[2]	<0.01[2]	<0.01[2]

[1]SFC:DRC = steam-flaked corn:dry-rolled corn.
[2]*P*-value calculated from G:F.

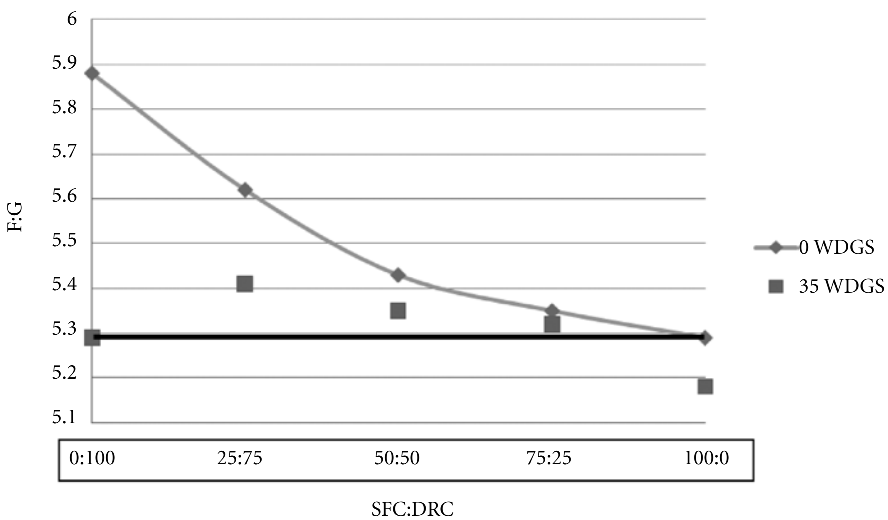

Figure 1. Effect of corn processing ratio and wet distillers grains with solubles (WDGS) on feed efficiency. Data indicate an interaction (*P* = 0.03) between WDGS and ratio. Both WDGS and steam-flaked corn:dry-rolled corn (SFC:DRC) impacted F:G (*P* < 0.01). A cubic and quadratic effect (*P* < 0.01) due to SFC:DRC was detected for F:G.

grain (SFC:DRC) replaced alfalfa hay during a 21-day period to acclimate cattle to the final finishing diet. The SFC utilized in the current study was procured from a local commercial feedlot (Panhandle Feeders, Morrill, Neb.) and was shipped into the Panhandle research feedlot three times weekly. Bushel weight and DM measurements were taken on each load of SFC. The average flake density for SFC utilized in the current feeding trial was 31.5 lb/bu. Steam-flaked corn was processed by a Ferrell-Ross mill which utilized 18 x 36 in. corrugated rollers. The experimental diets (Table 1) consisted of 7% corn silage, 3.5% alfalfa hay, 6% liquid supplement (DM basis), and varying proportions of SFC and DRC. Soybean meal (2.03%) and urea (1.07% DM) were included in the diet in order to meet the metabolizable protein needs with 0% WDGS.

Cattle were divided into two separate slaughter groups and slaughtered at a commercial abbatoir (Cargill, Fort Morgan, Colo.). Hot carcass weight and liver score data were collected on the day of slaughter. Carcass 12th rib fat, calculated yield grade, percentage of PYG, marbling score and LM area were recorded following a 48-hour chill. Yield grade was calculated using the USDA yield grade equation (yield grade = 2.5 + 2.5 (Fat thickness, in.) – 0.32 (LM area, in^2) + 0.2 (KPH fat, %) + 0.0038 (hot carcass weight, lb).

Intake variation was measured across week for each pen. Measurements were taken over a 13 week period. Since bushel weight measurements were collected on each load of SFC (n = 39) delivered to the feed yard, the relationship between bushel weight variation and DMI variation was also analyzed.

Animal performance, DMI variance, and carcass data were analyzed using the mixed procedure of SAS (SAS Inst. Inc., Cary, N.C.) as a randomized complete block design with pen serving as the experimental unit. Factors included in the model were corn processing ratio, WDGS, corn processing ratio x WDGS, with BW block as a fixed variable. If the corn processing ratio x WDGS interaction was significant (*P* < 0.05), simple effect means and *P*-values were reported and if a significant interaction was not detected, only main effect means and *P*-values were reported. Orthogonal contrasts were used to detect linear, quadratic, cubic, or quartic effects of corn processing ratio. The Proc Glimmix procedure of SAS was used for determining differences in liver score data.

Results

There was a significant corn processing ratio x WDGS interaction for carcass adjusted F:G (*P* = 0.03; Table 2). Steers fed diets containing WDGS exhibited heavier final BW, greater ADG, and DMI (*P* < 0.01). Gain for steers fed diets containing no WDGS tended (*P* = 0.07) to increase linearly as SFC replaced DRC. Feed conversion improved quadratically (*P* < 0.01) as SFC replaced DRC in diets containing no WDGS (Figure 1). In this study, the numerically optimal ADG for cattle fed corn diets with no WDGS appeared to be diets with 75% SFC, 25% DRC (% of corn DM). Cattle

(Continued on next page)

Table 3. Effect of corn processing ratio and wet distillers grains with solubles (WDGS) on carcass characteristics.

Item	SFC:DRC[1]					WDGS		SEM	P-value[2]		
	100:0	75:25	50:50	25:75	0:100	0	35		WxR	WDGS	SFC:DRC
Carcass Data											
HCW, lb	897	909	904	897	906	885	920	7.7	0.17	<0.01	0.42
Marbling[3,4]	538	555	540	558	569	556	547	11.8	0.65	0.22	0.06
12th rib fat, in	0.64	0.65	0.63	0.64	0.62	0.62	0.65	0.02	0.83	0.01	0.54
LM area, in^2	13.0	13.1	13.0	12.9	13.0	13.1	12.9	0.19	0.51	0.25	0.96
Yield grade[5]	3.74	3.82	3.78	3.77	3.77	3.63	3.91	0.07	0.70	<0.01	0.89
PYG[6]	3.59	3.61	3.60	3.59	3.60	3.54	3.65	0.03	0.61	<0.01	0.94
Liver Score											
A	10.42	2.13	9.57	11.46	5.38	7.98	8.05				
A+	6.25	2.13	1.06	4.17	2.15	3.36	2.97		0.14	0.95	0.06
0	83.33	95.74	89.36	84.38	92.47	88.61	88.98				

[1]SFC:DRC = steam-flaked corn:dry-rolled corn.
[2]P-values for liver score data were generated in Glimmix and came from the protected F test.
[3]Marbling score: 400 = Slight, 450 = Slight50, 500 = Small.
[4]Linear effect of SFC:DRC ratio (P = 0.02).
[5]Calculated as 2.50 + (2.5*fat depth, in) - (0.32*LM Area, in^2) + (0.2*2.5 KPH) + (0.0038*HCW, lb).
[6]PYG = Preliminary yield grade.

fed diets containing all SFC with no WDGS experienced a 12.3% improvement in F:G compared to steers fed all DRC and no WDGS. This response in F:G is fairly typical. Feed conversion was not different ($P > 0.05$) across the different corn processing ratios for cattle fed WDGS; however, steers fed diets with all SFC had 4.3% better feed conversion compared to cattle fed all DRC with WDGS.

There were no corn processing ratio x WDGS interactions ($P = 0.14$) for carcass characteristics (Table 3). Cattle receiving the 35% WDGS treatment diets had heavier carcasses (920 lb; $P < 0.01$) compared with steers that were fed no WDGS (885 lb). Marbling was not impacted by WDGS ($P = 0.22$). Cattle fed WDGS diets had greater back fat thickness ($P = 0.01$) compared with cattle fed 0 WDGS. Steers consuming finishing rations with 35% WDGS had greater calculated yield grade and preliminary yield grade ($P < 0.01$) compared with cattle fed control diets with no WDGS. Data indicate no effect ($P = 0.95$) of WDGS inclusion on liver abscesses. Marbling increased linearly as DRC replaced SFC ($P = 0.02$). Fat depth was unchanged ($P = 0.54$) across the different corn processing ratios. There was a tendency for cattle fed diets containing DRC to have numerically ($P = 0.06$) less severe abscessed livers (A+, adhered) compared with cattle fed rations with 100% SFC. This is likely due to a dilution effect of DRC in reducing the level of highly fermentable starch coming from SFC and presumably acidosis. Longissimus muscle area was not different for cattle fed WDGS or among corn processing ratios.

No interaction ($P = 0.95$) between corn processing ratio and WDGS was observed for DMI variation. As SFC replaced DRC, intake variation was not different ($P = 0.73$) across the different corn processing ratios. Lack of intake variation suggests that flaking had little impact on inducing subacute acidosis. In this study, simple correlation between SFC bushel weight variance and intake variance was measured. Steam-flaked corn bushel weight averaged 31.5 lb/bu and had an average weekly standard deviation of 1.6 lb with a minimum flake density of 27.5 lb/bu and a maximum of 34.5 lb/bu. There was a very low correlation ($r \leq 0.17$) between SFC bushel weight variance and intake variance. Most of the bushel weight variation was attributed to two loads of SFC (27.5 lb/bu) that were delivered on two consecutive loads and were fed over a five-day period. Intakes for all SFC treatments during this five-day period did not decrease in response to the more heavily processed SFC. Cattle fed diets containing 35% WDGS experienced less DMI variation ($P < 0.01$; 0.39 lb) than steers fed diets without WDGS (0.64 lb), which would suggest that steers fed WDGS experienced lower incidence of acidosis compared with steers not fed WDGS.

In summary, an interaction between corn processing ratio and WDGS occurred. Including WDGS in the finishing ration increased final BW, ADG, and DMI. Also, feed conversion was significantly improved by the addition of 35% WDGS in the diet. Feed conversion improved 4.3% when cattle were fed all SFC and 35% WDGS compared to steers fed all DRC and 35% WDGS. Cattle fed 0 WDGS experienced a quadratic improvement in F:G which resulted in a positive associative effect. The reason why F:G responded quadratically in steers fed diets with no WDGS is likely due to the reduction of acidosis by the addition of DRC which is less prone to induce sub-acute acidosis than SFC.

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Effect of Corn Processing on Feedlot Steers Fed Sugarbeet Pulp

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Summary

Impact of feeding three levels of beet pulp (0, 10, 20%, DM basis) with either dry-rolled corn (DRC) or steam-flaked corn (SFC) in feedlot rations was evaluated. Final BW, DMI, and ADG decreased linearly as beet pulp replaced corn in the diet. Beet pulp linearly decreased HCW, 12th rib fat, and yield grade. Corn processing had no impact on carcass characteristics. Feeding SFC improved F:G, compared to feeding DRC. The inclusion of beet pulp in the diet did not impact F:G, however, because of the decrease of both DMI and ADG.

Introduction

Pressed beet pulp (24% DM, 9.5% CP, DM basis), has a relatively high level of fiber (44% NDF, DM basis) remaining after extraction of sugars from beets (*Journal of Animal Science*, 85:2290-2297). The fiber fraction of sugarbeet pulp is highly digestible and has been shown to be a very effective corn silage substitute in growing diets (1992 *Nebraska Beef Cattle Report*, p. 24; 1993 *Nebraska Beef Cattle Report*, p. 48; 2000 *Nebraska Cattle Beef Report*, p. 36). However, results from finishing studies where beet pulp replaced corn (dry rolled or high moisture) indicate beet pulp may be a better corn silage substitute than a corn replacement (*1993 Nebraska Beef Cattle Report,* pp. 48-49; *2001 Nebraska Beef Cattle Report,* pp. 67-68; *Journal of Animal Science*, 2007, 85:2290-2297). Data are limited on how corn processing method interacts with the feeding of beet pulp. The objectives of this experiment were to determine the effects of feeding different levels of beet pulp in combination with dry-rolled corn (DRC) or steam-flaked corn (SFC) on finishing performance and carcass characteristics.

Procedure

In the current study, 432 yearling British x Continental steers (initial BW = 690 ± 54 lb) were used in an experiment conducted at the University of Nebraska–Lincoln (UNL) Panhandle Research and Extension Center Panhandle Research Feedlot. Prior to the start of the experiment, cattle were given Bovi-Shield® Gold, Vision® 7, Ivomec, electronic and visual ID, and branded. Cattle were limit fed (2% of BW) a 50% forage, 50% distillers grains diet for five days before the initiation of the trial in an effort to reduce variation in gut fill at time of weighing. Steers were individually weighed two consecutive days (day 0 and day 1) after the limit feeding period to obtain an initial BW. On day 0 (11/30/10) cattle were implanted with Component® TE-IS and were vaccinated with Somubac®. Cattle were stratified by BW within respective weight block (three blocks: Light, Medium, and Heavy) and assigned randomly to 36 pens (12 steers/pen). Steers were reimplanted with Component® TE-S 72 days after initial implant. Six dietary treatments (n = 6; six replications) were assigned randomly to pens within weight blocks. A randomized complete block design was used with a 2x3 factorial treatment structure. The first factor was corn source which consisted of either SFC or DRC, and the second factor was level of beet pulp inclusion (0, 10, 20% DM).

A 21-day grain adaptation period was used, in which incremental percentages of corn (SFC or DRC, dependent upon treatment) replaced alfalfa hay to allow cattle to become acclimated to the final finishing diet. Beet pulp inclusion levels remained constant from day 1 of the adaptation period until the end of the finishing trial. The SFC was processed off-site at a local commercial feedlot (Panhandle Feeders, Morrill, Neb.; target flake density of 27-28 lb/bu) and was shipped to the Panhandle Research Feedlot three times weekly (Monday, Wednesday, and Friday). The experimental diets (Table 1) consisted of 15% corn silage, 20% wet distillers grains with solubles, 6% liquid supplement (DM basis), and varying proportions of SFC or DRC. Beet pulp was included in both the DRC and SFC based diets at 0, 10, or 20% (DM) respectively, replacing corn. Urea was supplemented to both DRC (0.30% DM) and SFC (0.40% DM) diets to meet degradable intake protein requirements. The liquid supplement was formulated to provide 360 mg/steer/day Rumensin and 90 mg/steer/day Tylan.

Cattle were individually weighed at the end of the trial. Carcass adjusted performance was calculated using carcass weights adjusted to a common dressing percentage of 63%.

Cattle were split up into two

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Table 1. Experimental diets (DM).

	DRC			SFC		
Ingredients	0	10	20	0	10	20
DRC[1]	59.0	49.0	39.0	—	—	—
SFC[2]	—	—	—	59.0	49.0	39.0
Beet Pulp	—	10.0	20.0	—	10.0	20.0
WDGS[3]	20.0	20.0	20.0	20.0	20.0	20.0
Corn Silage	15.0	15.0	15.0	15.0	15.0	15.0
Supp.[4]	5.7	5.7	5.7	5.6	5.6	5.6
Urea	0.3	0.3	0.3	0.4	0.4	0.4
Nutrient Composition						
CP%	12.5	12.7	12.9	12.7	12.9	13.1
Fat%	4.5	4.2	3.9	4.2	4.0	3.8
Ca%	0.57	0.64	0.70	0.57	0.64	0.71
P%	0.35	0.34	0.32	0.34	0.33	0.31
S%	0.14	0.15	0.15	0.14	0.15	0.15

[1]DRC = dry-rolled corn.
[2]SFC = steam-flaked corn.
[3]WDGS = wet distillers grains with solubles.
[4]Formulated to provide 360 mg/steer/day Rumensin and 90 mg/steer/day Tylan.

Table 2. Effect of corn processing method and sugarbeet pulp level on finishing performance.

	DRC			SFC				*P*-value[1]		
Item	0	10	20	0	10	20	SEM	Corn Type	Level	CxL
Carcass Adjusted Data										
Initial BW, lb	690	689	690	692	692	689	4.8	0.74	0.89	0.83
Final BW, lb[2]	1314	1296	1259	1306	1305	1279	15.2	0.42	<0.01	0.46
DMI, lb/day[2]	23.5	22.7	21.4	22.6	22.0	21.6	0.3	0.03	<0.01	0.07
ADG, lb/day[2]	3.72	3.63	3.41	3.68	3.67	3.53	0.08	0.42	<0.01	0.35
F:G[3]	6.30	6.24	6.29	6.15	6.01	6.11	0.117	<0.01	0.49	0.86

[1]Corn type = main effect of corn processing method, Level = main effect of beet pulp level, CxL = simple effect of the corn processing method x beet pulp level interaction.
[2]Linear effect of beet pulp concentration ($P < 0.01$).
[3]Statistically analyzed as G:F, the reciprocal of F:G.

Table 3. Effect of corn processing method and sugarbeet pulp level on carcass characteristics.

	DRC			SFC				*P*-value[1]		
Item	0	10	20	0	10	20	SEM	Corn Type	Level	CxL
Carcass Data										
HCW, lb[1]	828	817	793	823	822	806	9.6	0.44	<0.01	0.47
Marbling[2]	572	591	578	586	570	563	12.2	0.34	0.52	0.13
12th rib fat, in1	0.61	0.57	0.55	0.60	0.59	0.56	0.02	0.44	<0.01	0.63
LM area, in^2	12.3	12.5	12.3	12.5	12.6	12.3	0.17	0.36	0.20	0.82
Yield Grade[1,3]	3.60	3.43	3.33	3.55	3.47	3.42	0.10	0.68	0.02	0.61

[1]Linear effect of beet pulp concentration ($P < 0.01$).
[2]Marbling score: 400 = Slight, 450 = Slight50, 500 = Small.
[3]Calculated as 2.50 + (2.5*fat depth, in) - (0.32*LM Area, in^2) + (0.2*2.5 KPH) + (0.0038*HCW, lb).

separate groups (group 1, heavy; group 2, medium and light) and slaughtered at a commercial abattoir on day 154 and d 174. Hot carcass weight (HCW) data were collected on the day of slaughter. Carcass 12th rib fat, calculated yield grade (YG), preliminary YG, marbling score and longissimus (LM) area were recorded following a 48-hour carcass chill. Yield grade was calculated using the USDA YG equation (YG = 2.5 + 2.5 (Fat thickness, in) – 0.32 (LM area, in^2) + 0.2 (KPH fat, %) + 0.0038 (HCW, lb).

Animal performance and carcass data were analyzed using the Glimmix procedure of SAS (SAS Inst., Inc., Cary, N.C.) as a randomized complete block design with pen serving as the experimental unit. Factors included in the model were corn processing, beet pulp level, corn processing x beet pulp level, with BW block as a random variable. If the corn processing x beet pulp level interaction was significant ($P < 0.05$), simple effect *P*-values were reported, and if a significant interaction was not detected, only main effect *P*-values were reported. Orthogonal contrasts were used to detect linear and quadratic effects of beet pulp level across both corn processing types when no significant interaction existed and within corn processing when a significant interaction was present.

Results

No significant corn processing x beet pulp interaction was detected for the carcass adjusted finishing performance data (Table 2). Final BW decreased linearly ($P < 0.01$) as level of beet pulp increased in the diet. Dry matter intake decreased linearly ($P < 0.01$) as beet pulp inclusion level increased in both DRC and SFC based diets. Gain decreased linearly ($P < 0.01$) with increasing levels of beet pulp in both DRC and SFC finishing diets. However, F:G was not different ($P = 0.49$) among levels of beet pulp in the finishing diet. The inclusion of 20% beet pulp in DRC based diets decreased ADG by 9.1% compared to diets without beet pulp. In SFC diets the inclusion of 20% beet pulp decreased ADG 4.2%. The lack of difference in F:G is likely due to the fact that the change in magnitude for DMI (9.8 and 4.6%, for DRC and SFC, respectively) was similar to the change noted for ADG (9.1 and 4.2%, for DRC and SFC).

Cattle fed DRC based diets had greater DMI ($P = 0.03$) compared to cattle fed diets containing SFC. Also, feed conversion was improved ($P < 0.01$) for cattle consuming diets containing SFC compared to diets with DRC as the grain source.

Similar to finishing performance, no corn processing x beet pulp interaction was detected for carcass data (Table 3). Since carcass adjusted final BW decreased with increasing levels of beet pulp supplementation, HCW also decreased ($P < 0.01$) linearly. Marbling and LM area were not impacted ($P = 0.13$) by corn processing method or by the inclusion of beet pulp in the finishing diet. Yield grade, and 12th rib fat thickness decreased linearly ($P < 0.01$) as beet pulp increased in the diet. Corn processing did not impact ($P > 0.17$) carcass characteristics.

In summary, the inclusion of beet pulp in the finishing diet decreased DMI and ADG in both DRC and SFC diets. Since there was a concomitant decrease in DMI and ADG, feed conversions were not different, which resulted in estimates for the calculated dietary energy content to be similar among beet pulp levels (data not shown). As beet pulp level increased in the diet, fat deposition (YG and fat thickness) decreased. Feed conversion was improved when DRC was replaced with SFC, which is a common response when comparing the two corn processing methods.

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Distillers Grains With Solubles and Ground Ear Corn in Feedlot Diets

Terry L. Mader[1]

Summary

In a 162-day finishing study, steers were fed various levels of dried distillers grains with solubles (DGS) with ground ear corn harvested at 45% moisture, and compared with steers fed 25% DGS, rolled corn, and corn silage. Steers fed the highest level of DGS (37.5% of diet DM) with ground high-moisture ear corn had the lowest ADG and DMI, but F:G tended to be improved by feeding 25% and 37.5% DGS with ear corn as compared with feeding rolled corn plus corn silage. Feed cost of gain (COG) and total COG was most favorable (4.4% lower than control) for cattle fed the 25% DGS plus 35% ear corn diet.

Introduction

High moisture ground ear corn is one example of an alternative source of both energy and roughage for feedlot cattle. Ground ear corn can be harvested with a silage chopper equipped with a snapper head (called snaplage) or harvested with a combine modified to save a large portion of the cob but removing the husk and shank. High-moisture ear corn has several advantages: 1) increased yield from harvesting early, 2) increased feed value associated with fermentation, and 3) its inherent roughage that can replace forages typically added to diets for growing and finishing cattle. However, storage for the fermented feedstuffs is required. In general, the value of high-moisture ear corn has been defined (NRC, 2000), but when fed with dry distillers grains plus solubles (DGS), its value has not been determined.

Procedure

From a group of 235 steers, 156 head of the medium and heavy weight groups were selected. Prior to trial initiation, cattle were implanted (Revalor®-XS), revaccinated (Vision® 7), and fed a common ration at 95% *ad libitum* for five days. The steers subsequently were weighed and allocated to one of two 12-pen blocks (12 pens of seven steers/pen, and 12 pens of six steers/pen). Based on mean pen weight, within a block, diet treatments were assigned randomly to the pens. Diet treatments included high moisture ear corn harvested at 55% DM and fed at 35% of DM in combination with various levels (12.5; 25, and 37.5%) of DGS (Table 1). In addition, a typical DGS-dry rolled corn-corn silage diet was utilized as a control diet. Dry matter intake was recorded daily for the duration of the 162-day study. An intermittent weight was taken on day 64. At slaughter, carcass tags were matched to ID tags and carcass data were collected. Final weight was calculated from hot carcass weight using a dressing percentage of 63%. One animal was removed from the trial due to reasons unrelated to treatment.

Table 1. Rations containing dry distillers grains plus solubles (DGS) and high-moisture ground ear corn.

Ingredient	DGS25Control	DGS12.5	DGS25	DGS37.5
DGS	25	12.5	25	37.5
Rolled corn	53	47.5	35	22.5
Ground ear corn	0	35	35	35
Corn silage	17	0	0	0
Liquid supplement	5	5	5	5

Results

The study was conducted during the winter of 2009-10, which was one of the worst winters for feeding cattle in northeast Nebraska since the 1980s. Steers fed the highest level of DGS with ground, high- moisture ear corn had the lowest ($P < 0.01$) 64-day and overall ADG and the lowest DMI (Table 2). However, F:G tended ($P = 0.06$) to be improved by feeding 25% and 37.5% DGS with ear corn. When compared among diets containing 25% DGS, steers fed ear corn ate less feed and gained slower than cattle fed dry-rolled corn plus silage ($P < .05$), but their F:G was 6.5% superior. Relative to the control group, DMI and ADG were depressed more during the first 64 days by feeding the high moisture ear corn when compared with the remaining 98 days on feed, but the F:G advantage was quite similar for both parts of the feeding trial (7.5% early versus 5.5% later). The percentage of cattle grading choice and prime among steers fed high-moisture ear corn was greatest (97.3%) for the 12.5% DGS diet group and lowest (53.8%) in the 37.5% DGS diet group. Feed cost of gain (COG) and total COG was most favorable (4.4% lower than control) for cattle fed the 25% DGS plus 35% ear corn diet.

High-moisture ground ear corn has generally had a feed value comparable to feeding approximately 75% high moisture corn with 25% roughage, although in some trials, high-moisture ear corn without husk or shank has had a feeding value (ME or NEg) between 96 and 100% of high-moisture corn grain (*www.ansi.okstate.edu/research/research-reports-1/1995/1995-1%20Hills.pdf*). The relatively high feed value of ear corn combined with an approximate 20% greater dry matter yield per acre markedly increases return per acre of grain harvested. In the current study, the combination of 25% DGS

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with 35% ground high moisture ear corn appeared to produce the greatest complementary effects.

However, the enhanced feed value was associated with a linear ($P < 0.01$) decline in DMI as the % of ear corn increased. Both of these effects could be due to the high moisture (45%) of the ear corn and the high digestibility attributed to the early harvest, processing and fermentation of the fiber (cob, husks, etc.). In addition, rumen microbes, which complement the digestion of fiber in DGS, are quite similar to the microbes that digest fiber of the ear corn. Even though the digestion rate may have been lower, as evidenced from lower DMI, the extent of digestion appeared to be enhanced by feeding DGS with ear corn vs. with dry-rolled corn grain. The larger and potentially more homogenous microbial population in the rumen may have contributed to the enhanced feed value associated with feeding DGS and ear corn together. Thus, feeding high-moisture ear corn with DGS potentially enhances the feeding value of the combined ingredients over feeding DGS with corn in a feedlot finishing diet; however, duration of feeding period may need to be extended to compensate for the slower ADG for cattle fed ear corn.

Based on net energy calculations using observed DMI and ADG, net energy values for the four diets were 60, 61, 65, and 67 mcal NEg/cwt of dry matter. Assuming the NEg value of dry corn and DGS were constant, the NEg of the high moisture ear corn in these diets were 62, 69, and 73 mcal/cwt, respectively for the 12.5, 25 and 37.5% ear corn diets. Feeding value of the ear corn was superior to the combination of dry-rolled corn plus silage and combining more DGS with high moisture ear corn increased the value of the ear corn, the DGS, or both.

Table 2. Animal performance and cost of gain (COG) for cattle fed DGS and high-moisture ground ear corn (EC).

	Control DGS25	ECDGS12.5	ECDGS25	ECDGS37.5	*P*-value
Init. wt, lb	794	797	790	798	0.97
Final wt[1]	1,362	1,327	1,316	1,296	0.08
64 d ADG, lb	3.60[a]	3.45[ab]	3.27[b]	2.83[c]	<0.01
64-162 day ADG, lb	3.45	3.15	3.23	3.24	0.29
162 d ADG, lb	3.51[a]	3.27[b]	3.24[b]	3.07[c]	<0.01
64 d DMI, lb/day	22.56[a]	20.61[ab]	18.94[b]	17.35[c]	<0.01
64-162 day DMI, lb/day	21.03[a]	19.86[b]	18.64[bc]	17.78[c]	<0.01
162 d DMI, lb/day	21.63[a]	20.15[b]	18.76[c]	17.61[d]	<0.01
64 day F:G	6.29	6.02	5.82	6.21	0.25
64-162 day F:G	6.13	6.39	5.79	5.52	0.07
162 day F:G	6.19	6.17	5.79	5.74	0.06
USDA yield grade	2.66	2.61	2.55	2.44	0.44
USDA choice/prime	82.1	97.3	74.4	53.8	0.01
Feed (COG, $/cwt)[2]	62.42	61.72	57.35	56.28	—
Total (COG, $/cwt)[2]	83.23	84.02	79.56	79.7	—
% change	0	0.95	-4.41	-4.24	—

[abcd]Means with different superscripts differ ($P < 0.05$).
[1]Adjusted to 63% dress.
[2]Ear corn prices at 80% of the value of rolled corn on a DM basis.

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Feeding Field Peas in Finishing Diets Containing Wet Distillers Grains Plus Solubles

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Summary

A finishing study was conducted to evaluate the effects of feeding 0 or 20% field peas in dry-rolled corn-based diets with 0 or 30% wet distillers grains plus solubles (WDGS). There was an interaction for DMI, in which WDGS had no effect in diets without peas, but increased DMI by 2.7 lb in diets containing peas. Peas decreased DMI by 1.3 lb in diets with no WDGS but had no effect on DMI in diets containing WDGS. A peas × WDGS interaction also was observed for F:G with WDGS decreasing F:G by 12% in diets without peas, but having no impact in diets containing peas. Field pea inclusion decreased F:G by 4% in diets with no WDGS, but increased F:G by 4% when WDGS was present. The impact of WDGS on F:G was diminished in the presence of peas from 40% to 24% improvement relative to corn. However, the increase in ADG due to WDGS was similar with or without peas.

Introduction

Field pea production is increasing in the Northern Plains (NASS, 2009). The portion of the crop that does not meet quality standards for human consumption can be priced competitively enough to be utilized as a livestock feed. Previous research has focused on increasing inclusion of field peas in corn-based diets in which field pea inclusion has resulted in either no impact (*2005 Nebraska Beef Cattle Report,* p. 49), or a decrease in F:G. To date, no research has evaluated the impact of combining field peas with grain milling co-products in finishing diets, even though the majority of cattle on feed are being fed diets that take advantage of the availability and relatively high feeding value of distillers grains. Thus, the objective of this study was to determine the effects of feeding field peas as a partial replacement for corn in diets that contain WDGS, and to evaluate whether the two feeds interact with one another.

Procedure

Three hundred fifty-two crossbred steers (BW = 783 ± 59 lb) were received from multiple sources and used in a RCBD experiment at the University of Nebraska–Lincoln (UNL) Panhandle Research and Extension Center feedlot located near Scottsbluff, Neb. Cattle were bought from area ranches and fed a common maintenance diet until trial initiation. After receiving, steers were limit fed for five days, then weighed on day 0 and day 1 to determine initial BW. Animals were then blocked by BW into four blocks, stratified by BW within block, and assigned randomly to pen within strata. Treatments were assigned randomly to 32 open pens, with eight pens per treatment and 11 steers per pen. Treatments were arranged in a 2 × 2 factorial arrangement with one factor being presence or absence of 20% whole grain field peas and the other being presence or absence of 30% WDGS (DM basis, Table 1). Field peas and WDGS replaced dry-rolled corn in the diets.

Steers were implanted on day 1 with Revalor®-XS (Intervet, Millsboro, Del.) and then fed for either 140 or 159 days, depending on BW block. Cattle were harvested at Cargill Meat Solutions (Fort Morgan, Colo.),where HCW, LM area, 12th rib fat thickness, and marbling score were collected. Final BW and growth performance measures were calculated using a common dressing percent of 63%. Live final BW and dressing percent were calculated from live individual weights.

Weekly feed ingredient samples were collected, composited, and analyzed for nutrient composition. The nutrient composition (DM basis) of field peas used in this study was: 89.6% DM, 23.4% CP, 14.0% NDF, 1.2% crude fat, 49.7% starch, and 0.24% sulfur. Distillers grains used in this study was: 33.1% DM, 30.9% CP, 37.4% NDF, 10.9% crude fat, and

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Table 1. Diet composition and nutrient analysis for diets containing 0% or 20% field peas and 0% or 30% WDGS.[1, 2]

	0 Peas		20 Peas	
Item	0 WDGS	30 WDGS	0 WDGS	30 WDGS
Ingredient				
DRC	86.5	56.5	66.5	36.5
Field Peas	—	—	20.0	20.0
WDGS	—	30.0	—	30.0
Alfalfa Hay	7.5	7.5	7.5	7.5
Urea	1.1	—	0.4	—
Supplement[3]	4.9	6.0	5.6	6.0
Analyzed Composition, %				
CP	11.5	15.2	12.6	18.2
NDF	10.7	19.7	12.0	21.0
Crude Fat	2.8	5.1	2.4	4.7

[1]Values presented on a DM basis.
[2]WDGS = wet distillers grain with solubles; Peas = field peas; DRC = dry-rolled corn.
[3]Supplements formulated to provide: 30 g/ton of DM Rumensin® and 90 mg/steer daily Tylan®.

Table 2. Effect of field peas and WDGS inclusion on cattle performance and carcass characteristics.

	0 Peas		20 Peas			*P*-value		
Item	0 WDGS	30 WDGS	0 WDGS	30 WDGS	SEM	Peas[1]	WDGS[2]	Peas × WDGS[3]
Performance								
Initial BW, lb	788	786	782	783	2.1	0.04	0.77	0.48
Final BW, lb[4]	1398	1491	1391	1481	8.1	0.32	<0.01	0.83
DMI, lb/day	24.9[b]	25.6[b,c]	23.6[a]	26.3[c]	0.28	0.30	<0.01	0.001
ADG, lb	4.11	4.73	4.07	4.66	0.05	0.33	<0.01	0.82
Feed:Gain	6.06[a]	5.41[c]	5.81[b]	5.65[b]	0.07	0.96	<0.01	0.003
Live final BW, lb	1486	1409	1460	1408	13.4	0.33	<0.01	0.33
Carcass Characteristics								
HCW, lb	881	940	877	933	5.1	0.33	<0.01	0.80
Dressing %	62.4	63.5	62.2	63.5	0.01	0.60	<0.01	0.52
LM area, in^2	13.2	13.3	13.2	13.1	0.12	0.37	0.99	0.66
12th-rib fat, in	0.60	0.65	0.60	0.67	0.01	0.40	<0.01	0.25
Calculated YG	3.54	3.86	3.51	3.95	0.05	0.54	<0.01	0.24
Marbling Score[5]	595[a]	576[a,b]	563[b]	588[a]	8.7	0.30	0.72	0.01

[a,b,c]Means in a row with different superscripts are different ($P < 0.05$).
[1]Peas = *P*-value for the main effect of field pea inclusion.
[2]WDGS = *P*-value for the main effect of WDGS inclusion.
[3]Peas × WDGS = *P*-value for the effect of field peas × WDGS.
[4]Calculated from carcass weight, adjusted to 63% common dressing percent.
[5]Marbling Score: 500 = Small00, 600 = Modest00.

0.52% sulfur (DM basis).

Animal performance and carcass data were analyzed using the MIXED procedure of SAS (SAS Inst., Inc., Cary, N.C.) as a randomized complete block design with pen as the experimental unit. The model included the effects of block, peas, WDGS, and peas × WDGS. There was a small (6 lb) significant difference in initial BW for the main effect of peas, so initial BW was used as a covariate in the model. Two steers died and four were removed from the trial for reasons unrelated to treatment. Differences were considered significant at $P < 0.05$.

Results

Performance

A significant peas × WDGS interaction ($P < 0.01$; Table 2) was observed for DMI, in which WDGS had no effect ($P = 0.07$) in diets with no peas, but increased DMI by 2.7 lb in diets containing peas ($P < 0.01$). Peas decreased DMI by 1.3 lb in diets with no WDGS ($P < 0.01$), but had no effect ($P = 0.10$) on DMI in diets containing WDGS. As expected, WDGS improved ADG ($P < 0.01$), which is a common observation; and peas had no effect on ADG or F:G, also in agreement with previous studies (*2005 Nebraska Beef Cattle Report,* pp. 49-50; *2010 Nebraska Beef Cattle Report,* pp. 107-108). A significant peas × WDGS interaction ($P < 0.01$) was observed for F:G, with WDGS increasing F:G by 12% in diets without peas ($P < 0.01$), but having no impact ($P = 0.12$) in diets containing peas. Inclusion of field peas improved F:G by 4% in diets with no WDGS ($P = 0.03$), but F:G was 4% worse ($P = 0.03$) when WDGS was present. The decreased efficiency of cattle consuming the diet containing both peas and WDGS may be due to lower dietary energy density, as field peas fed in this study contained 31% less starch and 59% less fat than the dry-rolled corn being replaced.

Carcass Characteristics

A significant peas × WDGS interaction ($P = 0.01$) was observed for marbling score, as feeding WDGS decreased marbling score when peas were not included in the diet, but increased marbling score in the presence of peas. However, the magnitude of these differences was relatively small, with cattle in all treatments averaging USDA Choice quality grade. The main effect of field pea inclusion had no impact ($P > 0.30$) on carcass characteristics. There was a significant main effect of WDGS ($P < 0.01$) for final BW, HCW, dressing percent, 12th rib fat depth, and calculated yield grade. These results agree with previous work in which cattle fed WDGS gained more rapidly, and thus were fatter at equal days on feed.

Field peas can be utilized as a replacement for a portion of the corn in finishing diets. Inclusion of 20% field peas improved F:G by 4% in corn-based diets. Even though the positive impact of WDGS on gain efficiency is apparently diminished in the presence of 20% field peas, performance was acceptable when 50% corn is replaced with peas and WDGS.

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Ruminal Degradable Sulfur and Hydrogen Sulfide in Cattle Finishing Diets

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Summary

The relationship between ruminal degradable sulfur intake (RDSI) and ruminal hydrogen sulfide concentration ([H_2S]) as well as ruminal parameters were evaluated. Steers were fed diets containing organic, inorganic, and wet distiller grains with solubles (WDGS) sources of sulfur, as well as a control diet. A laboratory procedure was developed to measure RDS of ingredients. RDSI explained 65% of [H_2S] variation, whereas total sulfur intake and ruminal pH, individually, explained 29 and 12%, respectively. Availability of sulfur for ruminal reduction is more important than total sulfur in the diet.

Introduction

Sulfur (S) availability for ruminal fermentation can be variable depending on degradability in the rumen. Variation in ruminal hydrogen sulfide gas concentration ([H_2S]) may be better predicted by measuring ruminal degradable sulfur intake (RDSI) instead of only total S intake. Therefore, the objectives of this study are: 1) determine the relationship between RDSI and [H_2S], as well as other ruminal parameters; and 2) develop a laboratory procedure to measure ruminal S degradability.

Procedure

Diets, Feeding and Experimental Design

Five ruminally cannulated crossbred beef steers (1,209 ± 102 lb BW) were assigned randomly to one of the five treatments in a 5x5 Latin square design. Steers were fed once daily for *ad libitum* intake through five periods of 21 days each. Each of the five periods consisted of a 14-day adaptation to the diet followed by a 7 day collection period. Diets (Table 1) were formulated to provide: organic source of S (S amino acids from corn gluten meal) at two levels of inclusion; inorganic source of S (ammonium sulfate), as well as a control diet (dry-rolled corn base). A diet containing wet distillers with solubles (WDGS) was also used since this co-product contains both organic and inorganic sources of S.

Ruminal Degradable Sulfur (RDS) Coefficients

Initially, RDS of the diets were estimated (calculated) based on two assumptions: 1) inorganic sources of S are 100% available for ruminal reduction to sulfide; 2) organic sources of S (S amino acids) are available for ruminal fermentation similar to protein that is ruminally degraded (DIP). These generalizations do not account for the inorganic and organic sources of S that are incorporated into the bacterial mass, and are not available to be reduced to sulfide by sulfate-reducing bacteria, since the bacterial CP leaves the rumen. Other sources of S present in feedstuffs with unknown degradability characteristics, such as sulfolipids, glutathione, β-thioglucose, succinyl-CoA, and CoA, are considered 100% available for ruminal reduction. To measure degradability coefficients of S, an IVDMD study was performed. Ingredients (1.5 g of DM), were incubated (26 hours) in triplicate with 75 mL of ruminal fluid collected from heifers (n = 2; BW = 705 lb; fed 60% corn based diet) and 75 mL of McDougall's Buffer. After incubation, bottles were cooled in ice, centrifuged (18,623 x *g*; 20 min; 4ºC), decanted, and the precipitate was dried at 100ºC and analyzed for S. The RDS (% of DM) coefficients were obtained by the following equation:

RDS = {1 – [(g of S in the residue – g of S in the blank)/g of S in the original sample]}*100

Measured RDS coefficients from ingredients utilized in this study were used to adjust values of RDSI, and this correction is noted in the results by the word "measured."

Measurements and Statistical Analysis

Intakes were calculated based on DM offered after subtracting DM refused. Intake pattern was measured electronically since bunks were equipped with weigh cells coupled to a computer. On day 15, pH probes were calibrated to record ruminal pH each minute and were introduced through the cannula into the rumen, then removed on day 1 of the following period. Ruminal gas samples were collected on the last three days of each period, twice daily (8 and 13 hours post feeding), except for the first period when samples were collected on the last five days. A pipette was inserted through the ruminal cannula (cannula cap adapted to avoid gas exchanges during collection) and ruminal [H_2S] analyzed with a spectrophotometer. On day 21, ruminal fluid was collected through a manual vacuum pump at 9, 14, and 22 hours post feeding and frozen immediately to determine VFA molar proportions. Data were analyzed using the GLIMMIX procedures of SAS (SAS Inst., Inc., Cary, N.C.). Day was accounted as a repeated measure for ruminal pH, intake and [H_2S], as well as time for VFA data. Stepwise multiple regression analysis were performed to determine the effect of RDSI, total S intake, and ruminal pH measurements on ruminal [H_2S].

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Results

Intake, expressed as lb/day or % BW, was not different among treatments. However, steers fed inorganic S tended ($P = 0.12$) to decrease intake by 12% (Table 2). Greatest and least dietary total S and RDS ranged between 0.21 and 0.50, and 0.15 and 0.32% of DM, for Control and WDGS, respectively (Table 1). Ingredient RDS coefficient estimates from the *in vitro* study were predicted from DIP (% of CP). The DIP values were 50.7, 4.3, 30.2, and 45.0 for dry rolled corn (DRC), corn silage (CS), corn gluten meal (CGM), and WDGS, respectively. As a percentage of total S, RDS coefficient estimates were 45.0, 78.0, 40.0, and 70.8 for DRC, CS, CGM, and WDGS, respectively. Total S intake followed diet S concentrations (Table 1), being greater ($P < 0.01$) for steers fed WDGS followed by organic high, inorganic and organic low (not different), and the least for control diet. Calculated and measured RDSI were greater ($P < 0.01$) for steers fed WDGS followed by inorganic, organic high, organic low, and control diets (Table 2). Number of meals was not affected ($P = 0.23$) by sources of S. However, steers fed WDGS and inorganic diets spent 13% more time eating ($P < 0.01$) compared to other treatments. As DMI was not different, these two diets provided smaller rates of intake compared to other treatments (Table 2). Therefore, intake pattern appears to be related with RDSI, since rate of intake was slowed down when greater RDSI was observed.

There was an interaction ($P = 0.05$) between dietary treatment and time point of ruminal gas collection (Figure 1). Regardless of time of gas collection, similar [H_2S] was observed for steers fed inorganic and WDGS diets ($P = 0.28$), which were greater ($P \leq 0.05$) than other treatments. Greater [H_2S] at 8 hours post feeding compared to 13 hours was observed for steers fed organic high, organic low, and control diets ($P \leq 0.04$), regardless of dietary treatment. Greater RDSI for inorganic and

Table 1. Dietary treatments and nutrient composition of diets containing inorganic and organic sources of sulfur.

Ingredients, % DM	Control[1]	Inorg.	Org. High	Org. Low	WDGS
Dry-rolled corn	75.0	75.0	51.7	65.2	30.0
Corn silage	15.0	15.0	15.0	15.0	15.0
Corn gluten meal	—	—	23.3	9.8	—
WDGS	—	—	—	—	50.0
Molasses	5.0	5.0	5.0	5.0	—
Supplement[2]	5.0	5.0	5.0	5.0	5.0
Nutrient composition, % DM					
CP	12.5	12.5	23.9	15.1	19.5
Fat	3.9	3.9	3.5	3.8	7.6
NDF	14.5	14.5	14.6	14.6	22.9
Total sulfur offered	0.20	0.35	0.45	0.30	0.50
Total sulfur corrected for orts[3]	0.21	0.36	0.45	0.30	0.50
RDS (calculated)[4]	0.16	0.31	0.25	0.19	0.35
RDS (measured)[4]	0.15	0.30	0.21	0.17	0.32

[1]Treatment and S source: control – no extra S added; inorganic – extra S from ammonium sulfate; organic high and low – extra S from corn gluten meal; WDGS – no extra S.
[2]Supplements: Supplements were formulated to provide 30 g/ton of DM of Monensin, 90 mg/steer/day of Tylosin, and 150 mg/steer/day of Thiamine; control and inorganic had 27.3 and 17.7% urea, respectively; inorganic had 21.9% of ammonium sulfate.
[3]Corrected for orts – amount refused (orts) subtracted from amount offered. This correction was made only for total S, since orts were not analyzed for S degradability.
[4]RDS – ruminal degradable S: calculated denotes estimated based on DIP of ingredients, and measured denotes correction based on measured coefficients (*in vitro* study) of S degradability.

Table 2. Intake and intake pattern, ruminal pH and VFA profile from steers fed diets containing inorganic and organic sources of sulfur.

Variables	Control[1]	Inorg.	Org. High	Org. Low	WDGS	SEM	*P*-values Treat
Intake							
DMI, lb/day	24.3	21.4	24.5	24.8	23.5	2.22	0.12
DMI, % BW	2.01	1.81	2.02	2.04	1.94	0.13	0.22
S intake, g/day	22.2[d]	37.8[c]	48.7[b]	33.7[c]	55.9[a]	3.62	< 0.01
RDS intake[2] (calculated), g/day	16.4[e]	32.3[b]	26.8[c]	20.7[d]	38.6[a]	2.46	< 0.01
RDS intake[2] (measured), g/day	15.6[e]	31.5[b]	22.9[c]	18.6[d]	36.2[a]	2.88	< 0.01
Intake pattern							
Time eating, hours/day	9.6[cd]	10.5[ab]	9.9[bc]	8.9[d]	11.2[a]	0.84	< 0.01
Number of meals, n/d	5.3	5.4	4.8	4.6	5.2	0.37	0.23
Rate of intake, %/ hours	11.9[b]	11.3[c]	12.7[a]	13.1[a]	10.7[d]	1.45	< 0.01
Ruminal pH							
Average	5.65[a]	5.30[b]	5.46[b]	5.71[a]	5.67[a]	0.07	< 0.01
Variance	0.30[a]	0.21[b]	0.22[b]	0.28[a]	0.25[ab]	0.02	0.05
Area < 5.6, min*pH/day	184[c]	461[a]	293[b]	150[c]	116c	60	< 0.01
Volatile fatty acids, mMol/100 mMol of total VFA							
Acetate	49.1[ab]	46.1[c]	51.0[a]	48.0[bc]	50.0[ab]	1.33	0.01
Propionate	28.0[b]	35.1[a]	29.2	30.9[b]	30.5[b]	1.75	0.02
A:P ratio	1.87[a]	1.34[b]	1.78[a]	1.75[a]	1.74[a]	0.15	0.02
Butyrate	17.4	14.7	13.4	15.1	13.8	1.61	0.14
Total, mMol/mL	131.5[a]	133.8[a]	120.9[bc]	119.2[c]	130.6[ab]	5.87	0.06

[1]Treatment and S source: control — no extra S added; inorganic — extra S from ammonium sulfate; organic high and low — extra S from corn gluten meal; WDGS — no extra S.
[2]Calculated — denotes ruminal degradable S intake (RDSI) estimated based on DIP of ingredients; measured — denotes RDSI corrected for S degradability coefficients measured (*in vitro* study) from ingredients.

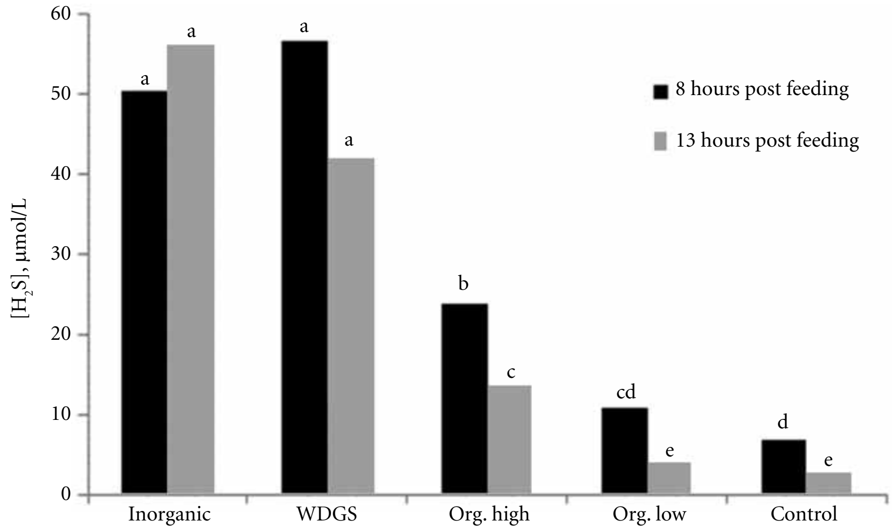

Figure 1. Ruminal hydrogen sulfide gas concentration ([H_2S]), µmol/L.

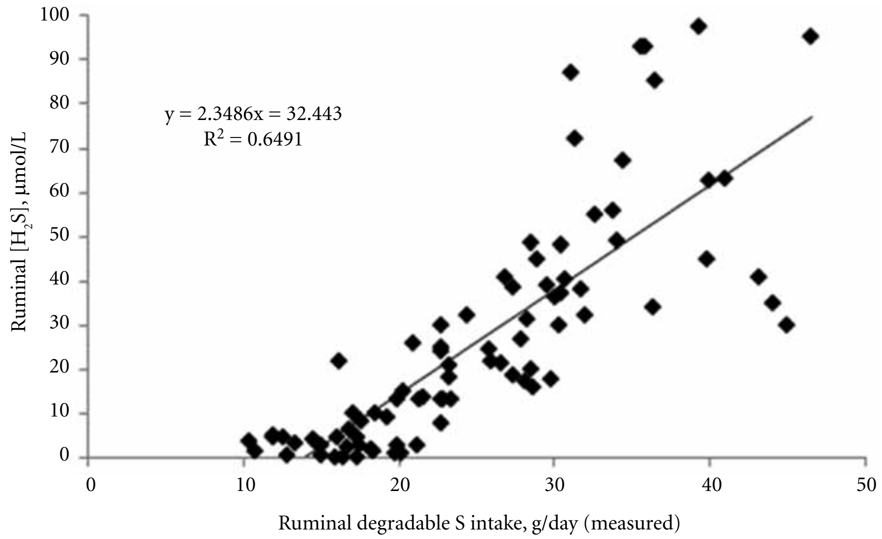

Figure 2. Regression between ruminal hydrogen sulfide gas concentration ([H_2S]) and ruminal degradable S intake (RDSI). Measuared denotes RDSI corrected for S degradability coefficients measured *in vitro*. A linear relationship ($P < 0.01$) where RDSI explained 65% of [H_2S] variation (quadratic relationship; $P = 0.69$).

WDGS diets matches with greater [H_2S] observed for these two treatments. Even though organic high and WDGS diets had similar total S concentration (0.45 and 0.50%, respectively), WDGS diet provided more RDS (0.32 vs. 0.21%), and therefore more [H_2S] was observed for this treatment. The same concept can be used to explain the similar [H_2S] for steers fed inorganic and WDGS, since both diets had similar concentration of RDS, even though WDGS diet had more total S.

Approximately 65% of [H_2S] variation was explained (linear; $P < 0.01$) by RDSI (Figure 2), whereas total S intake was able to explain only 29% of the variation in [H_2S] ($P < 0.01$). Average of ruminal pH was negatively related with [H_2S], however it accounted for only 12% of [H_2S] variation (linear, $P < 0.01$).

The only difference between control and inorganic diets was the presence of ammonium sulfate added to inorganic diet supplement. Lower average ruminal pH ($P < 0.01$), greater area of pH < 5.6 ($P < 0.01$) and less pH variance ($P = 0.05$) were observed for steers fed inorganic diet compared to control. Lower acetate ($P = 0.01$), greater propionate molar proportions ($P = 0.02$), and a lower A:P ratio ($P = 0.02$) were observed for steers fed the inorganic diet compared to control. This may explain why dietary S decreased DMI in performance study (*2011 Nebraska Beef Cattle Report,* p. 62) at a greater magnitude compared with ADG, since greater propionate molar proportion supports a greater energetic value compared to acetate.

Source of S plays an important role on ruminal S utilization. Availability of S for ruminal fermentation is more important than total S in the diet, since variation in [H_2S] is better explained by RDSI than total S intake. Coefficients of RDS for individual ingredients can be well predicted by the *in vitro* procedure proposed. Ruminal [H_2S] may modulate intake pattern.

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Meta-Analysis of the Effect of Dietary Sulfur on Feedlot Health

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Summary

A meta-analysis of University of Nebraska–Lincoln finishing trials was conducted to evaluate the effect of dietary sulfur on feedlot health. An interaction between level of dietary sulfur and forage NDF (P = 0.07) affected the incidence of polioencephalomalacia (PEM) cases. For a given level of dietary sulfur the relative risk for PEM decreased as forage NDF increased. Rumen degradable sulfur (RDS) was estimated for feedstuffs fed to cattle included in the analysis. As level of RDS increased in the diet, the incidence of PEM increased (P < 0.01). Rumen degradable sulfur is a better measure of PEM risk because it accounts for the dietary sulfur that contributes to hydrogen sulfide production.

Introduction

One of the challenges with using distillers grains plus solubles at large dietary inclusions is the potential for increased level of sulfur (S) in the ration (*Journal of Animal Science* 88:2444).

Polioencephalomalacia (PEM), or cerebrocortical necrosis, is a disease of ruminants that can occur sporadically.

The National Research Council (2000) suggests diets fed to feedlot cattle should not exceed 0.40%. Vanness et al., (2009 *Nebraska Beef Report*, p. 79) calculated the risk for PEM at increasing dietary S levels and concluded that incidence of PEM was low (0.14%) in diets containing 0.46% or less S. It also has been suggested that roughage level in high-byproduct diets may reduce the level of H_2S present in the rumen due to its ability to increase ruminal pH (2009 *Nebraska Beef Report*, pp. 81)

The objectives of the current study were to determine 1) effect of dietary S, 2) other dietary components, 3) or rumen degradability of sulfur on PEM risk, as well as 4) the relationship between other feedlot illnesses (i.e., respiratory, foot rot, bloat, and coccidiosis) and S.

Procedure

Data were compiled from finishing trials conducted at the University of Nebraska–Lincoln Agricultural Research and Development Center research feedlot (Mead, Neb.) from 2002-2009. The feedlot research program utilizes spring-born steers that are weaned in the fall. After the initial receiving period, the larger cattle are fed as calf-feds from approximately November to May, the medium weight steers are fed as short yearlings from May to October after grazing cornstalks in the winter and drylotting, and the smaller steers are fed from September to February as long yearlings after being wintered on cornstalks and grazing pasture in the summer.

Steers (n = 17,080) in these studies consisted of primarily black, crossbred steer calves or yearlings. Cattle included in the analysis were fed diets ranging from 0.120 to 0.723% S (DM). Sulfur undegradability was estimated for feedstuffs utilized in experiments included in the analysis. Sulfur undegradability was calculated by estimating % organic sulfur from sulfur containing amino acids (methionine and cysteine). This value was multiplied by undegradable intake protein (UIP) which yielded % undegradable intake S. Total S of the feedstuff was subtracted from rumen undegradable S which produced rumen degradable sulfur (RDS). Neutral detergent fiber (NDF) was measured for all forage sources. In the current analysis, we tested the effect of dietary S and NDF from forage on the incidence of PEM. The model tested three levels of forage NDF which were 0 NDF (no forage), 4% NDF (normal), and 8% NDF (2X normal). Most of the trials where byproducts were fed, cattle were supplemented with 150 mg/steer daily thiamine.

Computerized health records were maintained on all cattle. Feedlot illnesses of particular interest to the current study included PEM, respiratory disease, footrot, and bloat. Cattle were determined to be PEM cases if they were diagnosed by the feedlot health crew as exhibiting signs of PEM (poor coordination, disoriented, and blindness). Cattle suspected of suffering from PEM were treated with an intravenous injection of 5,000 mg thiamine. The cattle that did not recover from the PEM insult and/or died were necropsied and confirmed as having PEM if brain lesions were present.

Dietary sulfur, RDS, and NDF values were compared to health records to test for a relationship between level of S, RDS, NDF, and feedlot illnesses (PEM, respiratory, footrot, coccidiosis, and bloat).

The Proc GENMOD procedure of SAS (SAS Inst., Inc., Cary, N.C.) was used to test the effect of S level, NDF level, S x NDF level, RDS, or RDS x NDF level on PEM incidence, respiratory illness, foot rot, bloat, and cocci. Significance was declared at $P < 0.10$.

Results

Of the 17,080 cattle included in the current analysis, only 28 were diagnosed with or died due to PEM.

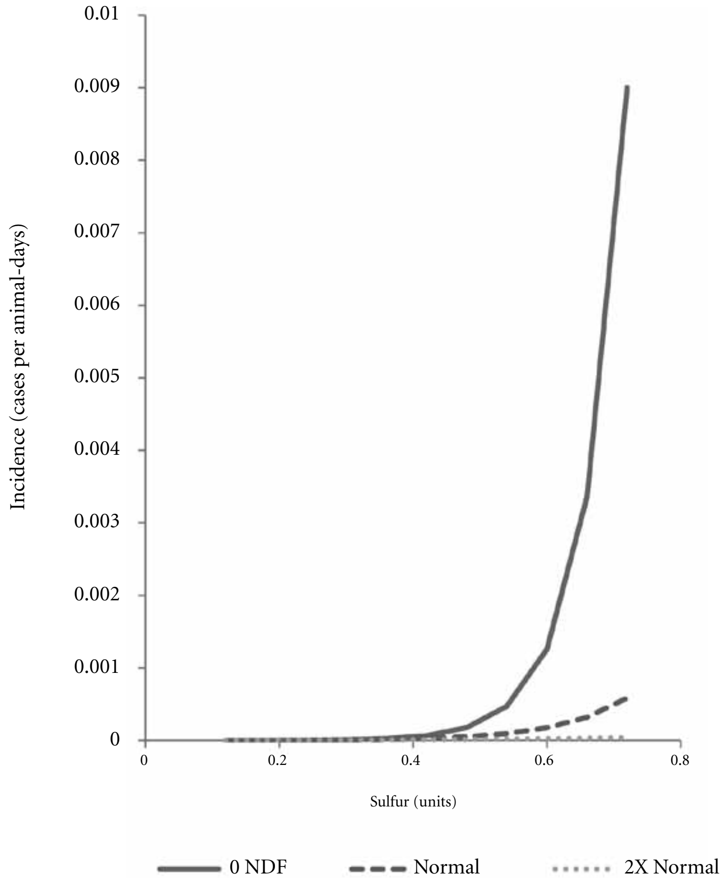

Figure 1. Effect of sulfur and forage NDF level on polioencephalomalacia (PEM) incidence. A dietary sulfur x forage level NDF interaction (*P* = 0.07) was observed. For a given level of forage NDF, the incidence of PEM increased as level of sulfur increased in the diet; however, for a given level of dietary sulfur the relative risk for PEM decreased as forage NDF increased.

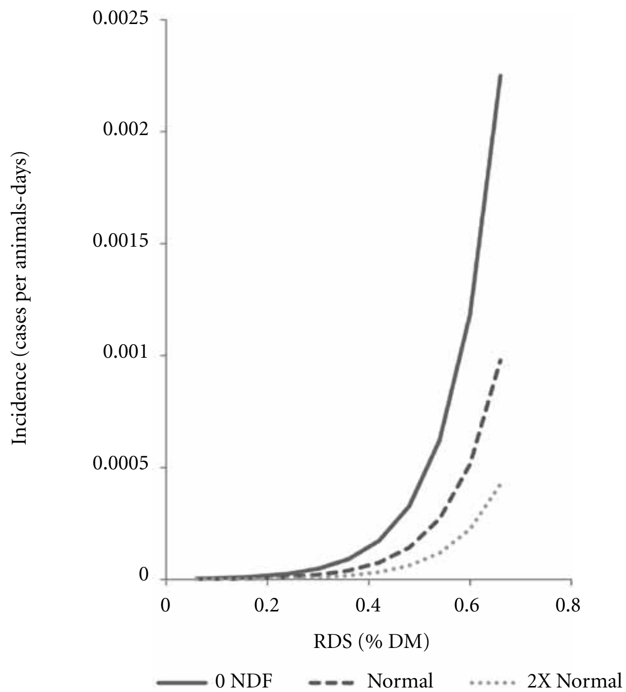

Figure 2. Effect of rumen degradable sulfur (RDS) and forage NDF level on polioencephalomalacia (PEM) incidence. A significant relationship was detected between RDS and PEM (*P* < 0.01). As level of RDS increased in the diet, the incidence of PEM increased. There was no RDS x forage level NDF interaction (*P* > 0.10).

Data indicate cattle started to exhibit signs of PEM about halfway through the feeding period. The relationships between dietary S and footrot, respiratory disease, and bloat were not significant (*P* > 0.05); therefore these feedlot illnesses did not appear to be related to diet S.

As the level of sulfur increased in the diet, the relative risk of cattle contracting PEM also increased (Figure 1; *P* = 0.02). According to the current model, cattle fed diets containing 0.42% S with normal forage level NDF would cause 0.56 cases per day in a 20,000 head feedlot. This diet would be considered a low PEM risk diet; therefore, the PEM cases resulting from this diet will be considered our baseline. Incidence of PEM for cattle consuming finishing rations containing 0.42% S and no forage was 0.00022 (cases per animal days), equivalent to about 2 cases per day in a 20,000 head commercial feedlot. Polioencephalomalacia increased to 23 cases per day (based off of a 20,000 head feedlot) when cattle consumed diets containing 0.60% S and no supplemental forage compared to the 0.42% S level (two cases per day).

There was an interaction between forage NDF and dietary S (*P* = 0.07). The addition of forage in finishing diets containing 0.40% S (DM) or more reduced PEM cases (Figure 1). Cattle fed diets containing normal forage NDF (DM) and 0.60% S (DM) had a reduction in incidences of PEM compared to cattle fed similar dietary S levels with no forage NDF. As the level of dietary S increased, forage level became increasingly important. In finishing diets containing more than 0.40% S and 2X normal forage NDF, risk of cattle contracting PEM was almost completely eliminated (Figure 1).

No RDS x forage NDF interaction (*P* > 0.10) was detected. As level of RDS increased in the diet, risk for cattle contracting PEM increased as well (*P* = 0.0072; Figure 2). Cattle fed diets containing 0.28% RDS and no forage had a greater risk for contracting PEM than cattle fed diets containing

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only 0.18% (DM basis) RDS and no forage. Finishing diets with no forage and a RDS level of 0.60% increased the number of PEM related cases in feedlot cattle compared to cattle fed a similar diet with 0.28% RDS. Risk of contracting PEM increased as dietary RDS level increased for all three forage NDF levels scenarios (no forage, normal, 2X normal; Figure 2).

Dietary NDF from forage decreased ($P = 0.10$) the risk of PEM in feedlot cattle in the RDS model. Unlike total dietary S, there was no interaction between RDS and forage NDF ($P > 0.10$). Rations containing 0.28% RDS and normal forage NDF exhibited a lower risk (0.34 cases per day) of inducing PEM than similar diets (0.28% RDS) with no forage (0.77 cases per day). A feedlot diet containing 0.28% RDS (26.9 DRC, 26.9 HMC, 41.3 WDGS, and 5 cornstalks; %DM) would have a total dietary S equivalent of 0.42% (Table 1). Data indicated that as level of RDS increased in finishing rations, PEM risk increased as well but, as forage NDF values increased, the risk of PEM decreased.

Our current recommendation for dietary S level is to not exceed 0.46% (assuming water sulfate is low). If cattle are drinking water containing 1,000 ppm sulfate during the summer, the dietary S equivalent would be about 0.13% S and 100% rumen degradable. A diet formulated to provide 0.46% S could contain 47.6% corn, 47.3% wet distillers grains plus solubles, and 5% cornstalks (DM). This diet would contain 0.31% RDS (DM). If cattle water source contains high levels of sulfate (1,000 ppm), then the diet can only contain 0.18% RDS or about 23% WDGS.

Results from this study confirm that as level of dietary S or RDS increase in finishing diets, risk of inducing PEM increased as well.

Table 1. Nutrient composition (% of DM) for UNL research feedlot trials summarized for 2002-2009.

Feed[1]	Sulfur	Rumen Degradable Sulfur (% of dietary DM)	Neutral Detergent Fiber
Protein Feeds			
WDGS	0.81	0.56	34.0
MDGS	0.78	0.53	34.0
DDGS	0.76	0.52	34.0
WDG	0.46	0.22	42.5
Dakota Bran Cake	0.41	0.39	30.3
CCDS	1.12	1.08	3.0
Sweet Bran®	0.50	0.44	37.8
ADM WCGF	0.47	0.41	37.8
Steep	0.58	0.38	2.0
Corn Bran	0.22	0.21	72.2
Brewers Grits	0.34	0.26	34.0
CGM	0.72	0.21	5.0
Energy Feeds			
SFC	0.14	0.06	10.8
HMC	0.13	0.09	10.8
DRC	0.14	0.06	10.8
FGC	0.14	0.06	9.0
Whole Corn	0.14	0.06	10.8
Reconstituted Corn	0.14	0.10	10.8
Roughage Sources			
Alfalfa	0.21	0.19	55.5
Brome	0.20	0.18	75.5
Cornstalks	0.20	0.18	81.3
Soyhulls	0.26	0.23	61.8
Sorghum Silage	0.10	0.08	62.2
Corn Silage	0.08	0.06	43.9
Wheat Straw	0.13	0.11	80.4
Grass Hay	0.18	0.16	76.0

[1]WDGS = wet distillers grains plus solubles.
MDGS = modified distillers grains plus solubles.
DDGS = dry distillers grains plus solubles.
WDG = wet distillers grains.
CCDS = condensed corn distillers solubles.
ADM WCGF = Archer Daniels Midland wet corn gluten feed.
CGM = corn gluten meal.
SFC = steam-flaked corn.
HMC = high-moisture corn.
DRC = dry-rolled corn.
FGC = fine-ground corn.

When a roughage source was included in the diet, PEM risk was reduced and continued to decrease as more roughage was added to the ration. It appears that roughage is an important factor in reducing PEM related illness in feedlot cattle, which may be due to its ability to regulate rumen pH. Dietary S level does not appear to be connected to other common feedlot diseases (respiratory, foot rot, and bloat). These data indicate that RDS is a better measure of PEM risk than diet S.

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Complete-feed diet RAMP™ in Grain Adaptation Programs

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Summary

Cattle were adapted to a common finishing diet over 22 days by decreasing RAMP (100 to 0%) and increasing finisher (0 to 100%) either as a blend in a traditional grain adaptation system or a two-ration program. The control treatment decreased alfalfa hay inclusion (45 to 7.5%) while corn inclusion increased. Steers adapted using RAMP were more efficient than traditionally adapted cattle. Using RAMP as an ingredient improved ADG compared to the traditional grain adaptation program.

Introduction

RAMP is a complete-feed starter ration containing a high level of Sweet Bran® and a minimal amount of forage, to serve as an alternative to a mixture of grain and forage for receiving cattle or adapting cattle to grain. Furthermore, many feedlots only mix two rations, a starter and a finishing ration, compared to four or five intermediate rations in a traditional adaptation system. Feedlots using a two-ration system will feed a starter and finisher to the same pen, either as a blend or two independent rations delivered separately, and gradually adapt cattle to the finishing diet by decreasing the amount of starter fed while increasing the amount of finisher. In a two-ration system, RAMP can eliminate the need to mix a starter diet. Previous research has shown that adapting cattle to grain using Sweet Bran led to increased ADG and F:G over the entire finishing period (*2009 Nebraska Beef Cattle Report,* pp. 53-55). The objective of this study was to compare performance and carcass characteristics of cattle adapted to grain using RAMP either as ingredient in transition rations or as a component in a two-ration system to cattle adapted to grain with a traditional adaptation system involving a series of rations where forage is decreased and corn increased.

Procedure

Yearling crossbred steers (n = 229; BW = 874 ± 63 lb) were blocked into three weight blocks, stratified by BW, and assigned randomly within strata to 18 feedlot pens, with 12 or 13 steers per pen. Treatments were imposed during grain adaptation (22 days) using three grain adaptation programs (Table 1). Two treatments involved decreasing RAMP inclusion (100 to 0%) while increasing inclusion of the finishing ration (0 to 100%), either delivered as independent rations in a two daily ration system (RAMP-2RS) or blended together by mixing RAMP with the various ingredients of the finishing ration as a single ration system (RAMP-1RS). The control adaptation treatment (CON) contained 25% Sweet Bran, 5% dry supplement (DM), with alfalfa hay inclusion decreasing from 45 to 7.5% while increasing the corn blend (60% high-moisture corn and 40% dry-rolled corn) from 25 to 62.5%, with the final ration serving as the common finisher for all treatments. RAMP, all step rations, and the first finishing ration contained 25 g/ton Rumensin® and 12 mg/lb thiamine (DM). Adaptation steps for RAMP-2RS were four days for first diet and three days for the six subsequent diets, with RAMP delivered as the first feeding for steps 1, 2, and 3, and the finisher as the first feeding for steps 4, 5, 6, and 7 (Table 2). Step rations for RAMP-1RS and CON were 4, 6, 6, and 6 days for steps 1, 2, 3, and 4, respectively. All cattle were offered *ad libitum* access to feed and water and fed two times per day at 0700 hours and 1300 hours.

Initially, steers were limit fed a 1:1 ratio of Sweet Bran and alfalfa hay fed at 2% of BW (DM) to minimize variation in gut fill. Weights were measured over two consecutive days (days 0 and 1) to determine initial BW. Feed refusals were collected and weighed when needed throughout the study and dried in a forced-air oven at 60°C for 48 hours to calculate DMI. All steers were implanted with Revalor-S on day 28. Following the grain adaptation period and after being on a common finishing diet for 6 days, BW were collected. Following collection of BW on day 28, cattle were switched to a second finisher, which contained 50% high moisture corn, 40% Sweet Bran, 5% wheat straw and 5% dry supplement (DM), which was formulated to provide 30 g/ton Rumensin and 90 mg/steer daily Tylan®. All cattle remained on the second finisher for the remainder of the feeding period.

Cattle were harvested at a commercial abattoir (Greater Omaha Packing, Omaha, Neb.) when each of the three weight blocks reached a similar final BW. Days on feed were 106 days for the heavy block, 120 days for the two intermediate blocks, and 141 days for the two light blocks. Hot carcass weight (HCW) and liver

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Table 1. Dietary composition (%) and DOF of control (CON) and RAMP™ 1 ration system (RAMP-1RS) adaptation methods (DM).

Days fed	1-4	5-10	11-16	17-22	23-28
Adaptation	1	2	3	4	Finisher 1
CON					
Alfalfa	45	35	25	15	7.5
HMC	15	21	27	33	37.5
DRC	10	14	18	22	25
Sweet Bran	25	25	25	25	25
Supplement[1]	5	5	5	5	5
RAMP-1RS					
RAMP	100	75	50	25	—
Alfalfa	—	1.88	3.75	5.62	7.5
HMC	—	9.37	18.75	28.13	37.5
DRC	—	6.25	12.5	18.75	25
Sweet Bran	—	6.25	12.5	18.75	25
Supplement[1]	—	1.25	2.5	3.75	5

[1]Supplement formulated to provide 25 g/ton Rumensin and 12 mg/lb thiamine on a DM.

abscess scores were obtained on the day of slaughter. Following a 48-hour chill, USDA marbling score, 12th rib fat thickness, and Longissimus muscle area (LM) were recorded. Yield grade was calculated using HCW, 12^{th} rib fat thickness, LM, and an assumed percentage (2.5%) of kidney, pelvic, and heart fat (KPH) using the following formula: 2.5+ (2.5 x 12^{th} rib fat) + (0.2 x 2.5[KPH]) + (0.0038 x HCW)-(0.32 x LM area). Carcass adjusted performance was calculated using a common dressing percentage (63%) to determine final BW, ADG, and F:G.

Performance and carcass characteristics were analyzed using the MIXED procedure of SAS (SAS Inst., Inc., Cary, N.C.). Pen was the experimental unit, fixed effect was treatment, and weight block was treated as a random effect. Treatment comparisons were made using pair-wise comparisons when the F-test statistic was significant at an alpha level of $P = 0.10$. Prevalence of liver abscesses was analyzed using the GLIMMIX procedure of SAS.

Table 2. Proportion of total DMI for each ration, delivered in two feedings as a two-ration system and DOF for the RAMP (RAMP-2RS) adaptation method.

Days fed	1-4	5-7	8-10	11-13	14-16	17-19	20-22	23-28
Adaptation	1	2	3	4	5	6	7	Finisher 1
RAMP-2RS[1]								
RAMP, %	100	75	55	45	35	25	15	0
Finisher 1, %	0	25	45	55	65	75	85	100

[1]RAMP delivered as AM meal for steps 1-3; finisher delivered as AM for steps 4-5.

Table 3. Feedlot performance and carcass characteristics of cattle adapted to grain using control (CON), RAMP one-ration system (RAMP-1RS), or RAMP two-ration system (RAMP-2RS) adaptation methods.

	Treatment				
Item	CON	RAMP-1RS	RAMP-2RS	SEM	*P*-value
Performance					
Initial BW, lb	877	873	873	2.1	0.21
Final BW, lb[1]	1356	1387	1374	14.0	0.13
DMI, lb/day					
28 days	26.2^{a}	24.5^{b}	24.7^{ab}	0.75	0.09
Final	29.4	28.9	28.7	0.47	0.39
ADG, lb					
28 days	4.55	4.49	4.53	0.28	0.98
Final	3.83^{a}	4.11^{b}	4.01^{ab}	0.12	0.09
F:G[2]	7.67^{a}	7.05^{b}	7.16^{b}	0.16	< 0.01
Final live BW, lb	1406	1426	1407	15.2	0.38
Carcass characteristics					
HCW, lb	855	874	866	8.9	0.13
LM area, in^2	13.0	13.1	13.1	0.18	0.78
Dressed yield, %	60.8	61.3	61.6	0.35	0.13
12^{th} rib fat, in	0.56	0.57	0.56	0.02	0.77
Yield Grade[3]	3.45	3.61	3.54	0.09	0.47
Marbling[4]	599	592	590	16.8	0.86
Liver abscess, %	7.8	10.5	10.6	—	0.79

[1]Final BW was calculated from HCW using a common dressing percentage of 63%.
[2]Statistics performed on G:F.
[3]Calculated as 2.5+ (2.5 x 12^{th} rib fat) + (0.2 x 2.5[KPH]) + (0.0038 x HCW)-(0.32 x LM area).
[4]400 = Slight, 500 = Small, 600 = Modest.
[a,b]Within a row, means without a common superscript are different ($P < 0.05$).

Results

Feedlot performance and carcass characteristics are summarized in Table 3. RAMP-1RS and RAMP-2RS decreased DMI during the adaptation period compared to CON ($P = 0.03$). Gain and F:G were similar among treatments during the grain adaptation period. During the overall finishing period, steers adapted using RAMP-1RS and RAMP-2RS were more efficient ($P < 0.01$) than cattle adapted using CON. RAMP-1RS increased ADG ($P = 0.03$) compared to CON during the finishing period. Increase in ADG for RAMP-1RS and decreased F:G for steers adapted with both RAMP treatments were due to the 22-day adaptation period, as the diet fed was the same beyond this point. In an another study where cattle were adapted to grain using Sweet Bran, increased ADG and improved F:G were observed (*2009 Nebraska Beef Cattle Report,* pp. 53-55). The authors of the previous research suggested positive gain responses associated with Sweet Bran adaptation may be due to increased diet digestibility or greater dietary energy content when Sweet Bran was used rather than alfalfa hay. However, gain responses associated with RAMP in the current study may not be attributed to either of these because gain improvements were not observed when cattle were weighed after 28 days. Difficulty associated with accurately measuring change in BW over short durations of time due to variation in gut fill may contribute to the differences. Performance improvements only during the finishing period in the current study may be due to a decrease in subclinical acidosis during the finishing period due to changes in eating behavior developed during the adaptation period. Previous research with Sweet Bran adaption indicated increased meals per day compared to control adaptation (2009 Nebraska Beef Cattle Report, pp. 56-58).

Carcass characteristics were not affected by adaptation method. Although no differences were observed for HCW ($P = 0.13$) or dressing percentage ($P = 0.13$), RAMP had numerically higher values for both. Furthermore, differences observed in ADG would suggest HCW or dressing percentage, or both, must be influenced by treatment. USDA marbling scores were similar among treatments, as well as 12^{th} rib fat thickness, indicating steers were finished to similar endpoints. Additionally, no differences were observed in LM, calculated YG, or prevalence of liver abscesses. Grain adaptation programs using RAMP are a viable alternative to traditional adaptation programs and improve overall feedlot performance.

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Use of Complete-feed Diets RAMP™ and Test Starter for Receiving Cattle

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Table 1. Performance of cattle fed RAMP, Test Starter, or a control receiving diet.

	Treatment				
Item	Control	RAMP	Test Starter	SEM	*P*-value
Initial BW, lb	576	578	573	11.2	0.89
Final BW, lb	645	657	645	10.3	0.36
DMI, lb/day	13.4	13.8	13.9	0.27	0.14
ADG, lb	2.73[a]	3.04[b]	2.81[ab]	0.13	0.07
Feed:Gain[1]	4.91	4.54	4.95	0.22	0.17
BRD incidence, %[2]	4.3	7.4	11.7	—	—
Treated for BRD, n	18/322	23/320	37/321	—	—

[1]Statistics calculated on Gain:Feed.
[2]Control vs. RAMP P = 0.03; Control vs. Test Starter $P < 0.01$.
[a,b]Means within a row without a common superscript are different, ($P = 0.03$).

Summary

Performance of newly arrived 576 lb steer calves, fed two complete feeds or a control ration was evaluated. Treatment diets were fed for 30 or 31 days and included a control receiving diet consisting of alfalfa hay, Sweet Bran®, dry-rolled corn, and supplement or one of two complete feeds: RAMP and Test Starter which contained a high level of Sweet Bran and a minimal amount of forage. RAMP increased ADG when compared with the control diet. Cattle fed Test Starter had similar performance to the control receiving diet.

Introduction

RAMP is a complete-feed starter ration developed by Cargill, which contains a high level of *Sweet Bran* and a minimal amount of forage. RAMP is intended to serve as an alternative to a mixture of grain and forage for receiving cattle or adapting cattle to grain, therefore eliminating a large portion of the forage needed in feedlots and the need to mix a starter diet. Test Starter, another complete feed developed by Cargill, is very similar to RAMP but contains more forage. The objective of the current study was to compare performance and health characteristics of cattle fed two complete feeds (RAMP and Test Starter) during the receiving period.

Procedure

Crossbred steers (n = 965; BW = 576 ± 11 lb) from two livestock auction markets were received at the University of Nebraska–Lincoln Agricultural Research and Development Center, Mead, Neb., over two consecutive days: Oct. 14 and Oct. 15, 2010. Steers were blocked by arrival date and randomly allocated to pens within block based on processing order, resulting in 15 and 20 cattle per pen for blocks 1 and 2, respectively, with 17 pens per treatment. During processing, steers were identified with an individual ear tag, individually weighed, vaccinated with Bovi-Shield® Gold 5, Somubac®, and Dectomax® Injectable, and orally drenched with Safe-Guard®. Thirteen days subsequent to initial processing, cattle were revaccinated with Bovi-shield Gold 5, Ultrabac® 7/Somubac, injected with Micotil® and weighed.

Treatments included a control receiving diet (35% alfalfa hay, 30% Sweet Bran, 30% dry-rolled corn, and 5% supplement; 16.7% CP, 36.7% NDF) and two complete feeds: RAMP (21.9% CP, 41.9% NDF) and Test Starter (23.4% CP, 43.5% NDF). Both complete feeds contained a high level of Sweet Bran and a minimal amount of forage, which was formulated and provided by Cargill Inc., Blair, Neb. All diets contained 25 g/ton Rumensin and 12 mg/lb thiamine (DM). Cattle were offered *ad libitum* access to treatment diets for 30 or 31 days followed by limit feeding a common diet (47.5% Sweet Bran, 23.75% grass hay, 23.75 alfalfa hay, and 5% supplement) for five days prior to collecting final BW to minimize variation in gut fill. Final BW were collected over two days following the five-day limit-fed period. Initial weight was not shrunk because steers were weighed within 12 hours of arrival and had no access to feed before weighing.

Performance data were analyzed using the MIXED procedure of SAS (SAS Inst., Inc., Cary, N.C.) with pen as the experimental unit. Block was treated as a random effect, and treatment was a fixed effect. Treatment comparisons were made using a protected F-test ($P < 0.10$) separated with Bonferroni t-test. Incidence of BRD was evaluated as the rate of respiratory illness or the number of steers treated for BRD in a pen divided by the number of steers in that pen. Incidence of BRD was then analyzed using the GENMOD procedure of SAS. Incidence of BRD was affected by DMI and ADG; consequently, ADG and DMI were added to the model when assessing treatment effects on BRD. No significant effect of block existed so it was removed from the model. Treatment means for BRD incidence were calculated using the PROC MEANS function of SAS.

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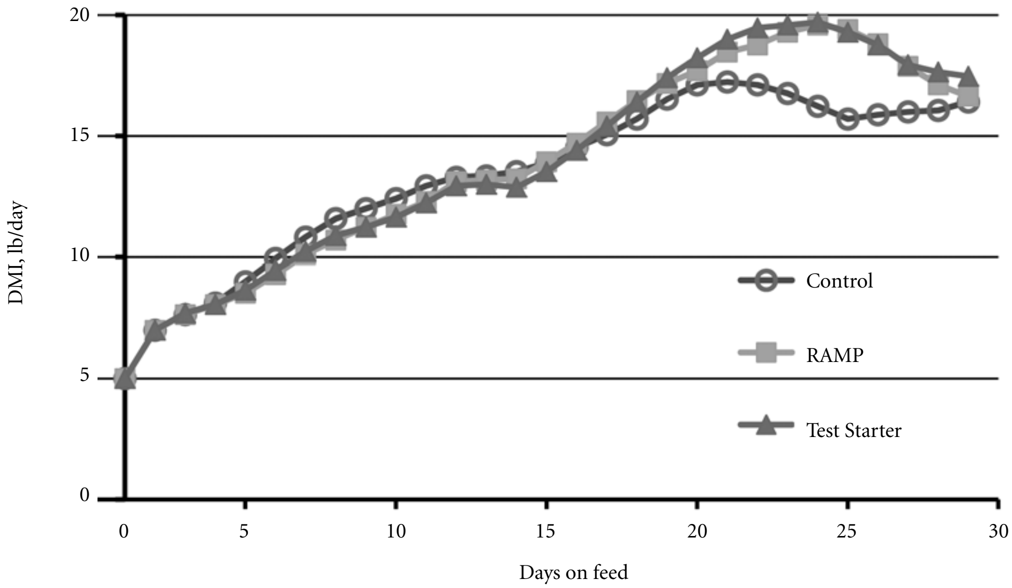

Figure 1. Dry matter intake over the receiving period for cattle fed control, RAMP, or Test Starter treatment diets.

Results

Feeding RAMP increased ($P = 0.02$) ADG compared to the control diet (Table 1). Daily gain of cattle fed Test Starter was not different ($P > 0.11$) from cattle fed control or RAMP. Dry matter intake was not different ($P = 0.14$) among treatments, although approaching significance with the complete feed treatments having numerically greater DMI than the control. On approximately day 19 of the feeding period, intakes of the control cattle seemed to plateau (Figure 1) and DMI of cattle on the complete-feed rations continued to increase, which might explain increased performance of the cattle fed RAMP. Final BW was not affected by treatment and F:G was similar for all treatments.

Incidence of BRD was affected by DMI and ADG; consequently, variation in ADG and DMI were accounted for in the analysis of treatment effects on BRD. Feeding both complete feeds increased ($P < 0.03$) the incidence of BRD; however, overall incidence of BRD was low (8%). Starting cattle on RAMP is a viable alternative to starting cattle on a mixture of grain and forage.

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Effects of RAMP™ on Feed Intake and Ruminal pH During Adaptation to Finishing Diets

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Summary

A metabolism trial was conducted using an adaption strategy where RAMP inclusion was decreased (100 to 0%) while increasing inclusion of the finishing ration (0 to 100%) was compared to a traditional adaption (Control) where alfalfa hay inclusion was decreased (45 to 7.5%) while increasing corn. Adapting cattle with RAMP increased DMI, had no effect on average pH, pH variance, or magnitude of change compared to Control. Grain adaption with RAMP is a viable alternative to traditional grain adaptation.

Introduction

RAMP is a complete-feed starter ration developed by Cargill, which contains a high level of *Sweet Bran®* **and a minimal amount of forage**. RAMP is intended to serve as an alternative to a mixture of grain and forage for receiving cattle or adapting cattle to grain, therefore eliminating a large portion of the forage needed in feedlots. Previous research has shown adapting cattle to grain using RAMP tended to increase ADG and improved feed efficiency over the entire feeding period (*2012 Nebraska Beef Cattle Report,* pp. ??). The objective of the current study was to evaluate the effects of grain adaption with RAMP on ruminal pH and DMI.

Procedure

A metabolism trial was conducted using six ruminally fistulated steer calves (BW = 561 ± 66 lb). Steers were gradually adapted to a finishing diet using four adaption diets over five periods consisting of seven days each, followed by seven days on a common finishing diet. Treatments were imposed during grain adaption using two grain adaptation programs (Table 1). With RAMP adaption, RAMP inclusion was decreased (100 to 0%) while increasing inclusion of the finishing ration (0 to 100%) by mixing RAMP with the various ingredients of the finishing ration as a single ration. The control adaptation treatment contained 25% Sweet Bran, 5% dry supplement, with alfalfa hay inclusion decreasing from 45 to 7.5% while increasing the corn blend (60% high-moisture corn and 40% dry-rolled corn) from 25 to 62.5% (DM). The final step diet served as the common finisher for all treatments the last seven days. RAMP, all step diets and the finishing diet contained 25 g/ton Rumensin® and 12 mg/lb thiamine. Steers were individually housed in box stalls and were offered *ad libitum* access to feed and water and fed once daily at 0800 hours. Feed refusals were collected daily, weighed, and a 10% representative sample was retained and dried in a forced-air oven at 60°C for 48 hours to obtain DMI.

Wireless pH probes were placed into the rumen of each steer for the trial duration. Each probe was attached to a weighted enclosure designed to maintain the electrode in the ventral sac of the rumen. Ruminal pH was recorded every minute continuously for seven days. Each probe was briefly removed from the rumen on day seven prior to feeding each period to download pH data and recalibrate the probe.

Data were analyzed as a 2 × 5 factorial design using the GLIMMIX procedure of SAS (SAS Inst., Inc., Cary, N.C.). Steer was the experimental unit and was treated as a random effect, and the residual was used to test for treatment affects. The model included period, treatment, period × treatment and day. Day was treated as a repeated measure.

Results

One steer from the control treatment was removed from the study for reasons unrelated to treatment. No period × treatment interactions occurred; therefore, main effects of adaptation treatment (Table 2)

(Continued on next page)

Table 1. Dietary composition (%) and days on feed of control and RAMP adaptation treatments (DM).

Days fed Adaptation	1-7 1	8-14 2	15-21 3	22-28 4	29-35 Finisher
Control					
Alfalfa	45	35	25	15	7.5
HMC	15	21	27	33	37.5
DRC	10	14	18	22	25
Sweet Bran	25	25	25	25	25
Supplement[1]	5	5	5	5	5
RAMP					
RAMP	100	75	50	25	—
Alfalfa	—	1.88	3.75	5.62	7.5
HMC	—	9.37	18.75	28.13	37.5
DRC	—	6.25	12.5	18.75	25
Sweet Bran	—	6.25	12.5	18.75	25
Supplement[1]	—	1.25	2.5	3.75	5

[1]Supplement formulated to provide 25 g/ton Rumensin and 12 mg/lb thiamine (DM).

and period (adaption diet; Table 3) are presented. Cattle adapted using RAMP had greater DMI ($P = 0.07$) than those adapted with the control treatment. Similar increases in DMI were observed when cattle were adapted to grain using Sweet Bran (*2009 Nebraska Beef Cattle Report,* pp. 56-58). Average ruminal pH, minimum pH, and maximum pH were not affected by adaption method. Adapting cattle with RAMP had no effect on magnitude of pH change or ruminal pH variance. These findings are contrary to previous research where adapting cattle with Sweet Bran increased pH variance and decreased average, minimum, and maximum pH values (*2009 Nebraska Beef Cattle Report,* pp. 56-58). Time below pH 5.6 or 5.3 were not affected by adaption treatment. Area below 5.6 was not different, but area below 5.3 increased ($P < 0.01$) for cattle adapted with RAMP.

Intake increased (Table 3) with each period as steers were adapted to the finishing ration ($P < 0.01$) and then decreased ($P < 0.01$) from adaption period 4 to the finishing diet. Average ruminal pH was not different during the adaption periods but decreased ($P < 0.05$) once on the finishing diet. Minimum pH decreased ($P < 0.05$) from adaption period 2 to adaption period 3 and from adaption period 4 to the finishing diet ($P < 0.01$). Maximum pH was not affected by adaption period. Time below pH 5.6 was not affected by adaption period, but area below pH 5.6 increased ($P = 0.02$) once cattle were fed the finishing diet compared to the first two periods. Time and area below pH 5.3 increased ($P < 0.01$) when the cattle were on the finishing diet compared to all other adaption periods. In summary, adapting cattle to grain using RAMP increased DMI and decreased area below pH 5.3, which is an indicator of subclinical acidosis, and thus is a viable alternative to traditional grain adaption programs.

Table 2. Effects of grain adaption with RAMP or control adaptation methods on intake and ruminal pH.

	Treatment		
Item	Control	RAMP	*P*-value
DMI, lb/day	11.02	16.17	0.07
Average pH	5.86	5.77	0.58
Maximum pH	6.51	6.38	0.33
Minimum pH	5.29	5.31	0.87
pH change	1.13	1.12	0.86
pH variance	0.07	0.06	0.49
Time < 5.6, min	351.8	363.3	0.93
Area < 5.6[1]	69.2	72.4	0.71
Time < 5.3, min	92.2	76.8	0.70
Area < 5.3[1]	15.6	8.1	< 0.01

[1]Area under curve (magnitude of pH < 5.6 or 5.3 by minute).

Table 3. Effect of adaption period[1] on intake and ruminal pH.

Adaptation:	1	2	3	4	Finisher	*P*-value
DMI, lb/day	10.68[a]	12.71[b]	14.63[c]	16.22[d]	13.75[bc]	< 0.01
Average pH	5.93[a]	5.87[a]	5.83[a]	5.81[a]	5.63[b]	0.01
Maximum pH	6.36	6.49	6.52	6.46	6.38	0.10
Minimum pH	5.57[a]	5.44[a]	5.26[b]	5.22[b]	5.00[c]	< 0.01
pH change	0.63[a]	1.08[b]	1.28[bc]	1.22[bc]	1.46[c]	< 0.01
pH variance	0.04[a]	0.06[b]	0.08[b]	0.07[b]	0.10[c]	< 0.01
Time < 5.6, min	334.3	301.1	318.8	363.6	470.2	0.12
Area < 5.62	72.9[a]	72.9[a]	63.2[ab]	45.7[ab]	99.1[b]	0.02
Time < 5.3, min	53.2[a]	63.3[a]	69.3[a]	72.6[a]	163.9[b]	< 0.01
Area < 5.32	7.1[a]	14.8[b]	8.2[a]	9.2[a]	20.1[c]	< 0.01

[1]Each adaption period consisted of an adaption diet fed for seven days.
[2]Area under curve (magnitude of pH < 5.6 or 5.3 by minute).
[a-c]Within a row, means without a common superscript are different $P < 0.05$.

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Potassium for Feedlot Cattle Exposed to Heat Stress

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Summary

Angus crossbred yearling heifers and steers (n = 144 and 168, respectively) were used to evaluate effects of feeding soybeans and additional potassium (K) on performance and tympanic temperature (TT) of cattle under heat stress and seasonal summer conditions. In Experiment 1, cattle fed diets supplemented with potassium carbonate had lower ADG and tended to have decreased water intake, G:F, and dressing percent. In Experiment 2, cattle fed diets supplemented with K with or without whole soybeans had lower or tended to have lower TT than control cattle during the hottest portion of the day (between 1300 and 2100 hours).

Introduction

Because fat has a low heat increment to metabolizable energy ratio, it may be beneficial to feed under hot environmental conditions. In addition, the low price producers periodically receive for soybeans may allow soybeans to be economically competitive as a source of fat in cattle rations.

During hot weather, declining feed intake requires increased dietary mineral concentration due to depletion of potassium (K) and sodium (Na) as a result of heat stress. Research (2007 *Nebraska Beef Cattle Report,* pp. 77-79; *2006 Nebraska Beef Cattle Report*, pp. 62-65) has evaluated effects of supplemental salt (NaCl) and potassium bicarbonate ($KHCO_3$) in feedlot diets. The objectives of the following study were to assess effects of providing fat in the form of soybeans and supplemental $KHCO_3$ or potassium carbonate (K_2CO_3) for cattle finished in the summer.

Procedure

Experiment 1

One hundred forty-four crossbred, previously vaccinated (Vision® 7/Somnus, Titanium® 5 PHM Bac® 1) heifers were implanted with Revalor®-H, weighed on two consecutive days and allotted to one of 24 pens. For a 71-day feeding period, three replicates were randomly assigned to four treatments arranged in a 2 x 2 factorial design. The diet treatments (Table 1) were 1) Control (CONTL), 2) a diet containing 1.75% K_2CO_3, 3) a diet containing 5% whole soybeans (SOYBN), and 4) a diet containing 1.75% K_2CO_3 and 5% whole soybeans (SOYK2).

Dry matter (DMI) and water intakes (DWI) were recorded daily. Treatment comparisons were also made for DMI and DWI during two five-day hot (days 21 to 25 and 62 to 66) periods and one four-day cool (days 35 to 38) period during the experiment.

Performance data and intakes were analyzed using Proc Mixed procedures of SAS (SAS Inst., Inc., Cary, N.C.). The model included K, soybeans, and the interaction of K by soybeans as fixed effects and replicate as a random effect.

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Table 1. Composition of diets fed in Experiment 1.

Ingredient	CONTL	K_2CO_3	SOYBN	SOYK2
Alfalfa	5.75	4	6	4
Corn silage	6	4	8	5
Dry-rolled corn	80.75	82.75	76.5	79.75
Rumensin-Tylan premix	2	2	2	2
Liquid supplement	3.5	3	3	3
Soybean meal	2	2.5	—	—
Whole soybeans	—	—	4.5	4.5
K_2CO_3	—	1.75	—	1.75
Nutrient composition				
NEg, Mcal/lb	0.650	0.650	0.650	0.651
Calcium, %	0.56	0.47	0.51	0.48
Phosphorus, %	0.33	0.33	0.33	0.33
Potassium, %	0.73	1.67	0.76	1.70

Table 2. Composition of diets fed in Experiment 2.

Ingredient	CONTL	$KHCO_3$	SOYK2	SOYKH
Alfalfa	7	4	5	4.75
Corn silage	6	6	7	6
Dry-rolled corn	80.5	80	77.5	78
Rumensin-Tylan premix	2	2	2	2
Liquid supplement	3	2.5	2.5	2.5
Soybean meal	1.5	3.25	—	—
Whole soybeans	—	—	4.5	4.5
K_2CO_3	—	—	1.5	—
$KHCO_3$	—	2.25	—	2.25
Nutrient composition				
Crude protein, %	12.99	13.01	13.09	13.02
NEg, Mcal/lb	0.650	0.648	0.650	0.648
Calcium, %	0.52	0.42	0.44	0.43
Phosphorus, %	0.32	0.33	0.33	0.33
Potassium, %	0.72	1.57	1.57	1.58

Table 3. Performance and carcass data for cattle fed in Experiment 1.

	CONTL	K_2CO_3	SOYBN	SOYK2	SEM	*P*-value K	SOY	K*SOY
Initial wt, lb	1007	1007	1012	1015	2.8	0.50	0.02	0.54
Actual final wt, lb[1]	1218	1204	1235	1211	8.1	0.03	0.16	0.52
Actual ADG, lb	2.98	2.78	3.15	2.75	0.111	0.02	0.54	0.39
DMI, lb	20.85	20.60	21.53	19.92	0.418	0.02	0.99	0.09
F/G	7.01	7.48	6.86	7.29	0.238	0.08	0.49	0.94
G/F	0.143	0.135	0.146	0.138	0.0045	0.09	0.48	0.95
DWI,[2] gal	9.08	7.38	8.47	7.95	0.474	0.06	0.96	0.24
DMI/DWI[2]	2.30	2.81	2.57	2.51	0.143	0.18	0.90	0.11
Carcass wt, lb	768	759	778	763	5.1	0.03	0.16	0.51
Marbling[3]	564	616	623	570	18.9	0.98	0.72	0.01
Yield grade	2.68	2.81	3.08	2.79	0.121	0.50	0.14	0.11
Actual dressing percent[4]	62.04	61.81	62.27	61.60	0.246	0.08	0.98	0.38

[1]Based on hot carcass weight, adjusted to 63% dressing percent.
[2]DWI = Daily water intake.
[3]450 = slight^{50}, 500 = small^{00}, 550 = small^{50}.
[4]Based on full weight, as recorded on the day before harvest (day 71).

Table 4. DM and water intake for hot and cool period in Experiment 1.

	CONTL	K_2CO_3	SOYBN	SOYK2	SEM	*P*-value K	SOY	K*SOY
Dry matter intake[1]								
Hot1	20.32^{ab}	20.74^{ab}	22.08^{a}	19.63^{b}	0.789	0.20	0.68	0.08
Cool	18.40^{ab}	19.53^{ab}	20.33^{a}	18.17^{b}	1.371	0.55	0.74	0.07
Hot2	22.50	22.55	21.80	20.73	0.509	0.33	0.02	0.28
Water intake[1]								
Hot1	9.77	8.35	9.09	8.42	0.495	0.05	0.47	0.38
Cool	8.27	7.24	7.83	7.29	1.045	0.44	0.84	0.80
Hot2	10.52	7.901	9.79	8.85	0.786	0.05	0.78	0.40
Dry matter/water intake[1]								
Hot1	1.97	2.66	2.40	2.410	0.178	0.10	0.65	0.11
Cool	2.22	2.83	2.70	2.51	0.245	0.43	0.75	0.18
Hot2	2.16	2.86	2.22	2.35	0.151	0.04	0.20	0.11

[1]Hot1 period = days 21-25, Cool period = days 35-38, Hot2 period = days 62-66.

Table 5. Panting scores (percent not panting) during days 16 to 22 for Experiment 2[1].

Period	CONTL	K_2CO_3	SOYBN	SOYK2	SEM	*P*-value K	SOY	K*SOY
Cool	76.6^{a}	96.7^{b}	74.4^{a}	82.6^{ab}	0.80	0.05	0.82	0.09
Hot	12.2	10.4	14.6	16.8	2.06	0.50	0.37	0.73

[1]Panting scores were compared by transforming lsmeans and SEM with (sin x)2. Cool = days 16 to 18 and Hot = days 19 to 22.
[ab]Means within a row with unlike superscripts differ ($P < 0.05$).

Table 6. Tympanic temperatures (ºF) during days 16 to 22 for Experiment 2[1].

Period	CONTL	KHCO3	SOYK2	SOYKH	SEM	Trt	Time	Trt*Time
Cool	102.1	102.1	102.2	101.9	0.18	0.43	<.0001	0.92
Hot	102.8	102.1	102.5	102.2	0.29	0.20	<.0001	<.0001
Overall	102.5	102.1	102.4	102.0	0.24	0.25	<.0001	.0005

[1]Cool = days 16 to 18 and Hot = days 19 to 22.

Experiment 2

One hundred sixty-eight crossbred, previously vaccinated (Vision 7 and Titanium 5 PHM Bac 1) and implanted (Ralgro®) steers were reimplanted (Revalor-S), weighed on two consecutive days, and allotted to one of 24 pens. Three replicates were randomly assigned to four treatments (Table 2): 1) a control diet (CONTL), 2) a diet containing 2.25% $KHCO_3$, 3) a diet containing 5% whole soybeans and 1.5% K_2CO_3 (SOYK2), and 4) a diet containing 5% whole soybeans and 2.25% $KHCO_3$ (SOYKH).

Dry matter and DWI were recorded daily. Additional body weights were obtained on day 38 and the day before harvest (day 83). At slaughter, hot carcass weight, yield grade, and marbling score were recorded. On days 16-22, TT were recorded at 1-hour intervals in three heifers per pen in one replicate using a Stowaway XTI® data logger (Onset Corporation, Pocasset, Mass) and thermistor. This interval contained three cool days (Cool = day 16 to 18) and four hot days (Hot = days 19 to 22). During this period, the percentage of cattle panting at 1500 hours was also recorded. Treatment comparisons of DMI and DWI were also made.

Performance data were analyzed similar to Experiment 1. Tympanic temperatures were analyzed using a repeated measures model that included diet treatment, time of day, and the interaction of diet treatment by day. The specified term for the repeated statement was animal.

Results

For Experiment 1, periods of heat stress were found on days 21 to 25 and 62 to 66 in which daily average THI [THI = ambient temperature – (0.55 – (0.55 x (relative humidity/100))) x ambient temperature – 58)] approached or exceeded 74. The THI during these days peaked around 80, which is considered a danger category based on the Livestock Safety Index.

Cattle provided K_2CO_3 diets had significantly lower gain and feed intake than CONTL and soybean only supplemented cattle (Table 3). These cattle also tended to have poorer F:G and lower DWI, which may be a result of lower DMI. Actual dressing percentage also tended to be lower in K supplemented cattle.

A K by soybean interaction ($P = 0.08$) during the first hot and the cool periods, suggests that supplementing cattle with soybeans alone enhanced DMI while supplementing with a combination of soybeans and K depressed DMI (Table 4). However, in the second hot period, both soybean treatments suppressed DMI. Potassium supplementation also suppressed DWI in both hot periods. Thus, DMI/DWI tended to be greater for the K supplemented cattle. No differences were found among treatments for TT, which happened to be obtained during the cool period.

In Experiment 2, the hot period was similar in THI to those found in Experiment 1. However, for the entire experiment, the THI was over three units lower than in Experiment 1. Performance differences among treatments were not found (data not shown). During the cool period, soybean and K supplemented groups had lower DMI than CONTL (data not shown). Water intake and DMI/DWI were not affected during any period; although DMI/DWI followed the same trend as was found in Experiment 1 with the SOYK2 treatment having the lowest ratio when compared among all treatments including the control group.

In Experiment 2, treatment differences occurred during the cool period for the percentage of cattle not panting. Cattle supplemented with $KHCO_3$ had the greatest number of cattle not panting when compared with CONTL and the SOYK2 treatments (Table 5). In addition, no treatment differences were observed in TT during the period temperatures were obtained (Table 6). However, treatment by time interactions were found for TT. In general, during the hottest portion of the day all supplemented groups had lower or tended to have lower TT than control cattle groups.

In general, feeding K_2CO_3 decreased ADG and tended to lower DWI, possibly by decreasing DMI, especially when fed with soybeans. Supplementing $KHCO_3$ by itself or with soybeans decreased TT, when compared to control cattle.

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Feeding Modified Distillers Grains With Solubles and Wet Corn Gluten Feed (Synergy) to Adapt Cattle to Finishing Diets

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Summary

An experiment with 236 steers and eight pens per treatment (14 or 15 steers/pen) evaluated two grain adaptation treatments. Treatments included adapting steers by decreasing alfalfa (CON) or decreasing a combination of distillers grains and corn gluten feed (SYNERGY) followed by feeding a common finishing diet to slaughter. Performance and carcass traits did not differ between adaptation systems. A combination of MDGS and SYNERGY can be used to adapt beef cattle to feedlot diets with efficacy of the traditional, forage-based method.

Introduction

Results of metabolism and feedlot research using wet corn gluten feed (Sweet Bran®; Cargill Corn Milling, Blair, Neb.) indicated decreasing Sweet Bran instead of forage was a viable method for adapting feedlot cattle to feedlot finishing diets (*2009 Nebraska Beef Cattle Report,* pp. 53-58). Using distillers grains in a similar comparison did not give as favorable results in metabolism studies (*2010 Nebraska Beef Cattle Report,* pp. 72-73) and has not been evaluated in the feedlot. However, ADM is combining modified distillers grains with solubles (MDGS) and wet corn gluten feed (WCGF) as a feed product (Golden Synergy, ADM, Columbus, Neb.). When steers were adapted with Golden Synergy, rumen pH and intakes were favorable compared to use of forage (*2011 Nebraska Beef Cattle Report,* pp. 57-59).

Our objective was to evaluate feedlot performance when comparing a combination of MDGS and WCGF to forage for adapting cattle to finishing diets.

Procedure

Two hundred and thirty-six yearling crossbred steers (BW = 945 ± 1.32 lb) were used to evaluate two different adaptation strategies. A randomized complete block design was used with four weight blocks. Before the trial began, steers were limit fed at 2% of their BW for five days to avoid variation in gut fill, and weighed on two consecutive days. All animals were implanted with Revalor®-S at the beginning of the study. The heavy block consisted of one replication of 30 steers, the medium-heavy block consisted of one replication of 30 steers, the medium-light block consisted of two replications of 30 steers and two replications of 28 steers, and the light block consisted of two replications of 28 steers. Steers were assigned randomly to a pen within block, and pens were assigned randomly to one of the two treatments (8 pens/treatment; 14 or 15 steers/pen).

The treatments consisted of decreasing concentrations of a blend of MDGS and WCGF (SYNERGY) in the diet throughout the 24-day adaptation period compared with decreasing concentrations of forage (CON). In both treatments, corn increased in the diet until steers were adapted to a common finishing diet. The SYNERGY steers were fed decreasing levels of the MDGS and WCGF combination (87.5 to 35%), whereas CON animals were fed the traditional grain adaptation diets with decreasing forage from 45 to 7.5%. Four adaptation diets (Table 1) were used to increase corn with diets fed 5, 5, 7, and 7 days, respectively. The common finishing diet was fed for 120 days after the 24-day adaptation period and consisted of 35% of the blend of MDGS and WCGF, 52.5% DRC, 7.5% alfalfa hay, and 5% supplement. Cattle were fed once daily at 0800. All diets provided 320 to 360 mg/steer of Monensin, 90 mg/steer of Tylosin, and 150 mg/steer of thiamine daily.

Final live weights collected before slaughter were shrunk 4% to account for gut fill in order to calculate dressing percentage. Final live weights were calculated from carcass weight adjusted to 63% dressing percentage. Steers were slaughtered at a commercial packing plant (Greater Omaha Pack, Omaha, Neb.) and HCW was collected on the day of slaughter. After a 48- hour chill, longissimus muscle (LM) area, 12th rib fat depth, and USDA marbling scores were recorded. A calculated USDA YG was determined from HCW, fat depth (FT), LM area, and an assumed constant value for KPH of 2.5% using the equation: 2.50 + (2.5*FT, in) – (0.32*LM area, in^2) + (0.2*KPH, %) + (0.0038*HCW).

All data were analyzed using the MIXED procedures of SAS (SAS Inst., Inc., Cary, N.C.) as a randomized complete block design with pen as the experimental unit. Live performance data were analyzed not only for the entire feeding period, but also for the adaptation period. Blocks were considered a random variable in the model.

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

	Adaptation				
Ingredients, % DM	STEP 1	STEP 2	STEP 3	STEP 4	Finishing
Control					
ADM Golden Synergy	35.0	35.0	35.0	35.0	35.0
Dry-rolled corn	15.0	25.0	35.0	45.0	52.50
Alfalfa	45.0	35.0	25.0	15.0	7.50
Supplement	5.00	5.00	5.00	5.00	5.00
CO-PRODUCT					
ADM Golden Synergy	87.5	74.375	61.25	48.125	35.0
Dry-rolled corn	0.00	13.125	26.25	39.375	52.5
Alfalfa	7.50	7.50	7.50	7.50	7.50
Supplement	5.00	5.00	5.00	5.00	5.00

Table 2. Growth performance during first 34 days while being adapted to finishing diet.

	Treatments[1]		
Live Performance	CON	SYNERGY	*P*-value
Initial BW, lb	945	945	1
Adaptation BW, lb	1088	1095	0.22
DMI, lb/day	24.8	23.9	<0.01
ADG, lb	4.05	4.23	0.28
F:G	6.10	5.65	0.04

[1]CON= Control treatment with traditional adaptation using roughage, SYNERGY = treatment utilizing a combination of modified distillers grains with solubles and wet corn gluten feed.

Table 3. Overall performance and carcass characteristics for steers adapted with forage (CON) or byproduct (SYNERGY).

	Treatment[1]		
	CON	SYNERGY	*P*-value
Initial BW, lb	945	945	1.0
Final BW[2], lb	1474	1463	0.31
DMI, lb/day	25.2	24.9	0.20
ADG, lb	3.66	3.59	0.35
F:G	6.90	6.90	0.84
Carcass weight, lb	927	923	0.35
Dressing percentage[3], %	62.2	61.7	0.04
Marbling score[4]	660	636	0.17
LM area, in^2	13.65	13.63	0.86
Fat depth, in	0.64	0.64	0.79
USDA YG[5]	3.76	3.73	0.66

[1]CON= Control treatment with traditional adaptation using roughage, SYNERGY = treatment utilizing a combination of modified distillers grains with solubles and wet corn gluten feed.
[2] Final BW based on carcass weight and 63% dressing percentage.
[3]Dressing percentage = carcass weight/average live weight (4% shrink).
[4]USDA marbling score where 450 = slight50, 500 = small0, and 550 = small50.
[5]USDA calculated YG = 2.50 + (2.5*FT, in) – (0.32*LM area, in^2) + (0.2*KPH, %) + (0.0038*HCW).

Results

Intakes were greater ($P < 0.01$) for the CON treatment than for SYNERGY during adaptation when evaluated after 34 days (24-day adaptation; Table 2). No differences were observed for ADG ($P = 0.28$) between treatments, resulting in a lower F:G ($P = 0.04$) for steers adapted with the SYNERGY treatment compared with CON during the first 34 days.

Over the entire feeding period, DMI, ADG, and F:G were not different ($P > 0.20$) between steers adapted with CON or steers adapted with SYNERGY (Table 3). Final BW calculated from carcass weight was not impacted by adaptation treatment ($P = 0.31$). Likewise, final BW measured live (shrunk 4%) was not different ($P = 0.63$) between treatments. The only difference ($P = 0.04$) detected for carcass characteristics was dressing percentage (62.2 vs. 61.7 for CON and SYNERGY treatments, respectively). These results suggest that decreasing inclusion of a combination of distillers grains and gluten feed adapted cattle to a high-concentrate diet similar to using forage in a traditional adaptation method.

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Using Beet Pulp to Adapt Cattle to Finishing Diets

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Summary

Cattle were adapted to a common finishing diet over 21 days by traditional adaption, reducing alfalfa hay inclusion (46 to 6%) or beet pulp (BP) adaption programs. A low beet pulp treatment (BP decreased from 18 to 6% and alfalfa hay from 34 to 6%) and a high BP treatment in which both BP and alfalfa hay were decreased from 26 to 6% were compared. Adapting cattle with high BP tended to decrease DMI during the adaption period. Both BP adaption programs increased ADG over the entire feeding period. Replacing up to 50% of alfalfa hay with BP during grain adaption had no impact on F:G or carcass traits and increased ADG.

Introduction

Replacing all of the corn silage in the diet (10 %DM) with beet pulp (BP) resulted in similar ADG and a trend toward improved feed efficiency in a feedlot finishing diet (1993 *Nebraska Beef Cattle Report*, pp. 48-49). Another study included BP at 8.5 and 12.5% of diet DM as the only source of roughage in a finishing diet and showed decreased ADG and DMI with no difference in F:G (2001 *Nebraska Beef Cattle Report*, pp. 67-69). Although BP is commonly used as a fiber source, little research has evaluated the use of BP in grain adaption programs. The objective of this study was to compare grain adaption programs using BP to traditional grain adaption with alfalfa hay.

Procedure

Yearling crossbred steers (n=232; BW=718 ± 32 lb) were separated into three weight blocks, stratified by BW, and assigned randomly within strata to 18 feedlot pens, with 12 or 13 steers per pen. Treatments were imposed during grain adaption (21 days) using three grain adaptation programs (Table 1). Within each program, four grain adaption diets were fed for 3, 4, 7, and 7 days. Each program increased dry-rolled corn (DRC) inclusion while roughage inclusion decreased. In the control treatment, alfalfa hay inclusion decreased from 46 to 6% and pressed BP (24% DM) was held constant at 6% in all step diets. Beet pulp adaption programs included a low BP treatment (LOBP) where BP was decreased from 18 to 6% and alfalfa hay from 34 to 6%, or a high BP treatment (HIBP) in which both BP and alfalfa hay were decreased from 26 to 6%. Subsequent to grain adaption, all steers were fed a common finishing diet for the remainder of the feeding period. All step diets and the finishing diet contained 20% wet distillers grains with solubles (WDGS), 0.25% urea, and 5.75% liquid supplement that was formulated to provide 33 g/ton Rumensin® and 90 mg/steer daily Tylan® (DM basis). All cattle were offered *ad libitum* access to feed and water for the duration of the study.

Prior to trial initiation, steers were limit fed a 55% alfalfa hay, 40% WDGS, 5% supplement diet for five days at 1.8% of BW to minimize variation in gut fill. Upon initiation of the study, cattle were vaccinated with Bovi-Shield® Gold 5 and Vision® 7, poured with Ivomec®, branded, tagged, and weighed. Weights were measured over two consecutive days (days 0 and 1) to determine initial BW. Feed ingredient samples were collected weekly throughout the trial, dried in a forced-air oven at 60°C for 48 hours, and analyzed for nutrient content. On day 28, following grain adaptation, and after being on a common finishing diet for seven days, BW were collected and cattle were implanted with Component® TE-S. A 4% pencil shrink was subtracted from this BW to obtain 28-day BW.

After 148 or 181 days on feed, cattle were weighed and transported to a commercial abattoir (Cargill Meats

Table 1. Dietary composition (%) and DOF of control (CON), low beet pulp (LOBP) and high beet pulp (HIBP) adaptation methods (DM).

Days fed	1-3	4-7	8-14	15-21	
Adaptation	1	2	3	4	Finisher
CON					
Alfalfa	46	36	26	16	6
Beet Pulp	6	6	6	6	6
DRC[1]	22	32	42	52	62
WDGS[2]	20	20	20	20	20
Supplement[3]	5.75	5.75	5.75	5.75	5.75
Urea	0.25	0.25	0.25	0.25	0.25
LOBP					
Alfalfa	34	27	20	13	6
Beet Pulp	18	15	12	9	6
DRC[1]	22	32	42	52	62
WDGS[2]	20	20	20	20	20
Supplement[3]	5.75	5.75	5.75	5.75	5.75
Urea	0.25	0.25	0.25	0.25	0.25
HIBP					
Alfalfa	26	21	16	11	6
Beet Pulp	26	21	16	11	6
DRC	22	32	42	52	62
WDGS	20	20	20	20	20
Supplement[3]	5.75	5.75	5.75	5.75	5.75
Urea	0.25	0.25	0.25	0.25	0.25

[1]Dry-rolled corn.
[2]Wet distillers grains with solubles.
[3]Supplement formulated to provide 33 g/ton Ruminsin and 90 mg/head/day Tylan (DM).

Table 2. Feedlot performance and carcass characteristics of cattle adapted to grain using control (CON), low beet pulp (LOBP), or high beet pulp (HIBP) adaptation methods.

Item	Treatment			SEM	P-value
	CON	LOBP	HIBP		
Performance					
Initial BW, lb	718	718	718	0.8	0.30
Final BW, lb[1]	1312	1342	1343	21.7	0.32
DMI, lb/day					
28 day	21.8[a]	21.4[ab]	20.9[b]	0.34	0.07
Final	23.8	24.2	24.0	0.40	0.58
ADG, lb					
28 day	4.19	4.10	4.23	0.20	0.80
Final[1]	3.63[a]	3.80[b]	3.81[b]	0.08	0.07
F:G,[2]					
28 day	5.20	5.22	4.94	0.14	0.20
Final[1]	6.56	6.36	6.30	0.08	0.11
Final live BW, lb	1317	1348	1341	17.4	0.20
Carcass characteristics					
HCW, lb	827	845	846	13.7	0.32
Dressed yield, %	62.8	62.7	63.0	0.4	0.78
LM area, in^2	12.4	12.4	12.4	0.20	0.99
12th rib fat, in	0.59	0.60	0.59	0.02	0.80
Yield Grade[3]	3.67	3.75	3.72	0.08	0.61
Marbling[4]	629	635	636	18.5	0.90
Liver abscess, %	19.5	16.9	12.9	—	0.63

[1]Final BW was calculated from HCW using a common dressed yield of 63%.
[2]Statistics performed on carcass adjusted G:F.
[3]Calculated as 2.5+ (2.5 x 12th rib fat) + (0.2 x 2.5[KPH]) + (0.0038 x HCW)-(0.32 x LM area).
[4]400 = Slight, 500 = Small, 600 = Modest.
[a,b]Within a row, means without a common superscript are different, $P < 0.05$.

Solutions, Fort Morgan, Colo.). A 4% pencil shrink was subtracted from this BW to obtain final live weight. Hot carcass weights (HCW) and liver abscesses scores were obtained on the day of slaughter. Following a 48-hour chill, USDA marbling score, 12th rib fat thickness, and Longissimus muscle area (LM) were recorded. Yield grade was calculated using HCW, 12th rib fat thickness, LM, and an assumed percentage (2.5%) of kidney, pelvic, and heart fat (KPH) using the following formula: 2.5+ (2.5 x 12th rib fat) + (0.2 x 2.5[KPH]) + (0.0038 x HCW)-(0.32 x LM). Carcass adjusted performance was calculated using a common dressing percentage (63%) to determine carcass adjusted final BW, ADG and F:G.

Animal performance data and carcass characteristics were analyzed using the MIXED procedure of SAS (SAS Inst., Inc., Cary, N.C.). Pen was the experimental unit, fixed effect was treatment, and block was treated as a random effect. Treatment comparisons were made using pair-wise comparisons when the F-test statistic was significant. Prevalence of liver abscesses was analyzed using the GLIMMIX procedure of SAS.

Results

Feedlot performance data and carcass characteristics are summarized in Table 2. Cattle adapted to grain using HIBP tended to have lower DMI (P = 0.02) during the adaption period. Another study found similar reductions in DMI when BP was compared to corn silage as a roughage source in a finishing diet (*2001 Nebraska Beef Cattle Report,* pp. 67-69). These reductions in DMI are likely due to differences in fiber digestibility between the roughage sources. BP contains highly digestible fiber that is a rich source of energy and could decrease DMI compared to corn silage or low quality alfalfa hay. Average daily gain and F:G were similar among treatments during the grain adaptation period. However, based off of carcass adjusted final BW steers adapted using HIBP and LOBP had greater ADG (P = 0.04) compared with cattle adapted with the control treatment. Increases in ADG could have occurred during the grain adaption period and were not realized until the end of the feeding period when carcass adjusted values were available. This could be due to the difficulty associated with accurately measuring change in BW over short durations of time due to variation in gut fill and differences observed in DMI at day 28 may lead to differences in gut fill. If gain responses were primarily during the adaption period, these differences may be attributed to an increase in digestibility or higher energy content of BP compared to low quality alfalfa hay. Several studies have noted improvements in ADG when BP replaced a portion of the corn silage in growing diets (*1992 Nebraska Beef Cattle Report*, pp. 24-25; *1993 Nebraska Beef Cattle Report*, pp. 48-49; *2000 Nebraska Beef Cattle Report*, pp. 36-37). Another study observed increased ADG when BP replaced corn silage at 8.5 and 12.5% of diet DM (2001 *Nebraska Beef Cattle Report*, pp. 67-69). Overall F:G was not different (P = 0.11) among treatments, although approaching significance with cattle adapted using BP having numerically lower F:G compared with cattle adapted with the control treatment. Dry matter intakes were not affected by adaption method.

Carcass characteristics were not affected by adaptation method. Hot carcass weights were similar (P = 0.31) among treatments, and dressing percentage was not different. No differences were observed in LM area or calculated YG and USDA marbling scores were similar among treatments, as well as 12th rib fat thickness (P = 0.80), indicating steers were finished to similar endpoints. Increases in ADG for HIBP and LOBP were likely due to the 21-day adaptation period, as the finishing diets were the same for the remainder of the study. Replacing up to 50% of alfalfa hay with BP during grain adaption increased ADG.

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Effect on Performance and Nutrient Mass Balance of Feeding Micro-Aid in Wet Distillers Grains Plus Solubles Diets

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Summary

Finishing cattle performance and mass balance were evaluated when Micro-Aid® was fed in diets containing wet distillers grains plus solubles (WDGS). There was no difference in performance and carcass characteristics between treatments. In a WINTER experiment, cattle fed Micro-Aid had a greater amount of OM and DM removed in manure. Micro-Aid in the diet increased the amount of manure N and decreased N losses in the WINTER. There was no difference in N excreted in manure or lost via volatilization in the SUMMER experiment.

Introduction

When WDGS was fed at 30% of diet, N excreted was 84.6 lb/steer, with 45.5 lb N lost in WINTER and 58.4 lb N lost in SUMMER (*2008 Nebraska Beef Cattle Report,* pp. 53-56). Micro-Aid is a feed ingredient from an all natural plant extract, which contains saponins that have natural detergent and surfactant properties. Information suggests it is excreted along with feces and enhances the microbial population, which converts undigested nutrients into organic nitrogen compounds. The objective of the current study was to determine effect of feeding Micro-Aid in WDGS diets on performance and nutrient mass balance on the pen surface.

Procedure

Cattle Performance

Two experiments were conducted using 96 steers each. Calves (665 ± 24 lb BW) were fed 180 days from November to May (WINTER) and yearlings (708 ± 19 lb BW) fed 160 days from May to November (SUMMER) to evaluate feeding Micro-Aid in diets containing wet distillers grains with solubles (WDGS) on nutrient mass balance in open feedlot pens. Steers were blocked by BW, stratified within block, and assigned randomly to pen (8 steers/pen). Dietary treatments consisted of 35% WDGS, 55% corn fed at a ratio of 1:1 dry-rolled corn and high-moisture corn, 5% straw, and 5% supplement (CON), with Micro-Aid being added in the treatment supplement at an inclusion of 1g/ steer daily (TRT). Cattle were adapted to finishing diets over a 21-day period with the corn blend replacing alfalfa hay. Rumensin® was fed at 345 mg/head/day in both experiments.

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

Variable	CON[1]	Micro-Aid	SEM	*P*-value
Performance				
Initial BW, lb	665	665	0.8	0.89
Final BW, lb[2]	1266	1255	13.5	0.58
DMI, lb/day	21.2	20.9	0.3	0.65
ADG, lb	3.33	3.28	0.07	0.66
Feed:Gain[3]	6.35	6.38	0.003	0.83
Carcass Characteristics				
HCW, lb	798	791	7.6	0.56
Marbling score[4]	547	560	12.7	0.48
12th rib fat, in	0.57	0.57	0.6	0.93
LM area, in²	12.5	12.1	0.2	0.09
Calculated YG[5]	3.40	3.40	0.7	1.00

[1]CON = Control.
[2]Final weight calculated as hot carcass weight divided by 0.63.
[3]Analyzed as gain:feed, reported as feed:gain.
[4]500 = Small 0, 600 = Modest 0.
[5]YG calculation = 2.50 + (2.5 * 12th rib fat thickness) – (.32 * LM area) + (.2 * KPH (2.5)) + (.0038 * HCW).

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

Variable	CON[1]	Micro-Aid	SEM	*P*-value
Performance				
Initial BW, lb	708	708	1.3	0.93
Final BW, lb[2]	1309	1302	11.3	0.67
DMI, lb/day	20.8	20.7	0.3	0.76
ADG, lb	3.75	3.72	0.07	0.71
Feed:Gain[3]	5.55	5.56	0.003	0.80
Carcass Characteristics				
HCW, lb	825	820	7.1	0.67
Marbling score[4]	546	537	14.4	0.66
12th rib fat, in	0.55	0.51	0.2	0.27
LM area, in²	13.0	13.1	0.2	0.67
Calculated YG[5]	3.13	3.01	1.1	0.72

[1]CON = Control.
[2]Final weight calculated as hot carcass weight divided by 0.63.
[3]Analyzed as gain:feed, reported as feed:gain.
[4]500 = Small 0, 600 = Modest 0.
[5]YG calculation = 2.50 + (2.5 * 12th rib fat thickness) – (.32 * LM area) + (.2 * KPH (2.5)) + (.0038 * HCW).

Table 3. Effect of Micro-Aid on nitrogen mass balance during WINTER[1].

Variable	CON	Micro-Aid	SEM	*P*-value
N intake	102.5	101.4	0.7	0.66
N retention[2]	12.1	12.0	0.1	0.76
N excretion[3]	90.3	89.4	0.7	0.68
Manure N[4]	40.9	56.6	2.2	0.03
N Run-off	2.36	2.25	0.3	0.92
N Lost	46.3	30.7	2.3	0.05
N Loss, %[5]	52.2	34.0	5.4	0.04
DM removed	6111	7852	292.6	0.09
OM removed	815	1178	42.7	0.02

[1]Values are expressed as lb/steer over entire feeding period (180 DOF).
[2]Calculated using the NRC net protein and net energy equations.
[3]Calculated as N intake – N retention.
[4]Manure N with correction for soil N.
[5]Calculated as N lost divided by N excretion.

Table 4. Effect of Micro-Aid on nitrogen mass balance during SUMMER[1].

Variable	CON	Micro-Aid	SEM	*P*-value
N intake	85.6	85.2	0.5	0.79
N retention[2]	12.0	11.9	0.1	0.73
N excretion[3]	73.7	73.3	0.5	0.83
Manure N[4]	17.7	16.9	0.7	0.78
N Run-off	3.00	2.40	0.2	0.20
N Lost	52.9	54.0	0.9	0.69
N Loss, %[5]	71.9	73.8	2.5	0.60
DM removed	1063	1050	96.3	0.97
OM removed	276	230	10.6	0.64

[1]Values are expressed as lb/steer over entire feeding period (160 DOF).
[2]Calculated using the NRC net protein and net energy equations.
[3]Calculated as N intake – N retention.
[4]Manure N with correction for soil N.
[5]Calculated as N lost divided by N excretion.

Steers in the WINTER experiment were implanted on day 1 with Revalor®-IS followed by Revelor®-S on day 80. Steers in the SUMMER experiment were implanted with Revalor-S on day 36. Steers were slaughtered on day 180 (WINTER) and day 160 (SUMMER) at a commercial abattoir (Greater Omaha, Omaha, Neb.). Hot carcass weight and liver scores were recorded on day of slaughter. Fat thickness and LM area were measured after a 48-hour chill, and USDA called marbling score was recorded. Final BW, ADG, and F:G were calculated based on hot carcass weights adjusted to a common dressing percentage of 63.

Nutrient Balance

Nutrient mass balance experiments were conducted using 12 open feedlot pens with retention ponds to collect runoff. When rainfall occurred, runoff collected in retention ponds, was drained and quantified using an air bubble flow meter (ISCO, Lincoln, Neb.). Before placing cattle in pens, 16 soil core samples (6 inch depth) were taken from each pen in both experiments. After cattle were removed from the pens, manure was piled on a cement apron and sampled (n = 30) for nutrient analysis while being loaded. Manure was weighed before it was hauled to the University of Nebraska–Lincoln compost yard. Manure was freeze-dried for nutrient analysis and oven dried for DM removal calculation. After manure was removed, additional soil core samples were taken from each pen to assess efficiency of pen cleaning.

Ingredients were sampled monthly and feed refusals were analyzed to determine nutrient intake using a weighted composite on a pen basis. Retained steer N and P were calculated using the energy, protein, and P equations (NRC, 1996). Nutrient excretion was determined by subtracting nutrient retention from intake (ASABE, 2005). Total N lost (lb/steer) was calculated by subtracting manure N (corrected for soil N content) and runoff N from excreted N. Percentage of N lost was calculated as N lost divided by N excretion. Dietary treatments were fed in the same pen for both experiments. Data were analyzed using the MIXED procedure of SAS (SAS Inst., Inc., Cary, N.C.).

Results

Feedlot Performance

Dry matter intake, ADG, and F:G were similar among treatments ($P > 0.65$) in both experiments (Tables 1 and 2). Feed efficiencies were not different ($P > 0.80$). Carcass characteristics were not influenced ($P > 0.05$) by the inclusion of Micro-Aid in the diet in either experiment.

Nutrient Balance

Nitrogen intake, retention, and excretion (Tables 3 and 4) were similar among treatments ($P > 0.10$) in both experiments. Total N in manure was greater ($P = 0.03$) for steers fed Micro-Aid in the WINTER, but was not different ($P > 0.10$) in the SUMMER. The amount of N lost via volatilization was greater ($P = 0.05$) for the CON cattle in the WINTER. The percent N loss expressed as a percentage of N excretion was greater ($P = 0.04$) for the CON group compared to the TRT diet. The inclusion of Micro-Aid in the diet fed in the SUMMER experiment had no affect ($P > 0.10$) on N lost, and no differences were found ($P > 0.10$) in the percent of N lost. Run-off N was not different ($P > 0.10$) among groups, and averaged 2.57% and 3.45% of total N excreted in the WINTER and SUMMER, respectively. In the WINTER, total dry matter removed was numerically greater ($P = 0.09$) for cattle fed Micro-Aid. Organic matter removed was greater ($P = 0.02$) for TRT cattle than the

(Continued on next page)

CON cattle. Dry matter and organic matter removed were similar ($P > 0.75$) between the CON and TRT group in the SUMMER.

Phosphorus intake, retention, and excretion were similar ($P > 0.10$) among treatments (Tables 5 and 6) in both experiments. Manure P was greater ($P = 0.02$) for cattle fed Micro-Aid than the CON cattle for the WINTER. Manure P was not different ($P > 0.10$) between the CON and Micro-Aid cattle during the SUMMER. Nitrogen to phosphorus ratios were similar ($P > 0.10$) in both experiments.

These data suggest inclusion of Micro-Aid in diets does not affect performance or carcass characteristics. When fed in WDGS diets in the winter, Micro-Aid increased the amount of DM and OM removed from pens. Additionally, N retained in the manure was greater for cattle fed Micro-Aid, as well as reducing the amount of N lost via volatilization. However, Micro-Aid in the diet showed no differences in nitrogen or phosphorus mass balance when fed in the summer.

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Table 5. Effect of Micro-Aid on P mass balance during WINTER[1].

Variable	CON	Micro-Aid	SEM	*P*-value
P intake	19.6	19.4	0.1	0.65
P retention[2]	2.96	2.93	0.03	0.81
P excretion[3]	16.7	16.5	0.1	0.67
Manure P	22.1	32.4	1.2	0.02
Run-off P	1.01	1.19	0.1	0.69
P manure+soil[4]	22.6	31.6	1.0	0.02
N:P ratio[5]	1.75	1.72	0.3	0.67

[1]Values are expressed as lb/steer over entire feeding period (180 DOF).
[2]Calculated using the NRC net protein and net energy equations.
[3]Calculated as P intake – P retention.
[4]Manure P with correction for soil P.
[5]Nitrogen to Phosphorus ratio, DM basis.

Table 6. Effect of Micro-Aid on P mass balance during SUMMER[1].

Variable	CON	Micro-Aid	SEM	*P*-value
P intake	17.4	17.4	0.1	0.79
P retention[2]	2.91	2.89	0.03	0.78
P excretion[3]	14.5	14.5	0.09	0.82
Manure P	2.85	3.73	0.5	0.57
Run-off P	1.21	1.04	0.07	0.48
P manure+soil[4]	7.48	7.83	0.5	0.82
N:P ratio[5]	1.90	2.01	0.8	0.48

[1]Values are expressed as lb/steer over entire feeding period (160 DOF).
[2]Calculated using the NRC net protein and net energy equations.
[3]Calculated as P intake – P retention.
[4]Manure P with correction for soil P.
[5]Nitrogen to Phosphorus ratio, DM basis.

Effects of Barley Diets with Distillers Grains Plus Solubles on Feedlot Performance and N and P Balance

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Summary

Effects of barley starch:NDF ratio and DDGS inclusion on feedlot performance, carcass characteristics, and N and P mass balance were evaluated in a commercial feedyard in Alberta, Canada. Yearling heifers were assigned randomly at reimplant to four treatments (0 or 20% DDGS and LOW or HIGH starch:NDF barley). Feeding LOW starch:NDF barley improved feedlot performance and increased N retention. Feeding 20% DDGS increased DMI, had a slight negative impact on F:G, and increased N and P losses.

Introduction

In a previous study, barley was segregated into high and low digestible energy based on Near Infrared Spectroscopy (NIR). Feed conversion on an adjusted carcass weight basis was improved for the low-energy barley compared to the high-energy barley. Using starch:NDF ratio by NIR instead of digestible energy may more accurately identify barley that will affect cattle performance.

Inclusion of DDGS in the diet has been shown to improve feedlot performance, but it also increases dietary nitrogen (N) and phosphorus (P), subsequently increasing the amount of N and P excreted and N lost. The objective of this study was to evaluate the impact of starch:NDF by NIR of barley and 0% or 20% DDGS on feedlot performance, carcass characteristics, and N and P mass balance in commercial sized pens.

Procedure

Crossbred yearling heifers (n = 9,538 in 32 pens, 1,085 ± 108 lb initial BW) were assigned randomly at the time of reimplant to a 2 x 2 factorial arrangement of treatments and fed for an additional 81 days from February to July 2010 at a commercial feedyard near High River, Alberta, Canada. Main effects included LOW or HIGH starch:NDF barley and 0 or 20% inclusion of DDGS. At reimplant, heifers were stratified by BW and implanted with Synovex® Choice.

Barley was characterized as HIGH (starch:NDF > 3.25) or LOW (starch:NDF < 3.25) at feedlot arrival based on values determined by NIR. One-third of the barley that arrived at the feedlot had a starch:NDF ratio greater than 3.25. Once a shipment of barley was determined to be HIGH or LOW, it was tempered, rolled, and stored in bins by barley treatment.

Treatment diets and nutrient analysis are presented in Table 1. The supplement included Rumensin® at 24.3 g/ton DM and Tylan® at 10.7 g/ton DM. Pens of cattle were fed *ad libitum* once daily in the morning at approximately 0700 hours.

At the end of the feeding period, heifers were shipped for slaughter by weight strata identified at reimplant. All cattle were slaughtered at the same commercial abattoir with the same number of heifers shipped within a replicate on a given day. Hot carcass weight, fat thickness, longissimus muscle area (LM), marbling score, USDA Quality Grade (QG), and USDA Yield Grade (YG) were recorded electronically at the packing plant.

Nutrient Balance

Nutrient mass balance was conducted using 32 open-air feedlot pens. Since the feedlot was a large commercial yard, runoff from the 32 trial pens could not be separated from runoff from the rest of the feedlot. Pens were cleaned initially at the time of reimplant while pens of cattle were at the rehandling facility. When all heifers in a pen had been shipped for harvest,

(Continued on next page)

Table 1. Composition of complete mixed finishing diets.

	Experimental Group[1]			
	HIGH/0	HIGH/20	LOW/0	Low/20
Ingredient, DM				
HIGH barley	98.08	78.08	—	—
LOW barley	—	—	98.08	78.08
DDGS	—	20.00	—	20.00
Supplement	1.92	1.92	1.92	1.92
Nutrient Composition, DM				
Starch	53.1	39.5	50.2	34.1
NDF	15.1	21.0	15.9	20.2
CP	11.5	18.2	12.1	18.1
Calcium	1.6	1.9	1.6	1.9
Phosphorus	0.3	0.5	0.3	0.5

[1]High barley (HIGH) is barley that was segregated based on a high starch:NDF ratio (> 3.25). Low barley (LOW) is barley that was segregated based on a low starch:NDF ratio (< 3.25). DDGS is corn based dried distillers grains with solubles. 0 is 0% DDGS included in the diet, 20 is 20% DDGS included in the diet.
[2]Supplement contained 24.3 g/ton DM Rumensin, 10.7 g/ton DM Tylan.

Table 2. Main effects of barley starch:NDF ratio and DDGS level on feedlot performance and carcass characteristics.

	BARLEY		DDGS			*P*-Value		
Variable	HIGH	LOW	0	20	sem	BARLEY	DDGS	INT
Carcass Adjusted Performance								
Initial BW, lb	1074	1074	1074	1074	51.8	0.79	0.86	0.90
Final BW, lb	1288	1300	1293	1295	5.6	0.03	0.70	0.46
DMI, lb/day	20.7	21.3	20.7	21.3	0.16	<0.01	<0.01	0.23
ADG, lb	2.47	2.61	2.54	2.54	0.21	0.02	0.92	0.94
F:G	9.20	8.96	8.91	9.25	0.60	0.25	0.12	0.72
Carcass characteristics								
HCW, lb	754	761	757	758	3.3	0.03	0.74	0.45
12th Rib Fat, in	0.46	0.45	0.45	0.47	0.01	0.28	0.02	0.22
LM Area, in	13.35	13.40	13.43	13.32	0.07	0.61	0.21	0.39

[1]High barley is barley that was segregated based on a high starch:NDF ratio (> 3.25). Low barley is barley that was segregated based on a low starch:NDF ratio (< 3.25). DDGS is corn based dried distillers grains with solubles. 0 is 0% DDGS included in the diet, 20 is 20% DDGS included in the diet.
[2]Carcass Weight Basis values were calculated using carcass weights obtained at slaughter, converted to live weights using a fixed dressing percentage of 60.0%.
[3]Live Weight Basis values were calculated using shrunk live weights obtained prior to slaughter.
[4]Marbling Score 600 = Modest, 500 = Small, 400 = Slight.
[5]Dressing % of cattle marketed in Canada will differ from that of similar animals marketed in the United States. The U.S. carcass weight includes the weight of the kidney, pelvic, and heart fat.

Table 3. Simple effects of barley starch:NDF ratio and DDGS inclusion on nitrogen and phosphorus mass balance.

	Experimental Group					*P*-Value		
Variable	HIGH/0	HIGH/20	LOW/0	LOW/20	SEM	BARLEY	DDGS	INT
Average days	84	84	86	86	12	0.13	0.81	0.71
Manure DM, lb/head	570.0	656.8	700.2	711.4	104.4	0.18	0.47	0.58
N Intake, lb/head	37.7[a]	60.50[b]	42.0[a]	57.8[b]	3.3	0.62	<0.01	0.04
N Retention, lb/head	4.6	4.6	4.7	4.9	1.1	0.03	0.28	0.35
N Excretion, lb/head	33.2[a]	55.9[b]	37.3[a]	52.9[b]	2.3	0.70	<0.01	0.03
N Removed manure, lb/head	5.1	5.7	6.0	6.6	0.9	0.17	0.34	0.98
N Loss, lb/head	28.1[a]	50.2[b,d]	31.3[a,b]	46.4[b,c]	1.7	0.83	<0.01	0.02
N Loss, %	84.18	89.44	81.98	87.67	1.90	0.19	<0.01	0.88
P Intake, lb/head	6.5[c]	9.6[a]	7.3[b]	9.4[a]	0.5	0.18	<0.01	0.03
P Retention, lb/head	1.1	1.1	1.2	1.2	0.3	0.03	0.28	0.37
P Excreted, lb/head	4.8[c]	7.4[a]	5.6[b]	7.7[a]	0.8	0.20	<0.01	0.05
P Removed manure lb/head	2.5	2.9	2.9	3.3	0.4	0.21	0.15	0.98
P Loss, lb/head	2.4	4.5	2.7	4.3	0.5	0.69	<0.01	0.43
P Loss, %	45.79	58.52	45.15	56.62	5.61	0.63	<0.01	0.89

[1]High barley is barley that was segregated based on a high starch:NDF ratio (> 3.25). Low barley is barley that was segregated based on a low starch:NDF ratio (< 3.25). DDGS is corn based dried distillers grains with solubles. 0 is 0% DDGS included in the diet, 20 is 20% DDGS included in the diet.
[2]Retention is retention in the animal calculated from NRC equations (NRC, 1996).
[3]Excreted is calculated as the difference between intake and retention.
[4]Removed is the waste material removed from feedlot surface when pens were cleaned after all animals had been shipped for slaughter.
[5]Runoff is included in the loss and is less than 5% of the total N loss, or an average of 1.46 lbs N/head and 0.13 lbs P/head.
[abc]Means with in a row with different superscripts differ (P < 0.05).

pens were cleaned by scraping manure into a pile in the middle of the pen and loading into a tractor-trailer using a loader tractor. Two composite manure samples were taken as the pile was hauled out of the pen by collecting 20 sub-samples. Composites were submitted to Agri-Food Laboratories for nutrient analysis. Trucks hauling manure were weighed and the weight was recorded by pen before the manure was hauled away.

Feedbunks and feed ingredients were sampled every two weeks to determine nutrient intake by pen. Retained heifer N and P were calculated using the energy, protein, and P equations (NRC, 1996). Nutrient excretion was determined by subtracting nutrient retention from intake. Total N lost (lb/head) was calculated by subtracting manure N from excreted N. Percentage of N lost was calculated as N lost divided by N excretion. Total P lost (lb/head) was calculated by subtracting manure P from excreted P. Percentage of P lost was calculated as P lost divided by P excretion.

Statistical Analysis

All data were analyzed using the Mixed procedure of SAS (SAS Inst., Inc., Cary, N.C.). Treatments were included in the model as fixed effects and replicate was included as a random effect.

Results

Feedlot Performance

No barley by DDGS interactions were observed when feedlot performance data were analyzed, therefore only main effects of barley starch: NDF ratio and DDGS are presented (Table 2).

With respect to the main effects of barley starch:NDF ratio, carcass adjusted final BW was 12.3 lb greater ($P = 0.03$) for heifers fed LOW starch:NDF barley compared to heifers fed HIGH starch:NDF barley. Carcass adjusted ADG was also greater ($P = 0.02$) for heifers fed LOW than HIGH, but carcass adjusted F:G was not different ($P > 0.10$). On a live weight basis, ADG and F:G were not different ($P \geq 0.24$) between the two barley treatments. Intake was 0.6 lb/day greater ($P < 0.01$) for heifers fed LOW starch:NDF barley than heifers fed HIGH starch:NDF barley. Barley treatment did not affect 12th rib fat, LM, marbling score, dressing percentage, YG or QG (P>0.10).

Carcass adjusted final BW, ADG, and F:G were not affected ($P > 0.10$) by DDGS treatment. On a live weight basis, ADG and F:G were greater ($P < 0.01$) for 20% compared to 0% DDGS. Fat depth and the percentage of YG 3 and YG 4 carcasses were greater ($P < 0.04$) for 20% DDGS compared to 0%, but no differences in USDA QG were observed ($P > 0.10$). Longissimus muscle area, marbling score, and dressing percentage were not affected ($P > 0.10$) by DDGS treatment.

Nutrient Balance

Barley by DDGS interactions were observed for several variables when nutrient balance data were analyzed; therefore, the simple effects are presented (Table 3). Barley by DDGS interactions ($P = 0.02$) were observed for N excretion and N loss lb/head. Nitrogen excretion, removal, loss (lb/head), loss expressed as a %, and total manure DM removed from the pen were not different ($P > 0.10$) between the HIGH and LOW barley treatments. Nitrogen retention was greater ($P = 0.03$) for the LOW starch:NDF barley compared to the HIGH starch:NDF barley. Nitrogen excretion, N loss (lb/head), and N loss expressed as a % were greater ($P = 0.01$) for 20DDGS compared to 0DDGS. Nitrogen retention and total manure DM removed from the pen were not affected by DDGS treatment.

Phosphorus balance data are presented in Table 3. Barley by DDGS interactions ($P < 0.10$) were observed for P intake and P excreted. Phosphorus excreted, P removed from the pen, P loss on a lb/head basis, and P loss expressed as a % were not affected ($P \geq 0.18$) by barley treatment. Phosphorus retained was greater ($P = 0.03$) for LOW starch:NDF barley compared to HIGH starch:NDF barley. Phosphorus excreted, P loss (lb/head), and P loss expressed as a % were greater ($P < 0.10$) for 20% compared to 0% DDGS. Phosphorus retention was not different ($P > 0.10$) between the two DDGS treatments.

Feeding LOW starch:NDF barley increased DMI, final BW on a carcass weight basis and HCW, improved ADG on a carcass weight basis, and had no effect on YG or QG. Feeding LOW starch:NDF barley increased N and P retention but did not affect N and P losses. Feeding 20% DDGS had a slight negative impact on F:G, and increased N and P losses to the environment.

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Feedlot Manure Utilization as Influenced by Application Scheme and Diet

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Summary

The BFNMP$ program was utilized to study effects of dietary nitrogen (N) and phosphorus (P), and N volatilization on economics of manure utilization. Feeding high CP (18.7%) and P (0.5%) diets increased manure net value $6.92/head compared to manure with a traditional diet (13.3% CP and 0.3% P) being fed. Spreading this manure on a four-year P basis is economical and environmentally friendly.

Introduction

The Beef Feed Nutrient Management Planning Economics (BFNMP$) computer program (available at *http://water.unl.edu/web/manure/software*; described in the *2006 Nebraska Beef Cattle Report,* p. 98; *2008 Nebraska Beef Cattle Report,* p. 59; and *2009 Nebraska Beef Cattle Report,* p. 89 can assist producers in understanding the impacts manure handling changes could have on their operation. The BFNMP$ program calculates manure management economics based on animal nutrient intake, manure nutrient availability, land requirements for spreading, operating costs, and fertilizer value. These values can be altered to fit individual operations or to look at industry averages. The first objective of this study was to look at the impacts of changing dietary nitrogen (N) and phosphorus (P) from levels found in a traditional grain-based diet to higher levels more indicative of a diet with 40% inclusion of distillers grains. A second objective was to study the effect of different N volatilization rates. A final objective was to evaluate the impact of changing manure application rates from N to P based and from one- to four-year rates.

Procedure

Several scenarios comparing diets (Table 1), N volatilization rates, and application rates (Table 2) were developed. While comparing scenarios, all other factors in the model were constant. The feeding scenario fed out 5,000 head of cattle per year in 100 head pens from 750 to 1,300 lb with 144 days on feed. Equipment used to clean pens included a four-yard loader and 20- ton truck-mounted spreader with $3.00/gallon fuel and a labor rate of $12/hour. Fifty percent of the land around the feedlot was accessible to spread manure on, 50% of which would be in corn each year with a corn and soybean rotation. Corn yields were set at 157 bu/ac and soybean yields at 42 bu/ac, which represent average yields in the United States from 2008-2010 (USDA-NASS). Fertilizer was valued at $0.55/lb N, $0.67/lb P, and $0.53/lb K ($0.25/lb urea, $0.30/lb P_2O_5, $0.32/lb K_2O). These represent three-year average prices paid in 2008-2010 for urea, P_2O_5, and K_2O in the north central region of the United States (USDA-NASS).

Results

An extensive survey of 29 feedlot nutritionists (*Journal of Animal Science*, 85:2772) looked at nutrient concentrations in feedlot diets. They found that, on average, feedlot diets, on a DM basis, are 13.3% CP, 0.7% Ca, 0.3% P, and 0.7% K. Based on this, two scenarios were evaluated, one with 13.3% CP and 0.3% P, and a more nutrient dense diet that would

Table 1. Impact of diet, N volatilization, and application rate on manure value and costs for a 5,000-head feedlot.

Diet	N volatilization	Application rate	Nutrient value[1], $/hd	Total cost, $/hd	Net value[2], $/hd	Average miles	Maximum miles
13.3% CP, 0.3% P	70%	N 1 year	18.18	6.26	11.92	0.2	0.4
13.3% CP, 0.3% P	50%	N 1 year	21.53	7.39	14.14	0.4	0.7
13.3% CP, 0.3% P	20%	N 1 year	26.55	8.96	17.59	0.6	0.9
18.7% CP, 0.5% P	70%	N 1 year	24.76	7.06	17.70	0.3	0.6
18.7% CP, 0.5% P	50%	N 1 year	29.70	8.64	21.06	0.5	0.9
18.7% CP, 0.5% P	20%	N 1 year	37.11	10.96	26.15	0.8	1.2
18.7% CP, 0.5% P	50%	N 1 year	29.70	8.64	21.06	0.5	0.9
18.7% CP, 0.5% P	50%	P 1 year	29.70	19.68	10.02	1.4	2.1
18.7% CP, 0.5% P	50%	P 4 year	29.70	9.35	20.35	1.4	2.1

[1]Based on inorganic fertilizer values of $0.55/lb N, $0.67/lb P, and $0.53/lb K. This does not take into account that when spreading on a one-year N rate every year there will be a buildup of P, which would decrease the value of the manure in subsequent years because the P is no longer needed.
[2]Net value accounts for increased value of manure with less N volatilization, but does not account for increased costs in order to achieve this.

Table 2. **Impact of manure application rate on land requirements and crop N and P requirements.**

Diet[1]	Application rate	Manure N, lb/year[3]	Manure P[2], lb/year[3]	Crop N required, lb/year	Crop P[2] required, lb/year	Land required, acres	Land required, acres/year
13.3% CP, 0.3% P	1 year N	76,163	78,534	76,163	25,387	672	672
13.3% CP, 0.3% P	4 year P	76,163	78,534	59,040	78,534	2,072	518
18.7% CP, 0.5% P	1 year N	112,336	148,425	112,336	37,490	995	995
18.7% CP, 0.5% P	4 year P	112,336	148,425	111,096	148,425	3,944	986

[1]Assume 50% N volatilization for all diets.
[2]P_2O_5.
[3]Crop available nutrients.

be typical of a 40% distillers grains diet with 18.7% CP and 0.5% P (*2006 Nebraska Beef Cattle Report,* p. 51).

Manure from cattle fed a traditional grain based feedlot diet, with 70% N volatilization, had a fertilizer value of $18.18/head (Table 1). This represents the value of all nutrients (N, P, and K) in the manure, but the actual value of the manure may be different if all nutrients are not utilized. Manure from cattle fed the same diet during the winter with 50% N volatilization was worth $21.53/head. When N volatilization was reduced to 20%, the manure value was $26.55/head. A more nutrient dense diet, i.e., 40% distillers grains, had a manure value of $24.76/head, $29.70/head, and $37.11/head for 70%, 50%, and 20% N volatilization, respectively. The best way of decreasing N volatilization is to clean pens more frequently; most likely this would increase costs as well as value of the manure. The increased cost of transporting and applying this manure is accounted for in the model.

Table 2 compares manure from the two different diets, with a constant 50% N volatilization, to show nutrient differences due to applying on a one-year N or four-year P rate. When manure is spread to meet N requirements of corn for one year, approximately four times the required amount of P is spread. If this is repeated every year there will be buildup of P in the soil and increased risk of P runoff into streams and lakes. Once P buildup occurs, future applications of manure are worth less because the P no longer has any value. If manure is spread to meet P requirements of corn for one year, then another source of N, such as anhydrous ammonia, will need to be added to the field. This requires going over the field twice each year to spread fertilizer, which is costly and unnecessary. In order to overcome both of these challenges, manure can be spread on a four-year P basis. The cost to spread on a one-year N rate is $8.64/head and requires the feedlot to travel an average of 0.5 miles around the feedlot to crop fields. Spreading on a one-year P rate increases this cost to $19.68/head and traveling to 1.4 miles. If the manure is spread on a four-year P rate, the cost is $9.35/head but the distance is still 1.4 miles because only one-fourth of the crop fields around the feedlot are being used each year. When applied on a four-year P rate, manure N closely matched crop N requirements for one year. For the four-year P application rate, total acres required to spread on are 2,072 or 3,944 for the low and high nutrient density diets, respectively. However, each year only 518 or 986 acres will be needed. By applying on a four-year P rate producers can avoid the environmental hazards of over applying P and get the most value out of the manure.

In conclusion, increasing dietary N and P increases excretion of these nutrients. Capturing these nutrients in the manure increases costs, but increases manure value at a greater rate. Spreading on a four-year P basis costs approximately the same as spreading on a N basis, but requires about three times the acres. However, spreading on a N basis results in buildup of P, which will lead to decreased value of the manure. Spreading on a one-year P basis is expensive and unnecessary. Fertilizer prices have increased dramatically in recent years which has renewed interest in manure fertilizer and enhanced the value of manure.

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Chemical Treatment of Low-quality Forages to Replace Corn in Cattle Finishing Diets

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Summary

A finishing experiment evaluated substitution of corn with crop residues in diets containing wet distillers grains. Corn stover, corn cobs, and wheat straw were alkaline treated at 50% moisture or fed without chemical treatment at 20% inclusion. Chemical treatment improved performance compared to untreated. Compared to control (10% roughage), treated diets had similar performance and carcass merit. Economic analysis revealed $6.46, $21.42, and $36.30 average profit per head advantage for diets containing treated residues relative to control when corn was priced at $3.00, $4.50, and $6.00 per bushel. Feeding chemically treated crop residues and wet distillers grains is a cost-effective strategy for replacing corn in feedlot diets without compromising performance or carcass quality.

Introduction

A pilot study (*2011 Nebraska Beef Cattle Report,* pp. 35-36) determined that chemical treatment of poor quality forages with 5% calcium oxide improved digestibility, with additional small increases using 3% CaO + 2% NaOH, and chemical treatment at 50% DM resulting in greater digestibility than at 35% DM. Given the complementary nature of distillers grains with forage on fiber digestibility, substituting corn for treated residue in finishing diets with wet distillers grains may result in acceptable performance while reducing diet costs. Therefore, the objective of this study was to evaluate replacing corn with treated residues in combination with wet distillers grains on cattle performance and carcass merit, along with economic implications.

Procedure

The experiment used 336 short-yearling steers (42 pens, 8 steers/pen) (BW= 784 ±25.4 lb). The experiment had three weight blocks, seven diets (six replications per treatment) and was designed as a randomized complete block design. Main factors included three crop residues (corn cobs, wheat straw, corn stover) treated or untreated; all of which replaced corn and were fed at 20% diet DM (Table 1). The control diet contained a higher amount of corn (46 vs. 36%) and less roughage (10%, equal parts untreated cobs, wheat straw, and corn stover). Chemical treatment consisted of water, CaO (Standard Quicklime), and ground residue (3-inch screen for corn stover and wheat straw, ¾-inch screen for corn cobs) weighed and mixed into Roto-Mix feed trucks. The mixture was calculated to be 50% DM with calcium oxide added at 5% of the total DM. Feed trucks dispensed treated residue into a silage bag, and the treatment process was completed 30 days prior to start of experiment. Untreated residues were ground and stored under roof (no added moisture or chemical). Orts were assessed weekly and were negligible (0.8% of total DM offered). Calcium oxide replaced limestone in treated diets. Data were analyzed using the MIXED procedure of SAS (SAS Inst., Inc., Cary, N.C.). The factorial was analyzed separately from control. To compare treated and untreated diets to the control, least squared means were separated by the pDIFF option with a protected F-test.

Partial budget analysis included costs for yardage ($0.45/steer/day), WDGS (70% value of corn), bagging costs ($8/ton), labor costs for bagging ($5 cobs, $10 corn stover, $15 straw; cost per ton DM), corn price ($3.00, $4.50, $6.00/per bu), roughage price ($50/ton; delivered price for cobs, wheat straw, and corn stover), calcium

Table 1. Dietary treatments.

		Corn Cobs		Wheat Straw		Corn Stover	
Ingredient, % of DM	Control	Treated	Untreated	Treated	Untreated	Treated	Untreated
DRC	46.0	36.0	36.0	36.0	36.0	36.0	36.0
Cobs–treated[1]	—	20.0	—	—	—	—	—
Straw–treated[1]	—	—	—	20.0	—	—	—
Stover–treated[1]	—	—	—	—	—	20.0	21.0
Cobs–not treated	3.3	—	20.0	—	—	—	—
Straw–not treated	3.3	—	—	—	20.0	—	—
Stover–not treated	3.3	—	—	—	—	—	—
WDGS	40.0	40.0	40.0	40.0	40.0	40.0	40.0
Supplement[2]	4.0	4.0	4.0	4.0	4.0	4.0	4.0

[1]Treated with 5% CaO and water added to 50% DM.
[2]Formulated to provide 360 mg/hd/day Rumensin® and 90 mg/head/day Tylan®.

Table 2. Performance and carcass characteristics.

Item	Control	Corn Cobs Treated	Corn Cobs Untreated	Wheat Straw Treated	Wheat Straw Untreated	Corn stover Treated	Corn stover Untreated	SE	All Diets F-test	Factorial *P*-value F[1]	T[2]	FxT[3]
Initial BW	785	784	782	790	782	791	780	25.4	0.34	0.86	0.19	0.73
Final BW[5]	1313[bc]	1304[bc]	1305[bc]	1350[a]	1278[cd]	1325[ab]	1267[d]	24.2	<0.01	0.27	<0.01	<0.01
Final BW[6]	1376[ab]	1388[a]	1414[a]	1414[a]	1292[b]	1402[a]	1373[ab]	37.3	<0.01	0.31	0.11	0.07
ADG, lb[8]	3.78[abc]	3.73[bcd]	3.74[bc]	4.01[a]	3.55[cd]	3.83[ab]	3.49[d]	0.08	<0.01	0.30	<0.01	0.01
DMI, lb	25.81	25.36	25.66	25.83	25.29	26.11	25.06	0.32	0.30	0.97	0.11	0.12
F:G[7]	6.83[ab]	6.80[ab]	6.86[ab]	6.44[a]	7.12[b]	6.82[a]	7.18[b]		0.06	0.31	0.01	0.16
Profit-$3.00*	0.00	2.06	6.91	17.37	-10.28	-0.05	-13.32					
Profit-$4.50*	0.00	14.78	18.30	35.80	-2.08	13.68	-6.70					
Profit-$6.00*	0.00	27.42	29.61	54.16	6.04	27.33	-0.16					
HCW	834[bc]	828[bc]	829[bc]	857[a]	811[cd]	841[ab]	805[d]	15.3	<0.01	0.28	<0.01	<0.01
12th rib fat	0.53[a]	0.47[bc]	0.48[bc]	0.50[ab]	0.44[c]	0.53[a]	0.44[c]	0.018	<0.01	0.79	<0.01	0.03
LM area	12.96	13.03	13.41	13.49	13.20	13.13	12.72	0.221	0.11	0.10	0.50	0.10
Marbling[4]	517	507	516	508	484	501	494	9.4	0.12	0.12	0.25	0.14
Calc. YG	3.46	3.23	3.20	3.29	3.12	3.45	3.21	0.101	0.16	0.39	0.08	0.59

[1]Fixed effect of forage fraction.
[2]Fixed effect of chemical treatment.
[3]Forage fraction x chemical treatment interaction.
[4]500 = Small, 600 = Modest.
[5]Calculated as HCW/common dress (63%).
[6]Pen weight before slaughter.
[7]Analyzed as G:F, reciprocal of F:G.
[8]Caculated from carcass-adjusted final BW.
*Average profit per head relative to control when corn is $3.00, $4.50, or $6.00 per bushel.
[abcd]Within a row, values lacking common superscripts, differ ($P < 0.05$).

oxide ($230/ton), and limestone ($100/ton). Due to differences in final BW, treatments were adjusted to a common endpoint (based on weight) by adding days on feed and assuming average DMI and ADG observed during the feeding period for each treatment. Control was calculated to break even at varying corn prices. Price per ton of untreated forage at the bunk was $64 per ton of DM and costs of chemical treatment increased costs to $75, $80, and $85 per ton DM for cobs, corn stover, and wheat straw, respectively. No cost was charged for water in this analysis.

Results

An interaction between chemical treatment and residue ($P < 0.01$) was noted for carcass adjusted final BW, ADG, G:F, and HCW (Table 2). Greater final BW was observed for treated stover (4.6%) and straw (5.6%) compared with untreated stover and straw; however, treated and untreated cobs were similar. Average daily gain was 9.7% greater for treated straw and 12.5% greater for treated stover, compared to untreated. Treated straw and stover diets had G:F improvements of 10.7% and 5.0% relative to diets containing untreated forms. Treated and untreated cobs had similar G:F and ADG. Marbling scores were similar among diets. Treated residues had $6.46 greater profit than control, when corn was priced at $3.00/bu. This difference increased to $21.42 and $36.30 and as corn price increased to $4.50 and $6.00 per bushel. Treated wheat straw had highest profit across diets and corn prices.

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Reducing Particle Size Enhances Chemical Treatment in Finishing Diets

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Summary

Three hundred-sixty calf-fed steers were fed either treated or untreated corn stover that was previously ground through a 1-in or 3–in screen. Treated stover diets improved ADG and F:G compared to untreated. Reducing particle size improved ADG and F:G but did not influence DMI. Compared to a control diet with 5% roughage and 15 percentage units more corn, diets with 20% treated corn stover had similar F:G, ADG, DMI, and carcass quality. Up to 15% additional corn can be replaced with treated corn stover when diets contain wet distillers grains, and may be further enhanced by reducing particle size before chemical treatment.

Introduction

A previous study (*2012 Nebraska Beef Cattle Report,* pp. ??-??) has demonstrated the potential to replace corn with corn stover that has been treated with 5% calcium oxide, with no reduction in performance or carcass characteristics compared to a diet that would be commonly fed in Nebraska. The focus of this experiment was to further investigate ways to enhance this feeding strategy, as corn stover and distillers grains are abundant in Nebraska. We hypothesized that reducing particle size may increase the extent of digestibility during the treatment process, leading to better performance.

Procedure

The experiment used 360 calf-fed steers (30 pens, 12 steers/pen) (initial BW: 822 ± 9.9 lb). The experiment had two weight blocks (three replications per block), five diets (six replications per treatment) and was designed as a randomized complete block design. Main factors included corn stover, which was ground through a 1-in or 3–in screen, and then alkaline treated with 5% calcium oxide at 50% moisture or not treated. Corn stover replaced a 50:50 blend (DM basis) of HMC and DRC and was fed at 20% diet DM (Table 1). The control contained a higher amount of corn (51 vs. 36%) and lower roughage (5%, untreated corn stover ground through 3-in screen). All diets contained 40% modified distillers grains plus solubles (MDGS; 59.3% DM). Chemical treatment consisted of water, calcium oxide, and ground corn stover weighed and mixed into Roto-Mix feed trucks. Feed trucks dispensed treated corn stover into a silage bag which was packed with a pressure setting of 400 psi, and this equated to a density of approximately 8 lb DM/ ft^3. Chemical treatment was considered completed with a minimum of seven days prior to feeding. Untreated corn stover was ground and stored under roof (no added moisture or chemical). Orts were assessed weekly and were only observed on 3-in untreated stalks diets. However, this amount was small (< 0.5% of total DM offered). Calcium oxide replaced limestone in treated diets. Cattle were fed once daily for 151 days. Data were analyzed in the MIXED procedure of SAS (SAS Inst., Inc., Cary, N.C.). Pen was the experimental unit. Block was included as a fixed effect. The factorial was analyzed separately with main factors of roughage source and treatment, as well as the interaction, included in the model. To compare treated and untreated diets to the control, means were separated by the pDIFF option with a protected F-test. Percentage of choice carcasses and above were analyzed in GLIMMIX assuming a binomial distribution.

Table 1. Dietary treatments.

		1" Grindsize		3" Grindsize	
Ingredient, % of DM	Control	Treated	Untreated	Treated	Untreated
HMC	25.5	18.0	18.0	18.0	18.0
DRC	25.5	18.0	18.0	18.0	18.0
Corn Stover—treated[1]	—	20.0	—	20.0	—
Corn Stover—not treated	5.0	—	20.0	—	20.0
MDGS	40.0	40.0	40.0	40.0	40.0
Supplement[2]	4.0	4.0	4.0	4.0	4.0
Composition of Corn Stover					
NDF, %		56.0	76.5	56.8	81.1
IVNDFD, %[3]		58.0	36.0	51.0	36.0

[1]Treated with 5% CaO and water added to 50% DM and ground through 1-in or 3-in screen.
[2]Formulated to provide 360 mg/steer daily Rumensin® and 90 mg/steer daily Tylan®.
[3]*In vitro* NDF digestibility, 48 hour incubation time.

Table 2. Performance and carcass characteristics.

Item	Control	1" Grindsize Treated	1" Grindsize Untreated	3" Grindsize Treated	3" Grindsize Untreated	SE	F-test	Factorial *P*-value Grind[1]	Factorial *P*-value Trt[2]	Factorial *P*-value GxT[3]
Steer performance										
Initial BW	823	822	823	821	825	9.9	0.99	0.94	0.80	0.88
Final BW[5]	1378[a]	1385[a]	1319[bc]	1362[ab]	1309[c]	14.8	<0.01	0.24	<0.01	0.60
ADG, lb[9]	3.67[a]	3.73[a]	3.28[b]	3.58[a]	3.21[b]	0.050	<0.01	0.02	<0.01	0.40
DMI, lb	24.01[abc]	23.60[bc]	24.50[ab]	23.45[c]	24.78[a]	0.33	0.04	0.87	<0.01	0.53
F:G[7]	6.54[ab]	6.32[a]	7.47[c]	6.55[b]	7.72[b]	0.087	<0.01	0.01	<0.01	0.90
Final BW[6]	1419[a]	1372[ab]	1339[b]	1360[ab]	1333[b]	21.0	0.05	0.52	0.03	0.83
Dressing %[8]	61.39	63.63	62.06	63.10	61.89	0.007	0.26	0.08	<0.01	0.37
Carcass characteristics										
HCW, lb	868[a]	873[a]	831b	858[a]	825[b]	9.4	<0.01	0.26	<0.01	0.63
12[th] rib fat, in	0.57	0.55	0.51	0.56	0.52	0.023	0.24	0.51	0.07	0.96
LM area, in^2	13.26	13.28	13.16	13.26	12.82	0.175	0.32	0.30	0.13	0.36
Marbling[4]	595	568	546	590	579	13.4	0.11	0.07	0.27	0.69
% Choice	86.1[a]	77.5[ab]	67.6[b]	81.4[a]	76.4[ab]		0.08	0.13	0.08	0.85
Calc. YG	3.48	3.43	3.21	3.41	3.32	0.102	0.38	0.63	0.13	0.50

[1]Fixed effect of grind size (1" vs 3").
[2]Fixed effect of chemical treatment.
[3]Grind size x chemical treatment interaction.
[4]500 = Small, 600 = Modest.
[5]Calculated as HCW/common dress (63%).
[6]Pen weight taken before slaughter.
[7]Analyzed as G:F, reciprocal of F:G.
[8]Calculated as HCW/Final live BW.
[9]Caculated from carcass adjusted final BW.
[abc]Within a row, values lacking common superscripts, differ, when F-test is significant ($P < 0.05$).

Results

There were no particle size x chemical treatment interactions noted in this trial. Chemical treatment was effective in solublizing approximately 30% of the corn stover NDF (Table 1) and this led to increases ($P < 0.01$) in ADG (12.6%) and improved F:G (17.4%) relative to untreated corn stover. Dry matter intake was lower for chemically treated stover compared to untreated ($P < 0.01$), which is reflective of energy density being diluted. Reducing particle size of the stover from 1 inch to 3 inch also improved ($P < 0.01$) ADG (3.2%) and F:G (3.5%). Compared to control, treated stover was not different for ADG, F:G, adjusted final BW or final BW measured before slaughter, marbling score, 12[th] rib fat, YG, or percentage choice and prime. Grind size tended to reduce marbling score ($P = 0.07$). Chemical treatment tended ($P = 0.07$) to increase 12[th] rib fat; however, this difference was small numerically. Reducing particle size improves the feeding value of feeding chemically treated corn stover in byproduct diets.

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Factors Influencing Profitability of Calf-Fed Steers Harvested at Optimum Endpoint

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Summary

Four years of data from calf-fed steers were utilized in determining factors that affect profitability of cattle marketed at an optimum endpoint. Profitability was evaluated on a live weight basis assuming $112/cwt selling price and $180/cwt dressed price. Profit was compared as corn price and Choice-Select spread increased. Overall, carcass weight was the dominant factor in determining profitability. However, at $7 corn, feed efficiency had the most influence on profit. As expected, yield grade decreased and marbling score increased in importance as Choice-Select spread increased. Under these scenarios, profitability was greatly affected by hot carcass weight, with efficiency being the most important at higher corn prices.

Introduction

Previous research has compared profitability using varying input costs, diets, endpoint target dates, genetics, Choice-Select spreads (Ch-Se), and marketing strategies. Profitability at the individual animal level was observed with cattle marketed at one endpoint and showed HCW accounted for 21% of the variation in profitability (*Professional Animal Scientist,* 21:380). It also has been found that discounts impact profitability more than premiums and removing the bottom 10% of carcasses by sorting improves the economic value approximately $20 per animal. The objective of this analysis was to quantify the effect of performance and carcass measurements on profitability of cattle harvested at an optimum endpoint across varying corn price and Ch-Se spread.

Procedure

Four years of data were collected (2006-2009) utilizing 1,488 Simmental, Angus, or Simmental-Angus crossbred steers. Individual intakes were obtained for all steers using the Growsafe automated feeding system. Final individual animal ADG and G:F were calculated based on carcass adjusted final BW. Steers in this analysis had endpoints designed to optimize carcass value. To predict optimum endpoint, steer weight and ultrasonic measurements of back fat thickness and marbling score were recorded every 28 days or 42 times throughout the feeding period. Cattle were harvested based on two factors of endpoint criteria: (1) minimum 0.4 in of BF or (2) BW greater than 1,285 lb; and after initial slaughter groups were removed, remaining steers were all marketed at one time. Days on feed (DOF) ranged from 120 to 195.

Five-year average price data (2003 to 2007) were collected for feedstuffs, and grid premiums and discounts. Because the price relationship of WDGS and DDGS relative to corn has ranged from 65 to over 100% (*2009 Nebraska Beef Cattle Report,* p. 50), dry byproducts were calculated at 90% the value of corn, and wet byproducts were calculated at 90% the value of dry byproduct (all on DM basis). Price for corn silage was calculated based on corn price using the following equation: [(6.5 * price/bu) + $5/t harvest and storage cost)/35% DM]. Live cattle price was $112/cwt and average dressed beef price was $180/cwt. Input costs included veterinary, medical, labor, and transportation costs ($50/steer), yardage ($0.35/steer/day), and feed markup ($24.20/t). Interest was assessed at 8% on calf purchase price and 50% of feed consumed per steer. Steer purchase price was $132/cwt, based on a 500 lb animal with a $1.50 slide per 25 lb. Carcass value was calculated for each animal using actual hot carcass weight (HCW) and associated premiums and discounts for carcass merit. Profit was defined as the difference between carcass value and total input costs per steer. Multiple regression models were constructed using the MIXED procedure. Importance of each variable within the model was ranked using standardized beta coefficients (STB).

Results

Standardized beta coefficients were used to compare factors on an equivalent basis of influence on profitability. For example, when corn is $4 and Ch-Se spread is $4, one standard deviation (SD) change in HCW changed profit by 0.78 SD (0.78 *$74.77 = $58.32/steer; Table 1). This means that HCW has a positive effect on profit which would be expected as more weight is sold with all other factors held constant. However, the variation in HCW was narrowed by sorting and as a dominant factor influencing profit, the SD of profit does not increase and remained relatively unchanged. Influence of HCW on profitability decreased as Ch-Se spread increased. Influence of marbling increased with increased Ch-Se spreads, and at $7 corn with Ch-Se spread of $12/cwt, became competitive with HCW in influencing profitability. The negative SD for YG is due to lower values being desired. Yield grade coefficients were unchanged as corn price increased but decreased as Ch-Se spread increased having less influence on

Table 1. Standardized betas for regression variables across varying corn prices and Choice-Select spreads.

Item	Corn Price[1]				
	$3	$4	$5	$6	$7
Choice-Select Spread, $4/cwt					
Std. Dev., Net Return	$75.79	$74.77	$74.12	$73.86	$74.48
	-----standardized beta coefficient[2,a] -----				
HCW	0.86	0.78	0.70	0.62	0.48
Marbling Score	0.12	0.12	0.12	0.12	0.11
Yield Grade	-0.31	-0.31	-0.32	-0.32	-0.31
Initial Weight	-0.23	-0.18	-0.11	-0.05	0.05*
Gain:Feed	0.37	0.43	0.48	0.54	0.63
Choice-Select Spread, $8/cwt					
Std. Dev., Net Return	$77.44	$76.36	$75.63	$75.27	$75.71
	-----standardized beta coefficient[2,a] -----				
HCW	0.85	0.77	0.69	0.61	0.48
Marbling Score	0.22	0.22	0.22	0.22	0.22
Yield Grade	-0.26	-0.26	-0.26	-0.27	-0.26
Initial Weight	-0.23	-0.17	-0.12	-0.06	0.04*
Gain:Feed	0.35	0.41	0.47	0.52	0.61
Choice-Select Spread, $12/cwt					
Std. Dev., Net Return	$82.17	$81.11	$80.38	$80.01	$80.28
	-----standardized beta coefficient[2,a] -----				
HCW	0.84	0.77	0.69	0.61	0.47
Marbling Score	0.31	0.31	0.31	0.31	0.31
Yield Grade	-0.23	-0.23	-0.24	-0.24	-0.24
Initial Weight	-0.22	-0.21	-0.11	-0.05	0.04*
Gain:Feed	0.33	0.38	0.44	0.49	0.57

[1]Corn price/bu.
[2]Represents the change in profit per standard deviation as each independent variable change.
[a]All values are significant ($P < 0.0001$) unless marked with asterisk.

profitability (-0.31, -0.26, and -0.24, respectively). Efficiency increased in influence as corn price increased and decreased as Ch-Se spread increased (approximately 0.3 to 0.6).

The results from this analysis indicate that factors affecting profitability of cattle harvested at optimum endpoint are complex and vary depending on input costs like corn price or market factors like Ch-Se spread. Initial weight was an important variable at low corn price and Ch-Se spreads and declined markedly as corn price increased. Marbling score was a more competitive factor for influencing profit at high Ch-Se spreads. Carcass weight was the most significant variable affecting profit in this population at low Ch-Se spreads and corn prices, even though variation in HCW was minimized by sorting. If cattle would not have been sorted before harvest, HCW would have been even more important due to variation in weight and resulting premiums or discounts. However, the importance of HCW declined as Ch-Se spread and corn price increased. Feed efficiency became the most important variable over HCW when corn price reached $7 within each Ch-Se spread comparison. Understanding these relationships would allow feedlot owners and operators to adjust their management and marketing strategies to accurately account for these variables as corn price and Ch-Se spread change.

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Grazing Supplementation and Subsequent Feedlot Sorting of Yearling Cattle

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Summary

Steers fed (0.6% BW) modified distillers grains plus solubles on the ground had increased ADG and BW at the end of summer grazing and were more profitable. Supplemented steers were fed 24 fewer days to reach feedlot harvest goal, had greater LM area, and lower marbling. Steers sorted on feedlot entry BW had increased HCW, marbling, and YG, but percentage overweight carcasses and profitability were similar. Steers supplemented during summer grazing had $11.80/animal greater overall profit.

Introduction

Co-products of the corn dry milling ethanol industry fit well into forage feeding programs because distillers grains are high in undegradable intake protein and provide a highly fermentable fiber source that does not negatively impact forage digestion. Sorting cattle on feedlot entry BW may successfully reduce carcass weight variation and overweight carcasses, which may be especially concerning when feeding heavier, later maturing animals.

The objectives of the study were to determine the impacts of supplementing modified distillers grains with solubles on the ground to long yearling steers on summer range and subsequent feedlot sorting on entry BW.

Procedure

Winter Phase

Each year of a three-year study, 240 crossbred steers (initial BW = 498 ± 44 lb) were backgrounded as a common group on cornstalk residue at the University of Nebraska–Lincoln Agricultural Research and Development Center (ARDC), Mead, Neb., from late fall to mid-spring (145 days). While grazing cornstalks, calves were supplemented 5.0 lb DM/animal/day of Sweet Bran®. After cornstalk backgrounding, steers were limit fed at 1.8% BW (DM) for five days. Initial BW for summer grazing was the mean of consecutive two-day BW measurements.

Summer Phase

On approximately April 15 each year, calves were implanted with Revalor® G, weighed, stratified by BW, and assigned randomly to one of two summer grazing treatments. Steers grazed smooth bromegrass pastures for approximately 23 days. Then, steers were transported to the University of Nebraska Barta Brothers Ranch to graze native Sandhills range where summer grazing treatments were applied (136 days). Summer grazing treatments included: 1) grazing native range with no supplementation (CON), and 2) grazing native range with modified distillers grains plus solubles (MDGS) supplementation at 0.6% BW (DM; SUPP). Supplement offered increased with increasing BW of SUPP animals and averaged 5.0 lb DM/animal/day over the grazing period. A tractor and feed wagon was used to feed MDGS on the ground six days/week.

Feedlot Phase

In late September, steers were transported to the ARDC, reimplanted with Revalor S, weighed (same procedure as above), stratified by BW, and assigned randomly to one of two feedlot sorting treatments within summer grazing treatments. Feedlot sorting treatments included: 1) cattle sorted three ways based on distribution of feedlot entry BW (25% light, 50% medium, 25% heavy; SORT); and 2) cattle not sorted (NOSORT). Upon arrival, steers were adapted to a common finishing diet. Within each summer grazing treatment-feedlot sorting treatment combination, steers were harvested when fat thickness was visually estimated to be constant (0.50 in).

Economic Analysis

An enterprise budget was created to illustrate economic implications of supplementation during summer grazing. Economic analyses were based on price averages from 2006 to 2010. Cattle purchase and sales prices for each phase of production were based on weekly weighted average prices for Nebraska sale barns. Cornstalk residue rental rates were included at $0.12/animal/day. Using the average regional pasture rental rate of $31.84/pair (1,300 lb), NRC energy equations to estimate forage DMI, and forage replacement of 17% for SUPP steers compared to CON steers; annual summer pasture rental rates were applied at $0.41/animal/day and $0.49/animal/day for SUPP and CON steers, respectively. Feed prices were as follows: corn ($3.74/bu DM + $0.05/bu DM for corn processing); MDGS ($111.69/ton DM; 75% corn

Table 1. **Performance and carcass characteristics of yearling steers supplemented MDGS on grass and sorted by weight into the feedlot in separate phases of production.**

Item	CON[1] NOSORT[4]	CON[1] SORT[5]	SUPP[2] NOSORT	SUPP[2] SORT	SE[6]	*P*-value[3] S	*P*-value[3] F	*P*-value[3] S x F
Winter phase								
Initial BW, lb	500	497	499	498	6	0.71	0.79	0.52
Ending BW, lb	696	698	695	699	5	0.92	0.14	0.71
ADG, lb	1.41	1.44	1.42	1.44	0.06	0.74	0.14	0.68
Summer phase[7]								
Ending BW, lb	914[a]	916[a]	1021[b]	1020[b]	12	<0.01	0.90	0.61
ADG, lb	1.36[a]	1.36[a]	2.04[b]	2.01[b]	0.07	<0.01	0.55	0.56
Feedlot phase[8]								
DOF	126[a]	133[b]	102[c]	111[d]	1	<0.01	<0.01	<0.01
DMI, lb	30.4[a]	30.1[b]	30.3[a]	29.5[b]	0.5	0.16	0.02	0.24
ADG, lb	4.00	3.98	3.95	3.80	0.26	0.07	0.17	0.29
F:G	7.81	7.78	7.99	8.01	0.48	0.11	0.97	0.82
HCW, lb	894[a]	911b	897[a]	906[b]	13	0.92	0.01	0.41
LM, in^2	13.65[a]	13.60[a]	14.03[b]	13.90[b]	0.25	0.01	0.46	0.74
FT, in	0.49	0.52	0.49	0.50	0.03	0.57	0.21	0.57
MB[9]	596	630	559	556	13	<0.01	0.05	0.02
YG[10]	3.26	3.40	2.96	3.15	0.16	<0.01	0.02	0.76

[a,b,c,d]Means without a common superscript differ (P < 0.05).
[1]CON = cattle grazing native range during the summer with no supplementation.
[2]SUPP = cattle grazing native range during the summer with modified wet distillers grains with solubles supplementation at 0.6% BW.
[3]*P*-Value: S = effect of summer grazing treatment; F = effect of feedlot sorting treatment; S x F = effect of treatment interaction.
[4]SORT = cattle sorted on feedlot entry BW.
[5]NO SORT = cattle not sorted.
[6]Pooled standard error of treatment means.
[7]Summer Phase = 23 days grazing brome grass + 136 days grazing native range; Initial BW = Ending BW from previous phase.
[8]Initial BW = Ending BW from previous phase.
[9]Small^{00} = 500.
[10]Calculated yield grade = (2.5 + (2.5 x FT) - (0.32 x LM) + (0.2 x 2.5 KPH) + (0.0038 x HCW)).

price); Sweet Bran ($132.21/ton DM; 95% corn price); supplement ($190.00/ton DM); and alfalfa hay ($90.30/ton DM). Veterinary and processing fees charged were $8.33/animal for each production phase. A common yardage value was included at $0.25/animal/day for all animals during the winter phase, yardage for CON steers was included at $0.10/animal/day during the summer phase, yardage for SUPP steers was included at $0.20/animal/day during the summer phase, and a common yardage value was included at $0.45/animal/day for all animals during the feedlot phase. The additional yardage assigned to SUPP steers over CON steers during summer grazing accounted for supplement delivery. An average death loss of 0.79% was charged, weighted by phase of production. Distances used to determine transportation fees remained constant across treatments, but weight transported reflected treatment averages. Marketing and risk management costs were assumed to be $0.25/cwt for each production phase.

Agricultural operating loan interest rates from the Federal Reserve Bank of Kansas City averaged 7.61% for Nebraska. Because SUPP steers were heavier entering the feedlot after summer grazing than CON steers, a $5.10/cwt price slide was used to adjust the price of steers at feedlot entry. Fed cattle sales price was included at $137.90/dressed cwt. CON NOSORT steers were considered the most traditional group of long yearlings in this system and served as control; thus, feeder cattle price at entry into the winter phase was adjusted to produce a $0.00 profit (breakeven). Profit or loss was calculated for each production phase and for the overall system by subtracting cost of production from animal sales price.

The experiment was a completely randomized design with treatments arranged in a 2 x 2 factorial design. Data were analyzed using the GLIMMIX Procedure of SAS (SAS Inst., Inc., Cary, N.C.) as a completely randomized design with 30 animal groups as the experimental unit. Summer grazing treatments and feedlot sorting treatments were considered fixed effects and year was considered a random effect. Probability values less than 0.05 were considered significant.

Results

Data collected in winter, summer, and feedlot phases are summarized in Table 1. By experimental design, initial BW, ending BW, and ADG during the winter phase were not different between SUPP and CON steers. At feedlot entry, SUPP steers were 106 lb heavier ($P < 0.01$) than CON steers. Therefore, SUPP steers had 0.66 lb/d greater ($P < 0.01$) ADG than CON steers during summer grazing. Because feedlot harvest date was targeted to equal fat thickness between CON and SUPP steers, 12th rib fat thickness (FT) was not different between the two treatments. Final BW was similar between CON and SUPP steers; however, it required 24 fewer ($P < 0.01$) d in the feedlot for SUPP

(Continued on next page)

steers to reach this point. Feedlot ADG tended to be greater ($P = 0.07$) for CON steers than SUPP steers, but F:G and DMI were not different .

Longissimus muscle area (LM) was greater ($P = 0.01$) for SUPP steers. Protein analyses of diet samples collected from nearby summer pastures where the yearlings were maintained, indicated CON steers were deficient in ruminally degradable protein in August and September. Because MDGS was fed in excess of metabolizable protein requirements, urea recycling likely supplied sufficient ruminally degradable protein to SUPP steers. Unsupplemented steers had greater ($P < 0.01$) marbling score (MB), likely due to the longer time spent on feed in the feedlot phase. Calculated yield grade (YG) was also greater ($P < 0.01$) for CON steers than SUPP steers.

As expected, BW and ADG were not different for SORT steers compared to NOSORT steers in the winter and summer phases of production. However, sorting cattle on feedlot entry BW resulted in 14 lb greater ($P < 0.01$) HCW for SORT steers than NOSORT steers, likely because SORT steers were in the feedlot 8 d longer ($P < 0.01$). Similarly, SORT steers had greater ($P = 0.02$) DMI than NOSORT steers; but ADG and F:G were similar. Although LM and FT were not different between the two sort treatments, SORT steers had greater ($P < 0.05$) MB and YG than NOSORT steers. These differences may also be explained by the longer time SORT steers spent on a finishing diet in the feedlot phase of production when compared to their NOSORT contemporaries. Sorting cattle on feedlot entry BW did not reduce the percentage carcasses over 1,000 lb; however, a 2.4% numerical reduction in overweight carcasses was observed (Figure 1).

Profitability was similar between CON ($39.63/animal) and SUPP ($40.62/animal) steers during the winter phase of production (Figure 2). Additional BW gain during summer grazing caused profitability for SUPP steers to be $9.81/animal greater ($P = 0.02$) than CON steers. Numerical losses in the feedlot for SUPP steers were $1.05/animal less compared to CON steers. When the entire yearling production system was analyzed, SUPP steers were $11.80/animal more profitable ($P = 0.05$) than CON steers. Sorting cattle on feedlot entry BW did not increase profitability in the feedlot phase when cattle were sold, likely due to similar HCW and FT for sorting treatments.

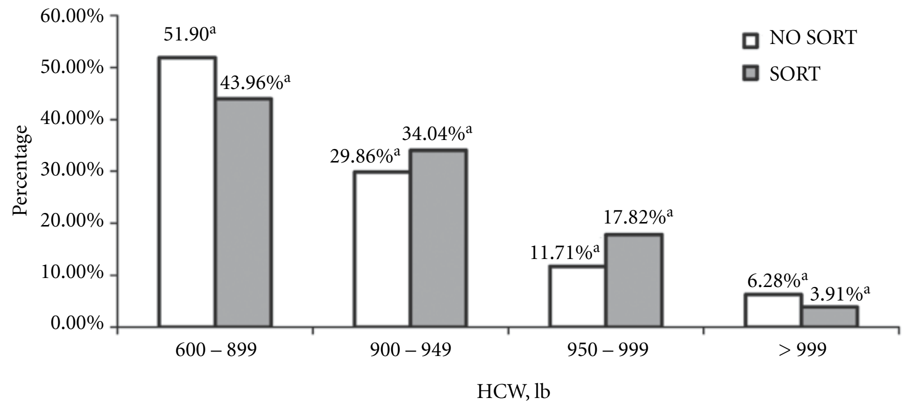

Figure 1. Carcass weight frequencies of yearling steers sorted by feedlot entry BW or not sorted. Means without a common superscript differ ($P < 0.05$). NO SORT steers were not sorted on feedlot entry BW. SORT steers were sorted on feedlot entry BW.

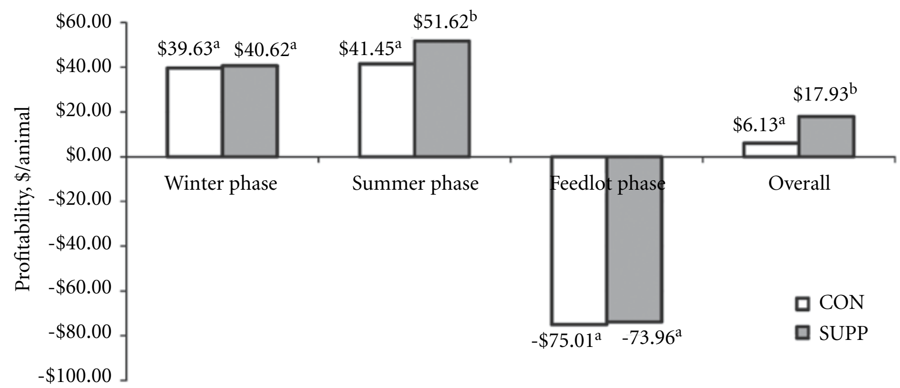

Figure 2. Profitability of each phase of production of yearling steers supplemented MDGS on grass. Means without a common superscript differ ($P < 0.05$). Winter phase profitability assessed over 145 days grazing cornstalk residue. Summer phase profitability assessed over 23 days grazing bromegrass + 136 days grazing native range. Feedlot phase profitability assessed over 118 days in feedlot on common finishing diet. Overall profitability assessed over winter, summer, and feedlot phases. CON steers grazed native range during the summer with no supplementation. SUPP steers grazed native range during the summer with modified wet distillers grains with solubles supplementation at 0.6% BW.

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Impact of Sorting Prior to Feeding Zilpaterol Hydrochloride on Feedlot Steers

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Summary

Crossbred yearling steers (n = 1000; 755 ± 23 lb) were utilized to evaluate effects of sorting and feeding zilpaterol hydrochloride (Zilmax®) on feedlot performance, carcass characteristics, and economics. Treatments were: unsorted negative control (–CON); unsorted Zilmax fed positive control (+CON); and three treatments where the heaviest 20% of steers within the pen were identified at beginning (EARLY), 100 days from harvest (MIDDLE), or 50 days from harvest (LATE) and marketed 28 days earlier. Dry matter intake was not different. Gain and G:F were improved by feeding Zilmax. Carcasses from the +CON and steers sorted EARLY, MIDDLE, and LATE were 61, 56, and 53 lb heavier than –CON, respectively. Fat depth and marbling were lower for +CON compared to –CON, but feeding Zilmax with any of the sorting treatments improved marbling to equal –CON.

Introduction

Zilpaterol hydrochloride (Zilmax) is an approved, orally-active ß-adrenergic receptor agonist that improves feed efficiency and increases carcass leanness in cattle fed in confinement for slaughter (*Journal of Animal Science, 2010,* 88:2825). Studies conducted using feedlot steers fed corn-based diets in the U.S. have demonstrated feeding Zilmax for the last 20 days prior to slaughter resulted in increased ADG, improved F:G, increased carcass weight, and increased carcass leanness compared to cattle not fed Zilmax (*Journal of Animal Science, 2009,* 87:2133). It has also been shown that feeding Zilmax reduces USDA choice grades about 10 percentage units compared to cattle not fed Zilmax. Previous research indicates that sorting cattle allows pens of cattle to be fed longer without causing a dramatic increase in overweight discounts (*1999 Nebraska Beef Cattle Report,* p. 71) and that profits for sorted cattle are greater than unsorted cattle due to overweight discounts for unsorted cattle (*2009 Nebraska Beef Cattle Report,* p. 92).

The objectives of the current study were to evaluate effects on performance, carcass characteristics and econmics of sorting and feeding Zilmax.

Procedure

Experiment

Crossbred yearling steers (n = 1,000; 755 ± 23 lb initial BW) were assigned randomly to one of 40 pens within three arrival blocks (25 steers/pen) to evaluate sorting and feeding Zilmax. The five treatments included an unsorted negative control (–CON), unsorted Zilmax fed positive control (+CON); and three treatments where the heaviest 20% within the pen were sorted and marketed 28 days early and the remaining 80% were fed Zilmax. The 20% were identified at the beginning (EARLY), 100 days from slaughter (MIDDLE), or 50 days from slaughter (LATE) by weighing steers individually.

Steers were fed Zilmax (Zilpaterol hydrochloride 4.8%, Intervet/Schering-Plough Animal Health, De Soto, Kansas) at 7.56 g/ton DM for 20 days followed by a three-day withdrawal. Basal diet and supplement ingredients are presented in Table 1. Feed refusals were collected when accumulation occurred and were subsequently weighed and dried in a forced air oven at 60ºC for 48 hours to calculate DMI.

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

Ingredient	% of diet DM
Basal Diet	
DRC	25.0
HMC	25.0
Sweet Bran	40.0
CornStalks	5.0
Supplement	5.0
Supplement	
Fine ground corn	2.94
Limestone	1.57
Salt	0.28
Tallow	0.12
Trace mineral	0.05
Rumensin-90	0.02
Tylan-40	0.01
Vitamin A,D,E	0.02

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

Steers in block one arrived at the feedlot in October and November 2009. Steers in blocks two and three were sourced from two auction markets 12 days and eight days prior to allocation to the study, respectively. All steers were implanted with Revalor-XS®at trial initiation. Prior to the start of the experiment, steers were limit fed a common diet at 2.0% of BW for five consecutive days to minimize variation in body weight due to gut fill. Following the limit feeding period, steers were randomly alloted to pen and pens were randomly allotted to treatment. The heaviest 20% of steers in each pen in the EARLY treatment were identified during weighing and processing on day 1. Cattle were fed *ad libitum* twice daily.

One hundred days prior to the target marketing date steers from pens in the MIDDLE group within a block were individually weighed to identify the heaviest 20% of steers. Fifty days prior to the target marketing date steers from pens in the LATE group within a block were individually weighed to identify the heaviest 20% of steers. Within a block, the heaviest

(Continued on next page)

Table 2. Performance data summary.

	Treatment							Contrasts		
		Zilmax Fed								
Variable	–CON	+CON	EARLY	MIDDLE	LATE	SEM	*P*-value	–CON vs. +CON	+CON vs. E,M,L	–CON vs. E,M,L
Pens	8	8	8	8	8					
Steers	200	200	200	200	200					
Average days[1]	167	167	176	176	176					
Live Performance[2]										
Initial BW, lb	757	746	761	761	756	6.8	0.52	0.26	0.10	0.76
Final BW, lb	1409^{b}	1425^{b}	1485^{a}	1468^{a}	1479^{a}	8.7	<0.01	0.20	<0.01	<0.01
DMI, lb/day	25.6	25.2	25.8	25.7	25.6	0.2	0.32	0.18	0.04	0.64
ADG, lb	3.93^{b}	4.09^{a}	4.15^{a}	$4.05^{a,b}$	4.14^{a}	0.05	0.03	0.03	0.68	<0.01
F:G	6.56^{a}	6.17^{b}	6.24^{b}	$6.38^{a,b}$	6.22^{b}	0.09	0.03	<0.01	0.26	0.01
Carcass[3] ADG, lb	2.74^{b}	2.95a	2.95^{a}	2.91^{a}	2.91^{a}	0.03	<0.01	<0.01	0.39	<0.01

[1]DOF for Block 1 +CON and –CON was 158, for heaviest 20% of sorted treatments was 141 and for the remaining 80% was 171. DOF for Block 2 +CON and –CON was 166, for heaviest 20% of sorted treatments was 153 and for the remaining 80% was 182. DOF for Block 3 +CON and –CON was 169, for heaviest 20% of sorted treatments was 153 and for the remaining 80% was 183.
[2]Live performance values were calculated using Dressing % and Hot Carcass Weight to calculate Live Weight prior to slaughter.
[3]Carcass adjusted performance values were calculated using carcass weights obtained at slaughter and live weights at allocation converted to carcass initial weight using a Dressing Percentage of 56.8% based on May et al., 1992.
[4]Average Dressing Percentage for Block 3 (3 replicates for treatments EARLY, MIDDLE, and LATE) was 64.2%. Therefore, all Zilmax fed cattle were assigned a Dressing Percentage of 64.2%. All cattle sold early as part of the heaviest 20% had a measured Dressing Percentage. Based on Elam et al., 2009, a 1.36% reduction was applied to the Dressing Percentage for cattle not fed Zilmax, resulting in a Dressing Percentage of 62.8%.
[a,b,c]Means with different superscripts differ ($P < 0.05$).

Table 3. Carcass characteristic data summary

	Treatment							Contrasts		
		Zilmax Fed								
Variable	–CON	+CON	EARLY	MIDDLE	LATE	SEM	*P*-value	–CON vs. +CON	+CON vs. E,M,L	–CON vs. E,M,L
HCW, lb	886^{c}	915^{b}	947^{a}	942^{a}	939^{a}	5.4	<0.01	<0.01	<0.01	<0.01
Change in HCW[3], lb	0	29	61	56	53	—	—	—	—	—
HCW C.V[2], lb	7.5	9.0	6.6	6.2	6.2	—	—	—	—	—
HCW Std. Dev, lb	67^{b}	82^{a}	63^{b}	58^{b}	58^{b}	4.1	<0.01	0.01	<0.01	0.16
HCW Over 950 lb, %	17.30^{b}	36.22^{a}	47.93^{a}	46.18^{a}	41.55^{a}	4.24	<0.01	<0.01	0.07	<0.01
HCW Over 1,000 lb, %	6.32^{b}	$13.80^{a,b}$	18.34^{a}	16.97^{a}	16.43^{a}	2.95	0.05	0.08	0.32	<0.01
HCW Over 1,050 lb, %	0.94	5.42	5.42	2.94	4.44	1.34	0.11	0.02	0.46	0.04
12th Rib Fat, in	0.59	0.55	0.57	0.58	0.59	0.01	0.10	0.02	0.02	0.54
12th Rib Fat S.D, in	0.15	0.15	0.15	0.16	0.15	0.00	0.88	0.81	0.75	0.99
LM Area, in^2	14.00^{b}	15.13^{a}	15.12^{a}	15.08^{a}	14.95^{a}	0.12	<0.01	<0.01	0.57	<0.01
Marbling Score[4]	567^{a}	544^{b}	575^{a}	567^{a}	570^{a}	5.12	<0.01	<0.01	<0.01	0.60
Marbling Score S.D.	87	76	91	86	80	5.03	0.25	0.12	0.11	0.73

[1]Average Dressing Percentage on Block 3 (3 replicates for treatments EARLY, MIDDLE, and LATE) was 64.2%. Therefore, all Zilmax fed cattle were assigned a Dressing Percentage of 64.2%. All cattle sold early as part of the heaviest 20% had a measured Dressing Percent. Based on Elam et al., 2009, a 1.36% reduction was applied to the Dressing Percentage for cattle not fed Zilmax resulting in a Dressing Percentage of 62.8%.
[2]HCW is hot carcass weight, C.V. is coefficient of variation and is calculated by dividing the Standard Deviation by the Mean and is expressed as a percentage.
[3]Change in HCW is the difference between the HCW in each treatment and –CON.
[4]Marbling Score 600 = Modest, 500 = Small, 400 = Slight.
[a,b,c]Means within a row with different superscripts differ ($P < 0.05$).

20% of steers in the Zilmax sorted treatments were sorted from their pen mates, weighed by pen, and shipped for slaughter 28 days before the remainder of the pen was scheduled for shipment.

Steers were harvested at a commercial abattoir. Liver scores and HCW were collected on the day of slaughter. Following a 48-hour chill, marbling score, 12th rib fat depth, and LM area were recorded. A calculated dressing percentage was used to calculate carcass adjusted performance to determine final BW, ADG, and F:G. Carcass ADG was calculated assuming a 56.8% dressing percentage for all steers at trial initiation (*Journal of Animal Science*, 1992, 70:444).

Economics

Profitability was examined using live, carcass, and grid based pricing. Purchase price was set such that the average profit of the –CON was zero, which was $0.9855/lb.

Yardage was charged at a rate of $0.45 per steer per day, interest rate was estimated at 6.5%, and the health

Table 4. Yield and quality grade data summary.

	Treatment							Contrasts		
		Zilmax Fed								
Variable	–CON	+CON	EARLY	MIDDLE	LATE	SEM	*P*-value	–CON vs. +CON	+CON vs. E,M,L	–CON vs. E,M,L
USDA Yield Grade[1]										
1	3.70	5.60	7.64	6.10	3.10	1.61	0.28	0.41	0.99	0.31
2	23.95[b]	39.18[a]	26.31[b]	26.51[b]	28.85[b]	2.93	<0.01	<0.01	<0.01	0.34
3	53.68	44.78	50.03	53.76	50.49	4.36	0.59	0.16	0.20	0.66
4	16.63	8.94	16.03	13.13	15.55	2.53	0.21	0.04	0.05	0.56
5	2.10[a]	0.55[b]	0.05[b]	0.05[b]	1.08[a,b]	0.51	0.04	0.04	0.79	<0.01
USDA Quality Grade[1]										
Prime	2.94	0.42	2.94	1.44	1.44	0.95	0.28	0.07	0.17	0.37
Choice+	5.15	2.11	8.15	6.67	5.65	1.57	0.11	0.18	0.01	0.36
Choice0	24.82	19.11	24.21	24.38	27.23	2.48	0.24	0.11	0.04	0.87
Choice-	46.84	49.88	43.09	46.84	48.09	3.75	0.77	0.57	0.38	0.85
Select	20.32	27.05	19.66	19.74	17.16	2.71	0.14	0.09	0.01	0.64
Standard	0.00	0.47	0.47	0.47	0.00	0.37	0.70	0.35	0.70	0.44
Choice and above	79.74	71.52	78.39	79.33	82.41	2.78	0.10	0.04	0.01	0.93
Select and below	20.29	27.52	20.12	20.21	17.12	2.67	0.10	0.06	0.01	0.71

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

and processing fee was $25.00 per steer. Death loss was 0.60%. Sale price used was the price received from the packing plant at the time of sale. Corn was priced at $6.50/bu, Sweet Bran® was priced at 90% the price of corn (DM basis), and corn stalks were priced at $86.00/ton. Total diet cost was $253.65 per ton DM.

Grid price was calculated using an average dressed price of $1.70/lb. Premiums were awarded for upper 2/3rd choice ($3.00) and Prime ($8.00), as well as Yield Grade 1 ($5.50) and 2 ($3.50). Discounts were given for Select (-$8.56) and Standard (-$12.75) carcasses, as well as Yield Grade 4 (-$10.00) and 5 (-$16.25), as well as for overweight carcasses (-$10.00 for carcasses over 950 lb and -$20.00 for carcasses over 1,000 lb).

Statistical Analysis

Both performance and economic data were analyzed as a randomized complete block design using the MIXED procedure of SAS (SAS Inst., Inc., Cary, N.C.). The analysis included the following preplanned contrasts: –CON vs. +CON, –CON vs. EARLY, MIDDLE, and LATE, +CON vs. EARLY, MIDDLE, and LATE. Steers were blocked by arrival group and pen was the experimental unit. Block and treatment were included in the model as fixed effects. Although the heaviest 20% of steers were shipped for slaughter early, they were included in the analysis with pen as the experimental unit.

Results

Due to the weight sort, steers in the Zilmax sorted treatments were fed an average of 14 days longer than the control treatments (Table 2). Steers fed the +CON had 16 lb heavier ($P < 0.01$) final BW than steers fed the –CON control. Steers sorted EARLY, MIDDLE, and LATE were 76, 59, and 70 lb heavier ($P < 0.01$) than –CON. Intake was not different among the five treatments. Gain was greater ($P < 0.05$) and F:G improved ($P < 0.03$) for the +CON than the –CON, but was not different among steers that received Zilmax.

Carcasses from steers fed the +CON were 29 lb heavier ($P <0 .01$) than –CON. Carcasses from steers sorted EARLY, MIDDLE, and LATE were 61, 56, and 53 lb heavier ($P < 0.01$) than –CON (Table 3). Standard deviation in carcass weight was greater ($P = 0.01$) for +CON than –CON, but was not different ($P = 0.16$) between –CON and Zilmax sorted treatments. The percentage of carcasses over 950 lb was greater ($P < 0.01$) for the +CON than the –CON (36.22% vs. 17.30%), and was greater (P < 0.01) for the sorted treatments than the –CON (average of 45.22% vs. 17.30%). The percentage of carcasses over 1,000 lb was greater ($P = 0.05$) in sorted treatments (average of 17.25%) than –CON (6.32%). The percentage of carcasses over 1,050 lb was not different (P = 0.11) among treatments. Thus, sorting was not effective in reducing the percentage of overweight carcasses when overweight discounts are applied at 950 or 1,000 lb due to the additional 14 days. Fat depth and marbling score were lower ($P < 0.02$) in +CON than –CON, but not different between –CON and sorted treatments suggesting the extra 14 days allowed for fatness to be equalized when feeding Zilmax. Longissimus muscle area was greater ($P < 0.01$) in +CON than –CON, but was not different ($P = 0.57$) between +CON and sorted treatments. Marbling score was lower ($P < 0.01$) for +CON than –CON.

The percentage of USDA Yield Grade 2 carcasses was greater ($P < 0.01$) for the +CON than the –CON and the Zilmax sorted treatments, but was not different between the –CON and the sorted treatments (Table 4). The percentage of USDA

(Continued on next page)

Table 5. Economic analysis summary.

	Treatment							Contrasts		
		Zilmax Fed								
Variable	–CON	+CON	EARLY	MIDDLE	LATE	SEM	*P*-value	–CON vs. +CON	+CON vs. E,M,L	–CON vs. E,M,L
B/E[1] ($/head)	100.43	99.88	99.58	100.44	99.43	±0.47	0.43	0.42	0.91	0.27
COG[2] ($/head)	97.81	96.28	95.66	97.26	95.41	±1.00	0.32	0.26	0.87	0.12
COP[3] ($/head)	1414.44[b]	1423.05[b]	1477.58[a]	1473.89[a]	1470.11[a]	±8.46	<0.01	0.47	<0.01	<0.01
Live P/L[4] ($/head)	0.00	10.02	19.51	6.43	21.49	±7.79	0.27	0.36	0.52	0.09
Carcass P/L[4] ($/head)	0.00[b]	39.74[a]	40.38[a]	35.96[a]	35.21[a]	±7.08	<0.01	<0.01	0.76	<0.01
Grid P/L[4] ($/head)	0.00[b]	34.48[a]	29.62[a]	25.70[a]	24.52[a]	±8.30	0.05	<0.01	0.42	<0.01

[1]B/E is break even=(initial steer cost + feed cost + interest + health and processing + yardage + death loss)/ final weight.
[2]COG is cost of gain=(feed cost + interest + health and processing + yardage + death loss)/(final weight- initial weight).
[3]COP is cost of production=initial steer cost + feed cost + health and processing + yardage + interest + death loss.
[4]P/L is profit/loss= final steer value- (initial steer cost + feed cost + interest + health and processing + yardage + death loss) with initial steer cost set such that profit of the –CON on average was 0.
[5]Diet cost was $253.65/ton, feed cost included the cost of Zilmax ($20.00 per head) when Zilmax was fed.
[a,b,c]Means within a row with different superscripts differ ($P < 0.05$).

Yield Grade 5 carcasses was greater ($P < 0.04$) for the –CON than the +CON and the sorted treatments, but was not different between the +CON and the sorted treatments. No differences in quality grade were observed ($P > 0.10$). Zilmax in combination with a weight sort to identify heavy carcasses increased carcass weight without increasing variation in carcass weight, and allowed for cattle to reach an optimum fat endpoint.

Economics

Economics were calculated for three different scenarios: 1) cattle sold on a live basis, 2) cattle sold on a carcass (or dressed) basis and 3) cattle sold on a grid basis. In order to calculate the marginal rate of return, the initial price was set such that the profits of the –CON were equal to zero (Table 5).

Total cost of production was greater (P < 0.01) for the Zilmax sorted treatments compared to the –CON and compared to the +CON, but was not different between the –CON and +CON. On average, the sorted cattle had an additional cost of $50.81 over the +CON and $59.42 over than the –CON. Breakeven cost and cost of gain were not different among treatments.

When steers were sold on a live basis, profits were not different among treatments. When steers were sold on a carcass basis, profits were $37.83/head greater ($P < 0.01$) for the Zilmax fed treatments compared to the –CON. Profits on a carcass basis were not different between the +CON and Zilmax sorted treatments. When steers were sold on a grid basis, profits were $28.58/head greater ($P = 0.05$) for Zilmax fed steers compared to the –CON. Profits on a grid basis were not different between the +CON and Zilmax sorted treatments. Profits on a grid basis were $9.25/head lower on average than carcass-based profits due to the overweight carcass discounts as sorting was not effective in reducing the percentage of overweight carcasses.

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Condensed Distillers Solubles and Beef Shelf Life

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Table 1. Effect of corn distillers solubles inclusion meat quality characteristics.

	CDS[1], %						
	0	9	18	27	36	SEM	*P*-value
Moisture, %	69.52	70.46	69.94	69.87	70.10	0.39	0.56
Fat, %	9.78	8.69	9.46	9.60	9.33	0.46	0.52
Cooking loss, %	18.63	19.65	17.39	18.62	20.34	1.11	0.39
Shear force, kg	2.58	2.72	2.57	2.60	2.74	0.09	0.48

[1]CDS = corn distillers solubles.

Summary

Condensed distillers solubles were fed to cattle at 0, 9, 18, 27, or 36% inclusion. There were no effects on objective steak color, subjective discoloration, Warner-Bratzler shear force, moisture content, fat content, or oxidation values. Diet did not affect polyunsaturated fatty acid levels in meat, but the control diet had higher total unsaturated fatty acids and monounsaturated fatty acids than all other treatments. Feeding condensed distillers solubles to cattle has no detrimental effects on shelf life.

Introduction

Feeding wet distillers grains with solubles to cattle causes an increase in polyunsaturated fatty acids and increased oxidation rates in the meat (*2009 Nebraska Beef Cattle Report*, pp. 110-112; *2009 Nebraska Beef Cattle Report*, pp. 113-115). With increased oxidation rates comes decreased shelf-life and a major loss of steak value. When distillers grains, without solubles, are fed to cattle the same effects can be seen (*2011 Nebraska Beef Report*, pp. 96-99). Little research has been conducted to describe the effects of the solubles portion on beef shelf life. The objective of the current project was to determine if feeding only solubles to cattle would have the same effects on shelf life as when distillers grains are fed.

Procedure

Condensed distillers solubles (CDS) were fed to cattle (n = 250) with inclusion rates of 0, 9, 18, 27, and 36% (DM). No distillers grains were added to any diets. After 132 days cattle were harvested at the Greater Omaha Packing plant in Omaha, Neb. Seventy-five carcasses grading USDA Choice, 15 from each treatment, were selected. Strip loins were wet aged for 14 days and then fabricated. Five steaks were cut from each strip loin.

The first steak, cut 1-in thick, was used for initial Warner-Bratzler Shear Force (WBSF) determination. The second steak, also 1-in thick, was placed on a Styrofoam tray, wrapped with PVC overwrap film, and placed in a retail display case for 7 days. Objective color was measured and subjective discoloration scores were assigned by a 4-member panel daily. At the end of retail display, WBSF was determined. Steaks 3, 4, and 5 were cut ½-inch thick and assigned to 0, 4, or 7 days of retail display, respectively. After retail display these steaks were used to measure oxidation.

Objective color was measured using a Minolta Chromometer CR-400 set at a D65 light source and 2° observer with an 8 mm diameter measurement area. L*, a*, and b* values were recorded using an average of six readings per steak. Subjective discoloration was evaluated based on percentage of surface discoloration (0% indicating no discoloration and 100% indicating complete discoloration of the entire steak) by four trained panelists.

Tenderness was determined using WBSF. Initial weight and temperature were recorded and then steaks were placed on a Hamilton Beach Indoor/Outdoor grill. When steaks reached an internal temperature of 95°F they were turned over and cooked on the other side until they reached an endpoint temperature of 160°F. Steaks were removed from the grill, final weight and temperature were recorded and cooking loss was determined. Cooked steaks were covered with plastic wrap and placed in a cooler overnight. The next morning six ½-inch cores were removed from each steak and sheared to determine WBSF.

For oxidation analysis, partially frozen 0, 4, and 7 day steaks were cut into small cubes, flash frozen using liquid nitrogen, and powdered using a Waring blender. A thiobarbituric acid reducing substances assay was used on the powdered samples to measure oxidation.

Powdered samples from 0 day steaks were also used to analyze fatty acid, moisture, and fat content. Gas chromatography was used to determine fatty acid content using a Chrompack CP-Sil 88 (0.25 mm x 100 m) column. Moisture was measured using a LECO thermogravimetric analyzer and fat was measured using an ether extract.

Data were analyzed using the Mixed procedure in SAS (SAS Inst., Inc., Cary, N.C.). Repeated measures was used to analyze color and oxidation data.

Results

Neither dietary treatments nor treatment by day interaction had an effect ($P > 0.10$) on subjective discoloration (Figure 1) or objective color a* (redness) values (Figure 2). There were no differences ($P > 0.10$) in WBSF, cooking loss, moisture or fat due to dietary treatment (Table 1).

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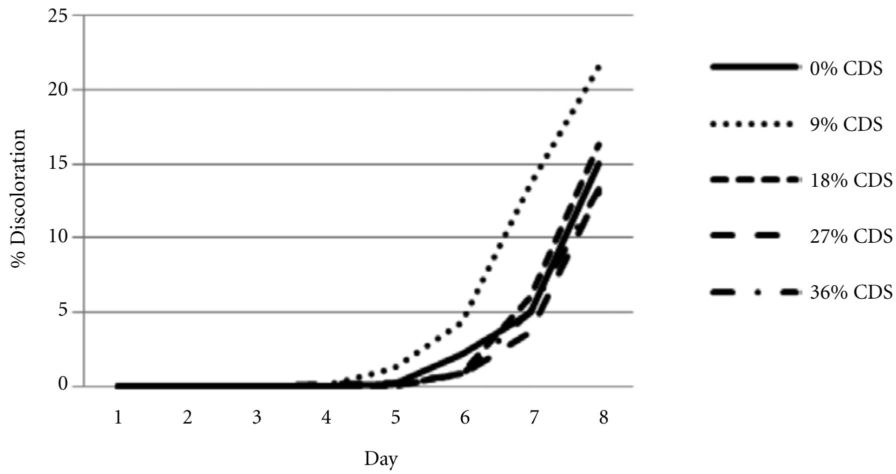


Figure 1. Effect of corn distillers solubles inclusion on subjective discoloration scores during retail display (*P* > 0.10)

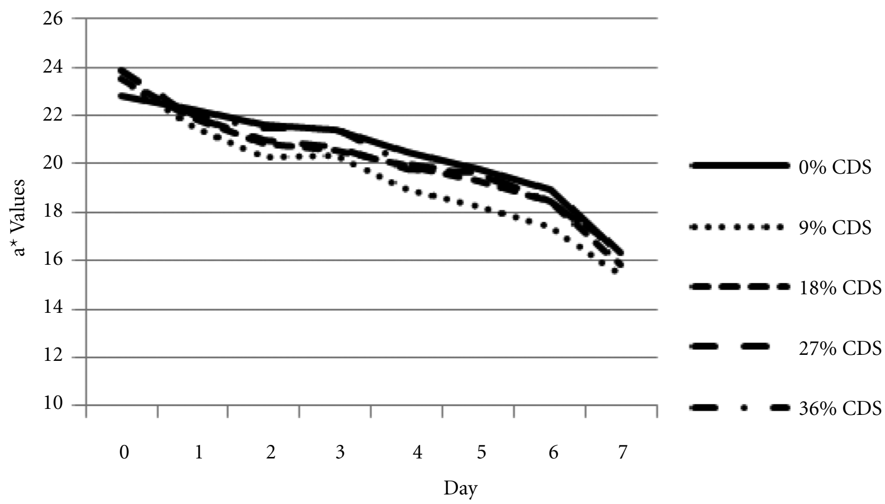
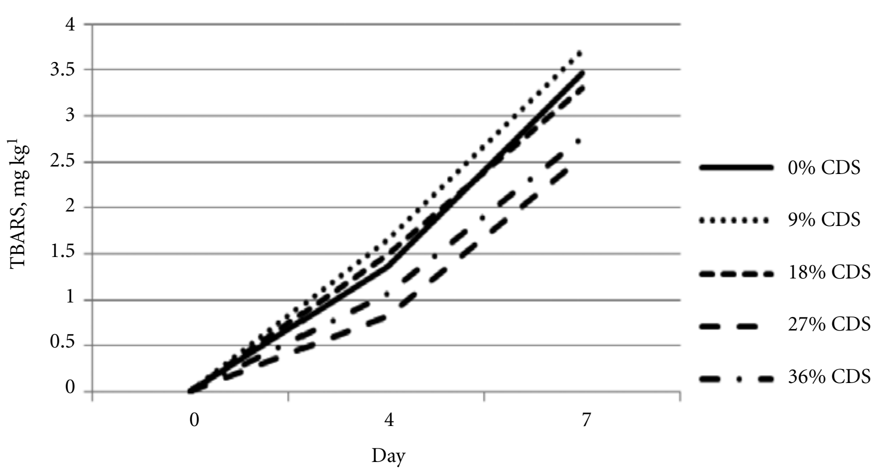


Figure 2. Effect of corn distillers solubles inclusion on a* (redness) values during retail display (*P* > 0.10)



[1]TBARS = Thiobarbituric acid reactive substances.

Figure 3. Effect of corn distillers solubles inclusion on oxidation values during retail display (*P* > 0.10)

Table 2. Effect of corn distillers solubles inclusion on fatty acid profiles.

	CDS[1], %						
	0	9	18	27	36	SEM	*P*-value
C10:0	0.04	0.04	0.04	0.04	0.04	0.002	0.60
C12:0	0.06	0.06	0.06	0.06	0.06	0.003	0.43
C14:0	2.85	2.90	2.84	3.06	2.91	0.098	0.49
C14:1	0.71	0.63	0.59	0.67	0.59	0.039	0.13
C15:0	0.52	0.52	0.51	0.54	0.51	0.020	0.81
*iso*16:0	0.20	0.24	0.18	0.21	0.18	0.021	0.23
C16:0	25.38	25.41	25.40	25.04	24.52	0.279	0.15
C16:1	3.54[a]	3.44[ab]	3.17[bc]	3.27[abc]	3.04[c]	0.107	0.03
C17:0	1.97	1.59	1.59	1.57	1.48	0.068	0.46
*iso*18:0	0.12	0.14	0.10	0.13	0.11	0.015	0.37
C17:1	1.24[a]	1.13[ab]	1.06[bc]	1.07[bc]	0.95[c]	0.059	0.03
C18:0	12.44[b]	13.51[a]	13.76[a]	13.70[a]	14.11[a]	0.334	0.02
C18:1 *trans*	2.85[c]	2.56[c]	3.51[bc]	4.68[ab]	5.77[a]	0.442	<0.01
C18:1 (*n*-9)	39.13[a]	37.74[ab]	37.58[ab]	36.53[bc]	34.95[c]	0.705	<0.01
C18:1 (*n*-7)	2.35[a]	2.27[a]	2.00[b]	1.85[bc]	1.73[c]	0.069	<0.01
C18:1 Δ13t	0.39[a]	0.15[b]	0.15[b]	0.28[ab]	0.21[b]	0.051	0.01
C18:1 Δ14t	0.25	0.24	0.26	0.27	0.26	0.011	0.33
C19:0	0.09[cd]	0.10[cd]	0.11[c]	0.12[b]	0.13[a]	0.004	<0.01
C18:2 Δ9t,12t	0.09[c]	0.10[b]	0.11[b]	0.13[a]	0.14[a]	0.005	<0.01
C18:2 Δ9c,12c	3.12	3.20	3.10	3.37	3.46	0.131	0.23
C20:0	0.08	0.07	0.07	0.07	0.07	0.006	0.58
C18:3 Δ6c,9c,12c	0.16	0.14	0.15	0.15	0.14	0.008	0.28
C18:3 (*n*-3)	0.16	0.16	0.17	0.16	0.17	0.005	0.16
C20:1	0.22[bc]	0.19[c]	0.23[b]	0.25[b]	0.30[a]	0.013	<0.01
C20:3	0.18[ab]	0.19[a]	0.16[bc]	0.16[bc]	0.15[c]	0.010	0.02
C20:4	0.57	0.66	0.54	0.56	0.50	0.046	0.17
C22:4	0.09	0.10	0.09	0.09	0.08	0.007	0.12
C22:5	0.17	0.13	0.11	0.12	0.10	0.026	0.46
Total FA	97.60[a]	97.19[b]	96.96[bc]	96.91[bc]	96.69[c]	0.122	<0.01
SFA	43.46	44.58	44.67	44.55	44.14	0.459	0.34
UFA	54.14[a]	52.61[b]	52.29[b]	52.36[b]	52.55[b]	0.454	0.04
SFA:UFA	0.81	0.85	0.86	0.85	0.84	0.016	0.20
MUFA	49.60[a]	47.91[b]	47.84[b]	47.62[b]	47.81[b]	0.461	0.03
PUFA	4.55	4.69	4.44	4.74	4.75	0.178	0.68

[1]CDS = corn distillers solubles.
[a,b,c]Means with different superscripts within the same row differ ($P \leq 0.05$).

There were no significant differences ($P > 0.10$) for oxidation due to either dietary treatment or treatment-by-day interaction (Figure 3).

Fatty acid content was the only parameter affected by dietary treatment (Table 2). The control diet had significantly higher levels of total unsaturated fatty acids than all other treatments ($P = 0.04$). Polyunsaturated fatty acid content was unaffected by treatment, but the control diets had significantly higher amounts of monounsaturated fatty acids ($P = 0.03$). Specifically, levels of the monounsaturated fatty acids C16:1, C17:1, C18:1, and C18:1 (*n*-7) (cis-vaccenic acid) were significantly decreased as CDS inclusion increased ($P = 0.03$, $P = 0.03$, $P = 0.004$, and $P < 0.0001$, respectively). Unlike distillers grains, CDS do not affect polyunsaturated fatty acids and therefore the meat is not as affected by oxidation. An isomer of conjugated linoleic acid, C18:2 Δ9t,12t, was found to linearly increase as inclusion of CDS increased ($P < 0.0001$). In summary, feeding CDS to cattle has no detrimental effects on beef shelf life when fed to cattle at inclusion levels as high as 36%.

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Effects of Antioxidants on Beef in Low and High Oxygen Packages

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Kimberly A. Varnold[1, 2]

Summary

Color, lipid, and protein stability of beef strip loin steak treated with different antioxidants (tocopherol, tertiary butyl hydroquinone, rosemary, or combinations of two of the antioxidants) and packaged in low oxygen (2-5% O_2) or high oxygen (80% O_2) modified atmosphere packages were studied. The application of tertiary butyl hydroquinone on steaks prior packaging (either in low- or high-oxygen modified atmosphere packages) was significantly effective in minimizing color and lipid oxidation during retail display. Under modified atmosphere packaging (low- or high-oxygen modified atmosphere packaging), oxidation of myoglobin color pigments and lipids were unrelated to beef tenderness.

Introduction

High oxygen modified atmosphere packages (80% oxygen and 20% carbon dioxide; HiOx– MAP) help sustain cherry red color of meat longer compared to steaks in oxygen permeable (PVC-OW) packages (*2011 Nebraska Beef Cattle Report,* pp. 100-102) or low oxygen modified atmosphere packages (LowOx-MAP; *2010 Nebraska Beef Cattle Report,* pp. 99-101). However, previous studies reported that HiOx-MAP significantly increases protein oxidation, thereby reducing steak tenderness (*2012 Nebraska Beef Cattle Report,* pp …). Dipping steaks in antioxidant solutions prior packaging may give a protective layer around steaks thereby minimizing color, lipid, and protein oxidation.

Therefore, two separate studies were performed to find out the effectiveness of application of different antioxidants, prior packaging, on color, lipid, and protein stability of strip loin steaks under HiOx- and LowOx-MAP systems.

Procedure

Five USDA Choice beef loin, strip loins (*longissimus lumborum*) for each study were aged at 36°F for 14 days from the boxed date. Each strip loin was cut into nine, inch-thick steaks (for color and instrumental tenderness tests), and half-inch thick steaks (half of the steak for either four or seven days retail display lipid oxidation test).

Steaks were held as untreated control (packaged in PVC-OW and LowOx-MAP or HiOx-MAP packages) or dipped in one of six antioxidant solutions containing alpha-tocopherol (Tocopherol; 300 ppm), tertiary butyl hydroquinone (TBHQ; 200 ppm), a commercial extract of Rosemary (Herbalox; 600 ppm; Kalsec Inc., Kalamazoo, Mich.), or combinations of two of the antioxidants (Tocopherol and TBHQ; TBHQ and Herbalox; Tocopherol and Herbalox). Preliminary tests were conducted to determine optimum concentrations and application methods. After antioxidant application, steaks were packaged in modified atmosphere packages containing low levels of oxygen (2-5% O_2, 10% CO_2 and 85% N_2; LowOx-MAP) or high levels of oxygen (80% O_2 & 20% CO_2; HiOx-MAP). All the packages were displayed for seven days in retail display cases at 32 ± 36°F under continuous 1,000-1,800 lux warm white fluorescence lighting. Color measurements (CIE a*redness values; by Minolta color meter) and discoloration (estimated as percent discoloration; by five trained panelists) scores were obtained daily during retail display period. The thiobarbituric acid reactive substances assay (TBARS) was performed to quantify lipid oxidation at 0, 4, and 7 days retail displayed steaks. Instrumental tenderness of steaks was measure by Warner-Bratzler shear force (WBSF) at the beginning and the end of retail display on steaks cooked to 160ºF.

Data were analyzed by ANOVA in the GLIMMIX procedure of SAS (SAS Inst., Inc., Cary, N.C.). Separation of means was conducted using LSMEANS procedure with PDIFF and LINES options in SAS at $P < 0.05$.

Results

Steaks packaged in LowOx-MAP discolored at a more rapid rate than those in HiOx-MAP (Figure 1). Under LowOx-MAP, steaks treated with solutions containing TBHQ had significantly less (Figure 1; $P < 0.0001$) discoloration after three days of retail display than steaks treated with the other antioxidants. These differences were evident after six days for the HiOx-MAP study (Figure 1; $P < 0.0001$). Steak a* values decreased (less redness) during retail display (data not shown). This decline was more severe (data not shown; $P < 0.0001$) for steaks dipped in solutions that did not contain TBHQ and packaged in LowOx-MAP. However, there were no differences in a* values among treatments using HiOx-MAP (data not shown; $P = 0.14$).

Lipid oxidation of steaks also progressed during retail display (Figure 2; $P < 0.0001$). This increase in lipid oxidation was more severe (Figure 2; $P < 0.0001$) for steaks treated solutions not containing TBHQ. At the end of retail display, steaks in HiOx-MAP had significantly higher TBARS values than steaks in LowOx-MAP (Figure 2).

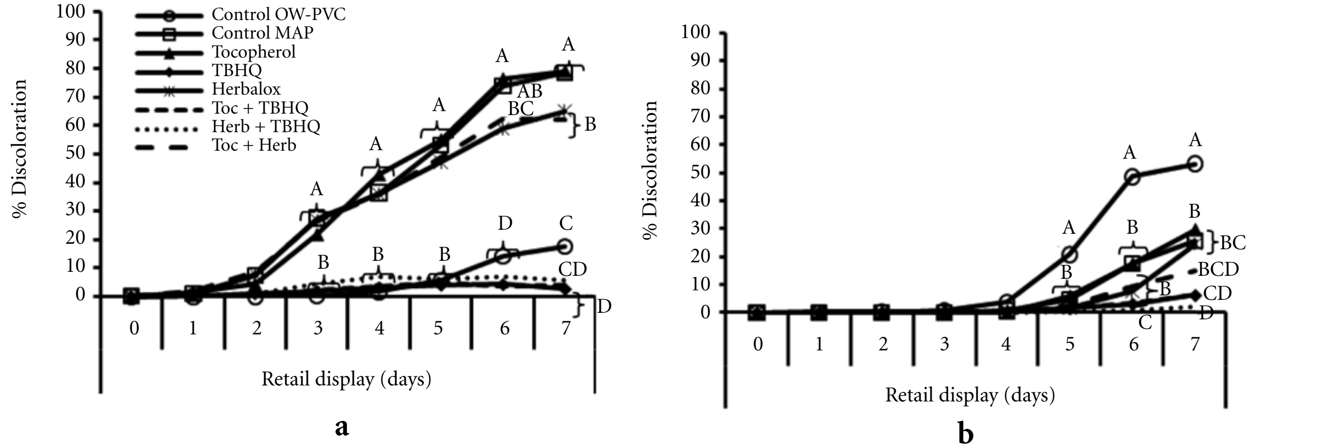

Figure 1. Means of percentage discoloration of antioxidant-treated-strip loin steaks packaged in a) low oxygen (LowOx-MAP) and b) high oxygen (HiOx-MAP) modified atmosphere systems during seven days of simulated retail display conditions (Treatment × day, $P < 0.0001$). A-D comparison among treatments within the same retail display day, means lacking a common superscript were significantly different at $P < 0.05$.

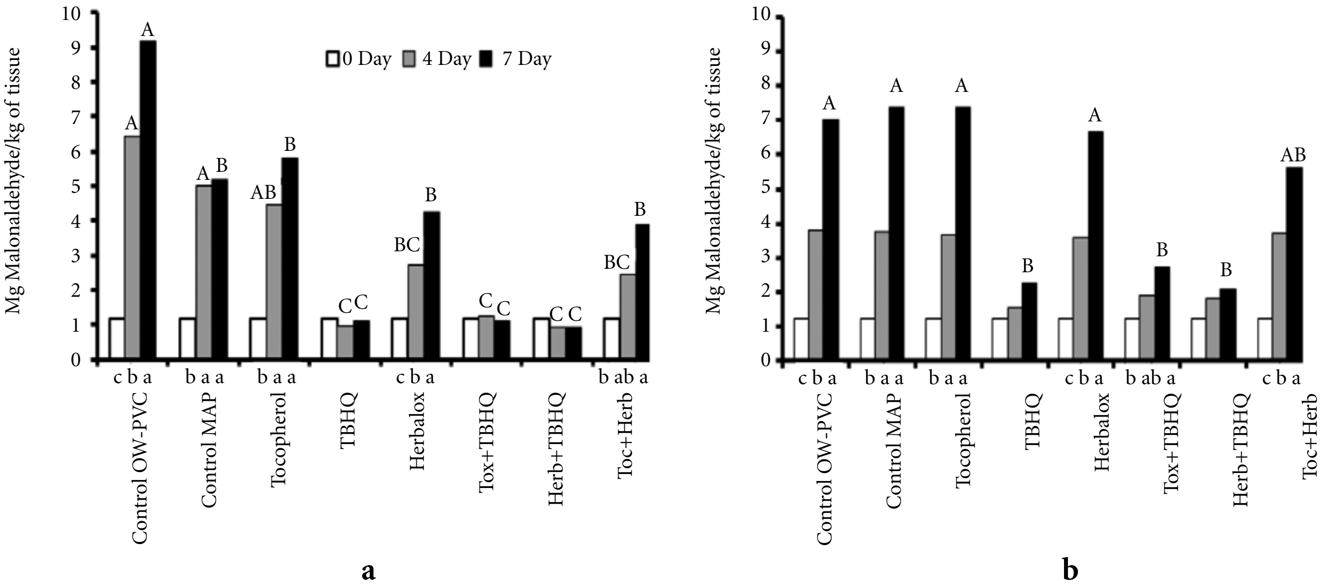

Figure 2. Means of thiobarbituric acid reactive substances values of antioxidant-treated-strip loin steaks packaged in a) low oxygen (LowOx-MAP) and b) high oxygen (HiOx-MAP) modified atmosphere systems during seven days of simulated retail display conditions (Treatment × day, $P < 0.0001$). A-C comparison among treatments within same retail display day, means lacking a common superscript were significantly different at $P < 0.05$. a-c comparison among retail display days within same treatment, means lacking a common superscript were significantly different at $P < 0.05$.

Under LowOx-MAP, steaks at the end of retail display had lower (data not shown; $P = 0.006$) WBSF values (more tender) than 0 day retail displayed steaks. This indicates that further postmortem tenderization is occurring during retail display period. However, a similar trend was not seen in steaks packaged in HiOx-MAP (data not shown; $P = 0.87$). A possible reason would be high oxygen condition in packages significantly interferes with further tenderization of meat by protein aggregation and inactivation of proteolytic enzymes. In addition, there were no significant differences in Δ WBSF (7 day – 0 day) values across all treatments for either study (data not shown; $P > 0.05$).

Under modified atmosphere packaging (LowOx- or HiOx-MAP), oxidation of myoglobin pigments, and lipids were unrelated to beef tenderness. The application of antioxidant TBHQ on steaks prior packaging in MAP (either Low or HiOx-MAP) was significantly more effective in minimizing myoglobin and lipid oxidation during retail display.

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[2]This project was funded by the UCARE, University of Nebraska–Lincoln.

Dietary Antioxidants and Beef Tenderness During Retail Display in High O_2

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Summary

Aged (8 and 29 days) strip loins, from cross-bred steers fed dry-rolled corn-based finishing diets containing 0 or 30% wet distillers grains with a synthetic antioxidant blend (AGRADO®PLUS) were packaged in high oxygen modified atmosphere packages (80% O_2:20% CO_2) and studied for decreased tenderness compared to steaks packaged in oxygen-permeable film during retail display. Steaks aged longer and packaged in high oxygen modified atmosphere packages decreased in tenderness, likely due to increased protein oxidation (more carbonyls and less free thiols), during retail display. Feeding AGRADO PLUS tended to decrease tenderness and increased protein oxidation during retail display under high oxygen conditions.

Introduction

High oxygen modified atmosphere packages (HiOx-MAP) are widely used in fresh beef retail markets to sustain the cherry-red color of meat. Steaks packaged in HiOx-MAP decrease remarkably in tenderness compared to steaks in oxygen-permeable (PVC-OW) packages (*2010 Nebraska Beef Cattle Report,* pp. 99-101; *2011 Nebraska Beef Cattle Report*, pp. 100-102).

Antioxidant supplementation (ethoxyquin and tertiary butyl hydroquinone; AGRADO PLUS; AG) helps to minimize oxidation of color and lipids of beef (*2011 Nebraska Beef Cattle Report,* pp 100 – 102).

Therefore, this study was conducted to investigate the mechanism of declining beef tenderness due to HiOx-MAP and to study effects of dietary antioxidant (AG) supplementation as a control measure for the problem.

Procedure

Cross-bred (British × Continental) yearling steers were randomly assigned to one of four dry-rolled corn-based feedlot diets, containing 0 or 30% (DM) wet distillers grains plus solubles (WDGS) with or without AG (AG; 150 ppm/steer/day for 145-160 days). After slaughter and chilling for 48 hours, both short loins from a total of 80 USDA Choice carcasses (20 from each dietary treatment) were obtained and aged for either 8 or 29 days at 36°F.

Each strip loin (*m. longissimus lumborum*) was cut into 1-inch-thick steaks from the anterior to the posterior. The first (for protein oxidation; 0 days retail displayed), and fourth (for shear force; 0 days retail displayed) steaks were immediately vacuum-packaged and stored at -4°F. The second and third steaks were split into halves and assigned for 4 and 7 day protein oxidation analysis either under PVC-OW or HiOx-MAP (80% O_2:20% CO_2) packaging systems. The fifth and sixth steaks were allotted for 7 day retail display shear force analysis under both packaging systems. Packaged steaks were placed on a table in a cooler at 32 ± 36°F and exposed to continuous 1,000-1,800 lux warm white fluorescence lighting to provide simulated retail display conditions. Steaks assigned for 4 and 7 days of retail display were removed from tables accordingly for protein oxidation, and shear force analysis, immediately vacuum-packaged and stored at -4°F.

Protein oxidation of steaks was determined by measuring carbonyl and free thiol (sulfhydryl) contents per mg of myofibrillar proteins. More carbonyls and fewer sulfhydryls indicate more protein oxidation of steaks. The change (delta; Δ; 4/7 day– 0 day) in carbonyls and free thiols were calculated. Instrumental tenderness testing of steaks was performed using Warner-Bratzler shear force test (WBSF). Steaks were cooked to an internal temperature of 160 °F and stored in a cooler for overnight. Six cores with 0.5 in diameter were removed from a steak parallel to the muscle fiber arrangement using a drill press. Cores were sheared on a tabletop WBSF analyzer with a triangular Warner-Bratzler shear attachment. An average of the peak shear force (lb) of six cores for each steak was used for statistical analysis (higher WBSF values indicate less tender).

Data were analyzed by ANOVA in the GLIMMIX procedure of SAS (SAS Inst., Inc., Cary, N.C.) as a split-split-split-plot design with dietary treatments as the whole-plot treatment, aging period as the first split-plot treatment, packaging systems as the second split-plot treatment and retail display time (repeated measures) as the third split-plot treatment with the animal as the experimental unit. Separation of means was conducted using LSMEANS procedure with PDIFF and SLICEDIFF options at $P \le 0.05$. In addition, the CONTRAST statements in SAS were used to compare the effects of feeding Corn *vs.* WDGS, Corn *vs.* Corn+AG, WDGS *vs.* WDGS+AG, and No AG *vs.* AG.

Results

Dietary treatments significantly (Figure 1a: $P = 0.02$) affected WBSF values. Steaks from AG-fed cattle had significantly (contrast $P = 0.04$;

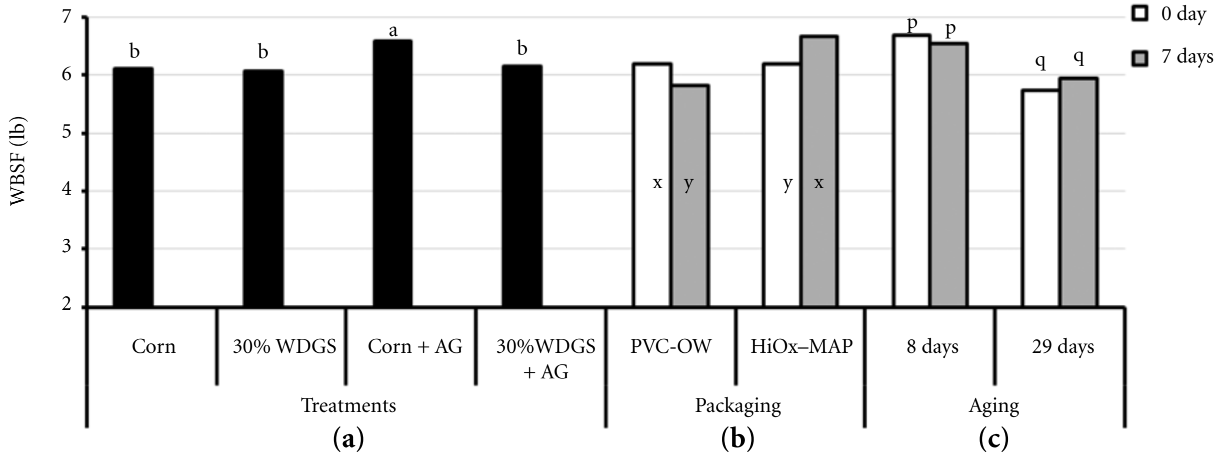

Figure1a. **Means of Warner-Bratzler Shear force (WBSF) values of strip loin steaks from different diets (Diet, $P = 0.02$). b. Means of WBSF values of steaks in PVC-overwrapped (PVC-OW) and high oxygen modified atmospheric (HiOx-MAP) packages during retail display period (Packaging × d, $P < 0.0001$). c. Means of WBSF values of steaks aged 8 and 29 days during retail display period (Aging × days, $P = 0.03$). [a-b, x-y, or p-q] Comparison within each category, means lacking a common superscript were significantly different at $P < 0.05$. d = retail display days; WDGS = Wet distillers grains plus solubles; AG = AGRADO PLUS.**

Table 1. **Means of carbonyls of 8 and 29 day aged strip loin steaks in PVC-overwrapped (PVC-OW) and high oxygen modified atmospheric (HiOx-MAP) packages during 7 days of retail display (Diet × aging × d, $P = 0.0044$).**

		Dietary Treatments				Contrast P values			
Aging	Day[1]	Corn + AG[1]	30% WDGS[1] + AG	Corn	30% WDGS	Corn vs Corn +AG	WDGS vs WDGS + AG	No AG vs AG	Corn vs WDGS
8	0	2.04^{Bb}	1.82^{Bb}	1.71^{Bb}	2.44^{A}	0.05	0.0002	0.23	0.01
	4	2.08^{b}	2.33^{a}	2.10^{a}	2.36	0.89	0.88	0.83	0.03
	7	2.46^{Aa}	2.30^{ABa}	1.99^{Bb}	2.22^{AB}	0.005	0.63	0.01	0.80
29	0	2.16^{Ac}	1.68^{Bc}	1.71^{Bc}	1.98^{ABc}	0.0003	0.09	0.44	0.17
	4	2.50^{Ab}	2.31^{ABb}	2.09^{Bb}	2.63^{Ab}	0.007	0.04	0.63	0.10
	7	2.98^{Aa}	2.81^{BCa}	2.55^{Ca}	3.28^{Aa}	0.06	0.03	0.80	0.06

[A-C]Comparison within rows among treatments, means lacking a common superscript were significantly different at $P < 0.05$.
[a-c]Comparison along columns within same treatment, means lacking a common superscript were significantly different at $P < 0.05$.
[1]d = retail display days; WDGS = Wet distillers grains plus solubles; AG = AGRADO®PLUS.

data not shown) higher WBSF values (less tender) compared to steaks from cattle fed non-AG supplemented diets. Overall, steaks from corn plus AG-fed cattle had the highest WBSF vales (Figure 1a) than steaks from cattle fed other diets. Perhaps AG interferes with proteolytic enzyme activity needed for postmortem meat tenderization.

During retail display, steaks in PVC-OW improved in tenderness while those in HiOx-MAP decreased in tenderness (Figure 1b; $P < 0.0001$). In addition, 29-day aged steaks were more tender than 8 dayaged steaks (Figure1c; $P = 0.03$). However, 29-day aged steaks tended to decrease in tenderness (higher WBSF values) during retail display (Figure1c; $P = 0.06$).

The high oxygen (80% O_2) level in MAP packages likely oxidized muscle proteins, especially myofibrillar proteins and proteolytic enzymes, consequently causing myofibrillar protein to cross-link (aggregate) and major proteolytic enzymes (calpains) to inactivate. An increase in carbonyls and a decrease in sulfhydryl (free thiol) groups in protein molecules are indicative of protein oxidation. Therefore, in this study carbonyls and free thiols were spectrophotometrically quantified.

Eight and 29 day aged steaks from corn plus AG diets had significantly (Table 1; $P < 0.05$) more carbonyls (more protein oxidation) than steaks from non-AG supplemented corn diets. There is no clear explanation for more carbonyls in steaks from cattle fed corn plus AG diets. Carbonyls (Δ) of all 29 day aged steaks increased during retail display (Figure 2a; $P = 0.0002$) as well as steaks in HiOx-MAP (Figure 2b; $P = 0.06$) indicating more proteins were oxidized when steaks were aged longer (29 days) or packaged in HiO_2-MAP system. These results explain the increase in WBSF values of steaks aged longer or packaged in HiOx-MAP during retail display period.

Free thiols decreased (more protein oxidation) during aging (Table 2; $P < 0.05$) and during retail display

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Table 2. Means of free thiols (sulfhydryls) 8- and 29-day aged strip loin steaks in PVC-overwrapped (PVC-OW) and high oxygen modified atmospheric (HiOx-MAP) packages during 7 days of retail display (Diet × aging × days, $P < 0.0001$).

Aging	Day[1]	Dietary Treatments				Contrast P values			
		Corn + AG[1]	30% WDGS1 + AG	Corn	30% WDGS	Corn vs Corn +AG	WDGS vs WDGS + AG	No AG vs AG	Corn vs WDGS
8	0	73.52^{Bab}	84.30^{Aa}	80.63^{Aa}	69.57^{Bab}	0.005	<0.0001	0.043	0.996
	4	75.22^{Aa}	71.94^{ABb}	68.81^{Bb}	73.30^{Aa}	0.005	0.511	0.109	0.673
	7	70.44^{b}	66.93^{c}	70.80^{b}	67.47^{b}	0.843	0.785	0.739	0.058
29	0	80.41^{Aa}	78.05^{ABa}	74.63^{Ba}	74.69^{Ba}	0.004	0.130	0.002	0.449
	4	70.15^{b}	66.48^{b}	69.92^{b}	66.52^{b}	0.991	0.940	0.965	0.010
	7	64.69^{c}	66.31^{b}	66.48^{b}	65.50^{b}	0.296	0.572	0.722	0.909

[A-B]Means along rows among treatments with different superscripts are significantly different at $P < 0.05$.
[a-c]Means along columns within treatments with different superscripts are significantly different at $P < 0.05$.
[1]d = retail display days; WDGS = Wet distillers grains plus solubles; AG = AGRADO®PLUS.

(Figure 3b; $P = 0.0002$). Before retail display (0 days), steaks from AG-fed cattle had higher free thiols (Table 2; $P < 0.05$; less protein oxidation) than steak from non-AG-fed cattle. Following retail display, steaks from cattle fed AG supplemented diets had greater decrease in free thiols ($P < 0.05$; data not shown) than steaks from non-AG-fed cattle; however, there was no clear pattern during retail display attributable to different dietary treatments. Steaks in HiOx-MAP tended to have fewer free thiols (Figure 3a; $P = 0.09$; more protein oxidation) compared to steaks in PVC-OW during retail display.

Overall results indicate steaks aged longer and packaged in HiO_2-MAP had more protein oxidation and reduced tenderness during retail display. Feeding AGRADO®PLUS tends to increase protein oxidation and decrease tenderness during retail display.

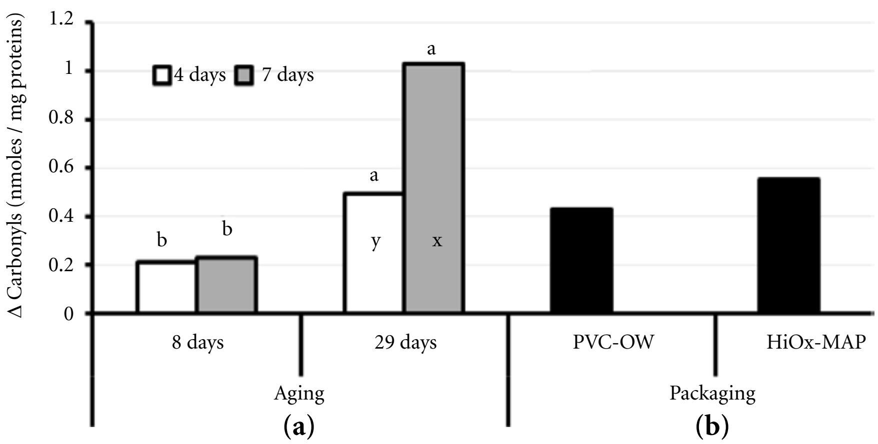

Figure 2a. Means of change (Δ; from 0 days to 4 or 7 days) in carbonyls of steaks aged 8 and 29 days during retail display period (Aging × day, $P = 0.0002$). b. Means of Δ in carbonyls of steaks packaged in PVC-overwrapped (PVC-OW) and high oxygen modified atmospheric (HiOx-MAP) packages (Packaging, $P = 0.06$). [a-b or x-y]Comparison within each category, means lacking a common superscript were significantly different at $P < 0.05$.

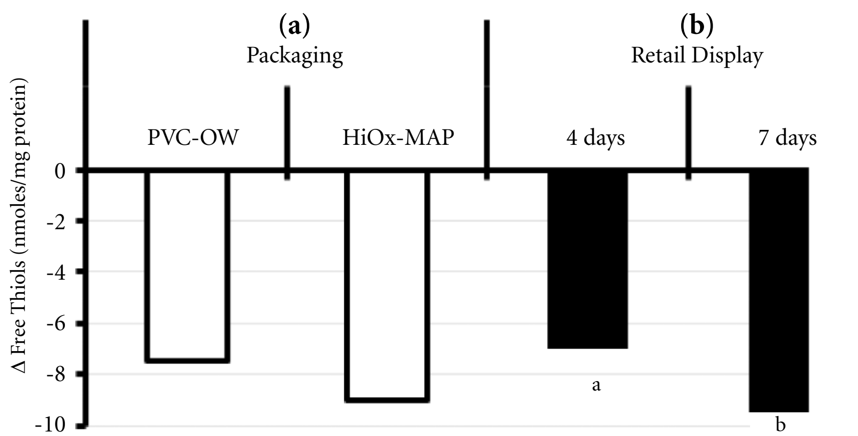

Figure 3a. Means of change (Δ; from 0 days to 4 or 7 days) in free thiols of steaks packaged in PVC-overwrapped (PVC-OW) and high oxygen modified atmospheric (HiO2-MAP) packages (Packaging, $P = 0.09$). b. Means of Δ in free thiols of steaks during retail display (Day, $P = 0.0002$). [a-b] Comparison among retail display d, means lacking a common superscript were significantly different at $P < 0.05$.

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Effects of Freezing and Thawing Rates on Tenderness and Sensory Quality of Beef Subprimals

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Summary

Beef ribeye rolls, strip loins, and top sirloin butts were aged for 14 days and then blast or conventionally frozen and slow or fast thawed, or were fresh, never frozen and aged for 14 days or 21 days (n = 270). Thawing method affected purge loss and tenderness, and freezing method had a minimal effect. Neither freezing nor thawing methods had an effect on sensory tenderness, and minimal effects on the other sensory attributes. It is possible to freeze and thaw beef subprimals and for the meat to be comparable in tenderness and sensory attributes to fresh, never frozen meat.

Introduction

The 2006 National Beef Tenderness Survey showed the average length of aging for steaks in restaurant settings to be 30 days (Savell et al., 2006, *Journal of Animal Science* 33:111), with a range of 7 to 136 days; 29% of the steaks had less than 14 days of aging. This can lead to inconsistency between products. In the summer not all restaurants have the supply of steaks needed to meet the demand and are forced to use steaks with too little aging. A solution could possibly be to freeze and store subprimals after a specific degree of aging. The hypothesis of this project was that if subprimals are properly frozen and thawed, these subprimals would have the same quality of fresh subprimals with similar aging.

Procedure

At 14 days postmortem, 60 ribeye rolls (*Longissimus Thoracic*, LT), strip loins (*Longissimus Lumborum* LL), and top sirloin butts (*Gluteus Medius,* GM) were frozen at a warehouse in a -18°F freezer in Denver, Colo. Thirty LT, LL, and GM were blast frozen. The boxes were placed on pallets with spacers between pallets and high air velocity to allow for more rapid freezing. The other 30 LT, LL, and GM were conventionally frozen. The boxes were left packed tightly on the pallet with minimal air movement. All LT, LL, and GM were frozen for a minimum of 14 days. Frozen subprimals were numbered, weighed and then placed on a table at 32°F for 14 days to allow for slow thawing. Fast thawing occurred in a 54°F water bath with air agitation in 41°F room in the Loeffel Meat Laboratory for 21 hours prior to cutting. The water bath temperature dropped as soon as the subprimals were added. The final water bath temperature was between 32-39°F. The fresh, never frozen beef subprimals were aged in a 32°F cooler for 14 and 21 days prior to cutting. The six treatments were: blast frozen – slow thaw (BS), blast frozen – fast thaw (BF), conventionally frozen – slow thaw (CS), conventionally frozen – fast thaw (CF), fresh, never frozen 14-day aged (14D), and fresh, never frozen 21-day aged (21D).

Top Sirloin Butt (*gluteus medius*) subprimals were cut into 1-in steaks. The two steaks from the center of the GM were used for Warner-Bratzler shear force (WBS), cooking loss, and sensory evaluation. Two 1-in steaks were cut from the anterior portion of LL and the posterior end of LT for WBS, cooking loss, and sensory evaluation.

All WBS steaks were cooked on the day of cutting. Sensory evaluation steaks were vacuum-packaged and placed in a 39°F cooler until sensory evaluation. All steaks were cooked within three days of being cut.

Purge Loss

Purge loss was calculated on every subprimal. Frozen weights were recorded prior to thawing. Prior to cutting, all thawed and fresh, never frozen subprimals were weighed.

Warner-Bratzler Shear Force and cooking loss

Shear force values were determined on one steak from each subprimal. Steaks were grilled on Hamilton Beach Indoor/Outdoor grills. Steaks were cooked on one side until the center temperature reached 95°F and then turned over. Cooking continued until the temperature reached 160°F. Steaks were weighed before and after grilling. Cooking loss was calculated. Steaks were placed on a tray and covered with oxygen-permeable film and placed in a 39°F cooler. Twenty hours later, the cooked steaks were cored into 6 ½-in cores and sheared to determine WBS.

Sensory Panel

For sensory panel evaluation, steaks were prepared and cooked in the same manner described for Warner-Bratzler shear force. Upon reaching 160°F steaks were removed from the grill and cut into 1.27 cm^2 cubes and kept warm (not more than 15 minutes) prior to being evaluated. The steaks were served to 4-7 trained panelists while still warm.

(Continued on next page)

Table 1. Least square means of Warner-Bratzler shear force (WBS) and purge loss.

Muscle	Trait	Treatments[1] 14 Day Aged	21 Day Aged	Blast Frozen, Fast Thaw	Blast Frozen, Slow Thaw	Conventional Frozen, Fast Thaw	Conventional Frozen, Slow Thaw	P-value[2]	Contrasts Blast Frozen vs. Conventional Frozen	Slow Thaw vs. Fast Thaw
Longissimus Thoracic	WBS, kg	3.44[c]	3.10[c]	4.45[a]	3.70[bc]	4.21[ab]	3.53[c]	0.001	0.4825	0.2897
	Purge Loss, %	0.68[b]	1.01[b]	0.98[b]	5.30[a]	0.72[b]	4.49[a]	<0.0001	0.5431	<0.0001
Longissimus Lumborum	WBS, kg	3.55[ab]	3.32[abc]	3.55[ab]	2.93[bc]	3.94[a]	2.83[c]	0.01	0.5177	0.0004
	Purge Loss, %	1.78[b]	1.88[b]	0.88[c]	3.53[a]	0.78[c]	3.53[a]	<0.0001	0.8171	<0.0001
Gluteus Medius	WBS, kg	3.35	3.21	4.08	3.48	3.51	3.54	0.08	0.2411	0.1845
	Purge Loss, %	1.25[bc]	1.56[b]	0.79[cd]	6.17[a]	0.53[d]	6.23[a]	<0.0001	0.7060	<0.0001

[a, b, c, d]Means in the same row having different superscripts are significant at $P \leq 0.05$.
[1]Blast Frozen = spacers placed between boxes of meat and placed in a -28°C freezer with high air velocity, Conventional Frozen = boxes of meat placed in a -28°C freezer with minimal air movement, Slow Thaw = subprimals set on a table in a 0°C room for 14 days, Fast Thaw = subprimals immersed in a circulating water bath (< 12°C) for 21 hrs 14 Day Aged = Aged for 14 days and fresh, never frozen, 21 Day Aged = Aged for 21 days and fresh, never frozen.
[2]*P*-value for the interaction between freezing process and thawing process.

Table 2. Least square means of sensory attributes.

Muscle	Trait	Treatments[1] 14 Day Aged	21 Day Aged	Blast Frozen, Fast Thaw	Blast Frozen, Slow Thaw	Conventional Frozen, Fast Thaw	Conventional Frozen, Slow Thaw	P-value[2]	Contrasts Blast Frozen vs. Conventional Frozen	Slow Thaw vs. Fast Thaw
Longissimus Thoracic	Tenderness	5.80	5.94	5.12	5.30	5.55	5.67	0.07	0.0613	0.4692
	Juiciness	5.08[a]	5.07[a]	4.12[b]	4.34[b]	4.48[b]	4.30[b]	0.001	0.4384	0.8965
	Connective Tissue	5.04	5.48	4.68	4.85	5.14	5.32	0.09	0.0268	0.3961
	Off-Flavor	2.10	2.14	1.88	1.97	2.05	2.02	0.30	0.1356	0.6648
	Cooking Loss	17.36[b]	16.53[b]	21.24[a]	19.41[ab]	22.31[a]	20.51[a]	0.001	0.3511	0.1230
Longissimus Lumborum	Tenderness	6.03	5.90	6.07	6.31	5.79	6.37	0.10	0.5327	0.0194\
	Juiciness	5.63	5.24	4.99	5.03	5.32	5.19	0.17	0.1977	0.8044
	Connective Tissue	5.61[ab]	5.55[b]	5.77[ab]	6.04[a]	5.37[b]	6.02[a]	0.02	0.1842	0.0032
	Off-Flavor	1.93	1.92	1.89	2.04	1.81	1.86	0.49	0.0751	0.1722
	Cooking Loss	20.95	16.51	17.21	19.33	19.36	17.67	0.41	0.8728	0.8882
Gluteus Medius	Tenderness	5.43	5.88	5.54	5.89	5.59	5.52	0.33	0.6811	0.8198
	Juiciness	5.01	5.36	5.33	4.70	5.04	4.55	0.07	0.3217	0.0108
	Connective Tissue	4.92	5.38	5.22	5.17	5.07	5.22	0.46	0.7670	0.7689
	Off-Flavor	1.90[b]	2.01[ab]	1.84[b]	1.96[ab]	2.10a	1.85[b]	0.02	0.2296	0.2505
	Cooking Loss	23.44	25.03	26.11	27.79	27.49	25.67	0.40	0.8005	0.9612

[a, b, c, d]Means in the same row having different superscripts are significant at $P < 0.05$.
[1]Blast Frozen = spacers placed between boxes of meat and placed in a -28°C freezer with high air velocity, Conventional Frozen = boxes of meat placed in a -28°C freezer with minimal air movement, Slow Thaw = subprimals set on a table in a 0°C room for 14 days, Fast Thaw = subprimals immersed in a circulating water bath (< 12°C) for 21 hrs 14 Day Aged = Aged for 14 days and fresh, never frozen, 21 Day Aged = Aged for 21 days and fresh, never frozen.
[2]*P*-value for the interaction between Freezing process and thawing process.
Tenderness (1 extremely tough – 8 extremely tender); juiciness (1 extremely dry – 8 extremely juicy); connective tissue (1 abundant amount – 8 no connective tissue); off-flavor (1 no off-flavor – 4 strong off-flavor).

Panelists evaluated six samples (one per treatment) per session. Sensory panels were conducted in a positive pressure ventilated room with lighting and cubicles designed for objective meat sensory analysis. Each sample was evaluated for tenderness (8 = extremely tender; 1 = extremely tough), juiciness (8 = extremely juicy; 1 = extremely dry), connective tissue (8 = no connective tissue; 1 = abundant amount) and off-flavor (1 = no off-flavor; 4 = strong off-flavor).

Statistical Analysis

Purge loss, cooking loss, Warner-Bratzler shear force, and trained sensory panel data were analyzed using the PROC GLIMMIX procedure of SAS (SAS Inst., Inc., Cary, N.C.). When significance ($P \leq 0.05$) was indicated by ANOVA, mean separations were performed using the LSMEANS and PDIFF functions of SAS. CONTRAST statements were used to see if there was significance ($P \leq 0.05$) between blast frozen and conventionally frozen as well as slow thaw and fast thaw subprimals.

Results

There were significant differences in purge loss among all of subprimals ($P < 0.0001$). Fast thawed subprimals had equal or lesser purge loss compared to the fresh never frozen subprimals. The slow thawed subprimals had the most purge loss ($P < 0.001$). There were no differences in purge loss between blast frozen and conventionally frozen subprimals ($P > 0.05$); the differences were between fast and slow thawing treatments (Table 1). The differences in purge loss between thawing treatments are likely because fast thaw subprimals were thawed to 28-30°F, and were still slightly frozen in the center when cut. The slow thawed subprimals were thawed to 32°F.

Strip loin and GM frozen steaks were all equal or superior in WBS to 14D and 21D steaks. Slow thawed steaks were equal in WBS to 14D and 21D steaks. All slow thawed steaks for the LT and LL were equal or superior ($P < 0.01$) in WBS when compared to fast thaw steaks (Table 1). There were no significant differences in WBS among treatments within the GM ($P = 0.08$).

There were few differences found in the sensory evaluation (Table 2). There were no significant difference in sensory tenderness within the LT, LL and GM ($P > 0.05$). There were no significant differences in juiciness in LL and GM steaks ($P > 0.05$). The 14D and 21D LT steaks were juicier than all frozen steaks ($P < 0.001$). The 14D and 21D LT steaks also experienced less or equal cooking loss than all frozen steaks ($P < 0.001$). There were no significant differences in cooking loss in the LL and GM. For all steaks, frozen treatments were equal to 14D steaks in connective tissue. There were no significant differences in connective tissue detected in LT and GM steaks ($P > 0.05$). Slow thawed steaks for the LL had less connective tissue than the fast thawed and 21D steaks. There was no significant difference detected in off-flavor among the treatments for the LT and LL. The CF had the strongest prevalence of off-flavor ($P = 0.02$) in the GM. Overall, neither freezing nor thawing rates had significant meaningful effects on Warner-Bratzler shear force or sensory. Freezing rate did not affect purge loss. When thaw rates are properly managed (the meat is thawed slowly or quickly and outer surface of the meat does not exceed 45°F), tenderness and sensory attributes will be comparable to fresh product.

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[2]This project was funded, in part, by the Beef Checkoff and Colorado Premium, Greeley, Colo.

Subprimal Freezing and Thawing Rates Affect Beef at Retail

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Summary

Ribeye, strip loin and top sirloin butt subprimals were either fast or slow frozen and then fast or slow thawed. Steaks were cut, placed in retail display for 8 days, and compared to fresh-never-frozen product for retail color and purge loss. Thaw purge loss was higher for slow thawed subprimals, with fast thawed product having the greatest purge loss during display. Overall, total purge loss was roughly 2-5% higher for all slow thawed products. Color data indicated frozen-thawed beef subprimals are comparable to fresh-never-frozen subprimals in color stability during day 1-4 of retail display. Total purge loss was increased for slow thawed subprimals; freezing rate had minimal effects on retail quality.

Introduction

To evaluate handling methods for frozen beef subprimals, the effects of freezing and thawing rates on retail shelf life and percent purge loss were compared to that of fresh-never-frozen product. In the retail industry subprimal pricing fluctuation occurs seasonally. If retailers can properly manage freezing and thawing rates to minimize detrimental effects on beef quality, economic value to purchasing subprimals at low seasonal prices can be obtained

Procedure

Three subprimal cuts — ribeye rolls, strip loins, and top sirloin butts — were utilized with three replications of five samples per treatment (n = 270). There were six treatments: fresh-never-frozen 14-day aged (14D), fresh-never-frozen 21-day aged (21D), blast frozen–fast thawed (BF), blast frozen-slow thawed (BS), conventional frozen-fast thawed (CF), and conventional frozen-slow thawed (CS). Blast freezing took place at the plant by placing spacers between boxes of meat on pallets at -18˚F with high air velocity. Conventional freezing also occurred at the plant with spacers between stacked pallets at -18˚F with minimal air flow. Fast thawing (to an internal temperature of 28˚F) occurred by immersion in a circulating water bath (<54˚F) for 21 hours at the Loeffel Meat Lab. Slow thawing spanned over a two week period with subprimals spaced on tables at 32˚F. Thawed subprimals were then weighed prior to cutting steaks from the *longissimus thoracis* (LT), *longissimus lumborum* (LL), and *gluteus medius* (GM). The steaks were weighed individually, placed on Styrofoam trays and wrapped with oxygen-permeable film. All wrapped steaks were then placed in retail display under continuous lighting at 35˚F for 8 days.

A Minolta Chromameter CR-400 (Minolta Camera Company, Osaka, Japan) was utilized for color measurements. Measurements were gathered with an 8 mm diameter measurement area, illuminant D65 and a 2° standard observer. The recorded measurements included L* (psychometric lightness; black = 0, white = 100), a* (red = positive values, green = negative values) and b* (yellow = positive values, blue = negative values). The Minolta was calibrated every day by normal standards with a white calibration plate that came with the machine from the manufacturer. Six random different readings were recorded on each steak daily. Discoloration percentages were estimated daily from a trained panel of five UNL meat science graduate students. Steaks were weighed at the end of display to calculate retail and total purge loss. Discoloration data were analyzed for the time at which a steak reached 40% discoloration, a value at which consumers begin to refuse to purchase

Results

Numerically, steaks from the 14D fresh-never-frozen treatment always had the best color stability (discoloration scores and a* - redness – values). All LL and LT steaks required approximately 4 d to reach 40% discoloration, with all GM steaks having 3 or more days. All frozen treatments for LL and GM steaks were equal or superior in color stability to 21D fresh steaks, except for the CS LL steaks, which discolored more rapidly. In all subprimals, purge loss during thawing was significantly higher for slow thawed subprimals. Fast thawed subprimals were equal or superior to 14D and 21D fresh subprimals in thawing purge; likely a result of thawing to subfreezing temperatures. During retail display, the greatest purge loss occurred in fast thawed treatments. Overall, total purge loss (moisture loss during thawing and retail display) when compared to 14D product was about 5% higher for slow thawed LT and GM and about 1.8% higher for slow thawed LL. These data indicate that frozen-thawed beef subprimals are comparable to fresh-never-frozen subprimals in color stability during days 1-4 of retail display. However, total purge loss was increased for slow thawed subprimals. Freezing rate had minimal effects on retail quality.

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[2]Funded in part by Colorado Premium and the Beef Checkoff.

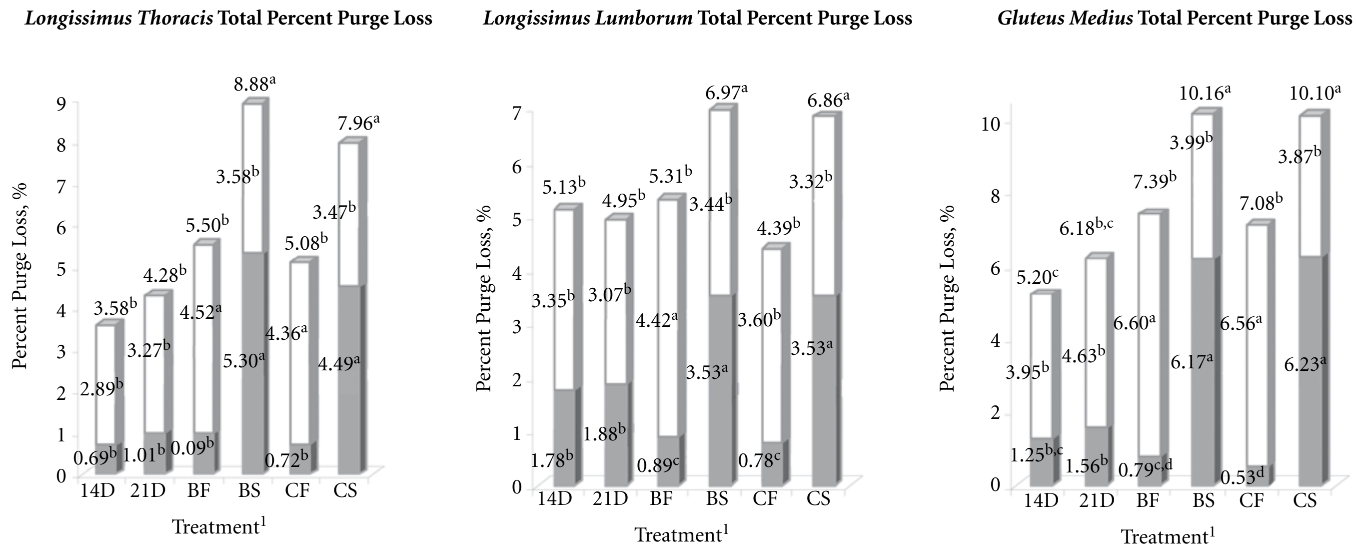
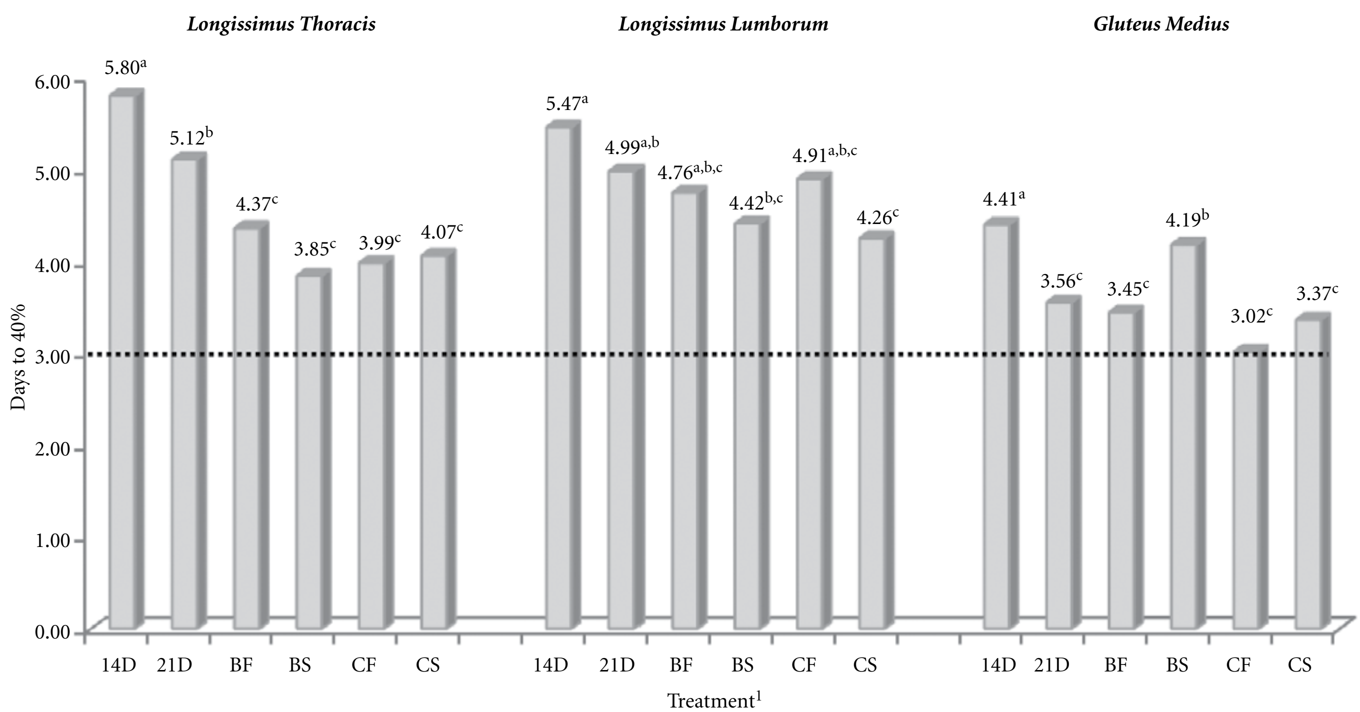


Chart legend: Lower set of numbers = thaw purge. Middle set of numbers = retail purge loss. Upper numbers = total purge loss.

[a, b, c]Signifies different superscripts, meaning values within the same muscle are different for thaw, retail, and total percent purge loss at ($P < 0.05$).

[1]14D = fresh-never-frozen and aged for 14 days; 21D = fresh-never-frozen and aged for 21 days; BF = Blast frozen, fast thaw; BS = Blast frozen, slow thaw; CF = Conventional frozen, fast thaw; CS = Conventional frozen, slow thaw. Blast frozen = boxed meat on pallets in a -18°F freezer with high air velocity. Conventional frozen = boxed meat on pallets in a -18°F freezer with minimal air flow. Fast thaw = immersion in a circulating water bath (<54°F) for 21 hours. Slow thaw = placed on tables at 32°F for two weeks.

Figure 1. Percent purge loss.



[a, b, c]Signifies different superscripts, meaning values within the same muscle are different for days-to-40% discoloration at ($P < 0.05$).

[1]14D = fresh-never-frozen and aged for 14 days; 21D = fresh-never-frozen and aged for 21 days; BF = Blast frozen, fast thaw; BS = Blast frozen, slow thaw; CF = Conventional frozen, fast thaw; CS = Conventional frozen, slow thaw. Blast frozen = boxed meat on pallets in a -18°F freezer with high air velocity. Conventional frozen = boxed meat on pallets in a -18°F freezer with minimal air flow. Fast thaw = immersion in a circulating water bath (<54°F) for 21 hours. Slow thaw = placed on tables at 32°F for two weeks.

Figure 2. Least square means for Days-to-40% discoloration.

Statistics Used in the Nebraska Beef Report and Their Purpose

The purpose of beef cattle and beef product research at UNL is to provide reference information that represents the various populations (cows, calves, heifers, feeders, carcasses, retail products, etc.) of beef production. Obviously, researchers cannot apply treatments to every member of a population; therefore, they must sample the population. The use of statistics allows researchers and readers of the *Nebraska Beef Report* the opportunity to evaluate separation of random (chance) occurrences and real biological effects of a treatment. Following is a brief description of the major statistics used in the beef report. For a more detailed description of the expectations of authors and parameters used in animal science, see *Journal of Animal Science Style and Form* (beginning pp. 339) at *http://jas.fass.org/misc/ifora.shtml*.

- **Mean** — Data for individual experimental units (cows, steers, steaks) exposed to the same treatment are generally averaged and reported in the text, tables and figures. The statistical term representing the average of a group of data points is *mean*.

- **Variability** — The inconsistency among the individual experimental units used to calculate a mean for the item measured is the variance. For example, if the ADG for *all* the steers used to calculate the mean for a treatment is 3.5 lb, then the variance is zero. But, this situation never happens! However, if ADG for individual steers used to calculate the mean for a treatment ranges from 1.0 lb to 5.0 lb, then the variance is large. The variance may be reported as standard deviation (square root of the variance) or as standard error of the mean. The standard error is the standard deviation of the mean as if we had done repeated samplings of data to calculate multiple means for a given treatment. In most cases treatment means and their measure of variability will be expressed as follows: 3.5 ± 0.15. This would be a mean of 3.5 followed by the standard error of the mean of 0.15. A helpful step combining both the mean and the variability from an experiment to conclude whether the treatment results in a real biological effect is to calculate a 95% confidence interval. This interval would be twice the standard error added to and subtracted from the mean. In the example above, this interval is 3.2-3.8 lb. If in an experiment, these intervals calculated for treatments of interest overlap, the experiment does not provide satisfactory evidence to conclude that treatment effects are different.

- ***P* Value** — Probability (*P* Value) refers to the likelihood the observed differences among treatment means are due to chance. For example, if the author reports $P \leq 0.05$ as the significance level for a test of the differences between treatments as they affect ADG, the reader may conclude there is less than a 5% chance the differences observed between the means are a random occurrence and the treatments do not affect ADG. Hence we conclude that, because this probability of chance occurrence is small, there must be difference between the treatments in their effect on ADG. It is generally accepted among researchers when *P* values are less than or equal to 0.05, observed differences are deemed due to important treatment effects. Authors occasionally conclude that an effect is significant, hence real, if *P* values are between 0.05 and 0.10. Further, some authors may include a statement indicating there was a “tendency” or “trend” in the data. Authors often use these statements when *P* values are between 0.10 and 0.15, because they are not confident the differences among treatment means are real treatment effects. With *P* values of 0.10 and 0.15, the chance random sampling caused the observed differences is 1 in 10 and 1 in 6.7, respectively.

- **Linear and Quadratic Contrasts —** Some articles refer to linear (L) and quadratic (Q) responses to treatments. These parameters are used when the research involves increasing amounts of a factor as treatments. Examples are increasing amounts of a ration ingredient (corn, byproduct, or feed additive) or increasing amounts of a nutrient (protein, calcium, or vitamin E). The L and Q contrasts provide information regarding the shape of the response. Linear indicates a straight line response and quadratic indicates a curved response. *P*-values for these contrasts have the same interpretation as described above.

- **Correlation (r) —** Correlation indicates amount of linear relationship of two measurements. The correlation coefficient can range from –1 to 1. Values near zero indicate a weak relationship, values near 1 indicate a strong positive relationship, and a value of –1 indicates a strong negative relationship.

Animal Science

http://animalscience.unl.edu

Curriculum – The curriculum of the Department of Animal Science at the University of Nebraska–Lincoln is designed so that each student can select from a variety of options oriented to specific career goals in professions ranging from animal production to veterinary medicine. Animal Science majors can also easily double major in Grazing Livestock Systems (*http://gls.unl.edu*) or complete the Feedlot Management Internship Program (*http://feedlot.unl.edu/intern*). Another expanding educational experience is the ***Nebraska Beef Industry Scholars Program,*** a unique four year certification program for UNL students.

Careers:

Animal Health
Animal Management
Banking and Finance
Consultant
Education
Marketing
Meat Processing
Meat Safety
Quality Assurance
Research and Development
Technical Service
Veterinary Medicine

Scholarships – Thanks to the generous contributions of our supporters listed below, each year the Animal Science Department offers scholarships to incoming freshmen and transfer students, as well as students at the sophomore, junior, and senior level within the UNL Animal Science Program. For the 2011-2012 academic year, over $33,000 in scholarships were awarded to incoming freshmen and transfer students, and over $58,000 in scholarships were awarded to upperclass UNL Animal Science students.

Elton D. & Carrie R. Aberle Animal Science Scholarship
ABS Global Scholarship
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Maurice E. Boeckenhauer Memorial Scholarship
Robert Boeckenhauer Memorial Scholarship
Frank and Mary Bruning Scholarship
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Derrick Family Scholarship
Doane Scholarship
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Feedlot Management Scholarship
Will Forbes Scholarship
Richard & Joyce Frahm Scholarship
G. H. Francke Livestock Judging Scholarship
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Nebraska Cattlemen Livestock & Meat Judging Team Scholarship
Nebraska Cattlemen NCTA Transfer Scholarship
Nebraska Cattlemen New Student Scholarship
Nutrition Service Associates Scholarship
Oxbow Pet Products Scholarship
Parr Family Student Support Fund
Parr Young Senior Merit Block and Bridle Award
Eric Peterson Memorial Award
Art & Ruth Raun Scholarship
Chris and Sarah Raun Memorial Scholarship
Walter A. and Alice V. Rockwell Scholarship
Frank & Shirley Sibert Scholarship
Sirius Nutrition LLC Scholarship
Philip Starck Scholarship
Max and Ora Mae Stark Scholarship
D.V. and Ernestine Stephens Memorial Scholarship
Dwight F. Stephens Scholarship
Arthur W. and Viola Thompson Scholarship
Richard C. and Larayne F. Wahlstrom Scholarship
Thomas H. Wake, III Scholarship
R.B. & Doris Warren Scholarship
Memorial Winkler Livestock Judging Scholarship
Wolf Scholarship