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2000 Nebraska Beef Cattle Report

NEBRASKA

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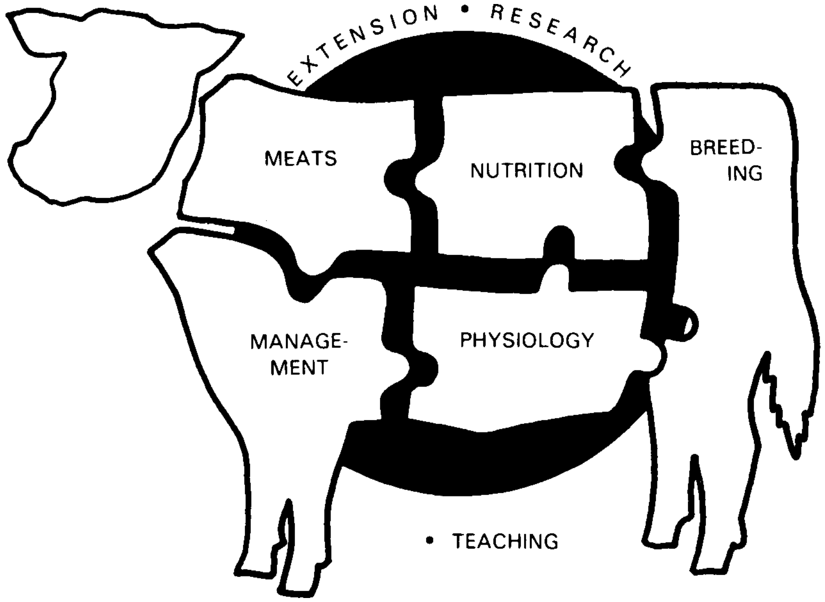

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Beef Cattle Report

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Age of Calf at Weaning of Spring-Calving Beef Cows and the Effect on Production Economics

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> Profit potential for different weaning systems is influenced by cow and heifer costs and time of the year when cull cows and heifers and finished steers are marketed.

Summary

Spring-calving cows were used to evaluate effects of calf age at weaning on production economics. Weaning treatments were early (calf age 150 d, EW), traditional (calf age 210 d, NW), and late (calf age 270 d, LW). Annual cow costs were greater for LW than EW and NW groups. Replacement heifer development costs were higher for EW compared to NW and LW heifers. Net income per finished steer was greater for EW and NW steers than for LW steers. When carcass data were adjusted to the fat depth of the EW steers, net income differences among groups were reduced. Breakeven for each system on a steer financial basis was lower for the NW and LW groups than for the EW group. Net income in each system is influenced by cow and replacement heifer costs and when finished steers, cull cows and heifers are marketed.

Introduction

Shifting calving and/or weaning dates can change herd performance. An increase in profit potential may be realized by greater herd reproductive performance and possibly through alternative calf marketing options when either the calving or weaning date is changed. The cow, calf, and feedlot production results of this experiment were reported in the 1999 Nebraska Beef Report. There is limited information on the economic impact of different weaning times on the production economics of weaning systems if steer calves are retained through slaughter. The objectives of this experiment were to evaluate the effects of weaning calves at 150, 210, and 270 days of age on subsequent cow and calf performance, and on factors that influence net income when calves are retained and finished.

Procedure

This experiment was conducted at the University of Nebraska's Dalbey-Halleck Farm in southeast Nebraska. In year one of this 5-year experiment, 180 MARC II (1/4 Angus, 1/4 Hereford, 1/4 Simmental, 1/4 Gelbvieh) spring (March-April) calving cows were assigned to one of three treatment groups based on weight, body condition, age and date of calving. Cows remained in their assigned groups unless culled from the herd for reproductive failure. Replacement heifers were selected from within the same group in which they were born.

Yearly, in a pre-determined sequence, one of the following three weaning times was applied to each group: August wean (EW; calf average age 150 d; n=60), October wean (NW; calf average age 210 d; n=60), or December wean (LW; calf average age 270 d; n=60). During the spring and summer, cows were managed as a single group and grazed cool and warm-season pastures. As calves were weaned, cow groups were managed in separate, but similar, pastures in order to record the amount of hay, supplement and inputs specifically associated with each group. All groups were fed to attain an average body condition score of 5 (1 = emaciated, 9 = obese) by about one month (Feb. 1) before calving. In all cases, when feeds were fed to cattle, labor and machine operating costs associated with the feeding of these feedstuffs were estimated to be $10 per ton fed.

Cows

Production costs associated with each group were documented for economic analysis. Amounts of hay, grain, protein supplement and salt and mineral fed were logged and expensed to each group. Ten-year average prices for hay and grain were used to calculate feed costs.

Grazing costs were based on the opportunity value of an animal unit month (AUM) in southeast Nebraska. During the winter months when cows grazed dormant range, value of an AUM was estimated to be about one-half of the summer value. Based on average cow weight, a suckled dam was estimated at 1.3 AU's. After weaning, the dam was estimated at 1.2 AU's. Grazing costs were calculated based on cow lactational status and AUM value. The summer and fall grazing period was six months and the winter grazing period was three months.

Cow cost included credit for cull cows and heifers, purchase-in price of replacement heifers, and heifer development costs. These calculations were based on two percentages: retainment rate, defined as the number of heifers retained for selection from the general group population divided by the number of cows in that group; and replacement rate, defined as the number of heifers selected as replacements from the retained group divided by the number of cows in that group. Cull cow credits were based on cull slaughter cow market value at the time of weaning, and cull heifer credits were based on heifer market value in February. Revenue received from selling of cull animals was allocated to the treatment group on a per cow basis. Cull cow revenue allocation was based on the group replacement rate, less an assumed death loss (1.5%), multiplied by the average weight of the cull cows, multiplied by the market value on a per unit of weight basis of the cull cows.

Revenue received from cull heifers also was allocated on a per cow basis.

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Cull heifer revenue allocation was based on group retainment rate, less group replacement rate, less an assumed death loss (.3%), multiplied by average weight Feb. 1 of cull heifers, multiplied by the market value on a per unit of weight basis of the cull heifers in February.

Both purchase-in price of replacement heifers and replacement heifer development costs were allocated similarly. Each was allocated based on the group retainment rate and allowed for the distribution of these expenses on a per cow basis.

Steers

At each weaning, steer calves were transported to the University of Nebraska feedlot at Mead, NE. An economic analysis and comparison of treatment feedlot performance was conducted yearly. The economic analysis evaluated treatment performance each year based on market prices, weaning and finishing weight, receiving and finishing DMI, days on feed (DOF), and USDA Quality and Yield Grade.

Live weight market prices used to value weaned and finished cattle were 10-year averages for the specific time periods in which the calves were weaned and marketed, and for specific weight ranges appropriate for each treatment. Ten-year average prices for feedstuffs were used in assigning ration costs. Ration costs were separated into receiving (28 d) and finishing (DOF - 28 d) ration costs. Total feed cost for each period was based on DMI, DOF and ration cost per pound.

Carcasses were discounted when Quality Grade was less than Choice (-) and/or Yield Grade 3.9. Discounts were based on 10-year average discounts for carcasses grading less than Choice (-) and/or Yield Grade 3.9 marketed during the same months as the treatment groups.

Because the NW and LW steers were slaughtered at a lower backfat thickness, feedlot performance, carcass and financial data for the NW and LW groups were adjusted, using regression, to the same final fat depth as the EW group. Using these equations, days on feed needed to achieve the same fat depth as the EW steers were determined, allowing us to calculate the financial impact of feeding all groups in the system to the same fat depth endpoint.

Gross income per steer, feed, yardage, processing, trucking, and interest expense, and net income per steer were calculated.

Replacement Heifers

Feed and labor costs associated with replacement heifer development were documented and used in the economic analysis. Ten-year average market prices for the feedstuffs used in the developing ration were used to price the ration.

Heifer value was based on the 10-year average market price for the month in which they were weaned and their average individual weight at that time. Replacement heifers were valued at feeder market price plus an assumed $100 per head premium.

Grazing costs were based on the average cost of an AUM in southeast Nebraska. AUM values during the winter months of dormant range were estimated to be one-half of the summer AUM values. We assumed that replacement heifers were equivalent to .8 AU during summer and fall. The summer and fall grazing period was six months and the winter grazing period was three months.

System Evaluation

Profit potential per cow for each system was evaluated based on the cost/return data from the cow, heifer and steer-feedlot enterprises. Income was generated by sale of feedlot finished steers, cull cows and cull heifers. Heifer replacements were bought into the cowherd in February, and valued at that time. The assigned calf value for each weaning system was based on the average weaning weight and value of steers and heifers within the particular system, and the actual replacement rate that occurred in each system. Net returns for the systems are returns to overhead, capital, management, some labor and risk. Labor for checking cattle while grazing was assumed to be covered by the AUM grazing cost while feedlot labor is part of the yardage charge. Calving and overhead labor were not estimated.

Breakevens

Breakevens for the weaned calf, finished steer on an economic basis, and finished steer on a financial basis were calculated. Breakeven for the weaned calf was calculated in the following manner: the numerator being the cow cost to produce the weaned calf, and the denominator was the average steer weight at weaning plus the average heifer weight at weaning divided by two and this quantity multiplied by percentage calves weaned of females exposed during the breeding season to produce that calf crop. The breakeven for the finished steer on an economic basis was calculated by adding the total costs of the finished steer plus the feeder calf valued at the opportunity cost and the sum divided by estimated final weight (hot carcass weight/.63). The opportunity cost for the feeder calf was determined by multiplying the average weight at the time of weaning and the steer value based on the 10-year average market price for the month in which they were weaned. Breakeven for the finished steer on a financial basis was calculated by adding the total costs of the finished steer plus the feeder calf valued at its production costs (cow costs to produce the weaned calf) and the sum divided by the estimated final weight.

Results

Yearly cow cost not including interest and depreciation expense on livestock, feed, and equipment differed ($P < .10$) for the LW group compared to both the EW and NW groups (Table 1). Total feed costs were $37.44 less for EW compared to the LW groups. Over 70% of the total feed cost difference was attributed to the greater amount of harvested forages fed to the LW cows. Cows in the LW weaned group were in lower body condition in late gestation and more harvested forages were needed to get them in an average body condition score 5 before calving.

Yearly heifer retainment rate and replacement rate also were used in the calculation of annual cow costs. Over the five years, heifer retainment rate averaged 21% for all groups and replacement rate averaged 11, 8, and 6 %

Table 1. Yearly cow costs per head not including interest and depreciation expense on livestock, feed, and equipment for Early (EW), Normal (NW), and Late (LW) weaned groups.

	Treatment			
	EW	NW	LW	SE
Harvest forage[a]	$82.23	$90.00	$108.69	
Grain[b]	$0.10	$0.13	$0.38	
Protein supplement[c]	$4.09	$4.76	$8.96	
Salt & mineral[d]	$8.03	$7.95	$7.65	
Grazing[e]	$195.07	$199.22	$201.30	
Total feed costs	$289.54	$302.06	$326.98	
Labor[f]	$14.13	$15.45	$18.73	
Sum of cull cow & heifer credits[g] less purchase-in cost of replacement heifer[h]	$18.75	$25.94	$28.10	
Heifer development costs[i]	$87.74	$77.76	$69.51	
Total cost	$410.16[j]	$421.21[j]	$443.32[k]	7.92

[a]Forage cost based on hay at $60.00/ton.
[b]Grain cost based on corn at $2.48/bu.
[c]Protein supplement cost based on 38% protein pellet at $280.00/ton.
[d]Salt & Mineral cost based on $300.00/ton.
[e]Grazing cost based on AU value and AUM's required. A summer and fall AUM was valued at $20.75, and a winter AUM was valued at $10.38.
[f]Labor cost based on a charge of $10.00/ton of feed fed.
[g]Cow and heifer cull credits were calculated using retainment and replacement rates, cull cow and heifer market values, with an assumed death loss of cows to be 1.5% and heifers to be .3%.
[h]Purchase-in price of replacement heifers was assumed to be market value of heifer + $100.00. Retainment rate was also used in this calculation.
[i]Heifer feed and grazing costs were calculated and allocated to cow costs using retainment rate.
[jk]Numbers within a row with differing superscripts are different (P < .10).

Table 2.Steer feedlot economic information and calculations for Early (EW), Normal (NW), and Late (LW) weaned groups.

	Treatment			
	EW	NW	LW	SE
Weaning wt, lb	428	537	592	
Market value @ weaning, $/cwt	$93.59	$81.75	$81.35	
Days on feed	247	204	164	
ADG, lb/day	2.94	3.11	3.32	
Estimated final wt, lb[a]	1154	1173	1136	
Market value @ finishing, $/cwt	$73.79	$72.00	$69.92	
Gross income from finished steer	$851.54	$844.06	$794.29	
Calf cost if purchased into feedyard	($400.57)	($439.00)	($481.59)	
Feed Costs:				
Receiving period, days [b]	28	28	28	
Receiving DMI, lb/day	10.93	13.66	16.76	
Receiving ration costs[c]	$.0378	$.0378	$.0378	
	($11.57)	($14.46)	($17.74)	
Finishing period, days[d]	219	176	136	
Finishing DMI, lb/day	18.99	20.88	22.81	
Finishing ration cost[c]	$.0544	$.0544	$.0544	
	($226.24)	($199.91)	($168.76)	
Miscellaneous expenses:				
Yardage[e]	$74.10	$61.20	$49.20	
Feedlot processing	$10.44	$10.44	$10.44	
Trucking[f]	$5.85	$6.32	$6.39	
Cattle and trucking interest[g]	$24.49	$22.18	$19.55	
Feed and yardage interest[g]	$4.99	$3.85	$2.78	
	($119.87)	($103.99)	($88.36)	
Less carcass discounts:				
YG 4 discount[h]	$12.42	—	—	
Select discount[h]	$5.52	$24.54	$27.76	
	($17.94)	($24.54)	($27.76)	
Net income per steer	$75.36[i]	$62.16[i]	$10.09[j]	6
Net income per steer, adjusted[k]	$75.36	$78.16	$41.76	

[a]Estimated final weight = hot carcass weight/63% yield.
[b]Receiving period represents the first 28 days on feed at the feedlot.
[c]Ration costs were based on 10-year average feedstuff prices.
[d]Finishing period represents DOF - 28 days.
[e]Charged at $0.30/head/day.
[f]Charged at $0.00375/lb of live weight transported.
[g]9% APR charged.
[h]Carcass discounts are based on 10 year average discounts for the time period in which calves were marketed.
[j]Numbers within a row with differing superscripts are different (P < .001).
[k]Net income per steer when steers are adjusted to the fat depth of the EW group.

for EW, NW, and LW groups, respectively. Heifer development costs per cow were $18.23 greater for the EW compared to the LW groups.

Feedlot phase net income per steer was calculated using the feed and performance parameters measured and is summarized in Table 2. Feedlot phase net income per steer was different (P < .001) between the LW ($10.09 + 6) steers compared to the EW ($75.36 + 6) and NW ($62.16 + 6) steers. Purchase-in costs were less for EW steers, but finishing ration costs were lower for NW and LW steers. NW and LW steers spend fewer days in the feedlot compared to the EW steers.

The EW had a greater fat depth than the NW and LW steers. We used equations to determine days needed in the feedlot for the NW and LW steers to achieve the same fat depth as the EW steers. Using these equations, we determined that the NW steers needed 10 more days and LW steers needed 33 more days in the feedlot to achieve the same fat depth as the EW steers. After carcass traits for the NW and LW steers were adjusted to the same fat depth of the EW steers, those parameters that comprise the calculations for net income per steer were calculated using the adjusted numbers. Differences in net income per steer among groups narrowed when steers were marketed at the same fat depth and averaged $75.36, $78.15, and $41.79 for EW, NW, and LW steers, respectively (Table 2).

Heifer development costs were different (P < .001) among all groups (Table 3). Total heifer development costs were $90.39 greater for EW heifers compared to LW heifers. Feed costs were $81.68 greater for EW compared to LW heifers. EW heifers spent more total days in the dry-lot being developed compared to the NW and LW groups.

System Analysis

System economic analysis evaluated calf value at weaning, yearly cow costs per head, and realized net revenue or loss from the marketing of a finished steer (Table 4). The system analysis indicated that a management system

(Continued on next page)

Table 3. Replacement heifer development costs per head not including interest and depreciation expense on livestock, feed, and equipment for Early (EW), Normal (NW), and Late (LW) weaned groups.

	Treatment			
	EW	NW	LW	SE
Hay[a]	$144.96	$133.74	$116.79	
Grain[b]	$68.14	$50.67	$40.20	
Protein supplement[c]	$46.55	$33.33	$22.93	
Salt & mineral[d]	$5.10	$3.60	$3.15	
Grazing costs[e]	$124.51	$124.51	$124.51	
Total feed costs	$389.26	$345.85	$307.58	
Labor[f]	$30.55	$26.21	$21.84	
Total development cost	$419.81[g]	$372.06[h]	$329.42[i]	6

[a]Forage cost based on hay at $60.00/ton (10 year average).
[b]Grain cost based on corn at $2.48/bu (10 year average).
[c]Protein supplement cost based on 38% protein pellet at $280.00/ton (10 year average).
[d]Salt & Mineral cost based on $300/ton.
[e]Grazing cost based on AU value and AUM's required. A summer and fall AUM was valued at $20.75, and a winter AUM was valued at $10.38.
[f]Labor cost based on a charge of $10/ton of feed fed.
[ghi]Numbers within a row with differing superscripts are different ($P < .001$).

Table 4. Net revenue or loss generated by system not including interest and depreciation expense on livestock, feed, and equipment for Early (EW), Normal (NW), and Late (LW).

	Treatment			
	EW	NW	LW	SE
Calf market value @ weaning per head[a]	$325.33	$393.75	$430.19	
Cow costs per head	($410.16)	($421.21)	($443.32)	
Net revenue from sale of finished steer[b]	$33.54	$28.90	$4.74	
Net revenue or loss per cow	-$51.29[c]	$1.44[d]	-$8.39[d]	4
Net revenue or loss per cow, adjusted[e]	-$51.29	$8.88	$6.52	

[a]Average market value of steer and heifer at their time of weaning multiplied by percentage of calves weaned of cows exposed during the breading season to produce that calf crop.
[b]Net revenue = sale revenue from steer minus feedlot cost and this revenue was adjusted to a per exposed cow basis. The adjustment for per cow exposed was calculated by dividing the percentage calves weaned of cows exposed by 2 (1/2 calf crop being steers).
[cd]Numbers within a row with differing superscripts are different ($P < .001$).
[e]Net revenue or loss per cow when steers are adjusted to the fat depth of the EW group.

Table 5. Breakevens for the weaned calf, finished steer-economic cost, finished steer- financial cost for Early (EW), Normal (NW), and Late (LW) management systems.

	Treatment			
	EW	NW	LW	SE
Breakeven for:		$/cwt		
Weaned calf	113.18[d]	86.81[e]	82.76[e]	2.06
Finished steer-economic[b]	65.76[f]	64.63[g]	66.78[h]	.30
Finished steer-financial[c]	66.05[i]	62.58[j] (64.00)[k]	62.70[j] (63.61)	1.22

[a]Cow costs to produce weaned calf/[(average weaning weight steer calf + average weaning weight heifer calf)/2] * percent calves weaned of females exposed during the breeding season to produce that calf crop.
[b]Finished steer-economic cost = [(Total costs for finished steer plus the feeder calf valued at the opportunity cost)/estimated final weight]*100.
[c]Finished steer-financial cost = [(Total costs for finished steer plus the feeder calf valued at its production cost)/estimated final weight]*100. The feeder calf valued at its production cost is the cow costs to produced the weaned calf.
[de]Numbers within a row with differing superscripts are different ($P < .001$).
[fgh]Numbers within a row with differing superscripts are different ($P < .05$).
[ij]Numbers within a row with differing superscripts are different ($P < .08$).
[k]Number in parentheses is the breakeven for the finished steer on a financial basis if the NW and LW steers were fed to the fat depth of the EW steers.

of NW ($1.44 + 4.26) generated the greatest ($P < .001$) net revenue per cow, and the EW (-$51.29 + 4.26) weaning management systems generated the least. Net revenue per cow for the LW group was not statistically different from that of the NW group. A similar pattern was observed when net revenue or loss per cow was calculated using the data when all steers were marketed at the same fat depth. Net revenue generated for the NW and LW systems was greater than that generated in the EW system.

Breakevens

Breakevens for the weaned calf, finished steer on an economic basis and finished steer on a financial basis are summarized in Table 5. Breakeven for the weaned calf was greater ($P < .001$) for the EW ($113.18/cwt) group than the NW ($86.81/cwt) and LW ($82.76/cwt) groups. Breakeven for the finished steer on an economic basis were different ($P < .05$) among groups and was greatest for LW steers, lowest for NW steers, and EW steers were intermediate the LW and NW groups. However, when breakeven for finished steers was calculated on a financial basis, breakeven was greater ($P < .08$) for the EW steer compared to the NW and LW steers and the breakeven between NW and LW steers were not different.

In conclusion, items that impact the profitability of alternate weaning systems are replacement rate, feed costs for the cow herd, replacement heifer development costs and time of the year when cull cows, cull heifers and finished cattle are marketed. When weaning age is the management tool chosen, producers need to understand how shifting costs from one livestock enterprise to another influences the economics of the operation and a livestock marketing plan needs to be developed.

[1]Rick Rasby, associate professor, Animal Science, Lincoln; Chuck Story, former graduate student; Dick Clark, professor, Ag Economics, West Central Research and Extension Center, North Platte; Todd Milton, assistant professor, Animal Science, Lincoln; Mark Dragastin, Farm Manager, Virginia, NE.

Supplementing Metabolizable Protein to Yearling Heifers Grazing Winter Range

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Supplementing metabolizable protein to grazing heifers in the winter improved performance in one of two years, and forage intakes declined with increasing stage of gestation.

Summary

Two experiments were conducted with pregnant yearling heifers grazing Sandhills winter range to evaluate response of supplementing to meet the metabolizable protein requirement of the heifers versus conventional supplementation based on crude protein. Supplements were fed from October to February (pre-calving) both years. Intake was measured in November, January and February of the first year. Supplementing to meet metabolizable protein requirement improved the heifers' ability to maintain weight in year one, but not in year two. Heifer intakes ranged from 2.2% of BW in November to 1.5% in February. Feeding hay reduced body weight loss compared to no hay feeding in year two.

Introduction

Nutritional systems that facilitate economical management of yearling heifers over winter to subsequently improve two-year-old pregnancy rate potentially could improve ranch profitability. Due to high protein requirements for growth and pregnancy, metabolizable protein (MP) may become limiting to heifers during the winter. Metabolizable protein is the sum of digestible rumen escape protein (UIP) and microbial crude protein (MCP) flowing to the small intestine. The production of MCP is dependent upon the energy content of the diet and is thus decreased as forage quality declines in the winter. Forage samples collected in the Sandhills of Nebraska during the winter with esophageally fistulated cows have less than 1% of DM as UIP, thus MP will become deficient in situations where the requirements are relatively high. Conventional protein supplementation strategies are based on the CP system, which erroneously assumes equal rumen degradability of all protein. In situations where supplemented protein sources are primarily degraded in the rumen, supplements may not supply adequate UIP to meet the animals' MP requirement. Supplementing to meet MP requirements during the winter using sources of protein high in UIP potentially could improve performance (weight and body condition) and reproduction of heifers.

A critical step in determining supplemental requirements of grazing heifers is an accurate estimate of forage intake (FI). Data have not been published on FI of pregnant heifers grazing Sandhills winter range, nor how FI changes as the heifers progress in gestation. Therefore, the objectives of this study were to evaluate the body weight, body condition score (BCS), and FI of pregnant heifers either supplemented to meet their MP requirement or supplemented with a conventional protein supplement, and to determine how FI of heifers changes over the winter.

Procedure

Experiment 1

Twelve pregnant, yearling heifers (average calving date March 1) grazing native range at Gudmundsen Sandhills Laboratory were stratified by weight and body condition score on Oct. 2, 1997 and randomly allotted to one of two supplemental treatments (six per treatment). Treatments were 1) a supplement designed to meet the MP requirement of the heifers through the winter (MPS) and 2) a conventional protein supplement fed to meet the CP requirement of the heifers (CONT). Feather meal was used for the UIP source in the MPS supplement (Table 1), with the supplement DM being composed of 49% CP and 27% UIP. The CONT supplement was composed of 49% CP and 13% UIP (DM basis). Supplements were individually fed three times weekly starting in mid-October. The CONT supplement was fed at the rate of .89 lbs/day (DM) throughout the trial, supplying 53 grams of UIP/day. The MPS supplement feeding rate increased gradually from .70 lb/day in October to 1.1 lb/day in February to meet MP requirements, supplying 86 grams UIP/day in October, 120 grams UIP/day in November, December, and January, and 135 grams UIP/day in February. No hay was offered during the

Table 1. Composition of supplements fed to heifers in Experiments 1 and 2 (% of DM).[a]

Ingredient	MPS	CONT
Cottonseed Meal	—	58.8
Feather Meal	40.2	—
Soybean Meal	—	17.8
Sunflower Meal	30.2	13.7
Wheat Middlings	26.2	—
Dist. Grains	—	3.4
Molasses (Cane)	2.1	2.1
Urea	—	2.8
Minerals/Vitamins	1.3	1.4

[a]Supplements were provided as range cubes fed 3 times weekly. MPS: designed to meet the metabolizable protein requirement; CONT: designed as conventional protein supplement.

(Continued on next page)

experiment. Beginning Oct. 22, weights were taken twice weekly and BCS once monthly. Weights were taken with no prior shrink at the same time each weigh-day (approximately 1:00 pm), and BCS were assigned by two trained technicians. The heifers were weighed and BCS off-test on Feb. 13, 1998.

Heifers were managed in one 81 acre pasture throughout the experiment at a stocking rate of .70 AUM/acre. The pasture was located on a sands range site in good to excellent condition which was dominated by little bluestem *(Schizachyrium scoparium)*, prairie sandreed *(Calamovilfa longifolia)*, sand bluestem *(Andropogon hallii)* and switchgrass *(Panicum virgatum)*. Estimates of standing herbage taken from a similar, adjacent pasture in October (during a simultaneous study; 1999 Nebraska Beef Report, pp. 5-6) were used to calculate cumulative grazing pressure (total AUM per ton of DM forage initially available), which was about .59 AUM/ton.

Intake measurements were taken in three, six-day periods beginning Nov. 10, 1997, Jan. 5, 1998 and Feb. 9, 1998. Chromium sesquioxide from time release boluses was used for determination of fecal output in each animal, and predictions were validated with four steers using total fecal collection. Diets were collected with esophageally fistulated cows during each intake period, and samples were used to determine IVDMD. Forage intake was calculated as: daily fecal output from forage/1-forage IVDMD. Instantaneous grazing pressure (animal units (AU) per ton of DM forage at any instant in time) was about .13, .14 and .15 AU/ton for the November, January and February intakes, respectively.

Experiment 2

On Oct. 21, 1998, 18 pregnant heifers at Gudmundsen Sandhills Laboratory were stratified by weight and BCS and randomly allotted to one of three supplemental treatments. Supplements were the same as those described in Experiment 1, and treatments were 1) heifers supplemented to meet MP requirement and receiving hay beginning in January (MPS/Hay), 2) heifers supplemented with conventional supplement and receiving hay beginning in January (CONT/Hay), and 3) heifers supplemented to meet MP requirement and offered no hay during the experiment (MPS/No Hay). Heifers were managed on the same pasture described for Experiment 1, with a stocking rate of 1.06 AUM/acre and an approximate cumulative grazing pressure of .83 AUM/ton (adjusted for hay that was fed). Hay was individually fed three times weekly at the rate of 4 lbs/day beginning Jan. 4, 1999. The amount was gradually worked up to 6.5 lbs/day by the first of February. The hay was late June harvested meadow hay containing 7.5% CP and was 65.6% digestible (determined by five day in-vivo trial with five yearling steers). Supplements were fed as described in the first experiment. The cattle were weighed twice weekly and BCS every other month. Heifers were weighed and BCS off-test on Feb. 20 and 21, 1999.

Results

Experiment 1

Heifers receiving the CONT supplement lost 26 lb over the winter, but heifers receiving the MPS treatment gained 10 lb (Table 2; P = .04). Considering fetal weight (fetus, placenta, fluids) was substantial during the time the experiment was conducted, all heifers lost body weight over the course of the experiment. Figure 1 shows body weights of each treatment group throughout the experiment. Both treatment groups gained weight from early October to late December, and during this period the MPS heifers appeared to gain weight faster than the CONT heifers. All heifers lost weight in January and Febru-

Table 2. Weight, BCS, and forage intake (FI) of heifers grazing winter Sandhills range from October 1997 to February 1998 (Experiment 1).[a]

Item	MPS	CONT	SD[b]
Beginning wt, lb	955	948	54
Final wt, lb[c]	965	921	49
Wt change, lb[d]	10	-26	27
Beginning BCS	6.4	6.3	.5
Final BCS	4.9	4.8	.3
BCS change	1.5	1.5	.7
November FI,[e,f]			
lb	22.1	20.6	2.5
% BW	2.2	2.2	.2
January FI,[e,f]			
lb	17.5	15.8	4.3
% BW	1.8	1.7	.4
February FI,[e,f]			
lb	14.8	14.3	2.6
% BW	1.5	1.6	.3

[a]MPS: heifers supplemented to meet metabolizable protein requirement; CONT: heifers supplemented with conventional protein supplement. No hay fed during the experiment.
[b]Standard deviation, n = 12.
[c]Treatments differ, P = .16.
[d]Treatments differ, P = .04.
[e]Dry matter basis.
[f]Intake declined linearly over time (P = .0001).

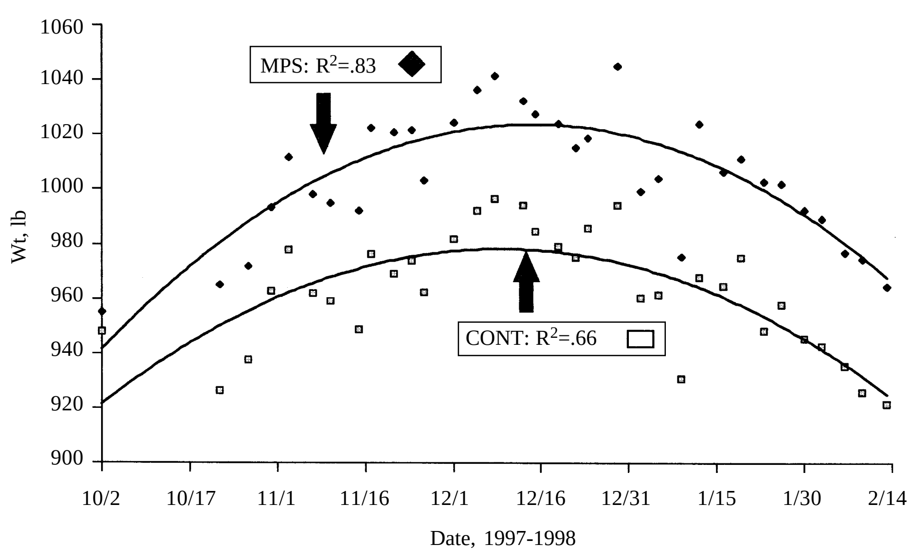

Figure 1. Weight change of heifers in 1997-1998 (Exp. 1).

Table 3. Weight and BCS of heifers grazing winter Sandhills range from October 1998 to February 1999 (Experiment 2).[a]

Item	MPS/Hay	CONT/Hay	MPS/No Hay	SD[b]
Beginning Wt, lb	940	945	923	41
Final Wt, lb[c]	914	921	808	69
Wt change, lb[d]	-26	-23	-114	48
Beginning BCS	6.1	6.0	6.1	.4
Final BCS[e]	5.7	5.4	5.0	.5
BCS change[f]	-.4	-.6	-1.0	.6

[a]MPS/Hay: heifers supplemented to meet metabolizable protein requirements and fed hay (average 5 lb/day) in January and February; CONT/Hay: heifers supplemented with conventional protein supplement and fed hay in January and February; MPS/No Hay: heifers supplemented to meet metabolizable protein requirements and fed no hay.
[b]Standard deviation, n = 18.
[c]MPS/Hay and CONT/Hay versus MPS/No Hay, P = .001.
[d]MPS/Hay and CONT/Hay versus MPS/No Hay, P = .0001.
[e]MPS/Hay versus MPS/No Hay, P = .01; CONT/Hay versus MPS/No Hay, P = .10.
[f]MPS/Hay versus MPS/No Hay, P = .10.

ary. It appears that MP was limiting growth of the heifers during the fall, while energy became first limiting in late December. There were no differences in BCS loss over the winter between the MPS and CONT heifers (P=.83), with both groups losing about 1.5 BCS. Most of this condition loss (approximately 66%) occurred after late December, when weights were declining.

Diets collected by the esophageally fistulated cows during each intake period had IVDMD averaging 52% in November, 49% in January, and 50% in February. Heifer FI was not different between treatments when expressed as lb/day or as a percentage of body weight for any of the three intake periods (Table 2). However, FI declined linearly across measurement dates (P = .0001). Heifer FI averaged 21.4 lb/day (2.2 % of BW) in November, 16.7 lb/day (1.8%) in January, and 14.5 lb/day (1.5%) in February. The 1996 NRC model predicted the heifers to have a DMI of 22 lb/day, which was similar to the FI measured in these heifers in November. However, the NRC model did not predict a reduction in intake across the measurement dates.

A reduction in the amount of forage available for grazing and/or stressful environmental conditions can cause reductions in intake. In addition, heifer intakes tend to decline as stage of gestation progresses and the fetus and fluids begin to compress the rumen, which reduces rumen volume. Because rumen fill likely limits intake on low quality diets, reduced rumen volume results in lower intake. However, the decline in FI over time measured in this study was more severe than expected, and the 1.5% of BW intakes measured in February were much lower than intakes measured in cows grazing similar Sandhills winter range during late gestation. With actual intakes used as inputs, the NRC model predicted the heifers to lose .2 BCS in November, .7 BCS in December, and 1.4 BCS in January. The heifers actually lost .3 BCS in November, .5 BCS in December, and .6 BCS in January. Therefore, the actual performance was better than predicted performance. However, the November intake data yielded predicted BCS losses similar to actual when modeled in the NRC. Sources of variation within actual and predicted BCS estimates and the lack of performance measurements in late February and early March (the trial ended) could account for the difference in NRC predicted performance and actual heifer performance in January (and early February). The data show that heifer intakes declined as stage of gestation increased. The decline in intake prior to calving was more severe than expected and predicted by the NRC.

Experiment 2

There were no differences between the MPS/Hay and the CONT/Hay in body weight change nor BCS change (Table 3). Heifers on the MPS/No Hay treatment lost more weight over the course of the winter than heifers on the other treatments (P = .0001). Heifers on the MPS/Hay treatment had higher BCS in February than those on the MPS/No Hay treatment (5.7 versus 5.0; P = .01), and tended to lose less BCS over the course of the experiment (P = .10). Heifers on the CONT/Hay treatment tended to have higher BCS than the MPS/No Hay treatment in February (5.4 versus 5.0; P = .10) and tended to lose less BCS over the course of the experiment (P = .16). With weight losses averaging 114 lbs for the MPS/No hay treatment compared to 26 and 23 lb for the MPS/Hay and CONT/Hay respectively, BCS differences would be expected to be greater between the hay and no hay treatments. It is possible, however, that less rumen fill in cattle on the MPS/No Hay treatment could cause final weights to be lower in this treatment relative to treatments receiving hay.

The addition of MP to the hay-supplemented diets did not improve the heifers' ability to maintain weight or BCS over conventional supplementation. The addition of energy to low-quality ruminant diets will increase MCP production if adequate degradable protein is available. This increases the flow of MP to the small intestine, and thus will decrease the need for supplemental UIP. However, this may not fully explain the lack of response to MP in Experiment 2 that was noticed in Experiment 1. Yearly variation in diet quality can be a factor.

Previous work in the Sandhills has shown that diet quality can change rather markedly between years (1998 Nebraska Beef Report, pp. 20-21). This can cause variation in intake and performance of cattle. Figure 2 illustrates that all cattle were losing weight until hay was fed to the MPS/Hay and CONT/Hay groups. Heifers were able to maintain body weight when hay was fed while heifers on the MPS/No Hay treatment continued to lose weight. This is unlike the response noted in Experiment 1 where cattle gained weight in the fall. When energy is not limiting, one would expect a growth response in the fall from supplying UIP, before gestation requirements and environmental factors begin to play a larger role in the winter months. In Experiment 2, energy could have been limiting performance in the fall. Reduced

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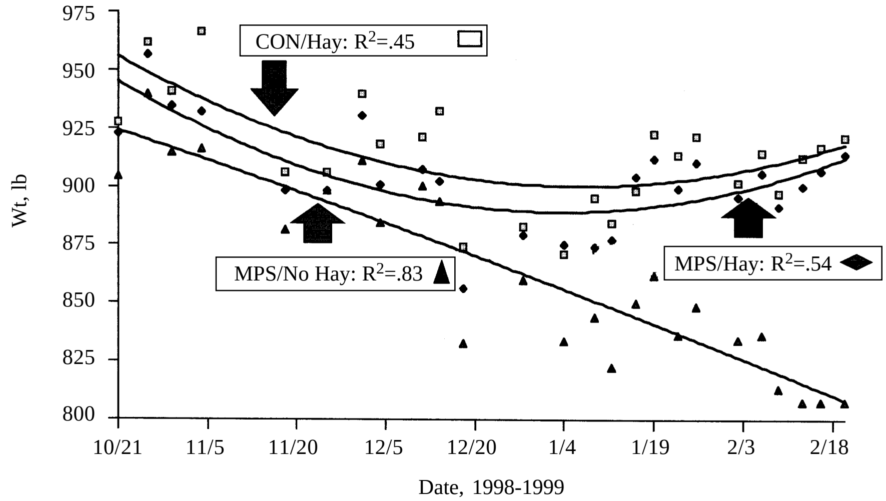

Figure 2. Weight change of heifers in 1998-1999 (Exp. 2).

energy intake was likely due to forage quality and/or the amount of forage available for grazing, as the grazing pressure was higher in year two. This is further supported by the fact that cattle on the MPS/No Hay treatment, which was an identical treatment to the MPS treatment in Experiment 1, lost substantially more weight in Experiment 2. Nevertheless, body condition losses were less in Experiment 2 than in Experiment 1. Rumen-fill differences, error associated with comparing BCS data on small groups of animals across years and composition of weight-loss differences could account for some of the year to year variation.

In conclusion, heifers supplemented with UIP (balanced MP requirement) maintained more weight in the fall of one year, but heifers did not respond to UIP supplementation in the fall of a second year. Year to year variation in forage quality or availability, environment, or other factors could have caused the year differences. Heifer intakes declined as stage of gestation increased. Managing heifers on native range without feeding hay resulted in large losses in body weight.

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Refinement of the MGA/PGF Synchronization Program for Heifers Using a 19-day PGF Injection

Gene Deutscher
Rex Davis
Dave Colburn
Doug O'Hare[1]

> When the MGA/PGF synchronization program was used on heifers, giving the PGF injection on day 19 improved cycling response and pregnancy rates during a 5-day period.

Summary

A two-year study was conducted on 240 yearling heifers to refine the MGA/PGF synchronization program by using a 19-day PGF injection. All heifers were fed MGA for 14 days and received PGF injection on either Day 17 or Day 19 after the MGA period. Heifers were heat detected and bred by AI using semen from one sire. The Day 19 PGF injection caused a higher (16%) percentage of heifers to cycle by 72 hours after injection, a higher (6%) percentage of heifers to cycle during the 5-day breeding period, and higher pregnancy rates in 5 days (8%) and in 50 days (5%) than heifers given PGF on Day 17. Similar results were found on a cooperating ranch using 1400 heifers.

Introduction

Proper management of replacement heifers is critical for increasing herd productivity and profitability. Estrous synchronization and AI programs can increase the percentage of heifers bred early in the first breeding season and improve overall reproductive performance. With the advent of commercially available sexed semen in the future, heifer synchronization and AI may become more popular.

Estrous synchronization programs are needed to achieve high conception rates during a short time period at low costs. The MGA/PGF program has the advantages of ease of administration, induction of estrus in some prepuberal heifers and low cost. However, can it be improved? If heifers are in the late luteal phase of their estrous cycle at the time of PGF injection, a greater percentage of them may show estrus with higher pregnancy rates.

The objective of this study was to compare the effects of giving the PGF injection on Day 19 versus Day 17 after the MGA feeding period (which is the standard procedure) on estrous response, conception rates and overall pregnancy rates of yearling heifers.

Procedure

This study was conducted over two years with 240 crossbred yearling heifers (140 in 1997 and 100 in 1998) at the West Central Research and Extension Center, North Platte. Heifers were managed in drylot and fed ground alfalfa hay, corn silage, and corn to reach prebreeding target weights of about 775 pounds.

Two blood samples were collected 10 days apart for serum progesterone levels before MGA feeding to determine puberty status. All heifers were fed MGA at .5 mg per head per day with ration in a feed bunk for 14 days. After the MGA feeding period, heifers were observed for standing estrus during the next eight days. This estrus was used to randomly assign the heifers to two treatment groups according to day of estrus for equal distribution. This estrus was also used to calculate the day of the estrous cycle for each heifer at time of PGF injection. Heifers in Group A were given the PGF (Lutalyse) injection on Day 17 after the MGA feeding period and heifers in Group B received the PGF injection on Day 19. Heifers were heat detected and bred using AI for five days after each injection. They were bred according to the AM-PM rule (12 hrs after standing estrus) using semen from one Angus sire each year. Three AI technicians were used each year and inseminated equal numbers of heifers in each treatment group. Figure 1 shows the experimental protocol.

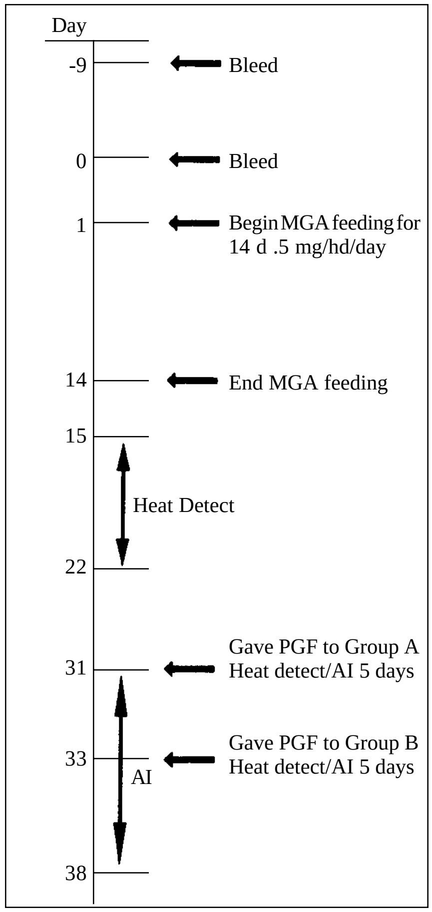

Figure 1. Outline of study procedure.

Angus bulls were placed with the heifers seven days after the AI period for a total 50-day breeding season. In 1997, the heifers were palpated twice for fetal age to determine day of conception which was confirmed by calving date. In 1998, ultrasound was used to determine day of AI conception and a pregnancy exam determined total pregnancy rate. Cycling and pregnancy rate data were analyzed by Chi-Square analyses.

A similar study was conducted in 1998 on a cooperating ranch (O'Hare Ranch, Ainsworth, NE) which compared the same two treatments using over 1400 heifers. All heifers were in drylots and fed MGA for 14 days. They then were divided into two groups and received the PGF injection at either 17 or 19 days. Heifers were heat detected and bred by AI on the AM-PM rule for 10 days. For this report, only the data on the first five days after each PGF injection were used. Heifers were also heat detected and bred by AI on their second cycle for a total 30-day breeding season. Day of conception was determined by ultrasound procedures. All data were analyzed by Chi-Square analyses.

Results

Results were similar for both years of the University study, so data were pooled. Table 1 shows the two-year summary. Similar percentages of heifers were cycling in both treatment groups before and after MGA feeding. A greater percentage of heifers in the 19-day group exhibited estrus during the five-day synchronization period than those in the 17-day group (92.4 vs. 86.7%, respectively, P < .17). First service conception rates also tended to be higher (5.1%) for the 19-day group of heifers, although not statistically significant. Percentage of heifers pregnant in the five-day AI period and in 50 days of breeding were higher (7.9% and 5.0%, respectively) for heifers in the 19-day group compared to the 17-day group. Even though these percentages were not statistically significant (P>.10), they may be biologically and economically significant and were confirmed by the results from the O'Hare Ranch study (Table 4).

The timing of estrus after PGF injection is shown in Table 2. A higher (P < .05) percentage of heifers in the 19-day group were in estrus by 72 hours after PGF than heifers in the 17-day group (70% vs. 54%). By 84 hours after PGF, 82% of the 19-day group had shown estrus. No heifers in the 19-day group

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Table 1. Comparison of PGF injections at 17 or 19 days in MGA/PGF synchronization program - two years.

	PGF treatment group[a]		
Trait	17 days	19 days	Difference
No. of heifers	120	119	
Cycling before MGA[b], %	76.7	73.9	
Cycling after MGA feeding[c], %	94.2	94.1	
Cycling during 5 days synch., %	86.7	92.4	+5.7*
No. conceived in 5 days	59	68	
First service conception, %	56.7	61.8	+5.1
Pregnant in 5 days of synch., %	49.2	57.1	+7.9**
Pregnant in 50 days of breeding, %	88.3	93.3	+5.0**

[a]Heifers fed MGA for 14 days then received PGF on assigned day. Heifers were heat detected and AI bred on AM-PM rule with semen from one sire.
[b]Cycling status determined by blood progesterone levels.
[c]Cycling determined by detection of standing estrus.
* (P<.17)
** (P<.20)

Table 2. Heifers in estrus after PGF injection by treatment group - two years.

Estrus after injection	PGF treatment group: 17 day No. (%)[b]	19 day[a] No. (%)[b]
48 hrs	8 (7)	17 (14)
60 hrs	37 (38)[e]	42 (50)[f]
72 hrs	20 (54)[c]	24 (70)[d]
84 hrs	23 (73)[e]	15 (82)[f]
96 hrs	8 (80)[e]	7 (88)[f]
120 hrs	8 (87)	5 (92)

[a]None of heifers in estrus before injection.
[b]Accumulated % of total in group.
[cd]Treatments differ (P<.05).
[ef]Treatments differ (P<.10).

were detected in estrus before the PGF injection, although about 1% did have a standing heat by 12 hours after the injection. These results indicate heifers in the 19-day group came into estrus earlier, so heat detection should begin at injection time. Heifers in estrus at injection time or shortly after are fertile and should be bred using the AM-PM rule.

Table 3 shows the effects of the day of cycle that the heifers were in at the time of PGF injection on AI conception rates. In general, heifers in the later stages of their estrous cycles had higher conception rates. Day of cycle was grouped into Late CL, Med CL, and Early CL subgroups. Fifty-three percent of the 19-day group were in the Late CL subgroup compared to only 2% of the 17-day group. The Late CL subgroup had the highest AI conception rate (67%). This helps explain why the heifers in the 19-day group had higher conception and pregnancy rates. The Early CL subgroup had 30% of the heifers in the 17-day group and only 5% of the heifers in the 19-day group. This subgroup had the lowest (P < .07) conception rate (43%). This also supports the higher pregnancy rates for the heifers in the 19-day group.

Table 4 shows a summary of the results from the cooperating heifer development operation (O'Hare Ranch) which compared the same two treatments. During the five-day synchronization period, 10% more heifers in the 19-day group exhibited estrus with a 7.6% higher pregnancy rate for this group (P < .05) compared to the 17-day group. Also, pregnancy rate after 30 days of breeding was 5.5% higher (P < .05) for the 19-day group. These results are similar to those of the University study and confirm the advantages of the 19-day procedure.

The heifers on this ranch also responded to the PGF injections with a significantly higher percentage of the 19-day group in estrus by 84 hours after PGF compared to the 17-day group (82% vs. 67%, respectively; P < .05). This indicates an earlier and tighter synchronization period. However, a few heifers (1.5%) were in estrus within 12 hours after the PGF injection, so early heat detection is needed.

The results of these studies indicate the following advantages for the 19-day PGF injection procedure:

1. A higher percentage of heifers cycled during the five-day synchronization period (6 to 10%).
2. A higher percentage of heifers (16%) cycled by 72 hours after PGF and up to a total of 82% cycled by 84 hours.
3. First service conception rates were as high or higher than for the 17-day group.
4. Percentage of heifers pregnant in 5 days and total pregnancy rates were higher (5 to 8%) for the 19-day group.
5. Considerably more heifers (50%) were in the late CL stage of their estrous cycle at PGF and were more fertile.
6. University results were confirmed by a field study on 1400 heifers on a cooperating ranch.

Table 3. Effects of day of cycle when PGF injection given on AI conception rate-two years.[a]

Day of cycle	Treatment groups: 17-day No. of heifers	19-day No. of heifers	Total conception[c] %
17	—	2	100
16	—	25	72
15	2	28	60
Late CL[b] (%)	(2)[d]	(53)[e]	67[f]
14	23	21	59
13	23	15	66
12	21	7	57
Med CL[b] (%)	(68)[d]	(42)[e]	61[f]
11	18	3	43
10	6	1	43
7-8-9	6	1	43
Early CL[b] (%)	(30)[d]	(5)[e]	43[g]

[a]Number of heifers in each day of their estrous cycle when PGF given and AI conception rates for each day of cycle.
[b]Estrous cycle separated into three subgroups with percentage of heifers in each.
[c]Conception percent for each day of cycle and each subgroup.
[de]Subgroup percentages differ by treatments (P < .01).
[fg]Subgroup percentages differ on percent conception (P < .07).

Table 4.Comparison of PGF injections at 17 or 19 days in MGA/PGF program on O'Hare Ranch.

Trait	PGF treatment group[a]: 17 days	19 days	Difference
No. of heifers	723	686	
Cycling during 5 days synch., %	77.6	87.6	+ 10*
No. conceived in 5 days	389	421	
First service conception, %	69.3	70.0	+ 0.7
Pregnant in 5 days, %	53.8	61.4	+ 7.6*
Pregnant in 30 days of breeding, %	72.3	77.8	+ 5.5*

[a]Heifers fed MGA for 14 days, then received PGF on assigned day. Heifers were heat detected and AI bred on AM-PM rule.
* (P < .05).

[1]Gene Deutscher, professor, Rex davis, beef unit manager, Dave Colburn, former research technician, Animal Science; West Central Research and Extension Center, North Platte. Doug O'Hare, Ainsworth, NE, conducted cooperative study on his heifer development operation.

Replacement Heifer Development Programs

Gene Deutscher
Andy Applegarth
Dave Colburn
Rex Davis[1]

Grazing subirrigated meadows in the spring with replacement heifers prior to breeding may cause lower pregnancy rates. Better management programs are needed for developing summer-born heifers for replacements.

Summary

A three-year study was conducted to evaluate heifer development programs using Sandhills resources. During the first two years, spring-born yearling heifers that grazed subirrigated meadows for 30 days in May prebreeding had greater weight gains. However, the heifers tended to have lower (10%) pregnancy rates than the heifers on hay and range during May. Grazing meadows in May with summer-born heifers had no effect on pregnancy rates when heifers were bred in September. In comparing spring- and summer-born heifers, initial results indicate yearling and 2-year-old reproductive performance and calf weaning weights may be lower for the summer-born heifers. Additional studies on heifer performance and economics are in progress.

Introduction

Proper development of replacement heifers is of major importance to the productivity and profitability of a cow herd. 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.

Grazing of subirrigated meadows in the Sandhills in early spring should increase heifer gains, increase percentage of heifers cycling and improve early conception rates, as well as reduce feed costs. However, some reports indicate that the lush green forage may lower fertility because of its very high protein level.

Summer calving is gaining interest in the Sandhills and heifer development programs are needed for these cow herds. How should heifer calves be managed so they will breed early in September to calve in mid-June? Will the 2-year-old heifers then breed back for their second calf and what will their calves weigh at weaning?

The objectives of this study were: 1) to compare two programs of developing heifers — grazing meadows in May versus range and hay, and 2) to begin comparing heifer development programs for summer calving cow herds versus traditional spring calving herds.

Procedure

Heifer calves from the MARC II cow herds at the Gudmundsen Sandhills Laboratory (GSL) near Whitman were used in this three-year project. During the first two years, about 50 heifers were selected from each of the spring and summer calving cow herds each year to study the effects of meadow grazing in May on reproductive performance. Less selection was possible on the summer-born heifers because of a smaller number of calves produced in the summer herd.

Each year, spring-born heifer calves were weaned in October and summer-born heifer calves were weaned in January. All heifers were fed meadow hay plus protein supplement and corn during the winter to achieve about one pound gain per day until May. Prebreeding (June) weights for the spring-born heifers were 750 lb in Year 1 and 690 lb in Year 2. Summer-born heifers weighed about 525 lb in May and had prebreeding (Sept.) weights of 740 lb in Year 1 and 720 lb in Year 2.

On May 4 each year, heifers were assigned randomly according to weight and age to two treatment groups (meadow or range) within each calving group. Half the heifers were placed on subirrigated meadows for 30 days while the other half continued on hay and supplement for 15 days and then were placed on native range about May 20. After June 4, all heifers grazed native range at GSL during the summer.

The breeding season began on June 5 for the spring-born heifers and on Sept. 5 for the summer-born heifers. Two blood samples were obtained from the heifers 10 days apart before each breeding season to determine progesterone levels and the percentage of heifers cycling. Heifers were also estrus synchronized using the Syncromate B system and were bred by AI using the AM-PM rule with semen from one Angus sire for a five-day period. Two Angus bulls then were placed with the heifers for 25 days to give a total 30-day breeding season. The same two bulls were used on both the spring and summer heifers.

Heifers were examined for pregnancy about 60 days after the end of the breeding seasons and the open heifers culled. Pregnant heifers were fed hay and supplement during the winter at GSL. About 30 days before calving, heifers were moved to the West Central Center at North Platte for the calving season. Spring heifers began calving on March 15 and summer heifers began calving on June 15. Heifers were assisted at calving if needed and calving data recorded. Two-year-old cows and calves were returned to GSL after the calving season for a 60-day breeding season using MARC II bulls. The breeding season began on June 5 for the spring calving cows and on Sept. 5 for the summer calving cows. Spring-born calves were weaned in early September and summer-born calves were weaned in November. Pregnancy rate for the second calf and the calving date the following year were recorded.

For the third year of the study, 82 spring-born heifers and 60 summer-born heifers were used to compare breeding and calving performance. Heifer calves were fed meadow hay and supplement

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during the winter at GSL to achieve prebreeding weights of 690 lb for both the spring-born and summer-born heifers. Heifers were not allowed to graze meadows in the spring. The breeding season began on May 20 for the spring heifers and on Aug. 20 for the summer heifers. These dates were two weeks earlier than previous years to help determine if earlier breeding may help increase overall reproduction and cow productivity. Five Angus bulls were used to natural service the heifers in both groups for a 45-day breeding season. Two blood samples were taken 10 days apart before the breeding season to determine percentage of heifers cycling.

Heifers were examined for pregnancy about 60 days after the end of the breeding seasons. Pregnant heifers were fed hay and supplement during the winter and spring and remained at GSL for calving beginning on March 1 (spring) and June 1 (summer). Heifers were assisted at calving if needed and calving data recorded. Two-year-old cows were placed with MARC II bulls for 60-day breeding seasons beginning on June 5 (spring) and September 5 (summer). Spring-born calves were weaned in early September and summer-born calves were weaned in late November. Pregnancy rate for the second calf was recorded.

Data were analyzed using SAS analysis of variance with treatment and season in model. Calf weaning weights were analyzed with calf age, sex and sire in model. Percentage data were tested using Chi-Square analyses. In year 3, cow productivity was calculated as pounds of adjusted calf weaning weight divided by number of heifers exposed to breeding. Calving interval was determined by number of days between first and second calving dates.

Table 1. Heifer development of spring-born heifers on range or meadow - 2 years.

	Year 1			Year 2		
Trait	Range	Meadow	Diff	Range	Meadow	Diff
No. of heifers	24	24		30	30	
Wt. on May 4, lb.	723	720		642	643	
Gain during May, lb.	23	42	+19*	39	55	+16*
Prebreeding June wt., lb.	746	762	+16*	680	697	+17*
Prebreeding June pel. area, cm^2	179	189	+10*	174	176	+ 2
Prebreeding June cond. score	5.2	5.4	+ .2	5.3	5.5	+ .2*
Gain during summer, lb.	134	135	+ 1	174	159	-15*
Cycling before breeding, %	83	96	+13	80	73	- 7
Pregnant in 5 days AI, %	29[a]	33[a]	+ 4	59	61	+ 2
Pregnant in 30 days, %	67[a]	58[a]	- 9	93	83	-10

[a]Pregnancy percentages low due to poor AI technique and bull injury.
* Treatments differ (P <. 05).

Table 2.Heifer development of summer-born heifers on range or meadow - 2 years.

	Year 1			Year 2		
Trait	Range	Meadow	Diff	Range	Meadow	Diff
No. of heifers	23	24		22	23	
Wt. on May 4, lb.	546	554		488	497	
Gain during May, lb.	33	57	+24*	46	51	+ 5
Prebreeding Sept. wt., lb.	731	752	+21*	713	730	+17
Prebreeding Sept. pel. area, cm^2	172	176	+ 4	168	175	+ 7
Prebreeding Sept. cond. score	5.1	5.3	+ .2	5.1	5.4	+ .3*
Gain during summer, lb.	152	141	-11	179	182	+ 3
Cycling before breeding, %	91	88	- 3	61	64	+ 3
Pregnant in 5 days AI, %	48	46	- 2	-[a]	-[a]	
Pregnant in 30 days, %	78	79	+ 1	-[a]	-[a]	

[a]Data not reported due to BVD outbreak.
* Treatments differ (P<.05).

Results

The heifer development results of the spring-born heifers on range or meadow for two years are shown in Table 1. Results are reported separately for each year because of some year differences. All heifers were lighter in weight on May 4 in Year 2 than in Year 1. Heifer gain on meadow during May for each year was higher (P < .05) than gain on range and hay. This weight gain increased prebreeding weight in June for the heifers on meadow and also tended to increase body condition scores.

Percentage of heifers cycling (based on serum progesterone) tended to be higher for the meadow heifers compared to range and hay heifers in Year 1 but lower in Year 2. Percentage of heifers pregnant during five days of AI was similar for both treatment groups in both years. However, in Year 1 percentages for both groups were low due to a poor AI technique. Total pregnancy rate was also reduced when a bull became injured and too many heifers had to be serviced by one yearling bull.

The 30-day pregnancy rates tended to be lower (10%) for the meadow heifers than the range heifers each year. These differences were not statistically significant with the small number of heifers in each group, but they may be real. Research on dairy heifers found that feeding excess rumen-degradable protein was detrimental to fertility. The researchers reported that the increased protein in the rumen increased plasma urea nitrogen (PUN) in the blood and lowered the pH of uterine fluids. This in turn reduced pregnancy rates. Other reports have indicated that lush grass with very high protein levels can lower conception rates and/or cause embryonic losses. To overcome this potential problem, cows and heifers could be removed from lush, subirrigated meadows a couple of weeks before and during the breeding season.

Table 2 shows the results on the summer-born heifers for two years. Heifers weighed about 525 lbs on May 4 and the meadow grazing increased gains during May. Prebreeding weights and condition scores in September were also slightly higher for the heifers grazing meadow. However, no differences were found in percentage of heifers cycling or pregnant between the two groups in Year 1. Therefore, meadow grazing in May did not affect pregnancy in September. Year 2 pregnancy results are not reported

Table 3. Calving results of spring and summer-born heifers - 2 years.[a]

Trait	Year 1 Spring Mar-Apr	Year 1 Summer Jun-Jul	Year 1 Diff.	Year 2 Spring Mar-Apr	Year 2 Summer Jun-Jul	Year 2 Diff.
No. of heifers calving	29	34		53	20	
Precalving wt., lb.	1028	951	77*	974	971	
Precalving pel. area, cm^2	268	246	22*	NA	256	
Precalving cow condition.	5.3	5.2		5.0	5.9	.9*
Calf birth date	Mar. 22	Jun. 17		Mar. 18	Jun. 28	
Calf birth weight, lb.[b]	75	75		69	76	7*
Calving difficulty, %	17	3	14*	22	0	22*
Calf losses to weaning (no.)	3	6		4	3	
Weaning date	Sept. 9	Nov. 4		Sept. 3	Nov. 24	
Avg. age of calf (days)	172	-[e]		170	148	22*
Actual calf weaning wt., lb.	431	-[e]		393	340	53*
Calf ADG, lb.	2.1	-[e]		1.9	1.8	
Adjusted calf weaning wt., lb.[c]	499	-[e]		451	439	12
Cow condition at weaning	5.2	-[e]		5.7	5.1	.6*
Cow weight at weaning, lb.	1064	-[e]		1001	958	43*
Cycling before second breeding season, %	15	-[e]		45	55	10*
Pregnant for 2nd calf, %	92	-[e]		92	65	27*
Calving interval 1st to 2nd calf (days)[d]	376	-[e]		383	370	13*

[a]No differences between development treatments, so data pooled and reported by calving seasons.
[b]Effects of sex and sire removed from calf birth weight means.
[c]Calf weaning weight adjusted to 205 day age, sire, and sex of calf.
[d]Days between first and second calf birth dates.
[e]Data not reported due to affects of a BVD outbreak
* Seasons differ (P<.05).

Table 4. Breeding and calving results of spring- and summer-born heifers - 3rd year.

Trait	Spring	Summer	Diff.
Breeding			
No. of heifers	82	60	
Wt. on May 16, lb.	688	562	
Summer ADG, lb.	1.5	1.4	.1*
Begin breeding season	**May 20**	**Aug. 20**	
Prebreeding wt., lb.	688	690	2
Prebreeding condition score	5.3	4.8	.5*
Prebreeding pel. area, cm^2	174	171	3
Cycling before breeding, %	83	75	8
Pregnant in 45 days, %	85	72	13*
Calving	**Mar.-Apr.**	**Jun.-Jul.**	
No. of heifers calving	69	43	
Precalving wt., lb.	963	933	30*
Precalving pel. area, cm^2	240	246	6
Precalving condition score	5.1	5.5	.4*
Calf birth date	Mar. 11	Jun. 8	
Calf birth wt., lb	77	72	5*
Calving difficulty, %	43	16	27*
Calf losses to weaning, %	12	14	2
Weaning date	Sept. 3	Nov. 23	
Avg. age of calf, days	176	169	7
Actual calf weaning wt., lb	389	333	56*
Calf ADG, lb.	1.77	1.54	.23*
Adjusted calf weaning wt., lb.[a]	441	386	55*
Cow condition at weaning	5.4	4.9	.5*
Cow weight at weaning, lb.	938	890	48*
Pregnant for 2nd calf, %	82	62	20*
Cow productivity, lb.[b]	328	238	90*

[a]Calf weaning wt. adjusted to 205 days of age and for sex of calf.
[b]Cow productivity equals pounds of calf weaned (adjusted wt.) per heifer exposed at breeding.
*Seasons differ (P < .05)

due to a BVD outbreak which caused some early abortions.

Because no differences were found between range and meadow heifer groups on calving data, the results were pooled and reported by calving season for the two years in Table 3. The variation in results may be due in part to the method of selecting the heifers from the spring and summer cow herds. Precalving heifer weights were heavier for the spring-calving than the summer-calving heifers in Year 1, but were similar in Year 2. Calf birth weights were heavier from the summer-calving heifers in Year 2, but were similar in Year 1.

Calving difficulty percentage was consistently greater (P < .05) for the spring-calving heifers. The summer heifers calved essentially unassisted both years. However, calf losses to weaning were greater for the summer heifers than for the spring heifers.

Calf weaning weights and pregnancy rates of the summer-calving cows in Year 1 were affected by the BVD outbreak so are not reported. In Year 2, calves from the summer calving heifers were younger at weaning, so were lighter in weight. Calf ADG and adjusted calf weaning weights were similar between the spring and summer groups. However, the summer calving cows were lighter (P < .05) in weight at weaning time and lower in body condition, which may have caused the lower (P < .05) rebreeding rate (92 vs. 65%, spring and summer, respectively). These summer cows were on native range during the breeding season in September and October, so grasses were mature and lower in quality than the green grass that the spring cows grazed during their breeding season in June and July.

Results of the third-year trial comparing spring and summer heifers are shown in Table 4. No meadow treatment was involved with these heifers. Prebreeding heifer weights were 690 lb for both groups. The breeding season began for the spring heifers on May 20 and for the summer heifers on Aug. 20. The summer heifers were lower in prebreeding body condition than the spring heifers which may have caused a 13% lower (P < .05) pregnancy rate in

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the 45-day breeding season (85 vs. 72%, spring and summer, respectively). Previous results also suggested a lower pregnancy rate for the yearling summer heifers.

The calving results on these heifers also are shown in Table 4. The spring heifers were 30 lb heavier at calving in March, but lower in body condition than the summer heifers calving in June. The spring-calving heifers were fed hay and supplement before and after calving, while the summer heifers were on winter and spring native range with some hay and supplement before calving. Calf birth weights were heavier (P < .05) for the spring-calving heifers and they had greater (P < .05) calving difficulty (43 vs. 16%, spring and summer, respectively). It appears that heifers calving in the summer calve much easier than heifers calving in the spring. This difference may be partially due to the relationship of size of calf and size of pelvic area, but other factors may be involved, such as warm temperatures and green grass which reduced stress on the heifers at calving. Interestingly, calf losses to weaning were similar for the two groups, with more early losses in the spring calves and more later losses in the summer calves. Calf scours were not a problem in either group, and heat stress during the summer calving was no problem.

Calves were sired by the same Angus bulls and were of similar age at weaning. Calf ADG was higher (P < .05) for the spring calves than for the summer calves (1.77 vs. 1.54 lb). The adjusted calf weaning weights were 55 lb greater (P < .05) for the spring calves than for the summer calves. The summer calving heifers had lower quality native range during the fall before weaning in November, so milk production was probably decreased.

The summer cows were 48 lb lighter at weaning and one-half body condition score less than the spring cows. These differences were probably the reason only 62% of the summer cows rebred for the second calf, compared to 82% of the spring cows (P < .05). Extra supplementation in the fall is probably needed for the young summer cows to breed back at a high level. Spring calving cows had a 90 lb advantage in cow productivity over the summer calving cows.

Additional studies on production and economics of spring and summer heifers are being conducted. However, from these initial results, it appears that summer calving heifers may be lower in reproduction as yearlings and as 2-year-olds and produce lighter calves at weaning. This means that extra inputs of feed and management will probably be needed at critical times of the production cycle for the young summer calving heifers to be highly productive.

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Copper Levels and Sources in Pre- and Post-calving Diets of First-Calf Cows

Dennis Brink
Gene Deutscher
Erick Muehlenbein[1,2]

Calf health and cow pregnancy rates were not affected by Cu additions to diets fed pre- and post-calving to cows with liver Cu concentrations of about 50 ppm 60 days prior to calving.

Summary

A study replicated over two years involving 197 first-calf cows compared reproductive performance, growth and health of calves and concentration of Cu in liver, colostrum, and milk. Three treatments were evaluated: control (no Cu but Mo and Fe added to hay diet); 200 mg Cu from $CuSO_4$; and 100 mg Cu from AvailaCu® added daily. In 1998 a fourth treatment, 400 mg AvailaZn® was included with 100 mg AvailaCu®. Supplementation of Cu and/or Zn did not improve total pregnancy rate, or growth and health of calves. In 1998 cows fed only AvailaCu® conceived 10 days earlier compared to controls; however, in 1997 no differences in date of conception were found. Cu in colostrum and milk, and IgG levels in colostrum and calf serum were not improved by Cu supplementation.

Introduction

Research studies and practical observations have resulted in major differences in recommendations regarding Cu supplements in beef cow diets to improve reproductive performance and calf health. The objectives of this study were to determine if supplementation of Cu in the organic or inorganic form, fed to 2-year-old cows pre-and post-calving, alters reproduction rate, calf health and performance, incidence of calf scours, passive transfer of immunoglobulin or liver and serum Cu concentrations.

Procedure

The study was conducted at the West Central Research and Extension Center (WCREC), North Platte for a period of two years using a total of 197 first-calf cows. In 1997, 77 crossbred MARC II (1/4 Angus × 1/4 Hereford × 1/4 Simmental × 1/4 Gelbvieh) cows were used, and in 1998, 120 (51 MARC II, and 69 1/2 Red Angus × 1/4 Gelbvieh × 1/4 Hereford) cows were used. As bred heifers, cows grazed native range during summer and fall. In winter, grass hay (Table 1) was fed ad libitum plus salt and dicalcium phosphate free choice. In November, 1997, bred heifers grazed cornstalks for 30 days.

The following three treatments were studied each year: 1) Control (CON), 2) Inorganic, CUSO ($CuSO_4$), 3) Organic (ORG), AvailaCu® Zinpro Corp., Eden Prairie, MN. CUSO supplied 200 mg Cu while ORG supplied 100 mg Cu to investigate if less dietary Cu is needed with an organic source of Cu which is

Table 1. Nutrient composition of grass hay by year (DM).

Nutrient	1997[a]	1998[b]
Crude protein, %	10.6	8.9
TDN, %	52.2	48.8
Calcium, %	.52	.60
Phosphorus, %	.25	.23
Copper, ppm	4.8	4.0
Zinc, ppm	17.1	23.0
Iron, ppm	219.0	82.0
Molybdenum, ppm	3.5	1.1

[a]Brome grass hay was harvested from meadows near North Platte, NE.
[b]Mixed grass hay harvested from meadows near Paxton, NE

suggested to have higher bioavailability. A fourth treatment was added in 1998, 4) ORG + Zn, (AvailaCu, 100 mg, Cu, and AvailaZn, 400 mg, Zn). Supplements were fed individually to the cows for at least 45 days prior to calving and on the average 60 days after calving. The precalving CON supplement in 1997 consisted of limestone and rolled corn plus iron sulfate and sodium molybdate to provide 600 mg Fe and 5 mg Mo/day. In 1998, the supplement consisted of rolled corn and dehydrated alfalfa plus the additional Fe and Mo. The CUSO supplement consisted of the CON supplement plus copper sulfate. The ORG supplement consisted of the CON supplement plus the organic Cu source. Supplements were formulated to meet recommended requirements for all ingredients except the supplemental trace elements. Additional corn was fed to provide supplemental energy (NRC, 1996).

Liver biopsies were performed in both cows and calves to obtain samples used to determine their trace element status. In each year, liver biopsies were collected from 15 cows/treatment. Liver tissue was collected on the cows prior to the initiation of the individual feeding (approximately Jan. 1 each year) to estimate the herd mineral status. Samples were also collected from cows and calves 10 + 3 days and at 30 + 3 days post-calving. Animals were restrained in a squeeze chute and hair between the 10th and 13th ribs was clipped. Local anesthesia was given in the form of a 5 ml lidocaine injection between the 12th and 13th ribs. A scalpel was used to make a small incision at the same point, and biopsies were collected using a Tru-Cut® (Baxter Healthcare Corporation, Valencia, CA) biopsy needle (14 × 6"). About six successful biopsies were needed to obtain enough liver tissue for analysis. Biopsy samples were placed in plastic tubes and stored at -20° C until mineral analyses were conducted.

Blood samples were collected from cows and calves, via jugular veinapuncture, at the time of calving as well as in conjunction with the liver biopsies at 10 + 3 and 30 + 3 days after calving. A blood sample also was collected from the calves at 24 to 36 hours of age for determination of passive transfer of immunity. Cows were bled in early May and again 10 days later to determine cyclicity. Serum progesterone was analyzed using a validated radioimmunoassay. Cows having a concentration greater than 2 ng/ml in 1997 and 1.5 ng/ml in 1998 for one of the sampling dates were considered to be cycling. Estrual activity was verified by rectal palpation of the ovaries.

Colostrum was collected at the time of calving and analyzed for both trace mineral content and immunoglobulin G titer. Milk samples were collected from the cows in conjunction with the post-calving liver biopsies and stored at -20°C until mineral analysis. Analyses of trace mineral concentrations in liver biopsies, serum, colostrum and feeds were performed (after samples were ashed), using a sequential inductively coupled argon plasma atomic emission spectrophotometer (ICP-AES) interfaced with an ultrasonic nebulizer.

Milk production of the cows was determined using the weigh-suckle-weigh method when calves were 30 to 45 days of age. In mid May 1997, cows and calves were moved to the Gudmundsen Sandhills Laboratory (GSL) near Whitman for summer pasture and breeding. In 1998, cows and calves remained at the WCREC, North Platte.

Passive transfer of immunity was determined via single radial immunodiffusion (SRID; VMRD, Pullman, WA).

Results

Cu Status

The Cu concentrations in the liver at initiation of the project were not different between treatments (P > .10); however, a significant year effect (P < .05) was present. Liver Cu levels for 1998 were lower (58 ppm, 1997; 39 ppm, 1998).

By 30 days after calving, the Cu level for CON fell to about 14 ppm both years, a level considered deficient (Puls, 1994), while liver Cu concentrations for the supplemented treatments tended to increase throughout the trial (Figure 1). Cows fed ORG tended to increase at a slower rate compared to the cows fed CUSO. It should be noted that 100 mg Cu was fed for ORG and 200 mg Cu was fed for CUSO. Changes of liver Cu concentrations indicate the combination of low (4 ppm) Cu in hay plus the presence of Fe and Mo, considered to

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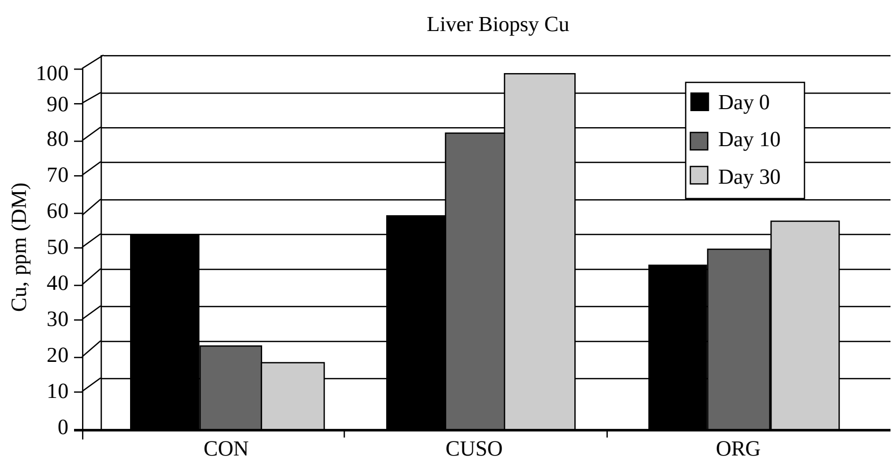

Figure 1. Liver Cu concentrations (dry matter basis) by day within treatments pooled over years [$CuSO_4$) = 200 mg Cu and ORG (AvailaCu) = 100 mg Cu]. Day 0=60 days before calving; Day 10 = 10 days post-calving and Day 30 = 30 days post-calving. All treatments are different at day 10 and 30 (P<.05).

Table 2. Liver Cu and Zn concentrations of calves pooled over years.

	10 days	SE	30 days	SE
CON				
No.	22		23	
Liver Cu, ppm (DM)	198	13.1	99[a]	9.3
Liver Zn, ppm (DM)	148	12.8	87[a]	6.8
CUSO				
No.	23		26	
Liver Cu, ppm (DM)	183	12.3	142[b]	15.9
Liver Zn, ppm (DM)	175	18.5	111[ab]	11.0
ORG				
No.	21		22	
Liver Cu, ppm (DM)	211	23.4	155[b]	13.4
Liver Zn, ppm (DM)	177	21.4	105[ab]	7.7
ORG + Zn				
No.	5		13	
Liver Cu, ppm (DM)	187	26.7	111[ab]	13.1
Liver Zn, ppm (DM)	146	24.2	128[b]	8.1

[a,b]Means with unlike superscripts within a column and mineral differ (P < .05).
CON = Control; CUSO = $CuSO_4$ providing 200 mg Cu; ORG = AvailaCu providing 100 mg Cu and ORG + Zn = AvailaCu providing 100 mg Cu and AvailaZn providing 400 mg Zn.

Table 3. Trace elements in colostrum and milk of cows in 1997[a].

	Colostrum[b]			Milk[c]		
Element/Treatment	No. of cows	Samples detected[d]	Mean + SE	No. of cows	Samples detected[d]	Mean + SE
Cu, ppm						
CON	25	15	.30 + .07	5	1	.12 + .12
CUSO	25	14	.30 + .06	8	1	.01 + .01
ORG	25	14	.22 + .06	8	3	.24 + .18
Zn, ppm						
CON	25	25	27.3 + 1.7	5	5	5.5 + .58
CUSO	25	25	29.8 + 1.5	8	8	4.8 + .53
ORG	25	25	32.0 + 1.8	8	8	4.6 + .19

[a]Only 1997 data reported as Cu levels in 1998 samples were below detectable level.
[b]Colostrum was sampled immediately after calving before calf nursed.
[c]Milk was sampled at 10 days + 3 after calving.
[d]Samples with detectable Cu levels of .12 ppm or higher. Many milk samples that had below detectable levels of Cu were recorded as zero and included in the means.
CON = Control; CUSO = $CuSO_4$ providing 200 mg Cu; ORG = AvailaCu providing 100 mg Cu.

be antagonistic to Cu absorption, resulted in depletion of Cu from the liver in late pregnancy. Results of supplementation on cow liver biopsy concentration (Figure 1) suggest storage of Cu in the liver, even in the presence of antagonists, is similar for $CuSO_4$ and organic Cu. The $CuSO_4$ was fed at twice the level of AvailaCu, and liver biopsy Cu concentrations were almost double for CuSO compared to organic Cu.

Calf liver Cu concentrations were similar 10 days after birth (Table 2). No supplemental mineral was provided to the calves, so milk and consumed forage accounted for their mineral source. All groups of calves showed a decrease (P < .10) in liver Cu concentration from day 10 to day 30 post-calving, but by day 30 post-calving, the liver Cu concentration for calves in CON had decreased to a level significantly lower (P < .05) than in other treatment groups.

Differences in liver Cu concentrations in calves at 30 days post-calving are difficult to explain when Cu concentrations in liver were not different 10 days post-calving. If 10-day values for calves in CON would have been lower, it would suggest transfer of Cu from the dam to the fetal calf was lower in the absence of supplemental Cu. Two possible explanations exist for the significant difference. First, the liver Cu status of CON occurred by chance or possibly the rate of depletion of Cu stores was greater for CON. Additional observations are necessary to determine an explanation.

Calf serum was collected at calving prior to the calf nursing. No differences (P > .10) were found between Cu treatments with all values near .30 ppm. These levels were sufficient to classify the Cu status of the neonatal calves as adequate (Puls, 1994). By 30 days after birth, the Cu levels of the calf serum had elevated (with no differences between treatments) to .69 ppm or higher, which is also considered adequate (Puls, 1994).

In 1998, Cu levels in the colostrum samples were all below the detection limit (.12 ppm). Data for 1997 colostrum and milk samples are presented (Table 3). Because no treatment differences were found, these data indicate that Cu supplementation to the cow before calving did not increase Cu levels in colostrum or early milk.

Passive Transfer of Immunity

A significant year effect (P < .05) was detected in the immunoglobulin G (IgG) response of the colostrum (Table 4). This was due to the evaluated levels of immunoglobulin detected in 1998 compared with 1997. A treatment difference (P < .05) was observed in the colostrum in 1997. Cows in the CON had lower IgG in the colostrum compared to CUSO. The IgG in the calf serum for that year was also lowest in the CON group. A year by treatment interaction (P < .05) was observed in the calf serum IgG response. This was due to the CON calf serum IgG titer for 1998 being significantly greater than that of ORG, but in 1997 the CON group was significantly lower than ORG. All levels of IgG in calf serum were in the range considered normal.

No significant differences were found (P > .10) between treatments in the incidence of sickness in calves. Sickness was defined as any time a calf was expelling loose, runny feces (scours), or appeared bloated. The greatest percentage (44%) of the calves treated for sickness was found in CON; however, this was not significantly greater than the percentage of calves treated in the other treatments (38%). Based on the year by treatment interactions and the lack of significant differences in calf health, it is difficult to conclude that supplementation of Cu to the dam will reduce the incidence of sickness in calves.

Animal Performance

No differences (P > .10) were found between treatments in cow weights at various times throughout the entire study.

Table 4. Passive transfer of immunoglobulin G (IgG) in colostrum and calf serum by year.[a]

	Year			
	1997		1998	
Item/Treatment	n	Mean + SE	n	Mean + SE
	(mg/dL)			
Colostrum				
CON	25	6118 + 354[b]	15	7487 + 239
CUSO	25	6914 + 334[c]	17	7611 + 189
ORG	25	6696 + 234[bc]	19	7236 + 305
Calf serum				
CON	25	2073 + 232[b]	16	3011 + 272[b]
CUSO	23	2433 + 149[bc]	17	2448 + 230[bc]
ORG	24	2924 + 260[c]	19	2395 + 150[c]

[a]Colostrum was sampled immediately after calving before calf nursed. Calf serum samples were collected between 24 and 36 h after birth. A year × treatment interaction was found (P<.05) in calf serum data.
[b,c]Means with different superscripts within column and category differ (P<.05).
CON = Control; CUSO = $CuSO_4$ providing 200 mg Cu; ORG = AvailaCu providing 100 mg Cu.

Table 5. Reproductive performance of 2-year-old cows supplemented with organic or inorganic Cu.

	Treatment			
Trait	CON	CUSO	ORG	ORG + Zn
1997				
No. cows exposed	22	23	24	NA
Estrus prior to May 15[a], %	5	9	13	NA
Pregnant first 30 days breeding[bd] , %	86[e]	57[f]	75[ef]	NA
Pregnant in 60 days, %	100	91	88	NA
No. nonpregnant cows	0	2	3	NA
Day of conception[cd]	170	178	174	NA
Second calving date[d]	3/31	4/7	4/2	NA
1998				
No. cows exposed	23	30	27	26
Estrus prior to May 15[a], %	9	23	30	19
Pregnant first 30 days breeding[bd], %	61[e]	80[ef]	85[f]	77[ef]
Pregnant in 60 days breeding, %	87	87	93	89
No. nonpregnant cows	3	4	2	3
Day of conception[cd]	178[e]	170[ef]	168[f]	173[ef]
Second calving date[d]	4/2[e]	3/26[ef]	3/22[f]	3/28[ef]
Two-year-data				
No. of cows	45	53	51	—
Estrus prior to May 15[a], %	7[e]	17[ef]	22[f]	—
Pregnant in 60 days breeding, %	93	89	90	—

[a]Estrus based on serum progesterone values.
[b]Determined by day of conception.
[c]Determined by breeding date, ultrasound, palpations and confirmed by calving date.
[d]Treatment × year interaction (P<.05).
[ef]Means with different superscripts within a row differ (P<.05).
CON = Control; CUSO = $CuSO_4$ providing 200 mg Cu; ORG = AvailaCu providing 100 mg Cu and ORG + Zn = AvailaCu providing 100 mg Cu and AvailaZn providing 400 mg Zn.

The same also was true for condition scores (P > .10). Cow weight changes during the mineral feeding period were also not different. Calf birth weights and May 12 weights (after supplementation period) were not different (P > .10) between treatments. Milk-production estimates of cows were not different between treatment groups. At weaning, a treatment by year interaction was detected (P < .05) for calf weights. The CON calves in 1997 were lighter (388 lb vs 416 lb) than CUSO calves, but in 1998, the reverse occurred with the CON calves being heavier than CUSO calves (393 lb vs 370 lb). The ORG calves were intermediate in weight each year.

Reproductive performance of the cows in the study is shown by year in Table 5. No significant treatment differences were observed within year for estrus cycling before the breeding season or cows pregnant in 60 days. However, when data were pooled over years, a higher percentage (P<.05) of cows in ORG cycled prior to the breeding season compared to CON cows. No differences were found (P>.10) in cows pregnant in 60 days when pooled over both years.

Year by treatment interactions existed (P<.05) for cows pregnant in first 30 days of breeding, day of conception and consequently, second calving date. In 1997 no significant differences occurred in day of conception. However, in 1998 cows in the group supplemented with AvailaCu® conceived earlier (10 days) than cows in the control group.

The year by treatment interactions may be due to differences in the Cu status of the herd at the initiation of the treatment period. In 1998 liver Cu concentrations were lower (39 ppm) than in 1997 (58 ppm). Therefore, in 1998 Cu status of the cows may have reached a point where additional Cu was beneficial relative to early conception. Also, cows in 1997 were taken to GSL for summer pasture and breeding, while in 1998 cows were left at North Platte. Therefore, another explanation for the interaction may be related to mineral content of forage consumed at different locations during the breeding season. Cu content of the grazed forage was not measured.

Results of the ORG + Zn treatment in 1998 did not differ from the other treatments for cow reproduction or calf health and growth. In general, results were similar to the CUSO treatment.

In conclusion, responses in calf performance and cow reproductive performance to additional Cu depend on Cu status of the cows. A hay-based diet containing 4 to 5 ppm Cu and Cu antagonists will cause liver Cu stores to deplete. If liver Cu is about 50 ppm 60 days prior to calving, cows in average body condition provided recommended protein and energy nutrition will not respond with improved calf health or number pregnant in 60-day breeding season when provided additional Cu, regardless of source (inorganic or organic). Further studies are needed to clarify relationships of Cu status, Cu source and Cu content of forage in breeding pastures on day of conception.

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Effects of Length of Grain Feeding and Backgrounding Programs on Beef Carcass Characteristics

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When carcass data are compared at equal fat endpoints, it appears that backgrounding system has little effect on marbling (quality grade).

Summary

Data from 534 cattle serially slaughtered indicate percentages of carcasses grading Choice increased 30 + 2.4 percentage units for each .1 in increase in rib fat. Marbling score increased 75 units (200 = Slight^{00}) for each .1 in increase in fat. If cattle are fed to a common rib fat endpoint, and within the ranges of winter (.51-1.35 lb/day) and summer gains (1.26-1.85 lb/day) studied, we conclude backgrounding program has little or no effect on marbling or carcass quality grade. Also, systems that increase age of cattle will reduce tenderness, but if meat is cooked properly, risk of tough steaks is small.

Introduction

Calves and yearlings enter feedlots at varying weights, ages and nutritional backgrounds. This variation could produce differences in carcass quality. Two basic measures of carcass quality can be made at the present time in commercial beef production. The first is yield grade or degree of fattening and the second is quality grade which is primarily dependent upon degree of marbling. Because both are measures of lipid content, they are related — the greater the amount of fat (higher yield grade) the greater the amount of marbling (higher quality grade). As cattle are fed (high grain diets) for longer periods, they become fatter and quality grade (marbling) increases. Therefore, an analysis of relationships of length of feeding period, fat thickness, quality grade and marbling as influenced by backgrounding program is important.

Results

Several experiments have been conducted which will allow for endpoint comparisons with some adjustments of data in order to compare animals at equal rib fat. Effects of time-on-feed are well illustrated in a study using Angus bulls with low and high EPD for marbling (1994 Nebraska Beef Cattle Report, pp. 54-56). The cattle fattened with time on feed (.0025 in/day increase in rib fat for the steers and .003 in/day for the heifers). Marbling increased by 1.48 units per day (200 = Slight^{oo}; 300 = Small^{oo}). Clearly as cattle are fed for more days, they increase in 12th rib fat (and yield grade) and in marbling. The second slaughter date for the high marbling steers and heifers was at the average fat thickness for commercial cattle (about .55 in). At that one slaughter time, the correlation between fat thickness and marbling score was .48. When both slaughter dates were analyzed as a continuum of time on feed, the correlation was .64 for the relationship of fat thickness to marbling score for the high marbling cattle.

Both steers and heifers sired by high marbling bulls had significantly higher marbling scores than calves sired by low marbling bulls. Interestingly, the relationship of fat thickness to marbling score was stronger for the high marbling cattle than the low marbling cattle (r = .64 vs .48). Further, the slope of the relationship was greater for the high marbling cattle than that for the low marbling cattle.

The percentage of calves grading Choice or higher increased with fattening similar to the change in marbling score. However, the rate of change was less with the high EPD calves because they were approaching 100% Choice.

To study adjustments of quality grade and marbling score for cattle of unequal fat depths to a common endpoint, we analyzed data from several serial slaughter experiments. There were 534 head, including calf-feds and yearlings, covering the range of cattle production systems. Fat depth at the first slaughter averaged .33 in and .50 in at the second slaughter. Cattle grading Choice increased 30 + 2.4 percentage units for each .1 in increase in fat depth. Marbling scores were available on some of the cattle. Marbling score increased 75 units (200 = Slight^{oo}) for each .1 in increase in fat depth. For cattle in different pens or treatment groups, it seems logical to adjust percentage Choice or marbling score using these values.

We can illustrate the adjustment with a comparison of yearlings to calf-feds (1991 Nebraska Beef Cattle Report, pp. 42-43). Calves were allotted randomly at weaning to calf-fed or yearling systems. The calf-feds were placed on high grain diets within 60 days of weaning. The yearlings were backgrounded on cornstalks in the winter and grazed grass in the summer. The yearlings were finished on high grain diets similar to those fed to the calf-feds. The yearlings con-

Table 1. Finishing performance and carcass characteristics for calves vs yearlings.[a]

Item	Calf-Fed	Yearling
DMI, lb/day	17.4	24.9
% of weight	2.1	2.5
ADG, lb	2.78	3.40
Feed/Gain	6.19	7.33
Fat thickness, in	.48	.38
Choice, %	76.0	64.9 (95.3)[b]

[a]1991 Nebraska Beef Cattle Report, pp. 42-43; 5 years, 489 head, 48 pens.
[b]Adjusted to .48 in fat thickness.

sumed more feed and gained more rapidly in the feedlot than the calves (Table 1). The calves were more efficient than the yearlings. Contrary to the common perception that calf-feds are leaner than yearlings, the yearlings had less fat and a lower percentage of carcasses grading Choice. It all depends on how long the cattle are fed. In this case the yearlings were not fed to a similar degree of fatness as the calves. We used the adjustments mentioned above and when the yearlings were adjusted to a fat thickness equal to the calves, the percentage of carcasses grading Choice was greater (95.3 vs 76%). These data suggest that calf-feds and yearlings have similar carcass quality when slaughtered at an equal fat endpoint and demonstrates how important it is to compare cattle at equal fat endpoints. We are reluctant to conclude yearlings grade better than calf-feds because the amount of adjustment was large.

Effect of Winter Gain on Carcass Quality

Several experiments have been conducted to study the effect of winter gains on subsequent compensatory gain on pasture and feedlot performance. This research allows us to evaluate the effect of rate of winter gain on subsequent carcass quality. In previous research at the University of Nebraska (1989 Nebraska Beef Cattle Report, pp. 34-35) calves were wintered over two years at .62 or 1.10 lb/day gain. The cattle grazed cool- and warm-season grasses, and were then finished in the feedlot for 112 days. Fat thickness ranged from .43 to .49 in (SE = .03 in) and quality grades were similar (Table 2). However, when adjusted to equal rib fat, calves wintered at a faster rate of gain had a somewhat higher quality grade compared to cattle wintered at a slower rate of gain.

In another trial, calves were wintered at .42 or 1.59 lb/day. Corn gluten feed was fed to calves on cornstalks to achieve the added gain. The cattle grazed smooth bromegrass or native range pastures and were finished for 71 to 124 days in the feedlot. Feedlot diets contained 35% corn gluten feed to minimize acidosis. Compensating yearlings are aggressive eaters and acidosis may limit their ability to make the compensatory gain. The cattle finished with nearly similar fat — the slow gaining winter cattle had .02 in less fat (Table 2). Quality grades were slightly less for the slow cattle as were the percentages of carcasses grading Choice. There was no difference in quality grade after adjusting to equal fatness (1998 Nebraska Beef Cattle Report, pp.63-65; 1999 Nebraska Beef Cattle Report, pp. 26-28).

In two additional trials, calves were wintered at .46 and 1.37 lb/day. Corn gluten feed was supplemented to the calves while grazing cornstalks to produce the difference. The cattle grazed native range and cool-season grass until entering the feedlot. They were fed for 92 to 96 days on a 35% corn gluten feed diet. Feedlot gains were similar, and the lower winter gaining cattle were slightly less fat than the higher winter gaining cattle with correspondingly lower marbling scores. However, when adjusted to equal fat thickness, the cattle had similar marbling scores and percentages grading Choice (Table 2; 2000 Nebraska Beef Cattle Report, pp. 30-32; 2000 Nebraska Beef Cattle Report, pp. 23-25).

The three previous studies used a total of 356 cattle over five years. Winter gains ranged from .42 to 1.59 lb/day over the four studies. There were no differences in quality grades due to rate of winter gains when cattle were adjusted to equal fat thickness at slaughter. We conclude winter gain does not influence carcass quality.

Table 2. Effect of winter rate of gain on finishing performance and carcass characteristics.

Item	Experiment					
	1989 Beef Report[a]		1998 Beef Report[b]		2000 Beef Report[c]	
No. of steers	40	40	72	72	48	48
Winter ADG, lb	.62	1.10	.42	1.59	.46	1.37
Summer ADG, lb	1.41	1.04	1.61	1.15	1.41	1.23
Finishing						
ADG, lb	3.62	3.84	4.28	4.63	4.72	4.76
DMI, lb/day	26.4	27.2	28.3	30.5	30.8	31.5
Feed/Gain	7.30	7.09	6.62	6.58	6.54	6.62
Carcass data						
Fat thickness, in	.49	.43 (.49)[d]	.49 (.51)[e]	.51	.40 (.46)[f]	.46
Quality grade	7.24[g]	7.24 (7.69)[dg]	19.1 (19.3)[eh]	19.4[h]	—	—
Marbling score	—	—	—	—	490 (534)[fi]	532[i]
Choice, %	—	—	84.6 (91.8)[e]	87.0	50.3(68.3)[f]	66.9

[a]1989 Nebraska Beef Cattle Report, pp. 34-35; 80 hd.
[b]1998 Nebraska Beef Cattle Report, pp. 63-65; 1999 Nebraska Beef Cattle Report, pp. 26-28.
[c]2000 Nebraska Beef Cattle Report, pp. 30-32; 2000 Nebraska Beef Cattle Report, pp. 23-25.
[d]Adjusted to .49 in fat thickness.
[e]Adjusted to .51 in fat thickness.
[f]Adjusted to .46 in fat thickness.
[g]Low Choice = 7.17, average Choice = 7.5.
[h]Low Choice = 19.
[i]Select = 400-499, low Choice = 500-599.

Effect of Summer Gain on Carcass Quality

Three studies were summarized to study the effect of summer gain on carcass quality. In the first study, summer gains were influenced by the quality of forage available (1998 Nebraska Beef Cattle Report, pp. 66-69). The cattle gained .68 lb/day over the winter on corn stalks. Summer gains were 1.59 and 1.81 lb/day, respectively, for cattle grazing bromegrass and bromegrass rotated to warm-season grass (Table 3). Feedlot gains were similar but the higher summer grass gains slightly reduced intakes and increased feed efficiency. Both fat depths and quality grades were similar.

In another trial, yearlings grazed on native Sandhills range and smooth

(Continued on next page)

Table 3. Effect of summer rate of gain on carcass quality.

	Experiment					
	1989 Beef Report[a]		1998 Beef Report[b]		2000 Beef Report[c]	
Item	Brome	Brome/WS	Slow	Fast	Slow[c]	Fast[d]
No. of steers	100	100	40	40	90	48
Winter gain, lb	.68	.68	1.18	1.18	.93	.93
Summer gain, lb	1.59	1.81	.62	1.79	1.12	1.98
Finishing						
ADG, lb	3.60	3.60	4.76	4.37	4.74	4.74
DMI, lb/day	26.7	25.8	30.3	30.1	31.4	31.4
Feed/Gain	7.46	7.25	6.37	6.90	6.62	6.62
Carcass data						
Fat thickness, in	.42	.42	.50	.48 (.50)[e]	.43 (.48)[f]	.48
Quality grade[g]	18.7	18.7	19.5	19.1 (19.3)	—	—
Marbling score[h]	—	—	—	—	529 (567)	517.0
Choice, %	—	—	90.0	74.0 (82.4)[e]	70.0 (85.2)[f]	68.0

[a]1998 Nebraska Beef Cattle Report, pp. 66-69.
[b]1998 Nebraska Beef Cattle Report, pp. 63-65.
[c]2000 Nebraska Beef Cattle Report, pp. 23-25.
[d]2000 Nebraska Beef Cattle Report, pp. 30-32.
[e]Adjusted to .50 in fat thickness.
[f]Adjusted to .48 in fat thickness.
[g]Select = 18, low Choice = 19, average Choice = 20.
[h]Low Choice = 500 - 599.

bromegrass following wintering on cornstalks (1.19 lb/day). Summer gains on the bromegrass were quite poor because of precipitation distribution during the summer. The low summer gains on bromegrass apparently produced some compensatory gain in the feedlot including improved feed efficiency. The slow (bromegrass) summer gaining cattle were slightly fatter at slaughter with slightly higher quality grades (Table 3). When adjusted to equal fat depths, quality differences essentially disappeared (1998 Nebraska Beef Cattle Report, pp. 63-65).

Two other trials had yearlings on two different summer native range pastures following wintering on cornstalks at .93 lb/day. One summer range had about one half the forage supplied as wet meadows containing cool-season species. With abundant rainfall, forage production was high and cattle gains were low (1.12 lb/day), probably due to overly mature forage. Rates of gain in the feedlot were similar as were feed efficiencies. The faster summer gaining cattle were slightly fatter at slaughter while marbling scores and quality grades were similar (Table 3). Adjusted to equal fat depths, the cattle gaining slower during the summer had somewhat higher quality grades. They were fed 23 days longer in the feedlot (2000 Nebraska Beef Cattle Report, pp. 30-32; 2000 Nebraska Beef Cattle Report, pp. 23-25).

The three reports reviewed provide a summary of 418 cattle over a seven-year period. When summer pasture gains varied by only .22 lb/day, there was no effect on carcass quality. In the two latter studies, the summer gain differed by 1.01 lb/day. The slower summer gaining cattle were fed for an average of 25 days longer than the cattle gaining faster in the summer. When adjusted to an equal fat depth, the slower summer gaining cattle had higher marbling scores and higher percentages grading Choice (16.2 percentage units). Because of the increased cost of gain with low pasture gains, it probably would not be feasible to attempt to enhance economics through increasing quality by having low summer pasture gains.

Carcass Palatability and Tenderness

Another major concern facing the beef industry is the issue of tenderness and variation in tenderness. We have conducted one study to investigate the influence of calf-feds vs yearlings on carcass palatability and tenderness (1995 Nebraska Beef Cattle Report, pp. 53-56). When the data were adjusted to equal marbling scores, no differences were observed for flavor or juiciness of steaks from cattle at 14, 19, or 21 mo of age. Results also showed that the risk of cattle of different ages being tough or undesirable was less than .05% for 14-mo old cattle, less than .52% for 19-mo old cattle, and less than 2.8% for 21-mo old cattle. While yearlings were statistically less tender than calves, the risk of producing tough or undesirable carcasses was very small.

Clearly, age reduces tenderness, but that doesn't mean yearlings are tough. The ribs in this study were aged 14 days and the steaks were not overcooked. In fact, a subsequent study with these steaks showed that the tenderness differences disappeared when steaks were cooked to 167°F rather than 149°F. While some would argue that calf-feds assure tenderness, subsequent aging and cooking can mitigate the differences. We conclude that backgrounding system has little if any effect on tenderness and has little risk of producing "tough" steaks if they are handled appropriately.

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Compensatory Growth Response and Breakeven Economics of Yearling Steers on Grass

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Todd Milton
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Increased winter gains resulted in heavier final weights and reduced slaughter breakevens compared to animals wintered on a minimal input system.

Summary

A trial was conducted to evaluate compensatory growth in yearling cattle while on summer pasture, following variations of winter feed restriction. Winter gains were FAST, FAST/SLOW, SLOW/FAST, and SLOW. No summer gain differences were found among restricted cattle (FAST/SLOW, SLOW/FAST, or SLOW); however, gains were increased on grass compared to steers on the FAST treatment. SLOW cattle compensated 17.4% during grazing. FAST steers had lower slaughter breakevens compared to SLOW (64.05 vs 66.94 $/cwt, respectively). Due to little compensation by steers on the SLOW treatment, steers on the FAST treatment had heavier slaughter weights resulting in lower slaughter breakevens.

Introduction

Backgrounding programs, by design, restrict cattle to varying degrees. The programs are typically minimal-input systems which are based on available feed resources, desired gain, and possibly even preferred marketing times. Because not all producers have the same resources available to them, it is important to examine the potential for compensatory growth which animals have following restrictions which vary in severity, duration and types of feedstuffs used. Previous research conducted at the University of Nebraska has resulted in variable results regarding compensatory growth of animals on grass (1999 Nebraska Beef Cattle Report, pp. 26-28). Reasons why animals compensate differently from year to year have been elusive; however, it would appear that severity and duration of restriction play some role. Upon the realimentation, or refeeding period, animals are placed either into the feedlot for finishing or on grass. Typically, summer grazing produces excellent gains (1.5-2.0 lb/day) and should result in ample opportunity for compensatory growth. In addition, maximizing grazed forage gain while cost of gain is low reduces overall breakeven costs of forage based systems (1997 Nebraska Beef Cattle Report, pp. 56-59). If animals that gain slower over the winter as a result of lower inputs can compensate during summer grazing, slaughter breakevens should be favorable.

The objective of our research was to evaluate duration of winter restriction on subsequent compensatory growth and slaughter breakevens of yearling steers on grass.

Procedure

Wintering Period

One hundred and eighty medium-framed crossbred steers (initial weight = 535 lb) were purchased in the fall and allowed a 28-day acclimation period. All steers were wintered on cornstalks from Dec. 4, 1997 through Feb. 19, 1998 (phase I), and placed in drylots from Feb. 20, 1998 through April 28, 1998 (phase II). Cattle were assigned randomly to one of five treatments which were used to establish winter gains for the evaluation of subsequent compensatory growth in the summer. Treatments were: 1) Steers supplemented with wet corn gluten feed (FAST) for the entire winter to produce higher gains, 2) Steers supplemented with corn (CORN) for the entire winter to produce higher gains, 3) Steers supplemented with wet corn gluten feed to produce faster gains during phase I of the winter period followed by minimal supplementation to produce low gains in phase II (FAST/SLOW), 4) Steers minimally supplemented to have low gains during phase I of the winter period followed by supplementation with wet corn gluten feed in phase II to produce faster gains (SLOW/FAST), and 5) Steers minimally supplemented to produce low gains for the entire wintering period (SLOW; Figure 1). Cattle were essentially managed in three groups during phase I of the wintering period. Group 1 (FAST) consisted of steers supplemented with 5 lb/hd/day (DM basis) of wet corn gluten feed (WCGF) while on cornstalks; group 2 (CORN) consisted of steers which originally were supposed to receive 4 lb/hd/day (DM basis) of corn and 1.4 lb/hd/day (DM basis) of a sunflower meal based supplement while on cornstalks. However, on Oct. 23, 1997 (prior to the majority of the corn harvest), an early and severe snowstorm hit Eastern Nebraska which resulted in an unusually large amount of residual corn remaining in cornstalk fields.

(Continued on next page)

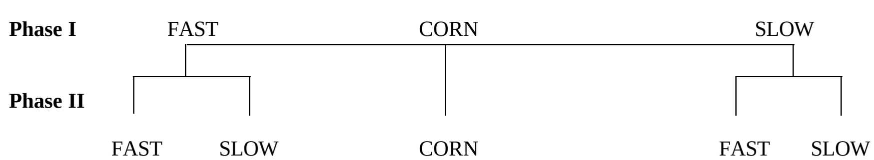

Figure 1. Treatment structure.

Because of excessive residual corn, a decision was made to estimate the amount of residual corn in all fields, and attempt to manage the stalks in a manner that would allow the steers to consume an appropriate amount of corn in the form of residual corn rather than corn supplemented in a bunk. In order to manage this, group 2 (CORN) was allowed to graze all of the stalk fields before groups 1 (FAST) and 3 (SLOW) so they would consume the majority of the residual corn. After group 2 had been in a particular field, either group 1 or 3 would follow. Group 3 (SLOW) consisted of steers which grazed cornstalks and received 1.4 lb/hd/day (DM basis) of the same protein supplement as described previously. In phase II of the winter period, half of the steers on the FAST treatment were switched to the SLOW treatment, and half of the steers on the SLOW treatment were switched to the FAST treatment. In this way, the FAST/SLOW and the SLOW/FAST treatments were developed (Figure 1). During phase II of the winter, steers again were managed in three groups. Group 1 (FAST) received ad-libitum ammoniated wheat straw, 5 lb/hd/day (DM basis) wet corn gluten feed, and 0.14 lb/hd/day (DM basis) of a mineral supplement. Group 2 (CORN) received ad-libitum ammoniated wheat straw, 4 lb/hd/day (DM basis) rolled corn, 0.47 lb/hd/day (DM basis) of the previously described protein supplement, and 0.2 lb/hd/day (DM basis) of a mineral supplement. Group 3 (SLOW) received ad-libitum ammoniated wheat straw and 0.2 lb/hd/day of a mineral supplement.

Summer Period

On April 29, 1998 steers were weighed, fly tagged, and implanted with Synovex®-S. Steers then were placed on bromegrass near Mead, NE for 45 days (April 29, 1998 through June 12, 1998). On June 13, 1998, steers were weighed and shipped to native warm-season pastures near Rose, NE, where they remained until Sept. 2, 1998 (82 d). On Sept. 3, 1998 steers were returned to Mead, NE where they grazed bromegrass regrowth until Sept. 28, 1998 (26 d). Steers were managed as one group throughout the summer, and an attempt was made to manage the forages to achieve maximum gains. Steers were rotated on bromegrass pastures both in the late spring and early fall so that forage never became limiting. Steers were rotated to a new pasture when it appeared forage quantity might begin to limit animal performance. On the warm-season pastures, steers were rotated between two 320-acre pastures (total = 640 acres) in the same manner.

Finishing Period

Upon removal from pastures, all steers were implanted with Revalor®-S and placed into the feedlot for finishing (18 head/pen). Steers were adapted to the final finishing diet in 21 days using four step-up diets containing 45, 35, 25, and 15% roughage fed for 3, 4, 7, and 7 days, respectively. The final diet (7.0% roughage) was formulated to contain a minimum of 12% CP, .7% Ca, .35% P, .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, 7.0% alfalfa, and 5% supplement (DM basis). Final weights were calculated using hot carcass weight and a common dressing percentage (62). Hot carcass weights were obtained at slaughter, and fat thickness over the 12th rib, quality grades, and yield grades were gathered following a 24-hr chill.

Initial and final weights in the winter, summer and finishing periods were the average of two consecutive day weights following 3 days of limit-feeding of a common diet containing 50% WCGF and 50% alfalfa hay fed at 2% of body weight.

The data set was analyzed as a completely randomized design using the GLM procedures of SAS with feedlot pen as the experimental unit.

Results

Winter Period

Winter performance data are presented in Table 1. Cattle remained on cornstalks for a total of 78 d. Steers then were moved into the drylot where they received ammoniated wheat straw and their respective treatment supplements for a total of 68 d. At the conclusion of the winter period, gains by treatment were 1.38, 1.34, 0.85, 0.86, and 0.47 lb/

Table 1. Steer performance and carcass data.

Item[a]	FAST	CORN	FAST/SLOW	SLOW/FAST	SLOW
Winter					
Days	146	146	146	146	146
Initial weight, lb	541[b]	534[c]	542[b]	530[d]	530[d]
ADG, lb	1.38[b]	1.34[b]	0.85[c]	0.86[c]	0.47[d]
Final weight, lb	742[b]	728[c]	665[d]	655[e]	598[f]
Summer					
Days	153	153	153	153	153
ADG, lb	1.03[b]	0.95[b]	1.17[c]	1.23[c]	1.19[c]
Final weight, lb	899[b]	874[c]	845[d]	843[d]	780[e]
Finishing					
Days	97	97	97	97	97
ADG, lb	4.67	4.80	4.70	4.84	4.78
DMI, lb/day	31.2[bc]	31.8[b]	31.6[bc]	31.6[bc]	30.8[c]
Feed/gain[g]	6.67	6.62	6.71	6.49	6.45
Final weight, lb[h]	1353[i]	1339[ij]	1304[j]	1313[ij]	1251[k]
Carcass Data					
Carcass weight, lb	852[i]	844[ij]	821[j]	828[ij]	788[k]
Yield grade	2.6[ij]	2.7[j]	2.5[ik]	2.3[k]	2.3[k]
Fat thickness, in	.45[i]	.42[i]	.43[i]	.38[j]	.38[j]
Marbling score[l]	535[m]	514[mn]	513[mn]	504[n]	498[n]

[a]FAST = fast winter gain; CORN = corn; FAST/SLOW = fast gain then slow winter gain; SLOW/FAST = slow gain then fast winter gain; SLOW = slow winter gain.
[bcdef]Means within row with unlike superscripts differ ($P < 0.10$).
[g]Feed/gain was analyzed as gain/feed. Gain/feed is the reciprocal of feed/gain.
[h]Calculated from hot carcass weight adjusted to a common dressing percentage (62).
[ijk]Means within a row with unlike superscripts differ ($P < 0.10$).
[l]Marbling Score: 400-499 = Select, 500-599 = low Choice.
[mn]Means within row with unlike superscripts differ ($P < .05$).

day for the FAST, CORN, FAST/SLOW, SLOW/FAST, and SLOW treatments, respectively. While all gains were slightly lower than projected (1.5 lb/day for fast treatments, 1.0 lb/day for intermediate, and 0.5 lb/day for slow), the critical differences between the treatments were established for examination of the compensatory growth response.

Summer Period

Summer performance of steers is presented in Table 1. While grazing summer forage, the three restricted treatments (FAST/SLOW, SLOW/FAST, and SLOW) all gained faster ($P < .05$) than the FAST and CORN treatments. Gains over the summer period were 1.03, 0.95, 1.17, 1.23, and 1.19 lb/day for the FAST, CORN, FAST/SLOW, SLOW/FAST, and SLOW treatments, respectively. No differences ($P > .10$) were noted in the gains of the two faster gaining treatments (FAST and CORN).

A longer period of restriction for the SLOW cattle (compared to intermediate gaining treatments) resulted in a smaller percentage of compensation in relation to the fast-gaining treatments. However, in terms of total pounds, cattle on the SLOW treatment made up the same amount of weight as the intermediate treatments, but they started with a greater deficit, resulting in a poorer percentage of compensation. One possible reason for the similar gains may have been the overall performance of the animals over the summer period. Summer gains were actually lower than winter gains of the FAST and CORN treatments. Obviously either quality or quantity of summer forage was limiting steer gains across all treatments. Based on the management scheme applied to these animals, gains approaching 2.0 lb/day are realistic. Steers were placed on smooth bromegrass early in the season while it was in the vegetative stage and quantity was not limiting. Steers then were moved to native warm-season range at a time when bromegrass typically experiences a summer slump in growth. Near the end of the summer period, steers then were moved back to bromegrass to use some of the regrowth. Steer weights (full weights; not reported) were collected prior to each forage change during the summer. Based on those full weights, it would appear that gains were typical of what might be expected on smooth bromegrass (2.0-2.5 lb/day) in the spring and late summer/early fall; however, gains on the native warm-season range through mid-summer were disappointing and resulted in lower than expected overall steer gains. When comparing SLOW vs. FAST, steers compensated 17.4% over the summer period. Intermediate gaining treatments (FAST/SLOW and SLOW/FAST) compensated 28.9 and 35.6%, respectively, when compared to FAST. Previous research conducted at the University of Nebraska has indicated that compensation results can range from 18-100%. Our results obviously agree with the lower end of that range. Despite poor summer performance of animals in this particular trial, it is not believed that the performance affected the compensation results. Another trial conducted in the same year involving cattle wintered similarly, but placed in another location during the summer found similar compensation results when steers gained nearly 2.0 lb/day on grass (2000 Nebraska Beef Cattle Report, pp. 20-22).

Finishing Period

Finishing data are presented in Table 1. Differences were noted in the feedlot only in DM intake when comparing cattle on the SLOW treatment to cattle on the CORN treatment ($P = 0.074$). However, an explanation for this difference is not readily apparent. Despite the difference in DM intake, no difference was noted in feed efficiency. The only other difference noted in the feedlot phase of the trial was in final weights. Final weight differences are to be expected based on the summer gains and lack of compensation by slower gaining animals.

Steers on the FAST treatment had a lower ($P = 0.056$) breakeven compared to steers on the SLOW treatment (Table 2). Additionally, the breakeven of steers

(Continued on next page)

Table 2. Economics and slaughter breakevens.

Item[a]	FAST	CORN	FAST/SLOW	SLOW/FAST	SLOW
Steer cost, $[b]	503.43	496.79	505.23	493.69	494.15
Interest[c]	46.03	45.39	46.23	45.09	45.15
Health[d]	25.00	25.00	25.00	25.00	25.00
Winter costs, $					
Feed[e]	60.07	72.51	50.26	51.37	41.56
Yardage[f]	18.00	18.00	14.60	18.00	14.60
Summer costs, $					
Grazing[g]	76.50	76.50	76.50	76.50	76.50
Finishing costs, $					
Yardage[h]	28.95	28.95	28.95	28.95	28.95
Feed[ij]	165.67	168.76	168.09	167.39	163.65
Total costs, $[k]	865.47	874.38	856.41	848.48	831.84
Final weight, lb[l]	1353	1339	1304	1313	1251
Breakeven, $/100 lb[m]	64.05[n]	65.38[no]	65.89[no]	64.63[no]	66.94[o]

[a]FAST = fast winter gain; CORN = corn; FAST/SLOW = fast gain then slow winter gain; SLOW/FAST = slow gain then fast winter gain; SLOW = slow winter gain.
[b]Initial weight × $80/100 lb.
[c]Interest rate = 9%.
[d]Health costs = implants, fly tags, antibiotics, etc.
[e]Winter feed includes stalks at $0.12/day, stalk mineral supplement at $0.0065/day, gluten feed at $0.225/day (5 lb/day; DM basis), corn at $0.20/day (4 lb/day; DM basis),ammoniated wheat straw at $0.02/lb, drylot mineral supplement at $0.00905/day for WCGF and $0.03026 for CORN and SLOW, and protein supplement at $0.12/day, where appropriate.
[f]Winter yardage includes $0.10/day while on stalks, $0.10/day for SLOW while in drylot, and $0.15/day for WCGF and CORN while in drylot.
[g]Summer grazing cost at $.50/day.
[h]Feedlot yardage cost at $.30/day.
[i]Average diet cost = $.0543/day (DM basis) and 9% interest for half of feed.
[j]Calculated using 15 yr average corn price at $2.41/bu.
[k]Total cost includes 2% death loss for each system.
[l]Calculated from hot carcass weight adjusted to a common dressing percentage (62).
[m]Slaughter breakeven price.
[no]Means within row with unlike superscripts differ ($P < .10$).

on the SLOW/FAST treatment tended to be lower compared to steers on the SLOW treatment (Table 2). The higher breakevens for steers on the SLOW treatment stem from poor compensation. Therefore, the faster gaining animals had more sale weight at the conclusion of the finishing period. However, animals on the SLOW treatment were leaner (P > .05) compared to steers on the FAST treatment. Had the two treatment groups been fed to a more common fat endpoint (which would likely have resulted in the sale of more weight), slaughter breakevens might have been more similar between the treatments. The correlation coefficient for final weight and slaughter breakeven was r = -0.886 (P = 0.0012). Despite steers on the CORN treatment having a higher final weight compared to the SLOW treatment, slaughter breakevens were only numerically different (Table 2). Supplementing corn rather than wet corn gluten feed resulted in higher input costs because the wet corn gluten feed brought energy, protein and P into the diet, which are all expensive to supplement. Steers on the CORN treatment required a protein supplement in addition to the corn, which also added to wintering costs. No other differences (P > 0.15) were noted among treatments.

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Evaluation of the 1996 Beef Cattle NRC Model Predictions of Intake and Gain for Calves Fed Low or Medium Energy Density Diets

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Dennis Brink[1]

The NRC model did not accurately predict intake and gain of growing calves over a wide range of diets, and predicted gain differed greatly from actual when low quality roughages were fed.

Summary

Data from feeding 54 diets in seven previous beef cattle growing studies were used to evaluate the 1996 NRC model for the accuracy of intake and gain predictions. Calf weights and diets were inputs into the model, and actual intakes were used to calculate predicted gain and actual gains were used to calculate predicted intakes. The model over-predicted calf intakes on low quality diets and under-predicted intakes on high quality diets. The model over-predicted gains on high quality diets and under-predicted gains on low quality diets. The NRC model did not accurately predict performance of cattle on low quality roughage diets.

Introduction

The 1996 Nutrient Requirements of Beef Cattle (NRC) comes with a software package that models the dynamic interactions between cattle type (physiological state), cattle age, diet quality, environment and other management factors on cattle intake, gain and nutrient requirements/balances. The NRC model has been shown to predict intake of finishing cattle relatively close to actual values on average, while tending to under-predict intake over the course of the finishing period in some studies (1998 Nebraska Beef Cattle Report, pp. 80-83). Likewise, the model tends to accurately predict gain of finishing cattle at the mid-point of the finishing period, while over-predicting gains early and under-predicting gains late in the finishing period. This may be attributed to the prediction equations being developed using average weights and gains over the course of the finishing period. However, with accurate estimates of cattle intake and gain, the model appears to accurately predict the metabolizable and rumen degradable protein balances of cattle on a finishing diet.

Unlike typical finishing programs, growing cattle diets use a wide range of feedstuffs with varying energy and protein contents. In addition, different growing programs target different levels of gain. The NRC model provides a potential means for producers and nutritionists to predict intake and gain of growing calves fed varying diets. Therefore, our objectives were to use previous growing trial data from the University of Nebraska to evaluate the accuracy of the NRC model equations in predicting intake and gain of growing calves.

Procedure

Seven growing trial studies previously conducted at the University of Nebraska, incorporating 54 different diets, were used to evaluate NRC predictions. Diets included low quality forage diets, medium quality (silage based) forage diets and diets incorporating various levels of energy from non-forage fiber products or concentrates. For more information regarding the details related to specific diets and/or experiments, refer to previous Nebraska Beef Reports

(1983, pp. 21-22; 1988, pp. 34-38; 1988, pp. 40-42; 1988, pp. 51-56; 1990, pp. 49-50; 1991, pp. 25-27; 1993, pp. 34-35).

Actual cattle weights and diets were used as inputs into the model. No adjustments were made for environment on either intake or gain, as the temperature was set at 60°F, the temperature considered to be thermoneutral by the NRC. Actual calf intakes were used to calculate a predicted ADG, and gain then was forced to the actual gain by using the NEm and NEg adjusters in the NRC software to get the predicted intake. The NEm and NEg adjusters can be changed from 80% (when gain is over-predicted) to 120% (when gain is under-predicted) to force the predicted gain to the actual gain (100% is no change). Both NEm and NEg adjustments were made by the same magnitude in the same direction, and will be subsequently referred to as the NE adjusters. If predicted gain could not be reached by the NE adjusters (NE adjusters >120% or < 80%), the predicted intake was recorded with gain as close as possible to the actual gain. Predicted intake at the actual gain was recorded for both 11-month-old and 14-month-old calves. Linear regression analyses were performed on predicted versus actual values to determine the statistical significance of the relationships.

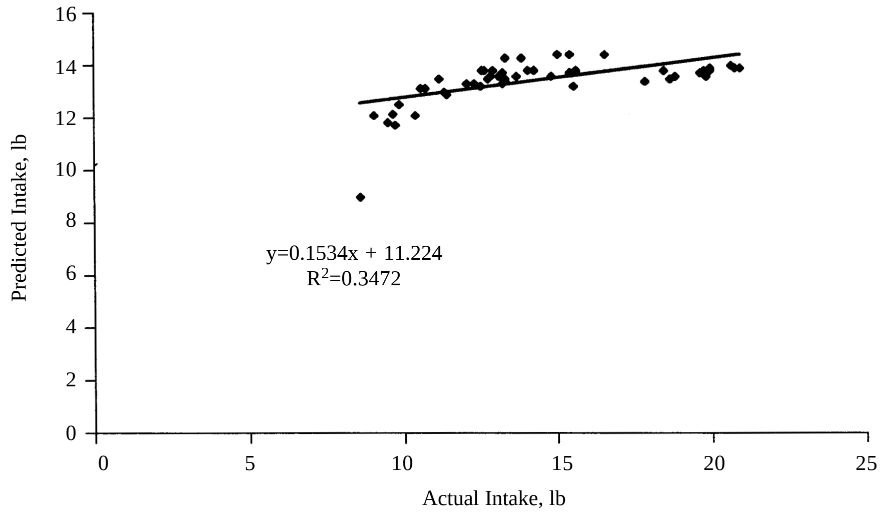

Figure 1. Actual intake versus intake predicted by the 1996 NRC model for 54 growing cattle diets in seven studies (DM).

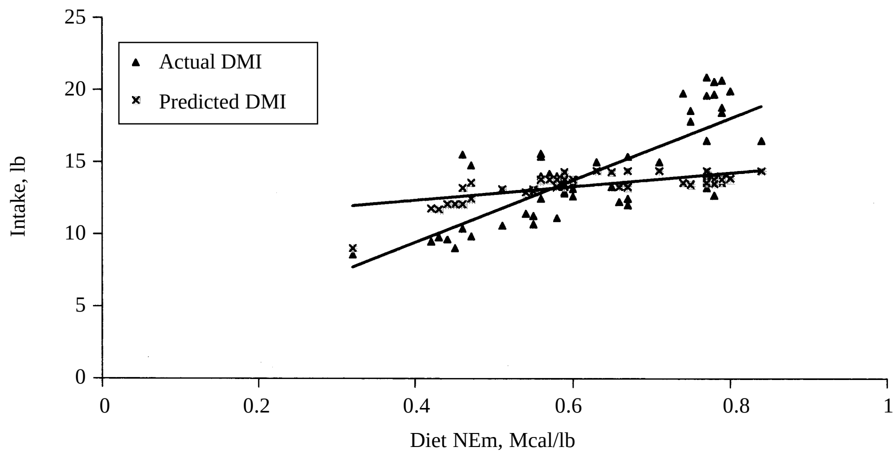

Figure 2. Predicted and actual calf DMI across increasing dietary energy level.

Results

The NRC model uses a different intake equation for growing yearling cattle (12 months or older) than for calves (under 12 months), based on data showing that older "yearling" cattle eat more as percentage of body weight than calves. However, intake changes on a continuum rather than a break at 12 months. Most cattle in growing programs will be between 8 and 14 months old (similar to those in the validation studies) and likely will have feed intakes more similar to a calf compared with a yearling. Over the range of the 54 diets evaluated, the calf equation did a better job of predicting intake than the yearling equation (16.0, 13.3, 14.3 lb/day for predicted yearling, predicted calf, and actual intake, respectively). However, when diet NEm was greater than .70 Mcal/lb (n = 19), the yearling equation predicted intake more accurately than the calf equation (16.4, 13.8, 17.9 lb/day for predicted yearling, predicted calf, and actual intake, respectively). When diet NEm was less than .70 Mcal/lb (n = 35), the calf equation was more accurate (15.7, 13.2, 12.5 lb/day for predicted yearling, predicted calf, and actual intake, respectively). Potential reasons for the varying accuracies of intake predictions across diet qualities will be discussed. Subsequent referrals to predicted intake will be using the calf equation.

Although the NRC model predicted intake relatively close to actual intakes on average (within 1 lb), it did not accurately predict intake over the range of the 54 diets evaluated (Figure 1, R^2 = .35). The model under-predicted intake at high actual intakes and over-predicted intake at low actual intakes (slope = .15). Figure 2 shows both actual and predicted calf intakes across dietary NEm levels. The NRC model accurately predicted intake at moderate energy levels (.58 - .60 Mcal/lb NEm), but over-predicted at low and under-predicted at high energy levels. There was one data point, where the dietary energy level was extremely low (.32 Mcal/lb NEm), that the predicted intake estimate was identical to the actual intake. This appears as an outlier in Figure 1, while other data from the same experiment (but higher energy levels) were similar to those in other

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trials.

When actual intakes were used as inputs, the NRC model predicted ADG (Figure 3) to increase twice as fast as actual ADG (slope = 2.2; R^2 = .75). The model under-predicted ADG at low actual ADG, but over-predicted gain at the high end of actual ADG. It is important to note these values for predicted gain are based on metabolizable energy (ME) allowable ADG, but the NRC model also predicts a metabolizable protein (MP) allowable ADG. Either MP or ME will show the lowest ADG, depending on which is first limiting. In certain cases in these data where dietary energy concentrations were high, MP allowable gain was slightly lower than ME allowable gain (n = 15). Although the MP allowable predicted ADG was still greater than the actual gains at these high energy levels, using MP allowable gain in place of ME allowable gain in these situations slightly improved the correlation between predicted and actual gains (slope = 1.7; R^2 = .80). Nevertheless, MP was not limiting in these diets when predicted gains were driven closer to actual gains by decreasing the NE adjusters. Thus, the focus of this discussion will be on gains predicted by net energy equations (ME allowable ADG) and not on those equations involving MP.

Figure 4 shows predicted and actual calf ADG across increasing dietary NEg. At low levels of NEg, the model under-predicted ADG, while it over-predicted ADG when dietary energy levels were higher. The NE adjusters thus had to be increased to get predicted ADG equal to actual ADG at low energy levels, and decreased at high energy levels. Table 1 shows predicted versus actual intakes and gains in the 54 diets evaluated, categorized according to dietary NEm. The diets in each NEm category fit into one of six NE adjustment categories (the NE adjustment required to get a predicted ADG equal to actual ADG). These data show, as previously discussed, that the model-over predicted intake and under-predicted gain at low energy levels, while the opposite was true at high energy levels. Fifteen out of 21 diets ranging in NEm from .32 to .58 Mcal/lb (first 2 energy ranges) had NE adjusters greater

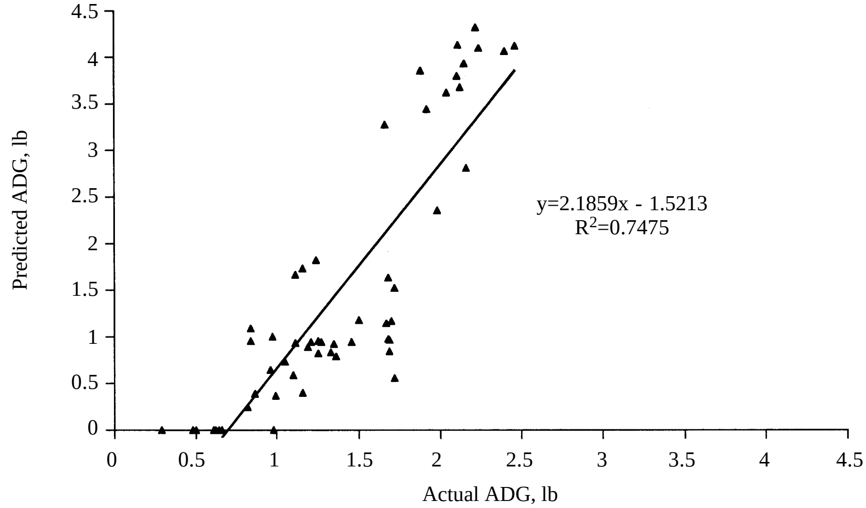

Figure 3. Actual ADG versus ADG predicted by the 1996 NRC model for 54 growing cattle diets in seven studies.

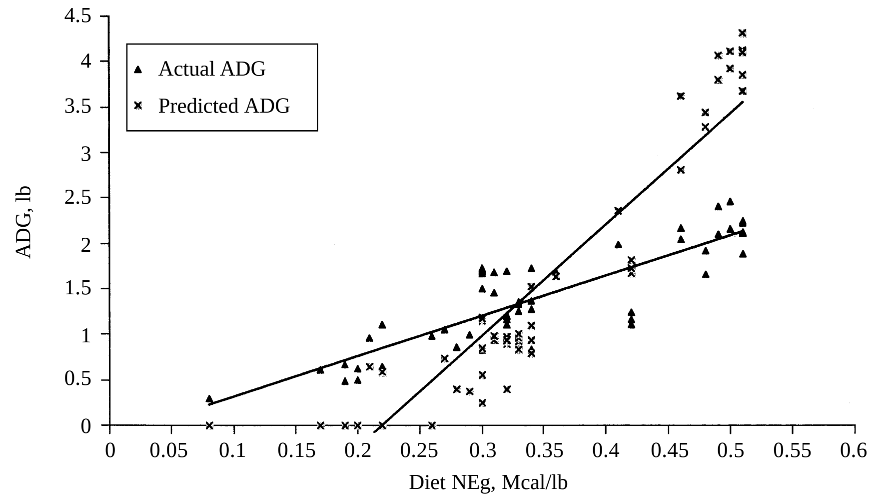

Figure 4. Predicted and actual calf ADG across increasing dietary NEg.

Table 1. NRC predictions of intake and gain versus actual intake and gain in growing calves across diets varying in energy concentration, and frequency of net energy adjusters required to achieve actual gain in the model.[a]

	Diet NEm, Mcal/lb				
Item	.32-.47	.51-.58	.59-.65	.66-.77	.78-.84
Number of diets	9	12	11	13	9
Diet NEg, Mcal/lb	.19	.30	.32	.41	.49
Predicted DMI, lb	12.0	13.4	13.8	13.7	13.9
Actual DMI, lb	10.8	12.8	13.3	15.9	18.6
Predicted ADG, lb	.14	.70	.91	2.33	3.62
Actual ADG, lb	.65	1.35	1.30	1.58	2.05
Frequency, NE adjusters:[b]					
< 80	0	0	0	5	7
81-90	0	0	0	3	2
91-100	0	0	0	3	0
101-110	0	1	3	2	0
111-120	1	4	8	0	0
>120	8	7	0	0	0

[a]Data collected from 54 diets in 7 previous growing trials at the University of Nebraska.
[b]Net energy (NE) adjusters are used to adjust feed energy values to drive predicted gain to actual gain in the NRC model. The units are in percent of normal (100 is no change). Given are the frequency of diets in the given energy range that required adjustments in each category.

than 120, meaning the model would not predict the actual ADG. Although the model predicted intake accurately with medium energy diets (.59-.65 Mcal/lb NEm), it continued to under-predict ADG. All 12 diets where the model markedly over-predicted ADG (NE adjusters < 80) were from one study in which lecithin and soapstock were mixed with soyhulls and added to a sorghum silage, alfalfa, and corn diet at graded levels replacing corn (1993 Nebraska Beef Report, pp. 34-35) . Truly, data from this study are the highest intakes and gains represented in the seven reviewed studies.

When the predicted ADG of cattle receiving all forage diets (no addition of non-forage fiber based energy or concentrate) was regressed on actual ADG, the correlation was less (predicted gain = -.37 +.85 * (actual ADG); R^2 = .73) than if the same regression was made for cattle consuming diets that had added non-forage energy (predicted gain = -2.01 + 2.62 * (actual ADG); R^2 = .83). When data from the study where lecithin and soapstock were added to the diet were removed and predicted ADG from diets with added non-forage fiber or concentrate were regressed on actual ADG, the correlation was very high (-1.09 + 1.65 *(actual gain); R^2 = .92). The model predicted performance closer to actual when higher quality feeds were fed, yet as indicated in Table 1, the predictions drifted further from actual values with diets of higher energy density.

The over-prediction of gain at high energy levels could be related to environmental temperatures at times when the studies were conducted. Since the temperature/weather conditions during each of the seven trials evaluated were not known, the diets were evaluated at thermoneutrality. However, temperatures were not likely at thermoneutral when most of the growing trials were conducted (fall and winter). Colder environmental temperatures will increase the amount of energy required for maintenance and can increase DMI, depending on diet and duration of cold temperatures. At colder temperatures, the increase in the amount of feed that goes to meet maintenance requirement can be greater than the increase in the intake of feed, thus the amount of energy available for gain is reduced and gains decrease. However, the above-mentioned study, where lecithin and soapstock were added to the diet and gains were markedly over-predicted by the NRC, was conducted in the summer. Extremely hot or muddy conditions will also depress gains in cattle. Environmental effects on maintenance could partially explain the over-prediction of gain by the NRC model when higher quality diets were fed, but other factors may also contribute to poor predictions of gain at high energy levels. The energy available for gain in low energy diets is less to begin with, so the effects of extreme environmental conditions on cattle gain are magnified. Therefore, if environmental conditions were included in the model, the gain predictions on lower quality diets would be even further from actual values. As Figures 3 and 4 indicate, some gain predictions were erroneously at zero, even with no adjustment for environment. Over the 54 diets evaluated, predicted gain differed greatly from actual gain when low quality diets were fed.

The NRC model calculates the net energy (NE) values of the feedstuffs from ME values, which are derived from TDN estimates entered by the user. The calculations converting ME to NEm and NEg involve different estimates of the efficiency of ME use for both maintenance and gain, based upon the ME concentration of the diet or feedstuff (i.e. the forage/concentrate ratio). Diets with high ME concentration (low forage/concentrate ratio) have a higher efficiency of ME utilization for gain and maintenance than feedstuffs with low ME concentration (high forage/concentrate ratio). The efficiency of ME use for gain is affected more than that for maintenance when dietary ME concentrations are low. For example, the NE equations show diets with 1.45 Mcal/lb ME to have an ME efficiency of 68.6% for maintenance and 47.3% for gain, whereas diets with .91 Mcal/lb ME have an ME efficiency of 57.6% for maintenance and 29.6 % for gain (NRC, 1984). It is possible that these equations under-estimated the NE values of the low quality feedstuffs in the roughage growing diets, which in turn under-estimated the amount and efficiency of energy use for gain. This would explain why gain was under-predicted when cattle were on low quality diets. Thus, the lower end of the calculated NEg values shown on Figure 4 may be erroneously low. The composition of gain likely has an effect on this efficiency, as muscle is deposited more efficiently than fat. The use of the NE system and the associated equations are not new to the 1996 NRC, as the equations were developed as part of the California Net Energy System in 1968 and have been used in NRC publications since 1976. The ability to use the California Net Energy System equations in the 1996 NRC computer program allows for potential errors in calculating ME efficiency to be illustrated. Truly, fewer data reflecting the performance of cattle consuming low quality diets were available when the NE equations were developed than for medium and high quality diets.

In conclusion, the NRC model over-predicted intake of low energy growing diets and under-predicted intake of high energy diets. The model did not accurately predict gain for growing cattle diets, and was especially poor at predicting performance of calves grown on low quality roughage. This may be due to NE equations, used in NRC publications since 1976, calculating erroneously low NEg values for the low quality diets. More work is necessary to determine the proper equations necessary to predict intake and performance of growing calves across multitudes of diets.

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Escape Protein Supplementation of Yearling Steers and Summer Born Calves on Native Sandhills Range

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Don Adams[1]

Escape protein supplementation improved pasture gains for yearling steers and summer born calves. Yearling steers were unable to maintain increased summer gain throughout the finishing period.

Summary

A trial was conducted to evaluate the effects of escape protein supplementation on pasture gains and subsequent finishing performance of cross-bred yearling steers and summer-born calves. Yearling steers and calves were assigned to one of two summer treatments: escape protein supplement or unsupplemented control. Escape protein supplementation improved pasture gains in supplemented steers and calves. Forage dry matter intake during summer grazing was lower for supplemented than unsupplemented steers and calves. Improved gains on range from escape protein were maintained in the feedlot by summer-born calves but not yearling steers.

Introduction

Actively growing forage may be limiting in escape or undegraded intake protein (UIP) when used by growing cattle (1991 Nebraska Beef Report, pp. 27-28). If limiting, supplementation with UIP should increase gains in growing cattle on summer range.

Digestible protein needs in high producing ruminants are separated into two categories: microbe and metabolizable protein needs. Protein needs for microbes must be met with a source of rumen-degradable protein (DIP) in order for microbial protein synthesis to occur. A response to metabolizable protein from UIP occurs primarily when degradable protein requirements of microbes are met, because reduced microbial growth decreases energy digestion in the rumen and limits animal growth. Native summer Sandhills range generally supplies a sufficient level of degradable protein to growing cattle. Therefore, UIP supplements for yearling steers and summer born calves grazing native summer range may be beneficial. Our objectives were to determine the effects of UIP supplementation on grazing performance and compensatory growth and to evaluate the effect of age on the response to supplementation.

Procedure

Sandhills range consisting of a mixture of warm and cool season species was used from June 1 to Sept. 8, 1998. Forty-eight yearling steers (745 lb) were used in a completely randomized design. Yearling steers were previously wintered at four rates of gain: 1.43 lb/day (fast), .54 lb/day (slow), .85 lb/day (fast/slow and slow/fast). Fast/slow and slow/fast steers are assigned to fast or slow treatments for half of the wintering period and then moved to the alternate treatment for the remainder of the winter. Thirty-two summer born (June-July 1997) steer calves (517 lb) from the Gudmundsen Sandhills Laboratory (GSL, Whitman, NE) also were used. Yearling steers (14 mo age) and summer-born calves (11 mo age) were assigned to one of two summer treatments, UIP supplement or unsupplemented control and grazed on 640 acres of Sandhills range as one group. Three days each week steers were gathered and fed their respective supplement in individual feeding stalls. The supplemented steers were fed 2.9 lb of supplement to supply .44 lb of UIP per day. Supplement consisted of 78.5% treated soybean meal, 18.5% feather meal and 3% molasses (DM basis).

Forage samples were obtained biweekly with ruminally fistulated steers and were analyzed for CP, UIP and in-vitro dry matter disappearance. All yearling steers and 12 of the summer-born calves were given a chromium-releasing Captec bolus to estimate fecal output. Fecal output was calculated by dividing amount of chromium released by the Captec bolus by chromium concentration in the feces. Forage intake was calculated by dividing fecal output by indigestibility of the forage. Total chromium output from the bolus was verified using total fecal collection of six steers.

All animals were placed in the feedlot (ARDC, Ithaca, NE) following summer grazing. Animals were sorted according to previous winter treatment (fast, slow, and slow/fast, fast/slow), summer treatment (supplemented or unsupplemented) and summer-born calves. All steers were stepped up to the finishing ration over a 20-day period using four steps. The final ration contained 7% alfalfa hay, 40% wet corn gluten feed, 48% high moisture corn and 5% supplement (DM). Yearling steers were fed 92 days and summer-born calves were fed 141 days until they reached about .45 inches of back fat.

Results

UIP supplementation on summer range improved (P = .0001) gains over unsupplemented control yearling steers and calves (Table 1). The effect of winter treatment was significant (P = .0001). However, there were no winter gain by

Table 1. Summer gains of supplemented and unsupplemented steers

Winter treatment	Summer Treatment			
	Unsupplemented		Supplemented	
	ADG, lb	SEM	ADG, lb	SEM
Fast[a]	1.57	.09	2.08	.09
Fast/Slow[a]	1.80	.09	2.03	.09
Slow/Fast[a]	1.77	.09	2.04	.10
Slow[a]	2.02	.09	2.34	.09
Summer born calves[b]	1.46	.06	1.78	.06

[a]Winter treatments were Fast 1.43 lb ADG, Fast/slow, Slow/fast .85 lb ADG, and Slow .54 lb ADG; winter by summer interaction (P = .6), summer (P = .0001), winter (P = .0001)
[b]Summer born calves were wintered at Gudmunsen Sandhills Laboratory on native range with supplement.

Table 2. Forage intake of supplemented and unsupplemented steers.

Winter treatment	Summer Treatment			
	Unsupplemented		Supplemented	
	Intake % BW	SEM	Intake % BW	SEM
Fast[a]	2.53	.15	2.59	.14
Fast/Slow[a]	2.84	.15	2.59	.15
Slow/Fast[a]	3.02	.13	2.73	.15
Slow[a]	3.13	.15	2.54	.14
Summer born calves[b]	3.02	.11	2.95	.18

[a]Winter treatments were Fast 1.43 lb ADG, Fast/slow, Slow/fast .85 lb ADG, and Slow .54 lb ADG; winter by summer interaction (P = .31), summer (P = .08), winter (P = .004)
[b]Summer born calves were wintered at Gudmunsen Sandhills Laboratory on native range with supplement.

Table 3. Crude protein, undegraded intake protein, and in-vitro dry matter disappearance of the summer range (DM basis).

Date	CP %	SEM	UIP %	SEM	IVDMD %	SEM
June	12.4	.55	2.6	.14	70.2	.8
July	10.1	.41	1.9	.10	64.1	.6
August	9.4	.51	1.6	.13	60.3	.8
September	11.1	.72	1.7	.19	54.3	1.1

Table 4. Feedlot average daily gain, DMI and F/G.

Winter trt.[a]	Summer trt.[b]	ADG[c]	DMI[c]	F/G
Fast	Unsupp.	5.18	32.2	6.2
Fast	Supp.	4.88	32.7	6.7
Slow	Unsupp.	4.94	31.3	6.3
Slow	Supp.	4.06	29.7	7.3
Summer born calves	Unsupp.	3.90	24.0	6.1
Summer born calves	Supp.	3.87	24.0	6.2
SEM		.36	1.1	.16

[a]Winter treatments are Fast 1.43 lb ADG, Slow .54 lb ADG, and summer born calves wintered on native range with supplement
[b]Summer treatments were supplemented with escape protein or unsupplemented control.
[c]ADG and DMI are expressed in lb.

summer supplement interactions (P = .6). Steers on the slow winter treatment had higher ADG on range than steers on the fast winter treatment. This higher ADG allowed slow-gaining steers to compensate for a portion of the winter weight deficit.

Slow gaining steers compensating for the winter weight deficit did not gain better as a result of supplementation. This is shown by a numerically lower response in weight gain to supplementation. Slow gaining supplemented steers showed a positive response of .32 lb/day over slow unsupplemented controls. Fast-gaining supplemented steers had a positive response of .5 lb/day over unsupplemented fast-gaining steers. Summer-born calves showed increased average daily gains on range of .32 lb/day from supplementation when compared to the unsupplemented control.

Crude protein content of the forage was variable during the grazing trial with the average CP content being 10.8 % while UIP value was about 2 % of dry matter. The average in-vitro dry matter disappearance was 63.1 % (Table 3).

Forage intake determination using chromium-releasing Captec boluses is presented in Table 2. Intake determinations showed a significant effect (P = .08) of summer treatment; supplemented animals showed lower forage intakes than the unsupplemented controls. The effect of winter treatment was also significant (P = .004); slow-gaining steers showed higher intakes as a percentage of body weight when compared to fast gain steers. This increase in intake as a percent of body weight with compensating steers has been shown in previous research. There were no significant (P = .31) winter treatment by summer treatment intake interactions.

Feedlot data showed unsupplemented yearling steers gained faster and were more efficient when compared to supplemented yearling steers (Table 4). This increased gain allowed unsupplemented yearling steers to make up the weight difference created with summer supplementation. Carcass data showed no effects of summer treatment on fat, marbling or yield grade for yearling steers.

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The feedlot ADG of summer-born calves showed gains to be similar between supplemented and unsupplemented treatments. This allows for maintenance of summer supplementation gain. Dry matter intake, F/G and carcass traits were also similar between supplemented and unsupplemented summer-born calves. This means that summer born calves' efficiencies were similar in the feedlot regardless of summer treatment. Increased gain with summer supplementation, similar feedlot gain and efficiency resulted in heavier animals at the end of the feeding period.

Overall, the response to UIP is not increased with compensatory growth or with animals at younger ages. Compensation with yearling steers showed that slow-gaining (compensating) steers did not respond more to UIP supplementation than the fast gaining steers. Age showed no effect on response to UIP, summer-born calves' response to supplementation was equal to the average response of supplemented yearlings.

UIP supplementation improved summer gains on range but the improved gains were not maintained during the finishing period by yearling steers. The summer-born calves gained similarly during the finishing period, resulting in maintenance of summer gains.

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Metabolizable Protein Estimates of Treated Soybean Meal Products

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The metabolizable protein concentrations of treated soybean meal products vary more from lot to lot than commodity soybean meal. Differences appear to be due to undegraded intake protein concentration.

Summary

The metabolizable protein (MP, % of CP) concentrations of the following three treated soybean meal (SBM) products and commodity SBM were estimated: nonenzymatically browned SBM (Soy Pass®), expeller SBM (SoyPlus®), and a heated SBM:soyhull mixture (AminoPlus®). Separate lots of each product were measured in two separate trials. Commodity SBM yielded consistent MP values, while treated SBM products differed by 11- 58% in MP. Differences in MP appear to be due to differences in undegraded intake protein (UIP) concentration. The UIP concentrations of treated SBM products merits regular monitoring.

Introduction

Previous University of Nebraska research (1999 Nebraska Beef Cattle Report, pp. 65-66) investigated the metabolizable protein concentrations (MP, % of CP) of treated soybean (SBM) products relative to commodity SBM. We concluded although all three treated SBM's tested had higher MP than commodity SBM, differences in MP existed between the products, because processing conditions designed to increase undegraded intake protein concentration (UIP) of each product may have lowered its true nitrogen digestibility (TND). Each product is sold on the basis of possessing higher UIP than commodity SBM and therefore contributing more MP to the animal. The objective of this trial was to estimate MP concentrations of three treated SBM products relative to commodity SBM using different lots of products than in 1999.

Procedure

Three treated SBM products and commodity SBM were obtained for estimation of MP: nonenzymatically browned SBM (Soy Pass®), expeller SBM (SoyPlus®), and a heated SBM:soyhull mixture (AminoPlus®). Two bags (100 lb) were chosen randomly from each lot and lots were at least one ton in size. Two separate lots of commodity SBM were obtained from different vendors to provide an estimate of between-vendor variation. Two separate lots of AminoPlus were purchased from different vendors because the pre-trial UIP estimate of the first lot was substantially lower than last year's AminoPlus.

A three-period digestion study was conducted with 29 crossbred wether lambs (75 lb mean weight). All lambs were fed a common basal diet at the same percentage of body weight (DM basis; Table 1). The basal diet was balanced to contain a minimum of 11.5% CP, .42% Ca, and .18% P. Urea was included to ensure rumen ammonia concentration did not limit digestion and to provide 40% of the basal dietary nitrogen (N).

Table 1. Composition of basal diet.

Item	Percent of diet DM
Cottonseed hulls	72.63
Dehydrated alfalfa pellets	15.00
Molasses	5.00
Dry rolled corn	5.00
Urea	1.48
Dicalcium phosphate	.34
Sodium chloride	.30
Ammonium sulfate	.17
Sheep trace mineral premix	.04
Vitamin premix	.03
Se premix	.02

Five lambs in each period were fed only the basal diet and served as a urea control. The remaining lambs consumed the basal diet at the same percentage of body weight (DM basis) as control lambs, with an additional 3.75% of the basal dietary DM added as units of CP from one of the treated SBM products. Treatment diets were isonitrogenous and each experimental treatment contributed 27% of the total N intake for treatment lambs.

Each period consisted of a 10-day diet adaptation phase, a four-day metabolism crate adaptation phase, and a seven-day of total fecal collection phase, for a total of 21 days. Lambs were housed in individual pens during the 10-day diet adaptation phase. Lambs were weighed at the end of each period. The amount of basal diet offered to each lamb was adjusted based on its most recent weight.

Feed, feces and orts were dried for 48 hours in a forced air oven at 140°F, and subsequently analyzed for DM and N. Apparent N digestibility was calculated for the urea control diet: {(N consumed - N excreted) / N consumed}. The following formula was used to calculate true nitrogen digestibility of each SBM source: $\{(A - (B * C)) / D\} * 100$, where: A = digestibility of N in total diet, B = apparent N digestibility of urea control, C = proportion of total N in diet supplied by basal diet, and D = proportion of total N in diet supplied by SBM.

The UIP concentrations of the treatments were estimated by the in-vitro ammonia release procedure. Briefly, rumen fluid was collected from a ruminally fistulated steer fed bromegrass hay (7.5% CP, DM basis) and strained through four layers of cheese cloth. A bicarbonate buffer solution was added to the rumen fluid and 30 ml of the fluid mixture were added to test tubes containing enough sample to provide 20 mg of N. Six tubes were incubated for each sample (three for 18 hours and three for 24 hours). Tubes were stoppered and incubated for the two different periods at 102°F. The ammonia concentration of fluid in each tube was used to calculate UIP relative to standards whose *in vivo* UIP concentrations have been measured. Three separate UIP values were calculated using one tube from each time point for each value.

The MP supplied by each treatment source was calculated from the UIP concentration and TND estimate, where: MP = UIP - (100 - TND). This value equals the percentage of N that escapes ruminal degradation and is digested in the small intestine.

Results

Estimates of CP, UIP, TND and MP for each sample in each year are shown in Table 2. All samples from both years were analyzed in the same ammonia release run in order to make relative comparisons of UIP. Both Soy Pass treatments ranked the highest in UIP, followed by AminoPlus, SoyPlus, and commodity SBM. Each sample was statistically different from the rest, except 1999 AminoPlus was not different from 2000 Soy Pass ($P > .05$).

Means for TND were separated statistically within year ($P = .05$). Both SoyPlus and AminoPlus had lower TND than commodity SBM and Soy Pass in 1999, but only SoyPlus was lower in TND in 2000 and all other treatments in 2000 were not different. The TND of Soy Pass was not lower than commodity SBM in either year. These data show SoyPlus is processed in a way that is detrimental to TND and therefore calculated MP. The data also show more variation in AminoPlus TND than commodity SBM.

No statistics are available for a year (same as trial) effect on TND of different treatments because each year had separate control animals. Statistics are also not available for MP because those values were calculated. However, several useful observations can be made about year effects on the variables tested. UIP and TND values for commodity SBM were very similar, both between years and between lots within year 2000. These data indicate commodity SBM is homogeneous both in CP concentration and protein quality (based on MP). A second concept indicated by this research is commodity SBM serves as an effective control in an MP estimation trial. A third observation is variation in the MP of treated SBM products exists (both within separate lots of product and among products) and is greater than commodity SBM.

All treated SBM's in these trials were processed using the same basic concept, known as nonenzymatic browning (heating to cause a chemical reaction between protein and carbohydrate). Soy Pass is produced by adding the carbohydrate xylose and heating it to induce browning. This treatment increases UIP while not affecting TND (in either year tested). SoyPlus was treated with heat alone; this method resulted in variable UIP and lower TND relative to commodity SBM (both 1999 and 2000). AminoPlus is produced by heating a SBM:soyhull

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Table 2. Comparison of the metabolizable protein concentrations of commodity soybean meal and three treated soybean meal products analyzed in two different years.

Treatment[a]	Year[b]	CP (% of DM)[c]	UIP (% of CP)	TND (%)	MP (% of CP)
SBM	1999	48.5	31.2[d]	91.4[n]	22.6
Soy Pass		52.1	80.2[e]	89.0[n]	69.2
SoyPlus		48.7	57.9[f]	81.4[o]	39.3
AminoPlus		54.6	71.4[g]	81.0[o]	52.4
SBM #1	2000	48.0	34.5[h]	87.0[p]	21.5
SBM #2		48.4	29.6[i]	91.6[p]	21.2
Soy Pass		52.1	71.6[g]	82.4[p]	54.0
SoyPlus		43.7	47.0[k]	69.5[q]	16.5
AminoPlus #1		51.4	55.8[l]	84.6[p]	40.4
AminoPlus #2		53.9	67.1[m]	79.6[p,q]	46.7

[a]SBM- commodity soybean meal.
[b]1999 data previously reported in 1999 Nebraska Beef Report, pp. 65-66.
CP and UIP from 1999 re-analyzed together with 2000 samples; some values vary from last year.
[c]CP = crude protein.
UIP = undegraded intake protein.
TND = true nitrogen digestibility.
MP = metabolizable protein, calculated as MP = UIP - (100 - TND).
[d-m]Means within column with different superscripts differ ($P < .05$).
[n,o]Means within column (1999) with different superscripts differ ($P < .05$).
[p,q]Means within column (2000) with different superscripts differ ($P < .05$).

mixture. Although it is not clear how this method is effective, it is obvious from the UIP concentration that the browning reaction is induced by this treatment. However, variable UIP results were achieved and the TND of the protein sometimes was affected. In 1999, AminoPlus was lower in TND than commodity SBM ($P < .05$). In 2000 one of the AminoPlus samples was numerically lower in TND than commodity SBM while the other AminoPlus sample was not lower than commodity SBM. These data demonstrate not all methods of treating SBM (to increase UIP) lower TND.

The MP concentrations of several treated SBM products were estimated. These products are marketed based on their higher UIP concentrations. However, UIP alone does not completely describe the protein value a product has in ruminant diets. Incorporation of UIP and TND in the calculation of MP is the true indicator of protein quality. We conclude that the MP concentrations of treated SBM products vary more from lot to lot than does commodity SBM. We also conclude that the UIP concentrations of all three treated SBM products tested are variable and should be monitored.

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Protein Evaluation of Porcine Meat and Bone Meal Products

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Commercially available porcine meat and bone meal products vary in apparent and true nitrogen digestibility as well as in concentration of crude, metabolizable, and undegradable intake protein.

Summary

Thirteen commercially available porcine meat and bone meal products from both independent renderers and commercial packing plants were evaluated in a lamb-digestion study for the following variables: crude protein, undegradable intake protein, metabolizable protein, apparent nitrogen digestibility and true nitrogen digestibility. As a whole, the products varied widely with respect to all of the variables measured with the exception of apparent nitrogen digestibility, indicating that feeding value of commercially available meat and bone meal products also varies widely, although all of the products tested had acceptable protein digestibilities.

Introduction

The recent government ban on feeding rendering products of ruminant origin back to ruminants has led to the development of porcine-only meat and bone meal (MBM) products to be fed to ruminants. Meat and bone meal is high in undegradable intake protein relative to soybean meal and improves performance in growing steers fed forage-based diets sufficient in degradable intake protein. Byproduct feedstuffs are variable due to source differences in processing conditions and raw materials. Variable quantities of raw materials (bone, hair, viscera and meat trimmings) influence both quantity and quality of protein. Processing conditions and production situations vary considerably within the rendering industry and influence the consistency of commercial MBM. Renderers apply heat to drive off moisture, extract fat and eliminate bacterial contamination from animal tissues. Ultimately, this cooking process enhances the resistance to microbial degradation in the rumen. The objective of this experiment was to determine the variability that exists among commercially available porcine MBM products in crude (CP), metabolizable (MP), and undegradable intake protein (UIP) and apparent (AND) and true nitrogen digestibility (TND).

Procedure

Twenty-nine crossbred wether lambs (84 lb) were used in a digestion study consisting of three periods. Lambs were fed a common basal diet (Table 1) at an equal percentage (2.3%) of body weight on a DM basis. The basal diet was formulated to contain a minimum of 10%

Table 1. Composition of basal diet.

Ingredient	% of diet DM
Cottonseed hulls	72.3
Dehydrated alfalfa pellets	15.0
Molasses	5.0
Dry-rolled corn	2.7
Supplement	5.0
Finely ground corn	2.325
Urea	1.204
Ammonium chloride	.500
Salt	.400
Dicalcium phosphate	.316
Ammonium sulfate	.170
Trace mineral premix	.040
Vitamin premix	.030
Selenium premix	.015

Table 2. Concentrations of crude (CP), undegradable intake (UIP), and metabolizable (MP) protein and percentage apparent (AND) and true (TND) nitrogen digestibility of thirteen porcine meat and bone meal products.

Product Number	CP[a]	UIP[ab]	MP[ac]	ASH[a]	AND[a]	TND[a]
1	54.6	41.5[de]	19.5	29.2	62.1[de]	78.0[de]
2	56.0	46.4[ef]	27.3	26.6	63.0[def]	80.9[def]
3	63.0	53.3[g]	33.5	26.7	62.5[def]	80.2[def]
4	54.8	63.0[h]	38.7	29.1	61.5[d]	75.7[d]
5	59.7	53.8[g]	31.4	21.4	62.0[de]	77.6[de]
6	60.9	50.7[fg]	27.7	21.3	61.9[d]	77.0[d]
7	65.5	52.2[g]	40.3	25.5	64.8[g]	88.1[g]
8	64.7	52.5[g]	36.3	24.8	63.7[efg]	83.8[efg]
9	62.9	49.7[fg]	30.7	29.3	63.0[def]	81.0[def]
10	53.5	48.6[fg]	30.2	27.8	63.0[def]	81.6[defg]
11	54.9	39.7[d]	21.5	24.8	63.2[defg]	81.8[defg]
12	61.9	49.3[fg]	28.2	28.3	62.2[de]	78.9[de]
13	60.5	45.6[ef]	32.1	25.9	64.1[fg]	86.5[fg]

[a]CP and ASH as percentage of DM; UIP and MP as percentage of CP; AND and TND as percentages.
[b]Measured by the ammonia release procedure.
[c]MP = UIP - (100-TND).
[defgh]Values within a column with unlike superscripts differ (P < .10).

CP, .42% Ca and .18% P. Urea was included to ensure rumen ammonia did not limit digestion. Thirteen commercially available porcine MBM products were obtained for protein evaluation. The MBM products represented various rendering sources, including both independent renderers and commercial packing plants. Either three or four lambs in each period were fed only the basal diet and served as the urea control. The remaining lambs consumed the basal diet at the same percentage of body weight as control lambs and were supplemented with an additional 3.75% of the basal diet DM as units of CP from one of the MBM products. Treatment diets were isonitrogenous and each treatment contributed 25% of the total N intake for treatment lambs.

The trial consisted of three, 14-day periods. Each period included seven days of dietary adaptation and seven days of total fecal collection. Lambs were housed in individual pens during dietary adaptation and individual metabolism crates during fecal collection. Lambs were reassigned randomly to another treatment at the end of each period. The amount of basal diet offered to each lamb was adjusted based on the average of weights taken on two consecutive days at the beginning of each period.

Feed, feces and orts were dried for 48 hours in a forced air oven at 140°F and analyzed for DM and N. Apparent nitrogen digestibility was calculated as (N consumed - N excreted)/ N consumed. The following formula was used to calculate TND of each MBM product: ((A - (B*C)) / D)*100; where: A = apparent digestibility of N in total diet; B = apparent N digestibility of urea control; C = proportion of total N in diet supplied by basal diet; D = proportion of total N in diet supplied by treatment.

The UIP concentration of the treatment sources was estimated by the *in vitro* ammonia release procedure. Rumen fluid was collected from a ruminally fistulated steer and strained through four layers of cheesecloth. A bicarbonate buffer solution was added to the rumen fluid and 30 ml of the fluid mixture were added to test tubes containing enough sample to provide 20 mg of N. Six tubes were incubated for each sample. Tubes were stoppered and incubated for two time periods (three for 18 hours and three for 24 hours) at 102°F. The ammonia concentration in the fluid of each tube was used to calculate UIP relative to standards whose *in vivo* UIP concentrations have been measured.

The MP (% of CP) for each MBM product was calculated from the UIP concentration and TND measurements where: MP = UIP - (100-TND). This value equals the percentage of N that escapes ruminal degradation and is digested in the small intestine.

Results

Estimates of CP, UIP, MP, ASH, AND and TND are shown in Table 2. Concentrations of CP ranged from 53.5 to 65.5%. Undegradable intake protein concentrations ranged from 41.5 to 63.0% of CP. The UIP content of product 4 was higher (P < .10) than all of the other products. Metabolizable protein estimates ranged form 19.5 to 40.3%. Ash values ranged from 21.3 to 29.3% of DM. Apparent nitrogen digestibility values ranged from 61.5 to 64.8%. Products 7 and 13 were similar in AND (64.8 and 64.1%, respectively) and were significantly higher (P < .10) in AND than products 1, 4, 5, 6, and 12. True nitrogen digestibility values ranged from 75.7 to 88.1%. Products 7 and 13 had the highest TND (88.1 and 86.5%, respectively) and were significantly higher (P < .10) in TND than products 1, 4, 5, 6, and 12.

The 13 MBM products used in this trial are representative of both independent renderers and commercial packing plants. As such, inputs (deadstock, tankage, meat trimmings and bones, amount of hair) are variable and contribute to the variability observed in the feeding value of the products. Likewise, processing systems and conditions differ among processors. The exact processing conditions of each product are not known. This trial demonstrates the variability that exists among commercially available porcine meat and bone meal products. Although these results indicate all of the porcine MBM products tested have relatively similar CP contents and adequate protein digestibilities, the range in MP values indicates the products may have large differences in feeding value for ruminants.

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Sugar Beet Pulp and Corn Silage for Growing Yearling Steers

Jessica Park
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Burt Weichenthal[1]

Feeding pressed beet pulp reduced dry matter intake but feed conversion improved compared to corn silage in growing diets fed to yearling steers.

Summary

British crossbred steers with an average weight of 735 lb were fed in a 92-day growing trial. Silo Guard II®, an additive containing an amylase enzyme and sulfur salts, was used to treat corn silage and beet pulp. Cattle received either untreated corn silage, treated corn silage, or treated corn silage and treated beet pulp (35% of ration DM). Average daily gains were not significantly different between treatments. Dry matter intake was lower with the diet containing beet pulp, resulting in a better feed conversion compared to the treated and untreated corn silage diets.

Introduction

Sugar beet pulp is a byproduct of the sugar beet industry and it has a highly digestible fiber fraction, making it a good energy source for cattle. The pulp is mechanically pressed at the factory to increase the dry matter content to about 24%. Replacing corn silage dry matter with increasing levels of pressed beet pulp increased daily gain and improved feed efficiency in growing steer calves (1992 Nebraska Beef Report, pp. 24-25). Replacing all of the corn silage in a finishing diet (10% of diet DM) with beet pulp resulted in similar daily gains and a trend toward improved feed efficiency in steer calves during finishing (1993 Nebraska Beef Report, pp. 48-49).

Several types of products have been used to treat corn silage at ensiling time in attempts to reduce storage losses and improve cattle performance. One of those products is Silo Guard II®, a registered trademark from International Stock Food Corporation, Marietta, GA. Silo Guard II® contains an amylase enzyme and sulfur salts as the active ingredients. Amylase is involved in the breakdown of starch to produce organic acids which are needed for preservation of ensiled feeds like corn silage. Pressed sugar beet pulp has about 76% moisture and ferments during storage, but data from treating beet pulp at ensiling with products to enhance fermentation are not available. Objectives of this trial were to evaluate performance of yearling steers fed growing rations that included corn silage treated or untreated with Silo Guard II® or a mixture of corn silage and sugar beet pulp when both were treated with Silo Guard II®, and to measure dry matter storage losses in corn silage.

Procedure

One hundred and twenty British crossbred yearling steers with an average weight of 735 lb were used in a 92-day growing trial. The steers were weighed individually on two consecutive days at initiation and conclusion of the trial. Weights were taken approximately every 28 days. The steers were randomly assigned to one of 12 pens. Three diet treatments then were randomly assigned to the 12 pens, which resulted in four replications per treatment with 10 steers per pen. The three diet treatments were: untreated corn silage (CON), treated corn silage (TCS), and treated corn silage with treated beet pulp (TCS/BP) where beet pulp replaced 35% of the corn silage dry matter. The remainder of the diet was made up of alfalfa hay and a protein supplement. The diets were formulated to be isonitrogenous with a crude protein level of 13.9%. This level is more than adequate in metabolizable protein according to the 1996 NRC Nutrient Requirements of Beef Cattle. This level was set so the energy differences in the beet pulp and corn silage could be evaluated without concern for protein level. The diet compositions are shown in Table 1. At the beginning of the trial, the steers were implanted with Synovex-S. Two steers were removed from the trial. Reasons for removal were not related to the treatments.

Three concrete bunker silos were used to store the untreated corn silage, treated corn silage and treated beet pulp. The corn silages were harvested on Sept. 9 and 10, 1998. The corn silage was treated with liquid Silo Guard II® in the field on the forage harvester at 1 lb/ton of corn silage. The beet pulp was hauled fresh from the factory and treated with Silo Guard II® at 2.5 lb/ton by scattering dry product on top of the pulp before and after dumping at the bunker. The corn silage was pushed into each bunker and packed with a tractor while the beet pulp was pushed into the bunker with a loader,

Table 1. Composition of diets and calculated nutrient analyses.

	Treatment[a]		
	CON	TCS	TCS/BP
Diet composition, dry matter basis			
Corn silage, %	69.6	69.6	37.1
Beet pulp, %	0	0	35.0
Alfalfa hay, %	22.4	22.4	22.4
Protein supplement 58, %[b]	5.5	5.5	5.5
Protein supplement 40, %[c]	2.4	2.4	0
Calculated nutrient analysis, dry matter basis			
Dry matter, %	45.6	45.6	36.7
Crude protein, %	13.9	13.9	13.9
NEm, Mcal/cwt	68.4	68.4	71.0
NEg, Mcal/cwt	44.7	44.7	45.2
Rumensin, g/ton	25.0	25.0	25.0

[a]CON = control untreated corn silage, TCS = treated corn silage, TCS/BP = treated corn silage and treated beet pulp.
[b]Supplement contains 58 percent crude protein, air dry basis, with Rumensin at 420 g/ton.
[c]Supplement contains 40 percent crude protein, air dry basis.

Table 2.Performance of yearling steers fed corn silage or beet pulp rations.

	Treatment[a]		
	CON	TCS	TCS/BP
No. of steers	40	40	38
Initial wt, lb	740	734	735
Final wt, lb	1031	1018	1041
Daily gain, lb[b]	3.17	3.09	3.31
Feed intake (DM), lb	23.27[c]	22.51[d]	20.93[e]
Feed/Gain[f]	7.34[c]	7.28[c]	6.32[d]

[a]CON = control, untreated corn silage, TCS = treated corn silage, TCS/BP = treated corn silage and treated beet pulp.
[b]P = .11 for the treatment effect.
[c,d,e]Means with different superscripts on the row are significantly different (P<.05).
[f]Feed efficiency was analyzed gain/feed.

then all three silos were covered with black plastic and tires.

Results

Steer performance by treatment is shown in Table 2. Average daily gain tended to be higher in the TCS/BP treatment (P=.11). The steers consuming the treated and untreated corn silage gained at the same rate. Dry matter intake was considerably lower for the cattle consuming the beet pulp ration with smaller differences between the treated and untreated corn silage rations (P<.05). Cattle consuming untreated silage had the highest dry matter consumption (P<.05). The dry matter content of the corn silage diets was drier than the beet pulp containing diet (45.6% versus 36.7%, respectively). The differences in dry matter content of the diets may have influenced the daily intake. The feed to gain conversions for the treated and untreated corn silage were similar throughout the trial. However, there was a reduction in feed required per unit of gain for TCS/BP (P<.05), and the reduction was consistent throughout the trial. Even though the cattle were eating less dry matter with the TCS/BP diet, the gains were comparable to those for the treated and untreated silage diets.

The improved gain and feed utilization of the cattle consuming beet pulp likely were due to the higher levels of energy in beet pulp compared to corn silage plus the complementary effect of beet pulp in the growing rations. Previous research and chemical analysis indicate that beet pulp has slightly higher energy values. Calculations to determine the comparative value of net energy for gain in corn silage versus beet pulp were made and it was found that the beet pulp was 51% greater. This increase in energy is due to two factors. First, the energy in the fiber of the beet pulp is greater than the combined fiber and starch in corn silage. Second, the fiber in pulp has a complementary effect on energy digestion in the total diet. This is due to the slower rate of digestion of the fiber in pulp, in contrast to the faster breakdown of starch in corn silage, which increases rumen acidity that adversely affects fiber digestion.

The corn silage used in this trial was characterized as well-eared which contains relatively high levels of energy and consequently, the overall gains of all steers in this trial were higher than predicted by the 1996 NRC model. Well-eared corn provides large quantities of nutrients for excellent fermentation when harvested at optimal dry matter levels (33 to 37% DM). The dry matter losses for both the treated and untreated corn silages were 14%. Dry matter storage loss for the treated sugar beet pulp was 13%.

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Whole or Cracked Corn in Growing Rations for Steer Calves

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Dry whole shelled corn can be fed separately from forage fed to weaned growing calves for a cost of gain comparable with corn cracked and/or mixed in a ration.

Summary

Crossbred steer calves were fed growing rations that included whole or cracked corn fed in a mixed ration or fed separately and cleaned up before feeding the other ingredients in the ration. Intakes of corn fed separately were regulated to match ad libitum dry matter intakes averaging 5 pounds per day in a 120 day trial. Daily gains and feed conversions were similar for both mixed rations and cracked corn fed separately, and only slightly lower when whole corn was fed separately. Including costs for corn cracking and/or mixing resulted in similar ration costs per pound of gain.

Introduction

Many farmers and ranchers with beef cow herds do not have equipment for cracking corn or for mixing rations, but want to obtain growth in calves after weaning on forage and limited amounts of grain. If whole corn can be fed separately from other ingredients without sacrificing calf performance, producers can feed a growing ration in their operations without buying processing or mixing equipment. Feeding trials with growing-finishing cattle have seldom shown performance benefits for cracking dry corn compared to feeding it whole. The objective of this trial was to compare daily gains and feed conversions of calves when dry corn was fed whole or cracked in a mixed ration or fed separately from the forage as was common in midwestern cattle-feeding operations before mixer units were used.

Procedure

British crossbred steer calves averaging 565 pounds were fed growing rations formulated for the dry matter (DM) to contain 13% crude protein (CP) and 0.46 Mcal/lb net energy for gain (NEg). Ingredients on a DM basis were 22.8% corn silage, 48.7% ground alfalfa hay, 1.9% of a supplement to supply Rumensin at 23 g/ton, and 26.6% corn (85% DM) fed whole or cracked in a mixed ration, or fed separately and cleaned up before feeding the other ingredients in a mixed ration. Ration intakes were regulated to match ad libitum intakes, with corn dry matter intakes averaging 5 lb/day in a 120 day growing trial. There were 3 pens/treatment and 9 or 10 steers/pen. Steers were weighed twice at the beginning and end of the trial. Cracked corn was obtained by rolling dry corn coarsely.

Table 1. Whole or cracked corn in growing rations for steer calves.

Corn physical form Corn feeding method	Cracked Mixed	Cracked Separate	Whole Mixed	Whole Separate	P-value
Number of pens	3	3	3	3	
Number of steers	29	29	28	29	
Initial weight, lb	565	562	567	568	
Ending weight, lb	893	886	899	879	0.42
Daily gain, lb	2.73	2.71	2.76	2.58	0.42
Feed DM/day, lb	19.2	19.3	19.2	19.3	0.99
Feed/gain ratio[a]	7.03	7.13	6.96	7.46	0.20
Feed DM cost/day, $[b]	0.77	0.77	0.77	0.77	
Corn mixing cost/day, $[c]	0.01	0	0.01	0	
Corn cracking cost/day, $[d]	0.01	0.01	0	0	
Total feed cost/day, $	0.79	0.78	0.78	0.77	
Total feed cost/lb gain, $	0.29	0.29	0.28	0.30	

[a]Feed/gain was statistically analyzed as gain/feed.
[b]Feed DM composition was charged at $.04/lb for all rations.
[c]Corn mixing charge of $.20/cwt (DM) was used when applicable.
[d]Corn cracking charge of $.20/cwt (DM) was used when applicable.

Results

Treatment daily gains, dry matter intakes and feed conversions are presented in Table 1. Performance was similar for cracked corn fed in a mixed ration or separately from the other ingredients as well as for whole corn fed mixed. There were non-significant reductions in gain and feed efficiency when whole corn was fed separately from the other ingredients. When corn DM mixing and cracking charges were included ($.20/cwt for either charge), total feed costs/lb of gain were similar for all rations. Although the ingredients other than corn were always mixed in this trial, eliminating all mixing charges for the ration with whole corn fed separately would make this a very competitive option. Thus farmers and ranchers who do not have corn processing or feed mixing equipment can expect to obtain competitive rates and costs of gain by feeding whole corn separately from forage components in calf growing rations designed to produce daily gains of 2.5 to 2.75 lb/day.

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Influence of Diet on Total and Acid Resistant *E. coli* and Colonic pH

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Manipulation of finishing diets does not reduce shedding of acid-resistant *Escherichia coli* in feces; however, short duration hay feeding reduces acid-resistant *E. coli* shedding in the feces.

Summary

Nine steers were fed finishing diets in a replicated 3x3 Latin square design to determine if dietary manipulation would alter total and acid resistant E. coli *populations. Manipulating diet by limit-feeding of finishing diets did not affect total or acid-resistant* E. coli *populations. Altering dietary ingredients did not affect total* E. coli *populations; however, steers fed diets containing dry-rolled or high-moisture corn had lower acid-resistant* E. coli *populations. Following completion of the Latin Square, all animals were fed alfalfa hay ad libitum for five days. Switching steers to alfalfa hay lowered both total and acid-resistant* E. coli *populations.*

Introduction

The bacterium *Escherichia coli* is a normal inhabitant of the intestinal tracts of human beings and animals. However, some strains of *E. coli* — for example, serotype O157:H7 — are capable of causing disease in humans. In cattle, *E. coli* O157:H7 is carried in the gastrointestinal tract and is shed in the feces while the animal shows no signs of disease. The organism is thought to enter the food chain through fecal contamination of the hide during slaughter. Two important features of *E. coli* O157:H7 are its low infective dose and acid resistance. The low infective dose for humans, coupled with the fact that complete prevention of microbial contamination at slaughter is not feasible, has lead to the development of the concept that food-borne illness might best be prevented by reducing pathogen prevalence in livestock, a concept also known as pre-harvest food safety.

Recently, short-duration hay feeding was suggested as a viable pre-harvest food safety technique (Diez-Gonzalez, et al., 1998, Science, 281:1578). When animals that had been consuming grain were fed hay for four days, the prevalence of both generic and acid-resistant *E. coli* was reduced. High grain diets allow undigested starch to accumulate in the colon. Accumulated starch is subsequently fermented resulting in volatile fatty acid production, an acidic pH, and facilitated growth of acid-resistant *E. coli*. The resulting hypothesis is that reducing the starch load in the colon will significantly reduce the numbers of *E. coli* O157:H7.

Regardless of the potential benefits of hay feeding, it is not a practical approach for cattle feeders. However, if the amount of starch being fermented in the colon is the key to reducing the prevalence of *E. coli*, there may be alternative means to achieve the same results. Wet corn gluten feed and high-moisture corn are two common dietary ingredients that offer opportunities to achieve similar results as observed with hay feeding. Wet corn gluten feed contains little or no starch and is 80% digestible in the rumen. Therefore, feeding wet corn gluten feed should reduce the starch load in the colon since material bypassing digestion in the rumen would be fibrous corn bran as opposed to starch. High-moisture corn is more extensively degraded in the rumen than dry-rolled corn. Therefore, comparatively less starch bypasses digestion in the rumen when feeding high-moisture corn. The net effect of replacing dry-rolled corn with wet corn gluten feed or high-moisture corn would be reduced starch load in the colon.

Therefore, our hypothesis for this study was by manipulating the finishing diet, the amount of starch being fermented in the colon would decrease, thereby increasing colonic pH and decreasing the number of acid-resistant *E. coli*. Also, it was hypothesized that limit-feeding of finishing diets may offer an alternative means of reducing acid-resistant *E. coli.* Limit-feeding of finishing diets should result in less fermentation in the colon (increased colonic pH) because of more complete digestion in the rumen due to slower rate of passage, increased retention time and increased extent of digestion.

Procedure

Experiment 1

Nine steers were fed finishing diets in a replicated 3 x 3 Latin square design. Treatments were finishing diets (Table 1) based on dry-rolled corn (DRC), high-moisture corn (HMC), or wet corn gluten feed (WCGF). Diets were formulated to contain a minimum of 12.5% CP, .7% Ca, .35% P, .6% K, and included 25 g/ton Rumensin and 10 g/ton Tylan.

Each period was 21 days in duration. During days 1-9 of each period, steers were fed at 1.8% of body weight (DM basis). Intake for each subsequent period was adjusted based on weights taken at the end of each 21-day period. Steers were allowed to consume feed ad libitum during days 10-21 of each period. Samples of colonic digesta were obtained on days 9, 20 and 21 and analyzed for volatile fatty acid concentration (analyses not completed; therefore, data not shown), pH and numbers of total and acid-resistant *E. coli*.

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Experiment 2

Upon completion of the final period of the 3 x 3 Latin Square, the nine steers were fed alfalfa hay ad libitum, allowing three steers each previously being fed dry-rolled corn, wet corn gluten feed, or high-moisture corn to be observed after short duration hay feeding. Samples of colonic digesta were obtained on two consecutive days following five days of hay feeding and analyzed for volatile fatty acid concentration (analyses not completed; therefore, data not shown), pH, and numbers of total and acid-resistant *E. coli*.

Results

Experiment 1

The effects of diet on DMI, most probable number (MPN) of total and acid-resistant *E. coli*, and colonic pH are shown in Table 2. During the period when steers were being limit-fed, neither total nor acid-resistant *E. coli* counts were statistically different among the three treatments; however, colonic pH was higher ($P < .10$) in steers fed WCGF than in steers fed DRC or HMC. There was no treatment effect on DMI when steers were switched to ad libitum feeding. Total *E. coli* numbers were similar among treatments. Steers consuming DRC or HMC had significantly lower ($P < .10$) acid-resistant *E. coli* numbers than steers consuming WCGF. Colonic pH was higher in steers fed WCGF or HMC ($P < .10$) than in steers fed DRC.

Our interpretation is that acid-resistant *E. coli* numbers can not be reduced through either limit-feeding or this type of dietary manipulation. However, feeding WCGF did increase colonic pH in steers during both the limit-feeding period and the ad libitum feeding period. Wet corn gluten feed is very low in starch concentration, but it does not appear that lowering the amount of starch reaching the colon will reduce acid-resistant *E. coli* numbers. Likewise, even though HMC is more extensively degraded in the rumen and colonic pH increased during ad libitum feeding compared to DRC, there was no reduction in

Table 1. Composition of finishing diets.

	Treatment[a]		
Ingredient (% of DM)	DRC	HMC	WCGF
Dry-rolled corn	84.707	33.773	40.832
High-moisture corn	——	50.866	——
Wet corn gluten feed	——	——	45.000
Alfalfa hay	7.500	7.500	7.500
Molasses	5.000	5.000	5.000
Limestone	1.338	1.337	1.304
Urea	.952	1.019	——
Salt	.300	.300	.300
Dicalcium phosphate	.107	.108	——
Potassium chloride	.032	.033	——
Trace mineral	.020	.020	.020
Rumensin premix	.016	.016	.016
Vitamin premix	.015	.015	.015
Tylan premix	.013	.013	.013

[a]DRC = dry-rolled corn; HMC = high-moisture corn; WCGF = wet corn gluten feed.

Table 2. Effect of diet on DMI and MPN of total and acid-resistant *E. coli*.

	Treatment[a]			
Item	DRC	HMC	WCGF	SEM
Limit-fed period[b]				
Total *E. coli*, $\log_{10}$[c]	7.87	8.54	8.50	.28
Acid-resistant *E. coli*, $\log_{10}$[d]	2.61	4.52	4.24	.77
Colonic pH	6.42[e]	6.61[e]	6.85[f]	.12
Ad libitum period[g]				
DMI, lb/day	18.69	18.03	18.88	.62
Total *E. coli*, $\log_{10}$[c]	8.25	8.45	8.46	.21
Acid-resistant *E. coli*, $\log_{10}$[d]	3.04[e]	3.24[e]	3.71[f]	.47
Colonic pH	6.21[e]	6.55[f]	6.68[f]	.14

[a]DRC = dry-rolled corn; HMC = high-moisture corn; WCGF = wet corn gluten feed.
[b]Limit-fed period = days 1-9.
[c]MPN = most probable number of total *E. coli* is expressed in $\log_{10}$ units.
[d]MPN = most probable number of acid-resistant *E. coli* is expressed in $\log_{10}$ units.
[ef]Means within a row with unlike superscripts differ ($P < .10$).
[g]Ad libitum period = days 10-21.

Table 3. Effect of hay feeding on MPN of total and acid-resistant *E. coli*.

	Treatment[a]			
Item	DRC	HMC	WCGF	SEM
Total *E. coli*, $\log_{10}$[b]	7.13	6.89	6.89	.34
Acid-resistant *E. coli*, $\log_{10}$[c]	1.70	1.00	1.33	.29
Colonic pH	8.00	7.86	7.96	.06

[a]DRC = dry-rolled corn; HMC = high-moisture corn; WCGF = wet corn gluten feed.
[b]MPN = most probable number of total *E. coli* is expressed in $\log_{10}$ units.
[c]MPN = most probable number of acid-resistant *E. coli* is expressed in $\log_{10}$ units.

Table 4. Effect of feeding alfalfa hay versus a finishing diet on MPN of total and acid-resistant *E. coli*.

	Treatment[a]		
Item	ALF	FIN	SEM
Total *E. coli*, $\log_{10}$[b]	6.97[c]	7.95[d]	.20
Acid-resistant *E. coli*, $\log_{10}$[e]	1.34[c]	3.99[d]	.33
Colonic pH	7.94[c]	6.52[d]	.14

[a]ALF = alfalfa hay; FIN = finishing diet.
[b]MPN = most probable number of total *E. coli* is expressed in $\log_{10}$ units.
[cd]Means within a row with unlike superscripts differ ($P < .01$).
[e]MPN = most probable number of acid-resistant *E. coli* is expressed in $\log_{10}$ units.

acid-resistant *E. coli* counts. Similarly, limit-feeding of the finishing diets did not alter acid-resistant *E. coli* numbers in comparison to ad libitum feeding. Potentially, one could limit intake more and possibly reduce acid-resistant *E. coli*; however, the reduced intake would impact daily gain and potentially carcass merit.

Experiment 2

The effect of switching steers to alfalfa hay for five days is shown in Table 3. Total *E. coli* counts were similar among treatments; however, counts were reduced from previously observed counts in Period 3 by .5, 1.27, and 1.16 $\log_{10}$ units for DRC, HMC, and WCGF, respectively. Similarly, there were no differences in acid-resistant *E. coli* counts among the treatments; however, counts were reduced from those previously observed in Period 3 by 2.35, 2.58, and 3.01 $\log_{10}$ units for DRC, HMC, and WCGF, respectively. These numbers indicate irrespective of diet, acid-resistant *E. coli* numbers were reduced when steers were fed alfalfa hay ad libitum for a period of five days.

Since there were no significant differences among DRC, HMC, or WCGF finishing diets when switched to alfalfa hay feeding, data were pooled to illustrate the effect of feeding alfalfa hay versus feeding finishing diets on the MPN of total and acid-resistant *E. coli* and colonic pH (Table 4). Switching steers to alfalfa hay lowered ($P < .01$) both total and acid-resistant *E. coli*. Total *E. coli* numbers were lowered by about 1 $\log_{10}$ unit while acid-resistant *E. coli* numbers were lowered by about 2.5 $\log_{10}$ units. Colonic pH was increased ($P < .01$) by over 1 pH unit in response to hay feeding. These data indicate short-duration hay feeding reduced acid-resistant *E. coli* populations in the feces by over 99%.

Dietary manipulation of finishing diets either by substituting ingredients or limit-feeding successfully increased colonic pH, indicating substrate changes at the level of the colon; however, increased colonic pH was not associated with reduced populations of acid-resistant *E. coli*. Feeding alfalfa hay both increased colonic pH and decreased acid-resistant *E. coli*. This study confirms Diez-Gonzalez (1998) report that feeding hay for a short duration can reduce acid-resistant *E. coli* populations.

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Effects of Programmed Gain Feeding Strategies on Performance and Carcass Characteristics of Yearling Steers

Tony Scott
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Terry Mader
Terry Klopfenstein
Simone Holt[1]

Programming gain for the first 21 or 42 days of the feeding period reduced the total amount of feed consumed but did not improve cumulative performance compared with ad libitum feeding.

Summary

Two hundred forty-five crossbred yearling steers were used in a randomized complete block design to determine effects of including a programmed gain phase in the feeding period on performance and carcass characteristics. Including a programmed gain phase in the finishing period resulted in similar cumulative daily gains and feed conversions when compared with steers allowed to consume feed ad libitum. Programming gain reduced the total amount of feed consumed per animal; however, the lack of an improvement in feed conversion coupled with slight numerical differences in hot carcass weights resulted in net profits favoring ad libitum feeding.

Introduction

Previous research regarding controlling intake during the finishing period has focused on maintaining a static intake relative to ad libitum fed control pens. Improvements in efficiency have been demonstrated; however, daily gain may decrease, resulting in increased days on feed. Recent studies (Knoblich, et al., 1997, J. Anim. Sci., 75:3094; Loerch and Fluharty, 1998, J. Anim. Sci., 76:371) have shown similar daily gains, hot carcass weights and days on feed. At the same time, reductions in the amount of feed consumed result in improvements in efficiency.

Currently research on controlling intake during the finishing period has shifted toward programmed gain systems. Programmed gain systems are based on the net energy equations in the NRC (1996). Based on the diet being fed, a programmed rate of gain is selected and the amount of feed required to achieve the programmed rate of gain can be calculated.

In a previous study (1999 Nebraska Beef Report, pp 46-48), programmed

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Table 1. Composition of finishing diet.

Ingredient	% of diet DM
Dry-rolled corn	49
Wet corn gluten feed	40
Corn silage	8
Dry supplement	3

gain strategies were investigated in calves. Since yearlings tend to consume large quantities of feed, the objective of our study was to determine effects of including a programmed gain phase in the finishing period on performance and carcass characteristics of yearling steers.

Procedure

Two hundred forty-five crossbred yearling steers (868 lb) were blocked by weight into seven weight blocks and randomly assigned within block to one of five pens (7 head/pen). Each pen was randomly assigned to one of five treatments based on rate and duration of programmed gain. Control (Ad Lib) steers were allowed ad libitum access to feed for the entire finishing period. Programmed gain treatments were as follows: 2.4 lb/day for 21 days (2.4/21); 2.4 lb/day for 42 days (2.4/42); 2.8 lb/day for 21 days (2.8/21); 2.8 lb/day for 42 days (2.8/42). Following the programmed gain phase (either 21 or 42 days), steers were allowed to consume feed ad libitum. Intake required to achieve the programmed rate of gain was calculated using the net energy equations contained in the NRC (1996) computer model and were adjusted every 7 days.

Adaptation diets contained 57, 44, 32 and 18% corn silage (DM basis). The final diet (Table 1) was formulated to contain a minimum of 13.5% CP, .70% Ca, .35% P and .65% K, and contained 25g/ton Rumensin and 10 g/ton Tylan (DM basis). Steers were implanted with Revalor-S® at the beginning of the trial. Steers were slaughtered when the ad libitum control group was visually estimated to have reached .45 inches of fat over the 12th rib. Following a 24-hour chill, USDA yield grade, marbling score, and 12th rib fat thickness were recorded. Final weights were calculated by adjusting hot carcass weights to a common dressing percentage (63%). In an effort to adjust for gut fill differences, weights of steers consuming feed ad libitum were shrunk 4% to be used in programmed gain period performance calculations.

Results

Cumulative performance and performance during the programmed gain period is shown in Table 2. During the programmed gain period, feeding steers ad libitum resulted in higher (P < .10) feed consumption compared with steers in treatments that included a programmed gain phase. Daily gain was reduced (P < .10) in steers programmed to gain 2.4 or 2.8 lb/day for 21 days compared with steers fed ad libitum or steers programmed to gain 2.4 or 2.8 lb/day for 42 days. Steers fed to gain 2.4 or 2.8 lb/day for 42 days gained more rapidly than predicted while steers programmed to gain 2.4 or 2.8 lb/day for 21 days gained at or near predicted levels. The underprediction of gain is consistent with previous research in that as duration of the programmed gain period increases relative to the entire feeding period, daily gain exceeds predictions. Feed conversion was improved (P < .10) in steers programmed to gain 2.4 or 2.8 lb/day for 42 days compared with steers fed ad libitum or steers programmed to gain 2.4 or 2.8 lb/day for 21 days. Feed conversion was numerically increased in steers programmed to gain 2.4 lb/day for 21 days and increased (P < .10) significantly in steers programmed to gain 2.8 lb/day for 21 days compared with steers offered feed ad libitum.

Over the entire feeding period, feed consumption was higher (P < .10) in steers allowed to consume feed ad libitum throughout the feeding period. Steers programmed to gain 2.4 or 2.8 lb/d for the initial 21 days of the feeding period had similar cumulative DMI and both consumed more feed (P < .10) than steers programmed to gain 2.4 or 2.8 lb/day for the first 42 days. Steers programmed to gain 2.4 lb/day for the initial 42 days of the feeding period consumed less feed (P < .10) than all of the other treatments. Slight numerical differences in daily gain existed among the treatments; however, only steers programmed to gain 2.4 lb/day for the initial 42 days of the feeding period gained slower (P < .10) than steers offered feed ad libitum. There were no differences observed in feed conversion among the treatments. Differences in total feed consumed (lb/head) were reflective of the differences in DMI.

Currently, our hypothesis as to why we have been unable to detect a significant efficiency response in this and a previous trial (1999 Nebraska Beef Report, pp 46-48) is related to the nature of our finishing diets. In both of our programmed gain trials, wet corn gluten feed has been included in the diet at

Table 2. Effect of programmed gain on performance of yearling steers.

	Treatment					
Item	Ad Lib	2.4/21	2.4/42	2.8/21	2.8/42	SEM
Treatment Description						
ADG, lb	Maximum	2.4	2.4	2.8	2.8	
Duration, days	98	21	42	21	42	
Days on feed	98	98	98	98	98	
Pens	7	7	7	7	7	
Initial Wt., lb	868[a]	870[a]	863[b]	868[a]	871[a]	2
Final Wt., lb	1265[a]	1253[a]	1223[b]	1245[a]	1253[a]	9
Programmed Gain Period[c]						
DMI, lb/day	23.63[d]	17.97[e]	17.94[e]	19.55[f]	19.78[f]	.18
ADG, lb	3.34[de]	2.33[f]	3.16[e]	2.44[f]	3.69[d]	.16
Feed/Gain	7.2[d]	8.1[de]	5.7[f]	8.6[e]	5.4[f]	.5
Cumulative Performance						
DMI, lb/day	25.17[d]	24.39[e]	22.22[f]	24.48[e]	23.50[g]	.28
ADG, lb	4.05[d]	3.92[d]	3.67[e]	3.85[d]	3.90[d]	.08
Feed/Gain	6.2	6.2	6.1	6.4	6.1	.1
Total feed, lb/head	2467[d]	2390[e]	2178[f]	2399[e]	2303[g]	27

[ab]Means within a row with unlike superscripts differ (P < .10).
[c]Days 1-21 for Treatments 2 and 4; Days 1-42 for Treatments 1, 3, and 5.
[defg]Means within a row with unlike superscripts differ (P < .10).

Table 3. Effect of programmed gain on carcass characteristics of yearling steers.

	Treatment					
Item	Ad Lib	2.4/21	2.4/42	2.8/21	2.8/42	SEM
Hot carcass weight, lb	785[a]	777[a]	758[b]	772[ab]	777[a]	5
Marbling score[c]	530	529	517	533	531	14
Yield grade	2.47[d]	2.34[de]	2.03[f]	2.24[ef]	2.47[d]	.13
Fat thickness, in	.50[d]	.47[d]	.40[e]	.47[d]	.47[d]	.02
Net profit, $[gh]	(.74)	(4.32)	(8.51)	(8.53)	(1.37)	5.07

[ab]Means within a row with unlike superscripts differ (P<.10).
[c]Marbling score: Small 0 = 500.
[def]Means within a row with unlike superscripts differ (P<.10).
[g]Values used in calculations: purchase price = $75.00/cwt; sales price = $65.00/cwt; yardage = $.30/d; feed cost = $100.00/ton; feed and cattle interest = 10%.
[h]Values in parentheses indicate losses.

relatively high levels (35-40% of DM). In previous studies reporting an efficiency response with programmed gain systems, the finishing diets did not contain byproduct feedstuffs. It has been shown that wet corn gluten feed inclusion in finishing diets helps to alleviate sub-acute acidosis. Part of the efficiency response that has been observed in previous studies could be related to a reduced level of acidosis that would likely accompany the limited amounts of feed offered to programmed gain treatment groups. Consequently, the number and severity of acidosis challenges during the feeding period could be reduced.

Carcass characteristics are shown in Table 3. Hot carcass weights were reduced (P < .10) in steers programmed to gain 2.4 lb/day for the initial 42 days of the feeding period compared with steers offered feed ad libitum, steers programmed to gain 2.4 lb/day for 21 days, or steers programmed to gain 2.8 lb/d for 42 days. There were no differences among the treatments in marbling score. Yield grade was lower (P < .10) in steers programmed to gain 2.4 lb/day for 42 days than in steers offered feed ad libitum, steers programmed to gain 2.4 lb/day for 21 days, or steers programmed to gain 2.8 lb/d for 42 days. Steers programmed to gain 2.4 lb/day for 42 days had less (P < .10) fat over the 12th rib compared with all other treatments. Though there were no significant differences in calculated net profit values, they are reflective of slight differences in hot carcass weight among the treatments. Offering feed ad libitum was calculated to be the most profitable of the feeding systems in this trial. However, in times of high feed costs, differences in the amount of feed consumed per animal may allow producers to effectively and economically utilize programmed gain feeding systems.

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Sorting or Topping-off Pens of Feedlot Cattle

Rob Cooper
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Sorting or topping-off finished cattle within a pen may increase overall pen profitability. Leaner cattle within a pen at slaughter are not necessarily poor performers.

Summary

Two sources of data were analyzed to determine performance differences of cattle with differing degrees of finish within a pen. One source of data was from large-pen commercial feedlots, while the other source of data was from individually fed steers at the University of Nebraska. The results indicate leaner cattle within a pen have lower quality grades and carcass weights, but are gaining faster and more efficiently than their fatter pen-mates at slaughter. Therefore, additional days on feed for the leaner cattle within a pen, in order to increase carcass weight and quality grade, may be economical.

Introduction

In most commercial feedlot situations, large variations exist in animal weight and finish within a pen. A previous marketing project conducted by the University of Nebraska in large-pen commercial feedlots (1999 Nebraska Beef Report, pp. 57-59) found an average of 540 lb variation in final weight and .89 inch variation in 12th rib fat depth within a pen at slaughter. If cattle are sold using a value-based marketing system, sorting or topping-off of cattle in a pen at market time may be beneficial. Sorting off the fatter cattle and marketing them early should help reduce yield grade 4 discounts. Additional time on feed for the remaining cattle in the pen should increase the percentage of carcasses grading USDA Choice and the overall pounds of carcass sold from the pen. Ideally, more pounds of higher grading carcasses would be sold from the pen, resulting in increased profitability.

There are two primary concerns with a system of topping-off pens of finished cattle. The first is the reduced number of cattle occupying a pen after the initial sort. The reduced yardage and efficiency of pen space needs to be weighed against

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the additional profitability of the cattle. The second concern is the quality of cattle remaining in the pen after the first or second sort. These cattle are leaner than pen-mates after the same days on feed. This leads to the questions if these leaner cattle are poor performers. If these cattle are in fact poor performers, then feeding them for additional days may not be economical. We have summarized data from both research and commercial pens of cattle to address this concern.

Procedure

Two sources of data were summarized in order to evaluate performance differences between cattle with differing degrees of finish at market time. One source of data was from large-pen commercial feedlots. Because individual intake and feed efficiencies cannot be determined with the large-pen data, data also were summarized from individually fed finishing steers at the University of Nebraska.

In the large-pen study, eight pens of cattle (1668 total head) in five commercial feedlots in Nebraska were used. Cattle were individually identified and weighed at processing or reimplant time. All pens of cattle were processed and fed according to the respective feedlot's normal procedures. At market time, each pen was sold as an entire pen when each feedlot determined they were finished. Carcass data were gathered on all animals at commercial slaughter facilities. Final weights were determined using carcass weight adjusted to a calculated dressing percentage.

In the individually fed study, 10 research trials were summarized using 431 finishing steers. All steers were individually fed using Calan electronic gates. Trials and treatments within trials were only used if no treatment effects were observed. In all trials at the University of Nebraska, initial weights were measured on two consecutive days. Final weights were calculated using carcass weight adjusted to a calculated dressing percentage.

In both the large-pen and individually fed studies, cattle within a pen or trial, respectively, were ranked by 12th rib fat depth. Cattle then were divided into four groups within each pen or trial. Sort 1 represents the fattest 25% of the cattle, Sort 2 represents the second fattest 25%, Sort 3 represents the third fattest 25%, and Sort 4 represents the leanest 25% of the cattle. Performance and carcass data then were summarized within sort group of each pen or trial. It is important to note that all cattle within a pen or trial were slaughtered at the same time, with the same days on feed. Our objectives were to compare the performance of each sort group and to determine if sorting or topping-off of the pens may have been beneficial. We also wanted to determine if the leanest cattle within a pen are poor performers.

Table 1. Summarized data from large-pen study.

		Sort Group[a]				
	All	1	2	3	4	SEM
Head count	1668	420	419	415	414	—
Fat depth, in.[b]	.42	.62	.46	.36	.23	.04
Processing weight, lb	854	867	860	852	836	27
Carcass wt, lb[b]	769	787	777	764	749	11
Daily gain, lb[c]	3.62	3.46	3.63	3.64	3.77	.15
Yield grade[b]	2.7	3.4	2.8	2.5	2.0	.1
%Choice or higher[b]	46.3	64.0	54.1	39.3	27.6	6.8

[a]All = whole pen averages, 1 = fattest 25% of pen, 2 = second fattest 25%, 3 = third fattest 25% ,and 4 = leanest 25%.
[b]Linear effect across Sort Groups ($P < .01$).
[c]Linear effect across Sort Groups ($P = .16$).

Table 2. Summarized data from individually-fed study.

		Sort Group[a]				
	All	1	2	3	4	SEM
Head count	431	111	109	106	105	—
Fat depth, in.[b]	.40	.57	.43	.34	.25	.03
DM intake, lb[c]	22.4	23.1	22.9	22.0	21.5	.7
Daily gain, lb	3.60	3.57	3.64	3.54	3.97	.28
Feed/gain	6.17	6.45	6.25	6.17	5.85	.01
Adjusted feed/gain[d]	6.22	6.27	6.25	6.29	6.08	—

[a]All = whole trial averages, 1 = fattest 25% of trial, 2 = second fattest 25%, 3 = third fattest 25%, and 4 = leanest 25%.
[b]Linear effect across Sort Groups ($P < .01$).
[c]Linear effect across Sort Groups ($P = .06$).
[d]Feed/gain adjusted to a common .43 inches fat depth.

Results

Results from the large-pen study are shown in Table 1. On average, the eight pens of cattle had a processing weight of 854 lb, were fed for 111 days, and gained 3.62 lb per day. Average carcass characteristics were: 769 lb hot carcass weight, .42 inch 12th rib fat depth, 2.7 yield grade, and 46.3% Choice or higher in quality grade. Feed efficiency is not reported because intake cannot be separated for the respective sort groups. When the data were separated into the four sort groups, average 12th rib fat depths were .62, .46, .36, and .23 inches for Sorts 1, 2, 3 and 4, respectively. Processing weight numerically decreased, while carcass weight, yield grade and percentage Choice decreased linearly ($P < .01$) from Sort 1 to 4. However, average daily gain numerically increased ($P = .16$) from Sort 1 to 4.

The results for the individually fed study are shown in Table 2. On average, the 431 individually fed steers consumed 22.4 lb of feed (DM basis), gained 3.60 lb per day, with a feed conversion of 6.17. When the data were separated into the four sort groups, 12th rib fat depth was .57, .43, .34, and .25 inch for Sort 1, 2, 3, and 4, respectively. Dry matter intake decreased linearly ($P = .06$) from Sort 1 to 4. Average daily gain was not different ($P = .67$) across sort groups.

Feed conversion numerically decreased (P = .22) from Sorts 1 through 4.

Both the large-pen and individually fed studies provide useful information concerning sorting of finished feedlot cattle. The results from the large-pen study suggest leaner cattle within a pen were lighter weight going on feed and at market time. The leaner cattle may have received a premium for yield grade, but would have received substantial discounts for quality grade. Although feed efficiency cannot be calculated, the average daily gains suggest it may have been profitable to feed the leaner groups of cattle for additional days. The results of the individually fed study provides information regarding the feed efficiencies of leaner cattle within a pen. Leaner cattle at slaughter tended to be more efficient, which is logical because fat takes more energy to deposit than lean tissue.

It is important to note although feed efficiency of leaner cattle is greater than their fatter pen-mates at slaughter, the feed efficiency of these leaner cattle will decrease if they are fed longer. In order to estimate the magnitude of this decrease, we summarized data from 57 pens of cattle which were randomly slaughtered at two time points. These data include pens of calf-fed and yearling steers and heifers. On average, cattle were slaughtered at 87 and 124 days on feed. Twelfth rib fat depths were .35 and .46, respectively, resulting in .003 inch/day rate of fattening. Feed/gain was 7.44 and 7.58, respectively. We calculate that whole feeding period feed/gain would increase by .171% or .013 units per one hundredth inch increase in fat depth. Based on these data, whole feeding period feed/gain would increase by .36% or .03 units per additional week on feed.

Adjusted feed conversions for the individually fed study are shown in Table 2. We chose .43 inches fat depth of group 2 as the target and adjusted feed conversion of the other groups, based on the calculations above, as if they had been sorted and fed for different days in order to achieve this fat depth. Based on our calculated rate of fattening, group 1 would have been marketed approximately 47 days prior to group 2, while groups 3 and 4 would have been fed for 30 and 60 days longer than group 2, respectively. The overall feed/gain for the entire pen increased from 6.17 to 6.22. However, assuming same intakes, 36 more live lb per animal in the entire pen would be sold. In addition, averaged across the pen, cattle grading Choice or better would increase by 10 percentage units (2000 Nebraska Beef Report, pp. 20-22).

Overall conclusions are that leaner cattle within a pen are likely performing better than their fatter pen-mates at slaughter, and therefore, may benefit from additional days on feed. In these two data sets, the leanest cattle within a pen do not appear to be poor performers. Therefore, sorting or topping-off a pen a cattle at market time should increase the overall return for the pen if they are sold on a value based marketing system.

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Growth Implants for Heifers

Terry Mader[1]

> Synovex® Plus™ improves gain and efficiency in feedlot heifers.

Summary

In a 110-d experiment, feedlot heifers (mean initial weight = 820 lb) that received an estradiol benzoate (EB) + trenbolone acetate (TBA) implant, Synovex® Plus™, gained faster and more efficiently than sham-implanted (control) heifers. Heifers that received only TBA implants had lower intakes and lower quality grades than control heifers, but were more efficient in feed conversion than control and EB implanted heifers. On the basis of improved yield grade and larger ribeye areas, along with no increases in fatness, the combined use of EB and TBA provided for greater quantities of lean meat from higher priced cuts than did control or other implant groups.

Introduction

The use of products that promote growth through hormonal activity has received much attention in recent years. Trenbolone acetate (TBA), a synthetic anabolic androgen, stimulates growth and enhances feed efficiency as do implants that have estrogenic activity (Ralgro®, Synovex®-S, Implus® and Compudose®). However, because androgenic and estrogenic products tend to have different mechanisms of action, the combination of TBA and estrogen have been shown to act additively. Synovex® Plus™, a combination product containing 28 mg estradiol benzoate (EB) and 200 mg TBA, has been shown to be an effective implant in steers, particularly when used in feedlot cattle about 100 days prior to slaughter. The objective of this study was to evaluate Synovex® Plus™ for use in feedlot heifers.

Procedure

Three hundred fourteen British x continental crossbred heifers were purchased in early July. Cattle were immunized against *Clostridial* diseases and *Haemophilus somnus* (Fermicon 7/Somnugen™) and bovine rhinotracheitis/parainfluenza$_3$/respiratory syncytial virus (BRSV Vac®), dewormed with fenbendazole (Safe-Guard® pellets), treated for external parasites (Tiguvon®), checked for pregnancy and examined for the presence of previous implants. Twenty-six animals were excluded from the pool of animals for any one or more of the following reasons: 1) too heavy or

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too light for the preferred weight range, 2) signs of injury or disease (pinkeye, BVD, etc.) 3) the animal had short ears, 4) the animal was a freemartin, 5) breed type was not appropriate (dairy cross), and 6) animals were randomly excluded. Heifers (288) were assigned to one of nine weight blocks. Within block, heifers were stratified by weight and randomly allocated to four pens which were randomly assigned the following treatments: 1) control (sham implanted); 2) 28 mg estradiol benzoate (EB); 3) 200 mg trenbolone acetate (TBA); and 4) Synovex® Plus (28 mg EB + 200 mg TBA).

On the day the trial began (d 0), heifers were weighed, implanted according to treatment assignment, and placed in designated pens. Initial weight was based on the average of weights taken over two consecutive days. During the receiving period, heifers were stepped up to finishing feedlot diets. At the start of the study, heifers were fed a 62.1 NEg Mcal/cwt diet, which subsequently was adjusted to a 65.0 NEg Mcal/cwt finishing diet which contained (DM basis): 7% alfalfa hay, 85% dry rolled corn, 3% soybean meal and 5% liquid supplement. Diets contained (DM basis) 13.4% crude protein. No ionophores or antibiotics were fed. During the trial, one heifer implanted with TBA died of bloat. At the end of the 110-d feeding period, heifers were weighed and shipped for slaughter. Liver abscess scores, masculinity scores, and hot carcass weights were recorded the day of slaughter. Additional carcass data were obtained after a 24-h chill. Adjusted final weights used for performance calculations were computed from hot carcass weight, assuming a 62% dressing percentage.

Data were analyzed as a randomized complete block design using analysis of variance procedures with weight block and implant treatment as independent variables in the model. Protected LSD's were used as the mean separation technique.

Table 1. Summary of heifer performance over a 110-day feeding trial comparing implant treatments.[a]

Item	Control	EB	TBA	EB + TBA
No. head	72	72	71	72
No. pens	9	9	9	9
Initial wt., lb	822	821	819	816
Average daily gain, lb/day[b]	2.78[c]	2.90[c,d]	2.98[d]	3.06[d]
DM intake (DMI), lb/day[b]	20.08[d]	20.07[d]	19.25[c]	19.90[c,d]
Feed efficiency, DMI/gain[f]	7.25[e]	6.92[d,e]	6.49[c]	6.52[c,d]
Final wt., lb[b]	1129[c]	1142[c,d]	1148[d]	1157[d]

[a]Control heifers were sham implanted, EB = 28 mg estradiol benzoate and TBA = 200 mg trenbolone acetate.
[b]Adjusted to a common dress of 62%
[c,d,e]Means with different superscripts differ ($P < .10$)
[f]DMI/gain was analyzed as gain/DMI.

Table 2. Summary of heifer carcass data comparing implant treatments.

Item	Control	EB	TBA	EB + TBA
Hot carcass weight, lb	700[b]	708[b,c]	712[c]	718[c]
Actual dress, %	62.2	62.1	62.2	62.7
KPH fat, % of carcass	2.19[c]	2.06[b]	2.05[b]	2.06[b]
Ribeye area, in^2	13.0[b]	13.4[b,c]	13.5[c]	14.0[d]
Estimated fat thickness, in	0.49	0.50	0.51	0.48
Marbling score[e]	507[c]	452[b]	447[b]	442[b]
Choice + Prime, %[f]	86.2	72.2	67.6	73.2
Color score[g]	4.96	4.82	4.74	4.97
Masculinity score[h]	4.85	4.92	4.88	4.86
Final yield grade[i]	2.66[c]	2.58[b,c]	2.55[b,c]	2.37[b]
Liver abscesses, %	5.6	9.7	19.7	13.9

[a]Control heifers were sham implanted, EB = 28 mg estradiol benzoate and TBA = 200 mg trenbolone acetate.
[b,c,d]Means with different superscripts differ ($P < .10$).
[e]Marbling score of 400 = Small, 500 = Modest, 600 = Moderate.
[f]TBA significantly different than control ($P < .10$) based on Chi-square analysis.
[g]Color score of 4 = light cherry red, 5 = cherry red, 6 = dark red.
[h]Masculinity score of 1 = least masculine, 9 = most masculine
[i]Final yield grade = 2.50 + (2.50 x estimated fat thickness) + (.20 x percent KPH) + (.0038 x hot carcass weight) - (.32 x ribeye area).

Results

Heifers that received TBA or Synovex® Plus™ had greater ($P < .10$) gains and final weights than control heifers (Table 1). Dry matter intakes (DMI) by TBA-implanted heifers were lower ($P < .10$) than DMI by control and EB-implanted heifers. Compared to controls, all implanted heifers had lower feed to gain ratios ($P < .10$). However, heifers implanted with only TBA had lower ($P < .10$) feed to gain ratios than heifers implanted with only EB.

Implanted heifers had lower ($P < .10$) % KPH and marbling scores than control heifers (Table 2), while heifers implanted with TBA or Synovex® Plus™ had greater ($P < .10$) ribeye areas than control heifers. Heifers that received only TBA had lower quality grade (% Choice and Prime) than control heifers. Ribeye color and masculinity scores did not differ between control and implanted heifers. Only heifers implanted with Synovex® Plus™ had lower yield grade than control heifers, while heifers receiving only TBA implants tended to have a greater incidence of liver abscesses than control heifers. This is opposite to trends found in a previous study (1996 NE Beef Report, pp. 71) in which non-implanted cattle tended to have a greater incidence of liver abscesses than implanted cattle. The greater overall incidence of liver abscesses could likely be attributed to the absence of a feed-grade antibiotic fed to control abscesses. Data suggest Synovex® Plus™ implants effectively improve gain and feed efficiency in crossbred feedlot heifers without significantly altering color or masculinity score.

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Delayed Implant Strategies Using Synovex® Plus™ on Performance and Carcass Characteristics in Finishing Yearling Steers

Todd Milton
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Implanting with Synovex Plus on day 35 resulted in performance and carcass characteristics similar to using Ralgro initially followed by Synovex Plus on day 70 in feedlot steers fed 152 days.

Summary

This experiment evaluated delayed single-dose Synovex Plus implant or reimplant strategies using Ralgro and Synovex Plus or Synovex S. Delaying Synovex Plus until day 35 produced similar performance and carcass characteristics as Synovex Plus initially or Ralgro initially followed by Synovex Plus on day 70. Delaying Synovex Plus until day 70 reduced gain, but efficiency was similar to other Synovex Plus strategies. Two doses of Synovex S increased marbling, but efficiency declined 4% compared with implant strategies using Synovex Plus.

Introduction

The use of low-dose estrogenic implants followed by a terminal implant containing a combination of estrogen and trenbolone acetate 70 to 90 days before slaughter have become common practice in feedlots. Based on large pen data, these implant strategies reduce the incidence of social challenges, such as bullers, compared with the administration of a single combination implant initially. Daily gain and feed efficiency appear to be enhanced with this reimplant strategy compared to a single combination implant. Another successful implant strategy has been delaying administration of a single combination implant until cattle have reached maximum or near maximum energy consumption and established a social order within the pen. With delayed strategies, cattle are usually administered the implant about 100 days before slaughter or after 20 to 40 days on feed, whichever occurs first. However, the optimal time for the delayed administration of a single combination implant has not been investigated in great detail. The objectives of this experiment were to: 1) compare single implant strategies using Synovex® Plus™ versus a reimplant strategy using Ralgro® and Synovex Plus, 2) evaluate time of Synovex Plus administration in a single implant strategy, and 3) compare a reimplant strategy using only Synovex® S versus a single administration of Synovex Plus and a reimplant strategy using Ralgro and Synovex Plus in finishing steers fed 150 days.

Procedures

Two hundred twenty-five steers (665 lb) were used in a randomized complete block design to evaluate the effect of delayed implant strategies using Synovex® Plus< on performance and carcass characteristics in finishing steers. Steers were blocked by body weight into five weight replicates. Within each replicate, steers were stratified by body weight to one of five pens. Pens were randomly assigned to one of five implant strategies: 1) Synovex Plus (**Syn-Plus**) on day one, 2) Syn-Plus on day 35, 3) Syn-Plus on day 70, 4) Ralgro on day one followed by Syn-Plus on day 70 (**Ral-Plus**), or 5) Synovex S (**Syn-S**) on day one and 70.

The corn-based finishing diet contained 45.2% high-moisture and 19.3% dry-rolled corn (70:30 combination), 20% wet corn gluten feed, 7.5% alfalfa hay, 3% tallow, and 5% milled supplement (DM basis; Table 1). The final finishing diet was formulated to contain 13% crude protein (minimum of 6.8% degradable intake protein), .7% calcium, .43% phosphorus, .60% potassium, 27 g/t Rumensin® and 10 g/t Tylan® (DM basis). Steers were acclimated to the final diet in 17 days using four step-up diets that contained 45, 35, 25 and 15% alfalfa hay (DM basis), replacing equal proportions of high-moisture and dry-rolled corn from the final diet formulation. Steers were fed once daily and allowed ad libitum access to feed and water.

Initial weights were the average of two consecutive early morning weights taken prior to feeding. Interim body weights were taken at reimplanting dates,

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Table 1. Finishing diet and ingredient composition.

Item	% of Dry Matter
Ration ingredient composition	
High-moisture corn	45.2
Dry-rolled corn	19.3
Wet corn gluten feed	20.0
Alfalfa hay	7.5
Tallow 3.0	
Supplement	5.0
Supplement composition	
Fin ground corn	44.92
Limestone	29.70
Urea	9.98
Sodium chloride	6.00
Ammonium chloride	5.00
Potassium chloride	.60
Tallow	2.00
Trace mineral premix	1.00
Vitamin premix	.20
Rumensin-80	.34
Tylan-40	.26
Ration nutrient composition[a]	
Crude protein, %	13.0
NE_m, Mcal/lb	94.6
NE_g, Mcal/lb	64.2
Calcium, %	.70
Phosphorous, %	.43
Potassium, %	.60

[a] Ration nutrient composition based on NRC values for ration ingredients.

Table 2. Effect of implant strategy on interim performance of finishing steers.

Item	Implant Strategy[a]						Contrast P values[d]			
	Plus-0	Plus-35	Plus-70	Ralgro/ Plus	Syn-S/ Syn-S	SEM[b]	F-test[c]	TBA vs E2 only	Linear TBA	Quad TBA
Day 1-70										
DM intake, lb/day	23.3[e]	23.3[e]	22.3[f]	23.4[e]	23.4[e]	.28	.05	.40	.02	.17
Daily gain, lb	4.99[e]	4.81[e]	3.84[f]	4.32[g]	4.51[g]	.10	<.01	.87	<.01	.01
Feed/gain	4.68[e]	4.85[e]	5.81[f]	5.44[g]	5.19[h]	.10	<.01	.93	<.01	.01
Day 70-152										
DM intake, lb/day	25.3[eg]	25.6[e]	23.9[f]	24.5[fg]	24.9[eg]	.35	.03	.95	.01	.03
Daily gain, lb	3.07[e]	3.47[fi]	3.80[gh]	3.67[fh]	3.29[i]	.08	<.01	.04	<.01	.75
Feed/gain	8.24[e]	7.40[f]	6.32[g]	6.70[h]	7.57[f]	.13	<.01	.01	<.01	.47

[a]Plus-0, Plus-35, Plus-70=implanted with Synovex Plus on day 0, 35, or 70, respectively; Ralgro/Plus=implanted with Ralgro on day 0 and reimplanted with Synovex Plus on day 70; Syn-S/Syn-S=implanted with Synovex S on days 0 and 70.
[b]SEM= Standard error of the mean.
[c]Overall F-test for treatment.
[d]TBA vs E2=average of steers implanted with Synovex Plus versus steers implanted with Synovex S; Linear TBA=linear effect of Synovex Plus administered on day 0, 35, or 70; Quad=quadratic effect of Synovex Plus administered on day 0, 35, or 70.
[e,f,g,h,i]Means in the same row not bearing a common superscript differ ($P < .10$).

Table 3. Effect of implant strategy on performance of finishing steers fed 152 days.

Item	Implant Strategy[a]						Contrast P values[d]			
	Plus-0	Plus-35	Plus-70	Ralgro/ Plus	Syn-S/ Syn-S	SEM[b]	F-test[c]	TBA vs E2 only	Linear TBA	Quad TBA
Live Performance										
Initial wt, lb	665	666	664	666	664	.94	.51	.42	.66	.27
Final wt.[e], lb	1266[gi]	1286[gh]	1244[i]	1268[hi]	1249[i]	10.2	.07	.16	.15	.02
DM intake, lb/day	24.4[g]	24.6[g]	23.2[h]	24.0[gh]	24.2[g]	.30	.04	.69	.01	.05
Daily gain, lb	3.96[gh]	4.08[h]	3.82[g]	3.96[gh]	3.85[g]	.07	.08	.18	.16	.03
Feed/gain	6.17[gh]	6.02[g]	6.08[g]	6.07[g]	6.28[h]	.06	.08	.01	.31	.20
Carcass Adjusted Performance										
Final wt.[f], lb	1264[gi]	1274[gh]	1236[i]	1261[hi]	1242[i]	10.8	.12	.18	.08	.09
Daily gain, lb	3.95[gh]	4.01[g]	3.77[i]	3.92[gh]	3.80[hi]	.07	.13	.19	.08	.10
Feed/gain	6.18[g]	6.14[g]	6.15[g]	6.14[g]	6.37[h]	.07	.14	.02	.78	.71

[a]Plus-0, Plus-35, Plus-70=implanted with Synovex Plus on day 0, 35, or 70, respectively; Ralgro/Plus=implanted with Ralgro on day 0 and reimplanted with Synovex Plus on day 70; Syn-S/Syn-S=implanted with Synovex S on days 0 and 70.
[b]SEM= Standard error of the mean.
[c]Overall F-test for treatment.
[d]TBA vs E2=average of steers implanted with Synovex Plus versus steers implanted with Synovex S; Linear TBA=linear effect of Synovex Plus administered on day 0, 35, or 70; Quad=quadratic effect of Synovex Plus administered on day 0, 35, or 70.
[e]Final live weight pencil shrunk 4%.
[f]Final live weight calculated as hot carcass weight divided .63.
[g,h,i]Means in the same row not bearing a common superscript differ ($P < .10$).

including steers not receiving an implant, and on day 105. Final 152-day body weights were determined as the average of two consecutive early morning weights taken prior to feeding and pencil shrunk 4%. Additionally, final weights were calculated using hot carcass weight adjusted to a common dressing percentage (63). Steers were slaughtered at a commercial packing facility and carcass characteristics were evaluated following a 24-hour chill. Carcass measurements included: hot carcass weight, dressing percentage, marbling score, KPH fat, 12th rib fat thickness, longissimus muscle area, overall maturity score and incidence of abscessed livers.

The data were analyzed using the General Linear Model of SAS as a randomized complete block design. Treatment means were separated by the LSMEANS procedure with a protected (significant) F-test. Independent contrasts were conducted to compare linear and quadratic effects of the timing of Syn-Plus administration and the average of those treatments using Syn-Plus compared with the reimplant strategy of Syn-S. Percentages of carcasses grading USDA Choice and liver abscesses were analyzed using the Frequency procedure of SAS. Variables were considered significant when $P < .10$. Pen means were regressed against time on feed and Syn-Plus administration using a quadratic model to estimate the optimal implant time when using Syn-Plus as a single-delayed implant strategy. Optimal implant timing was determined by calculating the point where the first derivative of the quadratic equation was zero.

Results

The effects of implant strategy on interim and overall performance are presented in Tables 2 and 3. During the first 70 days on feed, delaying the administration of Syn-Plus resulted in a linear

Table 4. Effect of implant strategy on carcass characteristics of finishing steers fed 152 days.

Item	Implant Strategy[a] Plus-0	Plus-35	Plus-70	Ralgro/ Plus	Syn-S/ Syn-S	SEM[b]	Contrast P values[d] F-test[c]	TBA vs E2 only	Linear TBA	Quad TBA
Hot carcass wt, lb	797[km]	802[k]	779[l]	794[kl]	783[lm]	6.8	.12	.18	.08	.09
Dressing percent	62.9	62.4	62.6	62.7	62.6	.33	.85	.95	.53	.35
Longissimus muscle area										
sq. in.	13.8[km]	14.0[k]	13.9[k]	13.5[lm]	13.2[l]	.17	.01	<.01	.53	.40
sq. in./cwt HCW	1.73[k]	1.74[kl]	1.79[l]	1.70[k]	1.69[k]	.02	.05	.06	.08	.53
KPH[e] fat, %	2.50	2.41	2.46	2.48	2.47	.03	.44	.84	.56	.09
Yield grade[f]	2.81[k]	2.60[l]	2.52[m]	2.77[kl]	2.93[kl]	.09	.03	.02	.03	.54
12th rib fat, in.	.48[k]	.42[l]	.42[l]	.43[kl]	.47[k]	.02	.12	.12	.05	.28
Marbling score[g]	5.13	5.12	5.10	5.08	5.33	.12	.55	.10	.85	.96
Maturity score[h]	1.57[k]	1.55[k]	1.50[lm]	1.55[k]	1.54[km]	.02	.01	.73	.01	.45
USDA Choice[i], %	68.9	61.4	55.5	61.4	80.0					
Abscessed livers[j], %	13.3	6.8	20.0	8.9	6.7					

[a]Plus-0, Plus-35, Plus-70=implanted with Synovex Plus on day 0, 35, or 70, respectively; Ralgro/Plus=implanted with Ralgro on day 0 and reimplanted with Synovex Plus on day 70; Syn-S/Syn-S=implanted with Synovex S on days 0 and 70.
[b]SEM= Standard error of the mean.
[c]Overall F-test for treatment.
[d]TBA vs E2=average of steers implanted with Synovex Plus versus steers implanted with Synovex S; Linear TBA=linear effect of Synovex Plus administered on day 0, 35, or 70; Quad=quadratic effect of Synovex Plus administered on day 0, 35, or 70.
[e]KPH=kidney, pelvic, and heart.
[f]Calculated using hot carcass weight, fat thickness, KPH fat, and ribeye area.
[g]5.0=Small 0; 5.5=Small 50, etc.
[h]1.0=A^0; 1.5=A^{50}, etc.
[i]Chi square statistic (P = .40).
[j]Chi square statistic (P = .22).
[k,l,m]Means in the same row not bearing a common superscript differ (P < .10).

(P = .02) decline in dry matter intake (Table 2). Delaying the administration of Syn-Plus resulted in quadratic (P = .01) response for daily gain and feed efficiency. Daily gain and feed efficiency were similar when steers were implanted with Syn-Plus on day 0 or 35, but improved compared with those receiving Syn-Plus on day 70. This is to be expected since steers allotted to receive Syn-Plus on day 70 had not yet been implanted. Steers implanted with Syn-Plus on day 0 or 35 gained 10% faster and were 11% more efficient compared with those implanted with Ralgro or Syn-S on day 0 (P < .10). Compared within steers receiving estrogen implants only, those implanted with Syn-S gained 4.3% faster and were 4.8% more efficient compared with those implanted with Ralgro.

During the final 82 days on feed (day 71 until slaughter), delaying the administration of Syn-Plus resulted in a quadratic (P = .03) response in dry matter intake (Table 3). Dry matter intake was similar for steers implanted with Syn-Plus on day 0 or 35, but higher than those implanted with Syn-Plus on day 70. Daily gain and feed efficiency were improved linearly (P < .01) by delaying the administration of Syn-Plus during this phase of the feeding period. Steers implanted with Syn-Plus on day 70 as the only implant during the feeding period were more efficient than all other implant strategies (P < .10). Compared with those implanted with Ral-Plus, steers implanted with Syn-Plus on day 70 only were 5.5% (P < .10) more efficient, while daily gain was similar between these two implant strategies.

Cumulative feedlot performance is presented in Table 3. A quadratic (P = .05) response was observed for dry matter intake with the delayed implant strategies using Syn-Plus. Dry matter intake was reduced when the administration of Syn-Plus was delayed until day 70, whereas dry matter intake was similar between steers implanted with Syn-Plus on day 0 or 35. Additionally, delaying the administration of Syn-Plus to day 70 resulted in lower (P < .10) dry matter intake compared with two doses of Syn-S or Ral-Plus. Based on the cumulative and interim data, it appears that delaying a single implant of Syn-Plus until day 70 does not increase dry matter intake similar to other strategies where implants, regardless of type or dosage, are administered earlier in the feeding period.

In general, the responses in daily gain and feed efficiency were similar among implant strategies when expressed on a live or carcass basis (Table 3). Daily gain of steers implanted with Syn-Plus on day 35 was higher (P < .10) than those implanted with Syn-Plus on day 70, but similar to those implanted with Syn-Plus on day 0 (quadratic, P = .03) and Ral-Plus. Additionally, steers implanted with Syn-Plus on day 0 or 35 or those implanted with Ral-Plus gained 3.8% faster (P < .10; live basis) than those implanted with Syn-S only. Feed efficiency was similar among Syn-Plus implant strategies, but improved 3.7% (P = .01, live basis; P = .02, carcass basis) compared with the implant strategy using Syn-S only.

The effects of implant strategy on hot carcass weight were similar to those observed for daily gain (Table 4). Carcass weights were reduced (quadratic; P = .09) by delaying the administration

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of Syn-Plus until day 70 compared with administration on day 0 or 35. Expressed as square inches (P < .01) or square inches/cwt of hot carcass weight (P = .06), ribeye area was larger for steers implanted with Syn-Plus compared with Syn-S only. Additionally, ribeye area per cwt of hot carcass weight was increased linearly (P = .08) by delaying the administration of Syn-Plus in a single implant strategy. Yield grade (P = .03), 12th rib fat (P = .05), and maturity score (P = .01) were decreased linearly by delaying a single Syn-Plus implant. Steers implanted with two doses of Syn-S had a higher yield grade (P = .02) and marbling score (P = .10) compared with implant strategies using Syn-Plus. Dressing percentage and percentage of USDA Choice carcasses were unaffected by implant strategy. Although no statistical differences were observed, implant strategies using Syn-Plus appeared to have some effect on the percentage of USDA Choice carcasses. Excluding the implant strategy using a single dose of Syn-Plus administered on day 70, the percentage of USDA Choice carcasses was reduced by 16 percentage units compared with the Syn-S strategy. Using a $10 Choice/Select spread, the 14-lb increase in carcass weight offsets the loss in revenue due to the reduction in USDA Choice carcasses. Due to the 3% improvement in feed efficiency, these three implant strategies using Syn-Plus would increase profitability compared with two doses of Syn-S.

Delaying the administration of Syn-Plus until 35 days on feed can be an effective implant strategy in cattle fed about 150 days. Delaying administration until 70 days on feed appears to reduce overall daily gain, but does not compromise feed efficiency. Regression analysis of these data suggested that daily gain would have been maximized if a single administration of Syn-Plus was administered at 29 days on feed (r^2 = .43; live basis) or 23 days on feed (r^2 = .41; carcass basis).

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Effect of *DiaFil* (Diatomaceous Earth) Fed With or Without Rumensin® and Tylan®, on Performance, Internal Parasite and Coccidiosis Control in Finishing Cattle

Todd Milton
Terry Klopfenstein[1]

The addition of 3% diatomaceous earth, *DiaFil*, reduced dietary energy concentration of corn-based finishing diets.

Summary

One hundred seventy-nine steers were used in a 2 × 2 factorial experiment to determine if DiaFil, *diatomaceous earth, enhances finishing performance. Treatments were: control; 3%* DiaFil*; Rumensin® and Tylan® (**R/T**) fed at 25 and 10 g/ton, respectively; or* DiaFil + *R/T (DM basis). Feeding* DiaFil *alone reduced daily gain compared with control and* DiaFil+ *R/T, while gain of steers fed R/T was intermediate. Compared with control, efficiency was reduced 8% when steers were fed* DiaFil *alone. Steers fed R/T or* DiaFil+*R/T were 9% more efficient than those fed* DiaFil *alone. The addition of* DiaFil *alone reduces dietary energy concentration.*

Introduction

DiaFil, diatomaceous silica (CR Minerals Corporation), is thought to have potential benefits as a feed ingredient and/or additive for finishing cattle based on field observations. It has been suggested that inclusion of diatomaceous silica, also referred to as diatomite, into the ration enhances health status and increases weight gain. Diatomite can be used in the human food industries as anti-caking agents and as a mild abrasive in toothpaste. *DiaFil* is comprised of skeletal remains of single-cell aquatic plants consisting of a single size and shape known as *Melosira*, and contains less than .1% crystalline silica. Although informal reports are available, the effect of feeding *DiaFil* to finishing cattle has not been investigated in a controlled research setting. Rumensin®/Tylan® is a feed additive combination widely used in the feedlot industry for improved feed efficiency and control of liver abscesses and coccidiosis. Diatomaceous silica is known to kill insects, but its effects on internal parasites and coccidiosis have not been reported.

The objectives of this experiment were to evaluate the effects of *DiaFil* on performance and carcass characteristics of feedlot cattle fed a corn-based finishing diet with or without Rumensin/Tylan, and determine the effects of *DiaFil* on internal parasites and coccidiosis.

Procedure

One hundred seventy-nine yearling steers (838 lb) were stratified by weight to one of four treatments in a completely randomized design with a 2 × 2 factorial arrangement of treatments (4 pens per treatment, 11 or 12 steers per pen). Dietary treatments were: control (no *DiaFil* or Rumensin/Tylan); *DiaFil* fed at 3% of the dietary DM; Rumensin and Tylan (**R/T**) fed at 25 and 10 grams/ton of diet DM, respectively; or *DiaFil* and R/T fed in combination. Finishing diets

Table 1. Composition of experimental diets (100% dry matter basis).

	Dietary Treatments[a]			
Ingredients	Control	*DiaFil*	R/T	*DiaFil*+R/T
High-moisture corn	51.6	49.8	51.6	49.8
Dry-rolled corn	34.4	33.2	34.4	33.2
Corn silage	4.5	4.5	4.5	4.5
Alfalfa hay	4.5	4.5	4.5	4.5
DiaFil	—	3.0	—	3.0
Supplement	5.0	5.0	5.0	5.0
Supplement composition				
Fine ground corn	19.4	19.4	18.8	18.8
Limestone	31.9	31.9	31.9	31.9
Urea	26.3	26.3	26.3	26.3
Potassium chloride	8.2	8.2	8.2	8.2
Sodium chloride	6.0	6.0	6.0	6.0
Ammonium chloride	5.0	5.0	5.0	5.0
Tallow	2.0	2.0	2.0	2.0
Trace mineral premix	1.0	1.0	1.0	1.0
Vitamin premix	.2	.2	.2	.2
Rumensin-80	—	—	.3	.3
Tylan-40	—	—	.3	.3

[a]Control=no *DiaFil* (diatomaceous earth) or Rumensin and Tylan; R/T=25 and 10 g/t Rumensin and Tylan, respectively.

Table 2. Effect of *DiaFil* with or without Rumensin/Tylan on performance of feedlot steers fed corn-based finishing diets.

	Dietary Treatments[a]					Contrasts[b]		
Ingredients	Control	*DiaFil*	R/T	*DiaFil*+R/T	SEM[c]	*DiaFil*	R/T	Dia×R/T
Initial wt. lb	840	840	839	834	3.1			
Final wt.[d], lb	1213	1189	1203	1220	8.2			
DM intake, lb/d	22.4	22.7	21.9	23.0	.3	.11	.41	.13
Daily gain, lb	3.19[f]	2.98[g]	3.11[fg]	3.30[f]	.08	.86	.14	.02
Feed efficiency[e]	7.12[f]	7.66[g]	7.05[f]	6.99[f]	.11	.05	.01	.02

[a]Control=no *DiaFil* (diatomaceous earth) or Rumensin and Tylan; R/T=25 and 10 g/t Rumensin and Tylan, respectively.
[b]*DiaFil*=main effect of *DiaFil*; R/T=main effect of Rumensin and Tylan; Dia×R/T=interaction of DiaFil and Rumensin/Tylan.
[c]SEM=standard error of the mean.
[d]Calculated as hot carcass weight divided by .63.
[e]Analyzed as daily gain/DM intake and reported as DM intake/daily gain.
[f,g]Means in the same row not bearing a common superscript differ (P < .10).

were based on dry-rolled and high-moisture corn (60:40 combination), and contained similar proportions of corn silage, alfalfa hay, and supplement (Table 1). *DiaFil* replaced equal proportions of dry-rolled and high-moisture corn when added to the diet. Steers were adapted to finishing diets using transition diets consisting of 45, 35, 25 and 15% alfalfa hay (DM basis) fed for 3, 4, 7 and 7 days, respectively. *DiaFil* and Rumensin/Tylan were fed during the transition diets, and steers were fed for 117 days. Steers were implanted with Synovex® Plus™ on day 1, and were not treated for any internal parasites. Steers were weighed initially on two consecutive days after being limit-fed the first transition diet at 2% of body weight (DM basis) for five days to minimize gut fill differences. Final weights were calculated based on hot carcass weight adjusted to a common 63% dressing percentage. Hot carcass weight and liver abscess scores were taken at slaughter, and following a 24-hour chill, 12th rib fat depth, USDA quality grade, and yield grade were recorded. USDA quality grade and yield grade were determined by a USDA grader.

Fecal samples were taken on days 1 and 28 from all steers to determine internal parasite and coccidia prevalence. Fecal grab samples were sent to a separate laboratory for egg counts and oocyte analysis.

Performance and carcass data were analyzed as a completely randomized design with a 2×2 factorial arrangement of treatments using the General Liner Model of SAS. Pen was the experimental unit. Main effects of *DiaFil* and Rumensin/Tylan and the interaction of *DiaFil* and Rumensin/Tylan were included in the model. Main effects and interactions were considered significant when P < .05. If an interaction was significant, treatment effects were separated using a t-test with P < .10. Incidence of liver abscesses and the presence of internal parasites and coccidia were analyzed using the frequency distribution of SAS.

Results

Results of feedlot performance are presented in Table 2. No differences in dry matter intake were observed between treatments. Interactions between *DiaFil* and Rumensin/Tylan addition to the diet were observed (P < .05) for daily gain and feed efficiency; therefore, treatment rather than main effect means are reported. Daily gain was lower (P < .10) for steers fed the finishing diet containing only *DiaFil* compared with those fed the control diet or the diet containing both *DiaFil* and Rumensin/Tylan. Daily gains were similar when steers were fed diets containing only *DiaFil* or Rumensin/Tylan. Steers fed *DiaFil* alone were 8% (P < .10) less efficient compared with the control, Rumensin/Tylan, or *DiaFil*+Rumensin/Tylan diets. Feed efficiency was similar between steers fed the control, Rumensin/Tylan, and *DiaFil*+Rumensin/Tylan diets.

An interaction (P < .05) was observed for hot carcass weight similar to that for daily gain (Table 3). Steers fed the control or *DiaFil*+Rumensin/Tylan diets had heavier (P < .10) carcass weights compared with those fed *DiaFil* alone. Hot carcass weights were similar for steers fed *DiaFil* or Rumensin/Tylan alone. Twelfth rib fat thickness, yield grade, marbling score, percentage of carcasses grading USDA Choice, and the percentage of liver abscesses were similar among treatments. Additionally, distributions of yield grades and liver abscesses by

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Table 3. Effect of *DiaFil* with or without Rumensin/Tylan on carcass characteristics of feedlot steers fed corn-based finishing diets.

	Dietary Treatments[a]					Contrasts[b]		
Ingredients	Control	*DiaFil*	R/T	*DiaFil*+R/T	SEM[c]	*DiaFil*	R/T	DiaxR/T
Carcass weight lb	764[g]	749[h]	758[gh]	769[g]	5.2	.66	.23	.03
12th rib fat, in.	.42	.38	.38	.4	.02	.72	.83	.12
Yield grade	2.18	2.04	2.06	2.16	.08	.82	.98	.18
Yield grade distribution, %								
1	11.1	13.3	17.8	14.0				
2	60.0	68.9	57.8	55.8				
3	28.9	17.8	24.4	30.2				
Marbling score[d]	4.89	4.78	4.72	4.89	.08	.63	.75	.10
USDA Choice[e], %	42.2	37.8	33.3	43.2				
Liver abscesses[f], %	17.8	17.8	15.6	9.1				
Liver abscess distribution by severity, %								
Mild (A-)	6.8	2.3	9.0	4.6				
Moderate (A)	4.4	8.9	0	2.3				
Severe (A+)	4.4	2.2	4.4	0				
Adhered (B)	2.2	4.4	2.2	2.2				

[a]Control=no *DiaFil* (diatomaceous earth) or Rumensin and Tylan; R/T=25 and 10 g/t Rumensin and Tylan, respectively.
[b]*DiaFil*=main effect of *DiaFil*; R/T=main effect of Rumensin and Tylan; DiaxR/T=interaction of *DiaFil* and Rumensin/Tylan.
[c]SEM=standard error of the mean.
[d]4.0=Slight 0; 4.5=Slight 50; 5.0=Small 0, etc.
[e]Chi square statistic (P = .76).
[f]Chi square statistic (P = .62).
[g,h]Means in the same row not bearing a common superscript differ (P < .10).

Table 4. Effect of *DiaFil* with or without Rumensin/Tylan on carcass characteristics of feedlot steers fed corn-based finishing diets.

	Dietary Treatments[a]				
Ingredients	Control	*DiaFil*	R/T	*DiaFil*+R/T	P-value[b]
Percentage of steers with parasitic eggs present in the feces					
Day 0	11.1	20.0	13.6	13.6	.65
Day 28	0	2.2	0	0	.39
Percentage of steers with coccidia present in the feces					
Day 0	17.8	26.7	20.5	13.3	.45
Day 28	2.2	6.7	0	0	.11

[a]Control=no *DiaFil* (diatomaceous earth) or Rumensin and Tylan; R/T=25 and 10 g/t Rumensin and Tylan, respectively.
[b]Probability of the Chi square statistic.

severity were similar among treatments.

Averaged across treatments, 16% of the steers used in this experiment had parasitic eggs present in the feces on day 0 (Table 4). Following 28 days on feed, parasitic eggs were for the most part undetectable across treatments. Only 2.2% of the steers fed *DiaFil* alone were found to have parasitic eggs present in the feces at day 28. This small and insignificant incidence is most likely a function of these steers having the highest concentration of parasitic eggs on day 0. The higher numerical count of fecal egg counts at the beginning of the experiment is merely due to random chance since the cattle were allotted to treatments based on weight alone. Averaged across treatments, 20% of the steers used in this experiment had coccidia in the feces on day 0. By the conclusion of 28 days on feed, those steers fed diets containing Rumensin/Tylan had no detectable coccidia, whereas those steers fed the control diet or *DiaFil* alone did have detectable levels of coccidia present in the feces (2.2 and 6.7%, respectively). Although coccidia were present in all treatments on day 0 and a portion of the steers had coccidia in the feces on day 28, no clinical signs of coccidiosis were observed for any steer during the experimental period.

Although interactions between *DiaFil* and the combination of Rumensin/Tylan were observed for animal performance, feeding *DiaFil* alone does not appear to enhance performance of finishing cattle when compared to diets without the feed additives evaluated in this experiment. Based on the response observed in feed efficiency, steers fed diets containing *DiaFil* alone were 8% less efficient than those fed the control diet. Additionally, steers fed Rumensin and Tylan were 9% more efficient than those fed *DiaFil*. This would suggest that replacing 3% of the corn in a finishing diet with *DiaFil* decreased the energy concentration of the diet. Therefore, any benefit from *DiaFil* inclusion must be large enough to overcome this reduction in dietary energy concentration.

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The Effect of V-Max® on Performance and Carcass Characteristics of Finishing Cattle Fed Corn and Corn By-product Finishing Diets

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Performance and carcass characteristics were unaffected in steers fed V-Max versus steers fed Rumensin®/Tylan®; however, incidence and severity of liver abscesses were increased with V-Max.

Summary

Seven hundred sixty-two crossbred steers were used in a feedlot trial to determine the effect of V-Max® on performance, carcass characteristics, and the incidence and severity of liver abscesses. Finishing diets included either V-max® or the combination of Rumensin® and Tylan®. Performance was not different between the two treatments; however, including V-max® in the diet resulted in an increased incidence and severity of liver abscesses. Numbers of steers with small abscesses were similar between treatments; however, moderate and severe liver abscesses were increased in steers fed V-Max® compared to steers fed the combination of Rumensin® and Tylan®.

Introduction

The use of feed additives in finishing diets to enhance performance has been widely accepted by producers. These compounds stabilize feed intake, decrease the incidence of subacute acidosis and are partially responsible for controlling liver abscesses. Feeding the combination of Rumensin® and Tylan® has become the industry "standard." Recently, virginiamycin (V-Max®) has become available for use as a feed additive in finishing diets for beef cattle. Virginiamycin has been shown to increase daily gain, improve feed efficiency and reduce the incidence of liver abscesses relative to unsupplemented controls (Rogers et al., 1995, J. of Anim. Sci., 73:9). Little is known about the effect of virginiamycin supplementation in finishing cattle diets containing grain byproducts such as wet corn gluten feed. Numerous experiments at the University of Nebraska have demonstrated that subacute acidosis is reduced when grain byproducts are included in finishing diets. Presumably, liver abscess incidence is also reduced. Wet corn gluten feed and wet distillers grains are commonly used feed ingredients in many Nebraska feedlot diets. Therefore, the objectives of this experiment were to determine the effects of V-Max® on performance, carcass characteristics and the incidence and severity of liver abscesses.

Procedure

Seven hundred sixty-two crossbred steers (732 lb) were blocked by source and randomly allotted to one of two treatments. Steers received either 17.5 g/ton V-Max® or the combination of 28 g/ton Rumensin® and 10 g/ton Tylan® (DM basis) as part of a pelleted supplement in the finishing diet. Numbers of steers within a replication were similar; however, numbers of steers across replications differed due to differing arrival dates. Four pens of calves and 8 pens of yearlings were placed on feed between July 12, 1997, and Aug. 13, 1997 (resulting in 6 replications/treatment with 60-68 head/pen). Upon arrival, steers were individually weighed and identified, vaccinated for viral and bacterial infections, treated for internal parasites and implanted with Synovex-S®. Steers were fed a high-concentrate finishing diet that included 52.5% dry-rolled corn, 20% wet distillers grains, 17% wet corn gluten feed, 5.5% pelleted supplement, 3% corn silage and 2% alfalfa hay (DM basis). The diet contained 16.5% CP, .85% Ca and .52% P. Steers were reimplanted with Revalor-S® towards the midpoint of the feeding period with reimplant dates ranging from 55 to 109 days on feed or 66 to 111 days prior to slaughter. Steers were slaughtered by replication such that days on feed within a replication were similar. Days on feed ranged from 121 to 220 days and averaged 158 days. Steers were slaughtered at a commercial packing plant where hot carcass weights and liver scores were obtained. Following a 36-hour chill, yield grade, quality grade, ribeye area, 12th rib fat thickness, kidney, pelvic, and heart (KPH) fat, and marbling scores were obtained. Final weights were

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Table 1. Effect of virginiamycin or a combination of Rumensin® and Tylan® on finishing performance of feedlot steers fed corn- and byproduct-based diets.

	Dietary Treatment			
Item	V-Max[a]	R/T[b]	SEM	P-value
Number of pens	6	6	—	—
Number of steers	372	376	—	—
Initial weight, lb	728	733	3.5	.41
Final weight, lb[c]	1332	1346	3.7	.03
DMI, lb/day	24.3	24.5	.3	.80
ADG, lb[d]	3.83	3.89	.03	.18
F/G	6.38	6.32	.08	.58

[a]V-Max = 17.5 g/ton V-Max®.
[b]R/T = 28 g/ton Rumensin® and 10 g/ton Tylan®.
[c]Final weight calculated as hot carcass weight divided by a common 63% dressing percentage.
[d]Calculated using carcass adjusted final weight.

Table 2. Effect of virginiamycin or a combination of Rumensin® and Tylan® on carcass characteristics of feedlot steers fed corn- and byproduct-based diets.

	Dietary Treatment			
Item	V-Max[a]	R/T[b]	SEM	P-value
Hot carcass weight, lb	839	848	2	.03
Dressing percentage	63.32	62.72	.24	.14
Fat thickness, in.	.57	.57	.01	.69
KPH fat[c]	2.43	2.46	.02	.44
Marbling score[d]	545	534	5	.19
Yield grade	3.1	3.1	.1	.70
Ribeye area, sq. in.	14.14	14.05	.20	.77
Quality grade distribution, %				.55[e]
Prime, %	1.43	1.69		
Upper 2/3 Choice, %	13.14	15.45		
Low Choice, %	44.86	39.33		
Select, %	34.57	38.48		
Standard, %	6.00	5.06		
Liver abscesses, %	36.1	17.3	—	<.01[e]
Distribution of severity, %				
None	63.4	82.6	—	<.01[e]
Small	10.4	8.9		
Moderate	11.5	3.5		
Severe	9.1	2.7		
Adhered to body wall	5.6	2.4		

[a]V-Max = 17.5 g/ton V-Max®.
[b]R/T = 28 g/ton Rumensin® and 10 g/ton Tylan®.
[c]KPH = kidney, pelvic, and heart.
[d]Marbling score of 500 = small 0.
[e]P-value from Chi-square analysis.

determined by adjusting hot carcass weight to a common dressing percentage (63%). This dressing percentage represents the average of the two treatments in the trial. Pen weights used to determine dressing percentage with off-truck weights shrunk 2.5%. Performance data were analyzed using the GLM procedure of SAS. Quality grade and incidence and severity of liver abscesses were analyzed using the Chi square (frequency distribution) procedure of SAS.

Results

Dry matter intake, ADG, and F/G were similar between steers fed V-Max® or the combination of Rumensin® and Tylan® (Table 1).

Also, steers fed the combination of Rumensin® and Tylan® had heavier ($P < .05$) carcasses than steers fed V-Max® (Table 2). However, a trend ($P = .14$) for increased dressing percentage and numerical differences in initial weight for steers fed V-Max® resulted in ADG similar to steers fed Rumensin® and Tylan® when carcasses were adjusted to a common dressing percentage. Twelfth rib fat thickness, KPH fat, USDA quality and yield grades and ribeye area were unaffected by treatment. The incidence of liver abscesses was higher ($P < .01$) in steers fed V-Max® compared to those fed Rumensin® and Tylan®. The incidence of liver abscesses was increased approximately two-fold in steers fed V-Max® and the magnitude of difference was similar across all replications and in calves and yearlings. The severity of liver abscesses was also greater ($P < .01$) in steers fed V-Max® compared to steers fed Rumensin® and Tylan®. Increases in moderate and severe liver abscesses and livers adhered to the body wall were responsible for the total increase in the incidence of liver abscesses in steers fed V-Max®. Although control of liver abscess incidence and severity was compromised, feedlot performance was similar for steers fed V-Max® or the combination of Rumensin® and Tylan®.

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Effects of Increasing Rumensin Level During a Potential Acidosis Challenge

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Increasing dietary Rumensin concentration to 45g/ton (90% DM Basis) reduced the effects of imposed acidosis challenge in steers fed a corn-based finishing diet.

Summary

Nine ruminally fistulated yearling steers were used in a 9 x 2 Incomplete Latin square to evaluate benefits of an increase in dietary Rumensin level during an imposed acidosis challenge. Feeding Rumensin, at either 30 or 45g/ton reduced acidosis on the challenge day. However, increasing the dietary Rumensin concentration to 45g/ton was required to reduce acidosis for the five days following that challenge. Feeding 45g/ton reduced ruminal pH area below 5.6 when compared to the normal level of 30g/ton during the five days following the challenge.

Introduction

Feed intake variation by cattle fed high-grain finishing diets is presumed to predispose animals to digestive disturbances such as acidosis. Subacute acidosis causes reductions in gain and efficiency, which can add up to a substantial economic cost for a pen of cattle. These costs become even more evident if cattle experience a more severe case known as acute acidosis which results in almost total feed aversion and possibly even death. Rumensin is commonly used in high-grain finishing diets to improve feed efficiency. However, in recent research at Nebraska, Rumensin has been shown to reduce the incidence of acidosis by reducing the area of ruminal pH below 5.6 and ruminal pH variance without affecting feed intake when cattle are fed ad-libitum (1997 Nebraska Beef Report pp. 49). It has also been shown at the University of Nebraska that there is an even greater advantage of using Rumensin to control acidosis without affecting intake in clean bunk management systems (1999 Nebraska Beef Report pp. 41). Considering previous research, increasing dietary Rumensin levels during times when feedlot cattle might experience intake variation may reduce incidence and severity of acidosis. The objective of our study was to evaluate the effects of increasing dietary Rumensin concentration from 30 to 45 g/ton during and for five days following an imposed acidosis challenge on ruminal pH and feed intake.

Procedure

Nine ruminally fistulated steers were used in a 9 x 2 Incomplete Latin square, six observations per treatment, to determine if there were responses to increasing levels of Rumensin in the diet during an imposed acidosis challenge. Steers were adapted to the finishing ration using four step-up rations decreasing in roughage level (45, 35, 25, and 15 %), over a 21-day period. Steers were randomly assigned to one of three Rumensin treatments and allowed seven days to adjust to the finishing diet before the start of the first period. The final diet consisted of 63.4 % high moisture corn, 21.1 % dry-rolled corn, 7.5 % ground alfalfa hay, 3 % molasses and 5 % supplement, (DM basis). The diet was formulated to contain 12 % CP, .7 % Ca, .3 % P, .6 % K, .95 Mcal/lb NEm, and .65 Mcal/lb NEg, (DM basis).

Rumensin was fed at 0g/ton for the entire period (CON), 30g/ton dietary Rumensin for the entire period (NOR),or 30g/ton fed prior to the challenge, then changing to 45g/ton day of the challenge and for the next five days (EXP), followed by a seven-day period of feeding 30g/ton. Dietary Rumensin levels were formulated on a 90 % DM basis.

Bunks were managed using a clean bunk management strategy (approximately 15-hour feed access). Bunks were read at 730 hrs and steers were fed once daily at 800 hrs. Individual feed bunks suspended from load cells were connected to a computer equipped with continuous data acquisition that allowed feed amounts to be recorded at one-minute intervals. By retrieving the feed weights at 2100 hrs, 2300 hrs and 100 hrs from the previous night, the feed amounts were adjusted so steers would consume their feed by approximately 2300 hrs.

Submersible pH electrodes were suspended in the rumen through the ruminal cannula. Each electrode was encased in a weighted four wire metal shroud and suspended about 5-10 inches above the ventral floor of the rumen, allowing ruminal contents to flow freely around the electrode. Ruminal pH was continuously recorded at one-minute intervals.

Periods were 35 days in length and consisted of six different phases. Days 1-14 were a diet adaptation phase. Submersible pH electrodes were placed in the rumen on day 14. On days 15-21, pre-challenge data were collected (intake and ruminal pH). On day 22, steers were fed only 50 % of day 21 intake in order to make steers eat more aggressively the following day. On day 23, the acidosis challenge was imposed by offering steers 175 % of day 21 intake, four hours late (1200 hrs). The dietary Rumensin level for EXP was increased from 30 to 45g/ton. Days 24-28 were a recovery period in which the Rumensin level on EXP remained at 45g/ton, and all cattle were returned to their normal clean bunk management. To determine if there were any negative effects of switching back from 45 to 30g/ton, days 29-35 steers on EXP were switched back

(Continued on next page)

to 30g/ton of Rumensin. In a two-week rest period between periods of the Latin squares, steers were placed on their second period diets to allow extra time for recovery from the previously imposed acidosis challenge. Steers fed Rumensin and switched to CON for the second period were reinoculated with rumen fluid from a donor steer that was maintained on a diet similar to CON.

Statistical analyses used the Mixed model procedure of SAS. Results were divided into four phases: pre-challenge (days 15-21, seven days in length); challenge day (day 23, one day); recovery 45g (days 24-28, five days following the challenge); and recovery 30g (days 29-35, seven days following first recovery phase). Pre-challenge data were analyzed separately from the other three phases since this occurred before the Rumensin treatment was imposed. Contrasts were used to compare CON vs the average of NOR & EXP. Challenge day, recovery 45g phase and recovery 30g phase were analyzed together. Treatment means were separated within each phase using the LS MEANS procedure with a protected F-test (P<.10)

Results

Pre-Challenge Phase

Results from the pre-challenge phase are reported in Table 1. During the pre-challenge phase, steers on Rumensin ate at a faster rate (P<.05) compared with control. Steers fed diets containing Rumensin had less pH variance when compared with CON (P<.05). This would suggest steers not fed Rumensin were experiencing some cases of subacute acidosis and had altered their consumption patterns to be less aggressive when eating. Total feed intake, number of meals per day , average meal size, time spent eating and ruminal pH below 5.6 were not influenced by treatment.

Challenge Day Phase

Results from the challenge day are reported in Table 2. Overall feed intake and intake rate were not affected by treatment. Steers fed CON and EXP ate fewer meals (P<.05) and consumed more

Table 1. Effects of increasing Rumensin level on intake behavior and ruminal pH of steers fed a corn-based finishing diet during the pre-challenge phase.

	Rumensin Level[a]			
Item	CON	NOR	EXP	SEM
Intake				
Lb/day, Asfed	28.9	28.4	28.4	1.8
Rate[b], %/hour	25.6	36.4	34.0	2.8
Meals				
Number/day	7.7	6.5	5.7	.75
Avg, lb	3.7	5.1	6.3	.78
Time spent eating				
Total, min/day	491	451	456	31.6
Avg. meal, min	63	78	91	8.6
Ruminal pH				
Average[b]	5.75	5.64	5.67	.11
Variance[b]	.21	.18	.16	.01
Area < 5.6[c]	192	249	223	23.8

[a]CON = 0 g/ton Rumensin, NOR = 30 g/ton Rumensin, EXP = (30 g/ton Rumensin pre-challenge, 45 g/ton Rumensin challenge day and for 5 days following, 30 g/ton Rumensin for the remainder of the period).
[b]Con vs Average of NOR & EXP differ (P < .05).
[c]Area = (magnitude of ruminal pH below specified pH) * (minutes below specified pH).

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

	Rumensin Level[a]				
Item	CON	NOR	EXP	SEM	F-test
Intake					
Lb/day, Asfed	43.2	42.7	42.2	2.3	.95
Rate, %/hour	29.7	24.2	32.5	3.1	.17
Meals					
Number/day	4.9[d]	6.7[e]	4.0[d]	.49	<.01
Avg, lb	10.1[b]	6.5[c]	10.9[b]	.89	<.01
Time spent eating					
Total, min/day	489	573	528	29.4	.15
Avg. meal, min	106[d]	89[d]	136[e]	9.1	<.01
Ruminal pH					
Average	5.53[d]	5.63[d,e]	5.76[e]	.06	.06
Variance	.57[f]	.49[g]	.48[g]	.03	.10

[a]CON = 0 g/ton Rumensin, NOR = 30 g/ton Rumensin, EXP = (30 g/ton Rumensin pre-challenge, 45 g/ton Rumensin challenge day and for 5 days following, 30 g/ton Rumensin for the remainder of the period).
[b,c]Means in a row with different superscripts differ (P < .01).
[d,e]Means in a row with different superscripts differ (P < .05).
[f,g]Means in a row with different superscripts differ (P < .10).

Table 3. Effects of increasing Rumensin level on intake behavior and ruminal pH of steers fed a corn-based finishing diet during the recovery 45g phase.

	Rumensin Level[a]				
Item	CON	NOR	EXP	SEM	F-test
Intake					
Lb/day, Asfed	24.5	28.4	26.6	2.3	.48
Rate, %/hour	18.3[b]	30.2[c]	22.2[b]	3.1	.03
Meals					
Number/day	8.3	7.7	7.5	.49	.59
Avg, lb/meal	2.8	4.2	3.8	.89	.53
Time spent eating					
Total, min/day	515	543	503	29.4	.62
Avg. meal, min	61	75	71	9.1	.53
Ruminal pH					
Average	5.56	5.54	5.71	.06	.11
Variance	.12	.11	.12	.03	.95

[a]CON = 0 g/ton Rumensin, NOR = 30 g/ton Rumensin, EXP = (30 g/ton Rumensin pre-challenge, 45 g/ton Rumensin challenge day and for 5 days following, 30 g/ton Rumensin for the remainder of the period).
[b,c]Means in a row with different superscripts differ (P < .10).

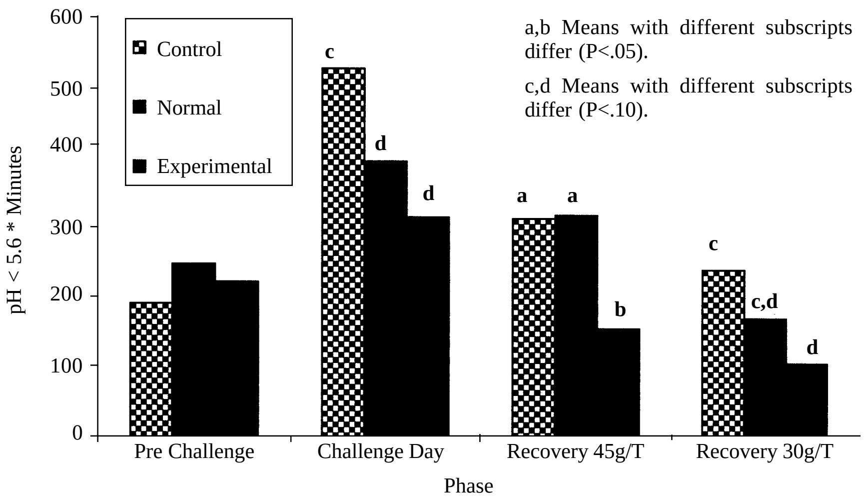

Figure 1. Ruminal pH area below 5.6 for pre-challenge, challenge and recovery phases.

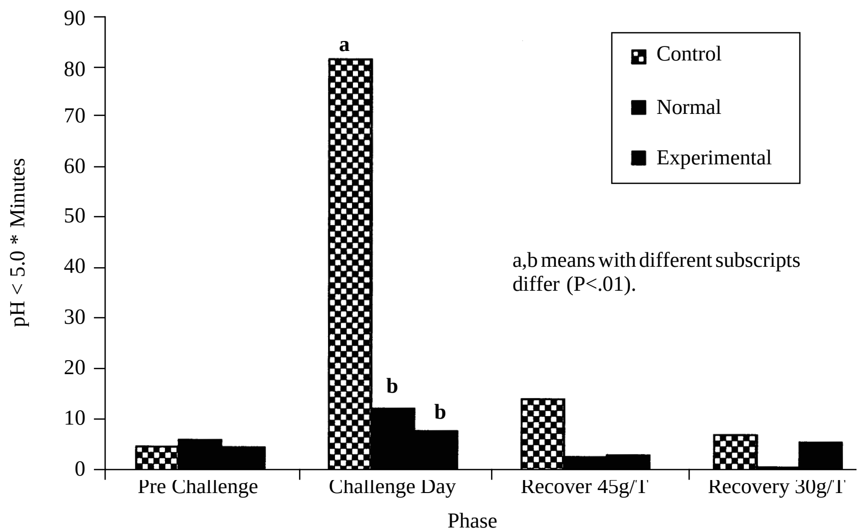

Figure 2. Ruminal pH area below 5.0 for pre-challenge, challenge and recovery phases.

feed per meal (P<.01) compared with those fed NOR. Steers fed EXP spent more time eating each meal (P<.05) compared with steers fed NOR and CON. Average pH for steers fed EXP was higher (P<.05) compared with steers fed CON, and pH of steers fed NOR was intermediate. These data would suggest increasing Rumensin concentration is beneficial. Rumensin fed steers had less ruminal pH variance (P<.05), ruminal pH area below 5.6 (P<.05; Figure 1) and ruminal pH area below 5.0 (P<.01; Figure 2) when compared with CON.

Acidosis Recovery Phase

Results from the acidosis recovery phase are reported in Table 3. Ruminal pH area below 5.6 was less (P<.05) for steers fed EXP when compared with CON and NOR (Figure 1). The EXP also tended to increase average ruminal pH (F-test, P=.11) when compared with CON and NOR (Figure 1). Intake rate was slower (P<.10) for steers fed CON and EXP compared with NOR. The increased level of dietary Rumensin for steers fed EXP probably caused this slower rate of intake, and effects of acidosis caused the slower rate of intake for steers fed CON. The steers fed CON ate 11 % less feed than the steers on Rumensin during this five-day acidosis recovery phase. No differences were observed in number of meals/day, average meal size or time spent eating.

Changing the dietary Rumensin concentration back to 30g/ton from 45g/ton had no effect on feeding behavior (data not shown). Average ruminal pH (5.97) of steers fed EXP was higher (P<.10) than those fed CON and NOR (average 5.75). This is most likely because the steers fed 45g/ton during the acidosis challenge and acidosis recovery phases had a higher average ruminal pH. This suggests that feeding 45g/ton of dietary Rumensin during an imposed acidosis challenge and for five days following may be beneficial throughout the entire feeding period as well.

Fanning (1999 Nebraska Beef Report pp. 41) showed steers fed Rumensin during the pre-challenge and recovery phases ate more meals/day when compared with steers receiving no dietary Rumensin. We observed steers fed Rumensin ate fewer meals/day during the pre-challenge and recovery phases when compared with steers receiving no dietary Rumensin. The ration used in our study could predispose steers more to acidosis due to its higher level of high moisture corn, which has a faster rate of fermentation compared to dry rolled corn. It would be possible that the steers receiving no dietary Rumensin may have altered their eating behavior to more meals/day, because during the acidosis challenge, they experienced severe cases of acidosis.

Feeding Rumensin at either 30 or 45g/ton reduced incidence of acidosis on the imposed challenge day. However, increasing dietary concentration to 45g/ton was required to reduce the incidence of acidosis during the five days following challenge. This would be beneficial after an event that disrupts the normal eating pattern of feedlot cattle. No adverse effects of switching the dietary Rumensin levels back to 30g/ton from 45g/ton six days after the imposed acidosis challenge were observed.

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Solvent-Extracted Germ Meal as a Component of Wet Corn Gluten Feed: Effect on Ruminal Acidosis

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Wet corn gluten feed, with or without solvent-extracted germ meal, can diminish subacute acidosis during grain adaptation and after overconsumption of a finishing diet when it replaces dry-rolled corn.

Summary

Dry matter intake and ruminal acid concentration were used to evaluate the influence of a dry-rolled corn (Control) and wet corn gluten feed diets (corn bran and steep liquor with distillers solubles, with or without solvent-extracted germ meal) on acidosis. Wet corn gluten feed without solvent-extracted germ meal promoted highest dry matter intake and daily minimum ruminal pH during grain adaptation. Control reduced intake and ruminal pH more than wet corn gluten feed diets, but increased propionate production. When solvent-extracted germ meal was included in wet corn gluten feed, intake was slightly reduced and ruminal pH was more variable.

Introduction

Wet corn gluten feed provides an alternative to corn as an energy source for finishing cattle. By replacing dietary starch from corn with highly digestible fiber, wet corn gluten feed can reduce the incidence and severity of acidosis and increase feed intake in finishing cattle. Solvent-extracted germ meal is a byproduct of corn oil production and may be included as a component of wet corn gluten feed. Previous research indicated solvent-extracted germ meal increases energy content of wet corn gluten feed (1999 Nebraska Beef Report, pp. 29-31), although its influence on acidosis has not been investigated.

The objective of our study was to evaluate wet corn gluten feed (corn bran and steep liquor with distillers solubles) with and without solvent-extracted germ meal relative to dry-rolled corn, as a means to reduce the potential for subacute acidosis in finishing cattle.

Procedure

Ruminally fistulated calves (n = 3, 833 lb) and yearlings (n = 3, 1164 lb) were blocked by age and used in a replicated 3 x 3 Latin square design to evaluate the influence of diet on DM intake, ruminal pH, and ruminal VFA concentration. Treatments were: dry-rolled corn control (DRC), and either a 50:50 blend of dry corn bran and steep liquor with distillers solubles (WCGF), or 33% dry corn bran, 33% steep liquor with distillers solubles, and 33% solvent-extracted germ meal (GERM). The two byproduct blends were fed at 43% of the dietary DM, replacing 50% of dry-rolled corn in the final diets (Table 1).

Steers were tethered in metabolism stalls with individual feed bunks suspended from load cells, and equipped with ruminal pH electrodes. Load cells and pH electrodes were wired directly to a computer that recorded feed weight and ruminal pH every minute throughout each period.

Periods consisted of 28 days. On days 1 through 12, adaptation diets containing 45, 25, and 15% alfalfa hay were fed at 9 a.m. each for four days. From day 13 through 18, the 7.5%-alfalfa hay final diet was fed daily at 9 a.m. (prechallenge). Orts were collected daily at 8:30 a.m. Day 19 of each period initiated an acidosis challenge. Orts were collected at 8:30 a.m. and cattle received the 7.5%-forage diet, but feed was withheld until 1 p.m. and increased 25% above the previous day's weight in order to induce hunger and the potential for overconsumption. The acidosis challenge was designed to simulate a feedlot situation in which cattle were fed late, or otherwise prone to overeat due to being under-fed or changes in weather. The postchallenge phase began with the acidosis challenge at 1 p.m. on day 19. On days 20 through 23, cattle resumed the 9 a.m. feeding

Table 1. Final diets fed to ruminally fistulated steers (% of DM)

	Treatment[a]		
Item	DRC	WCGF	GERM
Dry-rolled corn	85.47	42.92	43.12
Dry corn bran	—	21.51	14.34
Solvent-extracted germ meal	—	—	14.34
Steep liquor/distillers solubles	—	21.51	14.34
Alfalfa hay	7.50	7.50	7.50
Molasses	5.00	5.00	5.00
Limestone	.93	1.18	.98
Dicalcium phosphate	.09	—	—
Urea	.63	—	—
Salt	.30	.30	.30
Trace mineral premix[b]	.03	.03	.03
Vitamin premix[c]	.02	.02	.02
Rumensin[d]	.02	.02	.02
Tylan[e]	.01	.01	.01

[a]DRC = dry-rolled corn control, WCGF = 50% dry corn bran and 50% steep liquor with distillers solubles, GERM = 33% dry corn bran, 33% steep liquor with distillers solubles, and 33% solvent-extracted germ meal (DM basis).
[b]10% Mg, 6% Zn, 4.5% Fe, 2% Mn, .5% Cu, .3% I, and .05% Co.
[c]15,000 IU of vitamin A, 3,000 IU of vitamin D, and 3.75 IU of vitamin E per g of premix.
[d]80 g monensin per lb of premix.
[e]40 g of tylosin per lb of premix.

Table 2. Influence of treatment on measures of intake; dietary concentrate level analysis

	Treatment[a]			
Item	DRC	WCGF	GERM	SEM
DM intake, lb/d	24.0[b]	26.5[c]	24.5[b]	.9
Intake rate, %/hour	19.3[d]	16.3[e]	19.3[d]	.8
Total feeding time, min	409.5[f]	497.8[g]	544.7[g]	34.6
Average feeding time, min	45.8[b]	50.0[b]	58.0[c]	3.7
Maximum feeding time, min	95.5[f]	105.5[f]	138.1[g]	11.0
Maximum meal, lb DM	6.6	5.7	6.4	.5

[a]DRC = dry-rolled corn control, WCGF = 50% dry corn bran and 50% steep liquor with distillers solubles, GERM = 33% dry corn bran, 33% steep liquor with distillers solubles, and 33% solvent-extracted germ meal (DM basis).
[bc]Means within row with unlike superscript differ (*P* < .10).
[de]Means within row with unlike superscript differ (*P* < .01).
[fg]Means within row with unlike superscript differ (*P* < .05).

time. During the last five days of each period, data were not collected and cattle were allowed ad libitum access to ground alfalfa hay. Corn milling byproducts were maintained at 43% of dietary DM in adaptation and final diets.

Ruminal fluid was sampled using a suction strainer before feeding (8:45 a.m.) on the third day following each increase in dietary concentrate and subsequently analyzed for VFA and lactate content.

Means were calculated for average and minimum ruminal pH, daily pH variance, and the area of ruminal pH < 5.6 (magnitude of ruminal pH < 5.6 by min) as an indication of subacute acidosis. Daily observations of feed weight were used to calculate total, maximum, and average feeding time (minutes/meal); maximum meal amount (lb/meal); and rate of intake.

To test treatment effects across levels of dietary concentrate, mean daily intake and ruminal pH data were averaged for day within adaptation and final diets for each animal. A separate analysis was conducted to determine the influence of acidosis challenge on subsequent intake and ruminal pH measures. For both analyses, data were analyzed as a replicated Latin square design with a split plot incorporating repeated measures using the Mixed procedure of SAS (1990). Least squares means were separated using a protected *t* test when a significant fixed-effect *F*-test (*P* < .10) was detected.

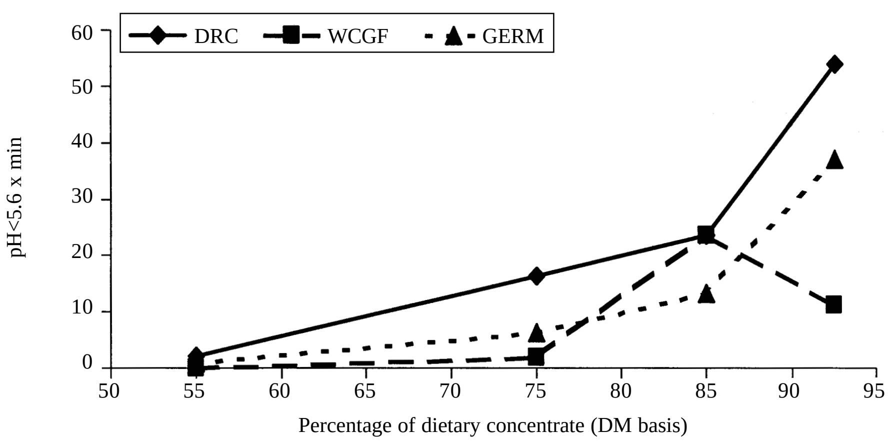

Figure 1. Treatment x dietary concentrate level interaction (P=.07) for area <pH 5.6 (SEM=6.77). DRC=dry-rolled corn control, WCGF=50% dry corn bran and 50% steep liquor with distillers solubles (DM basis) replacing 50% of dry-rolled corn DM in the final diet, GERM=33% dry corn bran, 33% steep liquor with distillers solubles, and 33% solvent-extracted germ meal (DM basis) replacing 50% of dry rolled corn DM in the final diet.

Results and Discussion

Analysis across levels of dietary concentrate

No treatment × dietary concentrate level interactions were observed for DM intake, intake rate, feeding time, or meal amount. Therefore, these data were pooled to assess effects of byproduct blends on intake variables. The WCGF treatment exhibited higher (*P* < .10) daily DM intake than DRC and GERM, although WCGF promoted the lowest (*P* < .01) rate of intake (Table 2). Average feeding time (*P* < .10) and maximum feeding time (*P* < .05) were greatest for the GERM treatment. Total time spent feeding was lower (*P* < .05) for the DRC treatment than byproduct diets.

Treatment × dietary concentrate level interactions were not observed for average or minimum ruminal pH, daily pH variance, or area of ruminal pH below 5.6. Therefore, these data were pooled to evaluate effects of byproduct blends. Average pH did not differ due to treatment, although daily minimum pH was maintained at a higher level by the WCGF treatment (*P* < .10; 5.65 vs 5.50 for DRC). Daily pH variance (*P* < .05) was greater for DRC and GERM treatments than the WCGF diet. A treatment × concentrate level interaction (*P* = .06) was observed for area below pH 5.6 (Figure 1). Although an interaction was observed, the area below pH 5.6 increased as the dietary concentrate level increased across treatments. However, the rate and magnitude of increase as the dietary concentrate level increased was greater for steers fed DRC compared with WCGF or GERM. The rate and magnitude of increase as the dietary concentrate level increased were similar between WCGF and GERM.

No treatment x dietary concentrate level interactions occurred for ruminal VFA or total lactate concentration; thus only treatment effects will be discussed. Total ruminal VFA concentration was greater for DRC than diets including corn byproducts (*P* < .10). Propionate concentration was greater (*P* < .05) for DRC than WCGF and GERM diets, whereas acetate was similar among

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treatments, which resulted in a lower ($P < .01$) acetate to propionate ratio for DRC. Ruminal lactate concentration was similar among treatments (data not shown).

Postchallenge phase

A treatment x day interaction ($P = .03$) was observed for DM intake (Figure 2). Intake of all treatments was similar for the acidosis challenge (day 1). Dry matter intake of the DRC diet declined abruptly on day 2 and gradually reached intake levels of WCGF and GERM diets by day 4. Intake rate, and average and maximum feeding time did not differ due to treatment or day (data not shown). Maximum and average meal amount differed due to day and averaged across treatments ranged from 7.98 (day 1) to 5.07 (day 2) lb and 3.02 (day 1) to 2.31 (day 3) lb, respectively, with the highest ($P < .01$) values on day 1, which suggested the procedure for acidosis challenge was successful in promoting overconsumption of high-concentrate diets. Total feeding time differed ($P = .02$) due to treatment, and with the exception of day 1, was higher for GERM (121 min) than WCGF (92 min) and DRC (98 min) treatments.

Treatment x day interactions ($P < .10$) occurred for average and minimum ruminal pH. In the WCGF treatment, minimum ruminal pH was not diminished to the extent exhibited by GERM and DRC diets due to the acidosis challenge (data not shown). Although minimum pH of the GERM treatment was similar to that of the DRC diet on day 1, GERM values for average pH exceeded the DRC treatment (data not shown). Generally, average ruminal pH data for WCGF and GERM diets resembled the consistency exhibited by DM intake data for these treatments, suggesting a decreased incidence and less extensive duration of subacute acidosis and a more rapid recovery. Ruminal pH measures for the DRC diet seemed closely linked to DM intake. Area of pH below < 5.6 tended (P = .13) to be greater for cattle fed DRC compared with those fed WCGF or GERM (Figure 3).

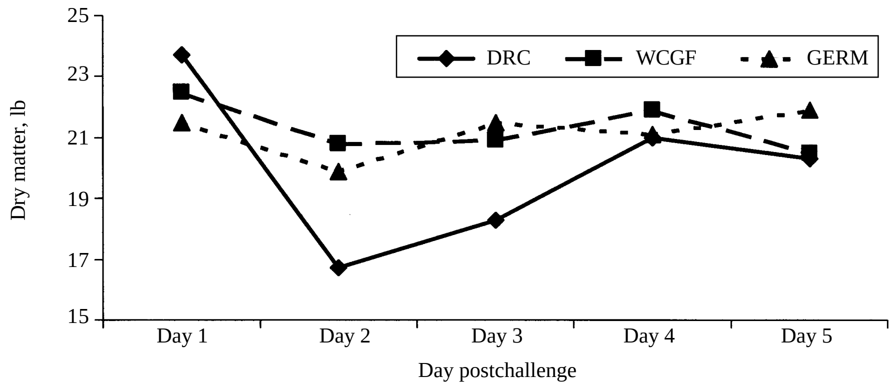

Figure 2. Treatment x day interaction (P=.03) for average DM intake (lb/d) following the acidosis challenge (SEM=1.4). DRC=dry-rolled corn control, WCGF=50% dry corn bran and 50% steep liquor with distillers solubles (DM basis) replacing 50% of dry-rolled corn DM in the final diet, GERM=33% dry corn bran, 33% steep liquor with distillers solubles, and 33% solvent-extracted germ meal (DM basis) replacing 50% of dry-rolled corn DM in the final diet. The acidosis challenge was initiated with late feeding at 1 p.m. on day 1.

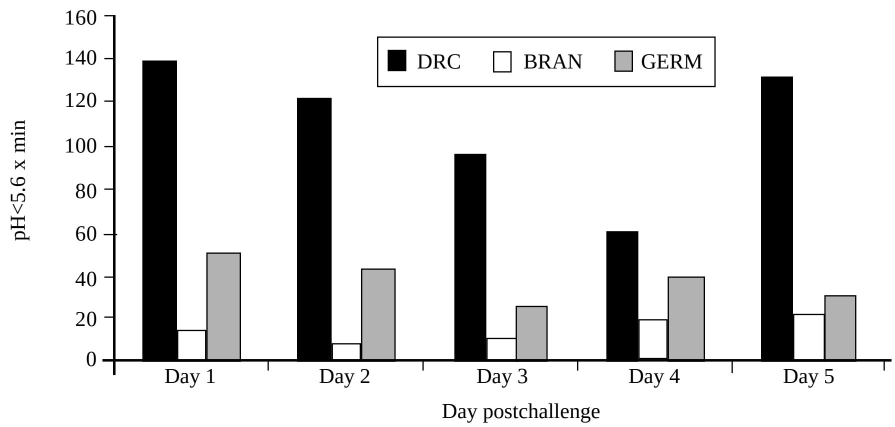

Figure 3. Area of pH<5.6 x min following the acidosis challenge. Treatments tended to differ (P=.13) (SEM=32). DRC=dry-rolled corn control, WCGF=50% dry corn bran and 50% steep liquor with distillers solubles (DM basis) replacing 50% of dry-rolled corn DM in the final diet, GERM=33% dry corn bran, 33% steep liquor with distillers solubles, and 33% solvent-extracted germ meal (DM basis) replacing 50% of dry-rolled corn DM in the final diet. The acidosis challenge was initiated with late feeding at 1 p.m. on day 1.

Results from the acidosis challenge were similar to those originating from the analysis involving dietary concentrate level. The WCGF and GERM diets were less apt to induce subacute acidosis than was DRC. Ruminal pH measures suggested that GERM was fermented more rapidly than WCGF, but did not reach the rate of acid production associated with DRC. Cattle consuming GERM were able to maintain a level of DM intake similar to WCGF after the acidosis challenge, although DM intake was lower during grain adaptation. Replacing a portion of the dry corn bran and steep liquor/distillers solubles with solvent-extracted germ in the production of wet corn gluten feed does not compromise the control of subacute acidosis in feedlot diets.

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Effect of Dry, Wet, or Rehydrated Corn Bran on Performance of Finishing Yearling Steers

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The form of corn bran (dry, wet, or rehydrated) used in the production of wet corn gluten feed has limited influence on nutritional value of the finished product.

Summary

Sixty steers were individually fed finishing diets to evaluate if corn bran form affects the energy value of wet corn gluten feed. Corn bran replaced 40% (DM basis) dry-rolled corn as dry (86% DM), wet (37% DM), or rehydrated (37% DM). Dry matter intake was higher for steers fed dry bran compared with other treatments. Daily gain and efficiency were 15 and 18% higher for the control diet compared with the average of corn bran diets. Gain and efficiency were similar among corn bran diets. Corn bran form has limited influence on the energy value of wet corn gluten feed.

Introduction

Corn bran and steep liquor with distillers solubles are combined in various proportions to produce wet corn gluten feed. The use of wet corn gluten feed to replace grain and forage in finishing diets has been widely adopted by Nebraska cattle feeders. Wet corn gluten feed can be produced from corn bran that is wet, about 40% dry matter, or corn bran that has been dried to about 85% dry matter prior to the addition of corn steep liquor/distillers solubles. The main purposes for drying the corn bran are to reduce the DM variation of a gluten feed product and to facilitate the incorporation of more steep liquor/distillers solubles into the wet corn gluten feed product. In general, when wet corn bran is used in the production of wet corn gluten feed, the amount of steep liquor/distillers solubles that can be added to the corn bran is limited due to ingredient separation.

Drying wet corn gluten feed or wet distillers to 10% moisture reduces the energy value compared to when these byproducts are fed in the wet form. Our objectives were to evaluate the influence of drying on the feeding value of corn bran fed in the presence of a constant level of corn steep liquor with distillers solubles.

Procedure

Sixty crossbred, yearling steers (623 lb) were individually fed using Calen gates in a completely randomized designed experiment to compare dry, wet, and rehydrated corn bran in feedlot finishing diets. Corn bran was fed at 40% of the dietary dry matter, replacing equal proportions of high-moisture and dry-rolled corn (Table 1). Dry and wet corn bran were produced from a wet milling plant located in Blair, NE (Cargill Corn Milling). The dry matter contents of the corn bran were 86% and 37% for the dry and wet corn bran, respectively. Rehydrated corn bran was produced by the addition of water, prior to bagging, to dry corn bran until the dry matter content was similar to the wet corn bran (37%). All forms of corn bran were stored in silo bags. All diets were formulated to contain a minimum of 12.5% crude protein, .7% calcium, .3% phosphorous, .6% potassium, 27 g/t Rumensin, and 10 g/t Tylan (DM basis). Corn steep liquor with distillers solubles (*Sweet Steep*) was included as an individual ration ingredient, fed at 9% of the dietary dry matter across all treatments. Initial weights were the average of three consecutive early morning weights taken prior to feeding. Steers were implanted with Synovex® Plus™ at the initiation of the experiment and fed experimental diets for 146 days. Steers were started on their respective finishing diet, and adapted to full-feed by increasing the finishing ration .5 to 1 lb/head/day until

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Table 1. Composition of finishing diets (DM basis).

	Treatment[a]			
Ingredient	Control	Dry Bran	Rehy Bran	Wet Bran
Dry-rolled corn	45.3	21.3	21.3	21.3
High-moisture corn	30.2	14.2	14.2	14.2
Alfalfa hay	7.5	7.5	7.5	7.5
Dry corn bran	—	40.0	—	—
Wet corn bran	—	—	—	40.0
Rehydrated corn bran	—	—	40.0	—
Sweet Steep	9.0	9.0	9.0	9.0
Tallow	3.0	3.0	3.0	3.0
Supplement	5.0	5.0	5.0	5.0
Ration Dry Matter, %	79	80	62	62

[a]Rehy=Corn bran rehydrated to similar moisture concentration compared with wet bran.

steers were at ad libitum consumption. Final weights were determined by dividing hot carcass weight by a common dressing percentage (63). Hot carcass weights were recorded at the time of slaughter, and 12th rib fat thickness, USDA yield and quality grades, and marbling score were determined following a 24-hour chill. Dietary NEg values were calculated using the 1996 NRC equations based on observed dry matter intake and daily gain. Statistical analyses of the data were conducted with the General Linear Model of SAS.

Table 2. Effect of corn bran form on performance of finishing yearling steers.

	Treatment[a]				
Ingredient	Control	Dry Bran	Rehy Bran	Wet Bran	SEM
Initial wt., lb	629	622	626	626	14.7
Final wt.[b], lb	1195[c]	1120[d]	1118[d]	1106[d]	22.1
Dry matter intake, lb/d	21.0[c]	22.8[d]	20.9[c]	20.9[c]	.59
Daily gain, lb	3.88[c]	3.41[d]	3.36[d]	3.28[d]	.11
Feed/gain	5.46[c]	6.70[d]	6.27[d]	6.40[d]	.16

[a]Rehy=Corn bran rehydrated to similar moisture concentration compared with wet bran.
[b]Final weight calculated as hot carcass weight divided by a 63% dress.
[c,d]Means within a row not bearing a common superscript differ (P < .05).

Table 3. Effect of corn bran form on carcass characteristics of finishing yearling steers.

	Treatment[a]				
Ingredient	Control	Dry Bran	Rehy Bran	Wet Bran	SEM
Hot carcass wt., lb	753[b]	705[c]	704[c]	697[c]	13.9
12th rib fat thickness, in.	.34	.32	.28	.28	.04
KPH[d] fat, %	2.47	2.32	2.23	2.30	.10
Yield grade	1.93	1.93	1.93	1.93	.19
Marbling score[e]	4.83	4.86	4.51	4.55	.12

[a]Rehy=Corn bran rehydrated to similar moisture concentration compared with wet bran.
[b,c]Means within a row not bearing a common superscript differ (P < .05).
[d]KPH=kidney, pelvic, and heart.
[e]Marbling score; 4.5=Slight 50, 5.0=Small 0, etc.

Results

Results of performance and carcass characteristics are presented in Tables 2 and 3, respectively. Dry matter intake was higher ($P < .05$) for steers fed dry corn bran compared with wet or rehydrated corn bran or the corn control (Table 2). Daily gain and feed efficiency were similar among the three forms of corn bran. Steers fed the corn control diet gained 15% faster and were 18% more efficient compared with the average of those consuming diets containing corn bran ($P < .05$). Based on actual dry matter intake and daily gain, the dietary NEg concentration of the diets containing corn bran was 19% lower ($P < .05$) than the corn control diet. The dietary NEg concentrations of the corn bran diets were similar. Using a NEg value of 70 Mcal/cwt for corn, these data suggest that corn bran had a NEg value of 52 Mcal/cwt, approximately 65% of the NEg value for corn grain. Previous Nebraska experiments (1997 Nebraska Beef Report pp.72) have demonstrated that approximately 15% dry bran inclusion in corn-based diets enhanced performance by reducing acidosis, but inclusion levels up to 30% of the dietary dry matter resulted in NEg values for corn bran approximately 80% of corn grain. The higher levels (40% DM basis) of corn bran fed in this experiment would have been more than adequate to reduce any deleterious effects of acidosis. This might explain some of the differences in the calculated NEg value for corn bran in the present experiment compared with the previous experiments.

Carcass weights were similar for steers fed diets containing corn bran (Table 3). Carcass weights of steers fed the corn control averaged 51 pounds heavier ($P < .05$) than those of steers fed diets containing corn bran. Twelfth rib fat thickness, USDA yield grade, and marbling score were similar among treatments.

The form of corn bran, dry, wet, or rehydrated, appears to have limited, if any, impact on the energy value of wet corn gluten feed. Because drying of corn bran alone has minimal effect on gluten feed, the reduced energy value of dried gluten feed with distillers solubles may be due to the extensive drying of steep (going from 50% DM to 90% DM) or the drying of corn bran in the presence of steep. Other factors such as the proportion of corn bran and steep liquor with distillers solubles (1999 Nebraska Beef Report pp. 29) appear to have the greatest nutritional impact on the finished product in the production of wet corn gluten feed.

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Phase-feeding Metabolizable Protein for Finishing Steers

Rob Cooper
Todd Milton
Terry Klopfenstein[1]

Phase-feeding metabolizable protein can reduce nitrogen excretion to the environment while maintaining equal performance. In this trial, performance was lower than projected causing metabolizable protein requirements to be overpredicted.

Summary

A finishing trial was conducted to evaluate phase-feeding of metabolizable protein in order to match requirements. Treatments were: 1) one finishing diet which matched requirements at initial weight; 2) one finishing diet which matched requirements at mid-weight; and 3) six finishing diets fed in sequential order which matched requirements throughout the feeding period. The 1996 Beef NRC was used to determine metabolizable protein requirements. No performance differences were observed. Gains and efficiencies were lower than projected, likely due to mud, causing protein requirements to be overpredicted. Phase-feeding metabolizable protein maintained equal performance and reduced nitrogen excretion compared to treatment 1.

Introduction

Typical feedlot diets often contain higher crude protein levels than predicted by the 1984 NRC. This is primarily because the factorial system (1984 NRC) does not account for the microbial nitrogen requirement. Therefore, typical feedlot diets are formulated with excessive crude protein levels in order to ensure maximum performance.

The 1996 NRC uses a metabolizable protein (MP) system which accounts for both the protein requirement for the animal as well as for the rumen microbial population. Because the metabolizable protein system more accurately predicts protein requirements, it may be efficacious to feed protein levels at or near the predicted requirement and still ensure maximum performance.

The primary reason for feeding protein levels at, but not above, the requirement is pending environmental regulations. In trials conducted at the University of Nebraska (1999 Nebraska Beef Report, pp. 60-63), yearling steers were fed finishing diets containing 13.5% crude protein, which was approximately 123% of the predicted requirement. During the 137-day feeding period from May to September, each steer excreted approximately 65 pounds of nitrogen onto the pen surface, of which about 71% volatilized into the air. In 192-day calf-finishing trials conducted from October to May, steers excreted approximately 71 lb of nitrogen onto the pen surface, of which, approximately 41% volatilized into the air.

The metabolizable protein system (1996 NRC) predicts large changes in the protein requirement throughout the feeding period due to changes in intake, body weight and composition of gain. The overall MP requirement does not change significantly; however, the composition or type of protein required does. The degradable intake protein (DIP) requirement increases due to a gradual increase in intake. The undegradable intake protein (UIP) requirement decreases due to both a larger supply of microbial protein and from a lower requirement because the composition of gain is increasingly more fat and less lean. Therefore, because the requirements are changing, a series of finishing diets fed in sequential order in order to meet, but not exceed both the DIP and UIP requirements throughout the feeding period (phase-feeding), should be beneficial. Therefore, objectives of the current trial were to evaluate phase-feeding of metabolizable protein in order to match requirements of finishing calves.

Procedure

One hundred and fifty crossbred steer calves (average initial weight = 585 lb) were used in a completely randomized design to evaluate phase-feeding of metabolizable protein. Steers were stratified by initial weight into one of 15 pens (10 steers per pen). Pens were randomly assigned to one of three treatments (five pens per treatment). Treatments consisted of: 1) one finishing diet fed throughout the feeding period which was formulated to match MP requirements at 700 lb body weight; 2) one finishing diet fed throughout the feeding period which was formulated to match MP requirements at 950 lb body weight; and 3) six finishing diets fed in sequential order to match MP requirements for every 100 lb increment in body weight change throughout the feeding period.

The 1996 NRC was used to determine the appropriate MP requirements. In order to use the 1996 NRC model to predict requirements throughout the feeding period, accurate projections of body weight, intake and gain are needed. We summarized all appropriate calf finishing trials conducted at the University of Nebraska ARDC Feedlot. Using intermediate weights, performance parameters for each 100 lb increment in body weight were calculated and shown in Table 1. These parameters were used as inputs in the NRC model to formulate the appropriate diets. Treatment 1 was formulated for 700 lb which was the initial weight of the steers when they reached the finishing diet. Treatment 2 was formulated for 950 lb body weight because it was the mid-weight of the feeding period. Because the UIP requirement decreases during the feeding period, treatment 1 should match the UIP requirement initially, but then

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overfeed UIP increasingly throughout the feeding period. Treatment 2 should be deficient in UIP up to the midpoint (950 lb), then become excessive for the remainder of the feeding period. Treatment 3 should match the UIP requirement throughout the feeding period. Our hypothesis was that treatments 1 and 3 would perform similarly, and both would perform greater than treatment 2. Treatment 3 would be the most economical because of less UIP supplementation compared to treatment 1, and improved performance compared to treatment 2.

Finishing diet compositions are shown in Table 2. In treatment 3, because dry rolled corn (60% UIP) and high moisture corn (40% UIP) have opposite DIP and UIP profiles, we altered the combination of these two ingredients in the six finishing diets in order to match the predicted requirements. Feathermeal and bloodmeal were added in order to meet UIP requirements beyond what dry rolled corn could provide in diets A, B, and C. The average dry matter percentages of dry rolled and high moisture corn in the six finishing diets of treatment 3, were about the same as those used in the finishing diets of treatments 1 and 2. All finishing diets were formulated to contain a minimum of .7% calcium, .3% phosphorus, .8% potassium, 27 g/ton Rumensin, and 10 g/ton Tylan (DM basis). Steers were brought up to full-feed in 21 days using four step-up diets containing 45, 35, 25, 15% alfalfa (DM basis).

Steers were weighed initially after being limit-fed at 2% of body weight for five days to minimize differences in gut fill. Steers were implanted with Revalor S on days 1 and 85 and fed for a total of 203 days. Final weights were calculated using hot carcass weight adjusted to a common dressing percentage (62%).

Table 1. University of Nebraska-Lincoln Feedlot performance parameters for finishing calves.

	Body weight lb	DM intake lb/d	DM intake % of body weight	Daily gain lb/d	Feed/Gain
	600	18.0	3.00	3.6	5.0
	700	19.0	2.71	3.6	5.3
	800	20.0	2.50	3.6	5.6
	900	21.0	2.33	3.6	5.8
	1000	21.5	2.15	3.6	6.0
	1100	22.0	2.00	3.6	6.1
	1200	22.5	1.88	3.6	6.3
	1300	23.0	1.77	3.6	6.4
Average	950	20.9	2.29	3.6	5.8

Table 2. Composition of finishing diets (% of diet DM).

	Treatment[a]							
	1	2	3					
			A	B	C	D	E	F
Dry rolled corn	46	46	67	67	67	29	20	14
High moisture corn	21	21	—	—	—	38	47	55
Wet corn gluten feed	20	20	20	20	20	20	20	20
Alfalfa	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Dry supplement	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5
Feathermeal	1.32	.12	1.04	.96	.20	—	—	—
Bloodmeal	.33	.03	.26	.24	.05	—	—	—
Crude protein	12.7	11.7	12.7	12.6	12.0	11.4	11.3	11.2

[a]Treatment 1 was balanced for initial weight, Treatment 2 was balanced for the mid-weight, and diets in Treatment 3 were fed in sequential order and balanced for every 100 lb increment in body weight.

Table 3. Performance, carcass, and nitrogen balance results.

	Treatment			
	1	2	3	*P* =
DM intake, lb	21.2	20.9	21.0	.69
Daily gain, lb	3.29	3.20	3.21	.21
Feed/gain	6.45	6.54	6.54	.30
Fat depth, in.	.49	.50	.48	.79
Marbling score[b]	505	506	503	.98
Yield grade	2.4	2.2	2.2	.27
Nitrogen intake, lb/head	87.2[c]	79.4[d]	80.5[d]	.0001
Nitrogen retention[f], lb/head	10.7[c]	10.5[d]	10.5[d]	.03
Nitrogen excretion[g], lb/head	76.6[c]	68.9[d]	70.0[d]	.0001

[a]Treatment 1 was balanced for initial weight, Treatment 2 was balanced for the mid-weight, and diets in Treatment 3 were fed in sequential order and balanced for every 100 lb increment in body weight.
[b]Marbling score of 500 = Small 0, 600 = Modest 0.
[cd]Means in a row not bearing a common superscript differ ($P < .05$).
[f]Nitrogen retention based on ADG, NRC equation for retained energy and retained protein.
[g]Nitrogen excretion calculated as intake minus retention.

Results

Results are shown in Table 3. No differences were observed ($P > .10$) for any performance or carcass parameters for treatments 1, 2, or 3. Based on past feeding experience with similar calves and diets, we projected these steers to consume 21 lb of feed and gain about 3.6 lb/day (Table 1). The steers in this trial consumed the amount we projected, but only gained about 3.2 lb/day. This trial was conducted during the winter and spring of 97-98. During this period, we experienced very poor feeding conditions with a lot of mud. It is our conclusion that the mud increased the steers' NEm requirement, increasing feed required per lb of gain by approximately 12%. Because gains were lower than expected, MP requirements were overpredicted. Treatment 2 provided the lowest level of supplemental UIP and should have been deficient during the first half of the feeding period, based on our projections. However, the actual UIP balance was positive during the entire feeding period for treatment 2, as well as for the treatments 1 and 3. Therefore, no performance differences would be expected.

Due to performance lower than projected, the results of this study do not properly evaluate phase-feeding of MP. Analysis with the 1996 NRC model agrees with the performance data in that the model predicts no response because all treatments were excessive in UIP and MP. However, there was a treatment difference in nitrogen excretion onto the pen surface. Treatment 1 consumed and excreted more nitrogen ($P < .05$) than treatments 2 or 3 (Table 3). As a result, treatment 1 not only had the highest ration cost, but also poses the greatest environmental concern. In this trial, treatment 2 was optimal because of lowest protein supplementation cost with equal performance. However, we would project under good feeding conditions, the performance of treatment 2 would be reduced compared to treatments 1 and 3.

This trial emphasizes the need for accurate predictions of performance in order to match MP requirements. Optimizing protein supplementation in order to minimize excretion and maintain maximum performance will become a very important issue for cattle feeding. Phase-feeding of MP throughout the feeding period may be efficacious; however, additional research is needed to validate this concept.

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Dietary Phosphorus Effects on Waste Management and Nutrient Balance in the Feedlot

Galen Erickson
Terry Klopfenstein
Todd Milton
Dan Walters[1,2]

Decreasing dietary phosphorus to not exceed requirements decreased phosphorus excretion and improved phosphorus mass balance in feedlot pens.

Summary

Four experiments were conducted, two with calves in the winter/spring and two with yearlings during the summer, to evaluate the effects of decreasing dietary phosphorus on nutrient balance in the feedlot. The control diets averaged .38% phosphorus, whereas the experimental diets were formulated to not exceed requirements (~.25%). Phosphorus excretion was reduced by feeding the lower phosphorus diet. Phosphorus removed in manure at cleaning was not different. However, when manure was corrected for soil phosphorus, phosphorus removal was decreased by 59% in the summer trials and 38% in the calf trials during the winter/spring by feeding the experimental diet.

Introduction

When manure is used as a fertilizer, either excess P is applied to the land base or extra fertilizer N needs to be applied to optimize crop yields. The ratio is typically much lower than 5:1 (required by most crops) because 50 to 70 % of the N volatilizes from the pen after excretion in either the feces or urine, whereas P is conserved. Increasing the N or decreasing the P will add value to the manure relative to crop needs.

From an environmental perspective, decreasing P excretion would be advantageous to improve the sustainability of the beef industry. If P excretion is decreased, less P will be present in manure. With lower P in manure, fewer acres would be required to apply manure in an environmentally sustainable manner.

Our objective was to formulate a diet to meet the animal's requirement for protein and phosphorus, and to determine the effects on animal performance and more importantly nutrient balance in the feedlot.

Procedure

Four experiments were conducted, two with 96 yearling steers each fed through the summer months and two with 96 calves each fed through the winter/spring months. Steers were randomly assigned (8 head/pen) to either the control (CON) or the experimental treatment (EXP). Yearlings were fed for an average of 137 days from May to October and implanted twice with Revalor-S with the second implant about 70 days from slaughter. Yearlings were stepped-up to highest energy diet in 21 days with four diets containing 45, 35, 25, and 15 % alfalfa hay which were fed for 3, 4, 7, and 7 days respectively.

The control diet (Table 1) was formulated to provide .35 % phosphorus (P) with all supplemental P from dicalcium phosphate. The control diet was considered typical for this region, based on published surveys. The experimental diet was formulated using the 1996 NRC

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Table 1. Diet composition (% of DM) for yearlings and calves.

	Yearlings				Calves								
		Exp				Exp							
Item[a]	CON	1	2	3	CON	1	2	3	4	5	6	7	8
DRC	81.3				82.5	82.5	82.5	82.5	82.5	59.5	35.0	4.5	
HMC		67.4	64.6	61.4						16.5	36.5	61.0	57.5
C.bran		17.2	19.9	23.1						6.5	11.0	17.0	25.0
Liq-32	6.2				5.0								
Molasses						5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Fat		3.0	3.0	3.0									
Alfalfa	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Suppl.	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Dical P	.48				.47	.10	.04						
P (%)	*.36*	*.25*	*.24*	*.22*	*.41*	*.31*	*.30*	*.29*	*.28*	*.27*	*.26*	*.23*	*.22*

[a]CON is control and EXP is experimental treatments, Dry-rolled corn, high-moisture corn, corn bran, Liquid-32 is a molasses based supplement.

model to not exceed P requirements. Since both DRC and HMC contain .25 to .30% P and the requirement is .23 % P, the EXP treatment also contained corn bran (0.10 % P) to meet but not exceed the P requirement predicted by the NRC model. Since the P requirement changes with days on feed, EXP finishing diets 1, 2, and 3 were fed for 28, 28, and an average of 54 days, respectively, with corn bran replacing HMC.

In the two calf trials, steers were fed for an average of 192 days from November to May. Steers were implanted twice with Revalor-S with the second implant about 85 days from slaughter. Cattle were adapted to finisher diets (7.5 % alfalfa) similar to the yearling trials except each diet was fed for seven days. The control diet was similar to the yearling diets and formulated to provide .35 % P. The experimental diet was formulated using the 1996 NRC model to meet changing calf requirements. The first seven finishers were fed for 14 days each and finisher 8 was fed until slaughter. The P requirement also decreases with increasing weight of the animal so DRC and HMC were gradually replaced with corn bran to prevent overfeeding of P. During the second year, calves were placed on finisher 2 and finisher 1 was skipped due to heavier initial weights than in year 1.

Initial weights were an average of weights taken on two consecutive days following a five-day limit-feeding period. At slaughter, hot carcass weights and liver scores were recorded. Quality grade, yield grade, and fat thickness at the 12th rib were recorded following a 48 hour chill. Final weights were calculated as hot carcass weight divided by a common dressing percentage (62).

Steers were fed in 12 waste management pens. Soil in pens was core sampled (0 to 6 inches) before the trial to estimate nutrient concentration on the pen surface. The animals then were fed in those pens for an average of 132 d over the summer or 183 d over the winter/spring after which pens were cleaned. Manure was sampled during removal and pen soil samples again were collected to estimate nutrient balances after the feeding period. Soil sampling allows adjustment for inevitable cleaning differences from pen to pen. These pens also contain runoff collection basins to determine total runoff from pens on different treatments. Due to pen design, two pens drain into one pond; therefore dietary treatments were assigned randomly in blocks of two pens. All samples including feed and orts were analyzed for P. Manure and soil samples were analyzed by combined nitric and perchloric acid digestion and the filtrate analyzed for P by inductively coupled plasma (ICP) analysis. Feed samples were analyzed by alkalimetric ammonium molybdophosphate method using a spectrophotometer.

Results

Gain and carcass characteristics were unaffected ($P > .20$) by dietary treatment in both yearling and both calf trials (Table 2), suggesting supplementation with mineral P is unnecessary to optimize animal performance. Another objective of these four trials was to determine the effects of matching dietary protein to requirements. Animal performance, nitrogen balance, and organic matter balance have been previously discussed for the two-year study (1999 Nebraska Beef Report, pp. 60-63). Feed conversions were influenced by dietary treatment. However, as previously discussed, the response is an energetic response to corn bran depressing conversions in the calf experiments and the

Table 2. Performance of calves and yearlings fed either conventional protein and phosphorus levels (CON) or the experimental diets (EXP) to minimize overfeeding protein and phosphorus combined across both years. Means are an average of 12 reps per treatment (6 pens per treatment per year).

	Yearlings				Calves			
Item	CON	EXP	SEM	P=	CON	EXP	SEM	P=
Initial weight,lb	694	697	1.8	.17	605	608	1.7	.25
Final weight,lb	1242	1256	7.4	.17	1264	1258	8.5	.60
DM Intake,lb	25.2	24.5	.2	.03	20.3	20.7	.2	.21
ADG,lb	3.98	4.07	.05	.27	3.45	3.40	.04	.43
Feed/gain[a]	6.33	6.02		.01	5.88	6.10		.04

[a]Analyzed as gain to feed, the reciprocal of feed to gain.

Table 3. Phosphorus (P) balance in the feedlot for the yearling and calf trials combined across both years and separated by dietary treatment (all values expressed as pounds per head over the entire feeding period).

	Yearlings				Calves			
Item	CON	EXP	SE	P=	CON	EXP	SE	P=
Intake	12.8	7.2	.11	.01	15.0	9.9	.16	.01
Retention[a]	1.9	1.9	.01	.82	2.5	2.4	.01	.24
Excretion[b]	10.9	5.3	.11	.01	12.5	7.5	.15	.01
Manure	5.2	5.5	.28	.54	14.6	12.2	1.2	.24
Runoff	.48	.25	.06	.04	.14	.22	.05	.28
Soil[c]	.6	-3.1	.34	.01	-3.3	-5.2	.34	.02
Difference[d]	4.7	2.7	.25	.01	1.1	.2	.9	.52
Manure+core	5.8	2.4	.33	.01	11.3	7.0	.91	.03

[a]P retention based on ADG, NRC equation for retained energy, retained protein and P.
[b]P excretion calculated as intake minus retention.
[c]Soil is core balance on pen surface before and after trial; negative values suggest removal of phosphorus present before trial.
[d]Difference calculated as excretion minus manure minus soil minus runoff. These values indicate that not all the P that was excreted is being recovered.

high-moisture corn and tallow improving conversions with the yearling experiments.

Feeding EXP decreased ($P < .01$) P intake without affecting ($P > .24$) P retained by the animal (Table 3). Calves did retain more P than yearlings probably due to greater bone growth during the feeding period. Decreasing P to NRC-predicted requirements decreased P excretion by 5 lb per steer (12.4 grams per day) for the calf trials (183 days) and by 5.6 lb of P (19.3 grams per day) for the yearling trials (132 days). When expressed as a percentage of P excreted by CON steers, 49% and 60% of the P was excreted by yearlings and calves fed EXP, respectively.

Decreasing P excretion did not affect P removed in manure removed at cleaning. However, when corrected for P in soil cores, P available for removal was decreased by 59% (3.4 lb) for the yearlings and by 38% (4.3 lb) for the calf trials. P removal was much greater (over 2 times) following the winter/spring feeding period with the calves compared with summer-fed yearlings. One potential explanation is much more soil is removed at cleaning in the spring primarily because pens are wetter and the soil is more thoroughly mixed with the manure. The negative core values suggest that more P was removed from the soil than was present at the initiation of each trial. Over time, the P in soil should gradually decrease if dietary P was decreased. At the initiation of each experiment, pens were reassigned to treatment at random. Some pens that were on the CON (high P) treatment from the previous trial were reassigned to the EXP (low P) treatment. All residual P in the soil from the previous experiment may be removed in manure at cleaning from the EXP pens, resulting in negative core values. In established feedlots, P removal in manure should be similar to P excretion.

In conclusion, it appears that decreasing dietary phosphorus to animal requirements will decrease P excretion. However, we are not accounting for all the P in soil between trials during the summer feeding periods. More P may be removed in the spring cleaning due to more soil being removed and therefore removing more fecal material that is mixed with the pen soil. P analysis is also challenging for measurement in soil and manure. In these trials we've analyzed for total P in soil and manure with no regard for available P. However, the concept is the same whether cleaning in the spring or fall. When manure is corrected for soil P by taking soil cores in open-dirt lots, decreasing dietary P will reduce P intake, P excretion, and subsequently reduce total P either removed in manure or left on the pen surface at cleaning. When expressed as a percentage of P in soil-corrected manure for the CON treatment, only 41% and 62% of the P were removed for the EXP treatment for yearlings and calves, respectively. The percentages in soil-corrected manure are similar to the percentages for P excretion (49 and 60%).

In these experiments, corn bran was added to replace either high-moisture corn or dry-rolled corn to decrease dietary P to NRC-predicted requirements. One management option is to eliminate supplemental P from mineral sources. Therefore, only feed P that would come from basal ingredients such as corn, corn byproducts and the roughage would be fed. In these experiments and previously reported studies (1998 Nebraska Beef Report, pp. 78-80), animal performance has been unaffected by exclusion of P from mineral supplements. Therefore, feedlots could improve the P mass balance if supplemental P is removed from the diet and allow manure to be spread across fewer acres.

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Effect of Increasing Dietary Corn Silage on Performance, Digestibility and Nitrogen Mass Balance in the Feedlot

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Increasing dietary corn silage in finishing diets decreased gains and increased manure nitrogen and organic matter without affecting N volatilization.

Summary

Three dietary corn silage levels (15, 30, and 45% of diet DM) were evaluated in corn finishing diets fed to calves through the winter/spring and yearlings during the summer to determine effects on performance and nitrogen mass balance in feedlot. Yearling gains decreased quadratically with increasing corn silage; however, N and OM removed in manure was greatest for the 30% silage treatment. Calf gains decreased linearly as silage increased; however, N and OM removed in manure was greatest for the 45% silage treatment. Increasing dietary corn silage resulted in decreased gains but did influence manure N with no effect on N volatilization.

Introduction

The imbalance between N:P ratio in manure relative to crop requirements is an emerging concern to feedlot producers. Management and nutritional techniques that will either increase N or decrease P in manure will improve the imbalance because typical manure contains a N:P ratio of 2:1 or lower and crop requirements are 5:1 or greater. Two contributing factors for the imbalance between N and P in manure relative to crop needs are P is overfed and N volatilizes off the pen surface presumably as ammonia.

One method to increase manure N is to increase OM (organic matter) supply on the pen surface. Feeding high fiber, less digestible diets may lead to improved retention of manure N and decreased volatilization due to increased OM on the pen surface. Corn silage may be a potential feedstuff that if fed at higher than typical levels, may improve N retention in manure because corn silage is less digestible than the corn it is replacing. However, based on previous research, increasing corn silage in finishing diets may be as profitable despite poorer feed conversions.

The primary objective of this research is to determine if increasing dietary corn silage can increase manure N and decrease N losses via volatilization. A second objective was to determine the effects of increasing dietary corn silage on animal performance, digestibility and nutrient balance in the feedlot.

Procedure

Two experiments were conducted, one with 96 yearling steers (BW=746 + 46 lb) fed through the summer months and the other with 96 steer calves (BW=692 + 22 lb) fed through the winter/spring months. Steers were randomly assigned (8 head/pen; 4 pens/treatment) to either 15, 30, or 45% (DM-basis) corn silage diets (Table 1). Yearlings were fed for 146 days from May to October and implanted initially with Synovex-S® followed with Revalor-S® 97 days from slaughter.

In the calf trial, steers were fed for an average of 194 days from November to May. Steers were implanted initially with

Table 1. Diet composition (% of DM) for yearlings and calves. Note: diet for digestibility trial was identical to the yearling diet except 1.5% urea was used to ensure abundant degradable nitrogen.

	Yearlings			Calves		
Ingredient[a]	15%	30%	45%	15%	30%	45%
Corn silage	15	30	45	15	30	45
DRC	70	30	0	80	65	50
HMC	10	35	50			
Supplement	5	5	5	5	5	5
Urea	.94	.92	.92	.88	1.01	1.15
Limestone	1.30	1.20	1.10	1.55	1.46	1.36
KCl	.67	.45	.23	.67	.50	.23
FM				1.20	.65	0
BM				.15	.08	0
Salt	.30	.30	.30	.30	.30	.30
Tallow	.10	.10	.10	.10	.10	.10
Tr. Min.	.03	.03	.03	.05	.05	.05
Vitamin ADE	.01	.01	.01	.01	.01	.01
Rumensin-80	.016	.016	.016	.017	.017	.017
Tylan-40	.013	.013	.013	.013	.013	.013
CP	11.3	11.3	11.4	12.1	12.0	11.8
DIP[b]	5.6	6.5	7.3	6.0	6.5	7.0
NE_m[c]	95.6	92.0	88.3	95.4	91.3	87.3
NE_g[c]	65.2	62.7	60.0	65.0	62.0	59.0

[a]DRC is dry-rolled corn, HMC is high-moisture corn, FM is feather meal, BM is blood meal, Tr. Min. is trace mineral premix.
[b]DIP was increased as corn silage increased because microbe efficiency is predicted to increase with higher levels of corn silage. DIP was increased from either a greater proportion of HMC in the yearling diets or from less feather meal/blood meal and more urea in the calf diets.
[c]NE values calculated using tabular values for ingredients.

Synovex-S® followed with Revalor-S® 115 days from slaughter.

Initial weights were an average of weights taken on two consecutive days following a 5-day limit-feeding period. At slaughter, hot carcass weights and liver scores were recorded. Quality grade, yield grade and fat thickness at the 12th rib were recorded following a 24-hour chill. Final weights were calculated as hot carcass weight divided by a common dressing percentage (62).

Diets were formulated to meet steers' metabolizable protein (MP) requirement at 800 lb for yearlings and calves. In each diet, MP was overfed by the same amount. In the yearling diets, grain source was changed to keep UIP (undegradable intake protein) that was overfed constant across the three levels of silage. In the calf experiments, feather meal and blood meal were added in an 8:1 ratio to the 15 and 30% silage diets to keep overfed UIP constant.

Steers were fed in 12 open-dirt pens. Soil in pens was core sampled (0 to 6 inches) before the trial to estimate nutrient concentration on the pen surface. Pens were cleaned after the entire feeding period when the cattle were marketed. Manure was sampled during removal and pen soil samples were collected again to estimate nutrient balances after the feeding period. Soil sampling allows adjustment for inevitable cleaning differences from pen to pen. These pens also contain runoff collection basins to determine total runoff from pens on different treatments. Due to pen design, two pens drain into one pond; therefore, dietary treatments were assigned in blocks of two pens. All samples including feed and orts were analyzed for N and OM.

Digestibility trial

Six ruminally and duodenally cannulated steers (BW=1125 lbs) were used in a replicated, 3x3 Latin square digestibility trial. Diets were similar to yearling diets except 1.5% urea and .25% chromic oxide (DM-basis) were provided in the supplement. Steers were fed by automatic feeders with feed provided every two hours. DM digestibility was determined by total fecal collection on rubber mats. Periods were 14 days in duration with total feces and urine collected during the last five days. On the first three days of each five-day collection period, rumen, blood, and duodenal samples were collected at three-hour intervals from 10 am to 7 pm on the first day. On the second day, samples were collected from 11 am to 8 pm, and the third day, samples were collected from 12 noon to 9 pm at three-hour intervals. Rumen pH was recorded immediately and all samples were frozen. Feces was collected daily, weighed and one aliqout frozen and subsequently freeze-dried and the other aliqout was dried in a 60°C forced air oven for DM determination.

Table 2. Performance of yearlings fed 3 levels of silage for 146 days.

Item	15% silage	30% silage	45% silage	SE	linear	quad.
Initial wt., lb	768.2	768.4	767.8	2.1	.87	.89
Final wt., lb	1303.6	1231.5	1254.3	9.8	.01	.01
ADG, lb/day	3.64	3.15	3.31	.06	.01	.01
DM Intake, lb/day	23.9	23.9	23.6	.2	.32	.52
Feed/gain[a]	6.54	7.58	7.09	—	.02	.01
Carcass wt., lb	808	764	778	6.1	.01	.01
Marbling score[b]	502	513	485	7.6	.16	.07
Fat depth, in.[c]	.42	.39	.37	.01	.02	.67

[a]Analyzed as gain to feed, the reciprocal of feed to gain.
[b]Marbling score where Slight 50 = 450 and Small 50 = 550.
[c]Fat depth at the 12th rib in inches.

Table 3.Performance of calves fed 3 levels of silage for 194 days.

Item	15% silage	30% silage	45% silage	SE	linear	quad.
Initial wt., lb	690.4	692.2	693.1	1.0	.08	.71
Final wt., lb	1370.8	1349.2	1299.2	9.5	.01	.25
ADG, lb/day	3.51	3.39	3.12	.05	.01	.27
DM Intake, lb/day	20.3	21.5	21.4	.3	.01	.07
Feed/gain[a]	5.78	6.33	6.85	—	.01	.47
Carcass wt., lb	850	837	806	5.9	.01	.25
Marbling score[b]	553	506	474	13.6	.01	.65
Fat depth, in.[c]	.54	.50	.43	.04	.06	.74

[a]Analyzed as gain to feed, the reciprocal of feed to gain.
[b]Marbling score where Slight 50 = 450 and Small 50 = 550.
[c]Fat depth at the 12th rib in inches.

Results

Performance-yearlings

Increasing corn silage from 15 to 45% in the yearling trial resulted in no differences (P > .20) in DMI; however, there was a quadratic response (P < .01) for ADG (Table 2). Steers fed the 30 and 45% corn silage diets gained less than steers fed 15% corn silage. Final weights and feed conversion, expressed as lbs of DM per lb of gain responded similar to ADG across silage levels. Fat depth, carcass weight and marbling score all indicate that steers fed the 30 and 45% corn silage diets were not as fat or as finished as steers fed 15% corn silage.

Performance-calves

In the calf trial, DMI response was quadratic (P < .10) with calves fed the 30 and 45% corn silage diets consuming more DM than the 15% silage treatment (Table 3). ADG decreased linearly (P < .01) across silage level and feed required per lb of gain increased linearly (P < .01) across silage level. Based on fat depth and marbling scores, calves on the 45% silage diets were not as fat and probably should have been fed longer to be sold at a similar endpoint as calves on the low silage diets. Based on gains, calves on the 45% silage diet should have been fed another 23 days. Assuming a fattening rate of .003 inches per day, to reach the same fat depth, calves should have been fed another 37 days.

Our hypothesis was that in both the calf and yearling trials, steers would consume more feed at the higher levels of corn silage. Despite feeding a lower

(Continued on next page)

energy diet by replacing corn with corn silage, ADG would be offset by the increased DM intake which would lead to poorer feed conversions with increasing silage. However, in both trials, ADG was depressed by feeding either 30 or 45% corn silage when compared with 15% silage. DM intake was unaffected in the yearling trial but did increase in the calf trial as predicted. Similar intakes across treatments in the yearling trial may be due to the HMC replacing DRC as silage level increased. DM intake may have been lower for the 30 and 45% silage treatments than if DRC was used. This experiment was conducted in the summer so feed condition in the bunk would be a concern; however, DM intake was still as high as the 15% silage treatment which suggests that feed condition was not a factor.

Diet cost was decreased by feeding the higher level of silage in both the calf and yearling experiments (Table 4). Despite the lower diet cost, cost of gain was increased by feeding the higher levels of silage to yearlings from $41.76 per 100 lb gain to $46.99 and $43.99 for the 30 and 45% silage diets, respectively. For calves, cost of gain increased from $38.82 to $40.81 and $43.06 for the 30 and 45% silage diets, respectively. The increase in cost of gain is due to lower gains and increased yardage and interest for the higher levels of silage. Calculated breakevens were similar to trends in cost of gain.

Table 4. Cost of gain, breakeven, and economic comparisons of cattle performance for both the calf and yearling experiments.

Item	15% silage	30% silage	fed to same wt. 30% silage	45% silage	fed to same wt. 45% silage
Yearlings					
Diet cost, $/ton[a]	74.85	73.04	73.04	71.28	71.28
Total gain, lb	536	464	536	486	536
Feeding costs[b]	223.86	220.65	251.88	215.93	235.80
Total costs[c]	838.26	835.05	866.28	830.33	850.20
Cost of gain, $/cwt.	41.76	47.55	46.99	44.43	43.99
Breakeven, $/cwt.	64.28	67.78	66.43	66.21	65.20
Calves					
Diet cost, $/ton[a]	75.94	73.74	73.74	71.46	71.46
Total gain, lb	681	657	679	606	678
Feeding costs[b]	264.37	268.80	277.10	263.26	291.98
Total costs[c]	850.87	857.00	865.30	852.31	881.03
Cost of gain, $/cwt.	38.82	40.91	40.81	43.44	43.06
Breakeven, $/cwt.	62.06	63.53	63.11	65.61	64.26

[a]Based on $2 per bu. corn, silage price based on silage value assuming 50% grain, 35% DM (NebGuide, G74-99; $20.93/ton as-is).
[b]Yardage-$0.30 per day, health cost of $25, and interest on cattle and feed of 9%.
[c]Assuming $0.80 per lb for 768 lb yearlings and $0.85 per lb for 690 lb calves.

Table 5. DM, OM, and N digestibility results from replicated Latin square digestibility trial using the yearling diets fed to ruminally and duodenally cannulated steers.

Item	15% silage	30% silage	45% silage	SE	F-test
DM intake, lb/day	24.5[a]	25.2[a]	22.7[b]	.7	.06
DM digestibility, %	80.6	79.1	79.3	1.1	.53
OM intake, lb/day	23.1[a]	23.9[a]	21.5[b]	.7	.10
OM excreted, lb/day	4.42	4.72	4.17	.30	.21
OM digestibility, %	81.2	80.3	80.5	1.2	.82
N intake, grams/day	217.9[a]	213.4[a]	195.2[b]	4.5	.07
N excreted, grams/day					
In feces	25.9	35.0	44.9	14.1	.46
N digestibility, %	88.1	83.9	77.2	4.5	.34
Rumen pH	5.78[a]	5.85[a]	5.99[b]	.10	.03
pH deviation[c]	.167[a]	.179[ab]	.240[b]	.026	.08

[a,b]Means with different superscripts differ (P < .10)
[c]Standard deviation calculated from 12 pH measurements from 3-day rumen fluid collection

Digestibility trial

In the digestibility trial, DM intake was depressed (P < .10) by feeding the 45% silage diet compared to the 15 and 30% silage diets (Table 5). OM intake and N intake responded similar to DM intake with the 45% silage treatment resulting in lower intakes (P < .10) than 15 and 30% silage treatments. Because the diets were all similar in concentration of N and OM, the decreasing nutrient intakes are directly related to the depression in DM intake. DM, OM, and N digestibilities were unaffected (P > .10) by silage level. Our hypothesis was that DM and OM digestibility would decrease linearly as silage level increased. However, the response was different than expected. Grain source was different between levels of silage to supply more DIP and less UIP to yearlings in the summer. The high-moisture corn may have increased digestibility on the 45% silage diet. Also, because DM intake was lower on the 45% silage treatment, digestibility would be higher than if DM intake was constant between treatments as was the case with the yearlings in the feedlot trial. Rumen pH increased linearly (P < .10) as silage level increased from 15 to 45% of diet DM.

Nutrient balance-yearlings

N intake and excretion were not different (P > .30) across silage levels in the yearling feedlot trial (Table 6). N removed in manure at cleaning responded quadratically (P < .03) with more N removed from the 30% silage treatment than the 15 and 45%. N in runoff was not a large proportion of N excreted (3 to 7%). In the summer yearling trial, 32 to 34 lb per steer of the 55.5 to 56.2 lb of N excreted volatilized during the summer. Level of silage did not affect (P > .60) N volatilization or percentage volatilized which averaged 59%. Volatilization estimates for previous summer feeding trials ranges from 60 to 70% of what the animal excretes (1999 Nebraska Beef Report, pp. 60-63).

OM intake decreased linearly (P < .02) as silage level increased. OM excretion was quadratic (P < .01) with the greatest amount excreted for the 30% silage treatment and similar amounts excreted for the 15 and 45% silage

Table 6. Nitrogen (N) and organic matter (OM) mass balance of yearlings fed 3 levels of silage for 146 days. Values are expressed as total pounds per steer.

Item[a]	15% silage	30% silage	45% silage	SE	linear	quad.
N intake	62.8	63.2	62.7	.6	.90	.55
N retained	7.4	7.0	7.1	.05	.01	.01
N excretion	55.4	56.2	55.6	.6	.84	.33
N removed	10.4	14.3	10.6	1.2	.94	.03
N soil	8.5	8.1	8.0	2.9	.91	.97
N runoff	3.9	1.7	2.9	.3	.05	.01
N volatilized	32.6	32.1	34.1	3.2	.75	.75
% volatilized[b]	58.9	57.1	61.2	5.6	.77	.68
OM intake	3249	3215	3135	30	.02	.54
OM excretion	611	633	611	6	.95	.01
OM removed	202	300	248	21	.16	.02
OM soil	113	149	118	35	.93	.45
OM runoff	87	30	75	20	.69	.07
OM volatilized	210	154	171	46	.57	.53

[a]N retained in the animal, N removed in manure, N soil is the soil core balance between soil sampled before and after cattle were fed and pens cleaned, N volatilized is the difference between N excreted and N removed, N soil balance, and N runoff.
[b]% volatilized is percentage of N excreted lost to volatilization.

Table 7.Nitrogen (N) and organic matter (OM) mass balance of calves fed 3 levels of silage for 194 days. Values are expressed as total pounds per steer.

Item[a]	15% silage	30% silage	45% silage	SE	linear	quad.
N intake	75.3	79.8	79.4	1.0	.01	.07
N retained	9.6	9.5	9.2	.05	.01	.16
N excretion	65.8	70.4	70.3	.9	.01	.07
N removed	41.3	41.0	44.6	2.3	.33	.51
N soil	-.4	-.8	-1.5	2.3	.73	.97
N runoff	1.7	.7	1.0	.3	.08	.10
N volatilized	23.1	29.4	26.2	2.2	.35	.12
% volatilized[b]	35.2	41.7	37.4	3.2	.65	.20
OM intake	3736	3958	3939	47	.01	.07
OM excretion	915	1069	1063	13	.01	.01
OM removed	783	926	1002	46	.01	.57
OM soil	84	88	6	48	.28	.49
OM runoff	24	12	14	3	.06	.12
OM volatilized	24	44	41	58	.83	.89

[a]N retained in the animal, N removed in manure, N soil is the soil core balance between soil sampled before and after cattle were fed and pens cleaned, N volatilized is the difference between N excreted and N removed, N soil balance, and N runoff.
[b]% volatilized is percentage of N excreted lost to volatilization.

treatments assuming, OM digestibility was similar across silage levels. OM digestibility was based on results from the digestibility trial. OM removed in manure was quadratic (P < .02) with more OM removed on the 30% silage diet which was similar to N removal and OM excretion.

Nutrient balance-calves

N intake and excretion were increased linearly (P < .01) by silage level in the winter/spring calf trial (Table 7). However, N removed in manure was not different between treatments. Runoff did not constitute much of what the calves were excreting, resulting in 1 to 2.6% of N excreted lost in runoff from pens. N volatilized was not different (P > .10) between treatments when expressed as total lb (average = 26.2 lb) or as percentage volatilized (average = 38.1%). The winter/spring feeding trial resulted in less N volatilization compared to the summer trial when expressed as either total lbs per steer or as a percent of N excreted which agrees with previous feeding trials.

OM intake increased linearly (P < .02) as silage increased from 15 to 45% of diet DM. The OM intake differences reflect differences in DM intake due to similar OM concentrations in the diet between treatments. OM excretion in the calf trials was not based on digestibility trial results because grain source was dry-rolled corn. OM excretion was calculated based on average digestibilities from three sources in the literature where dry-rolled corn was replaced with corn silage. OM digestibility values used for calculating OM excretion were 75.5, 72.3, and 72.3% of OM intake for 15, 30, and 45% silage treatments, respectively. OM excretion was quadratic (P < .01) with more OM excreted from calves fed the 30 and 45% silage treatments. OM in manure responded linearly (P < .02) with more OM removed from the 30 and 45% silage treatments. Runoff from pens resulted in 1.1 to 2.6% of OM that was excreted being lost from pens. OM volatilized estimates are relatively low and may not differ from zero considering the variation associated with the estimate.

In the feedlot trials, our hypothesis was that more OM would be removed from the 45% silage treatment compared to 15% silage. The increased OM in manure would "trap" more N in manure for the 45% silage treatment. However, the 45% silage treatment did not result in more N being removed from pens in the winter, calf feeding trial or the summer, yearling trial. More N was removed from the 30% silage treatment in the summer and numerically more was removed from the 45% treatment in the winter/spring trial. The 30 and 45% silage treatments did not affect N volatilization as predicted, but more OM was removed in manure from these treatments. Since P content of each treatment diet was similar, N:P ratio should only be influenced by amount of N in manure and reflect those differences.

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[1]Galen Erickson, graduate student; Terry Klopfenstein, professor, Todd Milton, assistant professor, Ryan Mass, graduate student, Animal Science, Lincoln.
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Feed Program Impact on Land Requirements for Managing Manure Nutrients from a Feedlot

Rick Koelsch[1]

Decisions relative to protein and phosphorus ration content of diets for a 1,000 head feedlot can alter the land requirement for managing manure nutrients from 500 to 1,250 acres.

Summary

Using data from UNL feeding trials (1998 Nebraska Beef Report, pp. 86-88) designed to compare the impact of protein and phosphorus intake on nutrient excretion, an estimate is made of the land requirement for manure application. A balanced diet formulated using the 1996 NRC was compared to other typical feed rations. The standard industry ration required an additional 100 and 400 acres of land to manage the additional manure nitrogen and phosphorus excreted, respectively, by a 1,000 head feedlot. A spreadsheet tool is introduced for estimating land requirements for manure produced by alternative feeding programs.

Introduction

Is sufficient land available for managing the nutrients in manure? This question is fundamental to sound environmental management of manure. It is being asked by the Nebraska Department of Environmental Quality (NDEQ) as permit applications are reviewed, and it should be addressed by any cattle producer housing livestock in confined facilities.

Current NDEQ permit procedures for livestock facilities require producers to document adequate land base available for manure application based upon manure nitrogen (N). Phosphorus (P) based management of manure typically requires significantly greater land area than N-based management. Currently, land requirements are not regulated based upon P. However, growing pressure exists for greater regulation of P buildup in soil. NDEQ requires that a producer submit soil tests for soil P levels, minimum of one composite per 40 acres. However, no upper limits for soil P level have been established at this time in Nebraska.

Many factors affect manure nutrient excretion and eventual land requirements for agronomic nutrient application. Decisions at the feed bunk will play a critical role. To examine the impact of diet on land requirements, UNL feed trial and manure excretion data were used.

Procedure

In the 1998 Nebraska study (1998 Nebraska Beef Report, pp. 86-88), the "balanced" diet formulated using the 1996 NRC was reported to not impact gains, slightly improve feed efficiency and reduce manure nutrient excretion compared to a more standard industry feed ration (control diet). Using these rations, manure nutrient-excretion was estimated by performing a "nutrient balance" on the animal. The nutrient balance approach estimates nutrient excretion by subtracting animal retention of nutrients in weight gain from nutrient consumption in the diet. For beef cattle, National Research Council procedures are used for estimating N and P retention by beef cattle.

To account for nutrient losses, 55% of the N and 95% of the P was assumed retained in the manure after volatilization and feedlot runoff losses based upon standard Natural Resource Conservation Service estimates for feedlots. After losses were considered, land requirements were estimated, assuming continuous corn averaging 160 bushels per acre. All crop nutrient needs were assumed to be met from manure only.

Results

Protein not used for animal maintenance/growth needs will be excreted as urea or organic N in the manure. Typically, 85 to 90% of the N fed to animals as protein will be excreted by beef cattle in feedlots. Feeding protein in excess of animal requirements adds to the N in the manure.

An estimate of nutrient excretion and land requirements is presented for the control and balance rations, assuming a N based application rate (Table 1). Twenty percent more land is needed for manure N management for the higher protein control diet. For a 1,000 head feedlot, an additional 100 acres is needed for managing the N in manure.

Commonly observed ranges for P levels in feedlot rations can have an even

Table 1. Changes in land application area needs for a 1,000 head feedlot as a result of difference in diet protein content.

Crude protein dietary options	Manure nitrogen Excretion (lb. N/yr.)	Manure nitrogen After losses (lb. N/yr.)	Land requirement for managing N (ac)[a]
Balanced (11.5%)	134,000	72,000	510
Control (13.5%)	161,000	87,000	610

[a]Assumptions:
- Nutrient use in crop production assumes continuous corn (160 bushels/acre) and all crop nutrient requirements are met from manure.
- Assumes that 55% of the N and 95% of the P are retained in the manure collected for land application.

Table 2. Changes in land application area needs as a result of differences in diet P content.[a]

Phosphorus dietary options	Manure phosphorus Excretion (lb. P/yr.)[b]	Manure phosphorus After losses (lb. P/yr.)[b]	Land requirement for managing P (ac)
Balanced (0.22% P)	13,200	12,600	510
Control (0.35% P)	24,000	23,000	930
Diet using corn processing by-products (0.45% P)	33,000	31,000	1,250

[a]See Assumptions used for Table 1.
[b]To obtain phosphorus fertilizer equivalent, multiply P value by 2.29 to obtain P_2O_5 equivalent.

Table 3. Manure nutrient excretion based upon two alternative procedures for estimating manure nutrient excretion.

Estimating procedure	N excretion estimate lb. N/year	P excretion estimate lb. P/year.
Book value		
ASAE[a]	105,000	29,800
NRCS[b]	97,000	30,400
Nutrient balance[c]		
Control diet	160,800	24,000
Balanced diet	133,700	13,200

[a]American Society of Agricultural Engineers. 1999. ASAE Standards 1999. Published by American Society of Agricultural Engineers. St. Joseph, MI.
[b]Soil Conservation Service. 1992. Agricultural Waste Management Field Handbook. United States Department of Agriculture. Publication No. 651.
[c]Nutrient accretion is estimated from National Research Council. 1996. Nutrient Requirements for Beef Cattle. National Academy Press, Washington, D.C.

greater impact on land requirements (Tables 1 and 2). A diet containing .35% P will result in 50% more land needed for managing manure P than is needed for managing the N. For the control diet, an additional 290 acres of corn production was required for a 1,000 head feedlot.

A ration containing a 0.22% P results in almost half the manure P excretion as compared to a diet with 0.34% P (Table 2). In addition, 420 acres less land was required for a 1,000 head feedlot. The land requirements based upon P application rate are reasonably close to those required for an N-based application rate at this lower dietary P level. This should substantially reduce the buildup of P in soils and the resulting high soil P tests commonly observed around many feedlots.

It is also important to recognize the impact of alternative feeds such as the by-products of corn processing (Table 2). Use of these feed sources can result in dietary P levels of 0.45%. The resulting excretion of excess P will require almost 2.5 times more land for managing the P in manure as compared to the 0.22% P diet.

Typically, a book value estimate is used for manure nutrient production based upon accepted references relative to manure excretion. The weakness of a book value approach is that it assumes all beef cattle are fed the same ration and perform the same. A comparison of the two procedures for estimating manure nutrient production is illustrated in Table 3. Two common references for a book value estimate of nutrient excretion result in a lower estimate of N excretion as compared to the nutrient balance procedure. Conversely, the book value procedure estimates a greater nutrient excretion than the nutrient balance procedure for P excretion. The book value procedures estimate more P excretion than the animals are consuming for both the control diet (29,000 lb. of P) or balanced diets (18,600 lb. of P). A nutrient balance procedure should provide a more realistic estimate of manure nutrient excretion.

The implication of the nutrient balance procedure is that it will recommend the need for greater land requirements for managing N than current book value estimating procedures used by Nebraska Department of Environmental Quality. It also suggests the need for a smaller land base for managing P, although this is not a regulated issue at this time. If regulatory procedures base land requirements upon P, it will be to the producers' advantage to use the nutrient balance procedure.

The previous estimates of land application area needs may vary for individual farms for a variety of reasons. To develop a better understanding of land needs for an individual situation, a "Manure Nutrient Inventory" spreadsheet has been developed to assist Nebraska livestock producers and advisors. The spreadsheet can be accessed via the Internet from a home computer and used with Microsoft Excel (version 5.0 or later). The spreadsheet and a set of instructions are available at:

http://www.ianr.unl.edu/manure

Many Cooperative Extension and NRCS offices also have access to this same tool and would likely be able to assist one in reviewing an individual situation.

The purpose of the Manure Nutrient Inventory Spreadsheet is to estimate the excretion of nutrients by livestock and poultry, the quantity of nutrients remaining after losses and the land needs for using those nutrients at agronomic rates. A producer can evaluate the impact of 1) herd size, 2) feeding program, 3) method of storage and/or treatment of manure, 4) method of land application, and 5) crop selection, rotation and yield on estimated land requirements.

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Exporting Feedlot Manure to Off-Farm Users

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A small group of Nebraska feedlots are successfully marketing manure to off-farm users by packaging agronomic and nuisance avoidance services with the manure. Users indicate that such services are important to their use of feedlot manure.

Summary

A survey of Nebraska feedlots suggests the majority of feedlots do not export manure to off-farm customers despite a common lack of land base (owned or managed by the feedlot) for using the nitrogen and phosphorus in manure. Only a small portion of the feedlots in Nebraska are actively marketing manure as a product with value by packaging agronomic and nuisance avoidance services with the manure in an effort to enhance its value. A separate survey of manure users suggests that the reason users purchase manure was for its crop nutrient value. However, many users were uncomfortable relying on the nutrients in manure and so supplemented the manure with commercial fertilizer. End users need to be better able to determine manure's nutrient value.

Introduction

The concentration of nutrients is a common environmental concern of beef confinement systems. It is common for Nebraska feedlots to import 2 to 5 times more nitrogen and phosphorus (primarily as purchased feed) than leave the farm as managed products. The imbalance represents an environmental risk.

Export of manure nutrients to off-farm users represents one potential practice for reducing the concentration of nutrients. A survey was implemented to identify the practices of Nebraska feedlot managers to deliver manure to off-farm manure users. In addition, a survey instrument was completed by users of Mead Cattle Company manure. The objectives of this study were as follows:

1. Summarize current practices on Nebraska cattle feedlots relative to exporting of manure.
2. Review of the perceived benefits and costs by neighboring crop producers who accept manure.
3. Identify innovative strategies that encourage export of manure to off-farm users of manure.

Procedures

Two surveys were conducted. A mail survey was conducted of 210 feedlot owners using a mailing list from the Nebraska Cattlemen followed by a postcard reminder (one week later) and a copy of the survey and cover letter (two weeks later). A response rate of 117 of the original 210 (55%) surveys resulted. A second mail survey was prepared for users of manure from a single large Nebraska feedlot. The survey instrument was mailed to 100 individuals with similar follow-up reminders. Sixty completed surveys were returned.

Results

Feedlot Survey

The feedlots represented by the responses to this survey were commonly medium and larger feedlots (Table 1). On average, these operations maintained a one-time population of 5,650 animal units (AU...1,000 pounds of live weight) which were primarily finishing cattle. The average land base under the management of the operator was 1,323 acres. Feedlots less than 10,000 AU distributed manure over one-quarter or less of the available land under the farm's management. Those over 10,000 AU used most of their available land for manure application on an annual basis. Although feedlots over 10,000 AU had a smaller total land base for manure application, they tended to use an equal or larger land base for manure application per animal unit as the medium-sized farms (1,000 to 10,000 AU). In addition, the larger lots were more likely to export manure to off-farm uses. These two indicators would suggest that the manure from the largest feedlots is typically spread at lower nutrient application rates than manure from the medium-sized lots.

Typically, those lots under 1,000 AU were likely to have access to sufficient land for meeting both nitrogen and phosphorus needs. Those farms between 1,000 and 10,000 animal units had access

Table 1. Characteristics of feedlots involved in survey.

Size of Livestock Operation	<1,000 AU (11 farms)	1,000 - 4,999 AU (52 farms)	5,000 - 10,000 AU (27 farms)	>10,000 AU (15 farms)
Average Size				
- Animal Units	581	2,635	6,944	17,517
- Cropland (acres)	679	1,031	1,414	1,565
- AU/acre	0.9	2.6	4.9	11.2
Manure Distribution				
- % of Land Manured	24%	19%	26%	88%
- AU/acre Manured	3.6	13.4	19.2	12.7
Exporting Manure				
- % of total farms	9%	29%	41%	80%
- Do not export due to sufficient owned land.[a]	82%	60%	52%	20%

[a]Based upon livestock producer's judgment.

to adequate land for using the nitrogen although they may not be using sufficient land for adequate nitrogen management. These farms also lack sufficient land for managing phosphorus. The largest feedlots were short on land for both nitrogen and phosphorus management and most of this group (80%) exported manure. As a rough rule of thumb, sufficient land for managing nitrogen and phosphorus will limit animal concentration to 2 to 4 AU per acre and 0.5 to 1 AU/acre, respectively.

Regarding the export of manure nutrients to off-farm customers, 72 (64%) of the respondents said they did not export manure nutrients off-farm. The most common reason for not exporting (89%) was the producer's perception that sufficient owned or managed land base for use of the manure was available. Those farms that exported manure have, on average, 30 AU per available acre. Those who chose not to export manure averaged 7 AU per acre.

Fifty producers provided information about their efforts to export feedlot manure to off-farm users. Crop producers (96%) were the primary users of exported manure. Approximately one-third of those surveyed were also exporting manure to other users including local homeowners, landscaping services and businesses marketing gardening products.

The most common financial arrangements were to give manure away at no charge (54%) to at least some users (Table 2). For those who charged for manure, a wide range of approaches for pricing manure were reported. The most common charge was per unit volume, weight, or load (30%). Many producers combined a charge per unit volume or weight with a charge for application area or distance traveled. Very few producers charged for manure based upon the nutrient content of the product.

Table 2. Most common financial arrangement for transfer of manure to primary user.

I pay users of manure to accept manure.	2%
I give manure away at no charge.	54%
I charge per unit volume, weight, or load.	30%
I charge per unit distance manure is hauled.	20%

Table 3. Most common services provided by feedlots exporting manure.

Agronomic Services		Nuisance Prevention Services	
No Services	40%	No services	51%
Manure sampling	38%	Day application to avoid nuisance	33%
Measure of application rate	38%	Maintain setback distances	19%
Rate adjustment for individual fields/crops	31%		
		Manure Processing	
		No Processing Services	70%
		Composting of manure	23%

The survey attempted to identify those services that were packaged with the export of manure to off-farm customers (Table 3). However, there were a number of feedlots that offered services designed to enhance the value of manure. Many producers offered one or more agronomic services with manure sampling, measurement of manure application rate and adjustment in application rate for individual crop and field conditions being the most common. To minimize nuisance issues, daytime application to avoid noise nuisance and setback distance were the most commonly reported efforts. Composting of manure was reported by almost one-quarter of the feedlots exporting manure.

Most feedlots exporting manure (60%) have encountered some form of environmental or nuisance-related concern. The three most common issues encountered were odors (28%), road traffic (26%) and road maintenance (24%). Forty-one percent of feedlots indicated that no one has raised concerns with them. Experiences of most producers currently exporting manure to off-farm users has been sufficiently positive to warrant continuation of this practice. Eighty-three percent of feedlots currently exporting manure indicated they intend to continue or increase the marketing of manure. Of those feedlots not previously exporting manure, only 11% planned to begin this practice.

Many individuals shared their insights as to efforts that enhanced manure export including:

- It has become a valuable product for farmers. I can usually get a lot hauled at another's expense." Similar comment shared by nine feedlots.
- "Go the extra mile to establish good relationships with neighbors." The importance of community relations was shared by five feedlots.
- "Work very closely with the customer." Four feedlots stressed the importance of customer relations.
- "Provide as many services as possible to enhance the value of the manure being spread." Eight feedlots emphasized the importance of enhancing the value of manure with additional services.

A small number of the responding feedlots took an entrepreneurial approach in marketing manure as a product with value. The marketing package assembled by three of these feedlots is summarized in Table 4. Each of these three feedlots has assembled a package of agronomic services, nuisance-avoidance services, and financial charges for the manure. One feedlot relied on composting to limit nuisance concerns and reported road traffic as the only nuisance issue that had been encountered to date. Another feedlot encountered the whole range of nuisance and environmental concerns raised by neighbors and local government. In response to these community concerns, this lot has assembled a package of nuisance avoidance services including advance notification of neighbors and county government of spreading plans and same-day incorporation of manure to minimize exposure to odor and flies.

Those surveyed identified three critical information needs related to establishing or maintaining a manure marketing program. The three highest priority information needs included 1) avoidance of environmental/nuisance

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Table 4. Summary of three feedlots effort to actively market manure as a valued product to off-farm users.

	Feedlot #1	Feedlot #2	Feedlot #3
Animal Capacity	4,500 head finishing capacity	20,000 head finishing capacity	3,000 head finishing capacity
Crop Acres	340 acres	2000 acres	100 acres
Users of Feedlot Manure			
Customers	Crop producers	Crop producers and landscape services	Crop producers and landscaping services.
Financial Arrangement	Charge per unit volume or load	$2/acre loading cost + $1.2/ton hauling cost + $5/acre application cost.	$4.5/ton of compost + hauling and spreading cost
Who Transport Manure	Feedlot	Independent contractors	Feedlot
Services Provided			
Agronomic	Manure sampling, measured application rate, rate adjustment for individual field/crop, and customer report of nutrient application rate	Manure sampling, measured application rate, rate adjustment for individual field/crop, incorporation within 24 hours, and deep tillage for compaction.	Manure sampling, measured application rate, rate adjustment for individual field/crop, and soil sampling.
Nuisance Prevention and Manure Processing	Maintain setbacks	Advance notification of neighbors and local government, and same day incorporation.	Composting
Environmental/Nuisance Issues			
Concerns raised	None	Odors, flies, noise, surface and groundwater quality, and road traffic and maintenance.	Road traffic
Source of concerns	No one	Homeowners, other farms, & government	Homeowners
Lessons Learned and Advice for Others			
	-Manure applied to clay hills noticeably increases yields and helps control runoff. -Important to get manure tilled into soil soon as possible in spring when hauled in winter -Someone that has problems getting rid of manure should haul to neighbors for free 1 year to determine benefit. Following year you may have good demand.	-Provide as many services as possible to enhance the value of manure being spread. -Make sure transporting equipment is in tip-top shape. -Manure spills are very detrimental to public opinion. -If you claim fertilizers nutrients in the manure - make sure they are in the manure.	-This is a composting operation that sells to local crop producers. After composting, we have had no negative raction as to smell, flies, and pollution possibilities.

problems; 2) estimating agronomically based manure application rates; and 3) pricing of manure for competitive and profitable marketing of the manure resource.

Feedlot Manure User Survey

A more in-depth review of the issues encountered by Mead Cattle Company relative to manure marketing (Feedlot #2, Table 4) was also conducted. For this livestock operation, less than 15% of the nitrogen and 10% of the phosphorus in the manure could be used within the cropping program on land owned by this business. The feedlot has implemented a rather ambitious program to market slurry manure from confinement barns that is trucked by tanker trailers to fields to be surface applied and deep chiseled into the soil. The majority of the fields receiving manure application (70%) were an average distance of 10 miles or less and (7%) were a distance of 15 miles or greater. The feedlot had encountered several obstacles with this effort.

In a given year, respondents indicated that they applied Mead Cattle manure on an average of 103 acres. Growers noted that the preferred crop to be grown following application was corn. The survey results showed that 37% of the users purchased manure because they believed that it improved yield performance. Other common reasons for purchasing Mead Cattle manure included 1) organic matter source, 2) deep tillage when incorporated, and 3) lower cost nutrient source.

Manure was applied by Mead Cattle at a constant rate that is typically sufficient to supply the nitrogen needs of irrigated corn production. Forty-five percent of the users of Mead Cattle manure indicated that nitrogen was the primary nutrient of interest while 35% indicated that phosphorus was the primary nutrient. An alarming 45% of the growers preferred annually to apply additional nitrogen as an insurance against late-season deficiencies while an additional 22% said they did occasionally. However, only 10% preferred to apply additional phosphorus. The unwillingness of crop producers to rely completely on manure nutrient was partially explained by some of their reservations with manure. Lack of uniform manure coverage (58%) and variation in nutrient analysis from load to load (63%) were commonly expressed perceptions of these users. When asked “What additional information or services are needed?”, these customers suggested a need for manure analysis (65%), an estimate of manure nutrient availability (63%) and soil sampling (38%).

Nuisance issues were also of concern to many users. Concerning potential complaints from neighbors, 35% expressed a high level of concern. However, the recent level of neighbor complaints has been relatively low. Users of Mead Cattle manure (65%) indicated they did not receive any complaints from neighbors relative to spreading manure. Twenty-three percent indicated receiving one complaint and 7% indicated multiple complaints. These complaints was related to odors (38%), noise and traffic (17%) and flies (10%).

When asked what services might be provided by Mead Cattle Company to minimize neighbor nuisance concerns, 60% of the respondents indicated same-day incorporation of manure to limit odor and fly nuisances would be very effective. Twenty percent indicated they felt that notification of neighbors in advance of application would also be effective.

Conclusions

1. The majority of feedlots in the statewide survey do not export manure to off-farm customers. However, most feedlots over 1,000 AU lacked the land base to use the nitrogen and phosphorus in manure.
2. Approximately half of the feedlots in the statewide survey that export manure are charging for the manure or the services associated with its application. A wide range of pricing structures has been used to date.
3. Only a few feedlots in Nebraska are actively marketing manure as a product with value. These individuals are packaging agronomic and nuisance avoidance services with the manure in an effort to enhance its value.
4. The majority of feedlot manure users indicated that the reason for purchasing manure was for its crop nutrient value. However, many users (up to 2/3 of users) felt uncomfortable relying on manure and so supplemented the manure with commercial fertilizer.

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Cleaning Coliform Bacteria from Feedlot Water Tanks

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Routine cleaning or disinfection may not, by itself, reduce the likelihood of transmitting coliform bacteria to cattle through water tanks.

Summary

Three methods of physically or chemically cleaning feedlot water tanks were tested for their ability to reduce amounts of coliform bacteria in the water and biofilm during the summer months. Draining and refilling or draining, scrubbing and refilling water tanks did not reduce coliform bacteria in water or biofilm. Coliform bacteria in water and biofilm were reduced 99% and 99.9%, respectively, after draining, scrubbing and 15 minutes of chemical disinfection with chlorine bleach and refilling. However, coliforms returned to pretreatment levels 24 to 48 hours after treatment if cattle continued to drink from the tanks.

Introduction

Some have speculated that the transmission of *Escherichia coli* O157:H7, or other enteric pathogens between cattle might be reduced by routine cleaning of feedlot water tanks (Hancock et al. 1997 Compend Cont Ed Pract Vet. pp S200-S207). The objective of this study was to determine if levels of coliform bacteria in water and biofilm from feedlot water

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tanks could be reduced, and for how long, by any of three methods of physical or chemical cleaning.

Procedure

Microbiology

By definition, coliform bacteria include aerobic or facultative, nonsporeforming gram-negative rods that ferment lactose and form acid and gas within 48 hours at 35ºC (Hitchins et al, 1992, American Public Health Assoc. pp 326). This group includes *E. coli* O157:H7. The coliform bacteria density of water and biofilm was estimated as the most probable number of coliform bacteria per 100 ml (MPN of coliforms) (APHA, 1995 American Public Health Assoc. pp 9-44) from samples obtained before and after the treatments. Cleaning efficacy was measured as: 1) the change in each tank's MPN of coliforms in water or biofilm from before to immediately following cleaning; 2) the change in each tank's MPN of coliforms in water from before to 24 hours after cleaning; and 3) the change in each tanks MPN of coliforms from immediately following cleaning to 24, 48 and 96 hours after cleaning.

Statistics

The logarithmic values of the MPN of coliforms were used for all statistical analyses. Differences in the pre-treatment coliform levels and cleaning efficacy were tested by paired t-test, one-way analysis of variance (ANOVA) using Tukey's HSD to separate means, or repeated-measures ANOVA as appropriate for the hypothesis.

Trial 1

Three methods of cleaning were assigned systematically to six feedlot water tanks for three periods at three week intervals (six repetitions of three methods) as follows:

- Method 1) water tank was drained and refilled
- Method 2) water tank was scrubbed with a brush to remove any visible biofilm, drained and refilled
- Method 3) water tank was scrubbed with a brush as above, drained and refilled. Household chlorine bleach (5.25% Na hypochlorite) was added to the water tank to a final 1:32 dilution. The disinfectant solution was kept in the tank for 15 minutes before the tank was drained again and refilled.

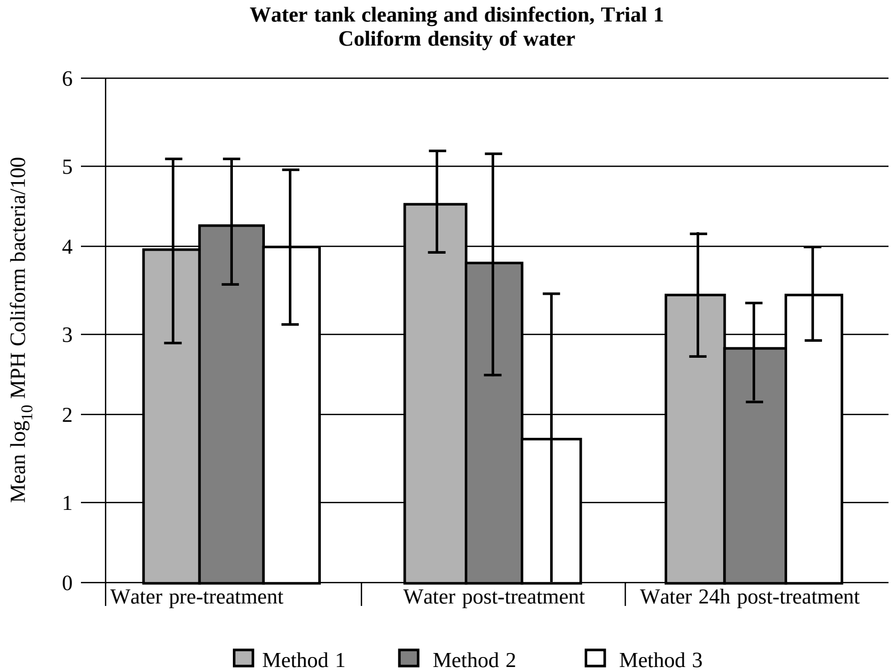

Figure 1. Most probable number (MPN) of coliform bacteria per 100 ml in water collected from feedlot water tanks cleaned by draining (Method 1, n=6), scrubbing and draining (Method 2, n=6), or scrubbing, draining and chemical disinfection (Method 3, n=6). Cleaning by method 3 significantly reduced the coliform bacteria in the biofilm immediately after treatment (P=.0003). Coliform levels at 24 hours were not different from pre-cleaning levels for any cleaning method (P=.12). Error bars show 1 standard deviation.

Trial 2

The hypothesis tested was that the change in MPN of coliforms after chemical disinfection (bacterial regrowth) would be different in water tanks with cattle drinking from them compared to tanks in empty feedlot pens because of additional contamination of the water with bacteria or substrate by cattle drinking from the tanks.

Twelve water tanks were scrubbed and chemically disinfected (using cleaning method 3, Trial 1). Cattle were removed from access to six of the water tanks when the tanks were cleaned; cattle continued to drink from the remaining six water tanks. The MPN of coliforms were calculated from cultures of the water and biofilm before and immediately following cleaning and from cultures of water 24, 48, 72 and 96 hours after cleaning.

Results and Discussion

Trial 1

The MPN of coliforms in the water collected immediately after treatment from tanks cleaned with chemical disinfection (method 3) was reduced (P=.0003) on average more than 99% (mean $10^{2.3}$ -fold reduction). The other cleaning methods did not reduce the MPN of coliforms in the water. The MPN of coliforms of the water collected from tanks at 24 hours post-treatment was not significantly different from the respective pre-treatment level regardless of the cleaning method (Figure 1, P=.12). Similarly, the MPN of coliforms of the biofilm in tanks cleaned with chemical disinfection was reduced (P<.0001) on average more than 99.9%

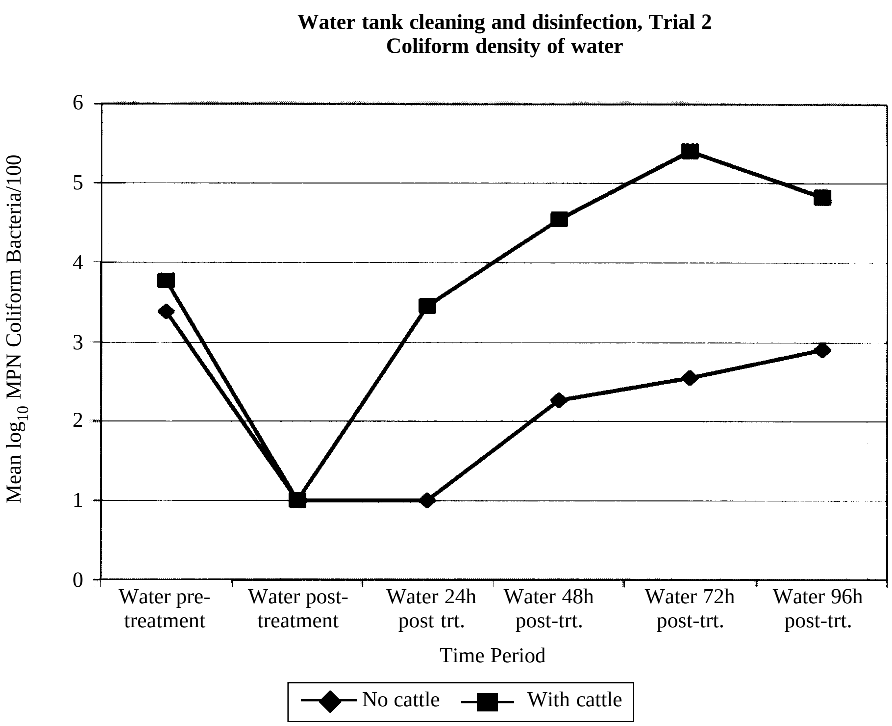

Figure 2. Most probably number (MPN) of coliform bacteria per 100 ml in water collected from six feedlot water tanks exposed (and six not exposed) to cattle after cleaning by scrubbing, draining and chemical disinfection. Coliforms in water (and biofilm) were reduced after treatment (P<.0001). Coliform levels in water increased with time after cleaning (P<.0001) and the coliform levels were higher in tanks with cattle access (P=.0003).

(mean $10^{3.6}$ -fold reduction). The MPN of coliforms of the biofilm in tanks physically cleaned was not significantly reduced.

Trial 2

The MPN of coliforms in water and biofilm were reduced immediately after water tank disinfection by averages of more than 99% (Figure 2) and 99.999%, respectively (P<.0001). The MPN of coliforms in the water increased in both groups following disinfection (P<.0001); however, during the four days after cleaning, the MPN of coliforms in water that cattle were drinking from was nearly 100-fold greater than water without cattle access (P=.0003, Figure 2).

The post-treatment rise in the MPN of coliforms measured in Trial 1 may have been due to introduction of bacteria and/or substrate into the water by cattle drinking from the tanks, or from regrowth of bacteria remaining in the water and biofilm. Trial 2 was designed to test if bacterial regrowth was directly from the tank or from recontamination by cattle. In Trial 2 coliform regrowth occurred within days of cleaning the tanks regardless of cattle access, but the magnitude of coliform regrowth was 100-fold greater in water from which cattle were drinking. These data indicate that coliform bacteria rapidly populate water tanks in the summer because cattle recontaminate them with coliform bacteria and/or substrate.

There may have been unmeasured shifts in the types of coliform bacteria repopulating the water tanks after cleaning and chemical disinfection of water tanks, so it is possible that populations of pathogenic bacteria were affected differently than other coliform bacteria. But, if the overall number of coliforms in a water tank reflects the likelihood of transmitting coliform bacteria from water tanks to cattle, then the benefits of cleaning and disinfecting water tanks to minimize the transmission of coliform bacteria to cattle are short-lived. The practice of cleaning feedlot water tanks is important for palatability and for other water quality reasons, but routine cleaning and disinfection may not, by itself, reduce the likelihood of transmission of coliform bacteria to cattle through water tanks.

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Adding Value to Low-Quality Beef Muscles through Glycolytic Inhibition in Pre-rigor Muscle

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Pre-rigor injection of specific glycolytic inhibitors may be an effective strategy to enhance tenderness of low-quality beef muscles.

Summary

Pre-rigor ***Semimembranosus, Triceps brachii*** *and* ***Supraspinatus*** *muscles were removed from 10 steers to determine effects of several glycolysis-inhibiting compounds on pH, tenderness and color. Muscles were injected and tumbled with 10% of sodium citrate, sodium fluoride, sodium acetate, or calcium chloride. Sodium citrate and sodium fluoride increased pH values in* ***Semimembranosus, Triceps brachii*** *and* ***Supraspinatus****. Tenderness improved in* ***Triceps brachii*** *and* ***Supraspinatus*** *with calcium chloride, sodium fluoride and sodium citrate when compared with controls. Color values were not different among treatments. Sodium citrate and sodium fluoride were successful in improving beef tenderness by maintaining a high pH in pre-rigor muscles.*

Introduction

Many beef muscles are low in quality and value because they lack tenderness. Given that the value of the beef chuck and round has dropped 20-30 % over the past 5-6 years, strategies should be developed to enhance tenderness of these low-quality muscles.

Muscle has an ultimate pH near 5.6. Higher muscle pH has been associated with enhanced tenderness, although most high pH meat is also darker in color. The opportunity exists to inhibit glycolysis, the metabolic pathway responsible for production of lactic acid which lowers muscle pH during development of rigor mortis. Our study was conducted to evaluate pre-rigor injection of different compounds for their effects on pH, color and tenderness of low-value beef cuts.

Procedure

Ten steers (22 to 24 months of age, 1,133 to 1,488 pounds live weight) were slaughtered at the University of Nebraska Meat Laboratory. Pre-rigor S*emimembranosus* (from the round), *Triceps brachii* and S*upraspinatus* muscles (from the chuck) were excised from both carcass sides. Muscles were randomly assigned to treatments: sodium citrate (200 mM), sodium fluoride (200 mM), sodium acetate (200 mM), and calcium chloride (300 mM). Control samples remained in the carcass at 40 °F for 24 hours, to simulate commercial conditions. Treatments were identified in a preliminary experiment (1999 Nebraska Beef Report, pp. 77-78). Calcium chloride was compared with the glycolytic inhibitors. At two hours postmortem, each muscle was injected with a volume equal to 8 % of the muscle weight. Each muscle was individually packaged (2 % of solution was added to complete 10 % of muscle weight) and tumbled for 30 min. Samples were taken for analysis three days after injection. Sarcomere length was determined by neon laser diffraction. pH was measured using a pH-meter with a combined glass electrode. A Hunter Lab Mini Scan Plus was used to evaluate color instrumentally for L*, a* and b* values. Water holding capacity was defined as the percentage of muscle weight removed by centrifugation. Meat samples were cooked on a grill to an internal temperature of 158°F. Tenderness was measured by shear force

Table 1. Effect of pre-rigor injection with glycolytic inhibitors in *Triceps brachii* muscles.

	Treatments				
Variable	Control	Calcium Chloride	Sodium Acetate	Sodium Fluoride	Sodium Citrate
L*[e]	28.18	32.15	31.36	28.27	29.56
a*[f]	25.26[a]	23.17[abc]	21.87[bc]	23.83[ab]	21.18[c]
b*[g]	6.50	6.23	6.38	6.39	5.72
WHC[h]	36.66	40.09	36.36	35.27	37.76
Sarcomere length, µm	2.41[a]	1.31[b]	1.53[b]	1.41[b]	1.62[b]
pH	5.28[d]	5.67[b]	5.48[c]	5.92[a]	5.73[b]
Shear force, lb.	12.50[a]	10.69[b]	14.26[a]	11.41[ab]	9.47[b]

[a,b,c,d]means within a row having different superscripts differ ($P<.05$).
[e]L*= lightness; 100= white, 0= black
[f]a*= redness; -80= green, 100= red
[g]b*= yellowness; -50= blue, 70= yellow
[h]Water Holding Capacity, %

Table 2. Effect of pre-rigor injection with glycolytic inhibitors in *Semimembranosus* muscles.

Variable	Treatments				
	Control	Calcium Chloride	Sodium Acetate	Sodium Fluoride	Sodium Citrate
L*[e]	29.15	29.44	32.06	27.06	30.18
a*[f]	27.57[a]	24.88[ab]	20.99[b]	22.48[b]	21.38[b]
b*[g]	7.10	6.58	5.86	5.99	5.85
WHC[h]	36.54	41.71	39.35	38.22	41.99
Sarcomere length, µm	1.81[a]	1.48[c]	1.73[ab]	1.52[bc]	1.72[ab]
pH	5.24[d]	5.60[c]	5.38[d]	6.00[a]	5.81[b]
Shear force, lb.	14.65	12.74	14.59	12.45	11.70

[a,b,c,d]means within a row having different superscripts differ (P<.05).
[e]L*= lightness; 100= white, 0= black
[f]a*= redness; -80= green, 100= red
[g]b*= yellowness; -50= blue, 70= yellow
[h]Water Holding Capacity, %

Table 3. Effect of pre-rigor injection with glycolytic inhibitors in *Supraspinatus* muscles.

Variable	Treatments				
	Control	Calcium Chloride	Sodium Acetate	Sodium Fluoride	Sodium Citrate
L*[d]	28.99	30.86	33.68	28.21	30.51
a*[e]	24.19	24.27	21.67	16.66	20.87
b*[f]	6.26	3.38	6.16	5.41	5.59
WHC[g]	40.03	36.71	35.94	34.19	32.72
Sarcomere length, µm	2.13[a]	1.30[c]	1.43[bc]	1.58[b]	1.46[bc]
pH	5.45[c]	5.54[c]	5.64[c]	6.14[a]	5.86[b]
Shear force, lb.	14.85[ab]	12.10[c]	16.73[a]	13.51[bc]	11.15[c]

[a,b,c]means within a row having different superscripts differ (P<.05).
[d]L*= lightness; 100= white, 0= black
[e]a*= redness; -80= green, 100= red
[f]b*= yellowness; -50= blue, 70= yellow
[g]Water Holding Capacity, %

using the Instron Universal Testing Machine. Data were analyzed by one-way analysis of variance. Means were separated using the least significant difference procedure.

Results

Sodium citrate and sodium fluoride showed (P<.05) the highest pH values in T*riceps brachii* (Table 1), in *Semimembranosus* (Table 2) and in *Supraspinatus* muscles (Table 3).

Shear force values decreased in *Triceps brachii* samples (P<.05) treated with calcium chloride (10.69 lb), sodium fluoride (11.41 lb) and sodium citrate (9.47 lb) compared with control (12.50 lb). In *Supraspinatus*, calcium chloride and sodium citrate also caused a significant (P<.05) decline in shear force (12.10 and 11.15 lb., respectively) compared to control (14.85 lb.). The same trend was observed in *Semimembranosus* muscle, but these differences were not significant (P>.05).

Sarcomeres lengths, an indicator of the contraction state of the muscle, were shorter with calcium chloride, sodium fluoride, sodium acetate and sodium citrate (1.31, 1.41, 1.53 and 1.62 µm, respectively) than the control (2.41 µm) in *Triceps brachii*. Pre-rigor excised muscles are more susceptible to shortening because there is no skeletal restraint. Treated S*upraspinatus and Semimembranosus* muscles also showed sarcomere shortening.

The higher pH and lower shear force of the samples with sodium fluoride and sodium citrate in comparison with the control showed high pH favors tenderness in meat. Even though sodium fluoride and sodium citrate increased pH in all muscles studied, which could indicate glycolytic inhibition occurred, water-holding capacity was not affected by treatments (P>.05).

Hunter color L* (lightness) and b* values (yellowness) were not different among treatments (P>.05). However, treated *Semimembranosus* and *Triceps brachii* muscles had less red color (lower a* values) than the control (P<.05). This result could indicate that brine injection affected color intensity of meat.

Sodium citrate and sodium fluoride were successful in improving beef tenderness, without detriment to lean color, by maintaining a high pH in pre-rigor muscles. Pre-rigor injection of specific glycolytic inhibitors may be an effective strategy to increase value of low-quality beef muscles.

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The Effects of Induced Stress and Supplemental Chromium on Meat Quality of Finishing Heifers

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The stress treatments were insufficient to generate dark cutting beef, so the benefits of chromium feeding could not be assessed. Stress reduced tenderness and redness of the lean.

Summary

Organic chromium was fed to heifers to evaluate its effect on reducing the consequence of stress. Cattle in this trial were subjected to induced stress by estrus and social interaction. The induced stress was not sufficient to cause dark cutting beef. Meat from stressed cattle tended to have lower (P = .09) redness (a) values, lower (P = .11) shear force, and higher (P= .09) ultimate pH than non-stressed animals. The effectiveness of chromium in the prevention of dark cutting beef could not be assessed.*

Introduction

Cattle exposed to pre-slaughter stress quickly exhaust their muscle glycogen stores and may produce dark cutting beef. This muscle lacks the essential substrate to produce lactic acid, which is responsible for the normal drop in muscle pH during postmortem metabolism. Meat that possesses a high pH is dark in color, dry in appearance and sticky to the touch.

Chromium is an essential mineral that plays a role in glucose metabolism. This mineral may increase glycogen deposition by increasing the efficiency of insulin. Supplemental chromium may aid in increasing glycogen reserves which may reduce the depletion of glycogen prior to slaughter. This study was conducted to evaluate the effects of stress and the benefits of chromium on meat quality of beef.

Procedure

Fifty crossbred heifers (12 - 13 head per pen) were used in this trial in order to study the effects of induced stress and supplemental organic chromium on the reduction of dark cutting beef. The stress in this trial included estrus and social stress.

Melengesterol acetate (MGA) was supplied in the finishing diets until seven days before slaughter. Removal of MGA was to initiate the onset of estrus. Three days prior to slaughter, cattle that were unfamiliar to the trial heifers were introduced into each pen. This interaction created social stress as the animals sought to re-establish a social order of dominance. Feed was analyzed to ensure that the organic chromium, supplied by a high-chromium yeast product, was provided at 400 ppb per head per day for the 62-day period prior to slaughter. Carcass information for these cattle can be found in Table 1. Meat quality was assessed by measuring pH at 45 minutes post mortem, ultimate pH (8 days post mortem) , L*, a*, and b* (90-minute bloom time), and Warner-Bratzler shear values of the longissimus muscles after 7 days of post mortem aging. The L*, a*, and b* values were used to characterize color. The L* value is the relative lightness or darkness of a color. The a* value is the relative redness of a color and the b* value relates to the level of yellowness of a color.

These treatments were arranged in a 2 x 2 factorial consisting of stress (stressed vs non-stressed) and supplemented dietary chromium (with or without Cr). Interactions were not significant, so only the main effects are presented.

Results

Differences among treatments were subtle. Induced stress failed to produce the dark cutting condition for any treatment within this study. Perhaps not all heifers came into estrus after the removal of MGA. The social interaction may also have been insufficient to deplete glycogen levels below the threshold necessary to induce dark cutting beef. Alternatively, the time from initiation of social stress to slaughter (three days) may have been sufficient for the animals to acclimate to each other and recover to some degree. Although not significant (P=.09), the trend (Table 2) was for stressed cattle to have slightly higher ultimate pH (5.53 vs 5.50), less red color (as expected) and

Table 1. Carcass measures for all treatment groups.

	No Cr, No Stress	No Cr, Stress	Cr, No Stress	Cr, Stress
Hot carcass weight, lb	828.5	824.9	821.6	806.6
Marbling score[a]	19.5	19.6	20.2	20.0
Fat thickness, in	.63	.53	.62	.55
Rib eye area, sq in	14.2	14.0	13.7	13.1
KPH%[b]	2.2	2.1	2.1	2.2
Maturity Score	A70	A66	A70	A62

[a]Marbling Score: 21 = Moderate, 20 = Modest, 19 = Small.
[b]Kidney, pelvic and heart fat percentage.

Table 2. The effect of induced stress on meat quality parameters in longissimus muscles of finishing heifers.

Parameter	Non-stressed	Stressed	P-value
pH 45 minutes post mortem	6.34	6.38	.37
Ultimate pH[a]	5.50	5.53	.09
Warner-Bratzler shear, lb	9.1	9.9	.11
L* (lightness)	38.07	38.27	.70
a* (redness)	32.17	31.54	.09
b* (yellowness)	25.37	25.11	.55

[a]Ultimate pH was determined 8 days post mortem.

Table 3. The effect of supplemental organic chromium on meat quality parameters in longissimus muscles of finishing heifers.

Parameter	Control diet	Supplemental chromium	P-value
pH 45 minutes post mortem	6.36	6.36	.89
Ultimate pH[a]	5.50	5.52	.41
Warner-Bratzler shear, lb	9.48	9.57	.87
L* (lightness)	37.79	38.55	.16
a* (redness)	31.86	31.85	.99
b* (yellowness)	25.27	25.22	.91

[a]Ultimate pH was determined 8 days post mortem.

higher shear values (P=.11, 9.9 vs 9.1 pounds, respectively). It is unlikely that the differences noted for pH are of any practical significance. The significance level may be further evidence that the stress was not completely effective in this study.

Although not significant, the color changes trend in the anticipated direction - stressed animals would be expected to have darker and less red-colored meat. This may suggest that the stress treatment was sufficient to affect meat color, but these color differences were not of practical significance. This is supported further by the fact that the ultimate pH values from the stressed cattle were not different.

Recently, color has been suggested as a means to identify carcasses likely to produce meat that is undesirable in tenderness. Although the differences were relatively small and not significant, the direction of the changes in shear force and color tends to support this strategy.

The absence of dark cutters in this study may explain the absence of any effects due to supplemental dietary chromium for any of the traits studied (Table 3). Given the insufficient stress, it is not possible to assess the beneficial effects of chromium supplementation in this study.

The only parameter that presented any differences by chromium treatment was muscle pH at 45 minutes. Heifers with no chromium supplementation that were stressed had higher (P =.04) pH at 45 minutes than non-supplemented, non-stressed heifers (6.43 vs 6.29 , respectively). These differences were also noted, but at a smaller magnitude and non-significant level, in the stressed and unstressed chromium fed cattle. Ultimate pH was not different among any of the treatments. The ultimate pH value is normally the parameter of greatest interest when dealing with dark cutting beef.

It can be concluded that the stress was insufficient to cause the dark cutting beef condition. This situation makes it difficult to assess the effectiveness of chromium in prevention of dark cutting beef. The data from this trial imply that supplemental organic chromium has subtle effects on meat quality.

The stress treated cattle in this trial did provide information, in the form of tenderness data, that brings up important questions. It has been accepted that stress prior to slaughter may compromise the overall acceptability of meat color. Generally, stress has not been thought to have a detrimental effect on tenderness of beef.

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