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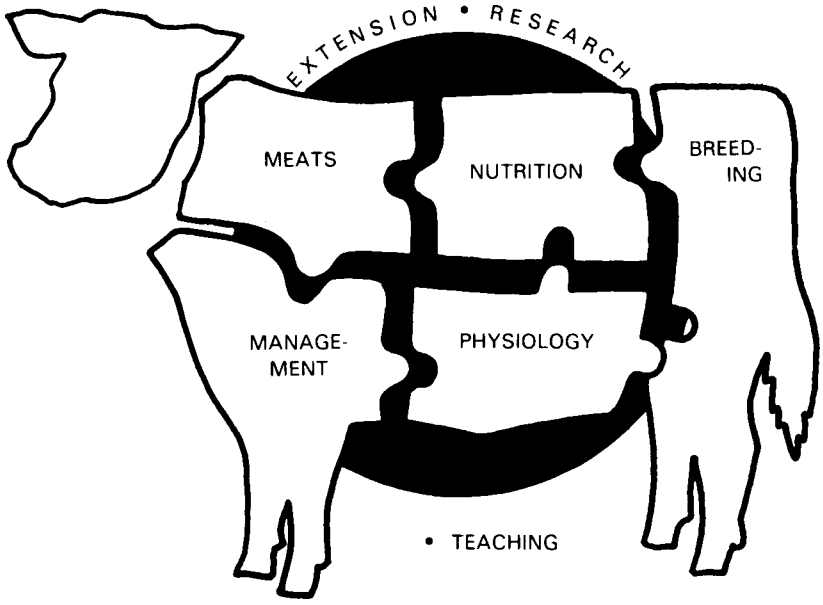
2002 Beef Cattle Report

NEBRASKA



MP 79-A

2002 Beef Cattle Report

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Weaning Date for Spring Calving Cows Grazing Sandhills Range

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When weaning is timed with the decline in forage quality, cow body weight, condition and calf performance can be maintained.

Summary

A two-year experiment was conducted with March calving cows to determine the effect of the weaning date on cow body condition score, cow body weight, and calf body weight. Treatments were of eight weaning dates imposed at consecutive two-week intervals, beginning in mid-August and ending in late November. Cow body condition score declined linearly as weaning date was later in the fall. Calf body weight gains from August through November increased with weaning dates from August 18 through October 13; however, weaning after October 13 provided no advantage of increased calf body weight gain.

Introduction

Weaning date is a tool to help beef producers obtain specific production and economic goals. Body condition score of the cow at spring calving in systems that extend grazing through the winter can be greatly influenced by weaning date. Producers may use weaning date to manage cow body condition.

Weaning has nutritional impacts on both the cow and the calf. Cows with suckling calves have greater nutritional requirements than dry cows. Nonlactating pregnant spring calving cows generally maintain body condition score on fall range as long as forage supply is adequate. In contrast, a lactating cow's requirements may not be met by dormant range forage during fall months. When a lactating cow's nutrient requirements are not met, cows will use body stores for milk production. Use of body stores results in a decline of body condition score and may affect subsequent reproductive performance.

Previous research with spring calving cows shows cows become thinner as weaning is moved later into the fall when forage quality is declining. The objective of this experiment was to evaluate effects of weaning date of March calving cows during the fall from 140 to 240 days after the beginning of calving on cow body weight, cow body condition score, and calf body weight gain.

Procedure

A two-year experiment was conducted at the Gudmundsen Sandhills Laboratory located near Whitman, Neb., using MARC II mature spring calving cows in 1999 (year 1; n=97) and 2000 (year 2; n=104). Cows were blocked by age and randomly assigned to one of eight weaning dates. In year one, weaning began August 18 and continued at two week intervals through November 24. In year two, cows were re-randomized and calves were weaned every two weeks beginning August 16 through November 22.

At weaning, calves were fed hay in a dry lot for five days and then grazed subirrigated meadow to the end of the trial in November. Cow/calf pairs were managed as a single group and grazed native sandhills range until weaning. After each weaning date, cows were rejoined with cow-calf pairs and grazed as a single group until the last group of calves was weaned.

Major grass species for native sandhills range include little bluestem (Schizachyrium scoparium [Michx.] Nash), prairie sandreed (Calamovilfa longifolia [Hook] Scribn.), sand bluestem (Andropogon gerardii var. paucipilus [Nash] Fern.), switchgrass (Panicum virgatum L.), sand lovegrass (Eragrostic trichodes [Nutt.] Wood), scribner panicum (Dichanthelium oligosanthes [Schult.] Gould), and grasslike plants (Carex spp. and Cyperus spp.). Common forbs included western ragweed (Ambrosia psilostachya DC.), cutleaf ironplant (Haplopappus spinulosus [Pursh] DC.), and prairie clover (Petalostemum purpureumn Vent.), and shrubs include leadplant (Amorpha canescens Pursh) and small soapweed (Yucca glauca Nutt.).

Individual cow body weight, cow body condition score (scale 1-9), and body weight of calves were taken at the first weaning date in August and at the last weaning date in November. Data were analyzed using the MIXED procedures of SAS. Calf sex was included in the model.

Results

No year x treatment interactions ($P>0.05$) occurred. Cow body condition score, cow body weight, and calf body weights were similar ($P>0.05$) among all weaning dates at the first weaning date in August.

Cow body condition score, cow body weight, change in cow body condition

(Continued on next page)

score, and change in cow body weight declined linearly (Table 1; P<0.05) from the first weaning date in August to the last weaning date in November. Cow body condition scores in November ranged from 5.9 for the initial weaning date in August to 5.0 for the final weaning date group in November. Cow body weight in November decreased from 1,243 lb for the initial weaning date in August to 1,144 lb for the last weaning date in November.

Average calf age for all groups at the first weaning date was 139± 3 days. Calf body weights at the last weaning date in November increased quadratically (Table 1; P<0.05) with the lowest body weight occurring for the initial weaning date (440 lb) and the highest for the November 10 weaning (535 lb). Calf body weight gain responded to weaning date in a quadratic fashion (Table 1; P<0.05). Calves weaned later in the fall had greater gains; however, the amount of gain diminished as weaning dates advanced from October through November. Declining cow body condition score and a diminishing return in calf body weight gain showed little biological advantage to weaning after October 13, 1999 or October 11, 2000.

Table 1. Mean ending and change in (August through November) cow body condition score, cow body weight, calf body weight and calf gains across weaning dates.

	Weaning Dates[a]								
	Aug 18	Sep 1	Sep 15	Sep 29	Oct 13	Oct 27	Nov 10	Nov 24	SE
BCS									
End[b]	5.9	5.7	5.6	5.5	5.4	5.3	5.3	5.0	.09
Change[b]	.36	.26	.20	.15	.05	-.04	-.11	-.35	.16
Weight, lb									
End[b]	1243	1225	1236	1218	1203	1159	1183	1144	27.00
Change[b]	53.7	38.5	37.5	1.06	3.35	-21.1	.013	-39.5	55.9
Calf Weight, lb									
End[c]	440	477	485	508	518	502	535	524	13.3
Gain[c]	80.0	102.6	115.9	127.2	133.7	134.4	145.8	147.6	13.7

[a]Weaning dates for year 2 started August 16 and ended November 22.
[b]Linear effect across weaning dates (P<0.05).
[c]Quadratic effect across weaning dates (P<0.05).

In summary, cow body condition score and cow body weight decreased linearly as weaning date was delayed to later in the fall, and calf weights increased quadratically with similar performance of calves weaned after October 13. Weaning calves after October 13 seems to show minimal advantage in calf performance while cow body condition score would decrease. Weaning earlier than October 13 and removing the calf from the low quality forage during fall grazing reduces the nutrient requirements of the cow and allows cow body condition score to increase.

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Replacement Heifer Development for Spring and Summer Calving Herds

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Rex Davis[1]

Rate of winter gain before first breeding did not affect reproduction and calf production of spring-born heifers. Summer-born heifers had normal yearling pregnancy rates, but 2-year-old rebreeding rates were low.

Summary

A three-year study on heifer development of spring-born (n=240) and summer-born heifers (n=146) was conducted using sandhills ranch management. Spring-born heifers developed during the winter to reach 53% of mature weight at breeding had similar reproduction and calf production as heifers that reached 57% of mature weight. Feed costs were $22/heifer less for the lighter weight heifers. Summer-born heifers that were developed to reach 60% of mature weight at breeding in early fall had normal yearling pregnancy rates, but rebreeding rates of the 2-year-old cows were low, which caused high culling rates. Two-year-old cows calving in May produced greater calf growth rates to weaning than cows calving in June.

Introduction

Proper development of replacement heifers is critical. Heifers should be managed to reach puberty early, conceive early in the first breeding season,

calve unassisted, and breed back early for their second calf. However, this development needs to be accomplished at low costs without sacrificing performance.

Summer calving has gained interest in Nebraska and heifer development programs are needed for these cow herds. How should heifer calves be managed so they will conceive early as yearlings and rebreed for a second calf? Should heifers be bred several weeks before the cow herd?

The objectives of this study were: (1) To compare development of spring-born heifers at two prebreeding target weights (55% or 60% of mature weight) on reproduction and productivity, and (2) To develop summer-born heifers to similar target weights, then compare two dates of breeding (30 days before cows or same date as cows) on reproduction and subsequent productivity.

Table 1. Winter feed rations and costs for spring and summer heifers over three years.

Item	Spring heifers[a]		Summer heifers (Breeding Group)[a]	
	Low	High	August	September
Rations (as fed)				
Meadow hay, lb	13.3	12.3	12.3	11.8
Midd pellets[b], lb	3.6	4.5	3.6	3.3
Corn, lb	0.5	2.4	1.3	0.4
Feeding period, days	155	155	118	118
Avg daily gain, lb	1.1	1.4	1.5	1.2
Costs[c]				
Feed costs per hd per day, $	.55	.69	.56	.47
Feed costs for feeding period, $	85	107	66	55

[a]Feeding periods were mid-December to mid-May for spring and mid-January to mid-May for summer heifers.
[b]Pellet composition: 48% wheat midds, 40% soybean hulls, 5% cottonseed meal, 5% cane molasses plus vitamin-mineral mix, urea and 80g/ton Rumensin.
[c]Average prices were: hay $40/ton; supplements $135/ton; cracked/delivered corn $2.75/bu.

Procedure

A three-year study was initiated using heifer calves selected from the MARC II cow herds at the Gudmundsen Sandhills Laboratory near Whitman, Neb. In 1998, 1999 and 2000, approximately 80 spring-born heifers and 50 summer-born heifers were selected each year as replacements for the spring (March and April calving) and summer (June and July calving) cow herds. The genetic profile of the cows was similar in each herd and the same bulls were used in both herds each year.

The heifers were randomly allotted within age and weight to the treatment groups in mid-December for the spring heifers and in mid-January for the summer heifers. The spring heifers were assigned to one of two treatments, low-gain or high-gain, to reach prebreeding target weights of 660 lb (55% of mature wt) or 720 lb (60% of mature wt), respectively by May 15.

The summer heifers were assigned to either an August or September breeding group. These heifers were developed so both groups would reach a similar target weight of about 720 lb or 60% of mature weight by beginning of breeding season. This weight would be similar to the higher gain Spring heifers. One group of summer heifers was exposed to bulls beginning August 5 (30 days before the cow herd) and a second group of heifers was placed with bulls beginning September 5 (same date as mature cows).

Each year heifers were placed in dry-lot pens by treatment groups for the winter feeding phase. They were fed meadow hay plus a wheat middlings and soybean hull-based pellet and cracked corn in balanced rations to achieve the desired gains and target weights. Hay (9%-10% CP) was fed ad libitum in bale feeders. Pellets (20% CP) with Rumensin (80g/ton) and a vitamin-mineral mix were fed in bunks with cracked corn as needed. Heifers were weighed monthly and rations were adjusted to obtain desired gains. Table 1 shows the feed rations for each group and the feed costs for the winter feeding phase over three years. For the spring heifers, the cost of feed for the high-gain group was $22/hd higher than for the low-gain group ($107 vs $85). For the summer heifers, the feed cost was $11/hd higher for the August group than the September group ($66 vs $55).

After the feeding phase each year, all heifers were weighed and body condition scored on May 15 and moved to native range for summer grazing. Before the breeding season began for each group, heifers were blood sampled twice (10 days apart) to determine puberty (cycling) status and were pelvic measured. Four Angus bulls were placed with the spring heifers on May 20 for a 45-day breeding season. The same bulls were used on the summer heifers for 45 days; but half of the heifers began the breeding season on August 5 and the other half on September 5. About 60 days after the end of each breeding season, heifers were examined for pregnancy, and were weighed and condition scored.

The bred heifers grazed subirrigated meadow after-growth during the fall and in the winter were fed meadow hay and supplement (1.5 lb/day, 40% CP) on range. Calving began about March 1 for the spring heifers, May 15 for the August-bred heifers, and June 15 for the September-bred heifers. Calving records were recorded on all heifers and calving assistance given as needed. After calving, spring heifers were fed good quality meadow hay plus supplement (1.5 lb, 40% CP). Summer heifers received the same ration until May 15, when all heifers were moved to summer range. Summer heifers calved on summer range.

The spring 2-year-old cows were exposed to MARC II bulls on June 5 each year for rebreeding, while all summer 2-year-old cows were placed with these same bulls on September 5. The summer cows were fed 1.0 lb/day of 48% CP cubes during the breeding season in 1999, and in 2000 the cows were fed these cubes 45 days before and during the breeding season. Calves from spring 2-year-old cows were weaned in early September, and calves from summer cows were weaned in late November. All bred 3-year-old cows were placed

(Continued on next page)

with the mature cow herds and fed and managed with them thereafter. Data were analyzed using least squares analyses of SAS and chi-square analyses.

Results

Spring Heifers

The feed ration for the high-gain spring heifers (Table 1) included 7 lb of corn and pellets, while the low-gain heifers received a total of only 4 lb. This supplement for the high-gain group caused a 0.3 lb/day increase in ADG (1.4 vs 1.1) and cost $22/hd more during the 155-day wintering period.

Table 2 shows the heifer weights and breeding results on the spring heifers over three years. In mid-December the heifers weighed 469 lb. At prebreeding in mid-May, the high-gain heifers weighed 51 lb more (P<0.05) than the low-gain group and had 0.4 unit higher (P<0.05) condition score. The high group heifers at prebreeding were at 57% of mature wt and the low group heifers were at 53% of mature weight. In both groups, heifers did not reach projected target weights. The percentage of heifers cycling before breeding was 11% higher (P<0.05) for the high-gain over the low-gain heifers (85 vs 74%). The 45-day pregnancy rate was 4% higher (P>0.20) for the low-gain heifers (92 vs 88%) than the high-gain heifers. This was unexpected and may have been due to the low-gain heifers gaining more rapidly on lush spring grass during the breeding season. At pregnancy check, the high-gain heifers averaged 25 lb more (P<0.05) than the low-gain heifers.

Table 3 shows the calving, weaning and reproduction results of the spring 2-year-old cows over two years. The third year data are unavailable at this writing. The high group cows were heavier (P<0.05) at calving and at weaning times. Average calf birth date, calf birth weight, calving difficulty, and calf losses were similar for both groups. Calf ADG to weaning also was similar for both groups of cows indicating milk production was similar. The 205-day adjusted calf weaning weights were nearly identical for both groups.

Table 2. Heifer development and breeding results for spring and summer heifers over three years.

	Spring		Summer (breeding)	
Trait	Low	High	August	Sept.
No. of heifers	120	120	73	73
Beginning wt.[a], lb	469	469	402	403
May 15 wt., lb	638[b]	689[c]	580[b]	549[c]
May body condition	5.6[b]	6.0[c]	5.5[b]	5.3[c]
May target wt., lb	660	720	590	560
Winter ADG, lb/day	1.1[b]	1.4[c]	1.5[b]	1.2[c]
Prebreeding wt., lb	638[b]	689[c]	703[b]	727[c]
Prebreeding body condition	5.6[b]	6.0[c]	5.5	5.4
Pelvic Area, cm^2	174	171	175[b]	181[c]
Cycling before breeding, %	74[b]	85[c]	89	92
Began breeding season	May 20	May 20	Aug 5	Sept 5
Pregnant in 45 days, %	92	88	88	93
Pregnant check wt, lb	827[b]	852[c]	785	778
Pregnant body condition	5.6[b]	5.8[c]	5.4[b]	5.3[c]

[a]Heifer development began in mid-December for spring and in mid-January for summer heifers each year.
[bc]Treatment means in row within season differ (P<0.05).

Table 3. Calf production and rebreeding of 2-year-old cows over two years.

	Spring		Summer (breeding)	
Trait	Low	High	August	Sept.
Calving season began	Mar. 1	Mar. 1	May 15	June 15
No. of heifers calving	71	67	43	47
Precalving wt., lb.	914[d]	945[e]	898	898
Precalving body condition	5.3	5.3	5.3	5.3
Calf birth date, day	Mar. 13	Mar. 12	May 23[d]	June 20[e]
Calf birth weight,[a] lb.	72	74	72	73
Calving difficulty, %	13	21	14[d]	2[e]
Calf losses-calving to weaning (No.)	2	2	1	1
Weaning date, day	---------Sept. 6---------		---------Nov. 27---------	
Calf age at weaning, days	177	178	187[d]	159[e]
Actual calf weaning wt.[a], lb.	402	403	388[d]	324[e]
Calf ADG[a], lb/day	1.87	1.85	1.69[d]	1.59[e]
205d adjusted calf weaning wt.[a], lb	455	453	418[d]	398[e]
Cow wt. at weaning, lb	900[d]	928[e]	916	911
Cow body condition	5.1[d]	5.3[e]	5.0	5.0
Cows pregnant with 2nd calf, %	90	91	79	75
Cow productivity[b], lb	387	368	357	350
Cows in herd at 3-years of age[c], %	77	73	63	67

[a]Calf weights adjusted for sex
[b]Productivity = number of calves weaned x adjusted weaning wt. divided by number of heifers developed.
[c]Number of cows remaining in herd to have second calf as 3-year-olds divided by number of heifers developed.
[de]Treatment means in row within season differ (P<0.05).

Percentage of cows rebreeding for their second calf was similar for both groups (91% vs 90%). Cow total productivity was slightly higher for the low-gain group. At second calving, calving date, calf birth weight and calving difficulty were similar for the two groups. If these results continue for the third year, they would indicate developing heifer calves to be 60% of mature weight at first breeding is not necessary, under similar management, and may be too costly. An economic analysis will be completed in the future.

Summer Heifers

Feed rations for the August heifers (Table 1) included 5 lb of supplement while the September heifers received only 4 lb because they had 30 days longer to gain the target weight before breeding began. August heifers gained 0.3 lb/day faster than the September heifers, but feed cost was $11/hd more.

Heifers averaged 403 lb in mid-January (Table 2). By mid-May, the August heifers weighed 580 lb while September heifers weighed 549 lb. At breeding, the August heifers weighed

703 lb while the September heifers weighed 727 lb ($P<0.05$). These weights were about 60% of mature weight. The percentage of heifers cycling before breeding was similar for both groups.

The 45-day yearling pregnancy rate was 5% higher ($P>0.20$) for the September heifers (93% vs 88%) over the August heifers. September heifers were 30 days older at breeding than the August heifers. At pregnancy check time, heifer weights were similar.

In Table 3, the 2-year-old cows in both groups had similar weights at calving and at weaning times. Calf birth weights were similar for the two groups, but calving difficulty percentage was higher for the cows calving in May (14%) than those calving in June (2%). The prebreeding pelvic area (Table 2) was slightly larger ($6cm^2$) for the June calving cows, which may have had some influence on calving difficulty. However, when comparing calving difficulty between the various groups (March vs May vs June calving), cows calving late in the spring or summer had fewer problems. This difference was not due to smaller calf birth weights. The factors influencing less calving difficulty may have included warmer temperatures, less heifer stresses, more pelvic relaxation, better nutrition on green grass and more heifer exercise.

Calf ADG to weaning was greater for the calves on the May calving cows. Actual calf weaning weights were 64 lb heavier ($P<0.05$) from the May calving cows, but the 205-day adjusted weights were 20 lb different ($P<0.05$) between groups.

Cow pregnancy rates for the second calf were low for both groups (May = 79%, June = 75%). This was probably due to the mature grass and lower nutrition during the September and October breeding season for these 2-year-old cows on range. However, cows were supplemented with 1.0 lb/day of 48% CP cake during the breeding season. Also, the summer cows were smaller (about 900 lb) at calving which may have influenced rebreeding rates.

Another year of data on calf production of the spring and summer 2-yr-old cows is being collected. However, the results at this writing indicate the following. Spring heifers developed during the winter at a low gain (1.1 ADG) to reach 53% of mature weight prebreeding, had similar reproduction and calf production as higher gain heifers (1.4 ADG) that reached 57% of mature weight.

Summer heifers bred to calve 30 days before the mature cows had slightly lower yearling pregnancy rates, but slightly higher 2-year-old pregnancy rates than heifers bred to calve at the same time as the cows. May calving heifers had heavier 205-day calf weaning weights compared to June calving heifers. Summer-born calves had similar birth weights to spring-born calves, but less calving difficulty was experienced with June calving.

Pregnancy rates of summer heifers were satisfactory at yearling breeding, but unsatisfactory at 2-year-old rebreeding. Only 54% of the summer heifers were still in the herd at 4 years of age. Growth rates of summer-born calves appear to be lower than spring-born calves.

---

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Urinary Allantoin as an Estimate of Microbial Protein Synthesis

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Urinary allantoin is a measure of bacterial protein production and has potential to be used in production settings.

Summary

Allantoin excretion in the urine was evaluated as a marker for bacterial protein production in lactating and dry cows grazing Sandhills range and meadows. Allantoin excretion declined with season as diet digestibility declined. Bacterial protein predicted from allantoin was significantly related ($R^2 = .62$) to bacterial protein predicted by NRC. Urinary allantoin has potential as a tool to predict bacterial protein production in grazing cattle.

Introduction

Supplementing forages with a protein source is a common practice used among cow/calf producers to improve the digestibility and intake of the forage. To be profitable, the supplement must provide the right type and adequate amount of protein. Metabolizable protein (MP) is the protein absorbed by the intestine and used by the host animal and is the sum of the digestible true bacterial protein produced in the rumen (BCP) and the digestible rumen undegradable intake protein (UIP) from the feedstuffs. There is little UIP in forages and therefore, BCP production is the primary source of MP; furthermore, most beef cows are fed forage diets of varying quality so it is important to have accurate estimates of BCP production.

Allantoin, an end product of purine metabolism excreted in urine, has been shown to be an effective indicator of BCP synthesis (*2001 Nebraska Beef Cattle Report,* pp. 115-116; *2002 Nebraska Beef Cattle Report,* pp. 66-68). The determination of allantoin in

(Continued on next page)

Table 1. Allantoin excretion, diets and BCP estimates for cows grazing Sandhills range or subirrigated meadows.

	May		June		July		August		September		December
Item	M[a]	R[a]	M	R	M	R	M	R	M	R	R
BW, lb	889	905	971	1005	1046	1064	1054	1080	1080	1093	1097
IVDMD	70.2	67.7	67.3	63.6	59.0	61.8	57.2	55.8	50.4	52.5	52.4
DMI, lb[b]	23.3	23.0	24.9	24.8	24.2	25.0	23.6	23.9	23.7	23.4	22.4
A:C[c]	3.87	3.23	4.00	3.20	4.03	3.56	1.80	1.67	1.88	1.63	1.07
Allantoin, g/d	41.5	34.9	47.1	38.8	49.4	46.0	19.4	21.7	23.9	20.5	14.5
BCP[de], g/d	889	745	1014	834	1085	989	496	467	524	459	308
BCP[f], g/d	964	922	994	895	713	820	644	597	434	490	463

[a]M = meadow, R = range.
[b]Predicted dry matter intake from NRC
[c]Allantoin:Creatinine ratio.
[d]Bacterial CP production estimated from allantoin.
[e]Standard error = 21.6; Meadow vs Range (P < 0.01); period effect (P <0.01).
[f]Bacterial CP production estimated from NRC, 1996.

urine has the advantage of being a noninvasive method which can be applied to a larger number of animals and under practical feeding conditions, in contrast to the use of cannulated animals. Therefore, the objectives of this study were to 1) determine the BCP production in forage fed beef cows by using allantoin excretion as a marker, and 2) to compare our results with NRC estimates.

Procedure

Sixteen March-calving cows (primiparous) were randomly assigned to either upland native range or subirrigated meadow at the Gudmunsen Sandhills Laboratory near Whitman, Neb. Cows were allowed to graze their respective pastures for two weeks, the first week for adaptation and the second week for collection, from May to September. Collections were made in May, June, July, August, September, and December. In December, cows were assigned only to the rangeland treatment. Approximately 50 ml of urine were taken as a spot sample from each cow for five days during the second week of each period. Samples were frozen and aliquots were analyzed for allantoin and creatinine. Urinary creatinine excretion is used as a marker of total urine excretion, and it has been suggested that the ratio of allantoin to creatinine in spot urine samples can be used to determine the amount of microbial protein supply. Creatinine is excreted in the urine at the rate of .14 mmole/kg BW. Individual body weights were taken in each collection period.

Esophageally-fistulated cows were used to obtain diet samples from range and meadow during each sampling period. Diet samples were freeze dried and analyzed for IVDMD.

The NRC (1996) model was used to predict BCP production and dry matter intakes (DMI). Actual measured body weights and measured IVDMD values were used as inputs.

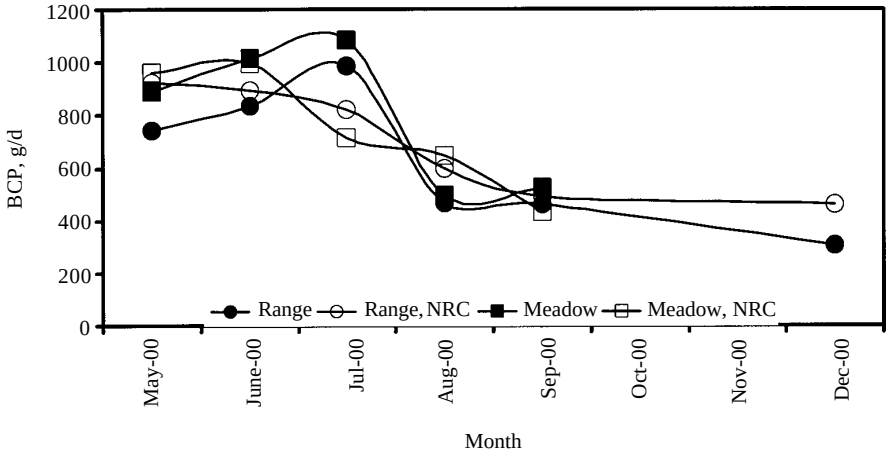

Figure 1. BCP predicted from allantoin or NRC.

Results

Cow weights increased from 900 lb in May to 1100 lb in September and December (Table 1). Range IVDMD decreased from 70% in May to 52% in September and December, Meadow IVDMD values tended to be higher than range values, especially early in the season. The allantoin to creatinine ratio, and therefore, the amount of allantoin decreased from May, June, and July to August, September, and December.

Bacterial CP was predicted by two methods — from allantoin excretion and by using the NRC model. The BCP values (Table 1) decreased with advancing season (Figure 1) and were related to the diet digestibility. Diet digestibility, DMI, and microbial efficiency are the primary factors that determine BCP production. The NRC model estimates the requirements for DIP by multiplying total digestible nutrients (TDN) intake by microbial efficiency. Microbial efficiency, the amount of microbial protein produced from TDN, is in general assumed to be 13%. However, at low TDN levels, which occurs in the case of low-quality forages, a decrease in microbial efficiency is likely to occur due to a slower rate of passage. Slower rates of passage lead to more energy used for microbial maintenance. Therefore, we estimated, in the NRC model, that microbial efficiency declined from 13% in May to 8% in December. The BCP predicted by allantoin excretion was well related to the BCP predicted by the NRC model (Figure 2; R^2 = .62).

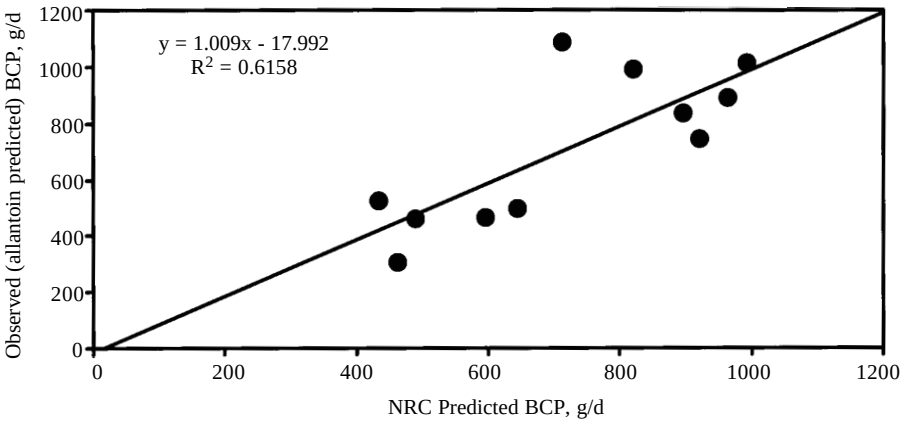

Figure 2. BCP predicted by NRC versus BCP predicted from allantoin excretion in urine.

It is very important to predict BCP production in grazing cows because the BCP supplies most of the MP to the cow. The NRC model may predict BCP production quite well, but that has not been well validated. The use of allantoin as a predictor of BCP production is interesting because it is noninvasive and the cows graze and produce normally. Urine is readily collected once daily. In general, there was good agreement between BCP predicted from allantoin and NRC (R^2 = .62). Where there was not good agreement, for example July meadow, either of the predictions could be incorrect. The NRC prediction is generalized over the days of the month and metabolic functions of the cow during that period; on the other hand, allantoin represents five specific days and the specific intake and functions of the cows on those days.

Specific examples where differences could have occurred follow. In May, the digestibility of range was high but forage availability may have limited intake and therefore the NRC intake would be over predicted. July is a transition period when digestibility of the diet is decreasing. Accurate estimates of the diet are critical. We used 11% microbial efficiency in the NRC model and that may be too low. The DIP content of the grasses in August, September, and December may have limited BCP production as estimated by allantoin but the NRC model does not account for DIP deficiency.

It was concluded that urinary allantoin has potential to be a useful tool to estimate BCP production in grazing cattle. We believe this will allow us the opportunity to further refine the MP system and allow more accurate supplementation schemes.

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Metabolizable Protein Requirements of Lactating Two-Year-Old Cows

Trey Patterson
Don Adams
Terry Klopfenstein
Amelia Hopkin[1]

Lactating two-year-old cows consuming meadow hay were deficient in metabolizable protein. Supplementation with undegradable intake protein alleviated the deficiency and improved postpartum weight gain.

Summary

Eighteen lactating two-year-old cows maintained on meadow hay were used to determine the effects of supplementation to meet metabolizable protein or degradable intake protein requirements on production traits during the first two months after calving. Cows supplemented to meet metabolizable protein requirements had a higher ADG than degradable protein supplemented cows. Milk production declined from 15.9 to 10.8 lb/day at 26 to 69 days after calving, respectively. Hay intake averaged 2.4% of body weight. Supplementation to meet metabolizable protein requirements increased postpartum weight change, but did not affect intake or milk production.

Introduction

Lactating two-year-old cows have a high requirement for metabolizable protein (MP), protein absorbed into the body, relative to nonlactating cows. The protein in meadow hay harvested in the Nebraska Sandhills is predominately rumen degradable intake protein (DIP). Conventional supplementation strategies typically supply DIP as the predominant source of protein. Meeting the DIP requirements of young cows is important, but supplemental undegradable intake protein (UIP), protein that escapes rumen degradation, may be necessary to meet MP requirements of two-year-old lactating cows consuming meadow hay in the Sandhills. In Montana, supplementing UIP to young, lactating cows improved weight gain and percentage of cows bred early in the breeding season. We hypothesized that meeting NRC (1996) requirements for MP would positively affect production traits in lactating two-year-old cows in the Sandhills.

(Continued on next page)

The objectives of this study were to determine the effects of supplementing UIP (to meet MP requirements) to two-year-old lactating cows consuming meadow hay on performance, intake, and milk production.

Procedure

The experiment was conducted at the University of Nebraska's Gudmundsen Sandhills Laboratory near Whitman, Neb. in spring of 1999. Eighteen two-year-old cows (average calving date March 23) were maintained in a large dry lot and allowed ad-libitum access to late-June harvested meadow hay (8.6% CP, 1.8% UIP, 80% NDF (OM basis), and 54% in vitro organic matter digestibility). On April 5, 1999, cows that were at least seven days postpartum (n = 13) were blocked by previous winter treatment (*2001 Nebraska Beef Report*, p. 19), stratified by weight and body condition score (BCS), and randomly assigned to one of two supplemental treatments. Treatments were: 1) supplementation to meet metabolizable protein requirements (MP**),** and 2) supplementation to meet DIP requirements (DIP). Cows and their calves were weighed both on April 5 and 6 without deprivation from food or water, and a BCS was assigned to each cow by two technicians on each day. At seven-day intervals, cows that were not allotted to treatments on April 5, but were at least seven days postpartum were assigned alternately to one of the two supplemental treatments. Cows and their calves were weighed and cows were assigned a BCS on two consecutive days when allotted to treatments. The five cows that were not allotted to treatments on April 5 eventually calved, with one additional cow allotted on April 12 and the final four cows allotted on April 19. Cows and calves were weighed off-test (without deprivation from feed or water) and cows assigned a BCS on May 27 and 28, 1999.

Both supplements were formulated to meet DIP requirements, and the MP had additional UIP to balance metabolizable requirements (Table 1). Requirements were generated using the NRC (1996) Model assuming a peak milk production of 12 lb, forage DM intake of 2.5% of BW, and diet microbial yield of 10.5% of total digestible nutrient intake. The NRC (1996) reports that microbial yield decreases with low-quality forages because of slow passage rates. In the *1998 Beef Cattle Report* (p. 7) it was proposed that values of 9% to 10% be used for low-quality forages plus one percentage unit after calving. We therefore used 10.5%. The MP supplement was 61% CP and 31% UIP (DM basis) and the DIP supplement was 32% CP and 2% UIP. The MP was fed at the rate of 1.2 lb/day (169 g of UIP/day) and the DIP supplement was fed at 1.3 lb/day (12 g of UIP/day). Supplements were pelleted and fed individually three times weekly from April 7 to April 24, 1999. Any refused supplement was weighed and the amount recorded.

Table 1. Composition of supplements fed to lactating 2-year-old cows consuming meadow hay (DM basis)[a].

Ingredient	MP[b]	DIP[c]
Soybean meal	55.0	—
Feather meal	38.4	—
Soybean hulls	6.6	91.9
Urea	—	6.9

[a]Supplements fed thee times weekly from 15 to 64 day post-parturition, on average. Meadow hay was 9.5% CP, 80% NDF (OM basis).
[b]Formulated to meet metabolizable protein requirement.
[c]Formulated to meet the degradable intake protein requirement

Twelve-hour milk production was determined by the weigh-suckle weigh method on April 21 and May 18. Twenty-four-hour milk production was estimated by multiplying 12-hour milk production by two. Intake measurements were taken in a six-day period beginning May 3. Time release chromium boluses were used to determine fecal output in each animal, and predictions were validated with four steers using total fecal collection.

Beginning April 12, cows were bled once weekly via jugular venipuncture. Plasma was harvested by centrifugation and stored in plastic screw-cap vials for subsequent determination of progesterone concentration. Animals were considered to be exhibiting normal estrous activity when plasma progesterone was greater than 1 ng/ml.

Data were analyzed in an unbalanced block design using the GLM procedure of SAS. Calving date was tested as a covariate for all variables. Calving date was only significant as a covariate for cow ADG, calf on weight, and calf off weight. All other variables were analyzed by analysis of variance.

Results

The average calving date was similar for the MP and DIP treatments (Table 2; March 23 and March 22, respectively). Cows on the MP treatment had a higher ADG (P =0.02) than cows on the DIP treatment (0.90 versus 0.31 lb/day for MP and DIP, respectively). There were no differences in cow BCS change ($P = 0.21$), but cows on the MP had positive BCS change compared to the negative change of cows in the DIP treatment. Calf gain was not affected by treatment.

Cow weights at the start of the intake period (May 3), which were estimated from initial weight and ADG for each animal, were the same (Table 3; 853$\pm$ 18 lb). There were no effects ($P = 0.53$) of treatment on hay intake. Hay OM intake averaged 20.3 lb and 2.4% of body weight.

Twenty-four-hour milk production did not differ ($P = 0.97$) between treatments in April or May (Table 4). Milk production declined ($P = 0.0005$) from an average 15.9 lb/day in April to 10.8 lb/day in May. Peak milk production occurred sooner than the predicted 8.5 wk postpartum time period (NRC, 1996). Milk production is important in young cows because it affects nutrient status and the ability of a young cow to return to estrous after calving. Previous research has demonstrated supplemental UIP to both increase and decrease milk production. The UIP levels supplemented in this study did not affect milk production.

The nutrient balance of both treatments in April and May are shown in Table 4. Cows on the DIP treatment did not consume all of the supplement offered. On average, the DIP cows consumed 1.0 of the offered 1.3 lb of supplement per day, with a range of 0.8 to 1.1 lb/day across all cows in that

Table 2. Performance of 2-year-old lactating cows (Exp. 3) consuming meadow hay and supplemented to meet metabolizable protein requirements (MP) or degradable intake protein requirements (DIP)[a].

Item	MP	DIP	SEM[b]
Calving date	March 23	March 22	—
Cow start BW, lb	831	842	20
Cow end BW, lb	875	860	15
Cow ADG, lb[c]	0.90	0.31	0.15
Cow start BCS	4.6	4.8	0.1
Cow end BCS	4.8	4.7	0.1
Average daily BCS change	0.004	-0.001	0.003
Calf start BW, lb	103	101	4
Calf end BW, lb	170	165	4
Calf ADG, lb	1.37	1.30	0.07

[a]Supplements fed thee times weekly from 15 to 64 day post-parturition, on average. Meadow hay was 9.5% CP, 80% NDF (OM basis).
[b]n = 18.
[c]Treatments differ, $P = 0.02$.

Table 3. Organic matter intake of 2-year-old lactating cows (Exp. 3) consuming meadow hay and supplemented to meet metabolizable protein requirements (MP) or degradable intake protein requirements (DIP)[a].

Item	MP[b]	DIP[c]
BW, lb[d]	853 ± 18	853 ± 18
Hay intake, lb	19.4 ± 1.8	20.9 ± 1.5
Hay intake, % of BW	2.3 ± 0.2	2.5 ± 0.2

[a]Supplements fed three times weekly from 15 to 64 day post-parturition, on average. Meadow hay was 9.5% CP, 80% NDF (OM basis).
[b]n = 6.
[c]n = 8.
[d]Body weight at start of intake (May 3, 1999) estimated by on trial BW and ADG.

Table 4. Milk production and estimated nutrient balance of lactating 2-yr-old cows (Exp. 3) consuming meadow hay and supplemented to meet metabolizable protein (MP) or degradable intake protein (DIP) requirements[ab].

	April 21, 1999		May 18, 1999	
Item	MP	DIP	MP	DIP
Milk production, lb/day[c]	15.9	16.1	10.8	10.6
DM intake, lb[d]	23.2	23.8	23.2	23.8
NE_m balance, Mcal	-2.4	-2.2	-0.6	-0.4
MP supplied, g[e]	643	531	643	531
MP required, g[e]	710	712	585	587
MP balance, g[e]	-66	-181	58	-57
DIP supplied, g[f]	858	863	858	869
DIP required, g[f]	592	608	592	608
DIP balance, g[f]	266	255	266	255
Days to lose one BCS	54	60	197	292

[a]Calculated using 1996 NRC Model, nine cows/treatment.
[b]Supplements fed three times weekly from 15 to 64 day post-parturition. Average calving day March 23, 1999. Meadow hay was 9.5% CP, 80% NDF (OM basis).
[c]Twenty-four-hour milk production determined by weigh suckle weigh procedure; SEM = 0.6; Intake declined ($P = 0.0005$) across measurement dates.
[d]Total intake; Hay intake determined using a marker on May 3-8, 1999.
[e]MP = metabolizable protein.
[f]DIP = degradable intake protein.

treatment. Few refusals were recorded for the MP treatment. Despite the low supplement consumption on the DIP treatment, DIP was in excess for both treatments in April and May based on the NRC model using 10.5% microbial efficiency. Energy was markedly deficient for both treatments in April and slightly deficient in May based on the model (days to lose 1 BCS). Metabolizable protein was deficient for both groups in April (-68 and -181 g/d for MP and DIP, respectively). The reason that the MP did not meet MP requirements in April is that milk production was under-predicted for the cows when supplements were formulated. In May, when milk production declined, the MP cows were 58 g/day positive in MP compared to -57 g/day for the DIP cows. Reducing the MP deficiency in April and alleviating the deficiency in May resulted in the higher ADG recorded for the MP cows. Plasma progesterone was not above 1 ng/ml for any cow at any sampling point, indicating no cows exhibited luteal activity by May 17 (second to last bleeding).

Research in Montana showed UIP supplementation increased percentage of cows bred in the first 21 days of the breeding season. Breeding performance was not measured in the current study, but no differences were noted in luteal activity within 60 days after calving. Young cows often have longer postpartum intervals (interval from calving to luteal activity) than mature cows. Postpartum intervals greater than 100 days in two-year-old cows have been reported by other researchers. Both precalving energy level and BCS at calving can affect postpartum interval. The cows in the current study were in a negative energy balance prior to calving (2001 Nebraska Beef Report, p 19). The BCS of the cows at the initiation of the experiment was 4.7, which is a marginal level of condition for young, lactating cows.

The results of the current study indicate supplementation of UIP to meet metabolizable protein requirements will increase postpartum weight change of spring calving, two-year-old cows consuming meadow hay of this quality.

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[1]Trey Patterson, Amelia Hopkin, graduate students; Don Adams, professor, West Central Research and Extension Center, North Platte; Terry Klopfenstein, professor, Lincoln.

Use of Sexed (Female) Sperm is Successful in Yearling Heifers

Gene Deutscher
Rex Davis
George Seidel
Zell Brink
John Schenk[1,2]

Sperm can be sexed with 90% accuracy and the sexed sperm can produce AI pregnancy rates slightly lower than normal sperm. Sexed sperm may be available to beef producers next year.

Summary

A two-year study was conducted on 457 yearling replacement heifers to evaluate effects of sexed (female) sperm compared to normal (control) sperm on AI conception rates, fetal sex ratio and pregnancy rates of heifers. All heifers were estrous synchronized, heat detected and bred by AI. Semen from three bulls was collected and sexed by a sperm sorter located at Colorado State University. Results showed a 3% to 13% reduction in AI conception rates of heifers inseminated with low dose, sexed sperm compared to normal dose, control sperm; with overall 50-day pregnancy rates being similar. Fetal female sex ratio was 92% for sexed sperm compared to 49% for control sperm. Sperm can be successfully sexed resulting in slightly lower AI pregnancy rates, but yielding 90% of the preselected sex of calf.

Introduction

Many techniques to separate male and female sperm have been investigated during the past 30 years with little success. However, a new technology using flow cytometry/cell sorting for DNA content of sperm has been developed with promising results. In cattle, the X-chromosome-bearing sperm (female) have 3.8% more DNA than the Y-chromosome-bearing sperm (male).

The sperm sorting procedure involves staining the sperm with a dye that binds specifically to the DNA. The diluted mixture passes through a flow cytometer in a fine stream; and a vibrating crystal breaks the stream into droplets. The stained sperm are illuminated by a laser beam and fluoresce. The female sperm glow brighter than the male. A computer quantifies the fluorescence of the sperm and attaches a positive or negative electrical charge to the sperm droplet. The male and female sperm are then deflected in an electrical field and collected into separate test tubes. Currently, the sperm sorter (SX Mo Flo, Cytomation Inc., Ft. Collins, Colo.) is capable of sorting bull sperm at up to 4,000 live sperm/sec. of each sex. The current sorting accuracy is about 90% for each sex (Schenk and Seidel, 2000).

Because of the expense involved with sorting sperm, research has focused on developing improved sorting technology and on methods to inseminate females with reduced sperm dosage per unit compared to conventional AI. However, pregnancy rates with sexed sperm must be similar to unsexed sperm if it is to be used extensively in commercial livestock production.

Two years of research was conducted in cooperation with Colorado State University and XY, Inc. at Ft. Collins, Colo. to compare the effects of sexed (sorted) female sperm with normal (unsorted) sperm on AI conception rates, fetal sex ratio, and pregnancy rates of yearling heifers managed under ranch conditions. Other treatments evaluated effects of bulls, ranches, AI technicians, and the site of sperm deposition.

Procedure

The two-year study was conducted at the West Central Research Center, North Platte, Neb., using yearling replacement heifers from one ranch (n=102) in 1999 and from three ranches (n=355) in 2000. Heifers were delivered to the center in February each year (except from one ranch in 2000), managed in drylots, and fed ground alfalfa hay, corn silage, and corn with Rumensin to reach prebreeding target weights of about 800 to 850 pounds. Heifers remaining on the third ranch were managed similarly in all aspects.

All heifers were fed MGA for 14 days and injected with PGF (Lutalyse) 19 days after the end of the MGA feeding period. Heifers were heat detected three times per day but bred by AI only once a day (evenings, 12 or 24 hours after onset of estrus) for five days after the PGF injection.

Table 1. Results of sexed (female) sperm on heifers — 1999[a]

	Group[b]	
Trait	Control	Sexed[b]
No. of heifers inseminated	31	62
AI conception[c], %	71	68
Fetus female sex ratio[c], %	38[d]	81[e]
Heifers pregnant in 50 days, %	87	87

[a]Heifers were estrous synchronized with the MGA/PGF 19-day program. They were heat detected and AI bred with semen from two Red Angus sires. Cleanup bulls were placed with heifers 10 days after AI period for a total 50-day breeding season.
[b]Semen from each bull was collected: Control-normal dilution and freezing, 7 million live sperm per straw; and sexed-semen sorted for female sperm, frozen, 0.5 - 1.0 million live sperm per straw.
[c]Heifers were ultrasounded at 60 days after AI for day of pregnancy and sex of fetus. Calf sex was confirmed at calving.
[de]Means differ (P<0 .01)

Table 2. Results of sexed (female) sperm on heifers from three ranches — 2000[a]

	Group[b]	
Trait	Control	Sexed[b]
No. of heifers inseminated	112	211
AI conception[c], %	67[e]	54[f]
Fetus female sex ratio[c], %	49[g]	92[h]
Heifers pregnant in 45 days[d], %	90	91

[a]Heifers were estrous synchronized with the MGA/PGF 19-day program. They were heat detected and AI bred with semen from two Red Angus sires. Cleanup bulls were placed with heifers seven days after AI period for a total 45-day breeding season.
[b]Semen from each bull was collected: Control-normal dilution and freezing, 7 million live sperm per straw; and sexed-semen sorted for female sperm, frozen, 0.5 million live sperm per straw.
[c]Heifers were ultrasounded at 60 days after AI for day of pregnancy and sex of fetus. Calf sex was confirmed at calving.
[d]Only two ranches bred heifers for 45 days total.
[ef]Means differ (P<0.02), but ranch and sire differences exist.
[gh]Means differ (P<0.01).

Each year semen from two Red Angus sires (one bull was used both years) was collected at Colorado State University by CSU and XY, Inc. scientists. The control (unsorted) sperm were diluted and frozen using conventional procedures and packaged to yield at least 7 million live motile sperm per straw after thawing. The sexed (female) sperm were collected from the sperm sorter (SX Mo Flo), as previously discussed, and were packaged and frozen in 0.25-mL straws containing at least 1.5 to 3.0 million total sperm (0.5 to 1.0 million live motile sperm after thawing). Laboratory evaluations of sexed sperm quality showed some compromise of sperm, but this was minimal compared to the damage caused by freezing and thawing which can kill half of the sperm.

Each year, our study was a part of a larger number of field studies conducted by CSU researchers. In both years, each heifer was systematically assigned to a treatment group in the breeding chute according to the order of insemination. Two-thirds of the heifers were assigned to be inseminated with sexed sperm and one-third with control sperm. Equal numbers of heifers per treatment were inseminated within bull, site of semen deposition, AI technician and ownership of heifers. Sexed sperm were deposited either into the uterine body (as were all controls) or half into each uterine horn using embryo transfer sheaths. Usually semen was deposited at least half way into each uterine horn but not so far as to cause tissue damage.

After the AI period, heifers were returned to their respective ranches in mid-May and cleanup bulls were placed with the heifers about seven to 10 days later for a total 45 to 50-day breeding season. All heifers were given an ultrasound exam about 60 days after AI to determine AI conception and sex of fetus. Calf sex was confirmed at calving. Data were analyzed using least square analyses of SAS and chi-square analyses.

Results

Since the secondary variables were equalized and blocked within the major treatments, the results of the treatments in 1999 are shown in Table 1. The AI conception rate for the heifers receiving the sexed sperm was similar (P>0.20) to the heifers receiving the control sperm (68% vs 71%). Conception rates were normal for both groups. Pregnancy rates in 50 days of breeding were identical for both groups. No differences were found between bulls, AI technicians, or site of semen deposition. The fetal female sex ratio was considerably higher (P<0.01) for the sexed group compared to the controls (81% vs 38%). However, both percentages were lower than expected.

The overall treatment results for the heifers from the three ranches in 2000 are shown in Table 2. The AI conception rate was lower (P<0.02) for the heifers receiving the sexed sperm compared to the controls (54% vs 67%). This difference was disappointing, but appeared to be influenced by ranch effects. Heifers from one ranch had identical AI conception rates for the two treatment groups, and were from the same ranch as heifers in the 1999 study. However, heifers from another ranch had a 30% difference between groups. Heifers from the latter ranch were smaller in type and lighter in weight. Heifers from both ranches were managed similarly at breeding using the same AI sires and procedures. The overall 45-day pregnancy rate for the control and sexed groups were very similar and at normal levels. The fetal female sex ratio was 92% for the sexed group and 49% for the control group as expected.

No differences were found between technicians or site of insemination. However, one bull tended to have higher conception rates than the other. Bull fertility differences have been found in many research studies.

Other research results previously reported (Schenk and Seidel, 2000) were:

a) sexed sperm conception rates were generally about 10% lower than those of control sperm.
b) sexed sperm from lower fertility bulls resulted in significantly fewer pregnancies compared to controls.
c) sperm from some bulls had higher tolerances for sorting, freezing and thawing than from other bulls.
d) pregnancy rates were similar for sperm dosages of 1.5 and 3.0 million total sperm per straw.
e) pregnancy rates from sexed sperm were not increased by depositing sperm into uterine horns compared to the uterine body.

(Continued on next page)

f) fetal female sex ratio from sexed sperm were between 85% and 90% in most studies.
g) results from using sexed male sperm were similar to female sperm.

In conclusion, sexed-frozen sperm have produced pregnancy rates that are slightly lower than control-frozen sperm, but fetal female sex ratio was close to 90% with sexed sperm. Maximum fertility from low dose sexed sperm may only be achieved with bulls of high fertility. Calf survival rate, calf birth weight and growth have been normal with sexed sperm.

Sex-specific sperm will not be used by all cattlemen, but could have a major impact on AI breeding programs. Dairymen could produce more female calves; beef seedstock producers could perform more specialized matings; and, beef replacement heifer development producers could produce more female calves for less dystocia at calving. Sexed sperm will cost more and will require greater cattle management and AI breeding skills. More research is needed on sperm sorting efficiency and on large-scale field trials to improve pregnancy rates of low dose, sexed sperm. Commercial sexed, frozen sperm should be available within one to two years in the United States. A commercial product has been available in the United Kingdom since early 2001.

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[1]Gene Deutscher, professor emeritus, and Rex Davis, beef unit manager, Animal Science, West Central Research and Extension Center, North Platte, Neb.; George Seidel, professor, and Zell Brink, research associate, Colorado State University; and John Schenk, reproductive specialist, XY, Inc., Ft. Collins, Colo.

[2]Appreciation is expressed to the Hansen 77 Ranch, North Platte, Neb., Schuler Red Angus Ranch, Bridgeport, Neb., and Jackson Ranch, Maxwell, Neb., for providing heifers (plus bulls for semen, Schuler) and excellent cooperation on this research. Also appreciation is extended to XY, Inc. for sexed semen and partial funding of research.

Estrous Synchronization Programs for Lactating Cows

Gene Deutscher
Brent Plugge
Rex Davis[1]

The Select Synch program for synchronizing estrus in lactating cows produced better results in a small study than the one injection PGF program and similar results to the CO-Synch mass AI program.

Summary

Two estrous synchronization experiments were conducted on lactating cows to compare the Select Synch program with the one injection PGF-10-day program and the CO-Synch mass AI program. The Select Synch program in both experiments produced good results. Pregnancy rates during the synchronization period were 62% and 81% for the Select Synch program compared to 49% for the PGF and 61% for the CO-Synch programs. The Select Synch program induced estrus in some noncycling cows. However, the Select Synch program requires two injections (GnRH and PGF) and about seven days of heat detection and AI breeding.

Introduction

Methods of estrous synchronization are needed that will achieve high conception rates during a short AI period at low costs. A major challenge of synchronizing lactating cows is a high percentage of cows are anestrous before the breeding season.

The Select Synch program can induce cycling in cows that have not resumed cyclicity. Researchers also have found calf removal in combination with Select Synch increased pregnancy rates in anestrus cows. The CO-Synch program was developed to include mass breeding; therefore, labor for heat detection is not needed.

Experiments were conducted over two years to compare the Select Synch program with the one injection PGF-10-day program in 1999, and to compare Select Synch with the CO-Synch program in 2000, on estrous response, conception rates, and overall pregnancy rates of lactating cows.

Procedure

Experiment 1

In 1999, 83 red crossbred 3-year-old cows at the West Central Research and Extension Center, North Platte, Neb., were used. The cows calved in March and April and were fed brome grass and alfalfa hay after calving plus some corn silage to meet their nutrient requirements. The cows were body condition 6.0 before the breeding season in early June and were 25 to 77 days post partum.

Cows were allotted to two treatment groups according to calving date and cycling status (determined by ovary palpation). In addition, two blood samples were taken at 10-day intervals before treatments were imposed to determine serum progesterone levels and actual cycling status. Group A cows (Select Synch) were given a 2cc injection of GnRH (Cystorelin, Rhone Merieux, Inc., Athens, Ga.) on day zero

and an injection of PGF (Lutalyse) on day seven with heat detection and AI between injections and for seven days after PGF. Group B cows (PGF) were heat detected and bred by AI for five days, then given PGF on day six and heat detected and bred by AI for five additional days (standard PGF one injection procedure). Semen used for AI was from one Red Angus sire. Two experienced technicians were used for AI and bred equal number of cows in each group.

Cows were moved to summer pasture after the synchronization period and two black Angus bulls were placed with them five days later for a 45-day natural breeding period. Ultrasound was used about 30 days after the synchronization period to determine AI conception rates, which were confirmed by calving dates. Cows were palpated for pregnancy at 60 days after bull removal to determine total pregnancy rates.

Experiment 2

In 2000, 75 red crossbred 4-year-old cows (same cows as in 1999) were used to compare Select Synch and CO-Synch programs. They were fed and managed after calving similarly to Experiment 1. The cows were body condition 5.5 before the breeding season and were 34 to 91 days post partum. The cows were allotted to treatment groups according to calving date and cycling status (ovary palpation). No blood samples were collected. Group A cows (Select Synch) were given GnRH and PGF injections using the same procedure as in Experiment 1. Group A cows were heat detected and bred by AI as in Experiment 1. The Group B cows (CO-Synch) were given the same injections at the same time as the Select Synch cows, but their calves were removed for 48 hours after the PGF injection. These cows were heat detected and bred by AI for two days before the PGF injection and two days after. All cows not detected in heat by 36 hours after the PGF injection were mass bred by AI at 48 hours and a second GnRH injection was given. No heat detection and AI were performed thereafter. All semen used for AI was from one Red Angus bull. One AI technician inseminated all cows in this experiment.

Cows were moved to summer pasture and two Red Angus bulls were placed with them for a 40-day breeding period. Ultrasound was used about 30 days after the synchronization period to determine AI conception rates, which were confirmed by calving dates. Pregnancy palpation at 60 days after bull removal was used to determine total pregnancy rates.

First service conception rate was calculated using the number of cows that conceived to AI, divided by number of cows bred by AI times 100. Percentage pregnant during the synchronization period was the number of cows pregnant to AI divided by total number of cows in treatment group times 100. All data were analyzed by chi-square analyses.

Results

Table 1 shows results of Experiment 1. The Select Synch program produced better results in all traits than the PGF program. However, more cows were cycling before treatment in the Select Synch group according to blood analysis. The Select Synch program yielded 20% higher (P<0.05) estrous response during the synchronization period, 20% higher (P<0.05) conception rates and 32% higher (P<0.05) pregnancy rates during the synchronization period compared to the PGF program. Overall, 60-day pregnancy rates were similar for both programs.

Table 2 shows results for the noncycling and cycling cows separately. The Select Synch program induced estrus in 36% (P<0.05) of the noncycling cows. First service conception rate was also higher (P>0.10) and pregnancy rate during synchronization period was considerably higher for Select Synch cows, (75% vs 39%, Select Synch and PGF, respectively, P<0.05). Results for the cycling cows also were positive for the Select Synch over the PGF program.

Table 3 shows results for Experiment 2. The Select Synch results were not as high as in Experiment 1. Only 73% of the cows cycled during the synchronization period, which was disappointing. The reasons for this low rate are unknown, but daytime temperatures were high (near 100°F) with strong winds during this period. Conception rate was high which yielded an average (62%) pregnancy rate during the synchronization period.

The CO-Synch results were slightly lower (P>0.25) for all traits than the Select Synch. The CO-Synch first service conception rate on the cows detected in heat was 77%, but it was only 38% for the cows that were mass bred by AI. The extra expense for semen, GnRH second injection and labor to mass breed the noncycling cows, in addition to the 48-hour calf removal,

(Continued on next page)

Table 1. Comparison of Select Synch Program with PGF-10 day program—Experiment 1[a]

Trait	Group	
	Select Synch	PGF
No. of cows	42	41
Cycling before treatment, %	71	56
Cycling during synch.[b], %	93[c]	73[d]
First service conception, %	87[c]	67[d]
Pregnant in synch. period, %	81[c]	49[d]
Pregnant in 60 days, %	98	93

[a]Cows were 3-year-olds, body condition 6.0 and from 25 to 77 days after calving before treatment. Select Synch program involved a GnRH injection and seven days later a PGF injection. PGF program was the standard procedure with one injection of PGF and five days of AI before and five days after injection.
[b]Synch. Period was 10 days for PGF program and 10 days for Select Synch (four days before PGF and six days after).
[cd]Means with different superscripts in same row differ (P<0.05).

Table 2. Comparison of programs for noncycling and cycling cows. Experiment 1[a]

Trait	Group	
	Select Synch	PGF
Noncycling cows[a]		
No. of cows	12	18
Cycling during synch.[b], %	92[c]	56[d]
First service conception, %	82	70
Pregnant in synch. period, %	75[c]	39[d]
Cycling cows[a]		
No. of cows	30	23
Cycling during synch.[b], %	93	87
First service conception, %	89[c]	65[d]
Pregnant in synch. period, %	83[c]	57[d]

[a]Cycling status determined by blood progesterone levels before treatments began.
[b]Synch. period was 10 days for both programs.
[cd]Means with different superscripts in same row differ (P<0.05).

Table 3. Comparison of Select Synch and CO-Synch Programs — Experiment 2[a]

Trait	Group	
	Select Synch	CO-Synch
No. of cows	37	38
Cycling before treatment, %	83	83
Cycling during synch.[b], %	73	58
First service conception, %	85	77[c]
Conception of mass AI, %	—	38[c]
Pregnant in synch. period, %	62	61
Pregnant in 55 days, %	95	92

[a]Cows were 4-year-olds, body condition 5.5 and from 34 to 91 days after calving before treatment. Select Synch program involved a GnRH injection and seven days later a PGF injection. The CO-Synch program involved the same injections as Select Synch plus 48 hour calf removal after PGF injection and mass breeding at 48 hours after PGF plus a second GnRH injection at AI.

[b]Synch. period was eight days for Select Synch (two days before PGF and six days after). Synch. period for CO-Synch was the same except all cows not AI bred by 36 hours after PGF were mass bred AI at 48 hours with no heat detection and AI thereafter.

[c]CO-Synch conception was 77% for cows detected in heat and 38 % for cows not heat detected and mass bred.

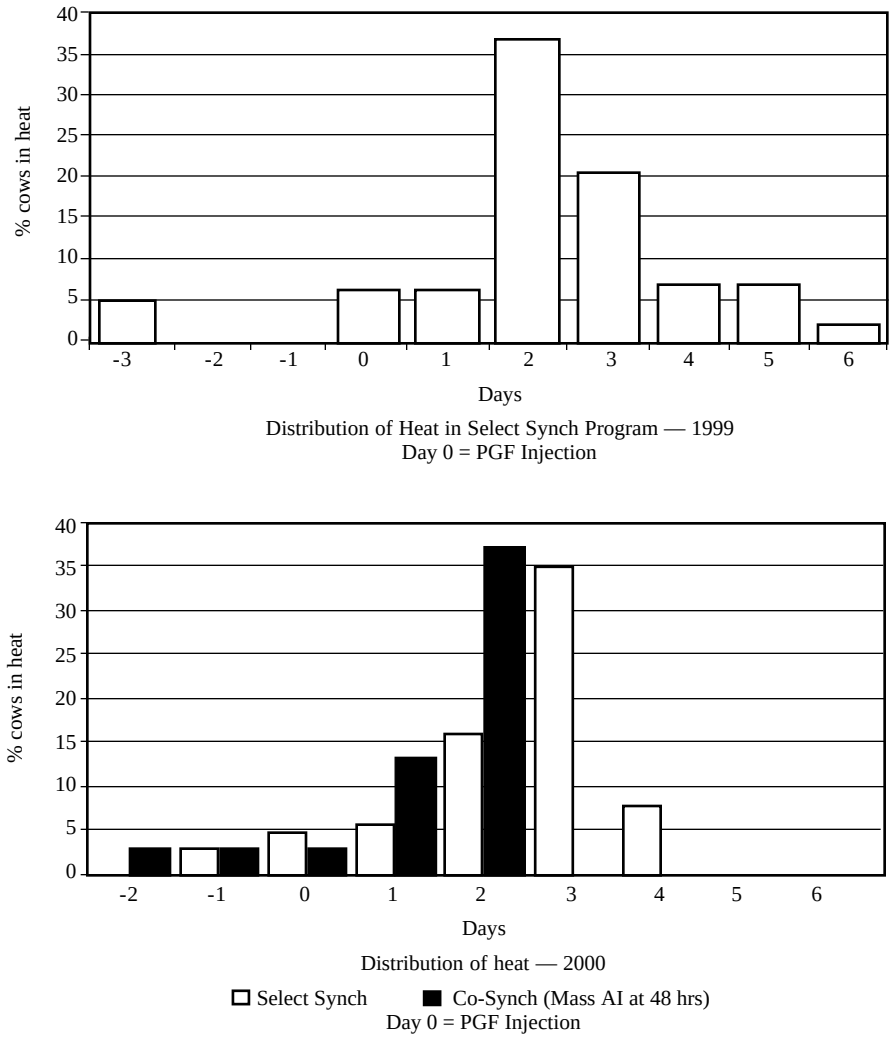

Figure 1. Distribution of cows in heat in 1999 and 2000 experiments.

was not justified in this small study. Experiments with large numbers of cows are needed to determine differences between programs.

Figure 1 shows the distributions of heat (estrus) for the Select Synch program in 1999 and 2000. Note the differences between years. Cows showed heat on days five and six in 1999, but not in 2000. Days two and three after the PGF injection had the large majority of cows in heat in the Select Synch program.

In the CO-Synch program, about 37% of the cows showed heat on day two. Our observations on the cows in this group indicated about 10 hours after the second GnRH injection all estrous activity ceased. The loss of estrous activity may have been due to the GnRH causing ovulation and cessation of heat. The timing of mass AI in relation to the GnRH injection may need to be delayed to get higher conception rates. Colorado research has indicated a 24-hour delay in mass AI is not necessary, but more research is needed.

Results of these two small experiments indicate Select Synch produced better results than the one-injection PGF program and similar results to the CO-Synch mass AI programs. Our results support research findings in other states. More information on these synchronization programs, is available in Extension Circular EC00-279, *Synchronizing Estrous in Beef Cattle*.

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[1]Gene Deutscher, professor emeritus, Animal Science; Rex Davis, beef unit manager, Animal Science, West Central Research and Extension Center, North Platte, Neb.; Brent Plugge, extension educator, Thedford, Neb. Appreciation is expressed to Alta Genetics, Watertown, Wis. for providing the bull semen for AI.

Windrow Grazing and Baled-Hay Feeding Strategies for Wintering Calves

Jerry Volesky
Don Adams
Richard Clark[1]

Windrow grazing of meadow forage was a cost-saving strategy for wintering calves. Quality of windrow-stored forage remained relatively constant through the fall and winter and resulted in adequate calf gains.

Summary

Windrow grazing is a strategy where livestock directly graze windrow-stored forage, generally during a time when packaged hay is provided. We evaluated calf performance, forage quality and waste, and determined economic returns under windrow grazing and bale-fed strategies. Quality of windrow-stored forage remained constant through fall and winter and resulted in adequate calf gains. Forage waste under windrow grazing was closely associated with grazing management. Economic analysis indicated costs for windrow grazing were substantially less than those associated with a bale feeding strategy. Correspondingly, net returns per head and acre were greater for windrow grazing compared to the bale-fed strategy.

Introduction

Using strategies that extend the normal grazing season is one approach to reduce costs in ranch enterprises. This has included using complementary grazing of seeded forages, grazing of stockpiled forages, or any approach that places greater reliance on the grazing animal for harvesting forages. Another strategy to potentially lower harvest and feeding costs is the direct grazing of windrows or swaths in lieu of baling. The objective of this strategy is to produce windrow-stored forage that will match the nutrient requirements of a certain class of livestock.

We initiated a two-year study in 1997 to evaluate windrow grazing of meadow forage with weaned calves as an alternative to the conventional feeding of baled hay. Our approach was unique in that we harvested regrowth meadow hay in an attempt to provide forage that would meet the nutrient requirements of a weaned calf. The objectives were: 1) to quantify calf performance, feed intake, and waste under windrow grazing and baled-hay feeding management strategies; 2) to quantify hay quality changes as affected by storage method and time; 3) to determine effects of windrow coverage on subsequent wet meadow herbage yield and composition; and 4) to compare costs and returns associated with windrow grazing and baled-hay feeding strategies.

Procedure

The study was conducted from 1997 to 1999 at the University of Nebraska, Gudmundsen Sandhills Laboratory, five miles northeast of Whitman, Neb. Experimental pastures (eight acres) were established on a subirrigated range site of a wet meadow that had primarily been used for hay production. Vegetation of the study pastures was dominated by cool-season species including smooth bromegrass, redtop bent, timothy, slender wheatgrass, Kentucky bluegrass, and several species of sedges, rushes, and spikerushes.

Each of three pastures were grazed by mature cows with calves at 39 animal-unit-days (AUD)/acre during the last two weeks of May in 1997 and 1998. This stocking rate resulted in heavy use with nearly all of the available forage being removed. Pasture forage was then allowed to grow until harvesting in September of each year. Cut forage was raked into windrows that were approximately 3 feet wide and 33 feet apart. Alternate windrows were then baled (1,000 lb round), and bales removed. Remaining windrows were left in place.

The grazing and feeding trial began in mid-November and continued through January of each year. Forty-eight steer calves were randomly allocated into three replicate groups (eight head each) for the windrow grazing (windrow) treatment and three replicate groups for the bale-fed (bale) treatment. Calves had an initial weight of 447 lb. Bale-fed calves were kept in dry-lot pens and fed hay packaged from the alternate windrows in the corresponding pastures.

Fecal output for estimation of forage intake was determined with 18 calves during December 1997 and 1998. Three calves from each windrow or bale replication were sampled. Each calf on the intake trial was orally dosed with an intraruminal continuous chromium (Cr)-releasing device five days before a six-day fecal collection period. Concurrent with the fecal collections for the windrow and bale calves, total fecal collections were made on eight steer calves that were similar in weight and age to those under the windrow and bale treatments. Four of the calves were individually fed baled hay and four were individually fed hay collected from windrows.

In the windrow grazing treatment, forage waste was determined from pre- and post-grazing weights of 6-foot sections of windrow. Under the hay-fed treatment, the amount of hay wasted was determined by collecting hay that was discarded and trampled in an area around the round-bale feeder. After the trial ended in late January, cows were placed in the windrow grazing pastures for

(Continued on next page)

additional grazing of the windrows. Pre- and post-grazing measurements of windrows were also made.

To evaluate the effect of time and method of storage on forage quality, samples of windrow, baled, and standing (not cut in September) forage were collected at the time of harvest and each month through February.

Windrows left on the meadow until they are grazed during the winter may have an effect on the vegetation directly underneath. Such effects were evaluated by sampling during the following July of each year. In each meadow pasture, quadrats were clipped in areas that were and were not covered by windrows. Clipped vegetation was sorted into grass, sedge, legume, and other forb components and then dried and weighed.

Partial budgeting techniques were used to compare the windrow grazing and bale feeding strategies. Some costs common to both strategies were included to determine whether either strategy could be profitable over a range of calf prices. For purposes of comparison, a 100 acre field, typical of ranch-scale operations, was assumed.

Results

Calf Weight Gain and Forage Intake

There was a year by treatment interaction effect for calf weight gain ($P < 0.05$; Table 1). During the first year of the trial, windrow-fed calves gained 81 lb compared to 59 lb for bale-fed calves. There was no difference in weight gain between treatments during the second year of the trial ($P > 0.05$). The greater weight gain for windrow calves during 1997-98 was likely due to the presence of high quality regrowth that occurred after haying. The fall of 1997 was relatively mild and our hay harvest date was three weeks earlier compared to 1998. Diet samples collected from esophageal-fistulated cows on December 8, 1997 contained 14.6% CP compared to 10.4% CP for hand-collected samples of windrows. Some of the regrowth in windrow pastures was observed to remain green as late as December 20, 1997.

In vivo organic matter digestibility of baled hay and windrow forage, as determined from steers that were individually fed and subject to total fecal collection, averaged 67.3% and was not affected by year or treatment ($P > 0.05$). Dry matter *in vivo* digestibility was 60.4%. Forage intake by individually fed steers was also similar between years and treatments and averaged 11.2 lb organic matter/head/day.

Table 1. Body weights and gains of calves grazing windrows or fed baled meadow hay.

		Treatment		
Trial year	Item	Windrow grazing	Bale-fed	SEM[a]
1997-98	Initial weight, lb.	449	447	4.19
	Final weight, lb.	531[b]	507[c]	4.49
	Total gain, lb.	81[b]	59[c]	2.88
	Daily gain, lb./day	1.16[b]	0.86[c]	0.04
1998-99	Initial weight, lb.	443	449	3.96
	Final weight, lb.	485	487	3.33
	Total gain, lb.	42	38	3.17
	Daily gain, lb./day	0.57	0.52	0.04

[a]Standard error of the mean, N = 6.
[b,c]Within rows, treatment means with unlike superscripts differ ($P<0.05$).

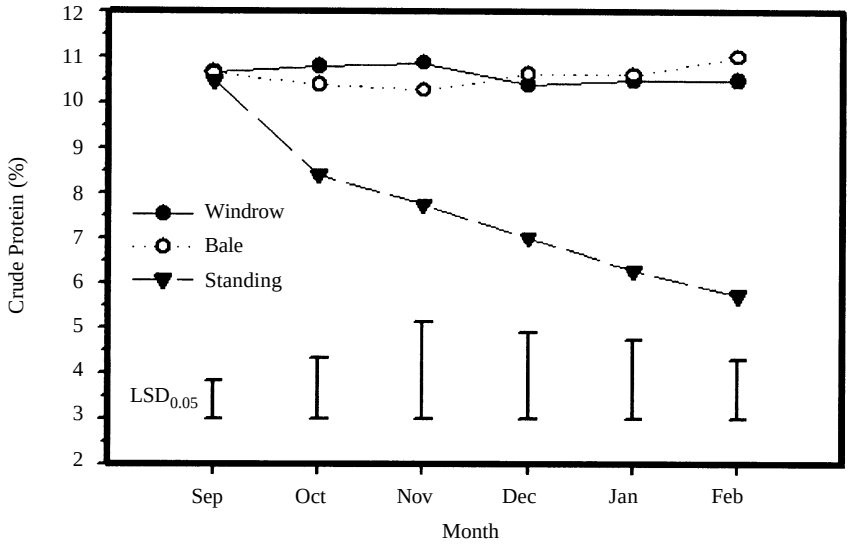

Figure 1. Effect of time and method of storage on crude protein content of wet meadow hay (organic matter basis), 1997-98 and 1998-99.

Forage Waste

Pregrazing weight of windrow-stored forage averaged 2.8 lb/linear-foot and pre-feeding weight of bales was 990 lb. Under our grazing management, forage waste (refusal) by windrow calves averaged 29% and was higher than waste by bale calves (12.5%, $P < 0.05$). We allowed cows to graze in the windrow pastures after the calf grazing period ended. This resulted in an additional 23% utilization of the windrow forage left by calves during the first year of the trial and an additional 75% utilization during the second year. Forage waste after the combined calf and cow grazing periods averaged 18% and 4% during the first and second year of the trial, respectively. The difference between years was largely due to the cow stocking rates that were applied.

Effect of Time and Method of Storage on Forage Quality

Year did not affect CP content, ADF, or NDF of windrow, baled, or standing (stockpiled) forage ($P > 0.05$). A treatment by month interaction was detected

Table 2. Effect of windrow coverage on subsequent wet meadow herbage yield and composition, July 1998 and 1999.

	Treatment		
Plant group	Windrow covered	Control	SEM[a]
	- - - - - - - - - lb/acre - - - - - - - - -		
Grasses	2,590[b]	3,730[c]	416
Sedges and rushes	1,800	1,780	387
Legumes	330	310	91
Forbs	200	80	47
Total	4,920[b]	5,900[c]	272

[a]Standard error of the mean, N = 9.
[b,c]Within plant group, treatments means with unlike superscripts differ (P < 0.05).

Table 3. Costs of forage production and grazing or feeding for windrow grazing and bale-fed strategies.[a]

Item	Windrow grazing	Bale-fed
Forage production	- - - - - - - - - - $/acre - - - - - - - - - -	
Fertilizer and application	32.35	32.35
Mow and rake	10.00	10.00
Bale (large round)	—	19.30
Move bales	—	6.13
Total	42.35	67.78
Grazing or feeding[b]	- - - $/acre - - -	- - $/ton - -
Hay cost	42.35	33.88
Feeding cost		
Labor	—	1.60
Bale feeder (depreciation, interest, repair)	—	5.06
Tractor (depreciation, interest, repair, fuel)	—	4.35
Fence	3.52	—
Labor	1.68	—
Total costs per acre or ton	$47.55/acre	$44.89/ton
Feed cost/head	$11.60	$21.24
Feed cost/head/day	$ 0.16	$ 0.30

[a]Based on 100 acres meadow, 410 calves (500 lb) and a 72 day windrow grazing or bale feeding period.
[b]Costs for windrow grazing are dollars/acre and costs for the bale-fed strategy are dollars/ton.

for CP content (P < 0.05). Crude protein content under windrow, baled, and standing storage treatments was similar in September (10.6%), but CP of standing forage declined to 5.7% by February (Figure 1). Crude protein content of windrow- and baled-stored forage was similar over all sampling months (P > 0.05).

Effect of Windrow Coverage on Subsequent Vegetation Production and Composition

In July of the growing seasons following windrow grazing, composition of wet meadow herbage averaged 63% grasses, 30% sedges and rushes, 6% legumes, and 1% forbs. Total herbage yield was 20% less in the area directly covered by windrows compared to the control (P < 0.05; Table 2). This difference was due to 1,140 lb/acre less grass yield under the windrow covered treatment compared to the control. Treatment did not affect yield of the sedge/rush, legume, and forb plant groups. Although our data indicate a 20% reduction in total herbage yield in the area covered by windrows, only about 9% of the total area of a pasture is affected by windrow-coverage when 3-feet wide windrows are created 33 feet apart. Applying this percentage to our data shows that for the entire pasture the net effect due to windrow coverage would be about 90 lb/acre or 1.5% less yield.

Economics

Estimated costs for producing and harvesting hay were about $25/acre (37%) higher for the bale-feeding strategy compared to windrow grazing due to baling and bale moving costs (Table 3). The costs of feeding bales are a major addition to the bale-fed strategy and are $11/ton or about 33% of the costs for harvesting hay. Additional costs for windrow grazing are for fencing materials and labor to install the fence and move the temporary fence while grazing windrows. The resulting strategy feed costs were $0.16/head/day for windrow grazing compared to $0.30/head/day for the bale-fed.

During the 1997-1998 trial year, net returns for windrow grazing were $72.26/head compared to $52.31/head for the bale-fed strategy. This difference reflects both the lower costs and the fact that animals gained better under windrow grazing that year. Net returns during 1998-1999 were $62.96/head for windrow grazing and $49.34/head for bale-fed with the difference primarily due to strategy costs since animal gains were similar. These returns do not include costs for land, management, or overhead.

In an analysis that projected net returns by strategy for the years 1992 through 1999, gain from the windrow grazing averaged $29.04/head compared to $19.86/head for bale-fed. This analysis held costs constant at 1998 level and permitted steer calf prices to vary according to actual prices, 1992-1999. Animal gains were held constant at 0.5 lb/day so the year to year differences reflect only calf price variations. Net returns for bale-fed were more variable compared to the mean as reflected by a coefficient of variation of 125% compared to 84% for windrow grazing.

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Forage Quality and Animal Performance of Steers Grazing Smooth Bromegrass/Legume Pastures

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Interseeding legumes into established bromegrass pastures increased both CP content and digestibility of diets, but improved animal performance appears to be an energy response.

Summary

A trial was conducted to evaluate effects of interseeding legumes into smooth bromegrass pastures on animal performance and forage quality. Animal gains on legume/bromegrass treatments were higher than bromegrass alone. Laboratory analysis of diet samples collected from ruminally fistulated steers indicated no difference in the undegradable intake protein content of pastures. Legume/bromegrass treatments had higher IVDMD than the control. Therefore, the increases in gain are attributed to increased energy of legume/bromegrass diets and not undegradable protein content.

Introduction

Forage proteins are degraded rapidly by ruminants and therefore supply relatively small amounts of undegradeable intake protein (UIP). Undegradable intake protein supplements are an alternative way to overcome this metabolizable protein deficiency, but not without a substantial increase in overall production costs. Previous research at the University of Nebraska has shown a response to UIP supplementation of yearling steers during the grazing season but the increased gains were not maintained during the finishing period (*2000 Nebraska Beef Report*, pp. 30-32; *2001 Nebraska Beef Report*, pp. 34-36). Growing legumes in combination with cool season grasses can reduce purchased inputs by contributing nitrogen via fixation, improve nutritive values of the forage produced, and provide more uniform seasonal distribution of forage growth. Ruminal protein degradation appears to be higher for legumes than grasses. It has been proposed that protein in birdsfoot trefoil, a nonbloating perennial, is less readily degraded by microbes in the rumen allowing its protein to be used more effectively by ruminants than the protein in alfalfa and clovers. Therefore, the objectives of this experiment were to evaluate the effects of interseeding legumes into smooth bromegrass pastures on animal performance and forage quality.

Procedure

Forty-eight steers (560 $\pm$ 35 lb) were assigned randomly to one of four treatments consisting of established smooth bromegrass pastures interseeded with 1) alfalfa (ALF), 2) birdsfoot trefoil (BFT), 3) kura clover (KC), or 4) fertilized with 50 lb N/acre (CON). Steers rotationally grazed pastures divided into nine paddocks designed to simulate two-, six-, and 36-paddock rotations in a modified nested paddock design, thus providing grazing periods of 18-, six-, and one-day respectively in a 36-day grazing period. The pastures were divided into three blocks with each block containing one pasture of each mixture plus the fertilized smooth bromegrass monoculture. Pastures in blocks one and three were 4.4 acres and pastures in block two were 5.5 acres. Movement of the cattle through the grazing rotation was from the largest paddock (18 days) to the smallest (one day), with each block starting in a different paddock to stagger the growth stage at which plants were first grazed and balance plant growth stage during defoliation across grazing systems.

In addition to the performance data obtained from the grazing steers, four ruminally fistulated steers were assigned randomly to one of four treatments in block two to maintain a constant stocking rate of 3.1 AUM/acre and used to collect diet and omasal samples. The fistulated steers were managed in the same manner as the performance cattle except they were rotated to a different treatment at the start of a new period. Three diet and omasal samples were collected each period via ruminally fistulated steers. Rumen contents were evacuated and an omasal sample was obtained by introducing the arm into the rumen and at least two fingers into the omasum through the reticulo-omasal orifice. The subsequent diet samples collected were representative of animal selectivity while grazing one-, six-, and 18-day paddocks. Forage samples were analyzed for CP (combustion method) and IVDMD. Undegradable intake protein of the diet samples was measured using a modified procedure of Mass (*1998 Nebraska Beef Report*, pp. 90-92). Diet samples were incubated in situ using Dacron bags for a period of time equivalent to the rate of passage, estimated from IVDMD, plus a 10-hour lag. Omasal samples, which have effectively escaped rumen fermentation, were placed in Dacron bags, and bacterial contamination was removed by refluxing the sample in neutral detergent solution. Dry matter passage at the omasum was estimated by the amount of in situ residue.

Diet samples collected from the 36-paddock system would not be representative of average forage quality. In this system, animals were rotated daily and diet samples were collected immediately following their movement into that paddock, allowing for maximum animal selectivity. The diets collected from two- and six-paddock systems were collected approximately midway through the respective grazing periods, allowing

Table 1. Average daily gains and response variables for legume/bromegrass mixtures and smooth bromegrass monoculture.

	Treatment[a]					
Item	ALF	BFT	KC	CON	SEM	P-value[b]
ADG, lb/day	1.90	1.94	2.05	1.72	0.088	.04
CP, %	16.8	16.3	17.4	16.1	0.82	.24
IVDMD, %	62.1[c]	62.9[c]	70.4[d]	62.6[c]	3.3	.09
Diet UIP, % DM	1.48	1.45	1.46	1.39	0.13	—
Omasal UIP, % DM	1.64	1.33	1.35	1.32	0.15	—
Forage UIP, % DM[e]	1.54	1.54	1.26	2.04	.29	—

[a]Smooth bromegrass pastures interseeded with Alfalfa (ALF), birdsfoot trefoil (BFT), kura clover (KC), or fertilized with 50 lb/acre of N (CON).
[b]Contrast of control treatment vs the average of the interseeded legume treatments.
[c,d]Means in he same row with unlike superscripts differ (P<0.05).
[e]Undegradable intake protein of the legume portion of the mixtures and the UIP of the CON.

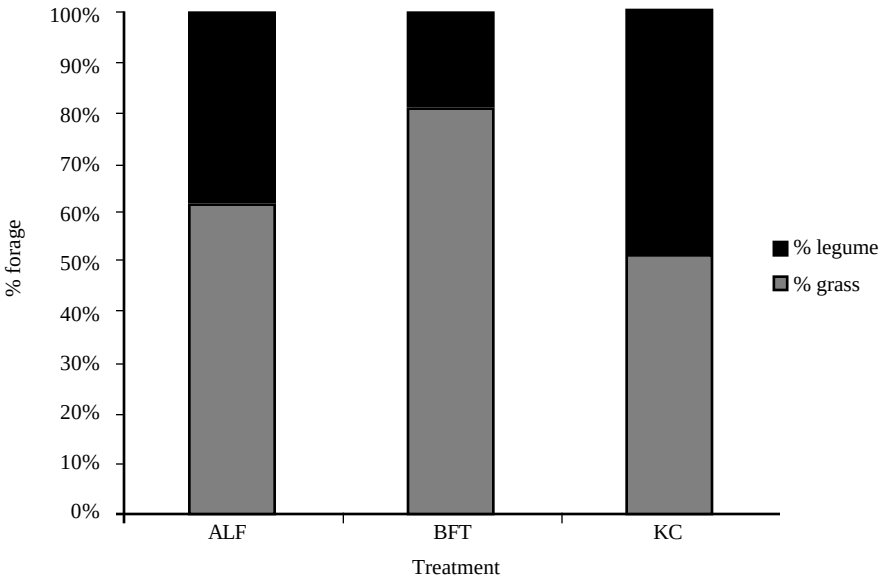

Figure 1. Biomass proportions for legume/bromegrass mixtures.

for average animal selectivity. Since previous research at the University of Nebraska concluded there were no differences in legume persistence, samples collected from the two- and six-paddock systems were thought to be representative of the diets consumed and averaged to evaluate any differences that may exist among treatments.

Biomass samples, clipped approximately 1 inch above ground level, were collected to coincide with the diet samples obtained. Five, seven, and 11 2-foot^2 plots were clipped randomly from 36, six-, and two-paddock systems respectively and separated into grass and legume fractions. By design, biomass data from the 36-paddock system were collected before grazing was initiated and is representative of the available forage without any effects grazing may have on the stand. Both two- and six-paddock system clip samples were taken from the paddock where animals were grazing potentially disturbing the accuracy of the biomass results. Samples were analyzed in the same manner as the diet and omasal samples.

Results

Table 1 summarizes the response variables of interest in this experiment. Crude protein contents of the diets across treatments were not statistically different (P=0.30). The KC treatment was significantly different (P<0.10) when compared to the control (17.4 vs 16.1) and appears to be dependent on the amount of legume present in the stand (Figure 1). In vitro dry matter disappearances were different across treatments (P<0.05). The IVDMD values differed (P<0.10) between legume/bromegrass mixtures and the control diet (65.2% and 62.6 % respectively) with KC being the most digestible (70.7%). There were no differences between ALF, BFT, and the CON IVDMD values indicating digestibility of KC caused this difference. Biomass data from the three legume/bromegrass treatments, shown in Figure 1, support these results. The legume portion of the KC treatment comprised nearly 50% of the stand. This may have allowed the animals greater selectivity of a higher quality diet than the other two mixtures. Since animal selectivity likely had a profound impact on diet quality, a greater proportion of legume increases the animal's ability to select a higher quality diet.

The UIP contents of the diets across treatments were not different (P=0.87). Undegradable intake protein results from omasal samples followed the same trend as the diet samples (P=0.14). Laboratory analyses of the clip samples for UIP also indicate there were no differences (P=0.23) among the legumes for UIP.

The BFT treatment contained less than 20% legume as a proportion of the total biomass (Figure 1). Crude protein and IVDMD values of the BFT treatment were not statistically different from the CON, suggesting diets selected were not different in composition from those of the CON. Therefore, there may not have been enough legume available to elicit a protein response.

Animal gains on legume/bromegrass treatments were higher (P = 0.04) than the control (1.96 lb/day vs. 1.72 lb/day) with KC gaining the most (2.05 lb/day). Because forage proteins are extensively degraded in the rumen, it may be assumed that there is an abundance of DIP. In addition, since no differences in UIP of the treatments were observed, increased digestible energy content of the diets must be responsible for the increase in gains observed in this experiment.

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Supplementing Yearling Summer-Grazing Cattle with Fat and Protein and Subsequent Feedlot Performance

Ivan G. Rush[1]

Protein and fat supplementation to grazing yearling cattle increases summer gain and this gain advantage is maintained throughout finishing.

Summary

Yearling steers supplemented with protein (40% - 29% NPN - 19% from biuret) while grazing primarily crested wheat grass in the summer gained at a faster rate than control steers which were only provided a commercial salt/mineral mix. A lower level of protein (20% - 6.7% NPN)/fat (15% -20%) combination supplement also increased gain over controls, but the supplement response was less than the higher protein supplement. Gain responses were greater during the latter part of the grazing season when forage quality was poorest. Supplementation intake varied but tended to be greater during the latter part of the grazing season. The control summer grazing cattle that gained at a slower rate did not compensate and gain faster when finished after the summer grazing season. When both the grazing and finishing phases were considered, cattle receiving either the protein or the protein/fat summer supplement gained 59 more pounds than the control mineral supplemented cattle. Carcass traits were similar for all cattle.

Introduction

Summer-grazing yearling cattle often offers relatively low cost of gain and thus can potentially lower the cost of producing beef. In some cases, summer gains can be increased by supplementing either energy or protein. After forages are mature and the protein content drops, gains will decrease because of protein deficiency. Some research has shown supplementing undegradable intake protein (UIP) can enhance gains in lush green pastures even though crude protein may be relatively high. Energy supplementation has the potential of increasing gain, however supplementing with high starch grains such as corn may interfere with forage digestion. Less is known about the effect of supplementing fat to yearlings grazing grass, but it could serve as an energy source without adversely affecting forage digestion if fed at low levels.

When gain is increased on grass, the level of compensation in the feedlot by the slower gaining cattle often offsets at least a portion of the previous advantage for the faster gaining cattle. The level of compensation is difficult to predict but is very important when considering the total production system.

The objectives of this experiment were to: 1) evaluate steer performance while grazing summer pasture when either supplemented with a commercial mineral or fat and/or protein in a prepared tub and to evaluate weekly intake of the supplements, 2) evaluate feedlot performance and carcass characteristics of cattle after the grazing period.

Procedure

Grazing Phase

Ninety head of primarily Angus steers weighing an average of 662 lbs were used in this 113-day summer grazing trial. The three supplemental treatments used were: 1) salt/mineral supplementation, 2) a 250 lb tub containing 40% protein (29% NPN - 19% from biuret), and 3) a 250 lb tub containing a combination of protein and fat. Initially the combination tub contained 20% protein (6.7% NPN) and 20% fat, and after the first 28 days the fat level was lowered to 15%. Primary ingredients for the 40% tub were distillers' grains and solubles. Fat was added using soy acid oil. Nine 105-acre pastures, which consisted of primarily crested wheatgrass (80-85%) with some buffalo and blue gramma grass dispersed throughout the pastures, were used. The nine pastures were arranged in three blocks (three pastures in a block), and one of three treatments was randomly assigned to one pasture within a block. The steers were then rotated within the pasture block every 28 days in an effort to avoid pasture (location) effect on the supplemental treatments.

The steers were weighed on two consecutive days at the initiation and conclusion of the grazing trial and once at 28 day intervals. The first initial weight was used to assign the steers into 10 weight groups from the heaviest nine steers to the lightest nine steers. The heaviest nine steers were then randomly allotted to the nine pastures followed by the next heaviest to the lightest group. After the allotment was complete in each weight group, the nine groups were randomly assigned to the nine pasture groups. All cattle were implanted with Synovex-S and tagged with a fly tag at the initiation of the trial.

Each supplement was weighed weekly and daily average supplement consumption was calculated. Forage samples were hand clipped every 14 days and were analyzed for crude protein, ADF plus other nutrients. Pumped well water was provided from one source in water tanks.

The placement of the tubs and weather vain mineral feeders containing the mineral was varied from the water location and was used to aid in the control of the level of the supplement intake.

Table 1. Performance of summer grazing yearling steers and supplemented with either minerals, protein or protein and fat.

	Supplement[a]		
	Salt/Mineral	Protein	Protein/Fat
No. Steers	30	29	30
No. Pastures	3	3	3
Live weights, lb			
Initial, 5/24	670	659	658
Final - 9/13	822	883	857
ADG, lb			
Period 1 - 28 day	2.91	3.38	3.17
Period 2 - 28 day	1.27	1.68	1.90
Accum. 56 day	2.09	2.53	2.53
Period 3 - 28 day	1.30	1.52	1.26
Accum. 84 day	1.83	2.19	2.11
Period 4 - 28 day	-0.06	1.43	0.76
Overall 5/24-9/13	1.36[b]	2.00[c]	1.77[d]

[a]Supplements were: Mineral - commercial mineral; Protein = 40% crude protein - 29% NPN - 19% from biuret; Protein/fat = Protein content is 20% (NPN 6.7%) fat was 20% up to 28 days and then was 15%.
[bcd]Means with different superscripts are different (P < 0.10).

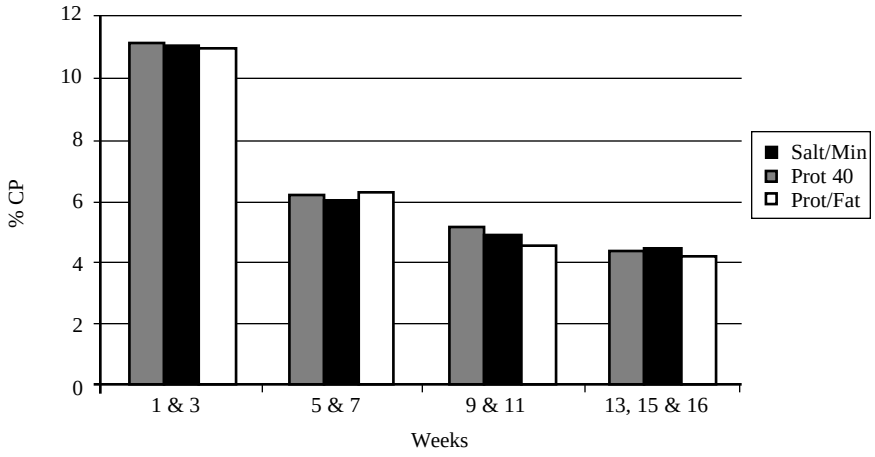

Figure 1. Forage crude protein over time for treatment pastures.

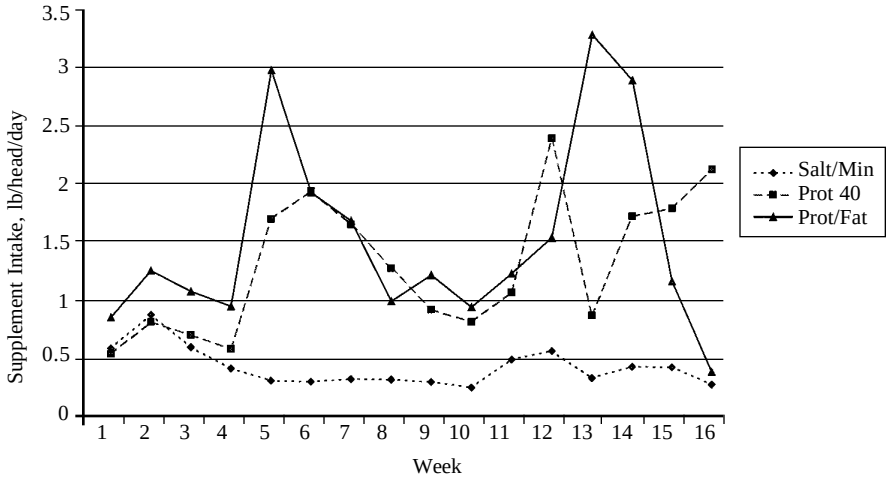

Figure 2. Weekly supplement intake.

Finishing Phase

After the cattle had summer grazed for 113 days they were shipped to the Panhandle Research and Extension Center for finishing on a common high grain diet. The final fall weights off of grass were used for the initial weight on feed. Upon arrival they were implanted with Synovex-S and vaccinated with a four-way modified live viral vaccine (IBR, BVD, PI_3 and BRSV) and back poured for external parasites. After 84 days on feed they were implanted with Synovex+. At the end of the finishing period they were weighed just prior to shipping to slaughter. The final finishing weight was determined by dividing final carcass weight by a standard dressing percentage (62).

Results

Grazing Phase

All cattle gained at a very high level the first 56 days of the trial when the forages were of high quality and some compensatory growth was achieved (Table 1). Cattle supplemented with protein only and protein plus fat gained at a higher level than those supplemented with the salt/mineral mix at 28, 56, 84 days and overall on the experiment. Protein alone produced slightly higher gain than the protein fat combination overall, however these differences occurred during the latter part of the grazing period when forages were very low in protein. There were major advantages of the protein supplements during the last 28 days of the experiment (Aug. 16 to Sept. 13) when the average protein content of the clipped grass samples was approximately 4% crude protein (Figure 1). Most likely the cattle selected a diet slightly higher in protein content than the clipped sample, however they still were protein deficient as was evident when no gain was achieved in the salt/mineral control supplement. The protein content of the grass was very low because of lack of rainfall in the late summer and fall of the grazing period. Also, the predominant forage was crested wheat grass, a cool season grass which loses nutrient

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content very rapidly after it reaches maturity. Also, the cattle had little ability to select from the forages available as the small amount of warm season grasses were grazed out earlier and only mature crested wheat grass was available. There was considerable quantity of standing forage available the entire grazing period.

Clipped samples of forages were relatively high in protein the first two weeks of grazing (Figure 1) then dropped to 5-6% crude protein on July 5, and afterwards ranged from 4-6% the remainder of the trial. Because considerable green growth was present during midsummer, it is probable that cattle were selecting a higher quality diet than the clipped samples indicated resulting in a smaller magnitude of protein response than was experienced the last 28 day period.

Supplement intake was somewhat variable throughout the trial from week to week. The differences in intake are not totally understood; however, they are very similar to intake variation encountered in these experimental pastures in previous years with various supplements. Initially, the mineral supplement consumption was very high so salt was offered free choice to aid in lowering the consumption of the commercial mineral.

Overall, the consumption of protein tub averaged 1.31 lb/head/day giving a crude protein intake level of 0.52 lb per steer daily. Of the 0.52 lb of crude protein, NPN accounted for 0.38 lb giving 0.14 lb of natural protein supplementation daily. There was a trend for the cattle to consume lower levels of protein in the earlier grazing season and increasing in the latter part (Table 3). The consumption of the combination protein/fat supplement averaged 1.52 lb per steer daily. This provided 0.30 lb of crude protein (0.10 lb from NPN) and approximately .20 lb of supplemental fat daily. The effect fat supplementation had on gain is not certain. It appears the limiting nutrient was protein because the cattle gained faster on the higher protein supplement.

Table 2. Performance of steers finishing on common diet after grazing period.

	Summer Supplement		
	Salt/Mineral	Protein	Protein/Fat
Summer ADG, lb	1.36	2.00	1.77
On feed wt, lb	822	883	857
Finishing weight[a], lb	1329[d]	1377[e]	1376[e]
Daily gain, lb	3.50	3.41	3.58
DM intake, lb	24.0	24.6	24.3
Feed (DM)/gain	6.86	7.21	6.79
Overall ADG[b], lb	2.55[d]	2.79[e]	2.78[e]
Carcass Characteristics			
Carcass wt, lb	824[d]	854[e]	853[e]
Dressing percentage	62.5	62.9	62.1
Fat, in	.58	.54	.56
Marbling[e]	4.3	4.5	4.4
Rib eye area, sq in	12.4	12.2	12.6
Percent > Select[+]	63	90	83

[a]Final weights were adjusted to a standard 62 percent dressing percent.
[b]Daily gain from starting on grass (May 16 - 113 days) to finish (Feb. 5 - 145 days).
[C]Marbling score of 4.0 = small[o].
[de]Means with different superscripts are different (P < 0.010).

Table 3. Supplement intake of summer grazing yearling steers supplemented with either salt/mineral, protein or protein and fat.

	Supplement[a], lb		
	Salt/Mineral	Protein	Protein/Fat
Consumption			
Period 1	0.63	0.67	1.04
Period 2	0.32	1.64	1.89
Period 3	0.41	1.30	1.23
Period 4	0.37	1.62	1.92
Overall	0.43	1.31	1.52

[a]Supplements were: Mineral - commercial mineral; Protein = 40% crude protein - 29% NPN - 19% from biuret; Protein/fat = Protein content is 20% (NPN 6.7%) fat was 20% up to 28 days and then was 15%.

Finishing Phase

Gains in the feedlot were not different for the steers regardless of previous summer gain (Table 2). The cattle previously supplemented with either protein or protein/fat gained at the same rate while on the finishing ration. There was a slight trend (P = 0.29) for the fastest gaining steers on grass that were supplemented with only protein to gain at a slightly lower rate than the other two summer treatment groups and they appeared to be slightly less efficient in feed conversion (P = 0.21). The level of compensation of the control group versus the summer protein supplemented group was only 2.6% which is much lower than found in most other studies. The cattle supplemented with fat and protein gained the same as the control group in the feedlot even though they came in the feedlot 47 lb heavier.

Overall, from the initiation of the grazing phase to finished weight, cattle supplemented with either protein or protein/fat during the summer gained 59 lb more than the control group and yielded an additional 30 lb of carcass weight. The additional carcass weight could be used to offset the added cost for the summer supplements.

Carcass traits were similar for all treatments. There appeared to be more cattle grading low choice and above for the summer supplemented cattle, however marbling scores were not different.

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Subsequent Summer Forage Intake Following Winter Gain Restriction

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Steers wintered at reduced gains compensated 17% and 48% in years 1 and 2, respectively. Increased forage intake, as a percentage of body weight, explained the compensation.

Summary

Data were collected to determine effect of winter gain on forage intake and summer and finishing performance of yearling steers. Steers wintered at reduced gains compensated 17 and 48% over two years. Intake, as a percentage of body weight, was increased for compensating steers. Steers gaining faster in winter had a reduced breakeven ($67.01 vs 70.05/cwt) and were more profitable ($5.79 vs -31.32/head) compared to slower gaining steers. Growing animals at faster (1.50 - 1.65 lb/day) compared to slower (0.45 - 0.55 lb/day) rates of winter gain is superior unless 65%-70% compensation is achieved.

Introduction

Feeding beef cattle near maintenance, especially during the winter when harvested feeds are required, is often encouraged by studies that indicate cattle will increase gain during the next phase of production. However, conclusions regarding mechanisms surrounding the increased gain are ambiguous. Reduced maintenance requirements, increased feed intake, and/or changes in the composition of tissues are most commonly implicated. On lush forage, a reduction in maintenance energy requirements and an increase in forage intake relative to body weight are likely key factors. Perhaps increasing intake, as a percentage of body weight, dilutes the maintenance energy requirements sufficiently to account for at least some of the compensation typically observed.

The objectives of this research were to evaluate the effect of winter gain on subsequent forage intake and summer and finishing performance of yearling steers. Additionally, slaughter breakeven and profitability were evaluated.

Procedure

Two years of data were collected. In year one, 80 medium-framed British-breed steers were allowed a 28-day receiving and weaning acclimation period and allotted randomly to one of eight feedlot pens (10 head/pen). In year two, 64 medium-framed British-breed steers were allowed a 28-day receiving and weaning period and allotted randomly to one of eight feedlot pens (eight head/pen). A feedlot pen was then assigned randomly to treatment. The treatment arrangement was a $2 \times 2 \times 2$ factorial with year, rate of winter gain, and summer location as factors. In the winter of year one, 40 steers (four feedlot pens) were assigned to a 'slow' rate of winter gain (SLOW), while the remaining 40 steers (four feedlot pens) were assigned to a 'fast' rate of winter gain (FAST). In years one and two, following the winter period, two pens from both the FAST and SLOW winter treatments were assigned to graze either native warm-season Sandhills range near Stapleton, Neb., or smooth bromegrass near Mead, Neb. Following summer grazing, steers were placed in the feedlot for finishing.

All steers were implanted with Compudose before summer grazing, and re-implanted with Revalor-S at the onset of finishing. Steers were slaughtered when visual appraisal indicated they had reached 0.5 in fat thickness over the 12th rib. Initial and final weights for all periods of the system were based on two-day consecutive weights following five days of limit feeding 50% alfalfa and 50% wet corn gluten feed at 2% of body weight (DM basis). Slaughter weights were calculated assuming a common dressing percentage (63%). Hot carcass weights were taken at slaughter, and fat thickness at the 12th rib, quality grades, and USDA yield grades were recorded following a 48-hour chill. Slaughter breakeven and profit/loss were calculated in order to determine which treatment was economically superior.

Wintering Period

In each of the two years, steers were managed in two groups. Group 1 (SLOW) grazed corn residues and were supplemented with 1.8 lb/head/day of a sunflower meal-based supplement for approximately 98 days (Phase I). For the remainder of the winter period, steers on the SLOW treatment were allowed ad-libitum access to grass hay and a mineral supplement for 65 days (Phase II). For the FAST treatment, steers grazed corn residues and received 5.0 lb/head/day (DM basis) of wet corn gluten feed with a mineral supplement for 98 days. For the remainder of the winter period, steers received ad-libitum grass hay and 5.0 lb/head/day (DM basis) of wet corn gluten feed with a mineral supplement for approximately 65 days.

Summer Period

In year one, twenty steers from each of the FAST and SLOW treatments were shipped to either native warm-season grass pastures near Stapleton, Neb. or grazed smooth bromegrass near Mead, Neb. In year two, methods were the same; however, each treatment contained

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16 head of both FAST and SLOW steers. In both years, steers were on pasture for 123 days.

Finishing Period

In both years, steers were adapted to the final finishing diet in 21 days using four step-up diets containing 45%, 35%, 25%, and 15% roughage. Diets were fed for three, four, five, and five days, respectively. The final diet (7.5% roughage) was formulated to contain a minimum of 12% CP, 0.7% Ca, 0.35% P, 0.6% K, 30 g/ton Monensin, and 10 g/ton Tylosin (DM basis).

Intake Determination

Procedures in years 1 and 2 were similar. Alteration of procedures between years will be noted, otherwise it should be assumed they were similar.

Year 1. Forage intake of 40 steers (20 steers/location, 10 steers/treatment) was measured in two four-day periods in May, two four-day periods in June, and two five-day periods in August. Fecal grab samples were collected for five days following administration of an intraruminal slow-release Cr bolus. Steers were allowed five to six days following administration of the bolus before fecal grab sampling was initiated in an attempt to assure that a steady state of chromium release was present.

Forage diet samples were collected in year one using two ruminally fistulated steers at the Sandhills location, and three steers at the bromegrass location. Forage diet samples were collected on days two and four of the respective intake period.

Year 2. Forage intake of 32 steers (16 steers/location, eight steers/treatment) was measured in two seven-day intake periods. The first intake period was conducted in May and the second intake period was in July. Fecal grab samples were collected for five days following administration of the intraruminal slow-release Cr bolus. Steers were allowed five to six days following administration of the bolus before fecal grab sampling was initiated in an attempt to assure that a steady state of chromium release was present.

Forage diet samples were collected using three ruminally fistulated steers at each location. Forage diet samples were collected on days two and four of the respective intake period.

Because each year had a different number of intake periods, the two intake periods in May for year 1 were averaged and analyzed as period 1 for year 1. The May intake period in year 2 was analyzed as period 1 for year 2. The two June and two August intake periods in year 1 were averaged and analyzed as period 2 for year 1. The July intake period in year 2 was analyzed as period 2 for year 2.

Forage intakes were measured using an orally dosed intraruminal continuous Cr-releasing bolus. At each location, five steers were used in a total fecal collection to validate the release rate of the Cr bolus. Steers were dosed with intraruminal continuous Cr-releasing devices from the same batch as those administered to steers used for intake determination. Steers were then fitted with fecal collection bags for total fecal collection to determine a correction factor for fecal output. Intake was then estimated by dividing fecal output by indigestibility of the forage diet.

Economic Analysis

Differences between systems in input costs will be noted, otherwise it should be assumed that inputs were similar. For initial steer cost, average weight of a pen was multiplied by the USDA 1992-1999 average October calf price ($82.57/cwt.) for 500-550 lb feeders. Health and processing for the winter period were charged at $8.33/head. Simple interest was charged on initial animal cost and health for the entire ownership period. All interest charges discussed herein were based on a simple 9.8% rate.

The two treatments were charged a stalk charge of $0.12/head/day during phase I. Interest was charged for half of the stalk grazing period and for half the supplements plus the remainder of ownership.

During phase II, all steers were fed grass hay ad-libitum. Intake of the groups was monitored for cost calculations (12.3 and 15.3 lb/head/day [as-is] for FAST and SLOW, respectively). Grass hay was priced at $40.00/ton (as-is). Interest was charged on all feed ingredients for both treatments for half of phase II plus the remainder of ownership. Stalk yardage was charged at $0.12 and 0.10/head/day for FAST and SLOW, respectively. Yardage charge differences were the result of increased feeding costs associated with wet corn gluten feed compared to the SLOW group. In addition, drylot yardage was charged at $0.24 and 0.22/head/day for FAST and SLOW, respectively. Interest was charged on drylot yardage for half of the respective period plus the remainder of ownership. Total winter costs, including 1% death loss, were the sum of steer purchase price with the appropriate health, feed, yardage, and interest charges.

For summer costs, grazing was charged at the rate of $0.50/head/day and interest was charged for half of the grazing period plus the remainder of ownership. Total summer costs included $8.33/head for health, 0.5% death loss, and the appropriate grazing and interest charges for the summer period.

Finishing costs included both feed and yardage. For feed, DM intake for a pen was determined and a diet cost of $115.14/ton (DM basis) applied. Feedlot yardage was applied at $0.30/head/day. Interest was charged on feed and yardage costs for half of the feeding period. Total steer cost was the sum of steer, winter, and summer costs, plus finishing costs which included health ($8.33/head), 0.5% death loss, feed, and yardage costs. To calculate slaughter breakeven, total cost was divided by slaughter weight.

For all supplemental ingredients, prices were generally determined based on actual prices paid for those ingredients by the University of Nebraska Feed Mill over the period of one year with a 5% handling fee. Supplemental ingredients included all ingredients used in the winter protein and mineral supplements, and the supplemental ingredients used in the finishing diet. Wet corn gluten feed and high-moisture corn were charged on an equal dry basis, and price was determined using 10-year average corn price for Nebraska of $2.48/bushel (as-is). A

Table 1. Steer performance and carcass data.

	Year 1		Year 2	
Item	FAST	SLOW	FAST	SLOW
Winter				
Days	163	163	163	163
Initial wt., lb	499	495	539	548
ADG, lb[a]	1.69[b]	0.68[c]	1.52[b]	0.20[c]
Summer				
Days	123	123	123	123
Initial wt., lb[a]	772[b]	609[c]	785[b]	576[c]
ADG, lb[a]	1.10[b]	1.32[c]	1.14[b]	1.96[c]
Finishing				
Days	85	112	101	101
Initial wt., lb[a]	906[b]	772[c]	928[b]	823[c]
ADG, lb[d]	4.53	4.16	4.18	4.03
DM intake, lb/d[d]	31.5	28.6	29.7	28.2
Feed/gain	6.94	6.90	7.09	6.99
Slaughter wt., lb[ae]	1296[b]	1236[c]	1353[b]	1228[c]
Carcass				
Wt., lb[a]	816[b]	779[c]	851[b]	772[c]
Yield grade	2.66	2.82	2.72	2.57
Fat depth, in	0.48	0.50	0.52	0.49
Quality grade[f]	19.3	19.1	19.5	19.2

[a]Year × treatment interaction ($P < 0.05$).
[bc]Means within a year and within a row with unlike superscripts differ ($P < 0.05$).
[d]Significant winter treatment effect ($P < 0.05$).
[e]Calculated from hot carcass weight adjusted to a common dressing percentage (63).
[f]High Select = 18, Low Choice = 19, Average Choice = 20.

10% shrink, processing, and handling fee was applied to corn and wet corn gluten feed. Alfalfa in the finishing diet was priced based on 10-year average price in Nebraska of $60.59/ton (as-is) along with a $10.00/ton markup for grinding, handling, shrink, etc.

Results

Animal Performance and Carcass Data

Animal performance and carcass data are presented in Table 1. For the winter period, a year x treatment interaction ($P < 0.05$) was detected for ADG. In year 1, steers on the FAST treatment gained 1.69 lb/day compared to 0.68 lb/day for SLOW. In year 2, steers on the FAST treatment gained 1.52 lb/day compared to 0.20 lb/day for SLOW. The interaction may be explained by the differences in wintering conditions, meaning that steers on the SLOW treatment in year 2 were likely consuming lower quality corn residues (less downed corn in the fields) compared to steers on the SLOW treatment in year 1. A year × treatment interaction ($P < 0.05$) also was found for initial grass weight, which is a residual effect of the winter ADG interaction. The absolute weight difference between FAST and SLOW steers was 163 lb in year 1, and 209 lb in year 2, meaning sufficient weight differences were established in the winter period which allowed for the subsequent evaluation of compensatory growth on grass.

In terms of ADG on grass, another year x treatment interaction ($P < 0.05$) was found. In year 1, steers on the SLOW treatment gained faster ($P < 0.05$) compared to FAST. Gains were 1.32 and 1.10 lb/day for SLOW and FAST, respectively. Likewise in year 2, steers on the SLOW treatment gained faster ($P < 0.05$) compared to FAST (1.96 vs. 1.14 lb/day, respectively). Steers on the SLOW treatment made more compensatory growth in relation to the FAST treatment in year 2 compared to year 1. In year 2, steers on the SLOW treatment were more severely restricted compared to year 1. Steers on the SLOW treatment in year 1 compensated 17% in relation to FAST, whereas in year 2, steers on the SLOW treatment compensated 48% in relation to FAST.

For feedlot initial weight, a year × treatment ($P < 0.05$) interaction was found. The year × treatment interaction resulted from the additional compensation made by the SLOW steers in year 2 compared to year 1. In terms of feedlot performance, steers on the FAST treatment gained more ($P < 0.05$), consumed more feed ($P < 0.05$), but were equal in terms of feed efficiency (gain per lb of feed consumed) compared to steers on the SLOW treatment. For slaughter weight, a year × treatment interaction ($P < 0.05$) was again found. The slaughter weight difference between steers on the FAST and SLOW treatments in year 1 was less (59 lb) compared to year 2 (125 lb). In year 1, steers on the SLOW treatment had more days on feed in relation to FAST. In year 2, steers on the SLOW and FAST treatments were fed the same number of days.

In terms of carcass weight, a year × treatment ($P < 0.05$) interaction was found. The interaction for carcass weight simply reflects the same interaction in slaughter weight. No differences were found between FAST and SLOW treatments for fat depth, yield grade, or quality grade.

Forage Intake Data

Forage intake data are presented in Tables 2 and 3. Table 2 represents forage quality and matches within location, year, and period. In May in year 1, forage CP and OM digestibility were high; however, by July CP and OM digestibility had substantially declined. The same trend was evident in year 2; however, the decline in forage quality was not as great. Table 3 shows the forage intake data for treatments by period. No treatment differences were found in daily forage intake (lb/steer). For intake expressed as a percentage of body weight, a period × treatment ($P < 0.05$) interaction was found. In both intake periods, steers on the SLOW treatment consumed more OM as a percentage of body weight compared to steers on the FAST treatment, however, the difference was greater in May. An effect of location was found for both forage intake and intake as a percentage of body weight. Steers at the Sandhills location consumed more forage (16.7 lb/day;

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$P < 0.05$) compared to steers at the Mead location (11.7 lb/day). The increase in forage intake corresponded to increases in steer performance ($P < 0.05$) at the Sandhills location (1.69 lb/day) compared to the Mead location (1.08 lb/day); however, no interactions were detected between location and treatment for forage intake. Compensation by the SLOW treatment in relation to FAST was similar between locations. Despite differences in performance and forage intake due to the type of forage grazed, forage intake differences and compensation results were similar on different forages. By increasing DM intake (as a percentage of body weight) compensating animals consume more feed/unit of body weight, thereby diluting maintenance energy costs and allowing more energy for gain which supports our hypothesis.

The cattle weights and gains and forage qualities were used in the 1996 NRC Model to estimate the response to higher intakes as a percentage of body weight by the compensating cattle. Condition score was maintained constant at 5. In order to obtain the 1.12 lb/day gain of the cattle, it was necessary to increase intake in the model to 16 lb/day. This suggests our estimates of intake were about 2 lb/day low. The compensating cattle (SLOW) were predicted to gain 1.60 lb/day by the model — they gained 1.64 lb/day. This further supports our hypothesis that the higher intake as a percentage of body weight by compensating cattle explains compensation on grass.

Economic Analysis

Data from the economic analysis are presented in Table 4. Year × location interactions were evident for both slaughter breakeven ($P < 0.05$) and profit/loss ($P < 0.05$). Despite the interactions for slaughter breakeven and profit/loss, it is desirable to express breakeven and profitability in terms of treatment differences over the period evaluated as this is real in terms of producer profitability over time. Steers on the FAST treatment had a lower ($P < 0.05$) slaughter breakeven ($67.01/cwt.), compared to SLOW ($70.05/cwt.). For profit/loss, the FAST treatment

Table 2. Crude protein and in vitro OM disappearance of diet samples and OM intakes.

	Year 1		Year 2	
Item	Bromegrass	Warm/Season	Bromegrass	Warm/Season
May				
CP, %	20.7	14.6	20.0	13.2
IVOMD[a], %	69.0	70.4	69.5	60.9
OM intake				
lb/day[b]	11.4	18.7	11.4	14.9
% BW[c]	1.83	2.77	1.83	2.41
July				
CP, %	15.9	10.9	15.6	9.8
IVOMD[a], %	51.4	62.0	56.2	59.8
OM intake				
lb/day[b]	10.8	18.3	12.8	15.1
% BW[d]	1.64	2.42	1.86	2.14

[a]IVOMD = in vitro OM disappearance.
[b]SEM = .46.
[c]SEM = .079
[d]SEM = .078.

Table 3. Summer forage OM intake[a] and OM intake as a percentage of body weight[b]

Item	FAST	SLOW	SEM
May			
OM intake, lb	14.2	14.0	.46
% of BW[c]	1.93[d]	2.50[e]	.079
July			
OM intake, lb	14.7	13.7	.46
% of BW	1.89[d]	2.13[e]4	.078

[a]Forage OM intake is calculated from fecal output corrected by total fecal collection.
[b]Period × treatment interaction ($P < 0.05$).
[c]% of BW = Percentage of body weight.
[de]Means within row with unlike superscripts differ ($P < 0.05$).

Table 4. Costs and slaughter breakevens.

Item	FAST	SLOW
Steer costs, $/head	428.79	429.66
Health	25.00	25.00
Interest	46.22	47.86
Total	500.01	502.52
Winter costs, $/head		
Stalks	45.39	30.78
Drylot	57.35	37.39
Interest	7.98	5.53
Total	110.72	73.70
Summer costs, $/head		
Grazing	61.50	61.50
Interest	2.55	2.86
Total	64.05	64.36
Finishing costs, $/head		
Feed	169.09	174.14
Yardage	27.90	31.88
Interest	2.51	2.97
Total	199.49	208.98
Death loss, $/head	13.03	12.80
Total costs, $/head	887.30	862.36
Slaughter wt., lb[ab]	1324	1232
Break, $/cwt.[cd]	67.01[e]	70.05[f]
Profit/loss, $/head[d]	5.79[e]	-31.32[f]

[a]Year × treatment interaction ($P < 0.05$).
[b]Calculated from hot carcass weight adjusted to a common dressing percentage (63).
[c]Slaughter breakeven.
[d]Year × location interaction ($P < 0.05$).
[ef]Means within a row with unlike superscripts differ ($P < 0.05$).

improved profits ($5.79/head) compared to SLOW ($-31.32/head).

Production costs for steers on the SLOW treatment were less than costs for steers on the FAST treatment (Table 2). However, steers on the FAST treatment had lower slaughter breakevens and increased profitability. Correlation coefficients were obtained which indicated that slaughter weight tended to be negatively correlated ($P = 0.0867$) with slaughter breakeven and positively correlated ($P = 0.1041$) to profit/loss. Slaughter weight accounted for 20% and 18% of the variation in slaughter breakeven and profit/loss, respectively. In the absence of more compensatory gain and compounded by reduced feedlot performance, steers on the SLOW treatment were lighter at slaughter, and therefore contained less saleable weight in relation to the steers on the FAST gaining treatment.

Because compensation on grass is highly variable, calculations were made to determine how much compensation would be required to numerically equalize breakevens for the SLOW treatment compared to FAST. Because feedlot performance was similar for FAST and SLOW cattle, it was assumed to be the same for the compensating animals regardless of percent compensation. Approximately 65% compensation would be required on grass for the SLOW treatment to have a similar breakeven compared to FAST.

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Longitudinal Patterns of Fecal Shedding of *Escherichia coli* O157:H7 by Feedlot Cattle

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The percentage of cattle shedding *Escherichia coli* O157:H7 varied from 1% to 80% over the feeding period with every animal shedding the organism at least once.

Summary

To describe the prevalence, incidence, and duration of fecal shedding of E. coli O157:H7, 99 feedlot steers were individually tested each week of the feeding period for presence of E. coli O157:H7 in rectal feces. E. coli O157:H7 was recovered from each animal at least once during the study. Both the incidence and mean duration of shedding peaked during the middle of the feeding period. The percentage of cattle shedding E. coli O157:H7 ranged from 1% to 80% over the course of the feeding period and was affected by both the incidence and the duration of shedding.

Introduction

Studies of *Escherichia coli* O157:H7 in feedlot cattle have demonstrated that the organism is common within groups of feedlot cattle (*2001 Beef Report*, pp. 81-84, Elder et al., 2000. Proc Natl Acad Sci USA, pp. 2999-3003). In studies conducted in commercial feedyards we found the percentage of cattle shedding *E. coli* O157:H7 did not differ between the feedyards, but within feedyards the percentage of cattle shedding *E. coli* O157:H7 within a pen varied greatly (*2001 Beef Report*, pp. 81-84). Since each pen of cattle in that study was tested only once we were unable to monitor changes in prevalence over time. The objective of this study was to describe prevalence, incidence, and duration of fecal excretion of *E. coli* O157:H7 by a defined group of feedlot cattle over the course of the feeding period.

Procedure

The study was designed as a longitudinal study to monitor individual cattle for the presence of *E. coli* O157:H7 in rectal feces. One hundred steers were randomly assigned to 10 pens (10 animals each) upon arrival to the research feedyard at the Agricultural Research and Development Center, University of Nebraska-Lincoln, Ithaca, Neb. The steers were fed a high concentrate finishing diet for 136 days starting in June 2000. One animal was removed from the study during the seventh week because of its behavior. The cattle were tested once each week for 19 weeks. Feces were collected from the rectum of each animal in each pen while they were restrained in a handling chute. The samples were immediately transported to the University of Nebraska-Lincoln and tested for the presence of *E. coli* O157:H7. Culture methods were specific for the detection of *E. coli* O157:H7 in fecal specimens and included selective enrichment, immunomagnetic separation and confirmation of suspect isolates by standard methods (*2001 Beef Report*, pp. 81-84).

Incidence was defined as the number of cattle shedding *E. coli* O157:H7 whose feces had been culture negative the previous week divided by the number of animals that were culture

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negative the previous week. The duration of shedding was defined as the number of consecutive weeks an individual animal was shedding a detectable level of the organism. Each animal could have more than one incident of shedding over the course of the feeding period, each with its own duration. Prevalence was defined as the proportion of cattle shedding a detectable level of *E. coli* O157:H7 on any given sampling date.

On two of the sampling dates, weeks 11 and 17, the shedding status of many cattle was not reliably determined because the culture media may have contained inappropriate concentrations of antibiotics inhibiting isolation of the organism. These cattle were assigned values for the missing observations based on the culture results from the week before and after. Animals were considered positive for fecal shedding of the organism on those dates if *E. coli* O157:H7 was isolated from their feces both the week before and the week following and otherwise considered negative.

Results

E. coli O157:H7 was recovered at least once from the feces of each animal that completed the study. The point-prevalence of cattle shedding the organism ranged from 1% (1 animal) on the first sampling date, three days following assignment to pens, to 80% (80 animals) during the tenth week of the study (Figure 1).

The first seven weeks of the feeding period were characterized by low incidence (<0.1 new cases/animal-week) of fecal excretion of *E. coli* O157:H7 with short mean duration of shedding the organism (≤2.5 weeks). Over the feeding period, the incidence increased dramatically in week nine (0.5 new cases/animal-week), reached the highest rate in week 14 (0.7 new cases/animal-week), and gradually decreased during the last five weeks of the study (Figure 2). Because new cases of shedding were not described for the proportion of samples affected by the media in weeks 11 and 17, incidence may have been underestimated for those two weeks. The mean duration of fecal shedding was longest through the middle of the feeding period, with cases starting in weeks eight and nine lasting 4.7 and 4.8 weeks, respectively (Figure 2).

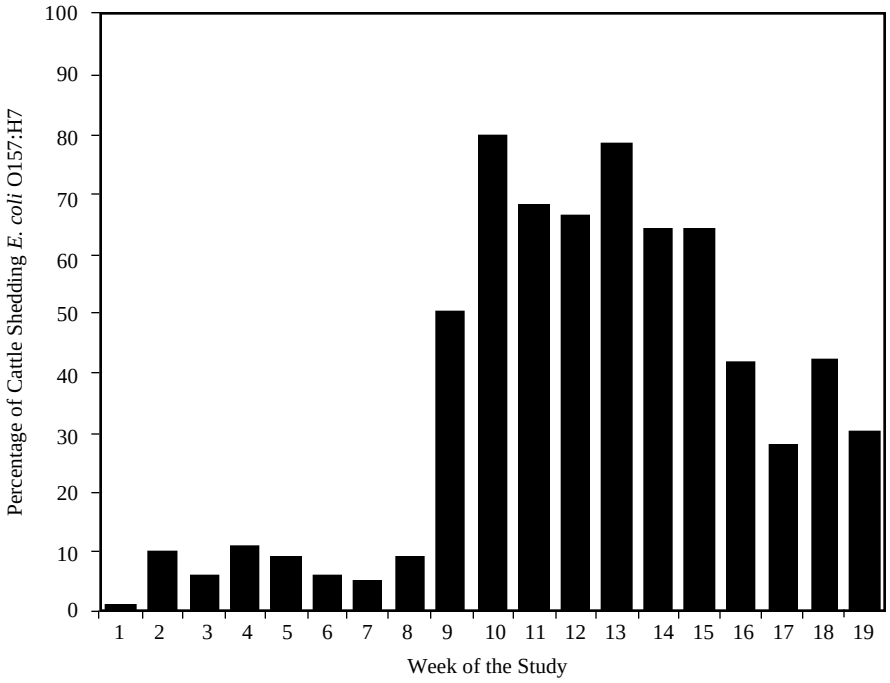

Figure 1. Percentage of cattle shedding a detectable level of *E. coli* O157:H7 during each week of the feeding period (June 2-Oct. 9, 2000).

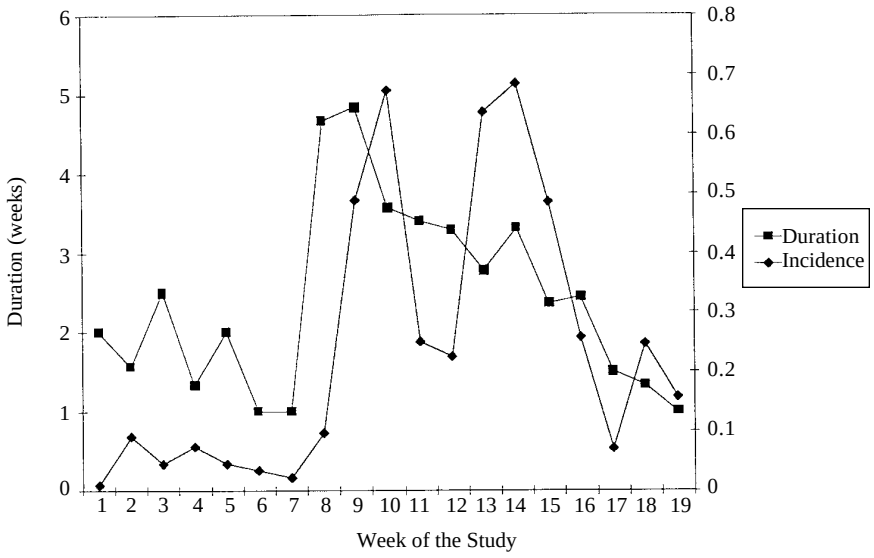

Figure 2. Incidence (new cases/animal-week) and duration (average number of consecutive weeks) of fecal shedding of *E. coli* O157:H7 by feedlot cattle for each week during the feeding period (June 2-Oct. 9, 2000).

On the last sampling date, 30% of the steers were excreting a detectable level of *E. coli* O157:H7 in their feces and these animals had been shedding the organism for a mean of 3.4 weeks. On this date, at least one animal was shedding the organism in nine out of the 10 pens. Ninety percent of the animals in one pen, 40% of the animals in three pens, 30% of the animals in one pen, 20% of the animals in two pens, and 10% of the animals in two pens were culture positive for *E. coli* O157:H7.

The prevalence of fecal shedding of a detectable level of *E. coli* O157:H7 within a given group of feedlot cattle varied widely over the feeding period and the variability in prevalence was a function of changes in both incidence and duration of fecal shedding.

E. coli O157:H7 appeared to be ubiquitous to this group of cattle since the organism was recovered at least once from each animal and the organism was detected from at least one animal every week of the study. It is interesting that the range of prevalence for cattle shedding *E. coli* O157:H7 in this longitudinal study was nearly identical to the range of prevalence we previously observed in a cross-sectional study of commercial feedlot cattle (*2001 Beef Report*, pp. 81-84). Identifying the factors that explain the difference between groups of cattle with high or low prevalence may be useful for devising a control strategy on farms to enhance food safety. Some of those factors may vary with time just as the prevalence of shedding does. Additional studies are in progress to identify time-dependent factors that explain fecal shedding of *E. coli* O157:H7 by feedlot cattle.

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Implant Programs for Feedlot Heifers using Synovex® Plus™, Revalor®-H, or Finaplix®-H with MGA

Casey Macken
Todd Milton
Bill Dicke[1]

Implanting feedlot heifers with Synovex Plus increases ADG and hot carcass weight but decreases grade compared to heifers implanted with Revalor-H or Finaplix-H and fed MGA.

Summary

A commercial feedlot experiment was conducted using 1,558 heifers to evaluate the effects of implant programs on finishing heifers. Implanting with Synovex Plus increased ADG and hot carcass weight compared to heifers implanted with Revalor-H or Finaplix-H and fed MGA. Heifers implanted with either Synovex Plus or Revalor-H had increased DMI compared to heifers implanted with Finaplix-H. Marbling score was influenced by each of the implant treatments, being highest for Finaplix-H followed by Revalor-H and Synovex Plus.

Introduction

In finishing heifer implant programs, the final implant (administered approximately 100 days prior to harvest) generally contains trenbolone acetate (TBA) or a combination of estradiol (E_2) and TBA. Along with these implants melengestrol acetate (MGA) can be fed to enhance the activity of TBA. Implants commercially available that contain TBA or the combination of E_2 and TBA are Finaplix-H (200 mg of TBA), Revalor-H (14 mg of E_2 and 140 mg of TBA), and Synovex Plus (28 mg of estradiol benzoate (20 mg of E_2) and 200 mg of TBA). Within these implants, dosage, combination of hormones, and carrier of active ingredients differ and may alter growth promoting activity. Objectives of this trial were to compare performance, carcass characteristics, and feeding economics in heifers implanted with Finaplix-H, Revalor-H, or Synovex Plus and fed MGA.

Procedure

The experiment was conducted between the dates of Jan. 11, 2000 and Aug. 3, 2000 using 1,558 heifers (761 lb) in a randomized block design. Heifers were kept separate by truckload following unloading and were weighed. Heifers from the separate truckloads were randomly assigned to one of three implant programs, one by one, using a gate sort into one of three arrival pens and then assigned to one of 18 home pens (six replications/treatment). Treatments were heifers terminally implanted with 1) Finaplix-H, 2) Revalor-H, or 3) Synovex Plus with all treatments receiving MGA supplementation. The finishing diet was formulated to provide 0.4 mg of MGA/head/d. Within a block, all heifers arrived at the feedyard at the same time. After sorting, pens were reweighed, processed, and moved to their home pen. During processing, heifers were vaccinated for viral diseases (BoviShield® 4, Pfizer Inc,), treated for internal and external parasites (Dectomax®, Pfizer Inc,), implanted with Ralgro®, and given a lot tag for identification.

Heifers were reimplanted with their respective treatment of Finaplix-H, Revalor-H, or Synovex Plus following

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45 (range 35 to 58 days) days on feed. Heifers were exposed to their final implant for an average of 95 days across replications (range 84 to 108). Heifers were not fed MGA in the adaptation diets (first 18 to 20 days on feed). The final diet contained 48.0% steam-flaked corn, 27.0% dry-rolled corn, 9.0% supplement, 7.5% alfalfa hay, 5.5% corn steep liquor, and 3.0% fat, and was formulated to contain 13.7% CP, 7.0% crude fat, 0.77% Ca, and 0.37% P. Heifers were fed an average of 139 days (range 127 to 166).

Initial weights were determined by prorating each arrival treatment pen weight back to the total of the group of heifers within block and adjusted to pay weight. For example, shrink (positive or negative depending upon the source of cattle) would be applied to the cumulative off-truck weight of all heifers within a block to determine pay weight for the entire group. The weight of individual pens, after heifers were sorted into arrival treatment pens, was divided by the cumulative weight of all three arrival treatment pens. The total pay weight for the entire group was multiplied by this percentage to calculate the initial starting (pay weight) weight for each home treatment pen. Final live weights were determined on a treatment pen just prior to shipment, and shrunk 4%. Final live weights were obtained under identical weighing conditions for each treatment pen within a block. Carcass weights also were used and adjusted to a common dressing percentage of 63% to calculate daily gain and feed conversion on a carcass-adjusted basis.

All pens within a block were harvested under identical conditions. Hot carcass weights were recorded on the day of harvest. Carcass fat thickness, marbling score, KPH fat, longissimus muscle area, and USDA quality grade were recorded following a 24- to 48-hour chill.

The economic influence of the implant treatments was determined using the ration cost at the feedyard during the period the experiment was conducted. The ration cost used in the analysis includes markup. Nonfeed costs (medicine, processing, etc.) were calculated for each pen of heifers in the experiment and averaged. This average nonfeed cost was applied to each pen of heifers for calculation of cost of gain and net return. Final heifer value was calculated by using a live price, dressed price, or a carcass-merit price based on individual heifer carcass value. Carcass value was calculated based on USDA quality grade, calculated yield grade, carcass weight and nonconformance (i.e. dark cutters). A carcass base price of $111/cwt was used for low Choice, yield grade 3 carcasses weighing 550 to 950 lb. Discounts were calculated as: $10, Select; $20, Standard; $30, dark cutters; $25,

Table 1. Effect of implant strategy on performance and carcass characteristics in finishing heifers.

	Implant Strategy[a]			
Item	PLUS MGA	REV MGA	FIN MGA	SEM[b]
Number of pens	6	6	6	
Number of heifers	523	519	516	
Days on feed	139	139	139	
Initial weight	760	761	760	3.0
Final weight[c]	1250[d]	1235[e]	1232[e]	4.2
Dry matter intake	20.3[d]	20.1[d]	19.5[e]	0.2
Daily gain, lb	3.52[f]	3.39[g]	3.38[g]	0.05
Feed/gain	5.76	5.94	5.77	0.09
Carcass weight, lb	787[d]	778[e]	776[e]	2.7
12th rib fat, in.	0.53	0.54	0.54	0.01
Longissimus muscle area, sq. in.	14.5[f]	14.2[f]	14.0[g]	0.1
Calculated yield grade	2.6	2.7	2.7	0.1
Marbling score[i]	5.26[f]	5.38[g]	5.48[h]	0.04
Quality grade distribution, %				
Prime	1.9	1.4	2.8	0.5
Upper 2/3 Choice	16.1[d]	21.7[e]	24.0[e]	3.2
Low Choice	37.1	42.4	40.5	3.1
Select	41.8[f]	29.8[g]	25.9[g]	2.9
Standard	3.1	1.4	1.4	0.7
Dark cutters, %	1.2	2.0	0.0	0.8

[a]PLUS = Synovex Plus, REV = Revalor-H, and FIN = Finaplix-H.
[b]SEM = Standard error of the mean.
[c]Final weight calculated as hot carcass weight divided by .63 (common dressing percentage).
[d,e]Means within a row with different superscripts differ (P < .10).
[f,g,h]Means within a row with different superscripts differ (P < .05).
[i]Marbling score: 4.0 = Slight; 4.5 = Slight 50; 5.0 = Small; 5.5 Small 50; etc.

Table 2. Effects of implant program on feeding economics of finishing heifers.

	Implant Strategy[a]			
Item	PLUS MGA	REV MGA	FIN MGA	SEM[b]
Ration cost[c], $/ton	131.50	131.50	131.50	
Cost of feed, $/head	185.36[d]	183.59[d]	178.27[e]	1.6
Total feeding cost, $/head	194.24[d]	192.95[d]	187.32[e]	1.6
Cost of gain, $/cwt	39.74	41.09	39.85	0.65
Carcass price[f], $/cwt	107.56[d]	108.62[de]	109.51[e]	0.5
Profit(loss)[g], $/head				
Live basis	62.77	54.15	61.73	5.0
Dressed basis	86.91	76.42	81.11	4.7
Carcass merit basis	59.90	58.19	70.37	5.3

[a]PLUS MGA = Synovex Plus fed MGA, REV MGA = Revalor-H fed MGA, and FIN MGA = Finaplix-H fed MGA.
[b]SEM = Standard error of the mean.
[c]Includes feed mark-up.
[d,e]Means within a row with different superscripts differ (P < .05).
[f]Calculated using a $111/cwt carcass base price: discounts = $10, Select; $20, Standard; $15, yield grade 4 and 5; $30, dark cutter; premiums = $8, Prime; $3, upper 2/3 Choice; $3, yield grades 1 and 2.
[g]Initial animal cost = $78/cwt; animal returns based on $70/cwt live price, $111/cwt carcass price, or calculated carcass value, respectively, interest not included.

light (<550 lb) and heavy (>950 lb) carcasses; and $15, yield grades 4 and 5. Premiums were calculated as: $8, Prime; $3, upper 2/3 Choice; and $3, yield grades 1 and 2.

Performance, carcass, and economic data were analyzed as a randomized block design using SAS. Least squares means were separated using the Least Significance Difference method when a significant (P < 0.10) F-test was detected. Variables were considered significant when probability values less than 0.10 were obtained.

Results

Data are presented with deads and chronics removed from the analysis. Feed intake and total head days were adjusted on a pen basis when deaths occurred or chronic cattle were sold before their home pen was. Feed intake and head days were adjusted one day prior to the removal of the animal from the pen as either a dead or chronic.

Effects of implant programs on performance of finishing heifers implanted with Finaplix-H, Revalor-H, or Synovex Plus supplemented with MGA are shown in Table 1. Dry matter intake was higher (P < 0.05) for heifers implanted with Synovex Plus or Revalor-H compared with those implanted with Finaplix-H. On a carcass-adjusted basis, heifers implanted with Synovex Plus as the final implant gained 4.2% (P< 0.10) faster than heifers implanted with Revalor-H or Finaplix-H as the final implant. This resulted in 17 lb heavier (P < 0.05) carcass-adjusted final weight for Synovex Plus heifers compared to Revalor-H and Finaplix-H heifers. Carcass-adjusted daily gain of heifers implanted with Revalor-H or Finaplix-H was similar. Live performance daily gain, final weight, and feed conversion were similar among implant treatments.

Carcass characteristics are presented in Table 1. Hot carcass weight was 10 lb or 11 lb heavier (P < 0.05) for heifers implanted with Synovex Plus compared with heifers implanted with Revalor-H or Finaplix-H, respectively. Hot carcass weight was similar for heifers implanted with Revalor-H or Finaplix-H. Dressing percentage tended (P = 0.13) to be significant among treatments. Longissimus muscle area was larger (P < 0.05) for heifers implanted with Synovex Plus compared with Finaplix-H, with Revalor-H being intermediate. Twelfth rib fat thickness and KPH fat were similar among treatments. Calculated yield grade was similar among treatments. Marbling score was lower (P < 0.10) for heifers implanted with Synovex Plus compared to those implanted with either Revalor-H or Finaplix-H. Revalor-H implanted heifers had a lower marbling score than Finaplix-H heifers. The percentage of carcasses grading USDA upper 2/3 Choice was lower (P < 0.05) and percentage of carcasses grading USDA Select was higher (P < 0.10) for heifers implanted with Synovex Plus compared to those heifers implanted with Revalor-H or Finaplix-H. Carcasses grading USDA Standard and the incidence of dark cutting carcasses were similar among treatments.

A summary of the economic analysis is provided in Table 2. Cost of gain was similar among treatments. Cost of feed and total feeding cost were (P < 0.05) less for those heifers implanted with Finaplix-H compared to heifers implanted with Synovex Plus or Revalor-H which is due to the decreased intake of Finaplix-H implanted heifers. Carcass price, calculated on individual carcasses using a grid for premiums and discounts as discussed previously in this report, for heifers implanted with Finaplix-H were higher (P < 0.05) compared to those heifers implanted with Synovex Plus, while Revalor-H implanted heifers were intermediate. Net return on a dressed basis price tended to be improved (P = 0.15) by $10.49 per head for those heifers implanted with Synovex Plus compared to Revalor-H. Net return on a carcass-merit basis tended to be improved (P = 0.20) by $10.47 or $12.18 per head for those heifers implanted with Finaplix-H compared to Synovex Plus or Revalor-H, respectively.

These data suggest implanting with Synovex Plus increases ADG and hot carcass weight compared to implanting with Revalor-H or Finaplix-H when MGA is fed. When MGA is fed, marbling score decreases with Synovex Plus compared to Revalor-H or Finaplix-H implants. Finally, implanting with Revalor-H decreases marbling compared to Finaplix-H. Part of the data from this experiment has been pooled with data from two other experiments reported in the following report (*2002 Nebraska Beef Report* pp. 34-35).

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Summary of Implant Programs for Feedlot Heifers using Synovex® Plus™ or Finaplix®-H with MGA

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Implanting feedlot heifers with Synovex Plus and fed MGA increases ADG, DMI, and hot carcass weight but decreases grade compared to heifers implanted with Finaplix-H and fed MGA.

Summary

Data from three feeding trials conducted in commercial feedlots designed to evaluate implant programs for finished heifers have been summarized. Implanting with Synovex Plus and feeding MGA improved ADG by 4.4% compared to implanting with Finaplix-H and feeding MGA resulting in 10 lb heavier carcasses. Heifers that were implanted with Synovex Plus had increased DMI compared to those implanted with Finaplix-H. Percentage of heifers grading Choice or above was lower for those heifers implanted with Synovex Plus compared to Finaplix-H, though marbling score only tended to be lowered for those heifers implanted with Synovex Plus compared to implanting with Finaplix-H.

Introduction

The use of trenbolone acetate (TBA) in a final growth implant has become a common practice for use in finishing heifers. Trenbolone acetate activity is enhanced with the combination of estrogenic compounds either from endogenous or exogenous sources. Estrogenic compounds can be supplied with the use of melengestrol acetate (MGA) or within an implant in combination with TBA. Three finishing trials were conducted, which have been reported in *2002 Nebraska Beef Report*, pp 31-33 and *2001 Nebraska Beef Report*, pp. 64-67, to evaluate the effects of TBA implants in combination with estrogenic compounds within implants and/or with MGA supplementation. This summary contains two treatments that where common across all trials: 1) Synovex Plus (28 mg of estradiol benzoate and 200 mg of TBA) fed MGA and 2) Finaplix-H (200 mg of TBA) fed MGA.

Procedure

The three experiments where conducted in commercial feedlots with two common treatments. Within the two treatments there were 2,494 heifers (768 lb) used in 28 pens (14 rep/treatment). Cattle handling procedures are reported in earlier beef report articles within this year and the prior year. Heifers were implanted with their respective treatment of Finaplix-H or Synovex Plus and were exposed to that final implant for an average of 96 days across replications (range 84 to 108). Heifers were fed an average of 136 days (range 106 to 172).

All pens within an arrival time were harvested under identical conditions. Hot carcass weights were recorded on the day of harvest. Carcass fat thickness, marbling score, KPH fat, longissimus muscle area, and USDA quality grade were recorded following a 24 - 48 hour chill.

The economic influence of the implant programs was calculated from costs that occurred at the feedlot at the time of the trials. Final heifer value was calculated by using a live price, dressed price, or a carcass-merit price based on individual heifer carcass value. Carcass value was calculated based on USDA quality grade, calculated yield grade, carcass weight and nonconformance (i.e. dark cutters). A carcass base price of $111/cwt was used for low Choice, yield grade 3 carcasses weighing 550 to 950 lb. Discounts were calculated as: $10, Select; $20, Standard; $30, dark cutters; $25, light (<550 lb) and heavy (>950 lb) carcasses; and $15, yield grades 4 and 5. Premiums were calculated as: $8, Prime; $3, upper 2/3 Choice; and $3, yield grades 1 and 2.

Data are presented with deads and chronics removed from the analysis. Feed intake and total head days were adjusted on a pen basis, one day prior to removal of the animal, when deaths occurred or chronic cattle were sold before their home pen was sold.

Performance, carcass, and economic data were analyzed using the MIXED procedure in SAS. Trial, trial by treatment, and block nested within trial were considered random variables. Variables were considered significant when probability values less than 0.10 were obtained.

Results

Effects of Synovex Plus supplemented with MGA compared to Finaplix-H supplemented with MGA on finishing heifer performance across three experiments are summarized in Table 1 (14 pens/treatment). Initial weight averaged 768 lb for 2,494 heifers. Carcass-adjusted ADG was increased (P = 0.002) by 4.4% for those heifers that received Synovex Plus implants compared to those that received Finaplix-H implants. This resulted in carcass-adjusted final weight that was 16 lb heavier (P = 0.005)

Table 1. Effects of implant programs using Synovex Plus or Finaplix-H, with MGA supplementation, on heifer performance (Pooled data).

Item	Implant Strategy[a] PLUS MGA	FIN MGA	SEM[b]	P-value
Number of pens	14	14		
Number of heifers	1247	1247		
Days on feed	136	136		
Initial weight, lb	766	769	2.6	0.26
Final weight, lb[c]	1222	1206	3.8	<0.01
Dry matter intake	20.4	19.8	0.2	0.02
Daily gain, lb	3.40	3.26	0.03	<0.01
Feed/gain	6.01	6.12	0.06	0.11
Carcass weight, lb	770	760	2.4	<0.01
Dressing percentage, %	65.0	64.5	0.1	<0.01
12th rib fat, in.	0.54	0.53	0.01	0.41
Longissimus muscle area, sq. in.	14.1	13.7	0.01	<0.01
Calculated yield grade	2.7	2.8	0.1	0.23
Marbling score[d]	5.42	5.50	0.05	0.14
Quality grade distribution, %				
Prime	2.9	2.4	0.8	0.55
Upper 2/3 Choice	20.2	23.4	1.8	0.09
Low Choice	40.7	45.0	2.8	0.15
Select	34.4	28.2	2.8	0.04
Standard	1.9	0.9	0.6	0.12
Dark cutters, %	0.8	0.0	0.4	0.07

[a]PLUS MGA = Synovex Plus fed MGA and FIN MGA = Finaplix-H fed MGA.
[b]SEM = Standard error of the mean.
[c]Final weight calculated as hot carcass weight divided by 0.63 (common dressing percentage).
[d]Marbling score: 4.0 = Slight; 4.5 = Slight 50; 5.0 = Small; 5.5 Small 50; etc.

Table 2. Economic analysis of using Synovex Plus or Finaplix-H, with MGA supplementation, as final implants in finishing heifers (Pooled Data).

Item	Implant Strategy[a] PLUS MGA	FIN MGA	SEM[b]	P-value
Cost of feed, $/head	158.51	154.63	1.6	0.03
Total feeding cost, $/head	182.18	178.16	1.6	0.03
Cost of gain, $/cwt	40.57	41.41	0.38	0.05
Carcass price[c], $/cwt	108.74	109.84	0.46	0.03
Profit (loss)[d], $/head				
Dressed basis	71.85	62.06	3.1	<0.01
Carcass merit basis	57.11	55.87	4.9	0.80

[a]PLUS MGA = Synovex Plus fed MGA, REV MGA = Revalor-H fed MGA, and FIN MGA = Finaplix-H fed MGA.
[b]SEM = Standard error of the mean.
[c]Calculated using a $111/cwt carcass base price: discounts = $10, Select; $20, Standard; $15, yield grade 4 and 5; $30, dark cutter; premiums = $8, Prime; $3, upper 2/3 Choice; $3, yield grades 1 and 2.
[d]Initial animal cost = $78/cwt; animal returns based on $70/cwt live price, $111/cwt carcass price, or calculated carcass value, respectively, interest not included.

for heifers implanted with Synovex Plus compared to Finaplix-H. Dry matter intake was increased (P = 0.02) by 2.7% and feed conversion tended to be improved (P = 0.11) by 1.8% for those heifers receiving Synovex Plus implants compared to those receiving Finaplix-H implants.

The carcass characteristics are presented in Table 1. Heifers implanted with Synovex Plus had 10 lb heavier (P = 0.009) carcasses compared to heifers implanted with Finaplix-H. Dressing percentage was increased (P = 0.005) by 0.5% units for heifers implanted with Synovex Plus (65.0%) compared to Finaplix-H (64.5%). Calculated yield grade, 12th rib fat thickness, and KPH fat were similar between treatments. Longissimus area was larger (P = 0.003) for heifers that were implanted with Synovex Plus compared to Finaplix-H. Marbling score tended to be increased (Sm^{50} vs. Sm^{42}, P = 0.14) for heifers implanted with Finaplix-H compared to Synovex Plus resulting in an increase (70.8 vs. 63.7%, P = 0.03) of 7.1% units grading USDA Choice or above for those heifers receiving Finaplix-H. Percentage of carcasses grading USDA Select was higher (P = 0.04) by 6.2% units and the percentage of heifers grading USDA Standard tended (P = 0.12) to be higher for heifers implanted with Synovex Plus compared to Finaplix-H. The incidence of dark cutting was higher (P = 0.07) for heifers implanted with Synovex Plus compared to those that were implanted with Finaplix-H.

Economic pooled data are presented in Table 2. Heifers implanted with Synovex Plus had higher (P = 0.03) feed cost and total feeding cost than those implanted with Finaplix-H. This is due to the increased feed intake. However, carcass-adjusted cost of gain was reduced by $0.84 / cwt (P = 0.05) for those heifers implanted with Synovex Plus. Finaplix-H implanted heifers had higher (P = 0.01) calculated carcass price, when premiums and discounts were applied to individual carcasses. The lower cost of gain for those heifers implanted with Synovex Plus offset the reduction of calculated carcass price so carcass-merit basis net return was similar ($57.11 vs. $55.87, P = 0.80) between Synovex Plus and Finaplix-H with the grid described earlier. Dressed basis net return was increased (P = 0.007) by $9.79 / head for heifers implanted with Synovex Plus compared to Finaplix-H.

Data from these trials suggest that implanting with Synovex Plus and feeding MGA improves heifer performance compared to implanting with Finaplix-H and feeding MGA. Using Synovex Plus has some negative effects on carcass characteristics though cost of gain is lowered enough to outweigh negative effects when carcasses are sold on a grid described earlier ($10 Choice-Select spread).

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Sorting Strategies in an Extensive Forage Utilization Beef Production System

Jim MacDonald
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Mark Blackford
D. J. Jordon[1]

Sorting yearling cattle by weight upon entry into the feedlot or by weight and fat depth at the end of the feeding period increases carcass weight without increasing fat thickness.

Summary

One hundred sixty crossbred steer calves were stratified by weight and allotted into four groups to test three sorting strategies against an unsorted control to compare methods of sorting long yearling steers to decrease variation in carcass weight and fat thickness, increase pounds of carcass weight sold, and increase profitability. Sorting by weight upon entry into the feedlot or by weight and fat thickness at the end of the feeding period increased average carcass weight. No statistical differences in variation or profitability were found, although numerical differences were present.

Introduction

Previous research conducted at the University of Nebraska suggests an average of 540 lb variation in final weight and 0.89 inch variation in 12th rib fat thickness exists within a feedlot pen at slaughter time (*1999 Nebraska Beef Report*, pp. 57-59). The previous research also found the relationship between reimplant weight and carcass weight to have correlation coefficients ranging from 0.46 to 0.86. However, this research used calf fed or short yearling steers. No data are available on long yearlings grown in an extensive forage utilization production system. Since these steers are older at slaughter, it is logical that more variation may exist. Also, these cattle likely only receive one implant while in the feedlot and thus do not have the opportunity to be sorted at reimplant time.

The objective of this trial was to test possible strategies for sorting long yearling cattle using logical methods in an extensive forage utilization production system. Logical sorting times for this type of production system include sorting at the beginning of the wintering period, at the beginning of the grazing period, at the beginning of the feeding period, and at the end of the feeding period. The goal was to increase average carcass weight and to reduce variation in carcass weight and 12th rib fat thickness by marketing individuals closer to their ideal marketing date. An individual animal's ideal marketing date is assumed to be when they reach 0.45 inch 12th rib fat depth but before they reach 1,500 lb in shrunk body weight. In doing this, pounds of carcass sold should be maximized while discounts received from overweight carcasses and yield grade four carcasses should be minimized.

Procedure

Two years of data collected at UNL were analyzed to determine the relationship of interim weights to final weight, and to determine the amount of variation in interim and final weights as well as variation in final fat thickness. Seventy-one animals were supplemented at a high rate of winter gain and shipped on the same slaughter date.

Based on the results from the analysis, 160 crossbred steer calves (550 lb) were stratified by weight and allotted into four treatments to test the effects of three sorting strategies. Treatments were: 1) 40 head sorted by weight going to grass (PASTURE), 2) 40 head sorted by weight entering the feedlot (FEEDLOT), 3) 60 head sorted by weight and ultrasound 12th rib fat thickness at the end of the feeding period (PEN), and 4) 20 head that were not sorted and served as the control (CON). Each treatment consisted of two replicates. Each replicate in the PASTURE and FEEDLOT treatments were sorted into heavy and light halves whereas cattle in the PEN treatment were sorted as individuals.

A main assumption of this trial is that a producer using this system purchases cattle from a ranch. It is therefore important to create a situation where the variation in the treatments is similar to that which could be expected from ranch cattle. To accomplish this, steers designated to this trial were from two ranch sources (two loads to obtain sufficient numbers of cattle). By using cattle from two ranches of similar average weights, it is assumed that each treatment has variability in weight and potential fat depth that is typical for cattle from a ranch source.

Steers were purchased in the fall and were wintered on corn residue from Nov. 30 through Feb. 9, and were then placed in a drylot from Feb. 9 through April 20. Cattle were fed ammoniated wheat straw while in the drylot and were supplemented with wet corn gluten feed (5 lb. per head per day, DM basis) during the entire winter period. On April 21, cattle were weighed, implanted with Revlor-G and were taken to smooth brome pastures near Mead, Neb. where they remained until May 15 (24 days). On May 16, they were fly tagged and transported to native warm-season pastures near Ainsworth, Neb. The light half of the PASTURE treatment was removed from grass on July 4 (44 days). The remaining cattle were removed from native range on Aug. 18 (95 days),

returned to smooth brome pastures near Mead, Neb., and were removed from grass on Sept. 12 (26 days). The light half of the PASTURE treatment was on grass for 68 days while the remaining cattle were on grass for 145 days.

Upon entry into the feedlot, all steers were implanted with Revlor-S and placed into pens. All cattle were in 10 head pens except for the PEN treatment which had 30 head per pen. Steers were stepped up on feed in 21 days using four step-up diets containing 45%, 35%, 25%, and 15% roughage fed for three, four, seven and seven days, respectively. The final diet contained 7% roughage and was formulated to contain 12% CP, 0.7% Ca, 0.35% P, 0.6% K, 30 g/ton monensin, and 10 g/ton tylosin (DM basis). The finishing diet contained 40% wet corn gluten feed, 48% high moisture corn, 7% alfalfa and 5% supplement (DM basis). Initial weights for the winter, summer, and finishing periods were an average of two weights taken on consecutive days following a four day limit feeding at 2% BW. The limit fed diet consisted of 47.5% wet corn gluten feed, 47.5% alfalfa hay and 5% supplement. This was done to equalize gut fill so that weights taken were a true reflection of relative differences in weight rather than differences in gut fill.

Each treatment had an individual marketing strategy based on fat thickness or a combination of fat thickness and weight. Ultrasound was used to estimate fat thickness. The PASTURE treatment was marketed in two groups (light and heavy halves) when the average of each group averaged 0.45 inch 12th rib fat thickness. The FEEDLOT treatment also was marketed in two groups (light and heavy halves). The light half was marketed when the group averaged 0.50 in 12th rib fat thickness to allow them to gain additional carcass weight. The heavy half was marketed when the group averaged 0.40 inch 12th rib fat thickness to avoid overweight carcasses. The average market fatness of the FEEDLOT treatment was intended to be 0.45 inch 12th rib fat thickness. The PEN treatment was marketed as individuals in four kill dates. Back fat thickness was measured by ultrasound periodically once the cattle were on feed for approximately 50 days. Cattle were marketed once they reached about 0.45 inch 12th rib fat thickness or 1,500 pounds shrunk body weight (4% shrink).

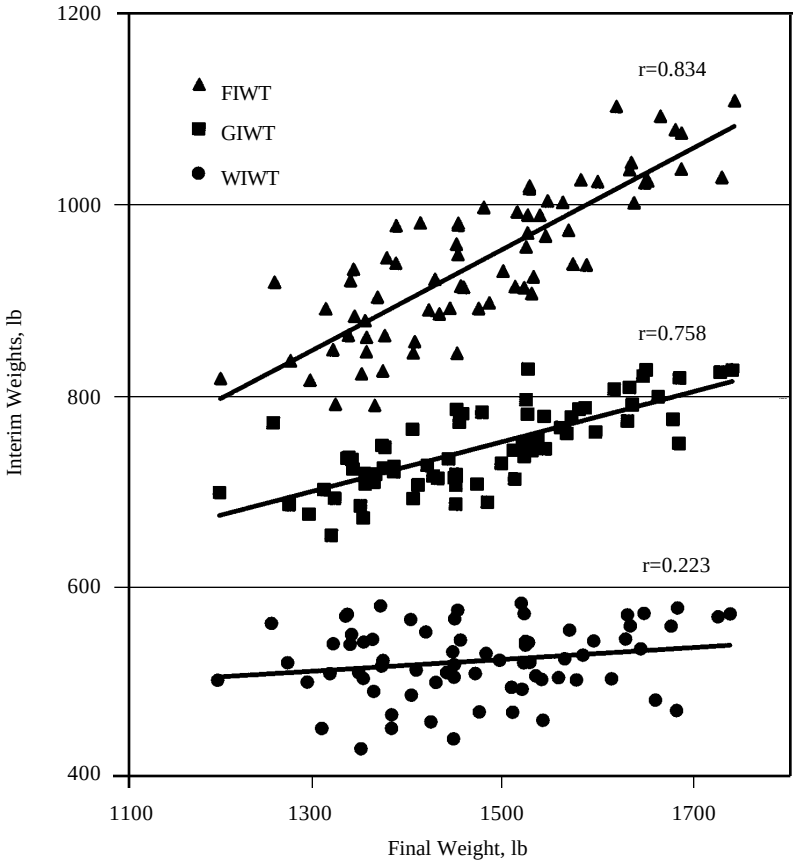

Figure 1. Relationship of interim weights to final weight from a previous research trial. FIWT=Feedlot initial weight, GIWT=Grass initial weight, WIWT=Winter initial weight.

Results

Figure 1 shows the relationship of interim weights taken at different times in the production system to final weight. Interim weights include winter initial weight, grass initial weight, and feedlot initial weight. These weights were selected because they are logical sorting points in this type of production system and because limit fed weight data were available for analysis. Correlation coefficients for these interim weights were 0.223, 0.758, and 0.834 respectively. This suggests a poor relationship to final weight at the beginning of the winter feeding period, but a reasonably good relationship to final weight when cattle go to grass and when they enter the feedlot.

Figure 2 shows the mean, standard deviation, and actual variation of interim weights, final weight, and final fat thickness for the two years of data that were analyzed. As cattle grow, variation in weight increases. The actual variation in final weight and final fat thickness agree with the findings of Cooper et. al. (*1999 Nebraska Beef Report*, pp. 57-59).

Performance, carcass, economic, and variance data for the sorting trial are shown in Table 1. Cattle in the PASTURE treatment were on grass fewer days, and thus had a higher average daily gain on grass. This difference in gain is probably due to the maturity of the forage while they were grazing. Since half of the pasture treatment was removed from grass early, cattle in other treatments were likely performing similarly during the same time period. Early removal from grass is also the likely reason the PASTURE treatment was

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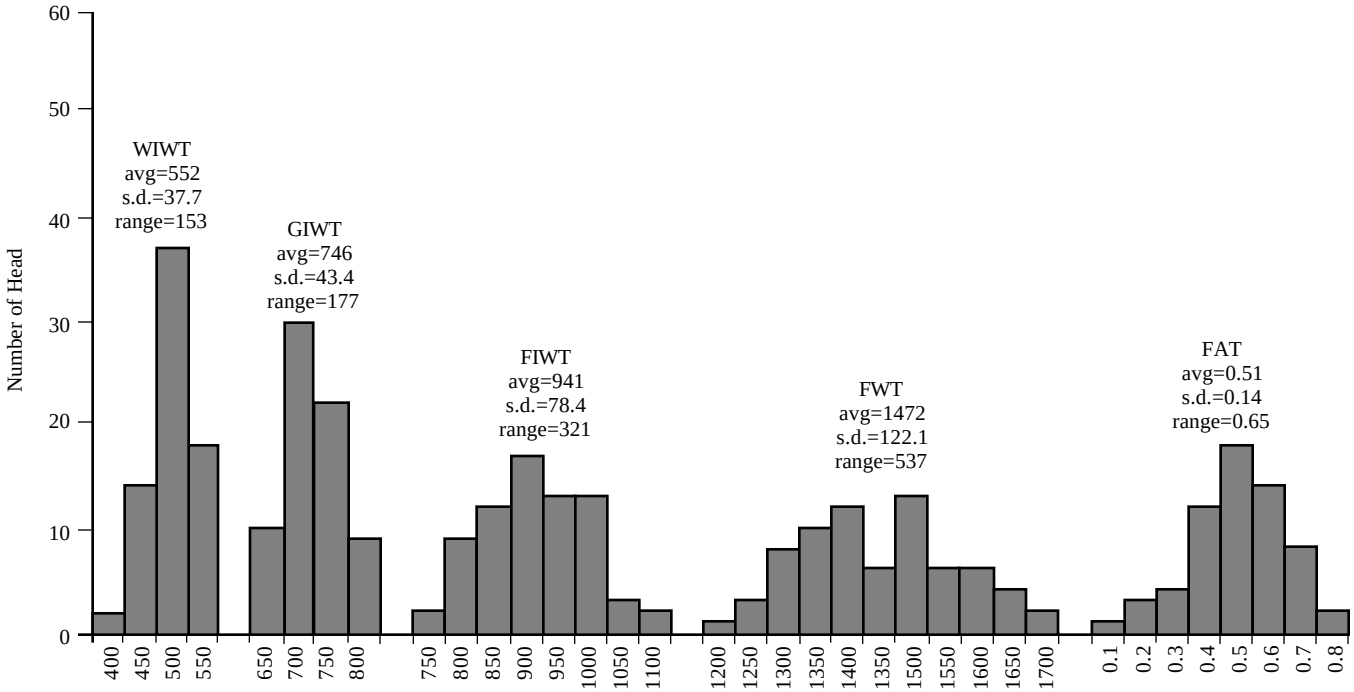

Figure 2. Mean and variances of weight and fat from a previous research trial. WIWT=winter initial weight (lb), GIWT=grass initial weight (lb), FIWT=feedlot initial weight (lb), FWT=final weight (lb), FAT=12th rib fat depth measured at slaughter (in), s.d.=one standard deviation from the mean (lb), range=actual difference between maximum and minimum weight (lb) or fat depth (in).

lighter entering the feedlot and required more days on feed compared to other treatments. The light half of the PASTURE treatment entered the feedlot on July 4, compared to Sept. 12 for all other treatments. The additional heat that cattle in the light half of the PASTURE treatment endured while in the feedlot combined with their lower weight entering the feedlot could explain their reduced dry matter intake.

The light half of the PASTURE treatment was marketed at a fat thickness of 0.55 inch rather than 0.45 inch. In order to compare them to other treatments, fat thickness was adjusted at a rate of 0.0048 inch/day to 0.45 inch fat thickness. This rate of fattening was arrived at by calculating the fattening rate for similar cattle that were serially slaughtered approximately 35 days apart. This was compared to the fattening rate of cattle that were progressively measured with ultrasound during the last four weeks of the feeding period. The two methods closely agreed on the rate of fattening for long yearling cattle during the end of the feeding period. Days on feed was adjusted back by 21 days for the light half of the PASTURE treatment and carcass

Table 1. Performance, carcass, economic, and variance data.

	Treatment[a]				
Item	Control	Pasture	Feedlot	Pen	SEM
Winter					
Days	142	142	142	142	—
Initial weight, lb	548	550	549	551	0.90
Daily gain, lb	1.15	1.13	1.18	1.19	0.01
Summer					
Days	145	110	145	145	—
Initial weight, lb	712	711	717	720	2.62
Daily gain, lb	1.68	1.80	1.69	1.71	0.03
Finishing					
Days	79	101	93	89	—
Initial weight, lb	955[e]	905[f]	962[e]	968[e]	5.02
Daily gain, lb	4.69	4.47	4.64	4.67	0.13
Dry matter intake, lb	31.51[e]	29.00[f]	30.97[e]	31.09[e]	0.20
Feed/gain	6.74	6.50	6.69	6.67	0.20
Carcass data					
Weight, lb	828[b]	845[bd]	867[c]	861[cd]	6.75
Yield grade	2.6[bc]	2.75[b]	2.5[c]	2.5[c]	0.06
12th rib fat, in.	0.445	0.470	0.440	0.450	0.01
Marbling score[g]	495[b]	539[c]	502[b]	509[b]	7.93
% choice	55.0	77.5	55.0	57.6	8.47
Break even, $/cwt	67.01	66.70	66.17	66.16	0.58
Profit, $/head	6.31	10.54	18.17	18.03	7.87
Standard deviation[h]					
Winter initial weight, lb	54.82	48.07	50.48	47.40	0.02
Summer initial weight, lb	63.56	60.20	60.52	58.84	0.02
Feedlot initial weight, lb	62.61[e]	35.28[f]	58.74[e]	65.85[e]	0.04
Carcass weight, lb	48.47[bc]	42.21[c]	46.21[c]	56.67[b]	0.03
Fat thickness, in.	.124	.135	.156	.111	0.11

[a]Treatments: control=no sorting, pasture=sorted based on weight going to grass, feedlot=sorted based on weight entering the feedlot, pen=sorted by weight and fat thickness at the end of the feeding period.
[b,c,d]Means within row with unlike superscripts differ (P < 0.10).
[e,f]Means within row with unlike superscripts differ (P < 0.05).
[g]Marbling score: 400 = slight 0; 450 = slight 50; 500 = small 0; 550 = small 50; etc.
[h]Statistical analysis and SEM based on log base 10 of standard deviation.

weight was adjusted by using individual ADG. These adjustments are critical for treatment comparisons of carcass weight break even, and profitability. It is difficult to make accurate adjustments in yield grade, quality grade, and percentage choice. Thus, these measurements were not adjusted, which accounts for the increase in these factors compared to other treatments.

Sorting upon entry into the feedlot or by weight and fat thickness at the end of the feeding period successfully increased carcass weight sold without increasing fat thickness compared to the control (Table 1). Although not statistically different due to a high standard error, profitability was numerically increased compared to the control. Numerical differences in profitability are likely due to additional pounds of carcass weight sold. Presumably, it is more profitable for a producer to add additional pounds of carcass weight to an animal as long as discounts are avoided. This is often difficult to accomplish because long yearlings are often heavy when entering the feedlot and gain weight quite rapidly. Furthermore, this type of cattle typically fatten at a rapid rate at the end of the feeding period. These characteristics lead to a small window of opportunity for marketing individuals. Since cattle are typically marketed as groups rather than as individuals, discounts received from overweight carcasses and yield grade four carcasses may by likely. An average of 3.14 % of cattle in this trial received discounts for overweight or yield grade four carcasses with no statistical differences among treatments. Sorting long yearling cattle by weight upon entry into the feedlot may be a viable way for producers to increase total pounds of carcass weight sold while avoiding discounts. If ultrasound technology is available, sorting by weight and fat thickness at the end of the feeding period may also increase carcass weight, decrease discounts received, and decrease variation in 12th rib fat thickness.

A Simulated Economic Analysis of Altering Days on Feed and Marketing Cattle on Specific Value-Based Pricing Grids

Dillon Feuz[1]

Cattle producers should remember, even with value-based pricing, they are still selling pounds of beef. If the market price exceeds the costs, selling more is better than selling less.

Summary

Profit can be increased by feeding some pens of cattle additional days on feed and selling on a pricing grid that rewards quality. Discounts for Yield Grade 4 and heavy weight carcasses for as many as 10% to 15% of a pen may not exceed the premiums for higher grading carcasses and the benefit of selling additional weight on all cattle sold. While the grid price can be increased by feeding some pens of cattle fewer days and marketing on a yield grade rewarding grid, net returns are often decreased because of selling fewer total pounds.

Introduction

Some cattle producers have been selling fed cattle on various value-based pricing systems, frequently referred to as pricing grids, for several years. While there are many different pricing grids, the majority tend to pay premiums for USDA Choice or higher grading and Yield Grade 1 and 2 cattle. Discounts are applied to Select or lower grade and Yield Grade 4 and 5 cattle. Too heavy or too light carcasses, as well as other nonconforming carcasses (dark cutter, stags, hard bones) also are discounted. To be successful marketing cattle on a grid not only requires that managers match cattle to the appropriate grid, but may also require a change in feeding and other management practices.

Some managers, targeting grids with large premiums for lean cattle, have reduced the number of days cattle are fed, while others have increased the number days cattle are fed and have marketed on grids with higher premiums for higher grading cattle. However, due to the biological antagonisms between marbling and leanness and due to the grid pricing structure, altering days on feed does not always achieve a higher price. Furthermore, when the number of days fed is altered the effect on carcass weight and feed costs also must be considered. The purpose of this report is to evaluate the economic consequences of altering the number of days cattle are fed. The evaluation will consider different types of cattle and different pricing grids.

Procedure

Eight actual pens of cattle were used to illustrate difference in value for different types of cattle marketed on different pricing grids. The pens varied considerably in the percentage cattle grading Choice or higher and in the percentage of cattle that were Yield Grade 1 and 2. The average of the eight pens of cattle is fairly representative of the average fed cattle slaughter mix in the United States. The cattle averaged 61% Choice or higher grade, and 54% of the cattle were Yield Grade 1 or 2. The

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percentage of the eight pens of cattle with various quality and yield grades is displayed in Table 1.

Table 2 presents three general value-based grid pricing systems. While these were not the exact premiums and discounts for any actual grids, they are very representative of the varying premiums and discounts available on alternative grids. The commodity grid is typical of a number of different packer grids. The yield grade rewarding grid is typical of those grids that are more concerned with rewarding leaner cattle, while the quality rewarding grid is typical of many of the grids rewarding the higher grading type cattle. The base price for each grid is a formula tied to the average dressed price, the USDA Choice-Select spread, and the percentage cattle grading Choice.

Prices were compared for the eight individual pens on the three grids and against the average dressed market price. The following assumptions were made for the pricing example: average dressed market price was $100/cwt., the USDA Choice-Select spread was $7.00/cwt. and the plant average for the base price was 60% Choice or higher grade. These values are based on averages from January 1994 through December 2000.

A simulation analysis was performed to evaluate the economic consequences of feeding two of the pens an additional two weeks and of feeding one of the pens two fewer weeks. The following assumptions were used for the simulation: 1) ADG was 2.7 lb. for the two additional weeks and dressing percentage increase 0.5 percentage points which equated to 30 lb. additional carcass weight; 2) ADG was 3.0 lb. for the last two actual weeks of feeding and marketing two weeks early would have reduced dressing percentage by 0.3 percentage points which equated to 30 lb. less carcass weight; 3) marbling scores changed 30/100 in two weeks and the quality grade on individual carcasses was adjusted accordingly; 4) approximately one-third of the carcasses changed one yield grade; this was adjusted based on fat thickness and carcass weight; 5) total cost of gain for the two additional weeks was $21 ($.55/lb. gain X 38 lb.) and the cost savings for the two fewer weeks was $19.74 ($.47/lb. gain X 42 lb.), these costs were based on $2.50/bu. corn price and $0.30/head/day yardage charge; and 6) a stable market price was assumed.

Table 1. Percentage of the cattle in each of the Quality and Yield Grade Categories.

	Yield Grades					
Quality Grade	1	2	3	4	5	Total
Prime	0.00	0.00	0.69	0.35	0.00	1.04
Upper 2/3 Choice	0.52	5.70	8.29	0.69	0.00	15.20
Choice	0.86	20.03	23.14	0.69	0.00	44.73
Select	4.49	21.59	11.74	0.00	0.00	37.82
Standard	0.52	0.69	0.00	0.00	0.00	1.21
Total	6.39	48.01	43.87	1.73	0.00	100.00

Table 2. Premiums and discounts for three alternative grids.

	Commodity	Yield Rewarding	Quality Rewarding
Prime	$6.00	$3.00	$10.00
Upper 2/3 Choice	$1.50	$0.00	$3.50
Choice	$0.00	$0.00	$0.00
Select	-$7.00	-$5.95	-$8.05
Standard	-$17.00	-$8.95	-$23.05
Yield Grade 1	$2.00	$3.00	$1.00
Yield Grade 2	$1.00	$2.00	$1.00
Yield Grade 3	$0.00	-$1.00	$0.00
Yield Grade 4	-$15.00	-$20.00	-$12.00
Yield Grade 5	-$20.00	-$25.00	-$17.00
Lt. & Hy. Carcass	-$15.00	-$15.00	-$15.00

Table 3. Carcass characteristics on eight individual pens of cattle and the net grid prices on three alternative grids based on a $100/cwt. Dressed weight price.

Pen	% Choice	% YGI-2	% Outs	HCW	Comm. Grid	Yield Grid	Quality Grid
1	80	62	4	658	$103.57	$103.37	$103.90
2	81	37	0	749	$103.10	$102.80	$103.17
3	78	37	7	800	$101.91	$101.27	$102.16
4	58	72	0	745	$101.78	$102.47	$101.24
5	60	37	0	776	$101.63	$101.55	$101.39
6	31	74	0	709	$99.88	$101.80	$98.54
7	30	92	14	842	$97.52	$99.20	$95.84
8	16	79	36	875	$93.69	$95.72	$91.55
		Average			$100.81	$101.07	$100.37

Results

The net prices received for the eight pens of cattle on the three different grids are displayed in Table 3. Clearly, the pens of cattle with a higher percentage of cattle grading Choice were rewarded with a higher price. Likewise, for cattle of an equal quality grade, leaner cattle (lower yield grades) also received a higher price. The top pens received a premium of more than $20 per head ($3.00 premium * 7 cwt.) over the average cash market (this assumes they would have received the average dressed market price). On the other hand, the poorer quality cattle were discounted more than $40 per head. The average price premium from selling all eight pens on each of the grids varied from $0.37 to $1.07 per cwt. of carcass, or $2.85 to $8.24 per head based on the 770-pound average carcass weight.

Table 4 contains the results of the economic simulation of feeding two pens of cattle two additional weeks to improve the quality grade. Pen 6 had an improvement in the percentage cattle grading Choice from 31% to 48%, a decrease in the percentage of Yield Grade 1 and 2 carcasses from 74% to 50%, an increase in the percentage of Yield Grade 4's from 0% to 5%, and average

Table 4. Economic simulation results of feeding two additional weeks.

		Commodity Grid	Yield Grid	Quality Grid
Pen 6				
	Original Price ($/cwt)	$99.88	$101.08	$98.54
	Simulated Price ($/cwt)	$100.43	$100.64	$99.91
	Original Revenue ($/head)	$709.14	$717.68	$699.65
	Simulated Revenue ($/head)	$743.22	$744.74	$739.37
	2 weeks Feeding costs ($/head)	$21.00	$21.00	$21.00
	Additional Return from Feeding longer ($/head)	$13.08	$6.07	$18.72
Pen 5				
	Original Price ($/cwt)	$101.63	$101.55	$101.39
	Simulated Price ($/cwt)	$100.50	$98.75	$101.44
	Original Revenue ($/head)	$788.65	$788.05	$786.81
	Simulated Revenue ($/head)	$810.06	$795.93	$817.58
	2 weeks Feeding costs ($/head)	$21.00	$21.00	$21.00
	Additional Return from Feeding longer ($/head)	$0.41	-$13.12	$9.76

Table 5. Economic simulation results of feeding two fewer weeks.

		Commodity Grid	Yield Grid	Quality Grid
Pen 3				
	Original price ($/cwt)	$101.40	$101.27	$102.16
	Simulated price ($/cwt)	$101.78	$102.00	$101.42
	Original Revenue ($/head)	$815.28	$810.15	$817.32
	Simulated Revenue ($/head)	$783.71	$785.38	$780.95
	Feeding costs Savings ($/head)	$19.74	$19.74	$19.74
	Additional return from reduced feeding ($/head)	-$11.83	-$5.03	-$16.63

carcass weight increased from 710 to 740 lb. Pen 5 had a larger increase in the percent grading Choice from 60% to 86%, the percentage of Yield Grade 1 and 2's declined from 37% to 12%, the number of heavy weight carcasses (> 950 lbs.) increased from 0% to 12%, the number of Yield Grade 4's increased from 0% to 6%, and average carcass weight increased from 776 to 806 pounds.

In general, increasing the number of days on feed was profitable. For pen 6 on all three grids and for pen 5 on the quality grid, the improvement in quality grade and the additional weight that is being sold more than off set the decline in price from an increase in yield grade and more than off set the added costs under all three grids. However, with pen 5, net returns from additional days on feed were negative with the yield grid and were only marginally increased on the commodity grade grid. This was primarily due to the fact that now 18% of the pen was heavy weight and/or Yield Grade 4 carcasses.

The opposite situation is presented in Table 5, which is a pen of cattle that was simulated to have two weeks fewer days on feed to decrease fat and enhance the yield grade of the cattle. The percentage grading Choice declined from 78% to 65%, the percentage of Yield Grade 1 and 2's did increase from 37% to 58%, the number of Yield Grade 4's declined from 7% to 4%, and averaged carcass weight decreased from 800 to 770 lbs. Returns are negative for this scenario under all three grids. The reductions in carcass weight and in quality grade have a greater impact than the improvement in yield grade. These results may not hold for all pens and certainly as feed costs increase this alternative will be more favorable. However, it is critical that cattle producers recognize that while the market price increased on two out of three grids, net returns decreased on those two grids because of the reduction in carcass weight sold. Selling for the highest price does not always result in the largest profit.

These results are based on three specific pens of cattle and on one average market scenario. In general, as the USDA Choice-Select spread increases, it would be even more profitable to feed cattle additional days. Likewise, the higher the overall market price, the more profitable it is to feed cattle longer because each successive pound is worth more in a higher market. Conversely, as the Choice-Select spread decreases and as feeding costs increase, the profit potential from feeding additional days would decrease and it would be more likely that feeding fewer days could be profitable on a yield grade rewarding grid.

Cattle that are generally grading on the border of Select and low Choice would be impacted more by altering days on feed than cattle that are predominantly Select or predominantly Choice. The uniformity of the pen with regard to carcass weight, yield grades and quality grades also will have a major impact on the success of feeding fewer or additional days. The less uniform the pen, the more likely that significant discounts will be applied to "Out" cattle.

If a manager is considering altering the number of days on feed to fit a particular pricing grid, carcass weight and feeding costs must be considered in addition to the grid priced received to determine the overall profitability of the strategy.

Lastly, this analysis assumed a stable market price. If the market price increases or decreases in the time period considered, results would be altered from those presented.

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Economic Analysis of Calf Versus Yearling Finishing

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Todd Milton
Rob Cooper
Tony Scott
Galen Erickson
Richard Clark[1]

Steers grown over the winter at a faster rate of gain were economically superior to either calf-finishing or a growing/finishing system using a slow rate of winter gain.

Summary

The objective of this report was to compare economics of calf- and yearling-finishing systems. Yearling steers were wintered at 1.54 lb/day (fast) or 0.42 lb/day (slow) then grazed over the summer followed by finishing. Calf-fed steers were purchased in the fall and finished. Profit was based on 1992 to 1999 average price levels. Steers on the fast treatment profited $21.00/head compared to -$20.66/head for slow and -$23.18/head for calf feds. Calf-feeding was also compared to only the finishing phase of yearling systems. Steers on the fast system profited $29.78/head compared to $17.83 for slow and -$23.18 for calf feds.

Introduction

Cattle may be placed into a feedlot setting immediately after weaning or they may be grown for any length of time in a backgrounding program before finishing. The extent to which backgrounding programs are used largely depends on the costs of backgrounding versus feedlot diets and profitability associated with calf-finishing or yearling systems. The objective of this report was 1) to compare the performance and carcass data of calf- and yearling-finishing systems and 2) to evaluate the economics of calf- and yearling-finishing systems.

Procedure

Experiments

Data from calf-finishing (CALF) and yearling grow/finish systems at the University of Nebraska from 1995 to 1998 were used. For the yearling systems, two winter systems were evaluated. In one system, steers were grown over the winter at 0.42 lb/day average over four years (SLOW). In the second system, steers were grown at 1.54 lb/day average over 4 years (FAST). The SLOW system represented 160 steers fed in 14 pens, while the FAST system represented 212 steers fed in 18 pens. Calf-finishing trials began in the fall (October and November). The calves were sorted from a pool of animals from which calves placed directly into the yearling systems originated. The CALF treatment represented 1,257 head of steers fed in 128 pens. Comparisons were made both between CALF and the entire yearling system (winter, summer, and finishing phases), and between CALF and only the finishing phase of the yearling systems.

Yearling Trials

The procedures for the yearling system and the economic analyses were described previously (*2001 Nebraska Beef Cattle Report*, pp. 29-34; *2002 Nebraska Beef Cattle Report* pp. 25-29).

Economic Analysis of Yearling Finishing. In order to economically compare CALF and yearling systems solely in the finishing period, some modifications were made to the economic procedures for the yearlings which were previously discussed. A purchase price was determined for the yearlings using the actual feedlot initial weight of the pen and a regression equation developed using September-October USDA 1992-1999 average feeder steer prices to determine price paid for the animals. The regression equation was: $y = 0.00005x^2 - 0.1071x + 127.3$ where y = price paid and x = pen weight ($r = 0.987$) and was based on price regressed on weight. Otherwise, calculations were made according to the procedures previously discussed for the finishing period of the yearling grow/finish systems.

Calf Trials

Economic Analysis. Calf-finishing slaughter breakevens were calculated on pens of animals from each of the respective trials. Initial animal cost was loosely based on the USDA 1992-1999 average October feeder cattle price of $78.44/cwt. for 600-650 lb steer calves. However, data from Oklahoma suggest approximately $2.66/cwt. (total = $81.10/cwt.) should be added back to the purchase price for black exotic-cross steers. In our calf-finishing trials, black exotic-cross steers were purchased. Additionally, calf purchase data compiled at Nebraska over the past seven years shows that $81.65/cwt. was paid for animals weighing 600-650 lb. An average between Oklahoma and Nebraska data was used to arrive at a purchase price of $81.38/cwt. for 600-650 lb steers used for calf-finishing. Interest was applied to initial cost of the animal over ownership. Health, processing, and implanting were assessed a flat rate of $25.00/head. Feed charges for the CALF treatment were based on the same finishing diet cost charged to the yearlings ($115.14/ton). Average DM intake for each pen was used to determine feed consumption. Yardage was charged at $0.30/head/day. Interest was charged on the finishing diet and yardage for half of the feeding period. A 2% death loss was applied to

Table 1. CALF vs. yearling steer performance and carcass data.

Item	CALF	FAST	SLOW
Winter			
Initial weight, lb	—	521	524
ADG, lb	—	1.54	0.42
Summer			
Initial weight, lb	—	763	592
ADG, lb	—	1.21	1.65
Finishing			
Days on feed	182	91	105
Initial weight, lb	612[a]	931[b]	814[c]
ADG[d]	3.47	4.59	4.39
Slaughter weight, lb[e]	1234[a]	1360[b]	1254[c]
DM intake[d]	21.0	31.0	29.5
Feed/Gain[d]	6.06	6.76	6.71
Carcass			
Weight, lb	777[a]	858[b]	790[c]
Fat, in	0.47	0.49	0.47
Yield grade	2.44[a]	2.64[b]	2.59[b]
Marbling score[f]	497	555	531

[a,b,c]Means within a row with unlike superscripts differ ($P < 0.05$).
[d]Year × treatment interaction ($P < 0.05$; Figures 1-3).
[e]Calculated from hot carcass weight adjusted to a common dressing percentage (63).
[f]400^{00} = slight, 500^{00} = small; treatment x year ($P < .01$).

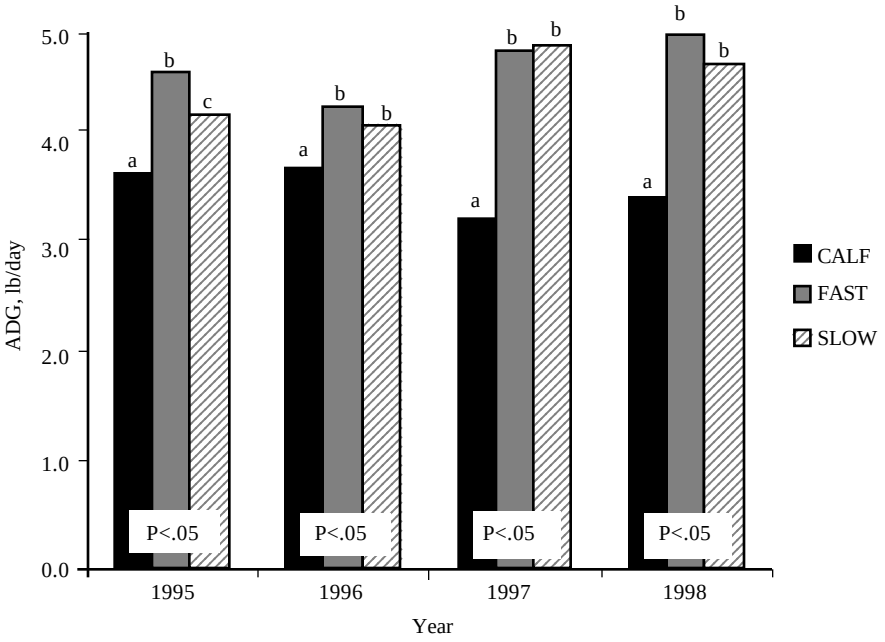

Figure 1. Feedlot ADG year × treatment interaction.

all of the calves. To calculate slaughter breakeven, total cost was divided by slaughter weight.

Profitability was determined for both CALF and yearling (FAST and SLOW) systems. Profitability was calculated using the 1992-1999 average May-June USDA Choice slaughter steer price ($66.21/cwt.) for the CALF data. Likewise, the 1992-1999 average December-January USDA Choice slaughter steer price ($67.48/cwt.) was used for yearling data.

Results

Animal Performance

Animal performance data are presented in Table 1. Initial weight (before the winter period) of the yearling-finishing systems were 521 and 524 lb for FAST and SLOW, respectively. Gains over the winter period were imposed to evaluate any potential compensatory growth response in the subsequent summer grazing period. Final winter and initial summer weights were 763 and 592 lb for FAST and SLOW, respectively. Average daily gains on grass were 1.21 lb/day for FAST and 1.65 lb/day for SLOW. Steers in the SLOW system exhibited some compensatory growth during the summer period as a result of lower winter gains.

Final weights off grass and initial feedlot weights were 931 lb for FAST and 814 lb for SLOW. Steers on the CALF treatment entered the feedlot weighing 612 lb. Significant year × treatment interactions ($P < 0.05$) were found for ADG (Figure 1), DM intake (Figure 2), and feed efficiency (Figure 3). For ADG, steers on the FAST system gained faster ($P < 0.05$) compared to SLOW, which gained faster ($P < 0.05$) compared to CALF in 1995. In 1996, 1997, and 1998 steers on the FAST and SLOW systems gained similarly compared to one another, but both gained faster ($P < 0.05$) compared to CALF. Steers on the FAST system consumed more feed ($P < 0.05$) compared to SLOW which consumed more ($P < 0.05$) compared to CALF in 1995 and 1996. In 1997 and 1998, DM intake for steers in the FAST and SLOW yearling systems were similar but increased ($P < 0.05$) compared to CALF. Calves were more efficient compared to yearling systems ($P < 0.05$) in 1995, 1996, and 1998; however, no differences in efficiency were noted in 1997. It is likely that inclement weather affected feed efficiency in the analysis. In three of the four years analyzed, calves were more efficient than yearlings; however, in the winter and spring of 1997 significant mud was encountered which likely decreased performance of the calves. Yearlings were on feed in the fall and early winter, and therefore were not exposed to the mud encountered by the calf-feds in 1997. Steers on the FAST system were heavier ($P < 0.05$) at slaughter compared to both SLOW and CALF. Steers on the SLOW system

(Continued on next page)

were heavier ($P < 0.05$) compared to CALF. The FAST cattle had 126 lb heavier final weights than CALF even though they were 91 lb lighter at the initiation of the feeding system.

Carcass Data

Steers on the FAST (858 lb) system produced heavier carcass weights ($P < 0.05$) compared to SLOW (790 lb), which were heavier ($P < 0.05$) compared to CALF (777 lb; Table 1). No differences were noted in fat depth over the 12th rib although yearlings (FAST and SLOW) had higher USDA yield grades ($P < 0.05$) compared to CALF. Marbling scores were higher for the FAST and SLOW cattle than CALF. There was a treatment by year interaction for marbling score ($P < .01$) but FAST cattle had higher scores than CALF each year. SLOW cattle had higher scores than CALF two of the four years.

Economic Analysis

Calf-Finishing vs Yearling Grow/Finish Systems. For slaughter breakeven and profit/loss, year × treatment interactions ($P < 0.05$) were found. However, despite the interactions it is acceptable to present the averages as this is real in terms of producer profitability over time. The four year averages for slaughter breakeven were $66.00, 68.10, and 69.21/cwt. for FAST, CALF, and SLOW, respectively. However, slaughter breakeven may not always be appropriate when comparing groups which were fed, and therefore sold and slaughtered, at different times. Profitability is likely a better measure, because it accounts for different marketing times. The FAST yearling system was the most profitable ($P < 0.05$) compared to CALF or SLOW, showing an average profit of $21.00/head over the four-year period. Losses incurred by CALF and SLOW were -23.18 and -20.66 ($/head), respectively.

Previous Nebraska work indicated similar results for slaughter breakeven when cattle were finished as calves compared to a yearling-finishing program (*1989 Nebraska Beef Cattle Report*, pp. 29-31). Cost of gain and slaughter breakeven were reduced for yearling-finishing systems, except when the price of corn was very low in relation to other inputs. Data from Kansas showed large deviations in the price spread for calves can occur with changes in the price of corn (*2000 Kansas State Cattleman's Day*, pp. 88-91). For example, the price differential between 500 and 800 lb steers with below average corn price ($1.68/bushel) is approximately $20.00/cwt.; however, when corn price rises to $3.56/bushel, the price differential can diminish to $7.00/cwt. for the same steers. Price differential paid for calves for calf-finishing compared to calves which will be grown in a yearling program can greatly impact breakeven and profitability. The impact of variations in corn price cannot be evaluated without considering the interaction between corn and steer price.

Another variable which could have an impact on the relative slaughter breakevens and profit/loss between CALF and yearling treatments is the price of summer forage. In the present analysis, $0.50/head/day was charged for summer forage. Increasing the charge to $0.70/head/day would result in similar slaughter breakevens between FAST and CALF treatments. A further increase to $0.75-0.80/head/day would be required to result in similar values for profitability.

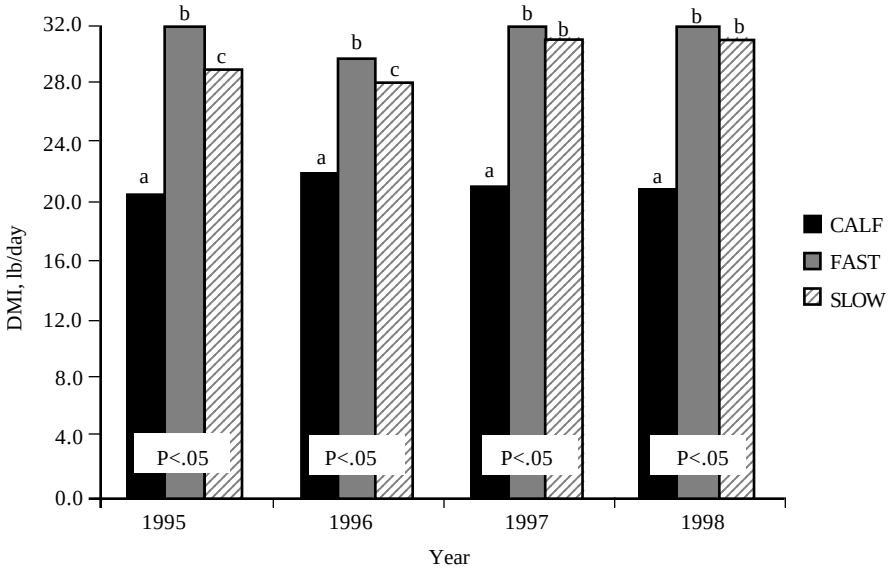

Figure 2. Dry matter intake year × treatment interaction.

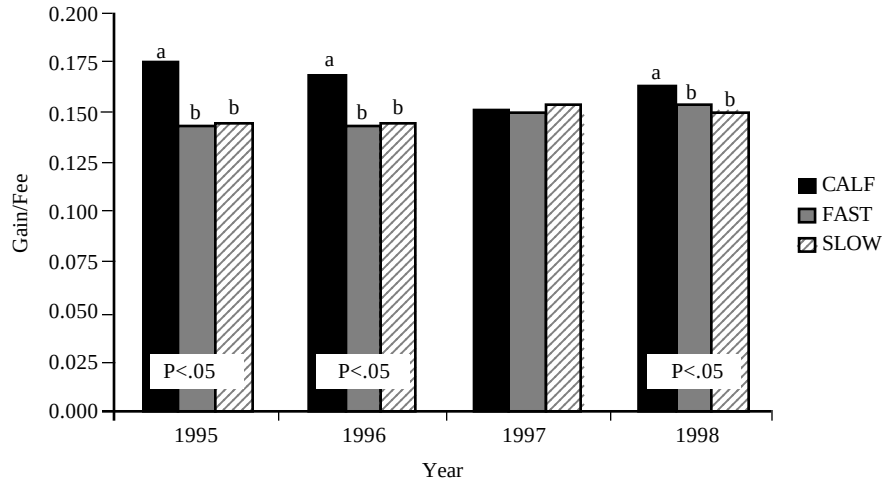

Figure 3. Feed efficiency year × treatment interaction.

Several factors may interact with slaughter breakeven and profitability such as purchase price, the cost of forage, the price of corn, and slaughter cattle price. In the absence of high levels of compensatory growth, yearlings produced with increased rates of winter gain result in the sale of more carcass weight and have reduced slaughter breakevens compared to yearlings grown over the winter with minimal inputs. While calf-feeding was not advantageous in the present analysis, reduced corn price combined with a narrow price spread for heavy and lighter weight calves would enhance calf feeding profitability.

In the present analysis, slaughter weight was the largest determining factor in terms of both slaughter breakeven and profit/loss, explaining 21% and 30% of the variation, respectively, based on regression analysis. Steers on the FAST system had more slaughter and carcass weight ($P < 0.05$) compared to both SLOW and CALF treatments, resulting in reduced slaughter breakeven and increased profitability.

Calf-Finishing vs Yearling-Finishing. Year × treatment interactions ($P < 0.05$) were found for both slaughter breakeven and profit/loss. However, the averages are meaningful and profit/loss is likely the best indicator. Average profits were $29.78/head for FAST compared to $17.83/head for SLOW, and $-23.18/head for CALF. When evaluated only during the finishing period, the yearling steers had higher profitability compared to calf-finishing.

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Phosphorus Requirement of Finishing Feedlot Calves

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Based on performance and bone characteristics, phosphorus requirements of feedlot calves are lower than previously thought, therefore, corn-based feedlot diets contain adequate phosphorus for optimum performance without supplementation.

Summary

Feedlot calves were individually fed to determine the phosphorus required for optimum performance during a 204-day experiment. The base diet consisted of high-moisture corn and corn starch/fiber with P treatments of 0.16, 0.22, 0.28, 0.34, and 0.40% of diet DM. Calves fed 0.16% P had the lowest plasma P but it was adequate (5.7 mg/dL). Bone mineral was not influenced by treatment, suggesting that dietary P was adequate to meet performance needs. Supplementation of P is unnecessary because requirements are less than 0.16% of the diet DM.

Introduction

Livestock operations are becoming increasingly aware of the challenges associated with nutrient management. Perhaps the largest challenge will be managing phosphorus when concentrated at livestock operations. One factor that may help alleviate the challenges of proper P management is diet modification, in particular, decreasing dietary P to not exceed cattle requirements. However, requirements are not well established for beef feedlot cattle weighing between 550 to 1,250 lb. Phosphorus requirements of yearling steers (850 lb) were evaluated previously, and we concluded that the requirement was less than 0.14% of diet DM or 70% of NRC predicted requirements (*1998 Nebraska Beef Report*, pp. 78-80). Other research has focused on light calves (< 500 lb) which have a higher P requirement than typical feedlot cattle. Therefore, P requirements for typical feedlot calves (> 550 lb) fed high-energy diets need to be evaluated to allow producers to decrease dietary P without compromising performance. Our objectives were to determine 1) the P requirement of finishing calves for optimum performance and 2) the impact of decreasing dietary P on bone metabolism and plasma inorganic P.

Procedure

Diets

A base diet was formulated to contain high concentrations of NEm and NEg yet low concentrations of P. Because corn contains 0.32 ± 0.04% P based on 3,500 samples analyzed across the country, only 34.5% of diet DM consisted of high-moisture corn (Table 1). Brewers grits, which is primarily corn starch, and corn bran, which is the digestible fibrous component of corn, were added to provide a high-energy, low-P substitute for corn. Dietary P treatments evaluated were 0.16 (contained no supplemental P), 0.22, 0.28, 0.34, and 0.40% of diet DM. Dietary P was increased by "top-dress" addition of NaH_2PO_4 (0 to 130 grams/day) directly to each day's aliquot of feed in the bunk. Therefore, P was

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replacing all of the diet (in small quantities) when added to the bunk instead of the supplement carrier. The dry meal supplement was formulated to meet or exceed the metabolizable protein requirements predicted by the 1996 NRC. Blood meal was gradually decreased because less UIP in the diet was required to meet the protein requirements as the experiment progressed. Diet CP concentrations for the three phases were 13.0, 12.6, and 11.8% of diet DM.

Animals

Calves were purchased from one commercial ranch in Nebraska and were managed similarly prior to weaning. At weaning, calves were transported to the University of Nebraska Agricultural Research and Development Center near Mead, Neb. Following a 25-day receiving period and a 14-day training period, calves were limit-fed (12 lb of DM/steer) 50% alfalfa hay and 50% wet corn gluten feed for seven days for accurate initial weights. Initial weights were based on weights taken on three consecutive days prior to morning feeding.

Forty-five, crossbred steer calves (584 ± 37 lb) were assigned randomly to one of five levels of P, either 0.16, 0.22, 0.28, 0.34, or 0.40. Steers were adapted to high-energy diets by limiting intake (8 lb DM initially) and gradually increasing DM offered at a rate of 0.5 lb/day until ad libitum intakes were achieved. This adaptation scheme required approximately 21 days. Steers were fed once daily and implanted on day 1 with Synovex-S followed by Revalor-S on day 84. Two-day weights were taken every 28 days for sampling and performance purposes. Steers were on the experiment for 204 days, from Feb. 2, 2000 to Aug. 24, 2000. At slaughter, hot carcass weights were recorded and two bones from the lower front leg (phalanx and metacarpal) were collected. Following a 24-hour chill, fat depth, loineye area, and marbling measurements at the 12th rib were collected. Final weight was calculated from hot carcass weight divided by a common dressing percentage (62).

Table 1. Diet composition (% of diet DM). At time of feeding, target levels of P were added as top-dress of NaH_2PO_4 to achieve added increments of 0.06%.

ITEM	% diet DM	Ingredient % P
High moisture corn	33.5	0.32
Corn bran	20.0	0.08
Brewers grits	30.0	0.08
Cottonseed hulls	7.5	0.11
Fat	3.0	—
Supplement[a,b]	6.0	0.09
Composition		
Crude protein	12.5	
Calcium	0.62	
Potassium	0.75	

[a]Supplement fed in three phases with decreasing amounts of blood meal to meet or exceed predicted metabolizable protein requirement.
[b]All diets contained 27 grams/ton Rumensin and 10.4 grams/ton Tylan

Table 2. Effects of dietary P on finishing performance and carcass characteristics for calves fed varying levels of P.

	Phosphorus, % of DM[a]						P-Value		
ITEM	0.16	0.22	0.28	0.34	0.40	SE	F-test	Linear	Quad
P intake, g/day	14.2	20.2	23.4	31.7	35.5	0.7	0.01	0.01	
Initial wt., lb	591	584	582	581	582	13	0.98	0.61	0.75
Final wt., lb	1275	1273	1185	1304	1244	24	0.02	0.69	0.33
DMI, lb/day	19.7	19.8	18.1	20.4	19.5	.5	0.03	0.92	0.32
ADG, lb/day	3.35	3.38	2.95	3.54	3.24	.09	0.01	0.86	0.28
Feed conversion[a]	5.85	5.85	6.13	5.75	6.02	—	0.30	0.65	0.79
Fat depth, inches	.38	.51	.46	.46	.46	.05	0.42	0.41	0.25
Ribeye area, inches^2	17.4	17.1	16.3	16.4	16.8	.4	0.44	0.19	0.21
Marbling[b]	529	533	516	566	571	31	0.67	0.25	0.57

[a]Analyzed as gain to feed (ADG ÷DMI) which is the reciprocal of feed conversion
[b]Marbling score where small 50 = 550 and slight 50 = 450.

Sample collection and analysis

Feed ingredients were sampled weekly for DM determination, ground through a Wiley Mill (1-mm screen), and composited by month for analysis. Feed refusals were collected when necessary (minimum of weekly), dried in 60°C forced air oven for DM determination, composited by steer, and ground through a Wiley Mill (1-mm screen) for analysis. Composited feed ingredients and refusals were analyzed for P by a common procedure, alkalimetric ammonium molybdophosphate method.

Blood samples were collected initially and every 56 days thereafter as well as the day of slaughter. Blood was collected in heparinized tubes, transported to the laboratory on ice, centrifuged, and plasma separated. Plasma samples from calves fed 0.16 and 0.40% P from day 0, 56, 112, and 204 were transported to Michigan State University for analysis of osteocalcin concentration using an enzyme-linked immunosorbent assay according to manufacturer's instructions (Novo-Calcin®, Metra Biosystems, Inc., Mountain View, Calif.). Once osteocalcin analysis was complete, those samples were shipped back to Nebraska for plasma inorganic P analysis. Plasma samples from all days and treatments were analyzed for inorganic P using colorimetric procedures (no. 670; Sigma Diagnostics, St. Louis, Mo.).

Results

Based on DMI and P concentration in diets versus orts samples, P intake ranged from 14.2 to 35.5 grams/day. Gain and DMI were variable; however, feed conversion expressed as DMI/ADG was not different across P treatments (Table 2). Because of variable gains, final weights were also variable but did not increase linearly or quadratically as dietary P increased. Figure 1 depicts the

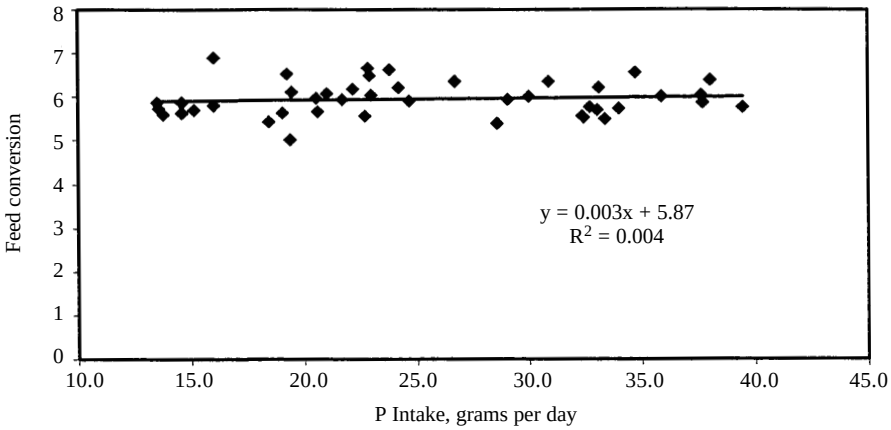

Figure 1. Scatterplot diagram for the relationship between feed conversion measured as DMI/ADG and P intake in grams per day. Each dot represents the average conversion for each steer averaged across the entire 204-day experiment.

Table 3. Effect of dietary P on phalanx and metacarpal bone ash from calf carcasses fed varying levels of P.

	Phosphorus, % of DM[a]						P-Value		
ITEM	.16	.22	.28	.34	.40	SE	F-test	Linear	Quad
Phalanx bone									
Total ash, g	27.8	29.3	27.8	30.9	27.6	1.1	0.19	0.72	0.23
Ash, g/100lb HCW	3.60	3.71	3.78	3.81	3.58	.09	0.46	0.87	0.08
Metacarpal bone									
Total ash, g	242	238	232	249	227	8	0.37	0.48	0.65
Ash, g/100lb HCW	31.5	30.2	31.6	30.8	29.5	.9	0.39	0.23	0.51

relationship between P intake in grams per day and feed conversion. The relationship in this experiment was poor (R^2 = 0.004). Carcass traits were also unaffected by P treatment suggesting that calves were all "finished." Fat depth, loin eye area, and marbling score are provided in Table 2.

The P requirement predicted by the NRC (1996) using actual performance of calves in this study was 18.7 grams/day or 8.4 lb over the 204-day finishing period. This calculation assumes maintenance requirement is 7.3 mg/lb of body weight (BW) and gain requirement is 3.9 grams of P per 100 grams retained protein. Based on retained energy calculations using ADG and average BW over the feeding period, retained protein was equal to 155 grams/day. Therefore, 6.7 grams/day of P for maintenance and 6.0 grams/day for gain is predicted as absorbed needs of the calves. NRC (1996) assumes a 68% absorption rate which means that dietary P requirements are 12.7 ÷ 0.68, or 18.7 grams/day. Despite using unique feed ingredients that are low in P such as brewers grits and corn bran, P intakes in this experiment were in the range of 76% to 190% of NRC-predicted requirements for P.

In these experiments, data suggest that current NRC recommendations are too high. The possible reasons are requirements for P are overestimated and/or the absorption coefficient is underestimated. The P maintenance requirements have been fairly well documented due to the ease of feeding cattle maintenance diets low in P. Only one study was found for estimating requirement for gain. The cattle used for whole-body analysis to define gain requirements were quite different than beef feedlot cattle fed today in terms of breed, body weight, age, and genetic potential. Furthermore, evidence exists that apparent P absorption is related to P intake because of changes in salivary flow of P. However, at low P intakes, true absorption of P from dietary ingredients may increase above 68%. Therefore, the two probable reasons for disagreement between the performance results in this study and the NRC-predicted requirements are inaccurate estimates of gain requirements and/or incorrect absorption estimates at low P intakes.

Phalanx bone ash expressed as total grams was not influenced by dietary P treatment (Table 3). Despite insignificant F-test, expressing phalanx ash as grams per 100 lb hot carcass weight tended (P = 0.08) to respond quadratically with percentage mineral being lowest for the 0.16% and 0.40% P treatments. Expressing mineral content of these bones as a percentage of carcasses should minimize any effects of bone size due to frame or BW differences. Metacarpal bone ash, expressed as either total grams or as a percentage of carcasses, was not influenced by dietary P treatment.

Based on the bone mineral results, calves were not resorbing P to meet their requirements for maintenance and gain. However, bones were collected at slaughter when P requirements are probably lowest relative to supply. Therefore, calves may have mobilized P from bone stores early in the feeding period when requirements were highest and replenished those stores once dietary supply was adequate to meet requirements. While bone mineral content is a critical assessment of P status of animals, osteocalcin in plasma from cattle on the lowest (0.16%) and highest (0.40%) P treatments was analyzed to gain insight into bone metabolism during the experiment. Osteocalcin is an indicator of bone turnover and/or formation. This protein is elevated in plasma during bone formation and turnover. Osteocalcin concentrations in plasma were similar on day 0, 56, 112, or 204 for calves on the 0.16% and 0.40% P treatments, suggesting that dietary P treatment did not alter bone turnover (Figure 2). Based on the osteocalcin and bone ash data, we conclude that dietary P was adequate to meet the requirements for maintenance and gain without compromising bone mineral accretion.

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Plasma inorganic P was measured every 56 days and did respond to P supplementation. Table 4 illustrates changes in plasma inorganic P due to dietary P treatment. When values are averaged for day 56, 112, 168, and 204, plasma P responded both quadratically ($P < 0.01$) and linearly ($P < 0.01$) with the lowest concentration in calves fed 0.16% P (5.71 mg/dL) compared to other dietary P treatments (average of 6.89 mg/dL). Numerous reports suggest that the threshold concentration is between 4.5 to 5.0 mg/dL. Based on average concentration from day 56 to 204 for the 0.16% P treatment, cattle were not deficient in P. However, because plasma P was 4.6 mg/dL on day 56 for the lowest level of P fed, those calves may have been marginally deficient. The plasma concentration for calves on the 0.16% treatment did increase past day 56 of the experiment which suggests that dietary supply relative to requirement was increasing. Plasma concentration of P can be a poor indicator of P status because bone resorption can maintain plasma concentrations above the lower threshold of 4.5 to 5.0 mg/dL. However, the data presented here suggest that calves fed the lowest level of P (0.16%) may have been marginally deficient at least during the first 56 days of the experiment.

Performance and bone data for the entire 204 days suggest calves were not deficient. However, performance and bone mineral data represent the entire 204 days and offer little insight when P requirements are presumably highest relative to supply. Plasma P data were quite variable in response to dietary treatment after the first 112 days. Interestingly, plasma collected on day 56 and day 112 from calves on the highest level of P (0.40%) contained less P than intermediate P treatments.

Dietary calcium was kept constant in this study at 0.62% of diet DM. Because % P varied from 0.16 to 0.40, calcium to phosphorus ratios ranged from 1.6 to 3.9. The ratios fed in this study should not have impacted performance or bone characteristics. Other research has demonstrated that cattle can tolerate Ca:P ratios between 1:1 and 7:1 assuming both calcium and phosphorus are included at or above requirements.

Phosphorus requirements for finishing calves are lower than previous estimates. Because requirements are less than 0.25% of diet DM, grain-based finishing diets contain adequate P to meet finishing cattle requirements for optimal performance and bone reserves. NRC-predicted requirements appear to be too high and should be modified. However, given the relatively large amount of P that grain-based finishing diets contain, requirements for feedlot cattle may be unimportant when using corn based diets. Supplementation of mineral P in finishing diets is an unnecessary economic and environmental cost for beef feedlot producers and should be discontinued.

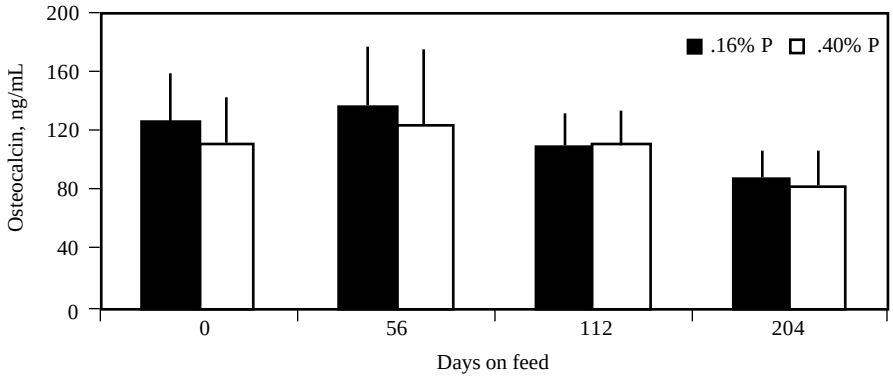

Figure 2. Osteocalcin (ng/mL) in plasma from calves fed either .16% or .40% P during the 204 day finishing experiment. Plasma was analyzed for day 0, 56, 112, and 204. Bars represent average of nine steers per level with standard deviation of the average osteocalcin.

Table 4. Effects of dietary P on plasma inorganic P (mg/dL)for calves fed varying levels of P from .16% to .40% of diet DM.

	Phosphorus, % of DM[a]						P-Value		
ITEM	0.16	0.22	0.28	0.34	0.40	SE	F-test	Linear	Quad
day 0	6.67	8.09	8.20	7.69	6.78	0.37	0.01	0.88	0.01
day 56	4.58	7.50	7.03	7.66	5.55	0.27	0.01	0.02	0.01
day 112	5.45	7.75	7.88	8.27	6.77	0.20	0.01	0.01	0.01
day 168	6.72	6.44	6.39	6.12	7.05	0.19	0.02	0.57	0.01
day 204	5.91	6.13	6.27	6.42	6.84	0.17	0.01	0.01	0.52
day 56 to day 204	5.71	6.95	6.89	7.19	6.55	0.12	0.01	0.01	0.01

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Liming Effects of Beef Cattle Feedlot Manure and Composted Manure

Bahman Eghball[1]

Beef cattle feedlot manure or composted manure usually contain 1% to 4% calcium carbonate and therefore can be used as lime sources on acid soils.

Summary

Soil pH can be increased by manure or compost application because cattle rations usually contain limestone (calcium carbonate). From 1992 to 1996 this study evaluated effects of phosphorus and nitrogen-based manure and compost applications (annual and biennial) management strategies on soil pH level. Manure and composted manure contained about 0.9% calcium carbonate resulting in application rates of up to 1,540 lb lime per acre in four years. The surface soil (0-6 inch) pH was significantly decreased with ammonium-N fertilizer application as compared to soil in the unfertilized check or to soil receiving manure or compost. Nitrogen-based applications resulted in higher soil pH than P-based, since P-based treatments also received N fertilizer.

Introduction

The recommended calcium level in beef cattle diet is 0.7% or about 1.5% calcium carbonate. Much of the added calcium carbonate is excreted in manure, which typically contains 1% to 4% calcium carbonate on a dry weight basis. Calcium carbonate is also added to swine and poultry diets.

About 70% of the cattle fed in the United States are in the Great Plains region where soils usually have high pH levels. Even within the Great Plains, areas where N fertilizer has been used for several years, soil pH has been reduced to levels where lime application is recommended for an optimum crop production level, especially in sandy soils. The objective of this study was to evaluate effects of application frequency and N or P-based rates of manure and compost applications on soil pH changes.

Procedure

An experiment was initiated in 1992 on a Sharpsburg silty clay loam soil under rainfed conditions at the University of Nebraska Agricultural Research Center near Mead, Neb. The initial soil had a Bray and Kurtz No.1 soil P level of 69 ppm and a pH of 6.2 (1:1 soil to water ratio) in the top 6 inches. The experimental design was a randomized complete block with four replications. Plots were 40 feet long and 15 feet wide (six corn rows). Ten treatments were applied which included annual or biennial manure or compost application based on N or P needs of corn (135 lb N/acre and 23 lb P/acre for an expected yield level of 150 bu/acre) and fertilized and unfertilized checks. Fertilized plots received 135 lb N/acre as ammonium nitrate and 23 lb P/acre as diammonium phosphate. If necessary, the P-based treatments (annual or biennial application) also received N fertilizer as ammonium nitrate to provide for a total of 135 lb available N/acre for the corn.

Beef cattle feedlot manure and composted feedlot manure were applied in 1992 based on the estimated plant N or P availability of 40%, 20%, 10%, and 5% of the N and P in manure or compost in the first, second, third, and fourth year after application, respectively. The first-year N availability assumption from compost was found to be too high, so availability assumptions were changed to 20%, 20%, 10%, and 5% for compost applications after 1992. The same N availability assumptions as 1992 were used for manure in all years. Phosphorus availability assumptions from manure and compost were changed to 60%, 20%, 10%, and 10% after 1992. Biennial manure or compost application was made to provide 135 lb N per acre for N-based and 23 lb P per acre for P-based rates in the second year after application based on the assumptions given above.

Manure and compost applications were made in late autumn after corn harvest. Manure and compost were applied by hand to plots and disked-in within two days after application. Soil samples were collected from all plots each year after corn harvest and before manure or compost application. Surface soil (0 to 6 inches) samples collected in 1996 were air dried, ground to pass 1-mm mesh, and analyzed for pH (1:1 soil to water ratio) to evaluate effects of manure, compost, and fertilizer application on soil acidity. The University of Nebraska Soil and Plant Analysis

(Continued on next page)

Laboratory using the standard test determined calcium carbonate concentration of manure and compost.

Least significant difference based on an analysis of variance was used to determine differences among treatments. A probability level ≤ 0.10 was considered significant.

Results

The manure and composted manure used in this study were collected from feedlot pens at the University of Nebraska Agricultural Research Center near Mead, Neb. The rations used in these pens seemed to contain less limestone than those usually used in commercial feedlots (usually about 2%-4% calcium carbonate). Manure collected from six feedlots across Nebraska contained 2.3% to 4.0% calcium carbonate (dry weight basis) while manure and compost used in our study contained < 1.4% calcium carbonate. Although, some of this calcium carbonate ($CaCO_3$) may come from the soil mixed with manure and scrapped from the feedlots, most is likely from feces. The $CaCO_3$ contents of beef cattle feedlot manure and composted manure used in our study (Table 1) were lower than the manure collected from commercial feedlots. The $CaCO_3$ amounts added with manure and compost ranged from 330 to 1,550 lb per acre (Table 2) indicating excellent liming potential of these organic resources when applied to low pH soils. When manure from commercial feedlots is used, one-time N-based manure or compost application may provide half of the lime required for a soil with a Woodruff buffer pH of 6.7 and 25% of the lime required for a soil with a Woodruff buffer pH of 6.5.

Applications of ammonium nitrate and diammonium phosphate for four years significantly decreased soil pH from 6.2 in 1992 to 5.6 in 1996 (Table 3). Phosphorus-based manure and compost applications also received additional N as ammonium nitrate fertilizer, but the lime applied with manure and compost maintained the soil pH level at the original 1992 level. Nitrogen-based manure and compost applications increased the soil pH as compared with the unfertilized check or the P-based application. Nitrogen or P-based manure or compost application resulted in significantly higher soil pH than fertilizer application. Biennial manure or compost application resulted in similar soil pH as annual application (Table 3). Soil pH was significantly related to the amount of manure and compost $CaCO_3$ applied (Figure 1). The relationship clearly indicates good correlation between the amounts of $CaCO_3$ applied and increases in soil pH. The soil in this study would not typically require lime addition, but the use of NH_4-based N fertilizers (especially anhydrous ammonia which is commonly used) can decrease soil pH to a level where lime application is recommended.

Liming materials passing through 60 mesh (60 openings per inch) sieve is considered 100% effective. Since lime in manure has passed through the digestive system of the animals it should be in

Table 1. Characteristics of beef cattle feedlot manure and composted feedlot manure applied in four years at Mead, Neb. All parameters are on dry weight basis.

Year and Source	Total Carbon	Total N	NH_4-N	Total P	$CaCO_3$
			%		
1992					
Manure	7.84	0.79	0.126	0.23	0.84
Compost	9.50	1.10	0.017	0.42	1.24
1993					
Manure	13.31	1.02	0.048	0.50	1.37
Compost	8.74	0.77	0.003	0.32	0.70
1994					
Manure	23.70	1.56	0.037	0.33	0.66
Compost	7.35	0.76	0.006	0.41	1.16
1995					
Manure	17.28	1.30	0.090	0.32	0.42
Compost	6.82	0.78	0.010	0.31	0.62

Table 2. Amounts of dry weight of composted or uncomposted beef cattle feedlot manure and calcium carbonate applied to soil in four years at Mead, Neb.

Treatment	Dry weight				$CaCO_3$				
	1992	1993	1994	1995	1992	1993	1994	1995	Total
	ton per acre				lb per acre				
Manure for N	21	8	5	6	352	226	71	54	703
Manure for P	13	3	3	1.2	212	78	38	10	338
Manure for N/2 y[a]	42	0	16	0	706	0	213	0	919
Manure for P/2 y	25	0	9	0	424	0	116	0	540
Compost for N	15	22	11	16	381	310	261	201	1153
Compost for P	7	4	2	1.3	170	64	78	16	328
Compost for N/2 y	31	0	34	0	765	0	781	0	1546
Compost for P/2 y	14	0	7	0	342	0	232	0	574
Fertilizer	—	—	—	—	0	0	0	0	0
Untreated check	0	0	0	0	0	0	0	0	0

[a]2 y indicates biennial manure or compost application.

Table 3. Surface soil (0-6 inch) pH after four years of composted and uncomposted beef cattle feedlot manure application at Mead, Neb.

Treatment[a]	pH[b]
Manure for N	6.53 de
Manure for P	6.15 g
Manure for N/2 y	6.52 de
Manure for P/2 y	6.26 fg
Compost for N	6.72 c
Compost for P	6.12 g
Compost for N/2 y	6.68 cd
Compost for P/2 y	6.19 g
Fertilizer	5.62 h
Untreated check	6.39 fe
$LSD_{0.10}$	*0.19*

[a]P-based treatments also received N fertilizer as broadcast and incorporated ammonium nitrate. 2 y indicates biennial manure or compost application.

[b]The initial surface (0-6 inch) soil pH of the field was 6.20.

[c,d,e,f,g,h]The values followed by the same letter are not significantly different based on least significant difference (P = 0.10).

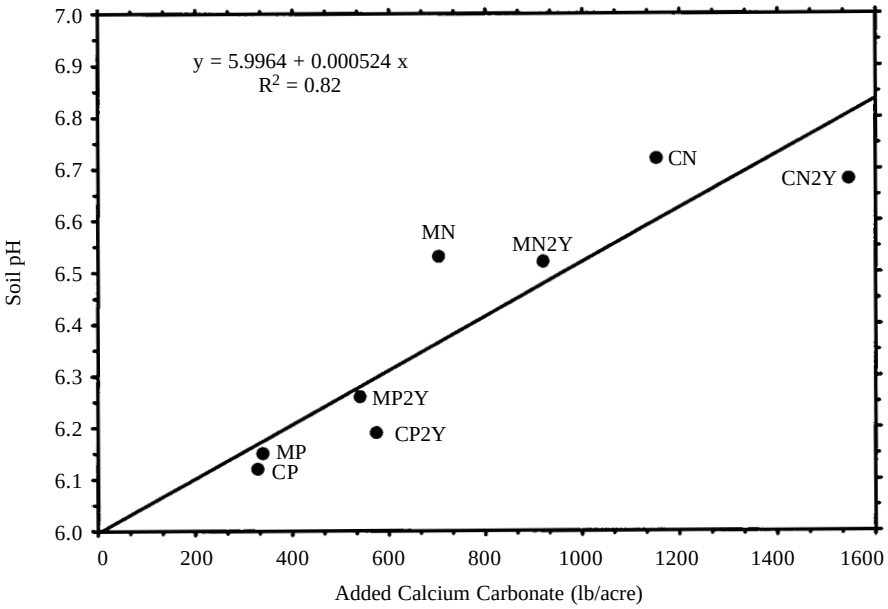

Figure 1. Effect of application of calcium carbonate in cattle feedlot manure or composted manure for four years on surface soil (0 to 6 inch) pH. Fertilized and unfertilized soils had pH of 5.62 and 6.39, respectively. CN is N-based compost, CP is P-based compost, MN is N-based manure, MP is P-based manure, and 2y is biennial application.

Table 4. Lime needed to bring soil pH to 6.5 according to Woodruff and SMP lime requirement tests[a].

Buffer pH	Woodruff		SMP	
	6.67[b]	8.0	6.67	8.0
	lb/acre		lb/acre	
6.9	1,000	1,200	—	—
6.8	2,000	2,400	2,000	2,400
6.7	3,000	3,600	3,500	4,200
6.6	4,000	4,800	4,800	5,800
6.5	5,000	6,000	6,000	7,400
6.4	6,000	7,200	7,800	9,400
6.3	7,000	8,400	9,200	11,000
6.2	8,000	9,600	10,700	12,800
6.1	9,000	10,800	12,000	14,400
6.0	10,000	12,000	13,500	16,200

[a]Data taken from D. Knudsen.1982. How much lime to use. Soil Science News, University of Nebraska Extension.
[b]Depth (inch) of incorporation of lime in soil

very small sizes and can be considered 100% effective. Manure and composted manure should be tested for calcium carbonate content and used similar to commercial lime on acid soils according to the University of Nebraska recommendation. The amounts of lime to apply to raise the soil pH to 6.5 are given in Table 4.

Conclusions

Manure and composted manure usually contain significant amounts of calcium carbonate and can contribute to liming reaction in fields with low soil pH. All or a fraction of the recommended amount of lime may be added when beef cattle feedlot manure or composted manure are applied based on N requirements of corn. Phosphorus-based manure and compost applications, with additional N as ammonium nitrate, maintained soil pH near its original level. Nitrogen-based applications of manure and compost resulted in higher soil pH than P-based applications. A P-based manure and compost application strategy, which needs to be used in sites vulnerable to P runoff losses, was not as effective as a N-based strategy for increasing soil pH. Biennial manure or compost application resulted in similar soil pH as annual application. Four years of inorganic N fertilizer (ammonium nitrate and diammonium phosphate) application significantly reduced soil pH relative to the initial level. Manure or compost from beef cattle feedlots can be good sources of lime.

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Effect of Sawdust or Acid Application to Pen Surfaces on Nitrogen Losses from Open-Dirt Feedlots

John Lory
Julie Adams
Bahman Eghball
Terry Klopfenstein
J.F. Powers[1]

Applying sawdust to increase carbon on pen surface led to more nitrogen in manure and reduced nitrogen loss without affecting performance.

Summary

Two nutrient management treatments (sawdust or sulfuric acid application to pen surface) were compared to conventional management using 12 pens (10 steers/pen) to determine effects on performance and nitrogen losses from pens. Performance and carcass characteristics for treatments were similar to the control. The sawdust treatment retained more nitrogen in manure when removed from the pen surface and after composting. Increasing carbon by sawdust additions reduced nitrogen losses by 21%. Applying acid to the pen surface did not affect quantity of nitrogen or organic carbon conserved in manure and compost.

Introduction

Nitrogen is lost from the feedlot surface and during manure handling through volatilization. This nitrogen loss reduces the amount of nitrogen available to crops when manure is used as a fertilizer source. Plants require a nitrogen:phosphorus (N:P) ratio of 5:1 or greater; however, after substantial nitrogen loss the N:P ratio of feedlot manure is 2:1 or less.

Adding an additional source of carbon may improve the nitrogen retaining properties of the manure on the pen surface and during composting. The addition of a carbon source, such as sawdust, widens the carbon:nitrogen (C:N) ratio of the manure. As the C:N ratio becomes greater, there is a tendency to retain more nitrogen.

The majority of nitrogen lost from feedlot manure is through volatilization. The pH where ammonia (form of nitrogen leading to volatilization) volatilization is greatest occurs above pH 9. Reducing pH below 5 can nearly eliminate ammonia loss.

The objective of this research was to examine the effectiveness of adding sawdust as a carbon source and lowering pen surface pH with sulfuric acid on nitrogen losses from feedlot manure and effects on cattle performance.

Procedure

One-hundred twenty yearling steers (672 $\pm$ 67 lb) were fed through the summer months for 132 days beginning June 14 and ending Oct. 16, 1995. Steers were initially implanted with Revalor-S and were randomly assigned to one of three treatments (10 steers/pen; four pens/treatment). Treatments were control, sawdust bedding application to pen surface and acidification of pen surface with sulfuric acid.

All treatments were fed the same diet formulated for 12% crude protein. Diet contained 80% dry-rolled corn, 10% alfalfa hay, 5% molasses and 5% supplement. Initial weights were an average of weights taken on two consecutive days following a five-day limit-feeding period. At slaughter, hot carcass weights were taken. USDA Quality grade and fat depth measured at 12th rib were recorded after a 24-hour chill. Final weights were calculated as hot carcass weight divided by a common dressing percentage (62).

Steers were fed in 12 open-dirt pens with a pen density of 273 ft^2/steer. Initial soil samples were taken to determine nitrogen and organic carbon percentage and pH. A pretest of experimental methods was performed to determine appropriate acid type and application rates, as well as amount of sawdust to be applied to the pen surface.

Before steers were introduced, the acid treatment pens were treated with sulfuric acid to initiate a pen surface between pH 4.5 and 5.5. Surface pH was monitored three to four times per week using one soil sample taken from four locations within each pen. Sulfuric acid was applied twice per week to regions of pens that measured above pH 5.5. An average of 1.3 moles/ft^2 (1 mol/L) was applied throughout the trial using a hand-held sprayer.

Sawdust by-product from a wood mill was added twice weekly to provide a 2:1 ratio of sawdust to fecal dry matter. Four-hundred sixty-five pounds of sawdust dry matter were added to pens each week. Sawdust was spread throughout the entire surface of each pen in the treatment at a rate of 0.17 lb/ft^2.

After steers were removed from pens, manure was scraped from the pen surface. Thirty manure samples were taken from each pen, and remaining manure was loaded onto trucks. An as-is weight was then taken and manure was hauled to a composting site. The manure was allowed to compost, and samples were taken after the composting process.

Manure and compost samples were frozen until analyzed at -20°C. Gravimetric water content was determined by drying for 24 hours at 105°C. Samples were analyzed for total nitrogen, ammonium (NH_4-N), nitrate (NO_3-N) and organic carbon content. Ammonium and NO_3-N analysis was conducted on moist samples while all other analysis was performed on air-dry samples.

Nitrogen intake (lb/steer) was calcu-

Table 1. Nitrogen balance.

Item	Treatment			P-Value	LSD[a]
	Control	Acid	Sawdust		
N intake, lb/steer	62.4	61.7	61.8	0.52	2.4
N retention, lb/steer[b]	7.3	7.3	7.3	0.84	0.2
N excretion, lb/steer[c]	54.4	54.5	55.2	0.72	2.4
Manure N, lb/steer	12.2	13.6	21.7	<0.01	3.5
N lost, lb/steer[d]	42.2	38.9	33.5	—	—
Compost N, lb/steer[e]	7.5	8.7	14.6	< 0.01	2.2
Organic carbon, lb/steer[f]	142	156	366	—	—

[a]Least Significant Difference (P=0.05).
[b]Determined using net protein gain equation (NRC,1996).
[c]Calculated as N intake minus N retention.
[d]Calculated as N excretion (lb/steer) minus manure N (lb/steer).
[e]Amount of N in compost, measured with ash as a marker of organic matter disappearance.
[f]Determined by laboratory analysis.

Table 2.Nitrogen and organic carbon content of manure removed from feedlot pens and final compost product expressed in dry matter.

Item	Treatment			P-Value	LSD[a]
	Control	Acid	Sawdust		
Manure					
Manure wt., lb DM/steer	885	958	1795	<0.01	280
Total N, %	1.45	1.43	1.21	0.14	—
NO_3-N, ppm	34	23	80	<0.01	22
NH_4-N, ppm	685	1664	765	<0.01	449
Compost					
N, %1.10	1.21	1.03	0.6	—	
Organic carbon, %	8.6	10.1	14.60	.07	5.2

[a]Least Significant Difference (P=0.05).

lated as concentration in diet multiplied by dry matter offered minus nitrogen in feed refused times dry matter feed refused. Nitrogen retention (lb/steer) was calculated by using the net protein gain equation (NRC,1996). Nitrogen excretion (lb/steer) was calculated as nitrogen intake minus nitrogen retention. Nitrogen loss (lb/steer) was determined as nitrogen excretion (lb/steer) minus manure nitrogen (lb/steer). Amount of nitrogen in compost was measured with ash as a marker of organic matter disappearance.

Results

Yearling performance

In this trial, there were no statistical differences (P<0.10) between treatments in ADG (3.66 lb.), feed conversion (6.41) or hot carcass weight (727 lb.). The cattle on the sawdust bedding treatment showed a slight decrease in fat depth (0.40 vs 0.48 in.) and USDA quality grade (17.8 vs 18.4, where 17=S° and 18=S^+) compared to the other two treatments.

Manure nutrient data

Total manure weight removed in sawdust treatment was two times greater than acid or control treatments. The sawdust treatment resulted in the most nitrogen (21.7 vs 12.2 control or 13.6 acid, lb N/steer) being removed from the pen surface in manure (Table 1). Sawdust treatment reduced nitrogen loss by 21% compared to the control (Table 1). In previous reports (*2000 Nebraska Beef Report*, pp. 65-67), <5% of all nitrogen excreted is lost through runoff, therefore it is hypothesized that most of the nitrogen lost during this trial was through volatilization. Adding sawdust as a carbon source to the pen surface resulted in the most pounds of manure dry matter and the highest concentration of organic carbon. Nitrate concentrations were highest in sawdust treatment (Table 2) implying aerobic conditions were increased over other treatments.

Pens treated with acid had an average surface pH of 5.4, while sawdust and control pens were 8.0 and 8.2, respectively. Applying an acid treatment was not effective in reducing the amount of ammonia volatilized or in increasing organic carbon concentration removed in manure above the control treatment. One explanation as to why nitrogen loss was unaffected is urea (primary form of nitrogen in urine) raised pH for short times at certain locations within the pen. Some nitrogen may be unaccounted for in runoff.

Compost nutrient data

Composting reduced nitrogen concentration of all treatments by 25% with no effect of treatment on nitrogen concentration loss (Table 2). The sawdust treatment lost the least amount of nitrogen per pound of nitrogen composted, but lost the most nitrogen in terms of total pounds, because it contained the most nitrogen initially. The sawdust treatment continued to contain the most organic carbon compared to control and acid treatments.

In this feedlot trial, sawdust applied to the pen surface allowed increased nitrogen retention over the acid and control treatments. However, reducing pen surface pH to 5 did not affect performance and carcass characteristics or nitrogen and organic carbon retention compared to the control. Using sawdust as a bedding could be one way to help reduce nitrogen losses from open-dirt feedlot pens.

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Corn Bran Level in Finishing Diets and N Losses from Open-Dirt Pens

Galen Erickson
Terry Klopfenstein
Todd Milton[1]

Increasing carbon excretion in feedlots negatively impacted performance, lowered nitrogen losses during the winter/spring months, and had little impact on nitrogen losses during the summer months.

Summary

Three experiments were conducted with yearling steers to evaluate diet digestibility effects on N volatilization from open-dirt feedlot pens. Digestibility was decreased by increasing dietary corn bran. Corn bran was fed at 0%, 15%, or 30% of diet DM. Intakes increased linearly and ADG decreased linearly as bran inclusion increased. Manure N was increased linearly and N volatilization decreased from 74% to 54% during October to May as bran increased. No differences were observed for N balance from May to October. Decreasing diet digestibility had variable results on manure N and volatilization depending on time of year.

Introduction

Nitrogen emissions from livestock production is a concern for producers. The large losses that occur are detrimental due to environmental pollution and decreased fertilizer value of livestock manure. Nitrogen volatilization estimates from open-dirt feedlots range from 30% to 70% of the N that is excreted.

One method to decrease NH_3 (ammonia) emissions is to increase the carbon to nitrogen (C:N) ratio of manure. Adding carbon to manure decreases N loss by lowering pH when stored anaerobically or by microbial immobilization when aerobically stored.

One method to increase C:N ratio of manure is by feeding diets lower in OM digestibility which contradicts most diet formulation principles used today. Corn bran is a fibrous byproduct of the corn wet milling industry and contains high concentration of NDF yet is highly digestible. In previous studies, corn silage was used to decrease digestibility, but was not effective at reducing N loss (*2000 Nebraska Beef Report*, pp. 68-71). Corn bran has been shown to have lower digestibility than corn it replaces in feedlot diets (*1998 Nebraska Beef Report*, pp. 69-71; *2002 Nebraska Beef Report*, pp. 66-68), yet may maintain or improve animal performance when fed at 15% to 30% of diet DM (*1997 Nebraska Beef Report*, pp. 72-74). Therefore, the objectives of these experiments were to determine the impact of replacing corn with corn bran on 1) animal performance and 2) N volatilization from open-dirt feedlots.

Procedure

Feedlot performance

Three experiments were conducted to assess the impact of increasing dietary corn bran on animal performance and mass balance of N. Experiments were conducted consecutively spanning 343 days with large, yearling cattle. Experiment 1 used 96 steers (848 $\pm$ 34.4lb) fed for 128 days from Oct. 5, 1999 until Feb. 9, 2000. Ninety-six steers (900 $\pm$ 43.4lb) were fed from Feb. 10 until May 24, 2000 or 105 days in Experiment 2. In Experiment 3, 96 steers (925$\pm$ 45.2lb) were fed from June 2 until Sept. 19, 2000 or 110 days.

In each experiment, steers were randomly assigned (eight steers/pen) to treatments (four pens/treatment). Treatments consisted of three different diets (Table 1) in each experiment that contained either 0% (0bran), 15% (15bran), or 30% (30bran) corn bran as a percentage of diet DM. Diets were evaluated using the 1996 NRC model to ensure adequate degradable intake protein (DIP) and metabolizable protein

Table 1. Diet composition (% of diet DM) used in the nutrient balance experiments.

	Corn bran level		
Ingredient	0bran	15bran	30bran
Corn bran	0	15	30
Dry-rolled corn	75	60	45
Corn silage	15	15	15
Molasses	5	5	5
Supplement	5	5	5
Composition			
CP	11.9	11.9	12.0
DIP[a]	6.7	7.6	8.7
NE_m, Mcal/lb[b]	.93	.90	.87
NE_g Mcal/lb[b]	.63	.60	.58
Ca	.65	.65	.65
P	.23	.21	.18

[a]DIP was increased as corn bran increased because microbial efficiency was predicted to increase with higher levels of bran. DIP increased because less feather meal/blood meal was included as bran level increased.
[b]NE values, Ca, and P calculated using tabular values for ingredients.

(MP) for 925 lb steers. As corn bran increased in the diet, effective neutral detergent fiber (eNDF) increased. The NRC model predicted a higher DIP requirement on the 15bran and 30bran treatments based on increased microbial efficiency from higher eNDF. The NRC model inputs for corn bran were 81% NDF that is 44% effective, and 11.7% CP that is 87% DIP. Dry-rolled corn (DRC) assumptions were 0% eNDF and 8.8% CP that is 40% DIP. Corn silage assumptions were 45% NDF that is 60% effective, and 8.7% CP that is 75% DIP. Dietary protein was relatively constant across treatments, but DIP increased and undegradable intake protein (UIP) decreased as corn bran increased from 0% to 30% of diet DM. The goal was to utilize the NRC model so dietary supply would meet or exceed protein requirements during the feeding period. If protein was supplied in excess of requirements, the excess supply was equivalent in grams/day across all treatments.

In each experiment, initial weights were based on two consecutive day weights recorded prior to feeding following a five-day limit fed period. Steers were implanted with Revalor-S® on day 27 in Experiment 1, day 19 in Experiment 2, and day one in Experiment 3.

Cattle were adapted to finishing diets by replacing alfalfa hay with DRC. Roughage was provided from both corn silage and alfalfa. Roughage levels during adaptation were 45%, 35%, 25%, and 15% fed for three, four, seven and seven days, respectively. Steers on the 15bran and 30bran were adapted similarly except corn bran was included at target levels (either 15% or 30%) during the entire 21 day adaptation period. Corn silage was the only roughage source in finishing diets and was included at 15% of diet DM. Corn silage was assumed to contain 50% grain and 50% roughage on a DM-basis.

At slaughter, hot carcass weights were recorded and used to determine final weights assuming a common dressing percentage (62%). Following a 24-hour chill, fat depth and marbling scores were collected at the 12th rib.

Nutrient Balance

Nitrogen mass balance was conducted in 12 open-dirt feedlot pens used previously to assess nutritional impacts on nutrient balance in feedlots. Nitrogen balance was divided into two separate components with one conducted from October to May (Experiment 1 and Experiment 2) and then Experiment 3 handled separately with steers fed from June through September. The main reason for combining Experiment 1 and Experiment 2 was difficulty in soil sampling and cleaning pens between Experiment 1 and Experiment 2 (February). Time of year can impact N volatilization due to effects of ambient temperature, therefore, the nutrient balance data were separated into winter/spring and summer time periods.

Mass balance for N was conducted to assess the impact of dietary treatment on N flow in open-dirt feedlot pens. Briefly, nitrogen intake was quantified by accounting for DMI and N concentration of dietary ingredients. Feed refusals were quantified, composited, and analyzed to correct N intakes. Nitrogen excretion was calculated by difference between N intake and N retained in cattle. Nitrogen retention in the animal was based on animal performance and weights using retained energy and retained protein equations from NRC. At the time of slaughter, cattle were removed and the pens scraped. Collected manure was piled on the cement apron and sampled at the time of removal. Wet manure was weighed at the time of removal and samples used to account for nutrients (DM, OM, N) removed in manure. Pens were cleaned in a manner to minimize soil contamination. Because of inherent differences in cleaning from pen to pen and the difficulty in minimizing soil contamination, clean pens were sampled before each experiment and again following cleaning. The soil cores from before and after the nutrient balance experiment were used to correct for either manure left in the pen or soil removed at cleaning. Soil cores (6 in. depth) were collected at 16 locations within each pen based on a grid to account for variation within the pen. Nitrogen in runoff was quantified by sampling each runoff event and measuring total volume. Nitrogen volatilization was calculated by difference between N excreted and N in manure, soil core balance, and runoff.

Performance and N mass balance in the feedlot was analyzed as a completely randomized design using GLM procedures of SAS. Performance data were tested for experiment by treatment interactions. If no interaction was detected, main treatment effects were evaluated for performance. Nitrogen mass balance data were analyzed as two separate components with Experiment 1 and Experiment 2 analyzed together and Experiment 3 separately. Orthogonal contrasts (linear and quadratic) were used to test effects of dietary bran level on performance and N mass balance.

Results

Feedlot performance

No significant interactions between experiment and treatment were detected for performance variables across Experiment 1, Experiment 2, and Experiment 3 which reflects the similar type of cattle used across experiments as well as the same dietary treatments. The only change between experiments was time of year. Therefore, performance data were pooled and are presented in Table 2. Final weight tended (P = 0.07) to decrease linearly as bran level increased in the diet, which reflects linear depressions (P = 0.05) in ADG. Intakes increased by feeding higher levels of corn bran in place of DRC. Dry matter intake increased 5.1% and 6.8% comparing 0bran to 15bran and 0bran to 30bran, respectively. Because ADG decreased while DMI increased, feed conversion tended to increase quadratically (P = 0.09) and linearly (P = 0.01) as bran level increased. Based on feed conversions, corn bran provided less energy than DRC. Cattle consumed more feed to offset lower energy intake and attempted to maintain ADG.

Level of bran inclusion (15% or 30%) caused non-linear responses. Feed efficiency decreased 7.8% comparing 0bran

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to 15bran, but only decreased another 2.8% when bran increased from 15% to 30% of diet DM (comparing 15bran to 30bran). Surprisingly, these performance data suggest that the second 15% increment was used more efficiently than the first 15% increment of corn bran.

Nutrient balance

Because nutrient balance in Experiment 1 and Experiment 2 had to be conducted together, data for N mass balance are presented as one balance period in Table 3. Nitrogen intake increased linearly (P = 0.01) as bran increased due to increased DMI. Nitrogen excretion responded similar to N intake because N retained by the animal was not impacted by dietary treatment. As the data suggest, most (>90%) of the N fed was excreted based on NRC (1996) prediction equations.

Nitrogen removed in manure corrected for soil core balance was increased linearly (P = 0.01) by increasing dietary corn bran in Experiment 1 and Experiment 2. Manure N increased 68% when comparing 0bran to 15bran and almost doubled (98% increase) when comparing 0bran to 30bran. When expressed as a percentage of total N excreted, 25.6%, 40.1%, and 46.0% of the N was in manure for 0bran, 15bran, and 30bran treatments, respectively. Nitrogen loss via volatilization was also linearly reduced (P = 0.01) by increasing dietary bran. Comparing 0bran to 15bran, N volatilization was reduced by 14.2%. Comparing 0bran to 30bran, N losses were reduced by 20.4%. More OM was removed from pens on the higher bran treatments compared to 0bran. However, despite increased manure N and decreased N losses, neither percent N in manure DM nor C:N ratios of manure were different across dietary treatments. These data suggest that more N was removed in the 15bran and 30bran treatments because more manure was removed. Manure N as a percentage of manure OM was 5.7%, 6.3%, and 5.5% for 0bran, 15bran, and 30bran, respectively. Amount of N lost via precipitative runoff was small (< 0.4% of excreted N) relative to N in manure and volatilized N.

Table 2. Effects of dietary corn bran on finishing performance and carcass characteristics of yearlings fed either 0 (0bran), 15 (15bran), or 30% (30bran) of diet DM as corn bran in place of dry-rolled corn. Data were pooled for Experiment 1, Experiment 2, and Experiment 3 with 96 steers in each and fed for an average of 114 d.

	Corn bran level				P-Value		
ITEM	0bran	15bran	30bran	SE	Exp*trt	Linear	Quad
Initial wt., lb	889	889	889	2.2	.99	.86	.93
Final wt., lb	1348	1333	1330	7.0	.47	.07	.48
DMI, lb d^{-1}	26.0	27.4	27.9	.2	.62	.01	.10
ADG, lb d^{-1}	4.01	3.89	3.84	.07	.31	.05	.58
Feed conversion	6.53	7.09	7.31		.10	.01	.09
Hot carcass wt., lb	836	827	825	4.4	.48	.14	.60
Marbling[a]	526	536	497	7	.16	.01	.01
Fat depth, in.	.42	.42	.42	.01	.92	.86	.93

[a]Marbling score where 450 = slight[50] and 550 = small[50].

Table 3. Effect of dietary corn bran on nitrogen balance in the feedlot and manure characteristics for steers fed from October to June (Experiment 1 and Experiment 2).

	Corn bran level				P-Value	
ITEM[a]	0bran	15bran	30bran	SE	Linear	Quad
N intake	119.9	127.5	131.1	1.2	0.01	0.20
N excretion	108.3	115.9	119.6	1.2	0.01	0.24
N manure[b]	27.8	46.5	55.1	3.5	0.01	0.28
N runoff	.4	.2	.1	.02	0.01	0.01
N volatilization	80.9	69.3	64.4	4.0	0.03	0.52
% volatilization[c]	74.1	59.8	53.8	3.2	0.01	0.33
% N manure[d]	1.80	1.69	1.76	0.11	0.83	0.55
C:N manure[e]	13.5	14.3	14.4	0.7	0.41	0.67

[a]Data were combined for both experiments and handled as one nutrient balance period, and expressed as total lb/steer for the entire time of both experiments (233 d).
[b]Manure N is corrected for change in pen soil concentration and N amount from before and after experiments.
[c]Percentage of volatilization expressed as a percentage of N excretion.
[d]Nitrogen concentration of manure removed at cleaning expressed as percentage of manure DM.
[e]Carbon to nitrogen ratio of manure removed at cleaning.

In Experiment 3 with yearlings fed from June until October, N intakes and N excretion tended to increase linearly (P = 0.08) as dietary bran increased (Table 4). Similar to Experiment 1 and Experiment 2, the small increase in N intake and excretion with the 15bran and 30bran treatments were related to increased DMI because N concentration in diets were similar. No differences were observed for N in manure, N in runoff, or N volatilized from the pen surface. Nitrogen losses were not decreased by feeding bran despite linear increases (P = 0.02) in C:N ratio of manure and OM in manure (P = 0.08). Nitrogen losses were large and averaged 66.8% of total N excreted. Approximately 30.7% on average was removed in manure at cleaning across dietary treatments. Runoff N was greater in Experiment 3 than Experiment 1 and Experiment 2 and averaged 4.5% of total N excreted.

In Experiment 3, increasing the C:N ratio of manure by dietary manipulation in the summer may not influence N volatilization because of the rapid losses with higher temperature. The average temperature for Experiment 1 and Experiment 2 was 42.8°F whereas average temperature for Experiment 3 was 73.6°F.

Another observation from these experiments is that N volatilization from pens on the 0bran treatment were higher (74.1% of N excreted) for Experiment 1 and Experiment 2 compared to Experiment 3 (66.3% of N excreted). Despite colder average ambient temperatures during Experiment 1 and Experiment 2, just as much N was

Table 4. Effect of dietary corn bran on nitrogen balance in the feedlot and manure characteristics for steers fed from June to October.

	Corn bran level				P-Value	
ITEM[a]	0bran	15bran	30bran	SE	Linear	Quad
N intake	54.5	56.6	57.2	.9	0.08	0.53
N excretion	49.6	51.7	52.3	.9	0.07	0.50
N manure[b]	14.4	16.7	15.8	2.9	0.76	0.70
N runoff	2.3	2.3	2.4	.3	0.82	0.79
N volatilization	32.8	35.9	34.1	3.4	0.79	0.57
% volatilization[c]	66.3	69.2	65.0	5.9	0.88	0.63
% N manure[d]	1.33	1.13	1.34	0.13	0.94	0.22
C:N manure[e]	12.6	13.5	14.0	0.4	0.02	0.61

[a]Nutrient balance data for N are expressed as total lb/steer for the entire experiment (110 days).
[b]Manure N is corrected for change in pen soil concentration and N amount from before and after experiments.
[c]Percentage of volatilization expressed as a percentage of N excretion.
[d]Nitrogen concentration of manure removed at cleaning expressed as percentage of manure DM.
[e]Carbon to nitrogen ratio of manure removed at cleaning.

lost from pens on the same diet as that in Experiment 3. This observation suggests an interaction between diet type (C:N ratio of manure) and temperature. It appears that if adequate carbon is present when temperatures rise in May, then N losses may be minimized. However, if inadequate carbon is present (0bran), then N losses will be just as large as continuous warm temperatures.

Rainfall was different across these two time periods (Experiment 1 and Experiment 2 versus Experiment 3). During Experiment 3, there were 10.8 inches of precipitation during the 110 d. In Experiment 1 and Experiment 2, precipitation totaled 7.5 inches during the 233 d. The increase of 3.3 inches in less than half as many days for Experiment 3 compared to Experiment 1 and Experiment 2 may have contributed to no differences between treatments in Experiment 3 when evaluating N losses. Numerous researchers have concluded that N volatilization is positively correlated with moisture content and is rapid during drying conditions.

Increasing the C:N ratio of feedlot manure by dietary manipulation may have value in decreasing N volatilization but is dependent on time of year. However, nutritional methods that increase C:N ratio of manure will lead to poorer feed conversions which may limit their adoption and usefulness for producers. Corn bran may offer more value in situations where acidosis-related problems are prevalent to both improve performance and minimize N losses. Nitrogen loss during the summer months is a concern and does not seem to be easily controlled by changing the C:N ratio of manure.

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Effect of Sprinkling on Heat Stressed Heifers

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Sprinkling of heat stressed heifers reduces body temperature, respiration rate and pulse rate while maintaining dry matter intake.

Summary

Six heifers were housed in controlled environmental stalls. All heifers were sprinkled with water between 1300 - 1500 hours for three days followed by a two-day period in which three were sprinkled between 1200 - 1600 hours and three were not. This was followed by a one day hot period during which all heifers were sprinkled (1300 - 1500 hours). Rectal temperature and respiration rate were reduced in all animals during the first three days of heat stress. On days four and five, heifers sprinkled four hours had lower rectal temperature, respiration rate and pulse rate than heifers which were not sprinkled. Comparison of rectal temperature on days one - three vs day six of heat stress revealed heifers not sprinkled on days four - five were higher on day six vs days one - three. Sprinkling cattle effectively alters physiological responses to heat stress and improves dry matter intake.

Introduction

Using sprinklers to improve animal performance and well-being during episodes of elevated environmental temperature has been reported previously (*2001 Nebraska Beef Report*, pp. 79-81). However, the experimental conditions when the sprinklers were tested allowed all animals adequate access to the sprinklers. Ideal situations such as this may not always exist in commercial feedyard settings. Inconsistent sprinkling may predispose animals to increased levels of stress.

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The objectives of this study were to determine individual animal responses to sprinkling when ambient conditions exceed the animal's thermoneutral zone. Additionally, effects of a missed or doubled sprinkling time were evaluated to determine if inconsistent water application alters the animal's physiological response to heat stress.

Procedure

Six Shorthorn heifers (avg. BW = 813 ± 88 lbs) were used in a 22 - day crossover experimental design. Heifers were housed in 9.8 x 3.3 ft stalls inside a semi-controlled environment facility at the University of Queensland - Gatton, Australia. Temperature within the facility can be maintained at any temperature between 60 - 104°F for extended periods. Relative humidity could not be controlled. Treatments (sprinkled or not sprinkled on days four - five of elevated temperature) were applied in two replications such that all animals were subjected to each treatment. Each replication consisted of a three-day thermoneutral period (TNL) and six-day period with elevated ambient temperature (HOT). During the first three days of HOT all animals were sprinkled for two hours (1300 - 1500 hours) using overhead sprinklers (.75 gal/hd/min). On days four - five of HOT, three animals were cooled (double wet) for four hours (1200 - 1600 hours), while the remainder were not sprinkled (no wet). On day six of HOT, all animals were sprinkled two hours (1300 - 1500 hours). The following day, all animals were subjected to a one-day rest period of thermoneutral conditions after which treatments were reversed. A time line for the trial is shown in Table 1.

Each stall was equipped with an individual feeder and waterer and animals were allowed ad libitum access to a finishing diet (12% CP, 155 Mcal ME/cwt) consisting of: barley, cottonseed meal, and sunflower hulls. Rectal temperature was recorded every 5.4 min and averaged over hourly intervals by a data logger attached to a thermistor. Respiration rate and pulse rate were recorded at bi-hourly intervals on day two of TNL and days one, four, five and six of HOT. Respiration rate was measured by visual observation of flank movement, while pulse rate was measured using an infrared pulse monitor attached to a shaved area on the ear of each animal. Dry matter intake was recorded by load cells under each feed bunk at 15 min intervals and averaged hourly. Ambient conditions (temperature and relative humidity) within the room at a height of 3 ft above the floor were recorded at 5.4 min intervals and averaged hourly. Temperature-humidity index (THI) was calculated using the following equation:

$$THI = Temp - (.55 - (.55 \times (RH/100))) \times (Temp - 58)$$

Figure 1. Effect of double (DW) vs. missed (NW) sprinkling on rectal temperature of heifers under hot environmental conditions. Treatment x time interaction (P<0.001). *Values within a time differ (P<.05).

Data were analyzed using repeated measures in Proc GLM of SAS. Results were analyzed by environmental period with the model for all parameters including animal, treatment, and replication.

Results

Rooms were heated between 800 - 1500 h each day, after which, rooms were allowed to cool. Mean temperature during the thermoneutral period was 68°F (range 67 - 74°F), and mean relative humidity was 65% (range 55 - 75%). These conditions, as well as the THI (range 65 - 70), were well within the thermoneutral zone for feedlot cattle.

During HOT, temperature averaged 88°F (range 79 - 100°F) and relative

Table 1. Time line of treatment application. Each Group contained three heifers.

Day	1	2	3	1	2	3	4	5	6
	TNL, no sprinkling			HOT, all cattle sprinkled (1300 - 1500 hours)			HOT, Group 1 Sprinkled (1200 - 1600 hours), 2 not sprinkled		HOT, all Sprinkled
Day	1	2	3	1	2	3	4	5	6
	TNL, no sprinkling			HOT, all cattle sprinkled (1300 - 1500 hours)			HOT, Group 2 Sprinkled (1200 - 1600 hours), 1 not sprinkled		HOT, all Sprinkled

Table 2. Main effect means of physiological measurements of heifers by period .

Item[a]	Treatments		SEM	P-value
	Double Wet	No Wet		
Thermoneutral				
Rectal temperature, °F	102.4	102.0	.2	.54
Respiration, breaths/min	41.0	41.0	3.5	.32
Pulse, beats/min	66.9	64.5	4.1	.49
HOT, days 1 - 3				
Rectal temperature, °F	103.2	103.4	.05	.56
Respiration, breaths/min	95.9	114.0	2.8	.18
Pulse, beats/min	74.6	80.8	1.7	.24
HOT, days 4 - 5				
Rectal temperature, °F	102.7	104.1	.04	.001
Respiration, breaths/min	92.6	117.9	1.8	.001
Pulse, beats/min	75.2	78.4	.9	.03
HOT, day 6				
Rectal temperature, °F	103.3	103.8	.05	.22
Respiration, breaths/min	109.8	99.4	2.6	.07
Pulse, beats/min	75.8	75.4	1.2	.77

[a]No sprinkling occurred during thermoneutral. Sprinkling was done on all heifers between 1300 - 1500 h during HOT, days one - three and six. During HOT days four - five, sprinkling was done on half the heifers (Double Wet) between 1200 - 1600 h, the balance were not sprinkled.

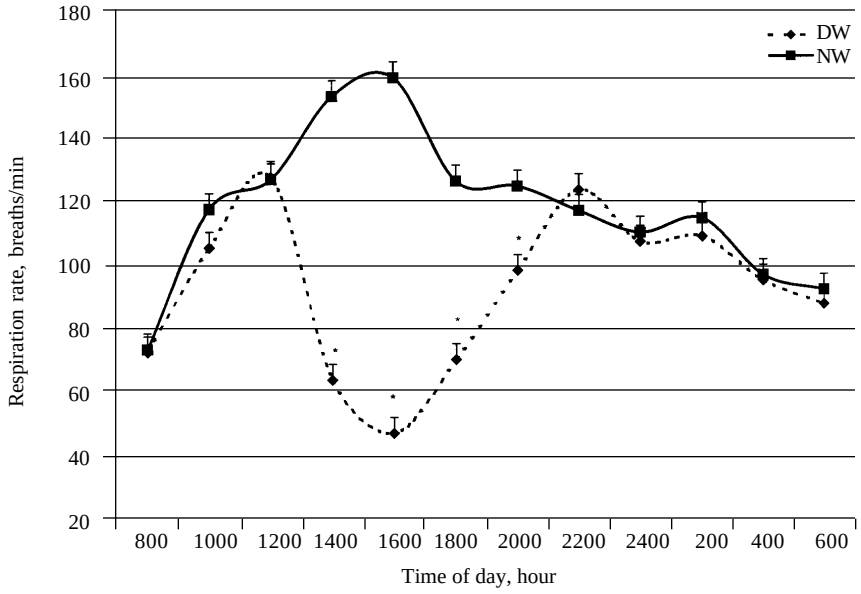

Figure 2. Effect of double (DW) vs. missed (NW) sprinkling on respiration rate of heifers under hot environmental conditions. Treatment x time interaction (P<.001). *Values within a time differ (P<.05).

humidity averaged 70% (range 50 - 96%). These conditions resulted in THI ranging from 76 - 88, and was above 80 for approximately 20 hours/day. According to currently accepted values, THI values > 79 are considered dangerous for feedlot cattle.

Dry matter intakes of heifers for TNL, HOT days one - three, HOT days four - five, and HOT day six are presented in Table 1. Intakes during TNL and HOT days one - three were not different between treatments (P > .2) and averaged 13.1 and 10.8 lb/d, respectively. Reductions in DMI during heat stress are an adaptative mechanism by the animal to reduce metabolic heat load. The 18% decrease in DMI between TNL and HOT days one - three confirm the animals were subjected to discomfort when ambient temperature was elevated. Intakes during HOT day four - five were affected by treatment such that No Wet heifers had 19% lower DMI than Double Wet heifers. Dry matter intakes for the subsequent HOT day six remained lower (P = 0.08) for No Wet heifers even though sprinkling times during this period were similar between treatments. Intakes of No Wet heifers were 33% lower than Double Wet heifers during this period.

Physiological measurements of the heifers are presented in Table 2. During the TNL period, no treatment differences were observed for any parameter and are considered within the normal range for beef cattle. Likewise, during HOT days one - three, rectal temperature, respiration rate and pulse rate of all heifers responded similarly to hot conditions accompanied by sprinkling. Treatment and treatment x time interaction were not significant. However, rectal temperature and respiration rate changed with respect to time (P < 0.01), while pulse rate was only minimally affected (P = 0.08). Rectal temperature was lowest at 900 hours (101.3 $\pm$ .10°F) then gradually increased (P < 0.05) until the initiation of sprinkling (103.6 $\pm$ .10°F; 1300 hours) at which time it began to decline to 102.7 $\pm$ .10°F at 1600 hours. Rectal temperature increased to a high of 104.2 $\pm$ .10°F at 2300 hours, then began to decline again. Respiration rate followed a similar trend by being lowest at 800 hours (72.3 $\pm$ 6.8 breaths/min), then increased (P < 0.05) until the initiation of sprinkling (127.7 $\pm$ 6.8 breaths/min at 1200 hours). Respiration rate declined 36% by 1600 hours, then increased to a maximum of 136.0 $\pm$ 6.8 breaths/min at 2000 hours, after which it slowly declined.

Figure 1 shows rectal temperature of heifers with respect to time (treatment x time, P < 0.001) during HOT days four - five. All heifers had similar increases in rectal temperature through 1200 hours. At 1300 hours, rectal temperature of Double Wet heifers began to decline (P < 0.05), while No Wet heifers increased (P < 0.05). The difference in rectal temperature was maximized 5 hours after

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the initiation of sprinkling (1700 hours) with Double Wet heifers having 3.5°F lower rectal temperature (101.8 vs 105.3 ± .09 °F). Differences in rectal temperature were continued through 700 hours. Figure 2 shows respiration rate of heifers during HOT days four - five with respect to time (treatment x time, $P < 0.001$). Like rectal temperature, heifers had similar respiration rate at the initiation of sprinkling. However, Double Wet heifers declined 50% ($P < 0.01$) by 1400 hours, while No Wet heifers increased 20% ($P < 0.05$). Differences in respiration rate were maximized at 1600 hours at which time Double Wet heifers had a 3-fold lower respiration rate than No Wet (47.3 vs 159.2 ± 4.8 breaths/min). Differences remained between the treatments until 2200 hours, at which time all heifers had returned to pre-sprinkling respiration rates. Pulse rate of heifers was variable with time (Figure 3), however Double Wet heifers were lower ($P < 0.05$) than No Wet at 1200 and 1600 hours.

Measurements of rectal temperature, respiration rate, and pulse rate during HOT day six were minimally affected by previous cooling strategy (Table 2). Figure 4 shows rectal temperature of heifers which tended to be affected by the interaction of treatment x time ($P = 0.14$). Double wet heifers tended to be lower than NW heifers until 1600 hours. Data were also analyzed for alterations in rectal temperature before and after HOT days four - five. Heifers which had been subjected to 2 x water application had no change in rectal temperature response either overall ($P > 0.10$) or with respect to time ($P > 0.10$). However, rectal temperature of animals which had missed a cooling application did differ with respect to time ($P < 0.01$; Figure 5). Rectal temperature of No Wet heifers between 1000 - 1600 hours was higher after missing a cooling period than prior to. This elevation of rectal temperature of rectal temperature is likely a carryover effect of not being cooled the previous two days. However, the profound differences in rectal temperature, respiration rate and pulse rate of between No Wet and Double Wet heifers during HOT days four - five illustrate their risk of heat stress related losses during such times.

Table 3. Dry matter intakes of heifers by period (lb/d).

	Treatments			
Period[a]	Double Wet	No Wet	SEM	P-value
Thermoneutral	12.08	14.08	1.41	.37
HOT, days 1 - 3	10.23	11.44	1.01	.45
HOT, days 4 - 5	12.10	9.32	.68	.03
HOT, day 6	10.29	6.88	1.04	.08

[a]No sprinkling occurred during thermoneutral. Sprinkling was done on all heifers between 1300-1500 h during HOT, days one - three and six. During HOT days four- five, sprinkling was done on half the heifers (Double Wet) between 1200 - 1600 h, the balance were not sprinkled.

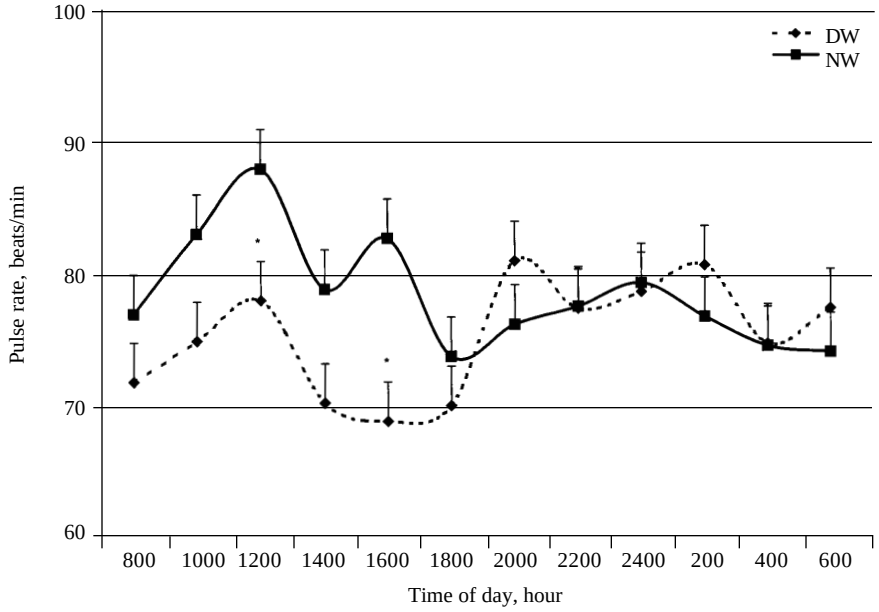

Figure 3. Effect of double (DW) vs. missed (NW) sprinkling on pulse rate of heifers under hot environmental conditions. Treatment xtime interaction (P<.05). *Value within a time differ (P<.05).

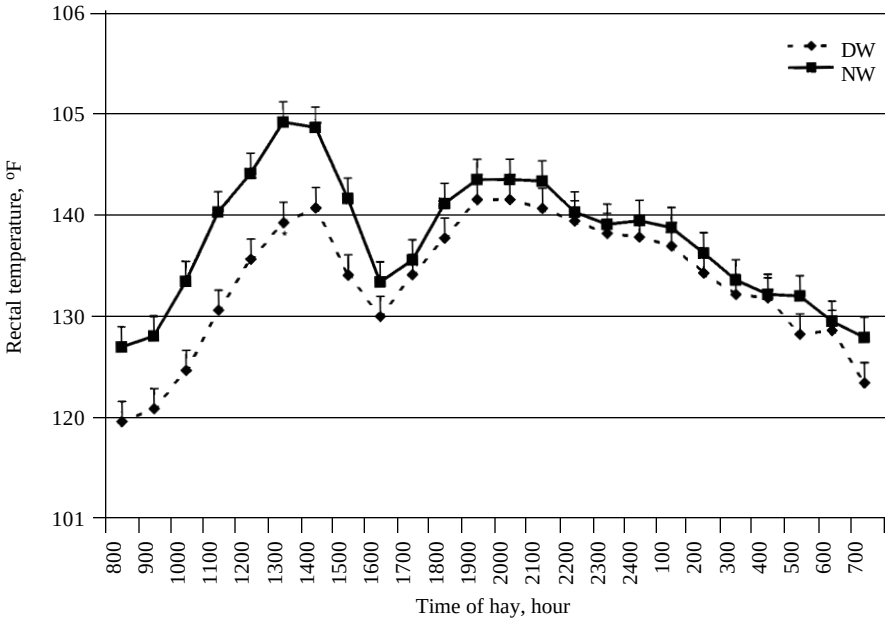

Figure 4. Effect of double (DW) vs. missed (NW) sprinkling on subsequent day (SS2) rectal temperature of heifers under hot environmental conditions accompanied by single sprinkling (1200-1400 h). Treatment x time interaction (P=.14).

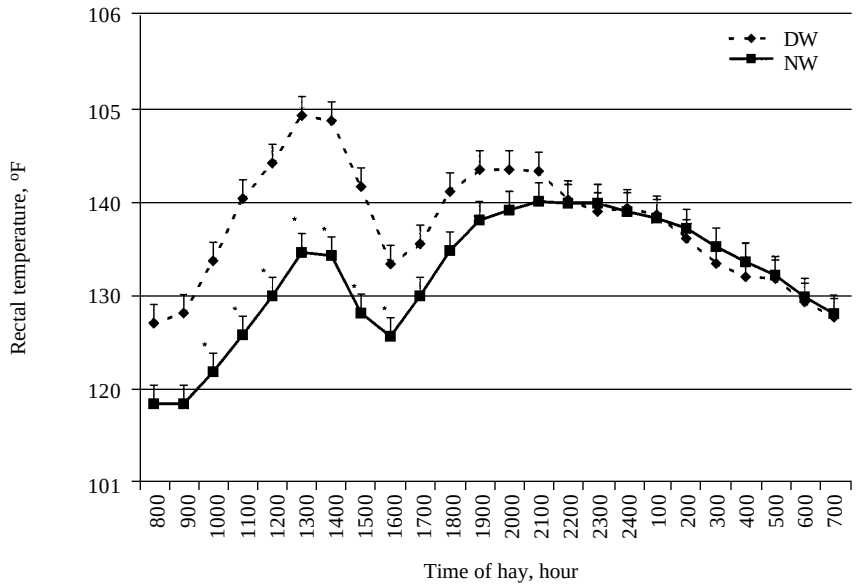

Figure 5. Comparison of rectal temperature of heifers prior to and after missing a sprinkling period. Before vs afer x time interaction (P<.01). *Values within a time differ (P<.05).

Sprinkling cattle is an effective method of altering animal response under conditions conducive to heat stress. Cooling cattle by use of sprinklers maintains dry matter intake under hot environmental conditions and effectively buffers a rise in body temperature which can lead to death. When cooling strategies are employed, they should be consistent and remain uninterrupted until weather conditions no longer pose any danger.

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Effect of Altered Feeding and Sprinkling on Performance and Body Temperature of Steers Finished in the Summer

Shane Davis
Terry Mader[1]

Sprinkling feedlot cattle to reduce heat stress improved overall feed conversion, reduced body temperature, and reduced water intake.

Summary

Effects of feeding time (800 vs 1400) and sprinkling on feedlot performance, body temperature, and mound microclimate were examined to determine their usefulness in reducing heat stress of feedlot steers. Feed conversion was improved overall for steers with access to sprinklers. Body temperature, early in the finishing period, was reduced by both sprinkling and afternoon feeding relative to steers fed at 800 h without access to sprinklers . Overall water intake was greater for steers fed at 800 without sprinkling than any other treatment.

Introduction

In the last decade, heat related production losses in Nebraska surpassed $100 million as a direct result of four heat waves in the years 1992, 1995, 1997 and 1999. In previous Nebraska Beef Reports (2001), we reported changes in body temperature and performance of steers subjected to either altered feeding regimens or water sprinkling, however additive benefits of these systems were not evaluated. Thus, this study was designed to examine altered feeding time with or without water sprinkling on body temperature and performance of feedlot steers.

Procedure

One hundred ninety-two crossbred (English x Continental) steers were received at the Northeast Research and Extension Center Feedlot, Concord, Neb. and processed according to normal procedures. Near the beginning of summer animals were weighed and randomly assigned to one of 24 pens (eight hd/pen). Treatments were assigned to pens using a factorial design, which

(Continued on next page)

consisted of feeding time (800 [AM] vs 1400 hours [PM]) and water sprinkling (none [DRY] vs sprinkling [WET]). Cattle on the PM feeding regimen were fed at 1400 hours and their bunks were managed such that there was no feed available to them between the hours of 800 - 1400. Sprinkling was accomplished via overhead sprinklers controlled by timers. Sprinkler placement allowed cattle to be sprinkled as well as adequately wetting the mound surface. Sprinklers operated 20 minutes every 1.5 hours between 1000 and 1730 on days when predicted maximum THI≥77. Predicted maximum THI was made using a linear relationship derived from data collected (July and August of previous two years) by a weather station in the center of the feeding facility. Linear relationships between maximum daily THI and THI at 0700, 0800, and 0900 hours were determined. Temperature-humidity index at 900 hours had the best relationship. The equation was programmed into a weather station located in the center of the facility. When THI at 900 hours was greater then or equal to 68, a solenoid connected to the water faucet supplying the sprinklers was opened, allowing the timer to operate the sprinklers.

All cattle were managed similarly from day 0 - 21 of the trial. During this time, no sprinkling was done and feed was delivered at 800 h. To obtain accurate baseline measurements all cattle were managed similarly (no sprinkling and 800 hour feeding).

Feed and water intakes were recorded daily. Body weights were obtained on days 0, 21, 56 and 83 (termination of the trial). On the morning of day 84, steers were transported to a commercial slaughter facility where hot carcass weight, marbling score, 12th rib fat thickness, liver abscess scores, and quality and yield grade were obtained. On days one - four, 31 - 35, and 58 - 63 tympanic temperatures (an indicator of core body temperature) were obtained from six hd/sprinkling-feeding time combination (TRT). Tympanic temperatures were obtained using Stowaway® XTI data loggers secured to the ear using tape and gauze. Thermistors attached to the data logger were inserted down the ear canal such that they were near the tympanic membrane. Temperature was recorded every 15 min and compiled into hourly readings. Microclimatic conditions (temperature and relative humidity) of the mound were monitored and recorded using HOBO Pro® data loggers. Loggers were attached at heights of 6 and 30 in to fence post that bisected the mounds. Loggers at 6 in. recorded ambient temperature and soil temperature at a depth of 1 in. via an attached probe. Ambient temperature and RH were recorded by the logger at 30 in., this allowed for THI to be calculated at this height.

Statistical analysis for performance, carcass, tympanic temperature and mound microclimate was done using General Linear Models procedures. The statistical model for performance data included feeding time, sprinkling, and feeding time x sprinkling with day 0 - 21 ADG being used as a covariant. Carcass data were analyzed similarly except no covariant was used. Tympanic temperature and mound microclimate data were analyzed using the repeated statement (to account for time of day) in SAS with the model including feeding time, sprinkling, and feeding time x sprinkling, day included in the model. Data were compared within time of day with $P < 0.05$ used to determine significance.

Results

Climatic conditions for days 21 - 83 are summarized in Table 1. Sprinklers operated on 31 of 63 days during the TRT period. Ninety percent of the days (28 of 31) the sprinklers operated, maximum THI was greater than or equal to 77. Temperature-humidity index exceeded 77 on 7 of the 32 non-sprinkling days of the treatment period. The equation used to predict maximum THI was accurate between 82 - 90% of the time.

During days 0 - 21, similar performance was found among TRT (Table 2). Also, for the 21 - 56 day performance, ADG, feed conversion, and DMI remained similar among TRT. However a feeding time x sprinkling interaction ($P < 0.05$) was found for water intake. Water intakes were 10 and 13% greater for AM/DRY steers than PM/DRY and PM/WET steers, respectively. For days 56 - 83 ADG and daily DMI remained unaffected by TRT and averaged 3.47 lb and 21.39 lb, respectively. Feed conversion during this time was affected by sprinkling ($P = 0.06$); steers in pens with sprinklers were 15 % more efficient than steers in pens without sprinklers. This difference resulted in an overall feed conversion improvement of 5% for steers in pens with sprinklers. Water intakes

Table 1. Climatic conditions during the 21 day common management and 63 day treatment period. Values represent the mean ± standard error.

Item	Mean	Maximum	Minimum
Days 0 - 21			
Temperature, ºF	70.3 ± 1.6	81.3 ± 1.9	59.8 ± 1.4
Relative humidity, %	61.9 ± 2.6	82.8 ± 2.0	40.1 ± 3.0
THI[a]	66.9 ± 1.1	73.5 ± 1.0	59.5 ± 1.2
Days 22 - 56			
Temperature, ºF	73.1 ± .9	82.4 ± 1.1	63.3 ± 1.0
Relative humidity, %	73.3 ± 1.0	90.0 ± .6	53.0 ± 1.7
THI[a]	70.4 ± .8	76.3 ± .8	62.9 ± .9
Days 57 - 83			
Temperature, ºF	73.0 ± 1.0	82.9 ± 1.5	63.6 ± .9
Relative humidity, %	78.2 ± 1.5	92.6 ± .5	58.7 ± 2.8
THI	70.7 ± .8	77.0 ± 1.0	63.2 ± .8
Days 22 - 83			
Temperature, ºF	73.0 ± .7	82.6 ± .9	63.4 ± .7
Relative humidity, %	75.4 ± .9	91.1 ± .4	55.3 ± 1.6
THI	70.5 ± .6	76.6 ± .6	63.0 ± .6

[a]THI = Temperature-Humidity Index = Temperature - (.55 - (.55 x (Relative humidity/100))) x (Temperature - 58)

Table 2. Effect of altered feeding time (800 [AM] vs 1400 [PM] h) with (WET) and without (DRY) sprinkling on feedlot performance of yearling steers.

	Treatments				
Item	AM/DRY	AM/WET	PM/DRY	PM/WET	SEM
Body weight, lbs					
Day 0	936.5	933.4	932.3	936.3	2.2
Day 21	1012.7	1009.4	1008.6	1012.5	2.2
Day 83	1239.1	1249.7	1236.0	1246.8	8.8
Average daily gain, lb/d					
Day 0 - 21[a]	3.83	3.53	3.75	3.42	.22
Day 22 - 83	3.64	3.86	3.64	3.79	.13
Dry matter intake, lb/d					
Day 0 - 21	20.21	20.03	19.88	20.98	.40
Day 22 - 83 21.38	20.94	20.94	21.31	.46	
Feed:gain					
Day 0 - 21	5.67	5.65	5.73	5.95	.15
Day 22 - 83[b]	5.89	5.45	5.78	5.64	.16
Water intake, gal/d					
Day 0 - 21	7.13	7.14	6.65	6.64	.74
Day 22 - 83[c]	10.03[d]	9.10[e]	8.97[e]	9.03[e]	.11

[a]Used as a covariate for subsequent performance (BW, gain, DMI and feed:gain) from days 22 - 83
[b]Sprinkling effect, P < .10
[c]Feeding time x Sprinkling interaction, P < .05
[de]Values within a row with different superscripts differ, P < .05

Table 3. Effect of feeding time (800 [AM] vs. 1400 [PM] h) with (WET) and without (DRY) sprinkling on carcass characteristics of yearling steers.

	Treatments				
Item	AM/DRY	AM/WET	PM/DRY	PM/WET	SEM
Hot carcass wt., lbs	771.0	768.5	766.6	761.7	4.4
Dress, %	62.1	61.6	61.9	61.3	.4
12th rib fat, in	.40	.47	.43	.44	.04
Yield grade	2.00	2.11	2.11	2.15	.08
1s and 2s, %	79.2	70.21	70.21	68.75	
Marbling score[ab]	550.6[c]	519.3[d]	505.5[d]	519.6[d]	10.5
Choice, %	75.0	57.5	63.8	66.7	

[a]Marbling score: 500 = Small 0 (low Choice)
[b]Feeding time x Sprinkling interaction (P < .05)
[cd]Values in a row with different superscripts differ (P < .05)

Table 4. Effect of feeding time (800 [AM] vs. 1400 [PM] h) with (WET) and without (DRY) sprinkling on tympanic temperature of yearling steers on days 30 - 32.

Time of day	Treatments			
0800	AM/DRY[a]	AM/WET[ab]	PM/DRY[b]	PM/WET[b]
0900 - 1400	AM/DRY[a]	AM/WET[b]	PM/DRY[b]	PM/WET[b]
1500	AM/DRY[a]	AM/WET[b]	PM/DRY[b]	PM/WET[a]
1600	AM/DRY[a]	AM/WET[c]	PM/DRY[bc]	PM/WET[ab]
1700 - 1900	AM/DRY[a]	AM/WET[c]	PM/DRY[bc]	PM/WET[b]
2000	AM/DRY[a]	AM/WET[b]	PM/DRY[b]	PM/WET[ab]
2100	AM/DRY[a]	AM/WET[b]	PM/DRY[b]	PM/WET[a]
2200 - 0200	AM/DRY[a]	AM/WET[b]	PM/DRY[b]	PM/WET[ab]
0300	AM/DRY[a]	AM/WET[b]	PM/DRY[b]	PM/WET[b]
0400	AM/DRY[a]	AM/WET[ab]	PM/DRY[b]	PM/WET[bc]
0500	AM/DRY[a]	AM/WET[a]	PM/DRY[b]	PM/WET[ab]
0600	AM/DRY[a]	AM/WET[ab]	PM/DRY[bc]	PM/WET[ab]
0700	AM/DRY[a]	AM/WET[bc]	PM/DRY[c]	PM/WET[ab]

[abc]Treatments in a row differ (P < .05)

for days 56 - 83 continued to be different in AM/DRY steers (feeding time x sprinkling, P < .05). These steers averaged 13% greater water intakes during days 56 - 83 and 11% greater overall. Other measures of performance remained unaffected by TRT.

Carcass traits of the TRTs are presented in Table 3. All TRTs had similar HCW, dressing percentage, QG, YG and fat thickness. However, marbling score was affected by a feeding time x sprinkling interaction (P < .05) with AM/DRY steers averaging 7% higher than all other steers.

Tympanic temperatures during the pre-TRT period (days 0 - 21) were not affected by TRT (data not shown), thus differences in subsequent TT measurements may be viewed as a direct result of TRT.

Tympanic temperatures on days 30 - 32 were affected by a Feeding time x Sprinkling x Time of day interaction (P < 0.05). Steers fed in the morning without access to sprinklers (AM/DRY) had higher TT than PM/DRY steers at all times sampled. Likewise, AM/DRY steers had higher (P < 0.05) TT than PM/WET at all times except 1500 - 1600 and 1900 - 200 h, and were higher (P < 0.05) than AM/WET steers at all times except 400 - 800 h. Differences between AM/WET, PM/DRY and PM/WET were minimal and variable and are best viewed by Table 4. With the exception of 800 h, cattle on TRTs designed to minimize heat stress had similar (P > 0.05) TT from 900 - 1400 h. On hour after feeding (1500 h) PM/WET steers had similar TT to AM/DRY, but both were higher than AM/WET and PM/DRY. These differences may be due to the fact that PM/WET steers were more comfortable because they had been sprinkled and had not experienced metabolic heat load associated with eating and therefore their increased TT may be attributed to an eating event.

Sprinkling x time of day interaction (P < 0.01) also affected TT on days 30 - 32 (Figure 2). During this time, TT of sprinkled steers was lower at 1400 and 1600 - 1900 h than non-sprinkled cattle. Maximum differences in TT of these animals was at 1800 h where DRY steers

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were 1°F higher than WET steers. These findings suggest provision of cattle with sprinklers moderated body temperature during the hottest part of the day, preventing them from being placed at risk for heat related production losses.

When TT were obtained later in the feeding period (days 61 - 62) there was a feeding time x time of day interaction ($P < 0.001$). Steers fed in the afternoon had higher TT than those fed in the morning between 1500 - 1900 h (Figure 2). These differences suggest PM steers had higher TT due to increased metabolic heat load associated with eating. Dry matter intakes of these steers during this time were not different (data not shown), however the time in which the AM steers consumed their meal may have altered their TT. These steers had numerically higher TT between 800 - 1100 h. This may be due to a shift in eating pattern such that a larger percentage of their diet was consumed at night. If this is the case, this would be a self-imposed, adaptive mechanism by these steers. Steers fed in the afternoon on the other hand would have been previously conditioned and adapted to consuming feed in the middle of the day. So although they did have higher TT, this may not be indicative of greater heat stress.

Mound soil temperature as collected on days 31 - 33 are presented in Table 5. Sprinkling lowered overall soil temperature ($P < 0.001$) at all times sampled (sprinkling x time of day interaction, $P < 0.01$). Differences between WET and DRY soil temperatures were minimized on days 30 - 32 at 730 h. At this time soil temperatures were 5.8°F lower ($P < .05$) for WET vs DRY mounds. Differences in soil temperature between WET and DRY mounds were maximized at 1730 hours where WET mounds were 12.9°F cooler ($P < 0.05$) than DRY mounds. The opportunity for conductive heat exchange between the soil and animal depends on the temperature differential. Thus, wet mounds would be more conducive for conductive cooling for the animal.

Temperatures at 6 and 30 inches above the mound on days 30 - 32 (Table 5) were also affected by sprinkling ($P < 0.01$) and a sprinkling x time of day interaction ($P < 0.01$). No differences were observed at 730 hours at either 6 or 30 inches above the mound, however at 1000 hours, temperatures at 6 and 30 inches above WET mounds were 3.8 and 1.8°F cooler ($P < 0.05$), respectively. Temperatures 6 inches above WET mounds remained 4.6, 5.2, 4, and 1.2°F cooler than DRY mounds at 1230, 1500, 1730, and 2000 hours, respectively. While temperatures 30 inches above the mound were 3.3, 3.2, and 1.8°F cooler ($P < 0.05$) than DRY mounds at 1230, 1500 and 1730 hours, respectively. Differences in RH 30 inches above the mounds on days 30 - 32 were evident between 730 - 1730 h (sprinkling x time of day, $P < .05$). Differences ($P < .05$)

Figure 1. Effect of altered feeding regime (AM vs PM) and sprinkling (WET vs DRY) on tympanic temperatures of stress on days 31 - 33. Feeding time x sprinkling x time of day interaction (P<.05).

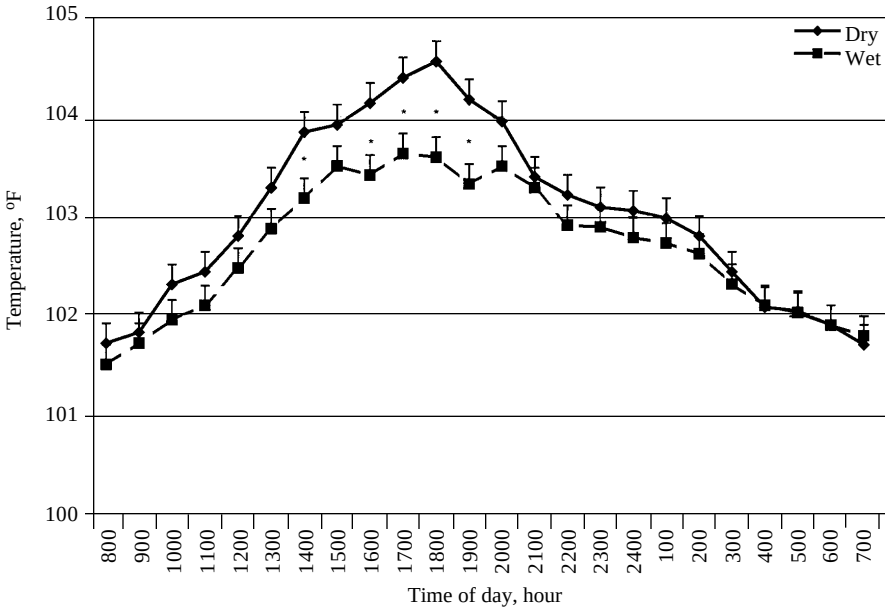

Figure 2. Effect of sprinkling on tympanic temperature of stress on days 31 - 33. Sprinkling x time interaction (P<.01). *Values within a time differ (P<.05).

Table 5. Effect of sprinkling on microclimatic conditions of the mound during days 30 - 32. Values represent least square mean ± standard error.

Item	Time of day, h					
	730	1000	1230	1500	1730	2000
Temperature, °F						
Soil[a]						
DRY	78.1 ± .4[b]	84.0 ± .5[b]	91.1 ± .7[b]	93.1 ± .7[b]	95.0 ± .6[b]	91.6 ± .4[b]
WET	72.3 ± .4[c]	77.7 ± .5[c]	83.0 ± .7[c]	82.3 ± .7[c]	82.1 ± .6[c]	80.0 ± .4[c]
6 inches[a]						
DRY	75.5 ± .4	84.2 ± .5[b]	91.5 ± .7[b]	92.8 ± .7[b]	91.6 ± .6[b]	85.7 ± .4[b]
WET	75.1 ± .4	80.4 ± .5[c]	86.9 ± .7[c]	87.6 ± .7[c]	87.6 ± .6[c]	84.5 ± .4[c]
30 inches[a]						
DRY	74.8 ± .4	83.1 ± .5[b]	90.6 ± .7[b]	91.8 ± .7[b]	90.3 ± .6[b]	85.3 ± .4
WET	74.4 ± .4	81.3 ± .5[c]	87.3 ± .7[c]	88.6 ± .7[c]	88.1 ± .6[c]	84.8 ± .4
Relative humidity, %						
30 inches[a]						
DRY	85.4 ± 1.1[b]	68.9 ± .6[b]	55.9 ± 1.4[b]	54.9 ± 1.2[b]	58.6 ± 1.4[b]	71.5 ± 1.2
WET	88.6 ± 1.1[c]	75.9 ± .6[c]	64.6 ± 1.4[c]	64.6 ± 1.2[c]	66.4 ± 1.4[c]	74.0 ± 1.2
Temperature-humidity index[d]						
30 inches[a]						
DRY	73.3 ± .2	78.7 ± .2[b]	82.4 ± .2[b]	83.2 ± .2[b]	82.7 ± .2	80.9 ± .1
WET	73.3 ± .2	78.1 ± .2[c]	81.4 ± .2[c]	82.4 ± .2[c]	82.3 ± .2	80.8 ± .1

[a]Sprinkling effect (P < .01)
[bc]Means within a parameter, position, and time with different superscripts differ (P < .05)
[d]THI = Temperature-Humidity Index = Temperature - (.55 - (.55 x (Relative humidity/100))) x (Temperature - 58)

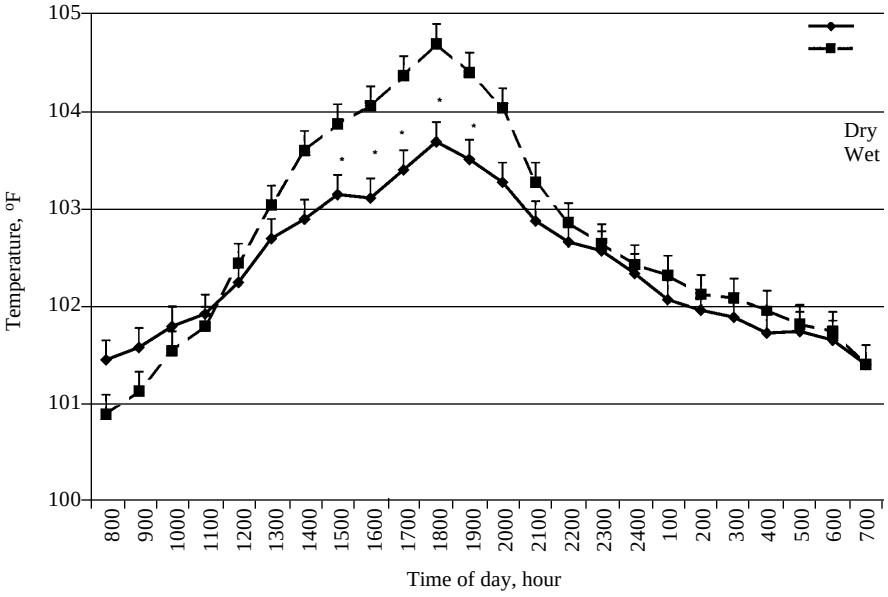

Figure 3. Effect of altered feeding time on tympanic temperature of steers on days 61 - 62. Feeding time x time interactino (P<.001). *Value within a time differ (P<.05).

across these times averaged 12% and ranged from 4% at 730 h to 18% at 1500 h. Despite increasing RH, THI was lowered (P < .05) in response to sprinkling. At 1000, 1230, and 1500 h, THI was lower (sprinkling x time of day, P < .05) 30 inches above WET mounds. Increased relative humidity accompanied by sprinkling can theoretically reduce the evaporative heat exchange mechanisms of the steers. However, the associated decreases in soil and ambient temperature would allow for greater animal comfort as well as increased conductive heat exchange. The decrease in body temperature observed in this study associated with sprinkling supports this theory.

Microclimatic conditions of the mounds obtained on days 30 - 32 and 61 - 62 (data not shown), collectively suggest that sprinkling alters the microclimatic profile of the sprinkled area making it conducive to greater heat flow away from the animal during hot environmental conditions. Although sprinkling did increase RH, animal comfort, as defined by THI, was improved in areas that were sprinkled. Both sprinkling and altering feeding time can decrease susceptibility of feedlot cattle to heat stress by lowering body temperature. Sprinkling cattle increases overall animal performance.

[1]Shane Davis, graduate student; Terry Mader, professor, Animal Science, Northeast Research and Extension Center, Concord, Neb.

Effect of Fiber Level in Finishing Diets on Diet Digestibility and Corn Silage Impact on Bacterial Crude Protein Production

Kyle Vander Pol
Galen Erickson
Ryan Mass
Terry Klopfenstein[1]

Daily bacterial crude protein production was greater when higher levels of dietary fiber were included in a finishing diet.

Summary

Two metabolism trials evaluated the impact of dietary fiber source, level, and digestibility on daily production of bacterial crude protein. In the first trial evaluating corn silage, digestibility was unaffected while daily bacterial crude protein production estimated from urinary allantoin excretion tended to be higher as corn silage replaced corn. In the second trial digestibility was significantly lower for the finishing diets containing higher levels of dietary corn bran.

Introduction

Increasing the fiber level of a beef finishing diet has the potential to increase bacterial crude protein (BCP) production due to an efficiency gain associated with effective neutral detergent fiber (eNDF) and rumen pH. Past research has demonstrated a good relationship between urinary allantoin excretion and duodenal flow of purines for measuring bacterial crude protein (BCP) production for beef cattle growing diets (*2001 Nebraska Beef Report*, pp. 115-116). However it is unclear as to how BCP levels are affected when the percentage of fiber in finishing diets is altered, or how digestibility of the diet affects BCP production. Therefore, it is important to understand what the impacts of source, level, or digestibility of fiber have on BCP production. In addition, effects of adding fiber to the diet on the carbon to nitrogen ratio in manure, and the relationship between diet digestibility and nitrogen loss from manure are important. Therefore the objectives of this research were: 1) to determine effects of increasing dietary corn silage and corn bran on digestibility, and 2) to evaluate how BCP production is affected when dietary corn silage is increased in typical corn-based feedlot diets.

Procedure

Six crossbred steers (1150 lb) were fitted with ruminal and duodenal cannulae and used in a replicated 3x3 Latin square digestibility trial. In Experiment 1, steers were randomly assigned to one of three treatments. Treatments were: 1) 15% corn silage and dry-rolled corn, 2) 30% corn silage with a dry-rolled/high-moisture corn mix, and 3) 45% corn silage and high-moisture corn (Table 1). Diets were formulated similar previous nutrient balance experiments in the feedlot (*2000 Nebraska Beef Report,* pp. 68-71). However, 1.5% urea was included to ensure adequate DIP for optimum BCP production. Steers were individually fed using continuous feeders with feed offered every two hours. The trial consisted of three, 14-day periods with seven days as adaptation, days eight-nine as rumen pH/VFA sampling, and days 10-14 as total urine and fecal collection. On days 10-14 total urine was collected by abdominal funnels attached to a vacuum pump; DM digestibility was determined by total fecal collection and using Cr_2O_3 as a

Table 1. Diet composition (% of DM) for Experiments 1 and 2.

	Experiment 1			[a] Experiment 2 [b]		
Ingredient	15CS	30CS	45CS	0bran	15bran	30bran
Corn silage	15	30	45	15	15	15
Corn bran	0	0	0	0	15	30
Dry-rolled corn	70	30	0	75	60	45
High-moisture corn	10	35	50	0	0	0
Molasses	0	0	0	5	5	5
Supplement	5	5	5	5	5	5
Urea	1.50	1.50	1.50	1.50	1.50	1.50
Limestone	1.30	1.20	1.10	1.45	1.42	1.39
Pot. chloride	0.67	0.45	0.23	0.46	0.46	0.46
Salt	0.30	0.30	0.30	0.30	0.30	0.30
Tallow	0.10	0.10	0.10	0.10	0.10	0.10
Cr_2O_3	0.25	0.25	0.25	0.25	0.25	0.25
Trace Mineral	0.03	0.03	0.03	0.03	0.03	0.03
Vitamin ADE	0.01	0.01	0.01	0.01	0.01	0.01
Rumensin-80	0.016	0.016	0.016	0.017	0.017	0.017
Tylan-40	0.013	0.013	0.013	0.013	0.013	0.013
NE_m Mcal/lb[c]	0.96	0.92	0.88	0.93	0.90	0.87
NE_g Mcal/lb[c]	0.65	0.63	0.60	0.63	0.60	0.58

[a] 15CS is 15% corn silage diet, 30CS is 30% corn silage diet, 45CS is 45% corn silage diet.
[b] 0bran is 0 corn bran in diet, 15bran is 15% corn bran in diet, 30bran is 30% corn bran in diet.
[c] NE values calculated using tabular values for ingredients.

marker. Following collection of rumen samples, pH was recorded immediately and samples were frozen. Feces was collected daily, weighed and one aliquot frozen and subsequently freeze-dried. Another aliquot was dried in a 60°C forced air oven for DM determination.

In Experiment 2, the same six crossbred steers were used in a similar replicated 3x3 Latin square digestibility trial, and were randomly assigned to one of three treatments. Treatments were: 1) no bran, (0bran), 2) 15% bran (15bran), and 3) 30% (30bran) in the diet (Table 1). Diets were similar to previous nutrient balance feedlot research (*2002 Nebraska Beef Report*, pp. 54-57). The experiment consisted of three 14-day periods, with days one-seven as adaptation, days eight-nine as rumen pH/VFA sampling, and days 10-14 as total fecal collection. Total urine was not measured in Experiment 2, and DM and OM digestibilities were estimated only by the chromium marker method, otherwise sampling procedures were the same as in Experiment 1.

In Experiment 1 BCP production was calculated through the use of a derived equation. Determination of BCP from urinary allantoin excretion was determined with the following equation:

$Ma=(Ea - (.385 \times Wt^{.75}))/.850$

$BCP\ (g/d) = ((Ma/.85) * 70 * 6.25) / (.116 * .830 * 1000)$

Where: Ma = allantoin that originates from microbes (mmol/d);
Ea = allantoin excreted by the animal (mmol/d);
0.385 = mmol of allantoin that originate from 1 kg of metabolic body wt;
0.850 = the proportion absorbed allantoin excreted in the urine;
0.850 = the proportion of purine derivatives that are allantoin;
70.0 = g of N / mol of purine;
6.25 = CP conversion factor;
0.116 = purine N : microbial N ratio;
0.830 = intestinal digestibility of purines.

Urinary allantoin excretion was measured by the Rimini-Schryver reaction. The results of the BCP production based on allantoin excretion were compared to NRC prediction for BCP production (Table 4). Using the NRC calculations, we predicted BCP by two different methods. The first method involved inputs corrected for DMI and eNDF to match measured pH in Experiment 1. The second method used actual DMI, but allowed the NRC to predict rumen pH from the eNDF of ingredients. Corn silage NDF was 45% of DM and eNDF was 60% of NDF. Both high-moisture corn and dry-rolled corn were 10% NDF but 0% eNDF.

Results

Experiment 1

Increasing corn silage from 15% to 45% of dietary DM in a finishing diet resulted in a linear increase ($P < 0.01$) in average pH, but was more variable as indicated by a linear increase in pH variance ($P < 0.03$). The pH variance was calculated as total across day variability. Mean rumen pH for all treatments was less than 6.0 (Table 2). No differences ($P > 0.19$) in DMI for all three silage levels were observed, suggesting little prevalence of sub-acute acidosis. Surprisingly, no differences were observed in DM digestibility or OM digestibility, which may have been a result of cattle being fed smaller amounts every two hours rather than a typical twice a day feeding. Comparing total fecal collection to chromic oxide marker, values appear to be slightly lower for DM and OM digestibility with the chromic oxide method. However, the values for DM and OM excretion appear to be consistent between methods.

In the corn silage experiment, urinary allantoin increased (Linear $P < 0.0001$) with increasing level of corn silage (Table 4). Bacterial crude protein levels predicted from urinary allantoin responded similar to urinary allantoin. The 45% corn silage diet produced higher BCP levels than the 15% and 30% corn silage diets. Increasing the level of corn silage in the diet has the potential to increase microbial efficiency which is associated with a increased rumen pH, this in turn can result in a greater level of BCP production. As corn silage increased in the diet, high-moisture corn replaced dry-rolled corn. Adding high-moisture corn may increase BCP production because more starch fermentation occurs in the rumen compared to dry-rolled corn. Therefore, BCP production with the higher silage diets may be partially attributable to the high-moisture corn.

As with any prediction method there are concerns with using urinary allantoin excretion to predict BCP. Allantoin is cleared by the kidneys at a rapid rate after the hepatic oxidation of purines. Despite this rapid clearance, there are some other intermediate products (xanthine and uric acid) associated with the

(Continued on next page)

Table 2. Rumen pH, dry matter, and organic matter data (Experiment 1).

Item[a]	15CS	30CS	45CS	SE	Linear	Quad
pH 5.78	5.85	5.99	.07	.01	.55	
pH var[b]	.167	.179	.240	.02	.03	.32
DMI	24.5	25.2	23.5	.64	.31	.19
OMI	23.4	23.9	22.3	.60	.26	.19
Total Fecal Collection						
DM excretion lb/d	5.0	5.3	4.7	.34	.40	.19
DM digestibility %	80.9	79.1	79.3	1.10	.31	.43
OM excretion lb/d	4.6	4.7	4.2	.34	.26	.28
OM digestibility %	81.5	80.3	80.5	1.21	.55	.61
Chromium Marker Method						
DM excretion lbs/day	5.3	6.1	5.2	.33	.98	.07
DM digestibility %	78.5	75.7	76.9	1.33	.44	.27
OM excretion lbs/day	4.8	5.5	4.6	.31	.75	.10
OM digestibility %	79.3	77.2	79.0	1.32	.87	.26

[a]15CS is 15% corn silage diet, 30CS is 30% corn silage diet, 45CS is 45% corn silage diet.
[b]Total across day rumen pH variability.

oxidative process of purines that can be passed by the urine. However, they are a small fraction of the total purine oxidation process and were, therefore, not analyzed in these trials.

Experiment 2

Dry matter intake, as well as, OMI were not affected by dietary treatment (Table 3). However according to the chromium marker concentration in the feces, DM digestibility decreased linearly (P = 0.05) as corn bran increased from 0% to 30% of the finishing diet DM. Similar to DM digestibility, OM digestibility decreased linearly (P = 0.05) from 77.3 to 73.1% of OM intake. Rumen pH, although not a significant (P = 0.16) linear increase, was numerically greater for 15% and 30% corn bran diets than for 0% corn bran diet. These cattle were on automatic feeders with feed offered every two hours. Feeding in this manner probably decreases the impact that bran may have on rumen pH.

Our daily BCP prediction from urinary allantoin excretion in Experiment 1 suggest that daily BCP production increases as dietary fiber level increases (Table 4). However, the BCP predictions from urinary allantoin excretion are lower than the values predicted by the NRC calculations. When eNDF in the NRC model is adjusted to measured pH in this study, the range in BCP production was 64 g. This difference between 45% corn silage and 15% corn silage may be higher in feedlot situations. Steers in this experiment were fed every two hours which may minimize the impact of increasing eNDF with corn silage. When the NRC model was allowed to predict BCP by using eNDF of ingredients, increasing corn silage from 15% to 45% resulted in a larger increase in BCP production (229 g/d). Furthermore, both allantoin and NRC prediction methods of BCP suggest that increasing dietary corn silage in finishing diets increases BCP.

Table 3. Rumen pH, DM and OM digestibilities (Experiment 2).

Item[a]	15CS	30CS	45CS	SE	Linear	Quad
pH 5.71	5.83	5.85	.11	.16	.53	
pH var[b]	0.23	0.25	0.20	.04	.37	.28
DMI	21.3	22.2	21.3	.23	.81	.23
OMI	20.3	21.1	20.2	.22	.87	.75
Total Fecal Collection						
DM digestibility %	75.75	74.26	71.70	1.48	.05	.74
OM digestibility %	77.27	75.86	73.13	1.56	.06	.69

[a]0bran is 0 corn bran in diet, 15bran is 15% corn bran in diet, 30bran is 30% corn bran in diet.
[b]Total across day rumen pH variability.

Table 4. BCP estimates from duodenal purine concentration and urinary allantoin excretion.

Item[a]	15CS	30CS	45CS	SE	Linear	Quad
Allantoin mmol/d	136	151	185	11	.01	.10
BCP g/d	549	674	705	51	.01	.17
NRC[b] g/d	836	890	900			
NRC[c] g/d	723	843	952			

[a]15CS is 15% corn silage diet, 30CS is 30% corn silage diet, 45CS is 45% corn silage diet.
[b]NRC predicted production of BCP using actual DMI, and correcting eNDF to actual pH measured.
[c]NRC predicted production of BCP using actual DMI without correcting rumen pH, but using assumed eNDF values for corn silage.

Crude Protein and Wet Corn Gluten Feed Levels for Steam Flaked Corn Finishing Diets

Hushton Block
Casey Macken
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Rob Cooper
Rick Stock[1]

Wet corn gluten feed at 20% to 30 % of diet DM optimized performance and increasing CP levels from 13.4% to 15.0% improved performance linearly for steers fed steam-flaked corn.

Summary

Data from three trials suggest steam-flaked corn finishing diets for yearling steers containing corn bran benefit from inclusion of steep liquor at 10% of diet DM, and indicate steam-flaked corn finishing diets for steer calves containing 20% to 30% wet corn gluten feed resulted in optimal performance. With 20% to 30% wet corn gluten feed, calves responded to CP above 13.4% and the requirement for CP is as high as 15.0%

Introduction

Corn steep liquor (± distiller solubles) and corn bran (± solvent extracted germ meal) are the primary components of wet corn gluten feed. Steep liquor has a higher energy value than dry rolled corn or corn bran, and complements corn bran in wet corn gluten feed. Wet corn gluten feed alleviates acidosis in dry-rolled corn finishing diets, improving performance. Both steep liquor and wet corn gluten feed supply degradable intake protein (DIP) as true protein and

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Table 1. Diet composition for Trial 1, 2, and 3 (% DM basis).

Treatment	Trial 1			Trial 2		Trial 3			
Steep liquor:	0%	10%	20%	0%	10%	—	—	—	—
Wet corn gluten feed:	—	—	—	—	—	0%	20%	30%	40%
Ingredient									
Steam-flaked corn	65	55	45	62.5	52.5	85	65	55	45
Corn bran	20	20	20	20	20	—	—	—	—
Steep	0	10	20	0	10	—	—	—	—
Wet corn gluten feed	—	—	—	—	—	0	20	30	40
Corn silage	—	—	—	—	—	10	10	10	10
Alfalfa hay	7	7	7	4	4	—	—	—	—
Cottonseed hulls	—	—	—	3.5	3.5	—	—	—	—
Molasses	3	3	3	3	3	—	—	—	—
Supplement[a]	5	5	5	7	7	5	5	5	5

[a]Includes urea, minerals, vitamins, and additives.

may improve performance compared to urea. Greater requirement for DIP has been demonstrated when feeding steam-flaked compared to dry-rolled corn (*2001 Nebraska Beef Report,* pp. 54-56).

The objectives of this research were to determine the optimum level of steep to include into yearling steer finishing diets based on steam-flaked corn and corn bran, and to determine the optimum level of wet corn gluten feed and CP to include in steam-flaked corn finishing diets for steer calves.

Procedure

Trial 1

Ninety-three yearling steers (863 ± 66 lb) were used in a finishing trial from Sept. 27, 2000 to Jan. 9, 2001 (104 d) to investigate effects of level of steep liquor inclusion in steam-flaked corn and corn bran based diets. The steep used in this trial was a combination of steep liquor and distillers solubles. Treatments for this trial consisted of adding steep at 0%, 10%, and 20% of diet DM. Twelve pens of steers, seven or eight steers per pen, were randomly allotted to the three treatments, resulting in four replicates per treatment.

Diets for this trial (Table 1) were formulated to contain (DM basis) a minimum of 13.0% CP, 0.70% Ca, 0.35% P, and 0.70% K, and included 27 g/ton monensin and 10 g/ton tylosin. Steers were adapted to the final diet by using four adaptation diets containing alfalfa hay at 45%, 35%, 25%, and 15% of DM for three, four, seven and seven days, respectively. Steers were implanted with Revalor-S and treated for internal and external parasites with Cydectin on day 1. Initial weights were an average of two consecutive weights taken before feeding. Final weights were calculated using hot carcass weight divided by a common dressing percentage (62.8). Hot carcass weights and liver abscess scores were recorded at slaughter. Fat thickness at the 12th rib, ribeye area, quality grade, and yield grade were recorded after a 24-hour chill. Data were analyzed for linear and quadratic effects of steep level using the mixed models procedure of SAS.

Trial 2

Eighteen individually fed yearling steers (765 ± 66 lb) were used in an individual feeding trial from April 19, 2000 to Aug. 16, 2000 (154 d) to investigate the effect of inclusion of steep in steam-flaked corn and corn bran based diets. The steep used in this trial was a combination of steep liquor and distiller solubles. Treatments consisted of adding steep at 0% or 10% of diet DM. Nine steers were individually fed and randomly allotted to each of the treatments.

Diets for this trial (Table 1) were formulated to contain a minimum of 13.4% CP, 0.70% Ca, 0.35% P, and 0.70% K, and included 28 g/ton monensin and 10 g/ton tylosin. Steer intakes were started at 11 lb DM/day and increased by 0.5 lb DM/day to ad libitum intake. Steers were implanted with Synovex-C on day 1 and re-implanted with Component-TES on day 41. Initial weights were an average of three consecutive weights taken before feeding. Final weights were a single weight taken before feeding and shrunk 4%. Data were analyzed for treatment effects using the mixed models procedure of SAS.

Trial 3

Three-hundred sixty steer calves (634 ± 24 lb) were used in a finishing trial from Nov. 8, 2000 to April 23, 2001 (166 d) to investigate the effects of level of wet corn gluten feed (Sweet Bran®)and level of CP in steam-flaked corn based diets. Treatments for this trial consisted of adding wet corn gluten feed at 0%, 20%, 30% and 40% and CP level at 13.0%, 13.7%, and 14.4% of diet DM. The CP levels were achieved by supplementation with urea. The combination of 40% wet corn gluten feed and 13.0% CP was infeasible due to the CP content of the feed ingredients. Previous research (*2001 Nebraska Beef Report,* pp. 54-56) has indicated the DIP requirement of steers fed steam flaked corn finishing diets were met by DIP levels of 7.1% or 9.5% of diet DM, CP levels 11.9% or 14.3% of diet DM, respectively, which corresponded to CP levels ≤ 13.7% of diet DM for this trial. This, in combination with pen availability, resulted in exclusion of the 0% wet corn gluten feed with 13.0% or 14.4% CP treatments. Variation in CP content of feed ingredients resulted in higher than anticipated CP levels. Resulting final CP levels were 13.9% for 0% wet corn gluten feed; 13.4%, 14.1%, and 14.8% for 20% wet corn gluten feed; 13.5%, 14.2%, and 14.9% for 30% wet corn gluten feed; and 14.5% and 15.0% for the 40% wet corn gluten feed treatments. Thirty-six pens of steers, 10 steers per pen, were randomly allotted to the nine treatments, resulting in four replicates per treatment.

Diets for this trial (Table 1) were formulated to contain (DM basis) a minimum of 0.70% Ca, 0.35% P, and 0.70% K, and included 27 g/ton monensin and 10 g/ton tylosin. Steers were adapted to the final diet by using five adaptation diets containing corn silage at 70% (30% and 40% wet corn gluten feed treatments

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had corn silage at 65% and 55% of diet DM respectively) for three days, followed by alfalfa hay at 45%, 35%, 25%, and 15% of DM for three, four, eight and seven days, respectively. Steers were vaccinated for respiratory disease (Pyramid), treated for internal and external parasites (Cydectin), and implanted with Synovex-S on d 1. On day 70, steers were retreated for external parasites (Saber) and implanted with Revalor-S. Initial weights were an average of two consecutive weights taken before feeding. Final weights were calculated using hot carcass weight divided by a common dressing percentage (64.58). Hot carcass weights and liver abscess scores were recorded at slaughter. Fat thickness at the 12th rib, ribeye area, quality grade, and yield grade were recorded after a 24-hour chill. Data were analyzed for linear and quadratic effects of wet corn gluten feed level, linear and quadratic effects of CP, linear interaction of wet corn gluten feed and CP, and lack of fit interactions (indicating interaction more complex than linear wet corn gluten feed and CP) using the mixed models procedure of SAS.

Table 2. Effect of steep liquor on feedlot performance and carcass evaluation.

Steep liquor:	0%	10%	20%	SE	Linear [a]	Quadratic[a]
Initial weight, lb	864	864	861	2.9	0.45	0.82
ADG, lb	3.67	4.00	3.97	0.13	0.14	0.28
DMI, lb/day	26.3	27.2	27.8	0.6	0.12	0.83
Feed:gain	7.22	6.83	7.01	0.15	0.34	0.16
Hot carcass weight, lb	781	804	800	10	0.20	0.29
Fat thickness, in	0.50	0.53	0.46	0.03	0.38	0.15
Marbling[b]	526	543	532	10	0.62	0.27
Ribeye area, in ^{2}	12.8	12.8	13.2	0.2	0.20	0.25
Yield grade	2.48	2.39	2.30	0.14	0.40	0.99
Choice, %[c]	82.8	77.4	74.2	—	—	—

[a]P-value.
[b]Marbling score: 500 = small (low choice), 600 = modest (average choice).
[c]Not analyzed for effect of steep level.

Table 3. Effect of steep liquor on feedlot performance.

Steep liquor:	0%	10%	SE	P-value
Initial weight, lb	758	773	22	0.66
Final weight, lb	1219	1226	33	0.87
ADG, lb	3.01	2.97	0.15	0.83
DMI, lb/day	21.8	20.9	0.55	0.26
Feed:gain	7.30	7.11	0.21	0.53

Results

Trial 1

The inclusion of steep at 0%, 10%, or 20% of diet DM did not affect (P > 0.05) the feedlot performance or carcass evaluation variables measured (Table 2). However, observed numerical differences suggest hot carcass weight, ADG, and feed efficiency tended towards quadratic patterns in response to increased levels of steep inclusion. There was a numerical benefit in hot carcass weight (+3%), ADG (+ 9%), and feed efficiency (+5%) to increasing the inclusion of steep from 0% to 10% of DM. Increasing steep from 10% to 20% of DM, resulted in reduced ADG (-1%), no benefit for hot carcass weight (0%) , and decreased feed efficiency (-3%).

Trial 2

The inclusion of steep at 10% of diet DM did not affect (P > 0.05) the feedlot performance parameters (Table 3). Observed numerical values for feed efficiency tended to be improved with inclusion of steep at 10% of diet DM. This trend is in the same direction as the numerical differences observed in Trial 1. Numerical differences for DMI in this trial were the reverse of those observed in Trial 1, suggesting this trend will not be revealed as significant in similar trials with more statistical power. The results of these two trials suggest inclusion of steep at 10% of diet DM in steam flaked corn and corn bran based finishing diets may be beneficial in improving feed efficiency.

Trial 3

Hot carcass weight, ADG, and feed efficiency (Table 4) responded to increasing levels of wet corn gluten feed in a quadratic fashion (P < 0.05). A linear response to wet corn gluten feed level existed for DMI (P < 0.05). Independent of CP level, ADG is predicted to be 3.42, 3.66, 3.64, and 3.52 lb while feed:gain is predicted to be 5.78, 5.64, 5.72, and 5.90 for wet corn gluten feed levels of 0%, 20%, 30%, and 40% of diet DM, respectively. Hot carcass weight, ADG, and feed efficiency responded to increasing levels of CP in a linear fashion (P < 0.05). Independent of wet corn gluten feed level, ADG is predicted to be 3.51 lb at 13.4% CP, and to increase by 0.11 lb for each addition 1% CP, up to 15.0%, while feed:gain is predicted to be 5.78% at 13.4% CP, and to decrease by 0.04 for each addition 1% CP, up to 15.0%.

Net energy levels for Trial 3 (Table 5) were calculated from feed energy values. Whereas the 20% and 30% wet corn gluten feed levels were optimal, and a formulated 13.0% CP level was not possible to include with the 40% wet corn gluten feed level, the 20% and 30% wet corn gluten feed levels were combined for nonlinear (breakpoint) analysis. A breakpoint of 8.6% DIP (13.8 and 14.0% CP for 20% and 30% wet corn gluten feed, respectively) was determined for ADG, and a breakpoint of 8.4% DIP (13.6% and 13.8% CP for 20% and 30% wet corn gluten feed, respectively) was determined for feed:gain. Metabolizable protein and DIP levels for Trial 3 (Table 5) were predicted by the 2000 NRC beef model using microbial efficiency values determined by balancing DIP requirements, as determined by non-linear analysis of feed:gain against DIP for combined wet corn gluten feed levels of 20% and 30%

Table 4. Effect of wet corn gluten feed and CP level on feedlot performance.

Wet corn gluten feed:	0%	20%			30%			40%		SE
CP:	13.9%	13.4%	14.1%	14.8%	13.5%	14.2%	14.9%	14.5%	15.0%	
Initial weight, lb	635	635	635	632	633	633	634	634	634	1.1
ADG, lb[a,b]	3.42	3.55	3.69	3.79	3.45	3.76	3.65	3.51	3.57	0.08
DMI, lb/day[c]	19.8	20.1	20.6	21.1	20.6	21.3	20.6	20.7	20.9	0.3
Feed:gain[a,b]	5.80	5.65	5.60	5.56	5.97	5.66	5.66	5.90	5.85	0.10
Hot carcass weight, lb[a,b]	776	792	806	815	779	812	802	786	793	8
Fat thickness, in	0.48	0.47	0.46	0.50	0.47	0.52	0.48	0.44	0.51	0.02
Marbling[d]	529	539	522	541	529	548	522	503	540	13
Ribeye area, in^2	13.2	13.7	13.4	13.7	13.1	13.5	13.9	13.6	13.5	0.2
Yield grade	2.23	2.27	2.21	2.30	2.30	2.57	2.23	2.13	2.44	0.11
Choice + Prime, %[e]	64.1	65.8	66.7	80.0	52.5	71.8	64.1	50.0	69.2	—

[a]Quadratic effect of wet corn gluten feed level ($P < 0.05$).
[b]Linear effect of CP level ($P < 0.05$).
[c]Linear effect of wet corn gluten feed level ($P < 0.05$).
[d]Marbling score: 500 = small (low choice), 600 = modest (average choice).
[e]Not analyzed for effect of wet corn gluten feed or CP level.

Table 5. Predicted energy and protein levels for Trial 3.

Treatment									
Wet corn gluten feed:	0%	20%			30%			40%	
CP:	13.9%	13.4%	14.1%	14.8%	13.5%	14.2%	14.9%	14.5%	15.0%
NEm	1.04	1.03	1.03	1.03	1.03	1.03	1.02	1.02	1.02
NEg	0.72	0.72	0.71	0.71	0.71	0.71	0.71	0.70	0.70
Metabolizable Protein, g/day									
Supplied	802	865	884	903	910	939	906	934	941
Required	745	764	784	798	749	794	779	759	767
Balance	57	101	100	105	161	145	127	175	174
Degradable Protein, g/day									
Supplied	808	742	827	917	755	849	888	838	897
Required	706	754	771	788	791	816	787	809	815
Balance	102	-12	56	129	-36	33	101	29	82

of diet DM. Inadequate DIP supply was indicated for 20% wet corn gluten feed at 13.4% CP and 30% wet corn gluten feed at 13.5% CP.

The NRC predictions suggest the CP requirement for the 20% and 30% wet corn gluten feed levels is approximately 13.7%. There was a small response in efficiency (Table 4) for the 20% level of wet corn gluten feed when CP was increased above 14.1%, but no response with a similar increase for the 30% wet corn gluten feed level.

The results of this trial indicate the level of wet corn gluten feed to include in steam-flaked corn based finishing diets to optimize ADG, feed efficiency, and hot carcass weight of steer calves is in the order of 20% to 30% of diet DM. It is important to note that the effect of wet corn gluten feed on observed animal performance means should only be evaluated at the higher CP levels, where DIP was not limiting. Predicted treatment means were remarkably similar for hot carcass weight (not shown) and ADG between the 20% and 30% wet corn gluten feed treatments. Additionally, if wet corn gluten feed is priced lower than corn, the lower price of wet corn gluten feed may justify higher levels of inclusion as the economic benefits may outweigh small losses in performance.

The optimal CP level was not determined in this trial as responses to supplemental CP were linear, however, it would appear to be as high as 15.0% CP, which was the highest level evaluated. The high requirement for CP indicated may be explained through increased ruminal fermentation of steam-flaked corn when compared to dry rolled corn, and the effectiveness of wet corn gluten feed in raising the rumen pH of cattle fed high concentrate diets. Both increased rumen fermentation and elevated pH allow for increased bacterial activity and crude protein synthesis, allowing for improved animal performance as a result of increased energy availability, but requiring higher levels of DIP, as observed in this trial.

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Type of Corn Bran and Corn Processing Method in Beef Finishing Diets

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Corn bran type has little effect on finishing steer performance in either dry-rolled or steam-flaked corn based finishing diets.

Summary

A finishing trial was conducted to evaluate the effects of drying corn bran on cattle performance in dry-rolled or steam-flaked corn diets. The inclusion of corn bran in dry-rolled or steam-flaked corn diets negatively affected feed conversion by 5.1% or 13.9%, respectively. Within both grain sources, drying corn bran had little effect on finishing steer performance. Feeding steam-flaked corn improved feed conversion by 17.0% compared with feeding dry-rolled corn without the inclusion of corn bran.

Introduction

When corn gluten feed is dried, the energy value is lowered (*1987 Nebraska Beef Report*, pp. 16 - 18). The exact cause of the lower energy value in dry corn gluten feed is not known, but may be due to some type of damage that occurs during the drying process. Corn gluten feed is comprised of two main components, corn bran and corn steep. Drying bran allows for incorporation of more corn steep when producing wet corn gluten feed and reduces variation in dry matter content of wet corn gluten feed. Previous work (*2000 Nebraska Beef Report*, pp. 61 - 62) has shown that the form of corn bran did not change the energy value in diets consisting of dry-rolled : high-moisture corn (60:40 ratio).

Feed efficiency tended to improve when wet corn gluten feed was added to feedlot diets containing corn processed more intensively than dry-rolling (*2001 Nebraska Beef Report*, pp. 59-63). The objective of this trial was to evaluate the effects of corn bran form in either dry-rolled or steam-flaked corn based diets on performance and carcass characteristics of finishing yearling steers.

Procedure

Three hundred forty crossbred yearling steers (780 lb) were stratified by weight and randomly assigned to one of 40 pens (10 steers/pen in replication one and eight steers/pen in replications two, three and four). Ten pens within replications were randomly assigned to one of 10 treatments. Treatments were assigned based on a 2 x 4 + 2 factorial design with factors of grain source and bran type. Grain sources were dry-rolled corn (DRC) or steam-flaked corn (SFC). Bran types were dry (90% DM) corn bran (DRY), wet (40% DM) corn bran (WET), dry corn bran rehydrated to 40% moisture (Rehy40), or dry corn bran rehydrated to 60% moisture (Rehy60). Corn bran was fed at 30% of the dietary dry matter, replacing either DRC or SFC. Dry and wet corn bran were produced from a wet milling plant located in Blair, Neb. (Cargill Inc.). Wet corn bran was stored in a silo bag. To produce Rehy60, similar moisture content as wet corn bran, the appropriate amount of water was added to dry corn bran prior to bagging. Rehydrated corn bran to 40% moisture was produced three times weekly with the addition of water to dry corn bran and then stored in a pile until used. The two control diets (NO BRAN) had no added bran. All diets were formulated to contain a minimum of 13.0% crude protein, 0.70% calcium, 0.45% phosphorus, 0.67% potassium, 28 g/t Rumensin, and 10 g/t Tylan (DM basis; Table 1). The same supplement was used in all diets at the same level, there-

Table 1. Finishing diet compositions (100% DM basis).

Ingredient Composition,%	NO BRAN	BRAN
Dry-rolled or steam-flaked corn	78	48
Bran	—	30
Corn steep	10	10
Alfalfa hay	3.5	3.5
Sorghum silage	3.5	3.5
Dry supplement	5	5
Nutrient Composition		
Crude Protein,%	13.00	13.66
DIP,%	7.66	9.41
UIP,%	5.34	4.25
Calcium,%	0.70	0.76
Phosphorus,%	0.51	0.44
Potassium,%	0.69	0.67

Table 2. Effects of grain source and bran type on animal performance and carcass characteristics.

	Treatments[a]										
	DRC					SFC					
	NO BRAN	DRY	WET	Rehy40	Rehy60	NO BRAN	DRY	WET	Rehy40	Reyh60	SEM
Days on feed	129	129	129	129	129	129	129	129	129	129	
Initial wt., lb	780	780	782	781	778	779	778	780	779	781	2
Final wt., lb[c]	1261^{d}	1266^{d}	1283de	1282de	1284de	1333^{f}	1283de	1299^{e}	1289de	1280de	16
DMI, lb/day	23.8^{de}	25.4^{fg}	25.6^{gh}	25.9^{gh}	26.7^{h}	23.4^{d}	24.6^{ef}	24.7^{ef}	24.4^{def}	24.2^{de}	0.6
ADG, lb	3.72^{d}	3.76^{de}	3.89^{def}	3.89^{def}	3.92^{def}	4.30^{g}	3.92^{def}	4.01^{f}	3.96^{ef}	3.87^{def}	0.12
Feed:gain	6.39^{de}	6.76^{f}	6.61^{ef}	6.69^{f}	6.80^{f}	5.46^{g}	6.28^{dh}	6.17^{h}	6.17^{h}	6.25^{dh}	0.12
Hot carcass wt, lb	795^{d}	797^{d}	808de	808de	809de	840^{f}	809de	818^{e}	813de	807de	10
Marbling score[i]	514	488	489	490	487	512	499	524	499	502	16
Choice or above,%	58.0	51.7	49.2	51.4	43.8	62.5	54.1	60.7	52.9	46.3	8.6
Ribeye area, in^2	14.9	15.3	15.0	15.6	15.3	14.5	15.4	15.6	15.6	15.3	0.4
Fat thickness, in	0.42	0.42	0.41	0.41	0.44	0.43	0.45	0.45	0.46	0.45	0.04
Yield grade	2.2	2.2	2.1	2.1	2.3	2.3	2.4	2.1	2.2	2.3	0.2

[a]DRC = dry-rolled corn, SFC = steam-flaked corn, NO BRAN = no corn bran, DRY = dry corn bran (90% DM), WET = wet corn bran (40% DM), Rehy40 = Rehydrated to 40% moisture corn bran, and Rehy60 = Rehydrated to 60% moisture corn bran.
[b]GR = grain source and BR = bran type.
[c]Final weight calculated as hot carcass weight divided by 0.63.
[d,e,f,g,h]Means within a row bearing unlike superscripts differ (P < 0.10).
[i]Marbling score: 400 = Slight 0, 450 = Slight 50, 500 = Small 0, etc.

fore, diets containing corn bran had higher percentage levels of CP and DIP due to the higher levels in corn bran compared to either dry-rolled or steam-flaked corn which it replaced. All diets contained corn steep liquor with distillers solubles at 10% of the diet DM. Sorghum silage was included in all diets, including step-up diets, at 3.5% (DM basis). Alfalfa hay was included at 3.5% (DM basis) in the final finishing diet. Step-up diets contained 41.5%, 31.5%, 21.5%, and 11.5% alfalfa hay (DM basis) replacing the corn in each treatment diet.

Initial weights were determined by the average of two consecutive early morning weights prior to feeding at the initiation of the trial. Steers were fed once daily and allowed ad libitum access to feed and water. Steers were implanted with Synovex® Plus™ on day 38. Cattle were fed for 129 days and harvested at a commercial packing plant where carcass data were collected. Hot carcass weight was collected the day of harvest and fat, ribeye area, marbling score, and yield grade following a 24-hour chill.

Results

Dry matter intakes (Table 2) were lower (P < 0.01) for steers fed SFC compared to steers fed DRC corn diets. Steers fed NO BRAN had lower (P < 0.01) DMI than steers fed DRY, WET, Rehy40, or Rehy60. Within DRC diets, ADG was similar among treatments. Daily gain in SFC diets was increased (P < 0.10) for the steers fed NO BRAN compared to the those fed DRY, WET, Rehy40, or Reyh60. In SFC diets, there was no difference between bran types for ADG. Daily gain was higher (P < 0.10) for steers fed SFC without bran compared to DRC without bran.

Feed conversion was better (P < 0.10) in DRC diets for those cattle fed NO BRAN compared to the those fed DRY, Rehy40, or Rehy60, however, cattle on the NO BRAN treatment had similar conversion to cattle fed WET. In SFC diets, steers fed NO BRAN had improved (P < 0.10) feed conversion compared to those fed DRY, WET, Rehy40, or Rehy60. Within each grain source, no significant differences in feed conversion were detected among bran types. When the two control diets are compared, steam flaking improved efficiency by 17.0%. In DRC and SFC diets, feeding corn bran decreased feed efficiency by 5.1% and by 13.9%, respectively.

Hot carcass weights were similar among treatments in DRC diets. In SFC diets, cattle fed NO BRAN had heavier carcasses compared to steers fed DRY, WET, Rehy40, or Rehy60. Cattle fed SFC diets tended to be fatter than cattle fed DRC diets, which led to higher marbling scores for steers fed SFC diets. There were no significant differences in percentage of carcasses grading Choice or higher, ribeye area, or yield grade among treatments.

This experiment shows drying corn bran has minimal effect on the nutritional value in either DRC or SFC diets. Feed efficiency was 2% higher for wet bran diets compared to dry. At 30% of the diet, this would be a 7% lower energy value for dry bran. It is important to note, however, that these differences were not statistically detected which may be due to the relatively small proportion (30% DM) within the diet. The wet and dry bran were statistically equal. Feeding SFC with no corn bran improved ADG and feed conversion compared to feeding DRC with no corn bran. Corn bran had lower apparent energy values than either SFC or DRC.

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Effects of Rumensin Level During an Acidosis Challenge

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Cal Parrott[1]

Feeding Rumensin reduced feed intake. Feed intake reduction was greatest when 45 grams of Rumensin/ton was fed following imposed intake variation.

Summary

Eighteen ruminally cannulated steers were used to determine effects of Rumensin level on incidence and severity of acidosis when an acidosis challenge was imposed. Steers received a high-concentrate finishing diet containing either 0, 30, or 45 grams/ton Rumensin. An acidosis challenge was created by feeding only 50% of diet intake one day followed by 175% of intake the next day, four hours post normal feeding time. Feeding Rumensin decreased feed intake during the prechallenge, challenge and acidosis recovery phase. Compared to 30 grams/ton, feed intake was decreased by increasing Rumensin to 45 grams/ton during the five days following the acidosis challenge. Other feeding behavior and ruminal pH measurements were similar among treatments in all phases of this experiment. The imposed feed intake variation in this experiment did not create a significant acidosis challenge.

Introduction

Clean bunk management programs can increase risk for subacute acidosis (*1997 Nebraska Beef Report*, pp. 41), and may also increase the risk of acidosis challenges. Since cattle on clean bunk programs are without feed some period of time prior to feeding, delays in feed consumption at normal times may result in subsequent over-consumption of the diet. Such an incident may occur when storm conditions markedly reduce intake, equipment malfunctions, or management mistakes occur. Blackford et al. (*2000 Nebraska Beef Report*, pp. 55) showed increased Rumensin concentration (45 grams/ton) in a high-moisture corn finishing diet reduced time and severity of pH below 5.6 compared to 30 grams/ton following a delayed feeding (acidosis challenge). Rumensin levels greater than 30 grams/ton may be beneficial in controlling acidosis in emergency or storm situations.

The objective of this study was to evaluate the effects of increasing dietary Rumensin from 30 to 45 grams/ton during and following an imposed acidosis challenge on ruminal pH, blood parameters, and feeding behavior.

Procedure

Eighteen ruminally fistulated yearling steers (BW = 1000 to 1050 lb) were used in a completely randomized design across two periods (nine steers per period). Steers were randomly allotted to one of three dietary treatments (three steers per treatment in each period) based on Rumensin supplementation strategy: 1) 0 grams/ton for the entire period (CON), 2) 30 grams/ton for the entire period (NOR), 3) 30 grams/ton prior to an acidosis challenge; changed to 45 grams/ton during and five days following the challenge; switched back to 30 grams/ton for seven additional days (EXP).

Steers were adapted to a final finishing ration with four transition diets (roughage level 45, 35, 25, 15) over a 20-day period. The final diet contained 63.4% high moisture corn, 21.1% dry-rolled corn, 7.5% ground alfalfa hay, 3% molasses, and 5% supplement (DM basis). Dry matter concentration of the diet was 76.7 $\pm$ 0.4% across treatments in both periods. Diets were formulated to have a minimum of 7% degradable intake protein (approximately 12% CP), 0.7% Ca, 0.3% P, and 0.6% K. Rumensin was included in the diet at 15 grams/ton (treatments NOR and EXP) during the first two transition diets, and Rumensin was included at 30 grams/ton (treatments NOR and EXP) during the final two transition diets and the final finishing diet. Cattle in the CON treatment never received Rumensin. Tylan was included in all diets at nine grams/ton (90% DM basis).

Steers were managed with a clean bunk management program (access to feed from 8 a.m. to 11 p.m. daily) through the transition period and while receiving the final finishing diet. Steers were individually fed diets and feed intake was monitored continuously with feed bunks suspended from load cells. The amount of feed in each bunk was recorded automatically at one-minute intervals throughout each day and stored on the computer. The program recorded a feed weight every six seconds and averaged those weights for every minute. Feed calls were made every morning at 7:30 a.m. based on the amount of feed in the bunk at 9 p.m., 11 p.m., 1 a.m., and 7:30 a.m. Feed was called to result in the next day's diet to be consumed by approximately 11 p.m.

Steers were adapted to the final finishing diet for approximately 40 days prior to initiation of the experiment. On day 1 of the experiment, a submersible pH electrode was placed in the rumen of

each steer through the cannula (*2000 Nebraska Report*, pp. 55). Rumen pH readings were recorded as previously outlined for feed intake data. Rumen pH was automatically recorded every six seconds and averaged for each minute throughout the day. On days 1 to 8, prechallenge data were collected (intake and ruminal pH). Because the steers were unhooked from the computer system for a period of time on day 7 of each period, pH and intake data collected on that day were not used in the analyses. On day 9, steers were fed only 50% of the day 8 intake in order to make steers eat more aggressively the following day. On day 10 (challenge day), the steers were fed 175% of day 8 intake four hours late (12 p.m.) to impose an acidosis challenge. On day 10, the dietary Rumensin level for EXP was increased from 30 to 45 grams/ton. Days 11 to 15 (recovery phase—45 gram) was a recovery period in which the EXP treatment remained on the 45 grams/ton Rumensin level. To determine if there were negative effects of switching back from 45 to 30 grams/ton Rumensin, feed intake and pH data were recorded on days 16 to 22 (recovery phase—30 gram) while the EXP treatment received the 30 grams/ton Rumensin level.

Feed intake measurements included DM intake, rate of intake, number of meals per day, average meal size, total time spent eating, and average meal length. Ruminal pH measurements included average pH, area of pH below 5.6, (time below x magnitude below), maximum pH, minimum pH, and pH variance.

Intake and ruminal pH data were analyzed using the mixed procedure of SAS. Results were divided into four phases: prechallenge (days 1 to 8, excluding day 7), challenge day (day 10), recovery—45 gram (days 11 to 15), and recovery—30 gram (days 16 to 22). Prechallenge data were analyzed separately since data were collected before Rumensin treatments were imposed. Steer was the experimental unit. Observations were recorded for period x phase x steer for intake and pH data. Contrasts were used to compare CON versus NOR and EXP, and NOR versus EXP. Treatment means were separated within each phase using the LS MEANS procedure with protected F-test ($P \leq 0.10$).

Table 1. Effects of increasing Rumensin level on feed intake and ruminal pH of steers fed a corn-based finishing diet during the prechallenge period.

	Rumensin Level[a]			
Item	CON	NOR	EXP	SEM
Feed Intake[b], lb/day (DM)	24.9	20.6	19.4	.8
Rate, %/hour	26	30	28	1
Meals				
Number/day	7.0	6.1	7.8	.7
Average size, lb DM	3.9	3.9	2.9	.5
Time spent eating				
Total, min/day	492	447	497	35
Average, min/meal	74	82	67	8
Ruminal pH				
Average	5.57	5.57	5.65	.13
Variance	.124	.188	.181	.04
Area < 5.6	356	329	259	91

[a]CON= 0 grams/ton Rumensin, NOR= 30 grams/ton Rumensin fed continuously, EXP= 30 grams/ton Rumensin prechallenge, 45 grams/ton Rumensin fed challenge day and for 5 days following, 30 grams/ton Rumensin fed for the remainder of the period.
[b]Control versus the average of 30 grams/ton and 45 grams/ton ($P < .05$).

Table 2. Effects of increasing Rumensin level on feed intake and ruminal pH of steers fed a corn-based finishing diet during the challenge period.

	Rumensin Level[a]			
Item	CON	NOR	EXP	SEM
Feed Intake				
lb/day, DM[b]	34.3	30.5	29.4	1.1
Rate, %/hour	42	44	68	9
Meals				
Number/day	3.2	2.7	2.2	.8
Average size, lb DM	15.9	13.6	18.3	2.9
Time spent eating				
Total, min/day	221	194	182	51
Average, min/meal	90	81	103	14
Ruminal pH				
Average	5.68	5.71	5.77	.10
Maximum	7.02	7.11	7.12	.09
Variance	.530	.618	.640	.06
Area < 5.6	365	389	370	104

[a]CON= 0 grams/ton Rumensin, NOR= 30 grams/ton Rumensin fed continuously, EXP= 30 grams/ton Rumensin prechallenge, 45 grams/ton Rumensin fed challenge day and for 5 days following, 30 grams/ton Rumensin fed for the remainder of the period.
[b]Control versus the average of 30 grams/ton and 45 grams/ton ($P < .05$).

Results

Prechallenge Phase

Results from the prechallenge phase are summarized in Table 1. Steers fed Rumensin consumed 20% less feed (20.0 vs 24.9 lb of DM) compared with steers fed the control diet containing no Rumensin ($P < 0.05$). Intake rate, total number of meals, average meal size, time spent eating, and average meal length were similar among treatments. Ruminal pH, pH variance and area below pH 5.6 were similar among treatments during the prechallenge phase.

Challenge Day Phase

Results from the challenge day are presented in Table 2. Averaged across treatments, steers consumed 146% more feed (31 versus 21 lb DM) on the challenge day compared with their average feed intake during the prechallenge phase. During the chal-

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lenge day, steers fed Rumensin consumed 15% less feed compared with their counterparts not being fed Rumensin ($P < 0.05$). Intake rate, total number of meals, average meal size, time spent eating, and average meal length were similar among treatments. Ruminal pH, pH variance and area below ruminal pH 5.6 were similar among treatments.

Acidosis Recovery Phase

Results from the recovery—45 gram phase are presented in Table 3. Steers fed 45 grams/ton Rumensin consumed 18% less feed than those fed the control diet during the five days following the challenge day ($P < 0.05$). Feed intake of steers fed NOR was intermediate to that of the steers fed CON and EXP treatments. Intake rate, number of meals, average meal size, time spent eating, and average meal length were similar among treatments. Ruminal pH, pH variance and area below 5.6 were similar among treatments. Results from the recovery—30 gram phase showed no deleterious effects of switching the EXP treatment back to a 30 grams/ton Rumensin after five days on the 45 gram/ton level.

The results of this experiment are in contrast to previous experiments conducted with similar treatments. Blackford (*2000 Nebraska Beef Report,* pp. 55) reported feeding Rumensin decreased ruminal pH variance and area below 5.6 and 5.0 during the challenge day. Furthermore, Blackford reported increasing the dietary concentration of Rumensin from 30 to 45 grams/ton increased average ruminal pH during the five-day period following an acidosis challenge. In the present experiment, increased feed consumption on the challenge day did not appear to create a significant acidosis challenge. Figure 1 summarizes the change in ruminal pH area below 5.6 during the prechallenge, challenge, and acidosis recovery phase. The average ruminal pH during the challenge day was 5.72, which was greater than the average pH during the prechallenge phase.

Reasons why an acidosis challenge did not occur in the present experiment are difficult to explain. Over the course of conducting several of these experiments, we have observed large animal-to-animal variation in how cattle respond to an imposed acidosis challenge despite using similar animals in experiments. Some animals have demonstrated the ability to handle large changes in feed intake without creating an acidosis challenge. Because the steers in this experiment were exposed to only one of the three treatments, animal-to-animal variation would influence our results. Additionally, ruminal pH of steers reached 7.0 or higher (Table 2) on the day of the challenge, which was a result of being fed only 50% of their normal feed intake the day prior to the challenge and four hours late on the challenge day. The high ruminal pH when the animals were exposed to feed on the challenge day may have provided a significant buffering effect to the large meals consumed. In contrast to previous studies (*2000 Nebraska Beef Report,* pp. 55)

Table 3. Effects of increasing Rumensin level on feed intake and ruminal pH of steers fed a corn-based finishing diet during the recovery period.

	Rumensin Level[a]			
Item	CON	NOR	EXP	SEM
Feed Intake				
lb/day, DM[b]	21.6	19.1	18.2	1.1
Rate, %/hour	18	22	26	9
Meals				
Number/day	7.1	7.0	6.5	.8
Average size, lb DM	7.2	4.3	5.0	2.8
Time spent eating				
Total, min/day	418	499	443	51
Average, min/meal	54	68	57	13.7
Ruminal pH				
Average	5.41	5.50	5.45	.10
Variance	.108	.121	.094	.063
Area < 5.6	433	386	399	104

[a]CON= 0 grams/ton Rumensin, NOR= 30 grams/ton Rumensin fed continuously, EXP= 30 grams/ton Rumensin prechallenge, 45 grams/ton Rumensin fed challenge day and for 5 days following, 30 grams/ton Rumensin fed for the remainder of the period.
[b]Control versus the average of 30 grams/ton and 45 grams/ton (P < .05).

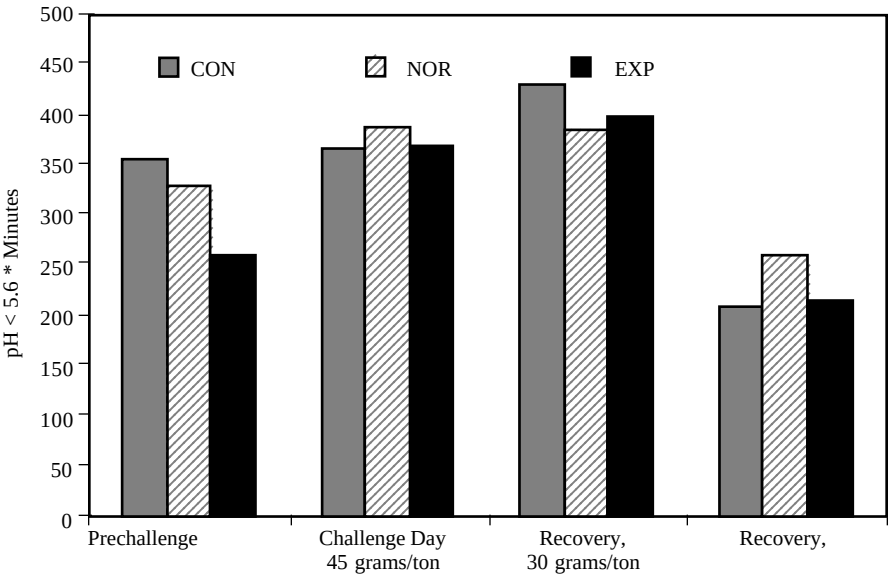

Figure 1. Ruminal pH area below 5.6 for prechallenge, challenge, and recovery phases.

where the acidosis challenge was imposed after a 14 day adaptation to respective diets, cattle in the present study were on the finishing diets 40 days prior to imposed acidosis challenge. It is not clear what effects time on feed (Rumensin) has on the incidence and severity of acidosis when a challenge is imposed.

Rumensin, fed at either 30 or 45 grams/ton, decreased feed intake during the prechallenge, challenge, and acidosis recovery periods. When fed at 45 grams/ton for five days following the imposed intake variation, the decrease in feed intake was greater than that observed with feeding 30 grams/ton. The reduction in feed intake with increased dietary Rumensin would be a positive aspect of controlling acidosis when feedlot cattle exhibit aggressive consumption patterns following an event that may disrupt normal feeding behavior.

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The Effects of Marination and Cook Cycles on High and Low pH Beef Muscles

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Muscles of the chuck and round vary in pH. Muscles with high pH values can be used more effectively in a marination system than muscles with low pH values.

Summary

Infraspinatus and Serratus ventralis, the muscles of the high pH group, had lower shear force values and higher sensory analysis scores for tenderness, juiciness and overall acceptability than low pH muscles (Deep pectoral and Biceps femoris). Increasing the phosphate level in the marination system increased moisture content of the cooked roast and sensory juiciness scores and decreased the cooking loss of the roasts. Low humidity cookery had higher sensory juiciness, tenderness and acceptability scores and lower cooking losses than high humidity cookery. The Infraspinatus and Serratus ventralis are recommended for use in a marination system with low humidity cookery.

Introduction

With the growing popularity of ready-to-eat food, enhanced (injected) beef products will be produced on a larger scale in coming years. Chemical and physical properties of the muscles of the chuck and round have been studied in recent years. These studies have produced information that will be valuable for the development of value-added beef products. Success of an enhanced and marinated beef product will lie with the muscle characteristics and ingredients used in the marinade. Ingredients such as phosphates increase the water retention of meat products. Increasing the water retention of the meat helps to hold the natural water of the meat and added marinade solution, to produce a juicy cooked product. Therefore, the objectives of this project were to increase precooked roast beef palatability and consistency by targeting pH differences in specific chuck and round muscles and evaluating high and low humidity cookery systems.

Procedures

This study examined four muscles (Infraspinatus, Serratus ventralis, Deep pectoral, Biceps femoris), three phosphate levels (0%, 0.25%, 0.5%), two cooking humidity levels (high and low), and two endpoint internal temperatures (140°F and 160°F). The Infraspinatus and Serratus ventralis were categorized as high pH muscles (pH >5.75) and the Deep pectoral and Biceps femoris were categorized as low pH muscles (pH <5.75). 144 roasts were marinated and cooked in three production days.

Boxed beef containing the specified muscles was purchased from the ConAgra Beef Company at Grand Island, Neb. and shipped to the University of Nebraska Loeffel Meat Lab. External fat and heavy external connective tissue were removed from the four muscle groups. Muscles were then sectioned into approximately four pound roasts and assigned to treatments. Roasts were injected with a marinade solution containing water, salt, flavorings and either 0, 0.25, or 0.5% phosphate. Roasts were pumped to approximately 10% above green weight and placed in a vacuum sealable bag. The remaining portion of solution for a 12% pickup was added to the bag. Bags were vacuum sealed and double bagged with the second bag having no vacuum. Treatments were tumbled for 30 minutes. Roasts were cooked in either a high humidity oven (100% RH) or low humidity oven (33% RH) to an endpoint internal temperature of 140°F or 160°F. The roasts were then cooled overnight and the following day weights were taken for determination of cooking loss and samples were taken for chemical and physical testing.

Proximate composition was conducted to determine moisture, fat, ash, and protein content of the samples. Total collagen content was determined by analyzing the hydroxyproline amount (mg of collagen/g) in the samples of sample. A 1-inch thick sample was taken from each cooled roast for analysis of

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tenderness using Warner-Bratzler shear force. The pH of the raw and cooked roasts was determined for initial categorization and change in pH. Eight consumer taste panels consisting of approximately 30 faculty, staff, graduate and undergraduate students of the university (each session) were conducted to look at tenderness, juiciness, and overall acceptability of the sample roasts. An 8-Point Hedonic scale was used with a score of 8 being extremely desirable and a score of 1 being extremely undesirable. Each panelist received a plate of six samples (1" x .5" x .25") to compare at each session.

Statistical analyses of the data were performed to study the fixed effects and interactions at P< 0.05. This was done using the Proc Mixed and LS Means procedure of SAS.

Results

Data collected for pH on the raw muscles showed significant differences between the muscles within the pH categories (Table 1). High pH muscles (Infraspinatus, Serratus ventralis) had significantly higher pH values (P< 0.001) than the low pH muscles (Deep pectoral, Biceps femoris). These data support information reported in the literature. The pH of the cooked muscles was significantly affected by muscle, phosphate level, humidity level, and end point internal temperature (Table 2). The differences between muscles remained similar to those observed with the initial pH of the raw muscles. By increasing the phosphate level in the product, the pH rose slightly but significantly (P< 0.05). Increasing the humidity level during cooking slightly raised the pH (P< 0.01), as did the 160°F endpoint internal temperature (P< 0.05).

Cooking loss of roasts was affected by phosphate level, humidity level, and endpoint internal temperature (Table 3). Increasing the phosphate level reduced cooking loss significantly between 0% and 0.25% (P< 0.0001). There was a decrease in cooking loss at the 0.5% level, but it was not significantly different from the 0.25% level. The low humidity cookery had significantly lower cooking loss (P<0 .001), as did the 140°F end point internal temperature (P< 0.0001).

The tenderness values determined by the Warner-Bratzler shear force test (Table 4) indicated significant differences between muscles within and between pH categories (P< 0.01). Tenderness scores (Table 5) collected during the taste panel sessions also showed significant differences between muscles within and between pH categories (P< 0.0001). Low humidity cookery revealed significantly higher tenderness scores than the high humidity cookery (P< 0.001). Sensory juiciness scores (Table 5) were significantly affected by muscle, phosphate level, humidity level, and end point internal temperature (P< 0.0001). High pH muscles were significantly juicier

Table 1. Initial pH of raw muscles.

	Initial pH	
Muscle	Mean	(S.D.)
Infraspinatus	5.80[a]	(0.207)
Serratus ventralis	5.87[a]	(0.133)
Deep pectoral	5.69[b]	(0.055)
Biceps femoris	5.64[b]	(0.060)

[ab]Means with different superscripts are different (P< 0.001).

Table 2. Cooked meat pH affected by treatments.

	Cooked meat pH	
Treatment	Mean	(S.D.)
Infraspinatus	6.06[a]	(0.177)
Serratus ventralis	6.07[a]	(0.104)
Deep pectoral	5.97[b]	(0.071)
Biceps femoris	5.95[b]	(0.081)
0.0% phosphate	5.98[c]	(0.104)
0.25% phosphate	6.02[d]	(0.105)
0.5% phosphate	6.05[d]	(0.107)
High humidity	6.03[a]	(0.104)
Low humidity	5.99[b]	(0.109)
140°F	5.99[c]	(0.100)
160°F	6.03[d]	(0.113)

[ab]Means with different superscripts are different (P< 0.01)
[cd]Means with different superscripts are different (P< 0.05)

Table 3. Cooking losses of sample roasts affected by treatments.

	Cooking loss (%)	
Treatment	Mean	(S.D.)
0.0% phosphate	28.17[a]	(4.64)
0.25% phosphate	22.63[b]	(5.35)
0.5% phosphate	23.52[b]	(6.31)
High humidity	26.73[c]	(5.54)
Low humidity	22.82[d]	(5.82)
140°F	22.56[a]	(5.01)
160°F	26.94[b]	(6.01)

[ab]Means with different superscripts are different (P< 0.0001)
[cd]Means with different superscripts are different (P<0 .001)

Table 4. Warner-Bratzler shear force values for individual muscles.

	Pounds of Force	
Muscle	Mean	(S.D.)
Infraspinatus	3.68[a]	(0.405)
Serratus ventralis	4.98[b]	(0.464)
Deep pectoral	12.00[c]	(1.590)
Biceps femoris	7.27[d]	(0.936)

[abcd]Means with different superscripts are different (P< 0.01)

Table 5. Sensory analysis scores affected by different treatments.

	Juiciness		Tenderness		Acceptability	
Treatment	Mean	(S.D)	Mean	(S.D)	Mean	(S.D)
Infraspinatus	5.39[a]	(1.40)	5.73[a]	(1.45)	5.44[a]	(1.48)
Serratus ventralis	5.56[a]	(1.50)	5.49[b]	(1.65)	5.29[a]	(1.64)
Deep pectoral	4.98[b]	(1.82)	4.14[c]	(1.82)	4.32[b]	(1.75)
Biceps femoris	4.79[b]	(1.63)	4.54[d]	(1.83)	4.51[b]	(1.82)
0.0% phosphate	4.92[a]	(1.61)	4.88	(1.91)	4.72	(1.79)
0.25% phosphate	5.26[b]	(1.44)	5.06	(1.79)	4.97	(1.70)
0.5% phosphate	5.36[b]	(1.54)	5.01	(1.79)	4.99	(1.73)
High humidity	5.04[a]	(1.55)	4.86[e]	(1.81)	4.77[e]	(1.73)
Low humidity	5.31[b]	(1.52)	5.10[f]	(1.84)	5.02[f]	(1.76)
140°F	5.37[a]	(1.49)	5.04	(1.84)	4.98	(1.74)
160°F	4.98[b]	(1.57)	4.92	(1.82)	4.81	(1.74)

[abcd]Means with different superscripts are different (P< .0001).
[ef]Means with different superscripts are different (P< .001)
Means with no superscripts are not significantly different.

than low pH muscles. Increasing the phosphate level increased juiciness scores. Significantly higher scores for the low humidity and 140°F end point temperature were observed. Sensory acceptability (Table 5) of the roasts was significantly higher for high pH muscles (P<0.0001) and low humidity cookery (P<0.001).

The results of this study show that an acceptable enhanced beef product can be produced if high pH muscles, such as the Infraspinatus and Serratus ventralis, are marinated with a 0.25% phosphate level and cooked to 140°F in a low humidity cookery system. This will allow the beef industry to help recapture value being lost in the chuck and round.

[1]Ryan Baumert, graduate student, Roger Mandigo, professor, Animal Science, Lincoln.

Factors Influencing Color Development in Beef

Kevin Kirchofer
Chris Calkins
Dennis Burson
Kent Eskridge
Dana Hanson[1]

Color development over time in beef carcasses is affected by chill length, fat thickness and hot carcass weight. Ultimate color can be accurately predicted after 9-12 minutes.

Summary

Use of color in an objective beef carcass grading system would require accurate color measurement soon after ribbing. Color development of 118 beef carcasses was followed with a portable colorimeter in two commercial slaughter facilities with different (24 and 42-48 hour) chill periods before grading. Redness (a) and yellowness (b*) were estimated with a negative exponential growth model. Linear regression models were used to predict lightness (L*). Color development was influenced by chill time, fat thickness, and hot carcass weight. Lightness was highly variable, while ultimate a* and b* can be accurately predicted after 9-12 minutes.*

Introduction

Implementing carcass sorting systems which use an objective measurement of muscle color to augment current USDA quality grade measurements requires the accurate prediction of ultimate (90 min) color. In commercial slaughter facilities, an estimate of ultimate muscle color must be determined while muscle color is still developing. A determination of factors which influence color development (bloom) over time in beef is therefore required.

The objectives of this study were to determine effects of chilling time, fat thickness, and carcass weight on beef color development and to determine how quickly after ribbing ultimate color could be predicted in carcasses varying in quality grade.

Procedure

The time course of color development (bloom) in ribbed beef carcasses was followed by measurement of L*, a*, and b* with a colorimeter. These are points within a three-dimensional color space which objectively define a specific color. They indicate lightness (L*), redness (a*), and yellowness (b*). Color was determined with a HunterLab Miniscan™ XE Plus Tristimulus colorimeter with a 1-inch port, using illuminate A and 10° standard observer. Carcasses were selected from two slaughter facilities with different carcass chilling lengths prior to grading (plant A, 24 hour and plant B, 42-48 hour), resulting in different internal loin temperatures (40°F and 34°F, respectively). A total of 59 carcasses were studied at plant A, and 39 carcasses at plant B. A second set of carcass data (n=20) was also collected at plant A after an extended, 48 hour weekend chill period. This extra chill time resulted in lower internal loin temperatures (34°F).

Carcass selection was based on a grid which included hot carcass weight (<700 lb or >800 lb), 12th rib fat thickness (<0.4 in or >0.7 in), and quality grade (Select, low Choice, or upper 2/3 Choice). The right sides of the tagged

(Continued on next page)

carcasses were ribbed normally, while left sides were unribbed. Carcass marbling scores were determined by USDA quality graders after a normal bloom period (10-20 min). Carcasses were then railed off in groups of 10 and left sides were ribbed at one minute intervals by plant personnel until all ten carcasses within the set were ribbed. Color measurements were determined 0, 3, 6, 9, 12, 15, 20, 30, 45, 60, and 90 minutes after ribbing. Two color measurements were averaged, one on each end of the rib-face surface of the *longissimus*. Carcass 12th rib fat thicknesses measurements were measured by University of Nebraska personnel with a fat probe, and internal loin temperatures were determined using a small diameter thermocouple attached to a digital thermometer.

As meat pigments absorb oxygen from the air, meat becomes lighter, redder, and yellower (less blue). A negative exponential growth model was used (Figure 1) to describe the time course of changes in a* and b* for each individual animal. (In the case of L*, the non-linear regression model had a poor fit and a linear model was fit.) Then, we evaluated the effects of chill time, carcass weight, fat thickness, and quality grade on the characteristics of the curves: intercept at time 0, shape (slope) of the response curve, and the ultimate color (asymptote). An estimate of goodness of fit (approximate R^2) of the predicted model with actual raw data was calculated from correlation analysis. This approach allowed us to predict the color development curve; therefore, color measurements taken at a known time after ribbing can be used to predict ultimate color characteristics.

The variation in each color characteristic decreased as meat pigments bloomed. In an attempt to determine the earliest appropriate time for color measurement, variation in a* and b* measurements over time was plotted. An arbitrary value of 10% more than baseline variation was used to suggest the shortest bloom time needed to obtain reliable results.

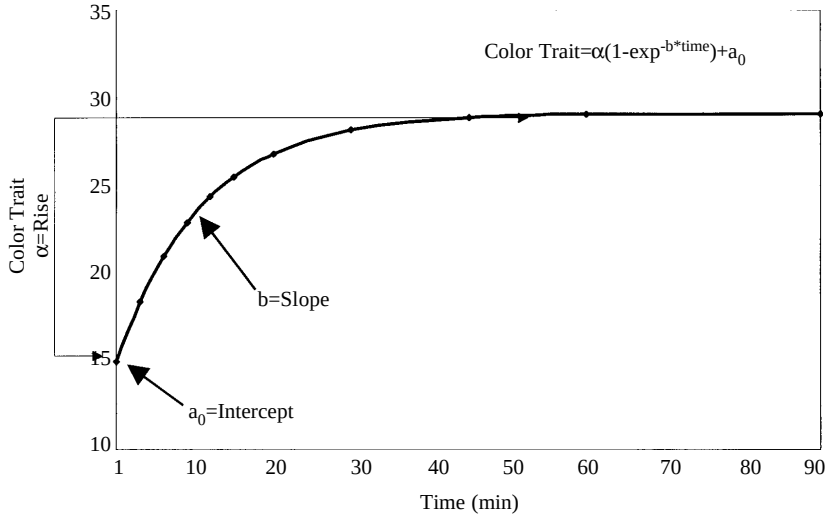
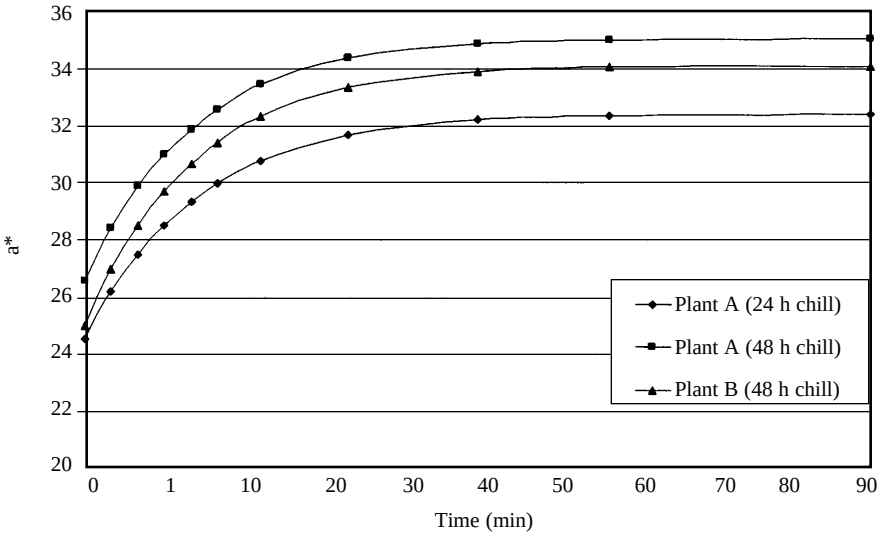
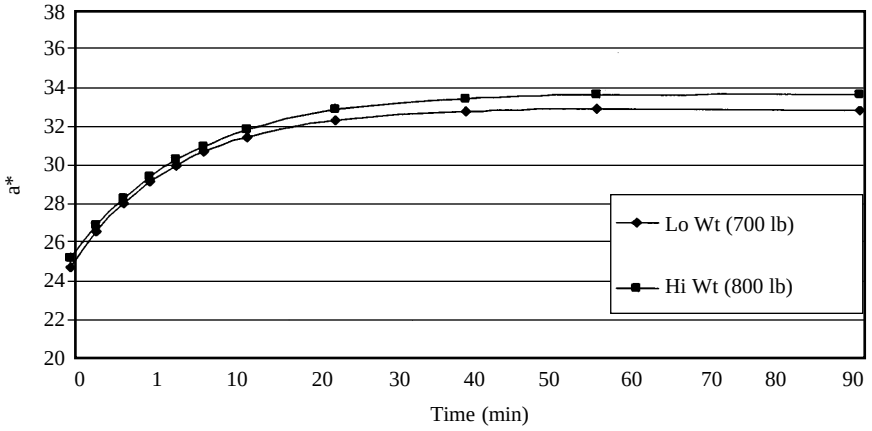


Figure 1. The negative exponential growth model used to define meat color changes after ribbing.

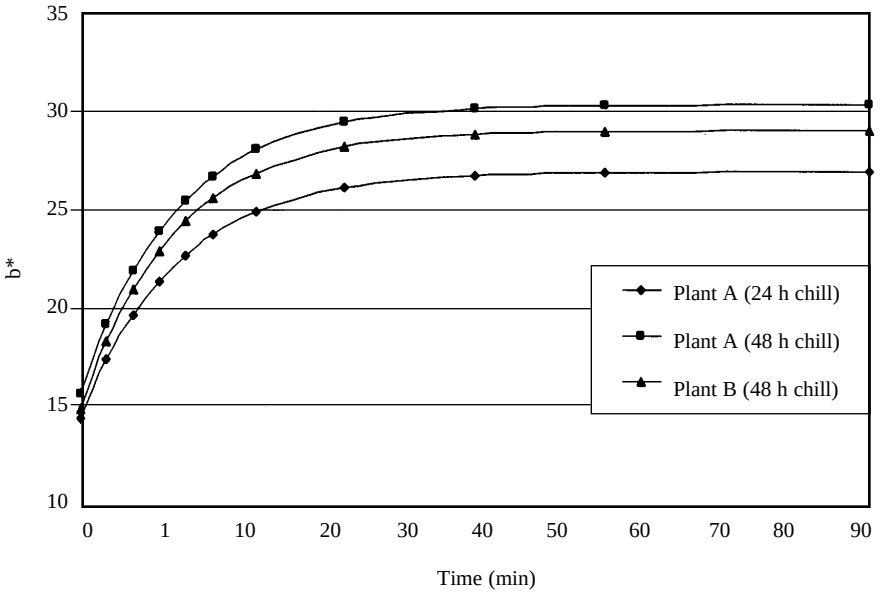


Plant differences in a* color development

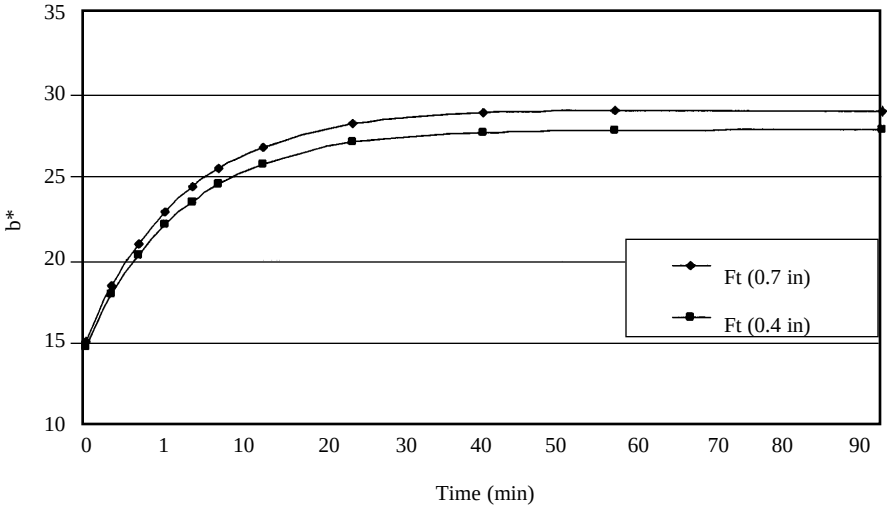


Weight differences in a* color development

Figure 2. Plant and weight differences in a* color development.



Plant differences in b* color development



Fat thickness differences in b* color development

Figure 3. Meat plant and fat thickness differences in b* color development.

Results

The slopes for the nonlinear models of a* and b* the slopes were unaffected by plant chill times. However, plant chill time and hot carcass weight significantly ($P<0.005$) affected a* color development (rise, α) over time (Figures 2 and 3, respectively). A significant ($P<0.001$) increase in the redness of meat will occur with an increase in chill length, or in heavier weight carcasses.

Differences in the standard operating practices may have resulted in increased a* values for plant A (48 hour chill). One noted difference in operating practices was the use of low voltage electrical stimulation (42 V, 21 second duration) in plant A.

Increased carcass weight affects cooling rate of the lean, as lean tissue deep within the interior of a heavy carcass cools more slowly during the chill period. Increased muscle temperature during the pH fall leading to rigor may result in a lower ultimate pH, which may give heavier carcasses greater redness values.

Meat plant and 12th rib fat thickness also significantly ($P<0.05$) affected b* color development; increased ultimate b* values were predicted in the 48 hour chill period versus the 24 hour chill. As with a* values, electrical stimulation and increased chill periods may lead to increased ultimate b* values.

Carcass fat thickness also significantly ($P<0.05$) affected b*. A fat thickness above 0.7 in, compared with a fat thickness less than 0.4 in, increased ultimate (90 minute) b* values. Increases in exterior carcass fat can also elevate lean tissue temperature during the pH fall, increasing measured b* values.

Although equations predicting L* were significantly affected by plant and plant-quality grade interactions, the predictive accuracy of all equations was never higher than 16%, indicating an inability to properly predict L* over time.

These results indicate that color development can be influenced by a variety of carcass traits and plant operation procedures. This suggests use of color in an objective grading system would need to take these intrinsic and extrinsic factors into account, greatly adding to the challenges associated with the application of such technology under commercial conditions.

Inherent in color assessment is the variability in color measurements within a carcass shortly after exposure to oxygen. To minimize the variability in color measurements within a carcass, and to choose the earliest possible time to make proper color assessment, an equation was created to show variation in color measurements over time. Both a* and b* exhibited variability shortly after ribbing, 48% and 38% higher than ultimate color variation, respectively.

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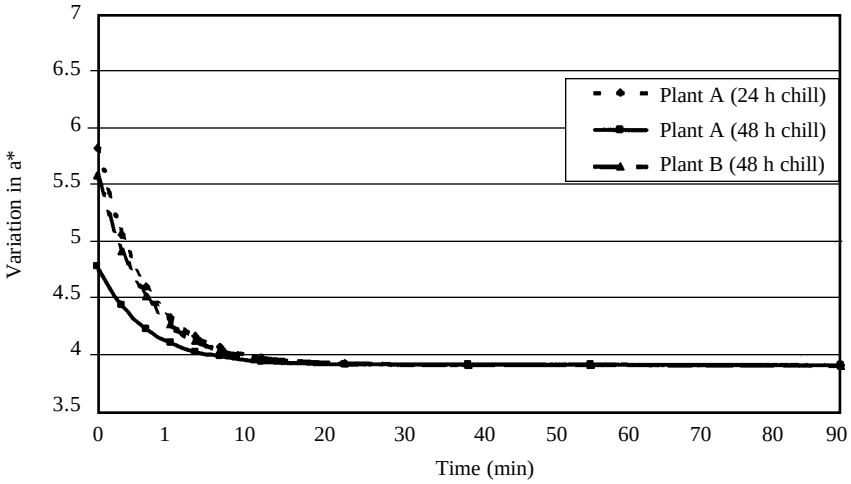
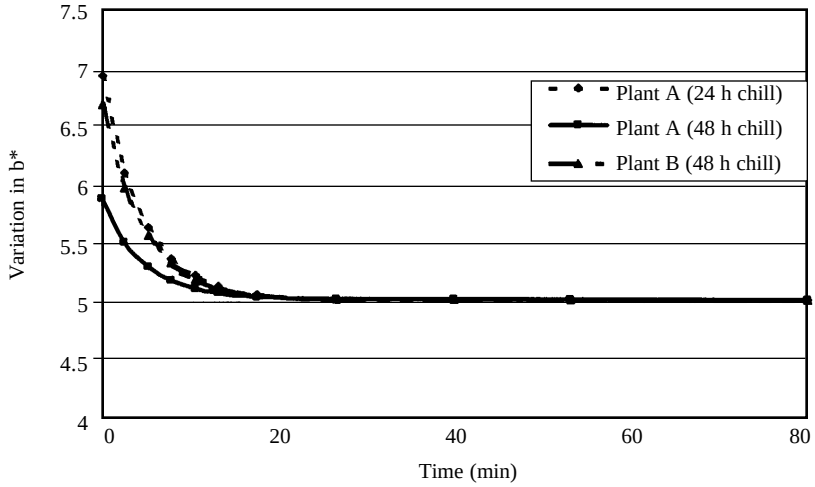


The variation in a* measurement due to plant



The variation in b* measurement due to plant

Figure 4. The variation in a* and b* measurement due to plant.

The variability in color quickly dropped below 10% over the variability in ultimate color (90 min) assessment after 12 minutes for a* and 9 minutes for b* (Figure 4). This suggests that a* and b* color assessment can be made after nine-12 minutes of bloom.

Conclusion

If time is closely monitored, beef color assessment for a* and b* can be made 9-12 minutes after ribbing. Color development, however, is influenced by a variety of carcass and plant operating procedures, making it difficult to use color in an objective grading system.

Using Lean Color and Marbling Score to Sort Beef Carcasses into Tenderness Groups

Kevin Kirchofer
Chris Calkins
Dana Hanson[1]

Muscle color measurements, either alone, or in conjunction with marbling scores, were no more effective than marbling alone to sort carcasses into tenderness groups.

Summary

Beef carcasses (n=290) were used to determine the effectiveness of color (L - lightness; a* - redness; b* - yellowness) measured at least 90 minutes after ribbing and marbling called by USDA graders to sort beef carcasses into one of three tenderness groups. Equations using any combination of marbling and color were no more effective in sorting beef carcasses into tenderness groups than marbling alone. None of the tough carcasses were correctly classified. Adding color to marbling does not improve effectiveness of sorting beef carcasses into tenderness groups.*

Introduction

Consumers rate tenderness as an important palatability trait affecting overall satisfaction of beef. Several

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researchers have correlated measurement of muscle color with meat tenderness, and have used color to sort beef carcasses into palatability groups.

This research was conducted to create a sorting system based on objective color measurements and marbling to sort beef carcasses into tenderness groups in a commercial slaughter facility in Nebraska.

Procedure

This study used 290 beef strip loins selected from three quality grades (Select, low Choice, and upper 2/3 Choice). University of Nebraska personnel collected beef strip loins at a commercial slaughter facility. A selection grid involving 90-minute L* color measurements made on the 12th rib surface of beef carcasses with a Hunter Miniscan™ Plus XE colorimeter (1-inch port) and quality grade (marbling score, called by a USDA grader) was used to select loins. Upper 2/3 Choice and low Choice had 2 selection cells with L*>44 and L*<44. The Select quality grade was divided into high (marbling scores Slight^{50}) and low Select (marbling scores< Slight^{50}) and involved carcasses with L*<44, >47, and between 44 and 47.

Color traits measured were L* (lightness), a* (redness) and b* (yellowness), which are points used to objectively define any color in a three-dimensional color space. The colorimeter was calibrated against a white plate using illuminant A and 10° standard observer.

The beef strip loins were labeled, vacuum packaged, boxed, and then shipped to the University of Nebraska, where they were allowed to age a total of nine days post-mortem at 34°F. After aging, the strip loins were frozen (-14.8°F) for further storage. The frozen loins were allowed to temper for a total of 24 hours at 34°F before being cut into 1-inch thick strip steaks on a band saw. The first steak from each loin was wrapped and frozen until it was analyzed for tenderness (Warner-Bratzler shear force).

Steaks were thawed at 34°F for 24 hours and cooked to an internal temperature of 104°F, turned, and cooked to a final internal temperature of 158°F. Steaks were cooled for two hours at 64°F before removal of eight cores (1/2 in. diameter) parallel to the longitudinal axis of the muscle fibers. An average of the peak shear force of 8 sheared cores was calculated for each strip.

Tenderness was predicted using equations that contained a*, b*, and marbling score, alone or in combination. Tenderness groups were based on shear force: tender (<8.5 lb), intermediate (8.5-10.0 lb), and tough (>10.0 lb).

Results

Marbling score was the best single-trait predictor of beef tenderness, explaining 12% of the variation in tenderness (Table 1). Color measurements (L*, a*, and b*) by themselves explained little (.6%, 2.9%, and 1.5%, respectively) of the variation in shear force values. Taken together, marbling, a*, and b* were able to explain 13.7% of the variation in beef tenderness. With the most complex model, which contained significant interactions of color measurements (a* and b*) and marbling, just 16.6% of the variability in beef tenderness was explained:

$$\text{Shear Force} = 13.79 - .31(b^*) + .03(a^*)(b^*) - .03(a^*)^2 - .18(\text{marbling})(a^*) + .01(\text{marbling})(a^*)^2$$

where marbling was coded as 4.00=Slight^{00} and 5.00=Small^{00}.

Table 1. The relationship of muscle color and marbling score, alone and in conjunction, to shear force value.

Trait	Coefficient of Determination $R^2 \times 100$
L*	0.5
a*	2.9
b*	1.5
Marbling Score	12.0
Marbling and a*	13.1
Marbling and b*	12.3
Marbling, a*, and b*	13.7
Complete Model[a]	16.6

[a]Complete model includes all possible interactions.

Muscle color measurements, marbling, and a combination of muscle color and marbling were used to predict beef tenderness categories (Tables 2, 3, and 4). Carcasses were sorted into tender (<8.5 lb), intermediate (8.5-10.0 lb), and tough (>10.0 lb) groups. Applying this classification method to actual Warner-Bratzler shear force values, 63.1% of the carcasses (183 of 290) were tender, 22.5% (65 of 290) were intermediate in tenderness, and 14.5% (42 of 290) were tough. When carcasses were classified into the predicted tenderness categories using a* and b* measurements (Table 2), 159 of 183 were correctly identified as tender, 14 of 65 were correctly identified as intermediate, and none of the 42 tough carcasses were correctly identified. Of the 238 carcasses predicted to be tender, 51 were actually intermediate in tenderness, and 28 were tough. Said

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Table 2. Actual versus predicted tenderness of beef carcasses utilizing muscle color measurements (a* and b*).

		Actual Shear Force Category			
		Tender	Intermediate	Tough	
Predicted Shear Force Category[a]		(<8.5 lb)	(8.5-10.0 lb)	(>10.0 lb)	Total[b]
Tender	Number	159	51	28	238
	% of those predicted tender	66.8	21.4	11.8	
	% of total correctly predicted	54.8			
Intermediate	Number	23	14	14	51
	% of those predicted intermediate	45.1	27.5	27.5	
	% of total correctly predicted		4.8		
Tough	Number	1	0	0	1
	% of those predicted tough	100	0	0	
	% of total correctly predicted			0	
	Total[c]	183	65	42	290
	% of	63.1	22.4	14.5	

[a]Predicted tenderness model (Shear force, lb = 13.41 - .33 (a*) + .18 (b*)).
[b]Total number of predicted carcasses in each classification.
[c]Total number and percent of total of actual carcasses in each classification.

Table 3. Actual versus predicted tenderness of beef carcasses utilizing marbling scores.

		Actual Shear Force Category			
		Tender	Intermediate	Tough	
Predicted Shear Force Category[a]		(<8.5 lb)	(8.5-10.0 lb)	(>10.0 lb)	Total[b]
Tender	Number	145	41	24	210
	% of those predicted tender	69.0	19.5	11.4	
	% of total correctly predicted	50.0			
Intermediate	Number	38	24	18	80
	% of those predicted intermediate	47.5	30.0	22.5	
	% of total correctly predicted		8.3		
Tough	Number	0	0	0	0
	% of those predicted tough	0	0	0	
	% of total correctly predicted			0	
	Total[c]	183	65	42	290
	% of total	63.1	22.4	14.5	

[a]Predicted tenderness model (Shear force, lb = 12.42 - .75 (marbling)), where Slight 0 = 400.
[b]Total number of predicted carcasses in each classification.
[c]Total number and percent of total of actual carcasses in each classification.

Table 4. Actual versus predicted tenderness of beef carcasses utilizing marbling scores and color measurements.

		Actual Shear Force Category			
		Tender	Intermediate	Tough	
Predicted Shear Force Category[a]		(<8.5 lb)	(8.5-10.0 lb)	(>10.0 lb)	Total[b]
Tender	Number	138	35	18	191
	% of those predicted tender	72.3	18.3	9.4	
	% of total correctly predicted	47.6			
Intermediate	Number	45	30	24	99
	% of those predicted intermediate	45.5	30.3	24.2	
	% of total correctly predicted		10.3		
Tough	Number	0	0	0	0
	% of those predicted tough	0	0	0	
	% of total correctly predicted			0	
	Total[c]	183	65	42	290
	% of total	63.1	22.4	14.5	

[a]Predicted tenderness model (Shear force, lb = 15.00 - .70 (marbling) - .22 (a*) + .13 (b*)), where Slight 0 = 400.
[b]Total number of predicted carcasses in each classification.
[c]Total number and percent of total of actual carcasses in each classification.

another way, just 2/3 of the carcasses predicted to be tender actually were tender. Clearly, the use of color alone is ineffective in sorting beef carcasses into tenderness categories.

When marbling was used to predict tenderness categories, 145 tender, 24 intermediate, and no tough carcasses were correctly identified (Table 3). For those 210 carcasses predicted to be tender, just 69% actually were tender; 41 were intermediate and 24 were tough, indicating marbling alone was not a good predictor of shear force in the population of carcasses studied in this research.

Combining marbling and color measurements did not substantially improve classification of carcasses into tenderness categories, in that 138 of 290 tender carcasses, 30 of 65 intermediate, and no tough carcasses were correctly sorted (Table 3). Of the 191 predicted to be in the tender category, 72% actually were tender; 35 were intermediate in tenderness and 18 were tough. It appears sorting carcasses on the basis of color and marbling is generally unsuccessful.

These data suggest color was not effective at finding tough carcasses, as tough carcasses were never predicted to be tough. At best, a small percentage of tough carcasses were predicted to be intermediate in toughness — clearly not an acceptable sorting tool.

In this experiment, beef carcasses were all from one slaughter facility in Nebraska, and were very similar in carcass traits, making it difficult to create a system to sort beef carcasses into tenderness groups. This would suggest that individual slaughter facilities which handle carcasses of similar traits may not benefit from a carcass sorting system of this nature.

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[1]Kevin Kirchofer, graduate student, Lincoln; Dana Hanson, graduate student, Lincoln; Chris Calkins, professor, Animal Science, Lincoln.

Use of Sodium Citrate to Enhance Tenderness and Palatability of Pre-Rigor Beef Muscles

Christian Perversi
Chris Calkins
Jesús Velazco[1]

Pre-rigor muscles pumped with a 400 mM solution of sodium citrate were almost always more tender than controls when evaluated objectively (Warner-Bratzler shear force) and subjectively (taste panel).

Summary

The objective of this project was to evaluate the response in tenderness and consumer acceptability of three muscles from the chuck that were pumped pre-rigor with different concentrations of sodium citrate solutions to inhibit glycolysis, while maintaining skeletal restraint for 24 hours. Controls were left on carcass, while the other three treatments had the thoracic limb removed and muscles pumped post-mortem to 10% of their weight with solutions of 0 mM, 200 mM or 400 mM sodium citrate. Although tenderness ratings were not always statistically different (comparing controls vs. 400 mM solution), there was a clear trend showing higher concentrations of sodium citrate make beef more tender and acceptable to consumers.

Introduction

Glycolytic inhibition diminishes post-rigor pH decline by preventing the formation of lactic acid from anaerobic degradation of glycogen within the muscle during rigor mortis. Injection of muscles with glycolytic inhibitors enhanced beef tenderness and palatability despite causing substantial contraction by injecting and tumbling of pre-rigor muscles (*2000 Beef Report*, p. 80). In the experiment reported here, skeletal restraint was maintained for 24 hours to help stop the muscles from shortening.

Knowledge of the appropriate concentration of sodium citrate, the glycolytic inhibitor that makes pre-rigor beef more tender, can help make the muscles from the chuck more valuable to the consumer and the industry. The objective of this study was to determine if sodium citrate in different solutions is effective in enhancing tenderness and consumer acceptability of beef when injected pre-rigor and with 24 hour skeletal restraint of the muscles.

Procedure

Steers (n=14) were slaughtered and thoracic limbs were removed and pumped (within two hr post-mortem) to 10% of muscle weight with water, 200 mM or 400 mM sodium citrate solutions (they had been previously randomly assigned to one of the four treatments). They were then left to chill in the carcass cooler for 24 hours. Unpumped, control limbs were left on the carcasses. Muscle pH was measured immediately prior to pumping and 24 hours post mortem. Steaks (1-inch thick) were removed after 24 hours from the *Infraspinatus*, *Supraspinatus*, and *Triceps brachii* muscles and randomly assigned either to be frozen immediately or aged for six more days. Samples of each muscle were placed with random number identification in a retail display for five consecutive days with daily subjective (performed by a trained operator) and objective color evaluation (performed with a HunterLab MiniScan XE Plus colorimeter with a 1-inch port), and microbial growth determination at entry and exit times of the retail display case.

A consumer taste panel (30-35 participants) evaluated palatability (juiciness, tenderness, connective tissue amount, and flavor desirability) on *Infraspinatus* and *Triceps brachii* steaks using 9-point hedonic scales (1 being very undesirable and 9 being very desirable) for each trait. Warner-Bratzler shear force values were determined on 0.5 inch-diameter cores from steaks that were broiled to an internal temperature

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of 158 F on Farberware Open Hearth electrical grills and then cooled.

Results

Significantly higher pH's were obtained through the glycolytic inhibition when measured 24 hours postmortem (5.79 and 5.80 for the 200 mM and 400 mM sodium citrate treated steaks respectively vs. 5.67 and 5.76 for the untreated steaks and the ones pumped with water, respectively).

Treatment with 400 mM sodium citrate improved shear force values over the controls at day 1 and day 7 for all muscles except the *Triceps brachii* and *Infraspinatus* on day 1 (Table 1). Tenderness ratings followed the same trend, except for the *Infraspinatus.* Connective tissue amount, flavor and juiciness of the 400 mM citrate treated-steaks (*Infraspinatus* and *Triceps brachii*) were rated as more desirable ($P < 0.10$) than the controls at day 1 and day 7 (data not shown). Characteristics of steaks treated with 200 mM sodium citrate were usually between the controls and the 400 mM concentration. Pumping with water was generally detrimental to tenderness and palatability. These data indicate that a 400 mM sodium citrate solution may be applied to pre-rigor beef muscles (constrained from contraction) to enhance tenderness and palatability.

Steaks treated with 200 mM or 400 mM sodium citrate were about 1 unit darker than controls for the first one or two days of retail storage , respectively, when visually rated on a 5-point scale (Table 2). No differences were observed during additional retail storage. Objective assessment of lightness (L*) revealed that *Supraspinatus* and *Triceps brachii* treated with sodium citrate were darker than their controls (Table 3). Similar to visual evaluation, differences in degree of redness (a*) and yellowness (b*) that existed on the initial day of retail display rapidly disappeared (Tables 4 and 5).

Table 1. Shear force (measured in lb) and sensory ratings of steaks treated with sodium citrate.

		Infraspinatus		*Triceps brachii*		*Supraspinatus*	
Trait	Treatment[a]	day 1	day 7	day 1	day 7	day 1	day 7
Shear Force	Control	7.94^{bc}	7.70^{cd}	8.16^{b}	7.90^{c}	11.52^{c}	10.51^{c}
	0 mM	8.71^{c}	8.34^{d}	9.97^{c}	9.70^{d}	11.26^{c}	10.78^{c}
	200 mM	7.85^{bc}	6.86^{bc}	8.47^{b}	7.85^{c}	8.99^{b}	8.43^{b}
	400 mM	7.30^{b}	6.14^{b}	7.81^{b}	6.80^{b}	8.60^{b}	8.87^{b}
Tenderness	Control	5.4^{bc}	5.5^{b}	4.7^{c}	4.6^{c}		
	0 mM	5.0^{c}	4.9^{c}	4.0^{d}	4.1^{d}		
	200 mM	5.4^{bc}	5.7^{b}	5.0^{bc}	4.8^{c}		
	400 mM	5.7^{b}	5.9^{b}	5.3^{b}	5.5^{b}		
Flavor	Control	5.2^{bc}	4.8^{c}	5.0^{b}	4.7^{c}		
	0 mM	5.0^{c}	4.7^{c}	4.6^{c}	4.5^{c}		
	200 mM	5.3^{bc}	5.4^{b}	5.2^{b}	4.9^{b}		
	400 mM	5.5^{b}*	5.4^{b}	5.3^{b}*	5.2^{b}		

[a]Control means these muscles were left unpumped on the carcass; 0 mM means these steaks were pumped with water; 200 mM and 400 mM means these steaks were pumped with 200 mM and 400 mM solutions of sodium citrate, respectively.
[b,c,d]Means in the same column within each trait with different superscripts differ significantly ($P < 0.05$).
*Control versus 400 mM differ significantly at $P < 0.10$.

Table 2. Visual color of steaks treated with sodium citrate.

Day	Control	0 mM	200 mM	400mM
0	3.3^{b}	2.9^{a}	3.7^{c}	4.1^{d}
1	3.8^{b}	3.4^{a}	4.0^{bc}	4.2^{c}
2	4.2^{b}	3.2^{a}	4.1^{b}	4.3^{b}
3	4.1^{b}	3.4^{a}	4.2^{b}	4.3^{b}
4	4.1^{b}	3.2^{a}	4.1^{b}	4.3^{b}
5	4.4^{b}	3.5^{a}	4.1^{b}	4.3^{b}

[a,b,c,d]Means within the same row with different superscripts are significantly different ($P < 0.05$).
A 5 point scale was used; 1= Pale cherry red, 3= Bright cherry red, 5= Dark purple red.

Table 3. L* Values of steaks treated with sodium citrate.

Muscle	Control/carc	Control/water	200mM NaCit	400mM NaCit
ISP	42.87^{a}	45.64^{b}	43.55^{a}	43.19^{a}
SSP	38.80^{b}	39.45^{b}	36.60^{a}	36.02^{a}
TBR	36.99^{b}	42.01^{d}	38.91^{c}	34.92^{a}

[a,b,c,d]Means within the same row with different superscripts are significantly different ($P < 0.05$)
ISP = *Infraspinatus*, SSP = *Supraspinatus*, and TBR = *Triceps brachii*.

Table 4. a* Values of steaks treated with sodium citrate.

Day	Control/carc	Control/water	200mM NaCit	400mM NaCit
0	26.64^{a}	27.47^{a}	23.92^{b}	23.94^{b}
1	23.28^{b}	24.56^{a}	23.44^{ab}	23.33^{b}
2	21.19^{b}	23.12^{a}	22.18^{ab}	21.40^{b}
3	20.23^{b}	21.86^{a}	20.84^{ab}	20.66^{b}
4	18.64^{b}	20.69^{a}	20.11^{a}	19.87^{a}
5	18.79^{b}	20.32^{a}	20.80^{a}	19.73^{ab}

[a,b]Means within the same row with different superscripts are significantly different ($P < 0.05$)

Table 5. b* Values of steaks treated with sodium citrate.

Day	Control	Water	200 mM Sodium Citrate	400 mM Sodium Citrate
0	19.68[b]	21.23[a]	17.37[c]	17.19[c]
1	19.35[b]	21.41[a]	20.13[ab]	20.14[ab]
2	18.99[b]	21.32[a]	19.72[b]	18.55[b]
3	18.92[b]	21.05[a]	19.22[b]	18.84[b]
4	17.97[b]	20.33[a]	18.79[b]	18.25[b]
5	18.90[b]	20.37[a]	19.90[ab]	19.34[ab]

[a,b,c]Means within the same row with different superscripts are significantly different (P < 0.05)

Table 6. Logarithmic Microbiological Growth Values.

Day	Control	0 mM	200 mM Sodium Citrate	400 mM Sodium Citrate
day 0	2.08[a]	2.50[ab]	2.58[b]	2.72[b]
day 5	3.59[c]	5.70[d]	5.45[d]	5.11[d]
difference	1.50[c]	3.21[d]	2.88[d]	2.40[d*]

[a,b]Means within the same row with different superscripts are significantly different (P < 0.05) - note the main effect of treatment was not significant (P < 0.10)
[c,d]Means within the same row with different superscripts are significantly different (P < 0.05)
* 400 mM differs from control (P < 0.10)

The handling required to inject muscles increased the initial microbial counts over the untouched controls. The increase in microbial numbers that naturally occurs during retail storage was similar for the controls and muscles injected with 400 mM sodium citrate (P > .10).

Conclusion

These data indicate that treatment of pre-rigor beef muscle with 400 mM sodium citrate results in meat that is more tender and flavorful, but is darker in color.

[1]Christian Perversi, graduate student; Chris Calkins, professor, Animal Science, Lincoln; Jesús Velazco, Instituto Tecnológico de Estudios Superiores de Monterrey, Monterrey, México.

Oral Dosage with NutroCAL™ (Calcium Propionate) to Enhance Beef Tenderness

Dana Hanson
Chris Calkins
Johnny Horton[1]

Oral drenching with NutroCAL™ (calcium propionate) prior to slaughter tends to increase muscle calcium and enhance tenderness of beef strip loin steaks.

Summary

Oral dosage of market-weight beef steers with NutroCAL™ (a source of calcium propionate) tends to increase strip loin calcium and enhance tenderness after a 14 to 21 day aging period. No responses were observed in the eye of round or the chuck tender. The time course for serum and muscle calcium response appears to be highly variable and different from calcium chloride drenching.

Introduction

Beef tenderness is one of the most important sensory characteristics to consumers. Concern about the consistency and quality of beef has led to a variety of research strategies to improve beef tenderness. Knowledge of mechanisms by which beef improves in tenderness offers the opportunity to develop strategies to control and enhance the aging process.

Calcium-dependent proteolytic enzymes (calpains) increase the tenderness of beef during aging. Their requirement of calcium for activity offers an opportunity to enhance beef tenderization through elevation of calcium in the body. Prior research has demonstrated that cattle orally administered a solution high in calcium and glucose precursors prior to slaughter have elevated blood calcium and serum glucose. Administration of a gel high in calcium propionate three to six hours prior to slaughter also elevated muscle calcium content, increased calpain activity, and accelerated postmortem aging. Clearly the strategy of manipulating muscle calcium prior to slaughter has potential to enhance product quality.

As a rich source of readily absorbable calcium, NutroCAL™ may be well suited to such an application. The objective of this research was to determine if orally drenching cattle with NutroCAL™ would elevate serum calcium levels, thereby enhancing muscle calcium levels and improving beef tenderness.

Procedure

Market-weight crossbred cattle (n=42) were randomly assigned to one of three treatments: oral drenching with 1 L water, 1 L of 4.27 M calcium chloride, or 2.5 L of NutroCAL™ (300 g/L of H_20) sufficient to deliver 150 g of calcium. Frequent mixing of the solution

(Continued on next page)

was required to maintain NutroCAL™ in suspension. Drenching occurred within 35-125 minutes of slaughter using a veterinary stomach pump with a flexible metal hose. Cattle were not provided access to water between the time of drenching and slaughter. Blood (50 mL) was obtained at slaughter to document total serum calcium.

Animals were harvested in a traditional fashion. Strip loins, eyes of round, and chuck tenders were obtained 24 hours post-mortem, shipped to the university meat laboratory and aged at 36°F. Two days post-mortem, muscles were cut into portions and samples were obtained for determination of muscle calcium. The muscle portions were vacuum packaged and frozen at periodic intervals (day 2, 5, 7, 14, 21) for the *Longissimus* (strip loin) and the *semitendinosus* (eye of round) muscles and at day 2, 5, and 7 for the chuck tender (*supraspinatus*). Prior to cooking, muscle portions were tempered for 24 hours at 36°F and cut into 1-inch thick steaks. Steaks were thawed for 24 hours and cooked on tabletop electric broilers to 158°F. They were allowed to cool 24 hours at 39°F and then 1/2-inch cores were removed, parallel to the long axis of fiber direction. Cores (6-8 per steak) were sheared using a Warner-Bratzler shear attachment to an Instron Universal Testing Machine.

Atomic absorption spectrophotometry was used to determine calcium content of previously frozen blood serum and frozen, powdered muscle samples. Muscle samples were immersed in glutaraldehyde so sarcomere length could be determined using the laser diffraction method.

Table 1. Least square means for blood serum calcium level, muscle calcium concentration and sarcomere length for strip steaks, eyes of round, and chuck tenders from cattle drenched with calcium chloride or calcium propionate just prior to slaughter.

Trait	Control (1)	Calcium Chloride (2)	Calcium Propionate (3)	Contrast P-values 1 vs 2	Contrast P-values 1 vs 3
Serum calcium, mg/100 mL	13.25 ± 1.11	15.89 ± 1.11	12.35 ± 1.11	.101	.571
Muscle calcium, μg/g					
Strip steak	28.40 ± 6.09	30.04 ± 5.86	38.11 ± 5.86	.848	.258
Eye of round	6.86 ± .30	6.74 ± .30	6.56 ± .30	.766	.480
Chuck tender	5.24 ± .17	5.64 ± .17	5.49 ± .17	.107	.310
Sarcomere length, μm					
Strip steak	1.84 ± .09	1.80 ± .09	1.87 ± .09	.778	.756
Eye of round	1.70 ± .03	1.69 ± .03	1.71 ± .03	.906	.748
Chuck tender	1.68 ± .07	1.52 ± .07	1.62 ± .07	.114	.511

Table 2. Warner-Bratzler shear force values (lb) of strip steak, eyes of round, and chuck tender steaks from cattle drenched with calcium chloride or calcium propionate just prior to slaughter.

Trait	Control (1)	Calcium Chloride (2)	Calcium Propionate (3)	Contrast P-values 1 vs 2	Contrast P-values 1 vs 3
Strip steak					
2	11.26 ± 0.59	10.79 ± 0.59	11.17 ± 0.59	.583	.909
5	9.16 ± 0.51	9.54 ± 0.51	8.50 ± 0.51	.602	.368
7	9.23 ± 0.44	8.70 ± 0.44	8.26 ± 0.44	.419	.141
14	8.28 ± 0.40	8.41 ± 0.40	7.36 ± 0.40	.811	.105
21	7.25 ± 0.46	7.56 ± 0.46	6.39 ± 0.46	.658	.191
Eye of round					
2	11.23 ± 0.55	10.18 ± 0.55	11.41 ± 0.55	.189	.829
5	9.82 ± 0.37	9.10 ± 0.37	9.82 ± 0.37	.164	.957
7	9.91 ± 0.37	9.63 ± 0.37	10.20 ± 0.37	.584	.590
14	9.36 ± 0.33	9.23 ± 0.33	10.09 ± 0.33	.772	.118
21	9.74 ± 0.42	9.69 ± 0.42	10.64 ± 0.42	.950	.134
Chuck tender					
2	11.83 ± 0.51	12.40 ± 0.51	11.83 ± .0.51	.436	.993
5	10.97 ± 0.62	11.65 ± 0.62	11.41 ± 0.62	.443	.613
7	10.42 ± 0.46	11.39 ± 0.46	11.54 ± 0.46	.148	.088

Results

None of the responses variables were significant for the overall effect of treatment. However, given the initial intent to compare specific treatments, results are presented to gain insight into the trends. The calcium chloride treatment elevated serum calcium levels above the control (P=.101); they were also significantly higher than NutroCAL™ (Table 1). Surprisingly, there was no difference between the NutroCAL™ treatment and the control. Previous research in our laboratory has shown drenching with calcium chloride caused a transient increase in serum calcium — we showed an immediate rise in serum calcium, peaking within 30 - 90 minutes and then rapidly falling off. From these results, one might conclude that the serum calcium response of an animal to an oral dosage of NutroCAL™ follows a different time course.

It is through the elevation of muscle calcium concentration that enhanced enzyme activity (and thus tenderization) would be expected. Table 1 shows the muscle calcium concentration for each of the three treatments and each of the muscles. Several issues are immediately apparent. First, strip loin muscles appear to have about five times more calcium than do the round or chuck muscles that were studied. This trend is consistent with data published in USDA Handbook 8-13 concerning nutrient composition of beef. The reasons for differential calcium concentrations among muscles are not known. Perhaps the transport mechanism is different among the muscles. Perhaps there is greater blood supply and vascularization of the strip loin, thereby offering greater opportunity for calcium to be taken up. At this point, it is not possible

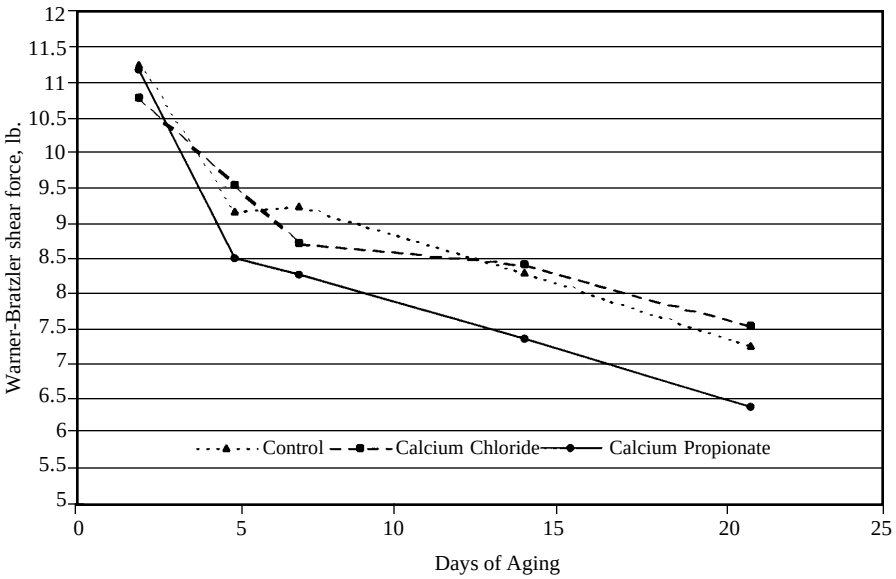

Figure 1. Warner-Bratzler shear force (WBS) values over time for longissimus muscle from steers treated with calcium chloride or calcium propionate prior to slaughter.

to say with certainty that the extra calcium within the muscle is actually within the muscle cell, rather than within the extracellular space.

The second obvious trend is the numerically higher value (by about 25%) for muscle calcium in the strip loins from cattle drenched with NutroCAL™. There was large animal-to-animal variation in muscle calcium levels, especially within the NutroCAL™-drenched animals. It would be useful to understand the reason for this variation. It does appear there is something within NutroCAL™ that seems to facilitate muscle calcium uptake, but it is difficult to determine from these data if it is time sensitive, as was observed with serum calcium. Perhaps the reason serum calcium levels were lower for the NutroCAL™ treatment is because that calcium was being subsequently incorporated into the strip loin muscle.

Shear force (tenderness) measurements taken during the postmortem aging of steaks from each of the three muscles are presented in Table 2. Again the animal-to-animal variation meant that the trends were not consistent enough to be significant. Nevertheless, there is a clear trend for strip steaks from animals treated with NutroCAL™ to be more tender, particularly after aging. To better view this relationship, the data for strip steaks are plotted in Figure 1. This trend is consistent with the hypothesis that elevated muscle calcium would increase proteolysis, which would occur during aging. Further evidence for this was obtained by correlating muscle calcium content to response to aging (the change in shear force from day 2 to day 14) across all treatments combined. The correlation was .47 overall ($P < 0.05$), suggesting muscles with more calcium experience a greater improvement in shear force than muscles with low levels of calcium.

There was one treatment effect for shear force of the chuck tender on day 7 (Table 2). Differences in the eye of round were observed only after 21 days of aging and do not favor the NutroCAL™ treatment. Given the failure of any of the treatments to elevate calcium concentration within either of these two muscles, these differences can be considered inconsequential.

One concern was that elevation of muscle calcium would support contraction of muscle during the rigor process, thereby reducing tenderness. Table 1 shows that there were no differences in sarcomere length among the treatments, suggesting that this strategy to enhance tenderness is not detrimental to muscle shortening.

Conclusions

Taken together, the results from this research suggest that drenching with NutroCAL™ tends to increase calcium content in the strip loin, with a resulting tendency for enhanced tenderness, especially with aging. No trends were observed for the muscles that were studied from the chuck and the round. These data suggest subtle differences in calcium localization and concentration may influence tenderness, and drenching with NutroCAL™ can influence these factors.

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[1]Dana Hanson, graduate student; Chris Calkins, professor, Animal Science, Lincoln; Johnny Horton, technical services, Kemin Industries, Des Moines, Iowa.

Effect of Conjugated Linoleic Acid on Insulin Sensitivity

Kim Hargrave
Jess Miner[1]

The ability of insulin to control blood glucose is lost when mice consume conjugated linoleic acid (CLA).

Summary

Mice were fed a mixture of conjugated linoleic acid isomers (CLA) for nine weeks and then underwent an insulin tolerance test. CLA was then removed from the diet and a second insulin tolerance test was conducted following five weeks of recovery. CLA consumption impaired glucose response to insulin. When CLA was removed from the diet, insulin sensitivity of a low heat-loss genetic mouse line returned to normal. However, mice of a high heat-loss line remained insulin resistant for at least 32 days.

Introduction

Conjugated linoleic acid (CLA) provides several health benefits in areas of cancer, cardiovascular disease and body composition. However, there may be an adverse effect of CLA supplementation. A Japanese laboratory has reported increased plasma insulin concentration and impaired glucose response to insulin in CLA-fed mice. This development of insulin resistance with CLA supplementation may overshadow its antiobesity benefit. We hypothesized that if dietary CLA does impair insulin action, this detrimental effect will disappear when CLA is removed from the diet. Therefore the objective of our study was to determine the effect of temporary CLA supplementation and removal on insulin sensitivity. A second objective was to determine if this CLA effect was consistent between two selection lines of mice that differ in metabolic rate.

Procedure

Twenty-seven high heat loss (MH) and 27 low heat loss (ML), 9-wk-old male mice consumed a 7% soy oil control diet (Control) or the control diet with 1% CLA replacing soy oil (CLA) ad libitum, or the control diet at ~65% of ad libitum (Restricted) for 9 wk. The restricted intake treatment was used to determine if reduced insulin sensitivity caused by CLA was due to loss of body fatness. The mice were then subjected to an insulin tolerance test whereby 0.5 mU insulin/g of body weight were injected intraperitoneally and plasma glucose was measured at 0, 30, 60, 90, and 120 min post-injection (day 0 of recovery). Three days later, 18 of the mice were killed and serum, epidymal fat pads and livers were collected. Body composition was also determined by x-ray densitometry. Remaining mice were then provided free access to the control diet and allowed 32 days of recovery. They then underwent another insulin tolerance test and were killed three days later.

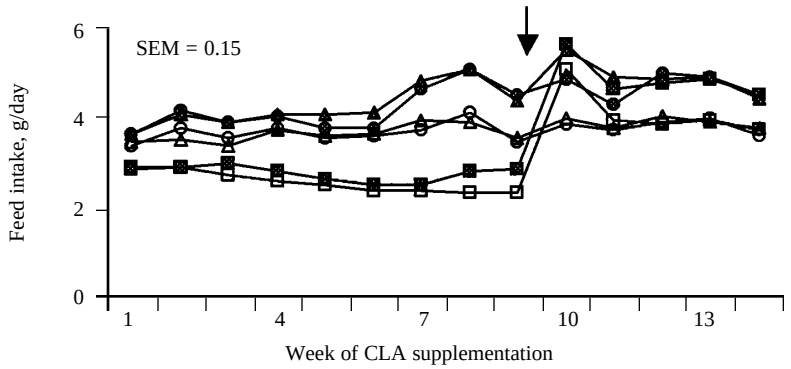

Figure 1. Effect of selection line and dietary treatment on feed intake. MH mice consumed more feed ($P < 0.01$) throughout, regardless of treatment. Prior to wk 9, restricted mice consumed less feed ($P < 0.01$). Filled symbols indicate MH mice and open symbols indicate ML mice. Circles represent the control diet, squares represent the restricted intake, and triangles represent the CLA diet. The arrow indicates when all mice were offered free access to the control diet.

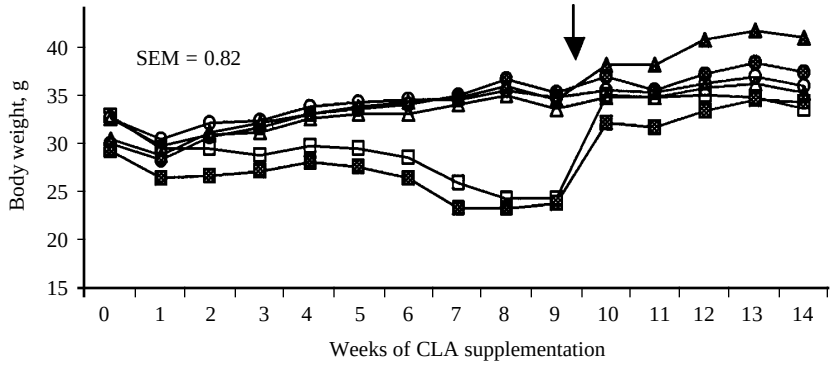

Figure 2. Effect of selection line and dietary treatment on body weight. The only significant effect through wk 9 was reduced ($P < 0.01$) body weight in feed restricted mice. After wk 9, previously restricted mice outgained all others but mice previously fed CLA were heaviest at wk 14. Filled symbols indicate MH mice and open symbols indicate ML mice. Circles represent the control diet, squares represent the restricted intake, and triangles represent the CLA diet. The arrow indicates when all mice were offered free access to the control diet ad libitum.

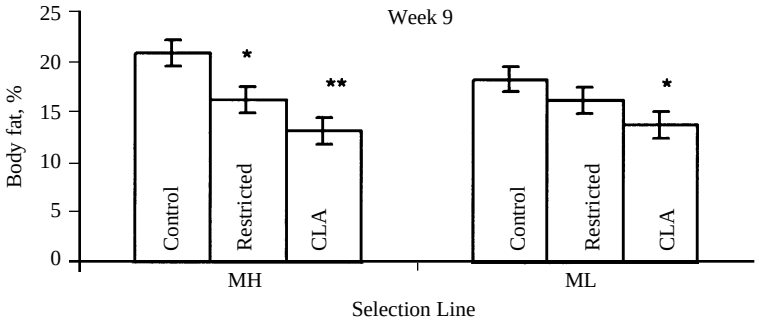

Figure 3. Effect of selection line and dietary treatment on body fat, wk 9 (d 0 recovery). *Means differ from control within selection line ($P < 0.10$). **Means differ from control within selection line ($P < 0.05$). Error bars represent SEM.

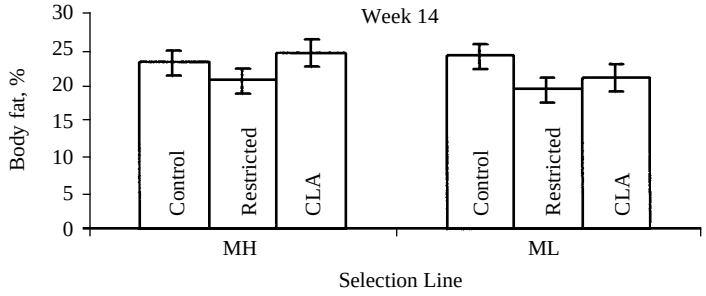

Figure 4. Effect of selection line and dietary treatment on body fat, wk 14 (35 d recovery). No effects of treatment or selection line were detected. Error bars represent SEM.

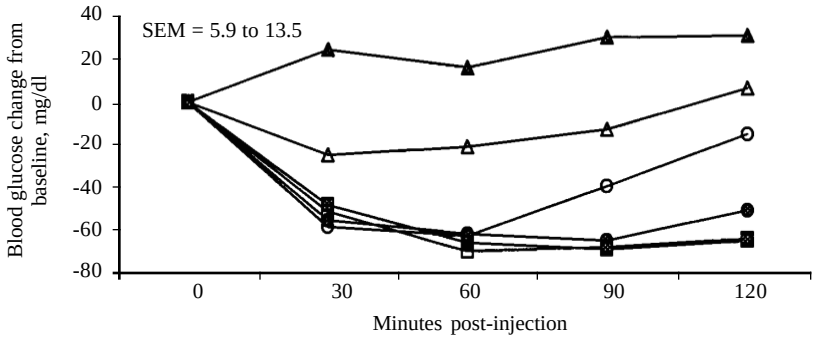

Figure 5. Effect of selection line and dietary treatment on glucose response to insulin, wk 9 (day 0 of recovery). Filled symbols indicate MH mice and open symbols indicate ML mice. Circles represent the control diet, squares represent the restricted intake, and triangles represent the CLA diet.

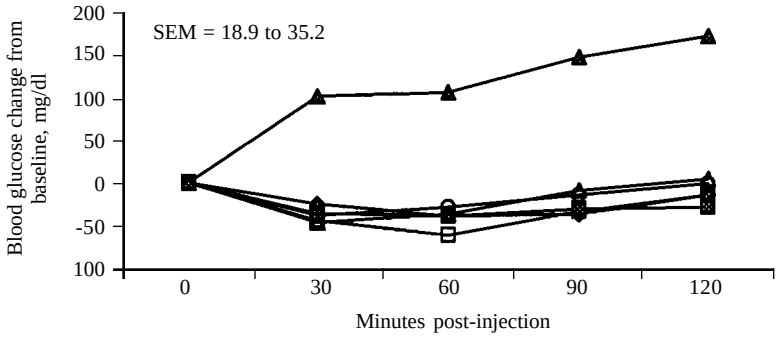

Figure 6. Effect of selection line and dietary treatment on glucose response to insulin, wk 14 (32 days of recovery). Filled symbols indicate MH mice and open symbols indicate ML mice. Circles represent the control diet, squares represent the restricted intake, and triangles represent the CLA diet.

Results

Feed intake was greater in MH mice than in ML mice ($P < 0.01$; Figure 1). Body weight was reduced ($P < 0.01$) in feed intake-restricted mice through wk 9. Following removal of CLA from the diet, MH mice previously fed CLA were the heaviest (Figure 2). There was a reduction ($P < 0.05$) of body fat in MH mice fed CLA vs the MH controls at day 0 of recovery (Figure 3). There was also a trend for a reduction ($P < 0.10$) of body fat in MH mice with restricted intakes and ML mice fed CLA vs their respective controls. Following 32 days of recovery there were no differences in body fat between either selection line or any of the dietary treatments (Figure 4).

Mice fed CLA experienced a lesser drop in blood glucose when injected with insulin, indicating insulin resistance relative to mice not fed CLA (Figure 5). At 11 days after termination of CLA feeding (recovery) the ML mice exhibited insulin sensitivities not different than controls while MH mice remained insulin resistant (data not shown). At 32 days after termination of CLA feeding the ML mice exhibited normal insulin sensitivity but the MH mice remained insulin resistant (Figure 6). Therefore, the effect of CLA on insulin sensitivity does not appear to depend on body fatness.

In conclusion, CLA supplementation did cause insulin resistance. The impaired insulin sensitivity effect of CLA may limit its role in treatment of human obesity or as a livestock feed additive. It is not known which isomer(s) of CLA are responsible for the insulin resistance. However, the sensitivity to CLA seemed to be greater in the MH mice regarding both insulin sensitivity and a loss of body fatness. Because it is known that the C18:2 d10,12 CLA isomer causes the change in body fatness, we can speculate that it may be this isomer that reduces insulin sensitivity (*2002 Nebraska Beef Report*, pp. 92-93). Ruminant products do not contain a relevant amount of C18:2 d10,12 CLA and therefore would not be expected to impact either obesity or insulin sensitivity by a CLA-dependent mechanism.

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[1]Kim Hargrave, graduate student; Jess Miner, assistant professor, Animal Science, Lincoln.

Influence on Body Fat of Linoleic Acid Isomers

Kim Hargrave
Kristin Nollette
Merlyn Nielsen
Jess Miner[1]

A conjugated isomer of linoleic acid, C18:2 Δ10,12, caused body fat depletion when fed to mice. The effect was greater in mice fed essential fatty acid (linoleic/linolenic) deficient diets.

Summary

In two studies mice were fed diets containing either a mixture of, or individual conjugated linoleic acid (CLA) isomers in the presence or absence of essential fatty acids. Mice fed the C18:2 Δ10,12 CLA isomer lost as much body fat as those fed a mixture of isomers. This effect was not caused by the C18:2 Δ9,11 isomer (predominant in beef) or by restricted feed intake. The loss was much greater in mice consuming an essential fatty acid deficient diet versus a control diet. This supports our hypothesis that for CLA to deplete body fat, it must first be metabolized in a manner similar to linoleic acid. Furthermore, we suggest that the loss of body fat may be mediated by metabolism of CLA to an isomer of arachidonic acid.

Introduction

Conjugated linoleic acid (CLA) is a group of isomers of linoleic acid (C18:2 Δ9,12), some of which are produced naturally and deposited in the fat of ruminant animals. CLA consumption has health benefits regarding cancer, cardiovascular disease and body composition. The predominant naturally occurring isomer is C18:2 Δ9,11 (CLA 9/11), while commercially synthesized CLA products usually contain relatively equal amounts of C18:2 Δ10,12 (CLA 10/12) and CLA 9/11 as well as smaller quantities of other isomers. The diverse benefits of CLA may depend on different isomers. Therefore our first objective was to determine which isomer(s) are responsible for the loss of body fat in mice.

Arachidonic acid (C20:4Δ5,8,11,14) is synthesized in animals from dietary linoleic acid. Similarly, CLA 10/12 can be metabolized to C20:4 Δ5,8,12,14. This product of CLA metabolism could antagonize the normal production of prostaglandins from arachidonic acid and therefore, mice fed a diet deficient in linoleic acid, and thus arachidonic acid, may be especially sensitive to the antiobesity effect of dietary CLA. Our second objective was to compare the effect of CLA in dietary essential fatty acid-adequate and -deficient diets.

Procedure

Experiment 1

Seventy-two mixed sex mice were allotted to one of five rations (each 7% fat) for five days:

Control	purified diet with 7% soy oil
Pair-Fed	control diet at intake of CLA Mix
CLA Mix	2% CLA Mix and 5% soy oil
CLA 9/11	0.82% CLA 9/11 isomer and 6.18% soy oil
CLA 10/12	0.88% CLA 10/12 isomer and 6.12% soy oil

Feed intake and body weight were measured daily. After five days the mice were killed and retroperitoneal (RP) fat pads were removed and weighed. Body fat was determined on carcasses by ether extraction.

Experiment 2

Eighty newly weaned male mice were fed either a control diet (7% soy oil) or an essential fatty acid deficient (EFAD) diet (7% coconut oil) for 6 weeks. Henceforth, half of each group of mice was supplemented with 0.5% CLA, replacing either soy or coconut oil, for two weeks. Then the mice were killed. RP fat pads, epidymal fat pads, and livers were removed and weighed. Carcass fat was determined by ether extraction.

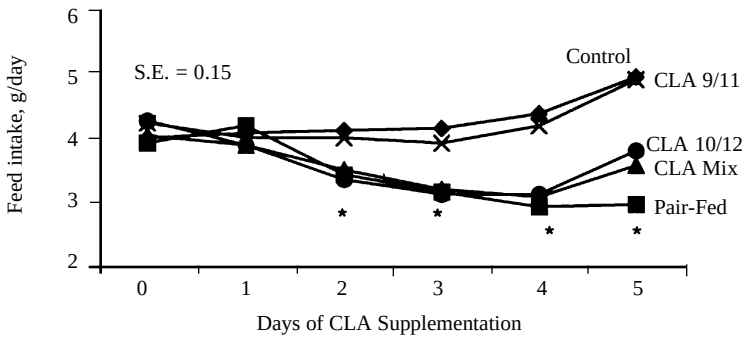

Figure 1. Effect of CLA Mix or individual isomers on feed intake (Experiment 1). *CLA 10/12, CLA Mix, and Pair-Fed differ from Control ($P < 0.001$).

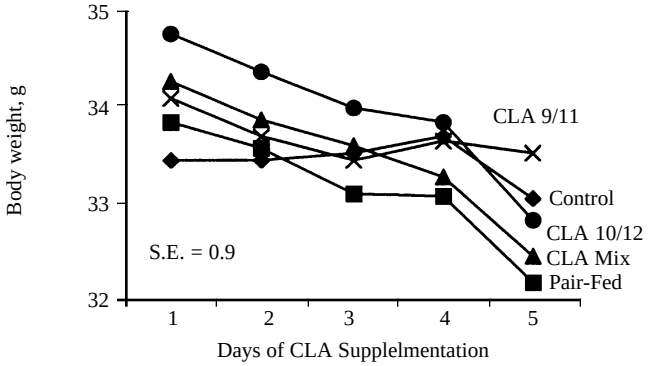

Figure 2. Effect of CLA Mix or individual isomers on BW (Experiment 1). No effect on BW was detected.

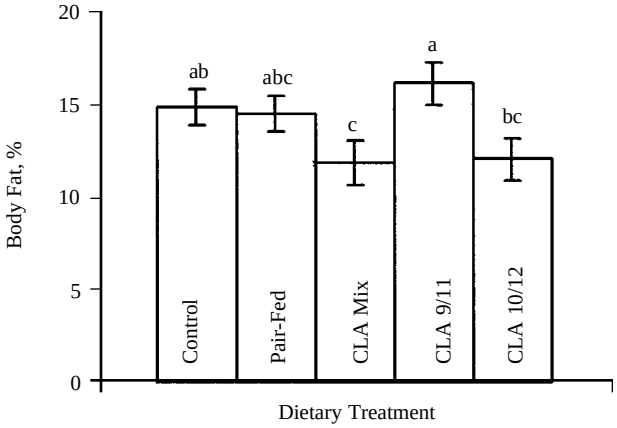

Figure 3. Effect of CLA Mix or individual isomers on body fat (Experiment 1). [abc]Means with different superscripts differ ($P < 0.05$).

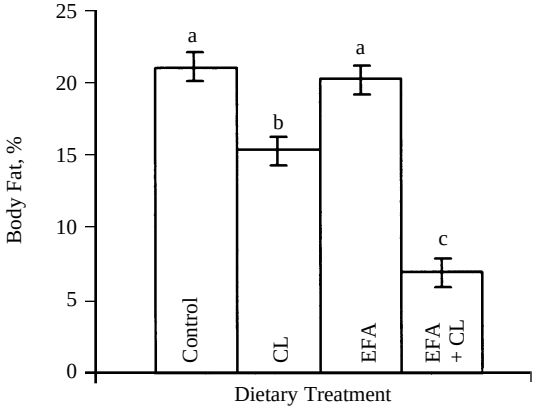

Figure 4. Effect of essential fatty acid deficiency (EFAD) and CLA supplementation on body fat (Experiment 2). [abc]Means with different superscripts differ ($P < 0.0001$).

Results

Experiment 1

Feed intake was reduced ($P < 0.001$) in mice fed CLA Mix and CLA 10/12 as well as the Pair-Fed mice, starting on day 2 (Figure 1). However body weight was not affected by diet in this short period (Figure 2). After 5 days of CLA supplementation there was a 20% loss ($P < 0.05$) of body fat in mice fed the CLA Mix and CLA 10/12 isomer compared to Control mice (Figure 3).

Experiment 2

Supplementation of CLA reduced ($P < 0.05$) both feed intake and body weight in the final two weeks of the study. CLA reduced ($P < 0.001$) RP (49%) and epidymal (19%) fat pad weights when added to the control diet. Furthermore, CLA reduced total body fat by 27% (Figure 4). The EFAD diet alone had no effect on feed intake, body weight, or body fat. However, when CLA was fed to mice deficient in essential fatty acids, its effects were greatly amplified ($P < 0.0001$); a 73% reduction in RP, 57% in epidymal, and 66% in total body fat (Figure 4).

In conclusion, CLA 10/12 is responsible for the loss of body fat observed when mice are fed a mixture of CLA isomers. This loss of body fat may be mediated through metabolism of CLA to an isomer of arachidonic acid. Arachidonic acid is a precursor to the series 2 prostaglandins, which have a multitude of actions in the body. Therefore, inhibition of the conversion of arachidonic acid to prostaglandin, or the production of prostaglandin-like molecules from CLA could explain the varied benefits of CLA. Essential fatty acids (linoleic and linolenic) partially protect against the full effect of CLA, possibly via competition for a common metabolic path.

Although ruminant-derived food products contain mainly the CLA 9/11 isomer, which does not appear to have any antiobesity effect, it is known that the CLA in beef and milk provides other health benefits such as mitigation of several cancers. CLA 9/11 can be metabolized similarly to CLA 10/12, forming a C20:4 Δ5,8,11,13 isomer of arachidonic acid. Therefore the health benefits of CLA, other than loss of body fat, may also be acting through this pathway.

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Evaluation of Calcium Propionate as a Nutrient to Prevent Dark Cutting Beef

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Dietary feeding of calcium propionate (NutroCAL™) as a nutritional supplement was unsuccessful in the prevention of dark cutting beef.

Summary

The objective of the study was to evaluate the ability of calcium propionate to prevent the dark cutting condition in beef. Angus crossbred steers (n=14) were assigned to two treatments: control and 0.25 lb of calcium propionate (NutroCAL™) per day for 14 days prior to (and 12 days after) the application of artificial stress with epinephrine at day 0. Biopsies of the longissimus muscle and blood samples were obtained at days –2, 0, 1, 3, 6 and 9. Calcium propionate had no effect on muscle glycogen content, extent of glycogen depletion, or glycogen repletion rates.

Introduction

Dark cutting beef is caused by total or partial depletion of muscle glycogen prior to slaughter. The depletion primarily occurs when the animal suffers stress. Dark cutting beef has an undesirable color to consumers, a different flavor profile and a shorter shelf life (more rapid microbial spoilage). These characteristics decrease the value of the beef, causing an economic loss for the producer. In the carcass of an unstressed animal, muscle glycogen will be converted to lactic acid, and cause a muscle pH decline from 7.0 to about 5.6 – the normal pH for beef. Muscle pH does not decline in meat from stressed animals because of low glycogen levels, causing a dark color and a high pH.

When NutroCAL™ was fed to dairy cattle, serum insulin and blood glucose levels increased. Both of these conditions are favorable for muscle glycogenesis and may increase the concentration of glycogen inside the muscle. Our study was conducted to evaluate feeding of calcium propionate (NutroCAL™) to prevent the dark cutting condition in beef.

Procedure

Fistulated, Angus crossbred steers (n=14) were randomly assigned to one of two treatments, the control or 0.25 lb of NutroCAL™ (calcium propionate) mixed with a diet that consisted of dry rolled corn, wet corn gluten, alfalfa and limestone (77.5% DM, 13.3% CP). Steers were fed 80% of *ad libitum* to ensure complete intake of the NutroCAL™. The steers were under this treatment 14 days prior to the first biopsy and during the 12 days that biopsies were performed. The animals were kept in individual pens with water *ad libitum*.

Biopsies were performed along the *longissimus* muscle using a biopsy needle on days –2, 0, 1, 3, 6 and 9; with day 0 being the day of stress. The skin in the incision area was anesthetized with a subcutaneous injection of lidocaine. Following surgery, incisions were treated with penicillin to minimize the risk of infection and one or two sutures were made. Blood samples for insulin and glucose measurements were obtained from the jugular vein immediately prior to biopsy. During the course of the study, six sites (3/side) along the *longissimus* muscle in the region of the loin were randomized for day of sampling.

Muscle glycogen, glucose, and glucose-6-phosphate levels were determined using an amyloglucosidase assay, and lactate levels were determined using a lactate dehydrogenase assay.

Glucose was determined using the Sigma Glucose Trinder Kit and insulin was determined using the DSL-1600 Insulin Radio-immunoassay Kit.

After biopsies and blood were obtained on day 0, the animals were artificially stressed by subcutaneous injection of 6 mg of epinephrine per 100 lb of live weight. The dose was equally divided in two parts and applied five hours apart. After the last injection, 1.0 lb of NutroCAL™ (calcium propionate) was placed into the rumen through the fistula in an effort to provide calcium propionate to the animal immediately after stress. Biopsies were conducted after training by a veterinarian and under the approval of the Institute Animal Care and Use Committee.

Results

Day –2 biopsies were taken to indicate initial muscle glycogen levels. Unfortunately, the sampling methods were not performed consistently, resulting in excessive blood and fatty tissue in the samples. As a result, the glycogen levels were exceptionally low and were not credible. These results were excluded from the analysis. Subsequent sampling periods yielded biopsies of much higher quality; essentially all muscle with little, if any, fatty tissue and (or) excess blood.

Figure 1 presents the estimated amount of glycogen in muscle during the course of the study. No significant differences were found in muscle glycogen content between the control and the NutroCAL™-fed steers at any sampling period, indicating a failure of calcium propionate to enhance muscle glycogen content, minimize glycogen

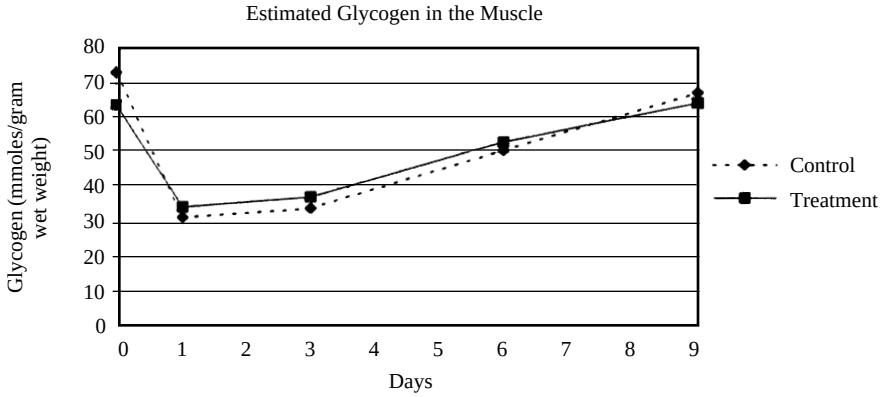

Figure 1. Estimated glycogen levels in the muscle pre and post stress. The first injection of epinephrine for artificial stress was applied after the day 0 biopsies were obtained.

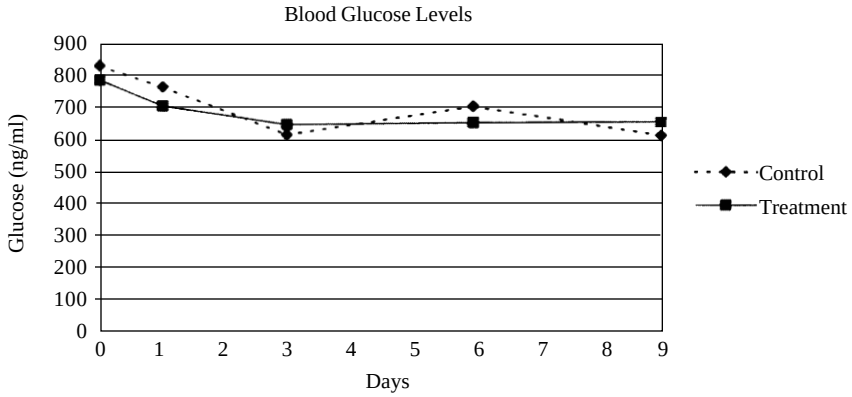

Figure 2. Glucose levels in the blood pre and post stress. The first injection of epinephrine for artificial stress was applied after the day 0 biopsies were obtained.

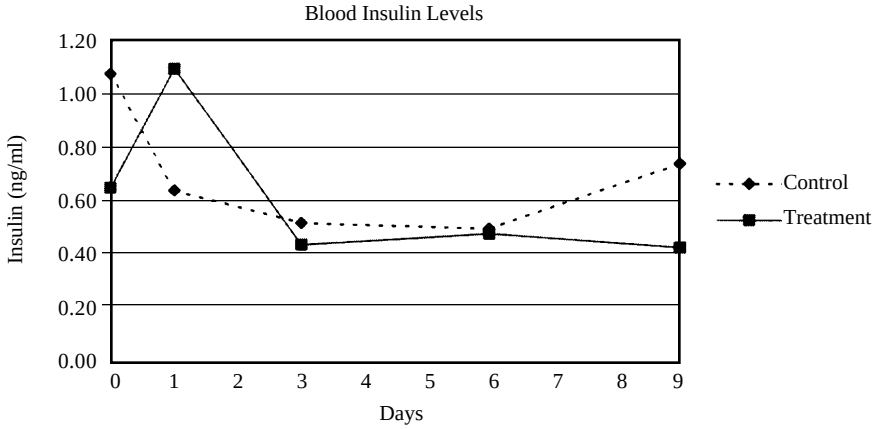

Figure 3. Insulin levels in the blood pre and post stress. The first injection of epinephrine for artificial stress was applied after the day 0 biopsies were obtained.

loss as a consequence of stress, and/or hasten the repletion of glycogen stores in muscle. The figure also shows that the use of epinephrine to produce artificial stress in steers was an appropriate method because the glycogen levels decreased significantly in all 14 animals.

The readings on day 0 were taken prior to the application of epinephrine and so indicate baseline levels of muscle glycogen. These values are in line with a muscle glycogen survey conducted by our laboratory the previous year (*2001 Beef Report*, p. 109-110), although they were slightly lower than expected. This could be related to previous stress of the animal in the holding pens or to the stress generated by the initial biopsy procedure on day –2. Reports in the literature indicate stress created during the biopsy procedure is fairly low. The fact that the animals did replenish muscle glycogen stores during the biopsy sequence is evidence that minimal stress was experienced.

Previous research indicated glycogen values above 60-65 mmole/kg were needed to prevent dark cutting. The repletion rates for redeposition of muscle glycogen were not different (Figure 1) between the two treatments ($P > 0.05$). These data suggest that to avoid being considered a dark cutter, animals require 8 days or more to replace sufficient muscle glycogen lost as a consequence of significant stress. Unfortunately, the extent of glycogen depletion caused by common stresses, rather than injection of epinephrine, are not well characterized, so it is impossible to know how much recovery time is needed.

Similar patterns of blood glucose changes were observed for the two treatments (Figure 2). There was a gradual decline up to three days following stress, followed by a leveling off period. Feed intake (which was not monitored) would likely have followed the same pattern.

Insulin levels fluctuate hourly within the blood. It is not clear if the higher level of insulin noted in the control cattle on day 0 is a consequence of sampling time or a true treatment effect (Figure 3). The fluctuations of insulin levels are comparable in magnitude to the normal changes in cattle under normal conditions. The increase in blood insulin that occurred after the 1.0 lb of NutroCAL™ was placed directly into the rumen through the fistula was apparently not big enough to produce a change in the muscle glycogen or blood glucose levels and it may be due to other factors like feeding time.

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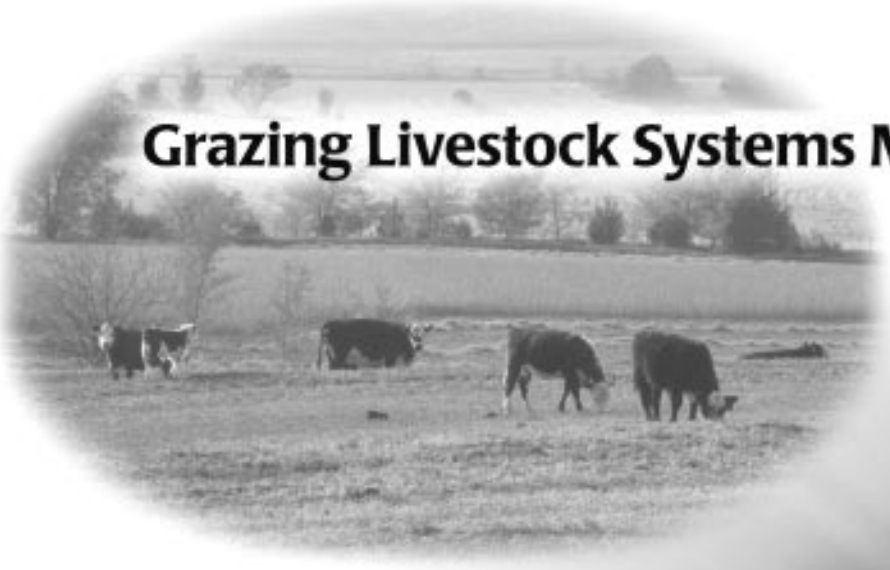

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