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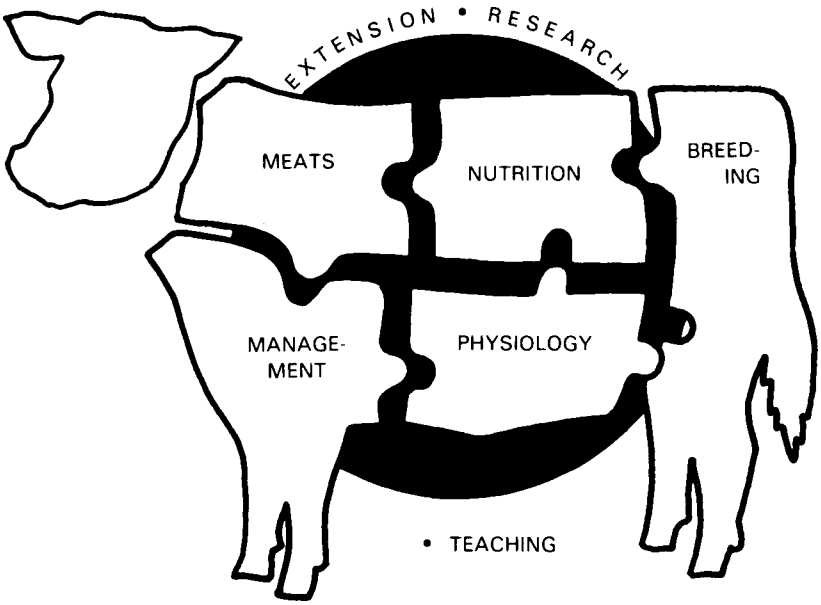

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2004 Beef Cattle Report

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An Evaluation of Economic Efficiencies of Two Beef Systems from Calving to Harvest

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Summary

Spring-calving, crossbred cows were used in a three-year experiment to determine the economic efficiencies of two different beef systems. Cows were either wintered on pasture (Control System) or on cornstalks (Treatment System). Control System steers were transported to a feedlot, fed a finishing diet and slaughtered. Treatment System steers were wintered on cornstalks, grazed pasture, fed a finishing diet and slaughtered. The Treatment System had lower weaning and slaughter breakeven, lower cost per weaned calf and greater profit potential when finished steers were sold on a live basis. Profitability was similar when finished steers were sold on a grid basis.

Introduction

Wintering the beef cow is an area of management that offers many producers significant opportunity to decrease input costs. Additionally, growing weaned calves on forages before finishing may produce more total beef at a lower cost per unit. Profit potential of cow/calf systems also is affected by the method of pricing weaned calves into the post-weaning phase of production. The marketing strategy used by a producer can further impact net income. There is limited data regarding the influence of these components on beef systems. Specifically, few studies have analyzed the economics of beef systems from calving to harvest where feed inputs have been reduced and grazing opportunities have been extended for the cow and calves post-weaning. Production data from this experiment, including cow performance, calf performance and carcass characteristics, are reported in the 2003 Nebraska Beef Report. The objective of this study was to evaluate the economic efficiency of a traditional beef production system with a system that matches cattle to forage resources.

Procedure

Cow/calf Economics

Cow cost, cost per weaned calf, and breakevens at weaning were calculated by evaluating annual inputs and revenues for the control (CON) and treatment (TRT) systems. The amounts of hay and supplements fed to cows and replacement heifers were recorded annually, as well as the number of days that cows grazed pasture and/or cornstalks each year. Input costs did not account for management, labor, or overhead.

Grazing costs were based on 10-year average rental rates for pasture in Southeastern Nebraska of $20.68 per 1.4 animal unit month (AUM) that included forage intake of a 300-lb calf. In the current experiment, this grazing cost was assigned to a 1200-lb cow. Adjustments in grazing costs were made for dormant season grazing, lactational status and body weight (lower weight of 2-year-olds and replacement heifers compared to mature cows). Cornstalk grazing was priced at $0.25/cow/day. Ten-year average prairie and alfalfa hay prices were $55.67/T and $57.42/T, respectively. Corn was priced at $2.37/bushel. Protein and salt and mineral were priced at $240/T. Costs associated with feeding were priced at $10/T feed fed. Bull costs were $20/cow unit, and health inputs per cow unit were priced at $15 per cow.

Initial cow costs were determined on a cow unit basis and included all costs described above, divided by the total number of females expected to calve within each treatment group each year. Initial cow costs were adjusted for non-calf revenue by accounting for gains/losses on cull cows and heifers. Weaning rates were similar ($P > 0.10$) between treatments, so cost per weaned calf was calculated by dividing the cow cost by the pooled weaning rate (86.5%). Actual weaning weight was similar ($P > 0.10$) between groups; therefore, breakeven at weaning was calculated by dividing cost per calf weaned by a pooled weaning weight (500 lb).

Post-weaning Economics

Steers were priced into the post-weaning phase of the system using both the economic price (15-yr average price received for the month in which the steer was weaned) of the weaned steer, as well as financial cost of producing the steer (cost/weaned calf). Trucking was priced at $0.005/lb. An operating loan interest annual percentage rate of 8.0 was used. Interest was charged on the initial cost of all steers and on trucking for the entire post-weaning ownership period. All feed inputs for each system were recorded annually, as well as the number of days the TRT steers were drylotted, grazed cornstalks and grazed pasture.

(Continued on next page)

Control steers were charged $25/head for processing. Yardage was priced at $0.30/head/day, and finishing rations were priced at $126.22/T. Interest was charged on processing, yardage and feed for half of the ownership period each year. An assumed death loss of 2% was applied to the final live weight value of each steer.

Treatment steers were charged a processing cost of $8.33/head for the wintering period, and interest was charged on processing for the entire ownership period. Drylot yardage before and after cornstalk grazing was priced at $0.23/head/day. Cornstalk grazing was priced at $0.12/head/day. The wheat straw offered to steers during the winter period was $44/T (as-fed) and intake was estimated to be approximately 12 lb/head/day (as-fed). Wet corn gluten feed was priced at $113.28/T (DM basis) and fed at the rate of 5 lb/head/day (DM basis). Mineral supplement for the TRT steers while in drylot was $338.82/T and fed at the rate of 0.15 lb/head/day; cornstalk mineral supplementation was fed at the rate of 0.24 lb/head/day and priced at $446.24/T. Interest was charged on drylot yardage, cornstalk grazing, wheat straw, wet corn gluten feed, and mineral for half of the wintering period and the rest of ownership. A 1% death loss was applied to the live weight value of the steer at the end of the wintering period.

During the summering period, TRT steers were charged $8.33/head for health care. Grazing costs were $0.45/head/day, and interest was charged on both health care and grazing costs for half of the summering period and the rest of ownership. A 0.5% death loss was applied to the live weight value of the steer at the end of the summering period.

Costs for TRT steer finishing period were similar to those of CON steer finishing, with the exception of processing charge being $8.33/head for TRT steers entering the feedlot. Interest was charged on processing, yardage and feed for half of the finishing period each year. A 0.5% death loss was applied to the final live weight value of the TRT steer.

Table 1. Yearly cow cost, cost per weaned calf, and breakeven excluding management, labor and overhead for control (CON) and treatment (TRT) systems.

Item	CON	TRT	P-value	SE
Number[a]	99	100		
Initial cow cost,$	339.75	316.46		
Non-calf revenue[b],$	(53.93)	(48.08)		
Adjusted cow cost[c],$	393.68	364.54		
Cost/weaned calf[d],$	455.12	421.43	0.07	6.83
Breakeven[e],$/lb	0.91	0.84	0.07	0.01

[a]Number of females expected to calve.
[b]Non-calf revenue = gain/loss cull cows + gain/loss cull heifers.
[c]Adjusted cow cost = cow cost + non-calf revenue.
[d]Cost per weaned calf = adjusted cow cost / weaning rate (0.865).
[e]Breakeven at weaning = (cost/weaned calf) / weaning weight (500 lb).

Table 2. Post-weaning cost per head, breakeven, revenue, and net profit/loss for the control (CON) and treatment (TRT) systems when steers are priced in on an economic basis excluding management, labor, and overhead.

Item	CON	TRT	P-value	SE
Winter period				
Initial steer cost[a],$/hd	433.95	433.95		
Trucking,$/hd	2.53	2.53		
Processing,$/hd		8.33		
Drylot yardage,$/hd		27.60		
Cornstalks,$/hd		9.28		
WCGF,$/hd		55.79		
Mineral,$/hd		5.04		
Wheat straw,$/hd		32.55		
Death loss,$/hd		5.79		
Interest[b],$/hd		27.93		
Total cost,$/hd		608.79		
Weight, lb		730		
Breakeven, $/lb		0.83		
Revenue,$/hd		578.61		
Net profit/loss,$/hd		(30.18)		
Summer period				
Initial steer cost[a],$/hd		578.61		
Grazing,$/hd		52.95		
Processing,$/hd		8.33		
Death loss,$/hd		3.53		
Interest[b],$/hd		13.37		
Total cost,$/hd		656.80		
Weight, lb		953		
Breakeven, $/lb		0.67		
Revenue,$/hd		706.86		
Net profit/loss,$/hd		50.07		
Finishing period				
Initial steer cost[a],$/hd	706.86			
Feed,$/hd	251.07	174.26		
Yardage,$/hd	63.20	27.00		
Processing,$/hd	25.00	8.33		
Death loss,$/hd	14.95	4.46		
Interest[b],$/hd	27.21	11.08		
Total steer cost,$/hd	817.91	932.00		
Final weight, lb	1058	1283		
Breakeven, $/lb	0.77	0.72	0.01	0.01
Revenue, live basis[c] ,$/hd	747.55	892.23		
Net profit/loss, live basis,$/hd	(70.36)	(39.77)	0.14	9.17
Revenue, grid basis[d],$/hd	770.75	885.14		
Net profit/loss, grid basis,$/hd	(47.16)	(46.86)	0.99	20.34

[a]Economic steer cost = cost of steer if it had been purchased using the 15-year average price for steers for the appropriate month and weight.
[b]8.0 Annual Percentage Rate.
[c]Revenue generated from the sale of a steer using weight and price categories for the month in which the steer was sold at the end of the feedlot period.
[d]Revenue generated from the sale of a steer using the pricing grid.

Table 3. Post-weaning cost per head, breakeven, revenue, and net profit/loss for the control (CON) and treatment (TRT) systems when steers are priced in on a financial basis excluding management, labor, and overhead.

Item	CON	TRT	P-value	SE
Winter period				
Initial steer cost[a],$/hd	455.12	421.43		
Trucking,$/hd	2.53	2.53		
Processing,$/hd		8.33		
Drylot yardage,$/hd		27.60		
Cornstalks,$/hd		9.28		
WCGF,$/hd		55.79		
Mineral,$/hd		5.04		
Wheat straw,$/hd		32.55		
Death loss,$/hd		5.79		
Interest[b],$/hd		27.12		
Total cost,$/hd		595.46		
Weight, lb		730		
Breakeven, $/lb		0.81		
Revenue,$/hd		578.61		
Net profit/loss,$/hd		(16.85)		
Summer period				
Initial steer cost[a],$/hd		595.46		
Grazing,$/hd		52.95		
Processing,$/hd		8.33		
Death loss,$/hd		3.53		
Interest[b],$/hd		12.74		
Total steer cost,$/hd		673.02		
Weight, lb		953		
Breakeven, $/lb		0.69		
Revenue,$/hd		706.86		
Net profit/loss,$/hd		33.84		
Finishing period				
Initial steer cost[a],$/hd		673.02		
Feed,$/hd	251.07	174.26		
Yardage,$/hd	63.20	27.00		
Processing,$/hd	25.00	8.33		
Death loss,$/hd	14.95	4.46		
Interest[b],$/hd	28.20	10.74		
Total cost,$/hd	840.07	897.81		
Final weight, lb	1058	1283		
Breakeven, $/lb	0.79	0.70	0.03	0.01
Revenue, live basis[c],$/hd	747.55	892.23		
Net profit/loss, live basis,$/hd	(92.52)	(5.58)	0.07	17.23
Revenue, grid basis[d],$/hd	770.75	885.14		
Net profit/loss, grid basis,$/hd	(69.32)	(12.67)	0.28	27.72

[a]Financial steer cost = cost to produce a weaned steer.
[b]8.0 Annual Percentage Rate.
[c]Revenue generated from the sale of a steer using weight and price categories for the month in which the steer was sold at the end of the feedlot period.
[d]Revenue generated from the sale of a steer using the pricing grid.

The live value was determined using average final weights for each year and the 15-year average live weight price for fed steers in Nebraska for month of slaughter. Breakevens were calculated by dividing the total costs of the post-weaning phase by final weight. Profit/loss per steer (live basis) was determined using total costs and live weight value.

Profit/loss per steer was determined for each system using a value-based grid. The basis used was the 1990-2000 average Nebraska dressed fed cattle price each year for the appropriate month. The 1990-2000 average USDA Quality Grade Choice/Select price spreads for the appropriate month were used to calculate premiums and discounts for marbling.

Systems Economics

Control and treatment systems were compared each year on an economic and a financial basis. Costs and revenues were calculated on a per cow exposed basis by assuming a 100-head cow herd, accounting for weaning rate (86.5%), and assuming a 50:50 ratio of steers and heifers at weaning. Economic and financial-based analysis used the summation of adjusted cow cost and the accrued costs of producing a steer for slaughter that included interest and excluded initial cost of purchasing the steer into the feedlot. Systems revenues accounted for the sale of weaned, non-replacement heifers as well as the sale of finished steers. Net system revenue was determined from the difference between systems costs and revenues, and then divided by 100 to establish net revenue per cow exposed.

Results

Cow/calf Economics

A summary of the economic evaluation of the control and treatment systems before weaning is reported in Table 1. Cost per weaned calf and weaning breakeven were higher (P = 0.07) for CON cows than for TRT cows. As functions of adjusted cow cost, cost per weaned calf and breakeven represent input costs. The most noticeable difference between input costs was in hay expense. Control cows consumed about 3144 lb/head while TRT cows consumed about 2057 lb/head of hay each year. This resulted in all costs associated with harvested forages feeding being $120.83 per cow for CON cows and $90.69 per cow for TRT cows, illustrating the impact that harvested forage feeding costs have on cost per unit of production.

Post-weaning Economic Analysis

Post-weaning steer costs and revenues for the CON and TRT groups when steers are purchased into the system on an economic basis are presented in Table 2. Slaughter breakeven was greater (P = 0.01) for the CON system than for the TRT system. Net profit/loss derived from live animal sale tended to be lower (P = 0.14) for the CON system; in the finishing period, the CON system lost $30.59

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more per steer than the TRT system. When steers were sold using the grid, profit/loss was not different between groups. Treatment steers had lower breakevens and improved profit potential when steers were sold on a live weight basis each year compared to CON steers. CON steers had higher marbling scores compared to TRT steers and TRT steers had heavier final weights compared to CON steers and these factors influenced breakevens when steers were sold on either a grid or live weight basis.

Post-weaning Financial Analysis

Table 3 reports results of the post-weaning phase when steers are priced into the system on a financial basis. Slaughter breakeven was lower (P = 0.03) for the TRT steers than for the CON steers. This difference was due to reduced initial steer cost and greater final feedlot weight for TRT steers. Profit potential when finished steers were marketed using a live sale price was also different (P = 0.07) between groups. When grid pricing was used, net profit/loss was not different.

Systems Economics

Tables 4 and 5 report the economic and financial analyses of the CON and TRT systems. Net profit/loss from live-based sale of finished steers was improved (P < 0.10) for the TRT system when compared to the CON system, regardless of method used to price steers into the feedlot or marketing technique of finished steers. The improved profit/loss for the TRT system is a function of the reduced cow costs and more revenue generated in the TRT system.

In conclusion, coordinating management of production with forage resources offers beef producers the opportunity to enhance sustainability and longevity in their operations. Net profitability of any beef production system is highly dependent on the feed costs, price received or paid for weaned calves and marketing strategies for finished cattle. Evaluation of the relative efficiencies of different cow/calf systems involves the comparison of these factors.

Table 4. Net revenue or loss generated for control (CON) and treatment (TRT) systems when steers are priced into the post-weaning phase of production on an economic basis, excluding management, labor, and overhead.

Item	CON	TRT	*P*-value	SE
Cow cost[a], $	39367.67	36454.00		
Steer cost (economic)[b], $	16510.28	21416.15		
Total system cost, $	55877.95	57870.15		
Steer revenue(live basis)[c], $	32145.65	38365.89		
Heifer revenue[d], $	17790.39	17790.39		
System revenue (live basis), $	49936.04	56156.28		
Net revenue/cow exposed (live basis), $	(59.42)	(17.14)	0.08	9.44
Steer revenue(grid basis)[e], $	33142.25	38061.16		
Heifer revenue[d], $	17790.39	17790.39		
System revenue (grid basis), $	50932.64	55851.55		
Net revenue/cow exposed (grid basis), $	(49.45)	(20.19)	0.28	14.45

[a]Cow Cost = adjusted cow cost (Table 1) * 100 head of cows.
[b]Total steer cost from weaning through slaughter with steer priced into the post-weaning phase on an economic basis, excluding initial steer cost (Table 2) * (100*0.865*0.5).
[c]Steer revenue derived from live weight sale (Table 2) * (100*0.865*0.5).
[d]Weaned heifer revenue using heifer weaning weight (494 lb) and the 15-year average price for heifers for the month weaned ($83.75/100 lb) * (100*0.865*0.5).
[e]Steer revenue derived from grid-based sale (Table 2) * (100*0.865*0.5).

Table 5. Net revenue or loss generated for control (CON) and treatment (TRT) systems when steers are priced into the post-weaning phase of production on a financial basis, excluding management, labor, and overhead.

Item	CON	TRT	*P*-value	SE
Cow cost[a], $	39367.67	36454.00		
Steer cost (financial)[b], $	16552.99	20484.34		
Total system cost, $	55920.66	56938.34		
Steer revenue(live basis)[c], $	32145.65	38365.89		
Heifer revenue[d], $	17790.39	17790.39		
System revenue (live basis), $	49936.04	56156.28		
Net revenue/cow exposed (live basis), $	(59.32)	(8.35)	0.06	9.75
Steer revenue(grid basis)[e], $	33142.25	38061.16		
Heifer revenue[d], $	17790.39	17790.39		
System revenue (grid basis), $	50932.64	55851.55		
Net revenue/cow exposed (grid basis), $	(49.88)	(10.87)	0.19	14.61

[a]Cow Cost = adjusted cow cost (Table 1) * 100 head of cows.
[b]Total cost from weaning through slaughter with steer priced into the post-weaning phase on a financial basis, excluding initial steer cost (Table 3) * (100*0.865*0.5).
[c]Steer revenue derived from live weight sale (Table 3) * (100*0.865*0.5).
[d]Weaned heifer revenue using heifer weaning weight (494 lb) and the 15-year average price for heifers for the month weaned ($83.75/100 lb) * (100*0.865*0.5).
[e]Steer revenue derived from grid-based sale (Table 3) * (100*0.865*0.5).

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A System for Wintering Spring-Calving Bred Heifers Without Feeding Hay

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Summary

Two systems for wintering pregnant, March-calving heifers were compared over two years on a commercial Nebraska ranch. The ranch's standard management system (CON) included grazed forage, supplement and hay. The alternative system (TRT) relied on grazed forage and higher levels of supplement, with no hay. Treatment effects on weight and body condition changes differed between years. Calves nursing TRT heifers tended to gain more weight. Two-year-old pregnancy rates did not differ. Partial budget analysis suggests the TRT system reduced expense by $7 per heifer, while maintaining a high level of performance.

Introduction

The costs associated with producing and feeding baled meadow hay (non-fertilized) in the Nebraska Sandhills have been reported to be $46.44 per ton (2002 Nebraska Beef Report, pp. 17-19). Because of the costs associated with providing harvested forages to beef cows in the Northern plains, interest has developed in designing supplementation programs that reduce dependence on harvested forages, and that may result in decreased winter feed costs. Such strategies may be of particular relevance during periods of drought or other conditions resulting in limited forage supplies.

Supplementing to meet the needs of spring-calving females in late gestation grazing dormant winter range is challenging, because diet samples collected in Nebraska during this time are low in both energy and metabolizable protein (1998 Nebraska Beef Report, pp. 7-11). This challenge is exacerbated when managing animals with relatively higher nutrient requirements, such as bred yearling heifers, which have been shown to be deficient in metabolizable protein (MP) when grazing winter range in Nebraska (2000 Nebraska Beef Report, pp. 7-10). In addition, low-quality forage intake by heifers in late gestation declines, perhaps due to physical inability to accommodate large volumes of forages which pass slowly from the rumen (2001 Nebraska Beef Report, pp. 19-22). These combined indicate that supplementation programs for pregnant heifers grazing dormant range must overcome a negative energy balance in addition to meeting MP requirements.

Byproducts of the corn milling industry are becoming increasingly available to Nebraska livestock producers. Dry corn gluten feed (DCGF), a product of the wet milling industry, has potential to be used as a supplement for grazing cattle. The energy and protein content of DCGF, as well as the price, permit its use in a variety of production settings.

The objective of this trial was to design a supplementation program for wintering pregnant heifers using grazed winter range and DCGF supplementation without feeding harvested forages before calving.

Procedure

The two-year study was conducted in cooperation with the Rex Ranch (Abbot Unit) near Ashby, NE. In the fall pregnant yearlings, heifers were weighed, assigned body condition scores (BCS; 1 = emaciated, 9 = obese) by two technicians, and allotted to treatment. Treatments included the ranch's standard heifer management system (CON; 558 heifers) and an alternative system (TRT; 559 heifers).

The CON system included access to native range with heifers being rotated to new pastures regularly and included supplementation of a high undegradable intake protein (UIP) supplement (Table 1), formulated to meet MP requirements (2000 Nebraska Beef Report, pp. 7-10). Hay feeding began in December and gradually was increased as the winter progressed. The amount of hay fed was at the discretion of the ranch manager and ranged from about 7 to 18 lb per heifer per day (average = 7.3). As the amount of hay was increased, the availability of ungrazed forage was decreased.

Heifers in the TRT system also were given access to standing

(Continued on next page)

range. However, the system was designed under the assumption that heifers would not be limited in the availability of grazed forage at any point. The TRT supplement (Table 1) was based on dry corn gluten feed (DCGF). Sunflower meal, fat and starch were added to improve pellet quality. The supplementation schedule was designed so predicted forage intake and DCGF supplement delivered approximately the same amount of energy as hay, control supplement and grazed forage intake in the CON system. Predicted MP requirements were met at all times for both systems.

The feeding schedule for each treatment was designed to begin Oct. 1 and continue through March 1 (estimated beginning of calving). Actual starting date was at the discretion of the ranch foreman and was dictated largely by amount and quality of available forage. The 1996 NRC Nutrient Requirements for Beef Cattle model was used to predict nutrient requirements. Predicted forage intake and diet quality were obtained from previous research conducted at the University of Nebraska (1997 Nebraska Beef Report, pp. 3-6; 2000 Nebraska Beef Report, pp. 7-10). Monthly changes in the feeding schedule were made to account for changes in forage quality and advancing gestation. The amount of supplemental feed was changed at the beginning of the month from October through January (0.7 to 1.1 and 0.7 to 4.0 lb for CON and TRT, respectively). Two-week changes were made during February to account for rapid increases in requirements during this time (1.2 to 1.8 and 5.7 to 7.5 lb for CON and TRT, respectively).

At the beginning of March, heifers again were weighed and independently assigned BCS by two evaluators. To alleviate differences in gut fill that resulted from the treatments, heifers were commingled and fed a common diet one day before processing. September to March (pre-calving) weight and BCS change were calculated. Heifers were managed as a single group during calving and the subsequent grazing season.

In the fall as 2-year-olds, heifers again were weighed, assigned BCS and rectally palpated to determine pregnancy. Weight and BCS change from calving through this time (post-calving) were calculated. Calf birth weight, weaning weight and ADG were recorded.

A partial budget analysis was used to compare the costs associated with implementing the two systems. Costs of the supplements were obtained through personal communication and amounts fed from ranch records. Intake predictions were used to calculate grazing costs, with a value of $12 per AUM used for standing winter range. This value is 50% the value of a growing season AUM in the Sandhills as reported in the 2001 Nebraska Livestock Budgets. The amount of hay fed was obtained from ranch records and valued at $0.025 per pound DM, or about $45 per ton as-fed.

Table 1. Composition of supplements fed to bred heifers.

	Composition, %DM	
Ingredient	CON	TRT
Dry corn gluten feed	—	72.0
Feather meal	40.0	—
Sunflower meal	30.0	22.4
Wheat middlings	26.3	—
Molasses	2.5	2.5
Bentonite	—	2.5
Salt	1.0	—
Starch	—	0.3
Fat	—	0.3
Vitamin pre-mix	0.3	0.1
Mineral pre-mix	—	0.1

Table 2. Weight, body condition, and conception rates of heifers in two systems.

Item	CON	TRT
Year One		
Pre-calving BW change, lb	100.0	98.3
Pre-calving BCS change	-0.16[a]	-0.08[b]
Post-calving BW change, lb	-100.1	-98.3
Post-calving BCS change	0.16	0.28
Year Two		
Pre-calving BW change, lb	-5.1[a]	12.3[b]
Pre-calving BCS change	-0.75[a]	-0.48[b]
Post-calving BW change, lb	2.82	0.04
Post-calving BCS change	-0.30[a]	-0.57[b]
Pooled Years		
Calf birth weight, lb	82.3	81.8
Calf weaning weight, lb	310.2	314.6
Calf ADG, lb	1.48[c]	1.52[d]
Pregnancy rate, %[e]	96.1	96.4

[a,b]Unlike superscripts within a row differ, $P < 0.05$.
[c,d]Unlike superscripts within a row differ, $P < 0.10$.
[e]Percentage pregnant with second calf. *P*-value reflects chi square analysis.

Results

Across years, heifers were 865 lb and had an average BCS of 5.5 at initiation of the trial, and neither differed ($P > 0.42$) by system.

The second year of the study (2001 - 2002) was marked by extensive drought. A number of year by treatment interactions were detected for weight and BCS change. Simple effects are presented for weight and BCS data (Table 2). In year one, pre-calving weight change was approximately 100 lb and was not affected by system. In year two, CON heifers lost a small amount of weight, while TRT heifers gained slightly. Average calf birth weight in this study was about 81 lb. If gestational weight gain (fetus, fluids, uterus, and placenta) is approximated by 1.7 times calf birth weight, heifers should have gained 138 lb with non-gestational tissues at maintenance. This suggests heifers in year one lost a small amount of weight, while heifers in year two may have lost more than 100 lb of body tissue.

Differences in pre-calving BCS change reflect the weight-changes observed. Heifers lost an average of 0.12 BCS units in year one, while in year two they lost 0.62 units. In both years, TRT heifers lost less ($P < 0.01$) condition than CON.

A year by system interaction was not observed for post-calving weight change; however, marked differences existed between years. In year one, heifers lost nearly 100 lb, while in year two their fall weight was similar to that recorded at calving. These changes, coupled with pre-calving changes, resulted in fall 2-year-old weights being similar to fall yearling weights in year one, with slight gains during year 2. This difference may be due to heifers having heavier initial weights in year 1. As drought conditions persisted, however, conditions may not have supported weight gain of the heavier heifers.

In year one, post-calving BCS change was slightly positive for both systems. In year two, heifers in both systems lost condition, with TRT heifers losing more. In year two, TRT heifers lost less condition pre-calving, but appeared to be more greatly affected by drought conditions, with a more rapid loss of condition during the summer.

Calf birth weights and weaning weights did not differ by system, although numerical trends in each lead to a tendency ($P = 0.10$) for calves nursing TRT cows to have higher ADG. While milk production was not measured in this study, perhaps TRT heifers had higher milk production. This could be supported by pre-calving BCS, rapid post-calving BCS loss in year 2, and the trend for calves to have higher ADG. Drought conditions in year two prompted early weaning, thus weaning weights were significantly lower in year two.

Second-calf pregnancy rate was 96% and was unaffected by treatment. Pregnancy rates tended to be lower in year two. Year one and year two conception rates were similar for CON heifers. Heifers in the TRT system, however, were three percentage units lower in year two compared to year one. This may be attributable to a greater loss of condition in year two among TRT heifers.

A partial budget analysis of the two systems results in an advantage of about $7 per heifer. An analysis of year one indicated a $6.01 advantage of the TRT system over the CON system, compared to $7.82 in year two. The differences result from changes in the amount of hay used, and different starting dates between years. Constant supplement and hay prices, labor costs, as well as winter range AUM values, were assumed. Equal cow and calf performance were assumed, with only cost differences used in the analysis. The cost of the CON system was most sensitive to changes in hay prices, whereas winter grazing costs and supplement costs were the largest determinants of TRT system costs. Labor comprised about 12% of CON system costs, compared to 6% for the TRT system.

In conclusion, a system of managing spring-calving bred heifers over the winter with supplementation and grazing winter range produced performance that was at least equal to a system including hay feeding, and did so with less total expense.

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Effect of Gestation and Supplementation on Intake of Low-Quality Forage

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Summary

Eighteen spring-calving heifers were paired by expected calving date and assigned to treatment. Treatments were a high undegradable intake protein supplement (CON) or one based on dry corn gluten feed (TRT). Heifers were fed to consume low-quality hay ad libitum. Supplement type did not affect body condition, milk production, or calf ADG. TRT heifers lost less weight than CON heifers. There was no effect of supplement on forage intake. Intake changed cubically with respect to calving; decreasing 17% during the three weeks prior to calving, and increasing 18% the week after calving.

Introduction

Pre-partum nutrition has proven to be an important determinant of subsequent reproductive performance, calf health and performance and overall ranch profitability. Many spring-calving herds rely heavily on low-quality forages to meet the nutritional needs of cows and heifers. However, often these forages are of low enough quality that passage rate is slowed, resulting in reduced intake. Some research has indicated that advancing gestation may inhibit intake immediately prior to calving, as fetal development exerts a physical limitation. In addition to reduced capacity to accommodate large volumes of forage, changes in hormonal profile occurring before parturition may inhibit intake as well. The net result is low intake of a low-quality feed at a time when nutrient requirements are increasing.

Gestating heifers are particularly at risk due to their reduced capacity to consume bulky feeds and their higher nutrient requirements relative to mature cows. Gestating heifers grazing native range in the Nebraska Sandhills consumed only 1.3% of BW (2001 Nebraska Beef Report, pp. 19-22), which translates into a negative energy balance during late gestation. Providing a non-bulky, energy-dense supplement late in gestation may improve female performance by correcting energy deficiencies that occur as a result of intake depression.

The objective of this trial was to examine the effect of gestation on intake of low-quality forage and to compare the effect of two supplements on intake, BCS, weight change, and milk production.

Procedure

The study was conducted at the Gudmundsen Sandhills Laboratory near Whitman, NE. Eighteen spring-calving heifers (894.8 $\pm$ 71.0) were paired by expected calving dates and assigned to one of two treatments. Treatments (Table 1) included an undegradable intake protein (UIP) supplement (CON; n = 4), and a dry corn gluten feed-based supplement (TRT; n = 5). Grass hay was fed for ad libitum consumption. Refusals were weighed weekly, with hay and ort samples collected at that time for DM analysis. Upland (3.8% CP, 48% TDN) and meadow (9.1% CP, 58% TDN) hays were ground with a bale processor and combined such that the quality of forage offered was similar to what would commonly be available through standing winter range (1997 Nebraska Beef Report, pp. 3-6). Both supplements were formulated to meet metabolizable protein (MP) and energy requirements (2000 Nebraska Beef Report, pp. 7-10). The supplements used and the feeding schedule of each were based on a previous study (2003 Nebraska Beef Report, pp. 5-8) in which the CON supplement was used to meet metabolizable protein requirements, while the TRT supplement was designed to meet energy demands as well as protein requirements. In general, the amount of each increased as gestation advanced, however the TRT supplement was increased to a larger extent (Table 1).

The trial began December 18 and concluded May 7, with weights and body condition scores (BCS) recorded on two consecutive days at those times. Heifers were weighed and assigned BCS every 28 days throughout the study, with data taken in the morning before

Table 1. Composition and feeding schedule of treatment supplements.

Item	Treatment CON	Treatment TRT
Ingredient, % DM		
Dry gluten feed	—	72.00
Feather meal	40.00	—
Sunflower meal	30.00	22.40
Wheat middlings	26.25	—
Molasses	2.50	2.50
Bentonite	—	2.50
Salt	1.00	—
Starch	—	0.25
Fat	—	0.25
Vitamin premix	0.26	0.05
Trace mineral premix	—	0.05
Feeding schedule, lb/day		
January	1.0	3.6
February 1 to 14	1.1	5.1
February 15 to calving	1.6	6.8

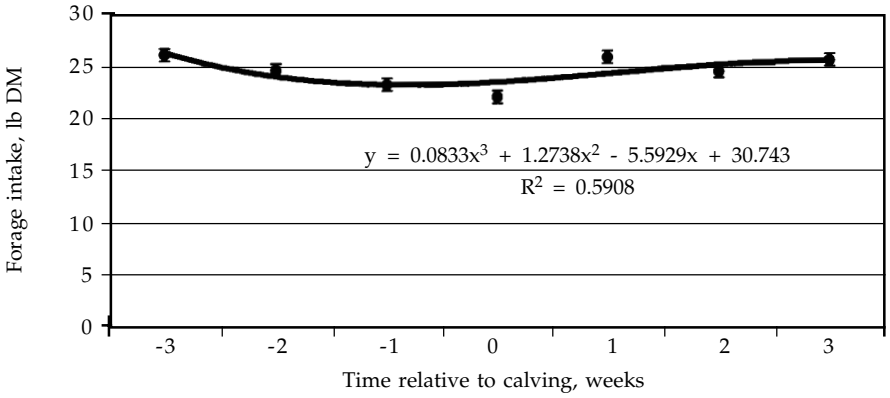

Figure 1. Change in voluntary forage intake three weeks before and after calving. Week 0 represents the week both heifers in the pen calved. Intake changed cubically (P = 0.03) over time.

feeding. Milk production was measured in May using a 12-hour weigh-suckle-weigh. Briefly, calves were sorted for approximately eight hours, commingled and allowed to nurse, then re-sorted for approximately 12 hours. Calves were then weighed, allowed to nurse, and re-weighed. The difference in the two weights was assumed to be from milk intake. Calf birth weights and ADG from birth to the conclusion of the trial were recorded.

In the intake analysis, time zero represents the last intake measured before the second heifer in each pen had calved. Times (1, 2, etc.) represent weeks relative to calving, with negative numbers representing weeks prior to calving and positive numbers after calving. A pen remained on the treatment supplement and experimental hay mixture until both heifers had calved, at which time all heifers were fed a common supplement and ad libitum meadow hay.

Results

Voluntary forage intake was not affected by treatment, and no time by treatment interaction was detected. Previous data have shown that supplementing at high levels can reduce voluntary forage intake, although studies showing this effect have not been conducted with heifers in late gestation. A substitution effect was not observed in this study, even with TRT supplement fed as high as 6.8 lb per day. If heifers in late gestation are eating to meet the high energy demands associated with rapid fetal development but are limited by physical fill, it appears supplements can be fed at a high level without reducing forage intake.

Forage intake changed cubically ($P < 0.03$) during a seven-week period around calving (Figure 1). Maximum DM intake for the entire trial (26.3 lb) occurred three weeks prior to calving, and was 17% lower (21.9 lb) at calving. By the week after calving, intake had returned to 25.7 lb, an 18% increase.

Total DM intake differed ($P < 0.01$) by treatment before calving (Figure 2). Relative to CON, TRT heifers averaged 17% higher DM intakes during the five-week period prior to calving. This is attributable to the fact that TRT heifers received 5.2 lb more supplement than CON heifers, without a concomitant reduction in forage intake. Few data are available that report intakes during this stage of production. Forage and heifer descriptors were used in the NRC (1996) Nutrient Requirements of Beef Cattle model to compare predicted vs observed intakes. The model under-predicted total DM intake for all heifers, with predicted total intake similar to observed forage intake. Total intake for CON heifers was 4 to 5% higher than predicted. Because TRT heifers were fed higher levels of supplement, there was a larger under-prediction (25%) of total DM intake.

Average calving date was March 19. Heifers calved within six days of their pen mates with one exception, in which the pair calved 14 days apart. The average number of days between heifers within a pen was 2.1 days. The pen with the two-week lag between heifers showed a nearly level intake pattern through-

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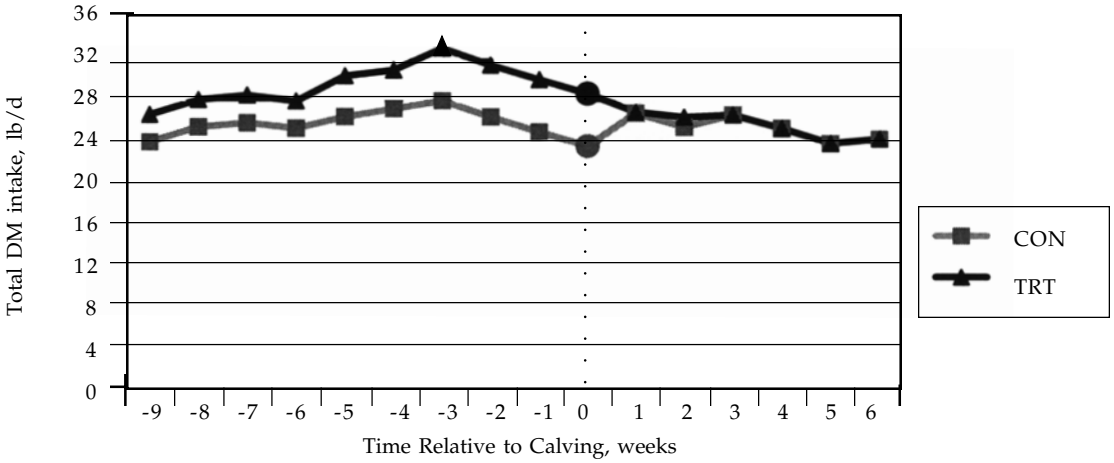

Figure 2. Effect of supplement on total dry matter intake over time. 'CON' = undegradable intake protein supplement; 'TRT' = dry corn gluten feed-based supplement. Values within a week differed (P < 0.05) between treatments from -8 to 0 weeks.

out, likely due to the increased intake during lactation of one heifer, masking the decreased intake during late gestation of the other.

Heifers weighed 895 lb in January and did not differ by treatment. By May, CON heifers had lost 54 lb, compared to three lb for TRT (P = 0.02). The lack of differences in forage intake suggests that weight differences were not due to treatment effects on rumen fill. Average BCS was 5.2 in January and 5.0 in May and was not affected by treatment. Weight and BCS data appear to disagree, although more animals may be necessary to detect treatment effects on body condition. While no difference was observed in condition, the difference in weight change may suggest that supplementing a high-energy feed in a non-bulky form allowed TRT heifers to maintain energy balance. With a loss of over 50 lb, heifers in the CON group appear to have been in a negative energy balance entering the breeding season. A larger number of animals is necessary to measure differences in reproductive performance that could result from treatments applied during gestation.

Some producers express concern that feeding higher levels of energy in late gestation may lead to heavier birth weights and an increased incidence of dystocia. Average birth weight in this trial was 78.7 lb, and was not affected by treatment. Two heifers from each treatment were assisted at calving. Average milk intake by calves nursing CON heifers was 14.0 lb, and 10.8 lb for TRT (P = 0.12). Calf weight in May (167.7 lb) and calf ADG from birth to May (1.79 lb/day) were not affected by treatment.

In conclusion, voluntary forage intake by bred heifers changed cubically with respect to calving. Intake declined prior to calving and increased rapidly after calving. Feeding a high level of a supplement high in digestible fiber did not reduce forage intake, did not affect birth weights or calf performance and decreased cow weight loss.

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A Review of Corn Stalk Grazing on Animal Performance and Crop Yield

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Summary

The highest cost to beef cow-calf and backgrounding operations is the feeding of stored feeds in winter months. Nebraska has an abundance of corn fields available for grazing following harvest. Utilization of corn crop residue is quite effective in reducing feed costs. There are a number of important considerations associated with residue utilization. Stocking rates, diet quality, genetically modified corn, subsequent crop yields and supplementation are discussed.

Introduction

The highest cost to beef cow-calf and backgrounding operations is the feeding of stored feeds in winter months. To lower feed costs, many producers attempt to extend the grazing season by utilizing corn crop residues. Although corn crop residue grazing is quite effective in reducing feed costs, some producers are concerned that it will have an adverse effect on subsequent crop yields. Other recent concerns include the possibility that genetic enhancements to corn may affect cattle performance when residue is grazed. The objective of this article is to summarize University of Nebraska research conducted on corn crop residue and crop production.

Procedure

This review summarizes Nebraska Beef Report articles and several other publications produced by University of Nebraska research. Reports containing information on corn stalk grazing and cattle performance were utilized as well as the impacts of corn hybrid differences and grazing impacts on subsequent crop yield were utilized.

Table 1. Relative amounts and values of corn residue plant parts.

	Plant Parts			
Item	Husk	Leaf	Stem[a]	Cob
Percent of residue dry matter	12	27	49	12
Crude protein, % DM	3.6	7.8	4.5	2.2
In vitro dry matter disappearance, %	67	47	45	35
Palatability	High	High	Low	Low

[a] Includes leaf sheath.

Results

Quality

Stalk grazing is a unique situation. All of the feed is on the ground at the start of grazing. Forage quality changes during the growing season in summer pastures. Stalks don't change over time like growing forages. However, fields that are grazed can change in quality but for reasons discussed later. Residual grain is the highest-quality feed component available in the field. Forage residue consists of four distinct qualities and apparent palatabilities (Table 1). The husk is digestible and palatable. The leaf is palatable, but not as digestible as the husk. The stem and cob are low in both digestibility and palatability and are consumed only when the amount of remaining leaf and husk is small. The leaf and husk are about 39% of the total corn residue. Cows or calves prefer the grain, followed by husks and then leaves. Stalks (stems) and cobs are rarely consumed. Digestibility of forage components in the field declines daily because of consumption of more digestible parts, trampling, and environmental losses (1988 Nebraska Beef Report, pp 31-33). Logically, greater stocking rates produce a faster decline in diet digestibility.

Digestibility of the diet is quite high at the initiation of grazing, but declines with time because of selection of the more digestible parts early in the grazing period (Figure 1). This decline is over a 60 day grazing period stocked so that essentially all of the leaf and husk was consumed (about 1/3 of the residue). If two animals grazed the same area, the decline would occur over 30 days. If 30 animals grazed the same are, then the decline would occur in 2 days. The only way to minimize this decline with time is to strip graze or move cattle so that new, ungrazed residue is available every few days. It is not clear if the effort and expense are worth the returns. The target gains of the calves or cows will dictate the management program. Many factors affect the average digestibility of the residue consumed. The average is 54-55% digestibility (TDN) but this could vary from 50% to 60%.

Forage disappearance rates are generally lower during winter months, likely because many of the environmental losses have occurred prior to initiation of grazing. Also, less trampling occurs during the winter because of frozen ground. Mud during fall months can reduce forage availability rapidly. The effect of trampling during muddy conditions can be minimized by strip grazing or shifting cattle to a grass sod or drylot during muddy conditions.

Stocking Rates

Stocking rate influences the amount of grain, husk and leaf available per animal. The amount

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of grain and husk available affect diet quality because both are highly digested. When smaller quantities of these are available at the initiation of grazing because of hybrid differences, more leaf is consumed, total intake declines and the animals eventually eat stems and cobs. The rate of decline in digestibility is affected by stocking rate, trampling, residue components available and environmental factors. Previous comparisons have shown that gains increase as stocking rate decreases. Stocking rate influences the quality of the diet consumed and, consequently, the animal performance. If cows are in good condition when stalk grazing is initiated, stocking rates can be high. Alternatively, if cows are in poor condition, the stocking rate should be relatively lower so that some improvement in condition can be made.

Residue (leaf and husk) yield is related to grain yield, but hybrids obviously vary in this relationship. With high producing corn (irrigated or with ample rainfall) there will be about 16 lb dry leaf and husk per bushel corn yield. The specific relationship is: lb leaf and husk per acre = ([bu/acre corn yield x 38.2] + 429) x 0.39. Some residue disappears by trampling and other factors. We estimate 50% utilization of the leaf and husk. Therefore, 150 bu corn produces 2400 lb leaf and husk and 1200 is consumed. This is equivalent to about 1.75 AUM. One acre would carry a 1200 lb cow for 44 days or a 600 lb calf for 88 days. Higher grain yields provide more AUM and lower yields less.

Previous research has shown gains in 56 days increased from 10 lb at a stocking rate of 0.5 acres per cow per month to 70 lb at a stocking rate of 2 acres per cow per month. Stocking rates of 0.5 acres per cow per month can provide gains of 20 and 40 lb in 56 days by continuous and strip grazing respectively. Strip grazing, or moving cattle to a new field every two to four weeks allows for a greater grazing capacity.

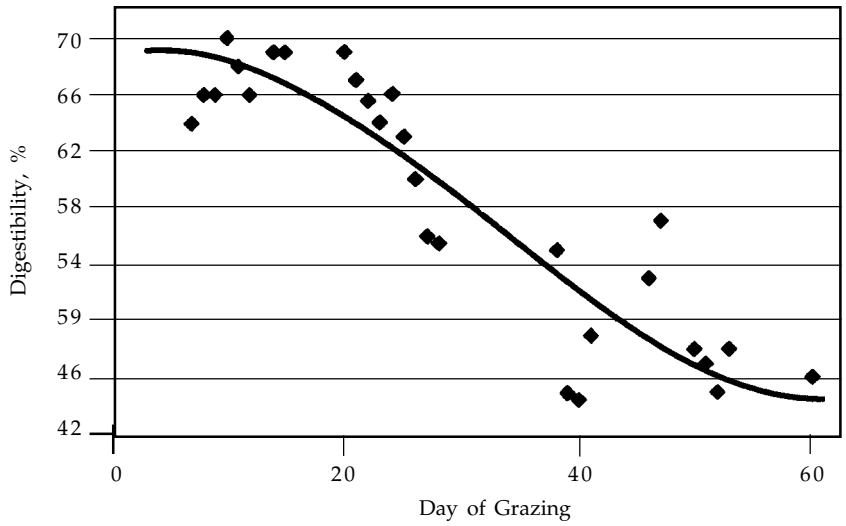

Figure 1. ***In vitro*** **dry matter disappearance of the roughage fraction of diets selected by esophageally fistulated calves grazing cornstalks.**

Genetically Modified Corn

Recent concerns with changes in animal performance due to genetically modified corn residues have also been evaluated. Steer calves grazing four different fields of corn residue (Bt corn root worm protected, nonBt, RR and nonRR) stocked at equal stocking density (1.06 acre/steer/60 days) were used to evaluate genetic enhancement on animal performance (2003 Nebraska Beef Report, pp 18-19). Steer performance was not different between Bt corn root worm protected or RR hybrids and their parental controls following the 60 day grazing period. The animal performance demonstrates feeding value of corn residue does not differ between genetically enhanced corn hybrids and their non-genetically enhanced parent hybrid. Similar research at the University of Nebraska also showed no difference in steer performance due to the incorporation of the Bt trait for corn borer protection (2001 Nebraska Beef Report, pp 39-41). There was also no preference between Bt and nonBt hybrids. During the grazing period, 47.5% of the steers were observed grazing Bt residue, and 52.5% of the steers were observed grazing nonBt residue.

To determine the effects of grazing crop residues for Bt-corn hybrids on performance of pregnant beef cows, one non Bt-corn hybrid and three Bt-corn hybrids were compared (2001 Iowa State Beef Research Report, pp 32-41). Rates of change in the concentrations of digestible dry matter and CP over winter were not significantly affected by corn hybrid. Mean amounts of hay required to maintain body condition score of cows maintained in a drylot were greater than cows grazing crop residues (3199 vs 825 lb/DM/cow) but did not differ between corn hybrids.

The data from these experiments suggest genetic enhancement has no effect on corn residue utilization by grazing beef cattle. Producers can take advantage of increased yields and reduced herbicide/pesticide use with Bt corn root worm protected or RR hybrids without adverse effects on corn residue grazing performance.

Time of Grazing and Crop Yield

Experiments were conducted during the fall and winter to evaluate performance of calves grazing cornstalks on conventional and ridge-till fields (1997 Nebraska Beef Cattle Report, pp 27-29). In these crop residue grazing experiments, calf stocking rate was 1.2 head/acre for a 60 day grazing period from December to February. To determine impact of grazing, yields were measured by

machine harvest the following fall from grazed and ungrazed areas of each tillage method. The three-year yield averages for ridge-till and conventional systems show little difference between treatments. Corn yields averaged 96, 101, 96 and 98 bu/acre for grazed ridge-till, ungrazed ridge-till, grazed conventional, and ungrazed conventional, respectively.

Cows grazed corn residue under 1/4 of a center pivot irrigation system in December and January. This was compared to 1/4 of the center pivot that was ungrazed. Irrigated soybeans were planted in the spring of each year and yields measured on the grazed and ungrazed fields in the fall. Results indicate no effect on soybean yields from grazing corn stalks during the fall and winter. For the three years of the experiment, soybean yields were similar for grazed and ungrazed fields.

Because no differences were observed due to winter grazing, spring grazing was evaluated to determine the impact of compaction on subsequent crop yield. When grazing caused surface compaction we hypothesized that tillage would offset the compaction and maintain yield. Crop production was based on an annual corn-soybean rotation with one-half of the field planted to each crop. Tillage treatments included ridge-tilling during the summer, no-tillage, fall tillage with a chisel followed by conventional tillage (disk) in the spring, or spring conventional tillage alone. All tillage treatments were conducted during the corn rotation with no tillage following the soybean crop. The first grazing trial (2001 Nebraska Beef Report, pp 43-45) was conducted with a calf stocking rate of 0.8 acres per calf for 60 days. The stocking rate was based on average stocking rates to optimize animal performance. Soybean yields showed no difference between grazed and ungrazed treatments. Spring and fall tillage treatments had no effect on soybean yield when compared to the no-till treatments. Corn yields two years post grazing showed no significant differences due to grazing or tillage treatments.

With this in mind the second two-year grazing trial (2003 Nebraska Beef Report, pp 20-21) was conducted with stocking rate increased 2.5 times to 0.32 acres per calf for 60 days. Overall grazing improved soybean yields over ungrazed treatments ($P = .015$) and included significant improvement in yield in no-till grazed over no-till ungrazed treatments. Spring and fall tillage had no effect on soybean yield when compared to no-till treatments. There was a trend ($P = .11$) for grazing to reduce corn yields the second year after grazing when compared to the ungrazed treatments. The no-tillage grazed treatment showed a significant depression in yield compared to no-tillage ungrazed treatment ($P = .05$). The ridge-till grazed treatment showed no difference when compared to ridge-till ungrazed treatment ($P = .79$). This suggests that grazing of ridge-till stalks in the spring is not detrimental to subsequent corn yields.

Grazing Impacts on Soil Density

A three-year study was conducted to evaluate the impact of grazing on soil density (2003 Iowa State Beef Research Report, pp 54-61). After corn grain harvest, fields were divided to determine the effects of cornstalk grazing on the yields of soybeans planted with no tillage or tillage once with a disk the year following grazing. Stocking rate was 0.67 acres/cow/28 days in each year. Soil samples were collected to determine any differences in soil bulk density present before and after grazing. Neither the initial soil bulk measurements nor the post-grazing soil bulk density ratios of areas grazed in any month have differed from the ungrazed areas in the three-year study. Post-grazing soil moisture contents did not differ between grazed and ungrazed paddocks in all three years.

Soybean yields did not differ between ungrazed and grazed areas in fields planted by disking or no tillage. However, soybean yields in the areas grazed in the second period were 8% lower ($P<0.05$) than ungrazed areas in fields planted with no tillage in year 3. The decrease in yield with the no tillage system in year 3 seemed to be an effect of the ground not being frozen during this time period. Therefore the effects of grazing corn crop residue by beef cattle on soil physical properties and subsequent soybean yields will be reduced if grazing is restricted to periods of below freezing soil temperatures.

Supplementation

Protein supplementation is necessary for calves grazing cornstalks. There is some indication that a protein supplement with at least 0.36 lb of escape protein per head per day is appropriate to get the best weight gains with calves. Total protein supplementation may need to be as high as 0.9 lb per day. Calves probably need more supplemental protein early in the grazing period than later because of their need to use the higher energy content of the diet at that time (Gutierrez-Ornelas et al., 1991, Journal of Animal Science, 69:2187-2195).

Corn milling byproducts, corn gluten feed and distillers grains, are readily available and excellent supplements for calves or cows grazing stalk fields. They are excellent sources of protein (16 to 30%), phosphorus (0.8 to 1.0%) and energy (100 to 125% energy value of corn grain). Byproducts could be used as a protein supplement and more could be fed to supply additional energy if needed (2001 Nebraska Beef Report, pp 41-43). Further, high levels could be limit-fed for short periods during periods of snow cover or mud.

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Feed Values for Annual Forages in Western Nebraska

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Summary

Forage quality testing was completed on annual forages grown during 1998 and/or 1999. Included were spring cereals, legumes and summer annuals like sorghum and millets. Using a single cut harvest system when the majority of summer annuals had produced seed heads, crude protein (CP) was generally more than 8% and total digestible nutrients (TDN) more than 63% of dry matter. Annual legumes had 12 to 18% CP and more than 63% TDN. Pearl and irrigated foxtail millets had higher crude protein levels than sorghum forages, but nitrate levels were also higher. Some mineral contents varied by location and associated management.

Introduction

Results of forage production and quality comparisons of individual annual forage cultivars were presented in the 2001 Nebraska Beef Cattle Report, pp. 26-28. However, only one year of forage quality results (1998) was available at that time. The purpose of this report is to summarize quality results by forage crops rather than individual cultivars and to show the results from macro- and micro-mineral tests for 1999 crops grown on the high plains of western Nebraska or eastern Wyoming.

Procedure

Dryland and irrigated annual forage trials were conducted over two years (1998 and/or 1999) to update forage production and quality characteristics of cultivars of spring triticale, oat, barley, pea, vetch, soybean, forage sorghum, sorghum x sudangrass, sudangrass, pearl millet and foxtail millet. A single cut harvest system was used for each group when the majority of grass cultivars had produced seed heads or when the legumes had reached early bloom

Table 1. Feed analyses for dryland spring planted cereal and legume annual forages grown in 1998-99.[a, b]

			Protein		Nitrate	Fiber			Energy				Digestibility
Forage Name Harvest Stage	Year	DM %	CP %	UIP %/CP	NO_3N ppm	NDF %	ADF %	ADL %	NE_m Mcal	NE_g Mcal	NE_l Mcal	TDN %	IVDMD %
Spring cereal													
Barley	98, 99	40	8.2	8	220	65	34	5.4	.68	.41	.68	66	69
Fresh,	N	16	16	6	16	16	16	16	16	16	16	16	16
soft dough	SD	6	.9	3	380	2.3	2	.4	.01	.01	.01	.6	3
Oat	98, 99	30	9.5	8	360	65	34	5.1	.68	.41	.67	66	73
Fresh,	N	24	24	9	24	24	24	24	24	24	24	24	24
head exerted	SD	3	1.6	3	530	4	2.2	.7	.01	.01	.01	.7	5.3
Triticale	98, 99	38	9.3	6	130	66	36	5.5	.67	.40	.67	65	70
Fresh,	N	16	16	6	16	16	16	16	16	16	16	16	16
head exerted	SD	25	1.6	1	140	2.2	2.3	.6	.01	.01	.01	.7	4.5
Legume													
Pea	99	26	17.1	9	—	40	33	—	.65	.38	.65	64	75
Fresh,	N	32	32	4	—	32	32	—	32	32	32	32	4
early bloom	SD	4	2.2	—	—	2.6	2.2	—	.03	.03	.03	2.4	1.3
Soybean	99	32	12.2	5	110	43	28	6.8	.72	.45	.71	68	77
Fresh,	N	24	48	10	48	48	48	48	48	48	48	48	48
early to mid pod-fill	SD	—	1.4	—	120	2.6	2.3	.7	.04	.03	.03	2.4	1.9
Vetch	99	29	18.3	8	—	40	32	—	.67	.40	.67	65	72
Fresh,	N	8	8	8	—	8	8	—	8	8	8	8	8
early bloom	SD	4	1.8	—	—	2.9	2	—	.03	.03	.02	2.1	—

[a]Dryland spring planted cereal, pea and vetch forages were grown at the University of Nebraska High Plains Agricultural Laboratory near Sidney, where the altitude is about 4300 ft above sea level. Soybean forages were grown at the University of Wyoming Research and Extension Center near Cheyenne, where the altitude is about 6000 ft. All contents are expressed on a dry matter basis.
[b]Abbreviations are: DM = dry matter; CP = crude protein; UIP = ruminally undegradable intake protein; NO_3N = nitrate nitrogen; NDF = neutral detergent fiber; ADF and ADL = acid detergent fiber and lignin, respectively; NE_m, NE_g and NE_l = net energy for maintenance, gain, and lactation, respectively; TDN = total digestible nutrients; IVDMD = in vitro dry matter digestibility; N = number of observations; and SD = standard deviation.

Table 2. Feed analyses for dryland and irrigated summer annual forages grown in western NE in 1998-99.[a,b]

			Protein		Nitrate	Fiber			Energy				Digestibility
Forage Name Harvest Stage	Year	DM %	CP %	UIP %/CP	NO_3N ppm	NDF %	ADF %	ADL %	NE_m Mcal	NE_g Mcal	NE_l Mcal	TDN %	IVDMD %
Dryland													
Forage Sorghum	98, 99	26	9.6	10	1170	59	30	3.6	.70	.43	.69	67	78
Fresh,	N	24	72	24	58	72	72	72	72	72	72	72	72
early heading	SD	2.7	2.8	4	570	4.8	4.5	1.6	.04	.04	.03	2.7	4.2
Sorghum x sudan	98, 99	24	9.0	10	1010	61	32	4.2	.69	.42	.69	66	72
Fresh,	N	18	54	18	41	54	54	54	54	54	54	54	54
head exerted	SD	1.9	2.9	4	450	4.3	4.3	1.2	.05	.04	.04	3.3	3
Sudangrass	98, 99	30	7.6	11	690	65	36	4.9	.67	.40	.68	66	66
Fresh,	N	4	9	3	7	9	9	9	9	9	9	9	9
head exerted	SD	1.8	2.3	1	380	4.4	4.5	1	.08	.07	.06	5.2	2.4
Pearl Millet	98	23	15.3	8	2090	60	30	3.5	.70	.43	.69	67	78
Fresh,	N	9	15	9	15	15	15	15	15	15	15	15	15
head exerted & vegetative[c]	SD	1.7	2	2	920	1.9	1.3	.3	.01	.01	.01	.4	3.2
Foxtail Millet	99	32	8.9	9	320	61	32	3.5	.69	.42	.68	66	73
Fresh,	N	27	36	27	36	36	36	36	36	36	36	36	36
head exerted & vegetative[c]	SD	4	1.1	2	230	2.2	2	.6	.04	.03	.04	4	3.8
Irrigated													
Forage Sorghum	98, 99	23	9.8	9	1040	61	35	4.9	.68	.41	.67	65	70
Fresh,	N	42	90	42	90	90	90	90	90	90	90	90	90
head exerted	SD	1.9	1.2	2	420	3.4	2.3	1.1	.04	.03	.03	2.4	3.5
Sorghum x sudan	98, 99	25	8.9	9	740	61	36	6.1	.67	.40	.67	65	64
Fresh,	N	30	50	30	50	50	50	50	50	50	50	50	50
head exerted	SD	2	.9	3	390	2	2	.8	.03	.03	.02	2.2	3.2
Sudangrass	98, 99	30	9.0	10	1050	66	40	6.5	.65	.39	.66	64	60
Fresh,	N	6	10	6	10	10	10	10	10	10	10	10	10
head exerted	SD	3.8	1.4	3	880	3.5	3.5	.8	.08	.07	.05	5	4
Pearl Millet	98, 99	20	11.3	9	2340	67	40	5.7	.65	.39	.66	64	64
Fresh,	N	27	30	27	30	30	30	30	30	30	30	30	30
head exerted & vegetative[c]	SD	4.6	1.7	4	1150	2.4	2.5	.7	.06	.06	.05	4.1	4
Foxtail Millet	98, 99	27	12.1	6	2010	62	36	4.9	.67	.40	.67	65	70
Fresh,	N	27	55	27	27	55	55	55	55	55	55	55	55
head exerted & vegetative[c]	SD	4.8	.9	3	770	2.9	2.5	.6	.01	.01	.01	.8	3.4

[a]Dryland and irrigated summer annual forages were grown at the University of Nebraska High Plains Agricultural Laboratory near Sidney, NE, and the Panhandle Research and Extension Center near Scottsbluff, NE, respectively. All contents are expressed on a dry matter basis.
[b]Abbreviations are: DM = dry matter; CP = crude protein; UIP = ruminally undegradable intake protein; NO_3N = nitrate nitrogen; NDF = neutral detergent fiber; ADF and ADL = acid detergent fiber and lignin, respectively; NE_m, NE_g and NE_l = net energy for maintenance, gain, and lactation, respectively; TDN = total digestible nutrients; IVDMD = in vitro dry matter digestibility; N = number of observations; and SD = standard deviation.
[c]One pearl millet cultivar and one foxtail millet cultivar were genetic types that generally would not produce seed heads, remaining vegetative in the environments tested.

or pod-fill stages of maturity. Plots in Nebraska were planted in rows 12 inches apart with a double disc grain drill with a cone seed distribution system. Fertilizer was applied preplant or as a side-dress and legume seed was treated with inoculants. Nitrogen application rates were 45 to 60 lb per acre for dryland grass forages and 120 lb per acre for irrigated forages.

There were generally 4 to 7 replications of cultivars per trial. Forage samples were taken and chopped immediately after harvest with a plot swather and then dried for quality analyses at the USDA Forage Research Laboratory and the University of Nebraska Soil and Plant Analysis Laboratory in Lincoln, or sampled immediately for freezing and subsequent determination of ruminally undegradable intake protein (UIP) at the Ruminant Nutrition Laboratory in the University of Nebraska Department of Animal Science (1997 Nebraska Beef Report, pp. 38-39).

Forage quality tests were conducted using a combination of near infrared reflectance spectroscopy (NIRS) and wet lab chemistry analyses as suggested by the National Forage Testing Association or established against standard reference materials by the labs in Lincoln. Ruminally undegradable intake protein was determined

(Continued on next page)

Table 3. Mineral analyses for dryland spring planted cereal and legume annual forages grown in 1999.[a, b]

Forage Name	Ca %	P %	K %	Mg %	S %	Na %	Cl %	Si %	Mn ppm	Fe ppm	Cu ppm	Zn ppm	Ti ppm	Ni ppm
Spring cereal														
Barley	.30	.20	2.3	.09	.13	.17	.18	4.3	45	460	5	10	30	25
N	8	8	8	8	8	8	8	8	8	8	8	8	8	8
SD	.04	.03	.5	.02	.02	.08	.05	.8	12	230	1.1	2.2	19	10
Oat	.35	.24	3.5	.11	.19	.09	.20	4.7	110	470	6	15	60	30
N	12	12	12	12	12	12	12	12	12	4	12	12	12	12
SD	.05	.04	.4	.02	.03	.09	.09	.8	29	120	.9	3.8	28	14
Triticale	.27	.24	2.7	.09	.16	.07	.14	4.5	70	350	7	16	25	20
N	8	8	8	8	8	8	8	8	8	8	8	8	8	8
SD	.05	.02	.3	.02	.02	.06	.03	.14	23	120	.6	3	7	7
Legume														
Pea	1.2	.33	2.8	.26	.19	.06	.06	3.9	105	—	8	23	—	—
N	32	32	32	32	32	4	4	4	4	—	4	4	—	—
SD	.2	.04	.4	.04	.02	.07	.01	1.6	23	—	2.4	5.8	—	—
Soybean	1.7	.24	1.9	.48	.21	.04	.01	.8	45	220	5	20	25	6
N	48	48	48	48	48	48	48	48	48	48	48	48	48	48
SD	.2	.03	.3	.06	.03	.05	.02	.6	10	150	1.1	4.8	6	1.9
Vetch	1.5	.31	2.9	.26	.20	—	—	—	—	—	—	—	—	—
N	8	8	8	8	8	—	—	—	—	—	—	—	—	—
SD	.3	.04	.3	.03	.02	—	—	—	—	—	—	—	—	—

[a]Dryland spring planted cereal, pea and vetch forages were grown at the University of Nebraska High Plains Agricultural Laboratory near Sidney, where the altitude is about 4300 ft above sea level. Soybean forages were grown at the University of Wyoming Research and Extension Center near Cheyenne, where the altitude is about 6000 ft. All contents are expressed on a dry matter basis. Mineral contents were determined with the use of X-ray analysis.
[b]Abbreviations are: Ca = calcium; P = phosphorus; Mg = magnesium; S = sulfur; Na = sodium; Cl = chlorine; Si = silicon; Mn = manganese; Fe = iron; Cu = copper; Zn = zinc; Ti= titanium; Ni = nickel; N = number of observations; and SD = standard deviation.

on frozen and freeze dried forage samples that were suspended in nylon bags in the rumen of fistulated beef cattle fed a high forage diet. Mineral contents of the 1999 forage crops were determined by x-ray analysis. Results for all quality tests were expressed on a dry matter basis. Data were analyzed with the SAS General Linear Model.

Results

Forage quality results (Tables 1 and 2) include columns for UIP as a percentage of crude protein to indicate the ruminally undegradable portion that bypasses to the intestinal tract. There was considerable variation in the UIP values for most of the cultivars, but UIP was generally in a range of 5 to 10% of CP for the fresh-cut, growing annual forages tested. These values were slightly lower than UIP levels suggested by the National Research Council (1996) for fresh grass and legume forages.

Crude protein levels were similar among cereal and sorghum forages when they were harvested after the majority of the cultivars had produced seed heads. Irrigated foxtail millet was higher in CP and in nitrate nitrogen than the sorghum forages. However, irrigated foxtail millet was fertilized with 120 lb of N per acre, which was the same rate used for the taller growing summer annuals. This rate was too high for the foxtail millet, resulting in nitrate nitrogen values greater than 2000 ppm, a threshold level for toxicity concern in ruminants. Although 1998 dryland foxtail millet was lost to poor stand, the 1999 dryland foxtail millet was lower in CP and nitrate nitrogen due to advanced maturity in a hot, dry growing season and nitrogen application limited to 45 lb of N per acre preplant. While pearl millet was higher in CP and nitrate nitrogen than sorghum forages, the highest levels among three cultivars were in a vegetative cultivar that would not mature and produce seed heads in the environments tested. Thus, variety, maturity and nitrogen management were factors in level of CP and nitrate nitrogen observed in these summer annuals.

Crude protein levels ranged from 12 to 18% of dry matter for soybean, pea and vetch forages when harvested at mid pod-fill (soybean) and

Table 4. Mineral analyses for dryland and irrigated summer annual forages grown in western NE in 1999.[a, b]

Forage Name	Ca %	P %	K %	Mg %	S %	Na %	Cl %	Si %	Mn ppm	Fe ppm	Cu ppm	Zn ppm	Ti ppm	Ni ppm
Dryland														
Forage Sorghum	.49	.13	2.7	.18	.11	.04	.07	4.2	50	240	7	15	20	14
N	32	32	32	32	32	32	32	32	32	32	32	32	32	32
SD	.09	.03	.4	.03	.02	.05	.05	.7	12	170	1.6	3.5	13	8.9
Sorghum x sudan	.43	.12	2.6	.15	.10	.04	.07	4.1	50	180	6	15	16	12
N	24	24	24	24	24	24	24	24	24	24	24	24	24	24
SD	.06	.02	.3	.02	.01	.05	.03	.6	7	80	1.2	2.4	5.7	4.7
Sudangrass	.41	.10	2.5	.17	.06	.011	.06	3.3	40	180	6	13	17	9
N	4	4	4	4	4	4	4	4	4	4	4	4	4	4
SD	.04	.02	.2	.02	.05	.01	.04	1.6	5	28	1	3.5	3.5	.8
Foxtail millet	.35	.12	3.2	.23	.14	.06	.03	3.9	60	100	6	13	12	7
N	36	36	36	36	36	36	36	36	36	36	36	36	36	36
SD	.09	.03	.9	.03	.01	.07	.01	.7	14	18	1.4	3.6	4.3	1.5
Irrigated														
Forage Sorghum	.44	.22	2.6	.29	.14	.16	.50	4.8	90	140	7	25	10	10
N	63	63	63	63	63	63	63	63	63	63	63	63	63	63
SD	.05	.05	.36	.04	.02	.09	.08	.8	20	50	1.6	5.6	5.7	4
Sorghum x sudan	.43	.20	2.5	.29	.13	.13	.48	4.7	100	110	8	26	9	9
N	35	35	35	35	35	35	35	35	35	35	35	35	35	35
SD	.04	.03	.4	.03	.02	.1	.07	.4	11	19	1.2	4.4	5.3	2.9
Sudangrass	.47	.19	2.8	.31	.15	.15	.52	4.7	90	110	7	24	9	7
N	7	7	7	7	7	7	7	7	7	7	7	7	7	7
SD	.05	.04	.5	.02	.02	.13	.06	.6	11	28	1.3	3.7	4.9	2.6
Pearl Millet	.51	.24	4.3	.33	.23	.26	.70	4.1	80	150	8	25.4	9	8
N	42	42	42	42	42	42	42	42	42	42	42	2	42	42
SD	.07	.04	.9	.06	.04	.09	.15	.7	14	38	1.7	5	6.2	4.7
Foxtail Millet	.48	.22	4.7	.31	.21	.14	.43	5.1	105	170	9	35	12	8
N	35	35	35	35	35	35	35	35	35	35	35	35	35	35
SD	.07	.03	.6	.05	.02	.09	.06	1	19	40	1.4	4.6	5.3	2.3

[a]Dryland and irrigated summer annual forages were grown at the University of Nebraska High Plains Agricultural Laboratory near Sidney, and the Panhandle Research and Extension Center near Scottsbluff, respectively. All contents are expressed on a dry matter basis. Mineral contents were determined with the use of X-ray analysis.
[b]Abbreviations are: Ca = calcium; P = phosphorus; Mg = magnesium; S = sulfur; Na = sodium; Cl = chlorine; Si = silicon; Mn = manganese; Fe = iron; Cu = copper; Zn = zinc; Ti= titanium; Ni = nickel; N = number of observations; and SD = standard deviation.

early bloom stages of maturity (pea and vetch). Available energy levels for the legumes were similar to those for the cereal, sorghum and millet forages, averaging about 65% TDN. All energy contents were predicted from acid detergent fiber (ADF) by formulas suggested by the National Forage Testing Association and used by the University of Nebraska Soil and Plant Analysis Laboratory.

Forage mineral levels are shown in Tables 3 and 4 for most of the annual forages harvested in 1999. The differences in mineral levels for the same cultivars and crops grown at different locations were likely due to differences in dryland versus irrigated management, soil type, soil fertility, and cropping history. Means and standard deviations are provided for the contents of macro- and micro-minerals that should be helpful in evaluating the mineral contributions from these annual forages to animal mineral requirements. For example, growing beef cattle weighing 660 lb and gaining 2 lb per day would require 0.36% Ca and 0.19% P in the dry matter of a diet containing 60% TDN. Cattle consuming irrigated sorghum and millet forages grown in this study could have met those requirements.

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Urea Inclusion in Forage Based Diets Containing Dried Distillers Grains

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Summary

Two experiments evaluated supplemental degradable intake protein requirements when dried distillers grains were fed as an energy source in forage-based diets. Diets were formulated to be greater than 100 g/day deficient in degradable intake protein but with excess metabolizable protein. In both experiments, no response in performance was observed when urea was added to the diet. Sufficient urea was probably recycled to correct the degradable intake protein deficiency. These studies indicate adding urea to meet the degradable intake protein requirement is not necessary when dried distillers grains are fed as an energy source in forage-based diets.

Introduction

As the corn milling industries continue to expand, an increased availability of distillers grains is expected. Dried distillers grains (DDG) are appropriate for forage-based production systems when forage quality is poor (winter) or quantity is limiting (drought). Dried distillers grains are considered a protein supplement when fed at less than 15% of the diet DM and as an energy source when fed at levels greater than 15% of the diet. Energy supplied by DDG is in the form of digestible fiber and fat (1996, Nebraska Beef Report, pp. 65-66) making its energy value superior to corn in forage-based diets (2003, Nebraska Beef Report, pp. 8-10). Dry distillers grains contain approximately 65% UIP (% of CP), consequently forage-based diets that include dried distillers grains fed as an energy source are commonly deficient in degradable intake protein (DIP) but contain excess metabolizable protein (MP). Cattle convert excess MP to urea which is potentially recycled to the rumen and can serve as a source of DIP. Many factors influence urea recycling and the amount of urea that is recycled when DDG is included in a forage-based diet is not known. The objective of these trials was to determine if added DIP (i.e. urea) is required in forage-based diets where DDG is included at levels in excess of the MP requirement.

Procedure

In experiment one, 60 Angus heifers (613 ± 36 lb) were stratified by weight then assigned randomly to one of five treatments. Treatments were designed to supply 0, 33, 67, 100 and 133% of the NRC (1996) predicted DIP deficiency of the base diet. Heifers were individually fed in Calan electronic gates for ad libitum consumption of a diet consisting of 58% ground corn cobs and 12% sorghum silage. The remaining 30% of the diet was one of the DDG based supplements described in Table 1. For five days before and at the end of the 84 day experiment heifers were limit fed. Heifer weights were recorded on three consecutive days following each limit-feeding period. Beginning on day 46 of the experiment, approximately 50 mL of urine was collected from each heifer for 5 consecutive days to estimate microbial crude protein (MCP) production. Urine samples were assayed for allantoin and creatinine. The ratio of allantoin to creatinine is indicative of the amount of MCP produced.

Feedstuffs used in the trial were analyzed for DM, organic matter (OM), CP, in-vitro dry matter disappearance (IVDMD) and for in-situ undegradable intake protein content (2003, Nebraska Beef Report, pp. 81-83, Table 2).

In experiment two, 48 crossbred heifers (451 ± 44 lb) were stratified by weight then assigned randomly to one of eight pens. Pens then were

Table 1. Ingredient composition of supplements (%DM) used in both experiments where 0, 33, 67, 100 or 133 % of the NRC predicted degradable intake protein deficiency was met with supplemental urea.

	Experiment 1[a]					Experiment 2[b]	
Ingredient	0	33	67	100	133	0	100
Dry distillers grain	95.59	94.25	92.92	91.58	90.24	94.20	91.85
Molasses	—	—	—	—	—	2.90	2.90
Urea	—	1.33	2.67	4.00	5.33	—	2.50
Limestone	3.16	3.16	3.16	3.16	3.17	1.60	1.60
Salt	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Trace mineral premix	0.17	0.17	0.17	0.17	0.17	0.16	0.16
Melangestrol Acetate	0.05	0.05	0.05	0.05	0.05	—	—
Vitamin premix	0.03	0.03	0.03	0.03	0.03	0.06	0.06

[a]Supplement comprised 30% of the diet.
[b]Supplement comprised 25% of the diet.

Table 2. Chemical composition (± SD) of feedstuffs used in Experiment 1.

Item	Sorghum silage	Corn cobs	DDG
DM, %	34.6 ± 0.008	88.8 ± 0.014	90.5 ± 0.007
OM, %	93.1 ± 0.001	98.1 ± 0.001	97.7 ± 0.003
IVDMD, %	68.1 ± 0.003	51.5 ± 0.017	—
CP, %DM	9.4 ± 0.17	4.6 ± 0.27	31.5 ± 0.15

Table 3. Performance and allantoin to creatinine ratios in urine of animals fed diets where 0, 33, 67, 100, or 133% of the NRC predicted degradable intake protein requirement was met with supplemental urea.

	Diet					F-Test	
Item	0	33	67	100	133	SEM	P-value
Experiment 1							
Initial BW, lb	611	611	615	617	614	11	0.99
Final BW, lb	694	697	680	702	702	15	0.85
ADG, lb	1.06	1.03	0.93	1.01	1.04	0.07	0.77
Total DMI, lb	11.3	11.4	11.4	11.5	11.4	0.2	0.95
F:G	11.1	11.8	13.2	11.8	11.7	0.9	0.54
Allantoin:creatinine	0.66	0.66	0.56	0.68	0.67	0.08	0.84
Experiment 2							
Initial wt., lb	452			449		1	0.10
Final wt., lb	579			585		4	0.38
ADG, lb	1.53			1.63		0.05	0.17
Total DMI, lb	11.9			11.6		0.5	0.76
F:G	9.8			9.1		0.5	0.33
Allantoin:creatinine	0.89			0.89		0.04	0.98

[ab]Means within a row with unlike superscripts differ (P<0.05)

Table 4. Diet evaluation using the NRC (1996) model where 0, 33, 67, 100, or 133% of the NRC predicted degradable intake protein requirement was met with supplemental urea.

	Experiment 1					Experiment 2	
Item	0	33	67	100	133	0	100
Inputs							
TDN, %	70	70	69	69	69	64	64
CP, %	12.6	13.6	14.6	15.6	16.6	11.8	13.6
NE adjuster, %	100	98	95	101	103	91	96
Outputs							
DIP balance, g/day	-124	-66	-7	54	112	-129	1
MP balance, g/day	120	127	138	108	97	219	188

assigned randomly to one of two supplement treatments. Heifers were fed for ad libitum consumption of grass hay (54% TDN, 7.4% CP) and supplemented with either 3 lb (DM) DDG/head/day or 3 lb (DM) DDG plus 0.1 lb urea/head/day. This was the amount of urea required to meet the NRC predicted DIP requirement. Supplement composition is listed in Table 1. Heifers were weighed on two consecutive days at the beginning and end of the 84-day trial. Beginning on day 55 of the experiment, approximately 50 mL of urine was collected from each heifer for 3 consecutive days. Urine samples were composited by animal and analyzed as described in experiment one.

Data were analyzed using animal as the experimental unit for experiment one and pen as the experimental unit for experiment two.

Results

In experiment one, heifer ADG did not differ among treatments. Similarly, total DMI and F/G did not differ (Table 3). We hypothesized that heifers consuming the 0, 33 and possibly the 67% diets would exhibit reduced ADG compared to the 100 and 133% diets because of their DIP deficiency (Table 4). This was not the case, however, as no differences in performance were observed. One explanation for this lack of difference is that sufficient urea was recycled to the rumen to meet the DIP requirement in all treatments. The NRC (1996) sets the DIP requirement equal to microbial crude protein (MCP) production. In this experiment we measured the allantoin to creatinine ratio in the urine to estimate MCP production based on the theory that these are directly related. Allantoin to creatinine ratio did not differ among treatments (Table 3). Our hypothesis was that allantoin to creatinine ratios would be similar for the 100, 133 and perhaps even the 67% treatments but would be reduced in the 0 and 33% treatments. The actual relationships among treatments for allantoin to creatinine ratios observed in this study fit nicely with the performance data and suggest that MCP production was not reduced in the DIP deficient diets relative to the diets where the DIP requirement was met with urea. Endogenous urea recycling explains the lack of difference among treatments for both ADG and allantoin to creatinine ratios.

Upon completion of the study animal performance, intake and nutrient analyses were used as inputs to evaluate the diets using the NRC (1996) model. Variables used as inputs as well as outputs generated from the model are reported in Table 4. These data are reported as an aid in formulating diets containing dried distillers grains.

In experiment 2, heifer ADG did not differ between treatments. Likewise, total DMI and F/G were not different (Table 3). Allantoin: creatinine ratio (Table 3) was also similar between treatments. These results are consistent with experiment 1 and also suggest that sufficient urea was recycled to the rumen to meet the DIP requirement of heifers not fed urea.

In conclusion, providing urea to meet the DIP deficiency did not improve ADG, intake, or F/G in either experiment. No differences in allantoin to creatinine ratio, which are indicative of microbial crude protein production, were noted in either experiment. We interpret these results to indicate that additional DIP is not necessary when DDG are fed as an energy source in forage-based diets.

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Effect of Distillers Grains or Corn Supplementation Frequency on Forage Intake and Digestibility

Tim W. Loy
Jim C. MacDonald
Terry J. Klopfenstein
Galen E. Erickson[1]

Summary

Ten ruminally cannulated heifers received no supplement, dry distillers grains (DDG) daily, DDG on alternating days, dry rolled corn daily, or corn on alternating days. Hay intake was higher for non-supplemented than for supplemented heifers. No intake differences were observed between DDG and corn-supplemented heifers. Heifers supplemented daily had higher and more consistent intakes than those in alternate-day treatments, particularly within corn-supplemented heifers. Ruminal pH and hay fiber disappearance were greater in non-supplemented heifers. Corn-supplemented heifers had slower rates of fiber disappearance than DDG-supplemented. Alternate-day energy supplementation increased intake variability compared to daily supplementation.

Introduction

Supplementation programs are integral components of many ranching systems that are dependent on low-quality forages to meet some portion of their annual feeding needs. Feed costs often represent the largest variable cost incurred by a ranching operation. Reducing the frequency of feeding supplement has been explored as one means of lowering the costs associated with supplementation programs.

In general, reducing feeding frequency has proven adequate when supplemental protein is being fed, presumably due to ruminants' ability to recycle N. Irregular feeding of energy supplements has proven less effective, often leading to reduced performance. However, energy supplements are typically grain based, and therefore contain significant amounts of starch. By reducing feeding frequency, more supplement is required per feeding, which can result in large amounts of starch being consumed at one time. This may lead to a depression in forage utilization due to a negative associative effect between starch and forage digestibility.

Many byproducts available to livestock producers contain large amounts of digestible fiber. These feeds provide energy in a form that may not inhibit utilization of forage. Distillers grains, a byproduct of the ethanol manufacturing industry, is high in digestible fiber, and may be a suitable supplement to high-forage diets. Research conducted at the University of Nebraska indicated that the energy value of dry distillers grains was about 125% the value of corn in a forage-based diet (2003 Nebraska Beef Report, pp. 8-10). The amount and form of energy found in distillers grains may provide an opportunity to reduce the frequency of energy supplementation without compromising forage utilization.

The objectives of this trial were to compare the effects of supplementation of distillers grains or corn, either daily or on alternate days, on intake and ruminal parameters.

Procedure

Ten ruminally cannulated heifers (BW = 917 lb) were used in a replicated Latin rectangle design, with four periods and five treatments, to test effects of supplemental energy form and frequency on intake and digestibility parameters.

Table 1. Composition (%DM) of supplements fed to heifers provided ad libitum levels of grass hay.

Ingredient	DRC[a]	DDG[a]
Dry rolled corn	86.8	—
Dry distillers grain + solubles	—	89.1
Molasses	5.4	5.6
Urea	2.6	1.6
Limestone	2.4	3.3
Dicalcium phosphate	2.4	—
Vitamin pre-mix	0.2	0.2
Mineral pre-mix	0.2	0.2

[a]DRC = dry rolled corn supplement fed at 0.46% of BW daily, or 0.92% of BW on alternate days; DDG = dry distillers grains + solubles supplement fed at 0.45% of BW daily, or 0.90% of BW on alternate days.

Table 2. Treatment effects on intake, neutral detergent fiber disappearance, ruminal pH, and intake pattern.

Item	CON[a]	DRC-D[a]	DRC-A[a]	DDG-D[a]	DDG-A[a]
Hay DMI, %BW[b, c]	1.88	1.69	1.58	1.69	1.66
Total DM, %BW[b,c]	1.88	2.10	1.98	2.09	2.06
NDF disappearance, %/hour[b,d]	4.34	3.43	3.65	4.09	4.01
96-hour NDF disappearance, %[b]	75.0	73.8	74.0	73.1	73.4
Average ruminal pH[b,d]	6.30	6.22	6.22	6.12	6.19
Meals per day[c,e]	5.9	6.6	4.0	6.0	5.1
Time spent eating, h[c,e]	13.2	15.4	11.0	13.9	12.7
Meal size, lb[c,e]	4.1	2.6	4.8	3.2	3.9

[a]CON = no supplement; DRC-D = dry rolled corn supplement fed at 0.46% of BW daily; DRC-A = DRC at 0.92% of BW on alternate days; DDG-D = dry distillers grains + solubles supplement fed at 0.45% of BW daily; DDG-A = DDG at 0.90% of BW on alternate days.
[b]CON vs supplemented treatments, $P < 0.05$
[c]Supplementation frequency effect, $P < 0.10$
[d]DDG vs DRC, $P < 0.05$
[e]Supplement x frequency interaction, $P < 0.08$

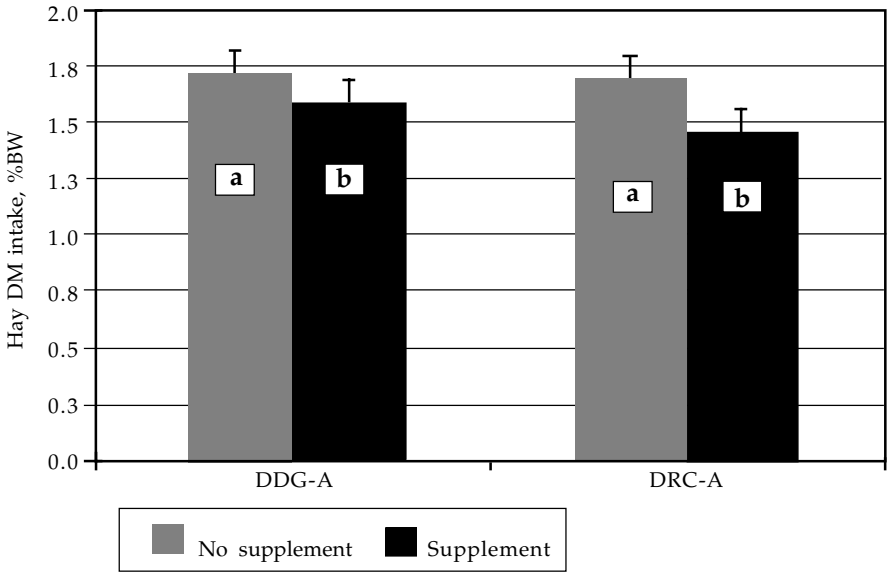

Figure 1. Effects of supplementation on voluntary hay intake among treatments supplemented every-other day. 'No supplement' = days supplement not fed. 'Supplement' = days supplement was fed. Bars with different letters are different (P<0.01).

Heifers received no supplement (CON), dry distillers grains daily (DDG-D), dry distillers grains on alternating days (DDG-A), dry rolled corn daily (DRC-D), or dry rolled corn on alternating days (DRC-A; Table 1). Chopped grass hay (8.2% CP) was fed for ad libitum consumption. Supplements were fed daily at 0.45% and 0.46% of BW for DRC-D and DDG-D, respectively. The small difference was to account for different inclusions of DRC or DDG in the supplements. Heifers in alternate-day treatments received twice the amount of supplement per feeding as heifers in daily treatments. Supplements were fed in the morning, prior to feeding hay. Feed bunks were suspended on load cells and intake pattern was measured continuously. Number of meals per day, time spent eating, and average meal size were calculated.

Rumen fluid samples were collected prior to feeding, and at 2, 4, 6, 8, and 10 hour post-feeding; and pH was measured. Rate and extent of in situ disappearance were calculated with 0, 12, 24, 48, and 96-hour incubations. Two incubations per period were conducted on heifers in alternate-day treatments. The 48-hour time point began on a supplement day for the first incubation, and a non-supplement day for the second.

Data were analyzed using the mixed procedure of SAS. Contrasts comparing CON vs supplemented treatments, daily vs alternate-day supplementation, and DRC vs DDG were included. Additionally, comparisons were made between days on which supplement was fed and non-supplementation days within the alternate-day treatments.

Results

Control heifers had higher ($P < 0.01$) hay DMI than supplemented heifers (1.88% vs 1.66% BW, respectively); although total DMI was lower ($P < 0.01$) for CON than supplemented (1.88% vs 2.06% BW, respectively). An average of 3.7 lb of supplement DM was fed per feeding in this trial. This level resulted in a substitution effect, regardless of the supplement type or frequency with which it was fed. Intake did not differ ($P = 0.45$) between DRC and DDG treatments.

Hay DMI was lower ($P = 0.04$) for heifers supplemented on alternating days (1.62% BW) than for those supplemented daily (1.69%BW). Previous research demonstrated a similar response with heifers supplemented three times weekly having lower intakes than those supplemented daily (2003 Nebraska Beef Report, pp. 8-10).

Within the alternate-day treatments, hay intake was 10.7% lower ($P < 0.01$) on days supplement was fed than on non-supplement days (Figure 1). Corn-supplemented heifers ate 13.8% less hay on supplementation days, compared to a 7.7% reduction for DDG-A. Hay

(Continued on next page)

intake variation coupled with the supplementation schedule lead to large variation in daily dry matter intake among heifers in alternate-day treatments. In general, reducing supplementation frequency had more marked effects on DRC treatments than on DDG (supplement x frequency interaction, $P < 0.08$; Table 2). Reducing DRC supplementation to every-other day reduced the number of meals by 39%, time spent eating forage by 29%, and increased meal size by 85%. Reducing DDG supplementation frequency decreased meal number by 15%, time spent eating forage by 9%, and increased meal size by 22%. Overall, heifers in alternate-day treatments ate fewer and larger meals, and spent less time eating than those supplemented daily (Table 2).

Control heifers had higher (P =0.04) rate and extent of hay neutral detergent fiber (NDF) disappearance than supplemented heifers. Rate of hay NDF disappearance was lower ($P = 0.02$) for DRC than for DDG, although extent of disappearance was not significantly different between supplemented treatments. This may suggest that a negative associative effect was elicited by supplementation, and that the effect was exacerbated by supplementing corn.

Average rumen pH was greater ($P < 0.01$) for CON than supplemented heifers (6.30 vs 6.19, respectively). Heifers in the DDG treatments had lower ($P = 0.03$) ruminal pH than DRC heifers (6.15 vs 6.22, respectively). Although lower rumen pH is generally associated with reduced forage digestibility, values above 6.0 are considered optimum for forage digestion. These pH differences may reflect increased VFA production resulting from increased rate of NDF disappearance observed in heifers within DDG treatments.

In conclusion, supplementation decreased hay intake and changed digestion kinetics. Reducing supplementation frequency affected amount and pattern of intake, and increased intake variation. Rate of hay NDF disappearance was greater in non-supplemented heifers compared to supplemented, and for DDG than DRC.

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Dried Distillers Grains as a Grazed Forage Supplement

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Summary

Thirty heifers grazing smooth bromegrass were individually supplemented with 0, 1.0, 2.1, 3.1, or 4.2 lb per head per day (DM) dried distillers grains (DDG) for 84 days to determine effects of DDG supplementation on ADG and forage intake and to determine the value of DDG in grazing enterprises. Forage intake was estimated using the 1996 NRC model. Supplementation of DDG resulted in a linear increase in ADG and decreased estimated forage intake. DDG may be an attractive forage supplement due to increased revenue from additional ADG and savings from decreased forage intake.

Introduction

The cost of grazed forages in Nebraska has increased by 20 to 25 percent over the past 10 years while the price of corn has remained relatively constant within a cyclical price pattern. By-products of the corn milling industry may fit well into high forage utilization production systems. They provide a highly fermentable fiber source that would not be expected to negatively affect forage digestion. These by-products also supply additional undegradable intake protein (UIP) to meet metabolizable protein deficiencies common in grazing situations. The corn milling by-products are becoming increasingly available and are typically priced relative to corn. Therefore, as the cost of grazed forages increases relative to price of corn, by-products may prove to be an economical forage supplement.

Characteristics of forage supplementation may include improved performance and/or reduced forage intake (i.e. forage substitution). Forage substitution allows for additional animal units to graze a fixed amount of forage and thus is an important consideration when determining value of a forage supplement. By-products which are accurately priced into a grazed forage system must be characterized in terms of their effects on forage intake as well as animal performance. The objective of this research was to determine effects of dried distillers grains (DDG) supplementation on animal performance and forage intake in a grazed forage production system and to demonstrate how DDG might be valued in this situation.

Procedure

Experimental design and animal performance

Thirty heifers (650 lb, SD = 80) were supplemented with 0, 1.0, 2.1, 3.1, or 4.2 lb per head per day (DM) DDG for 84 days. Heifers rotationally grazed four smooth bromegrass pastures which were 15 acres each. Heifers in this study were a part of a larger supplementation experiment investigating the effects of supplemental methionine. Levels of DDG provided were based on supplying 0, 1, 2, 3, or 4 grams of supplemental methionine. Heifers were stratified by weight, blocked by treatment from the previous experiment due to weight differences and assigned randomly to treatment. Supplemental DDG was provided individually using a Calan gate system. Heifer performance was determined by measuring ADG. Heifers were limit fed for five days at the beginning and end of the trial and weights were measured for three consecutive days to minimize variation in gut fill.

Determination of forage intake

Forage intake was estimated using the 1996 NRC model. DDG intake was known and forage intake was adjusted to achieve the observed ADG. DDG included solubles and had a fat content of 8.5%. It was assumed DDG contained 100% TDN, 29.5% CP, and 17.7% UIP (DM). Smooth bromegrass inputs were based on previous IVDMD and CP analysis and were assumed to be 61.5% TDN, 20% CP, and 1% UIP (DM). Animal inputs were based on a 14 month old 2 way british-continental cross animal weighing 730 lb with a 1350 lb mature weight. Implants and additives were not used. Net energy adjusters were set at 100% and microbial yield was set at 13%.

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Determination of DDG value

The value of DDG supplementation to grazed forages was determined by combining the estimated value of the additional gain achieved per unit of DDG supplementation with the estimated value of the forage that was replaced. The value of the additional gain achieved by supplementing DDG was determined by calculating the additional weight sold at the end of the grazing period. Price paid per hundred weight was estimated using the regression equation $y = 0.00005x^2 - 0.1071x + 127.3$ where y = price paid and x = animal weight. This equation was previously developed from September - October average feeder calf prices from 1992 - 1999. The equation has a good relationship to actual prices (r = 0.987) and accounts for a price slide where heavier cattle sell for less money on a per hundred weight basis. The value of the forage replaced by DDG was assumed to be the 10-year average Nebraska pasture price of $21.65 per animal unit month (AUM).

Results

Figure 1 shows the relationship between supplemental DDG and ADG. Additional supplementation of DDG tended to result in higher ADG ($P = 0.16$). There was a linear relationship between level of supplemental DDG and ADG ($P = 0.10$). This relationship can be described by the equation $y = 0.06x + 1.50$ ($r^2 = 0.45$) where y = expected ADG (lb) and x = DDG supplemented (lb per day, DM). Thus an additional 0.06 (±0.05) lb per day gain can be expected for every lb per day DDG supplemented in situations where unsupplemented cattle would gain 1.50 lb per day.

Figure 2 shows the relationship between supplemental DDG and forage intake as predicted by the 1996 NRC model. This relationship

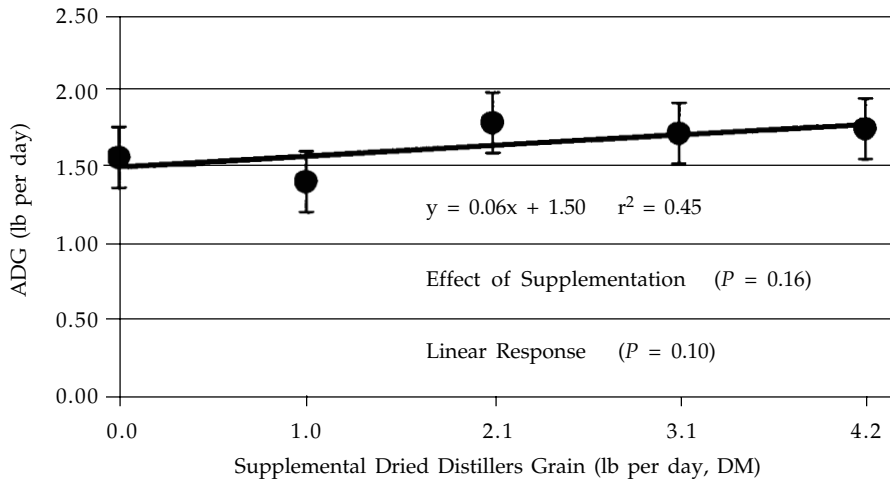

Figure 1. Effect of supplemental dried distillers grains on ADG.

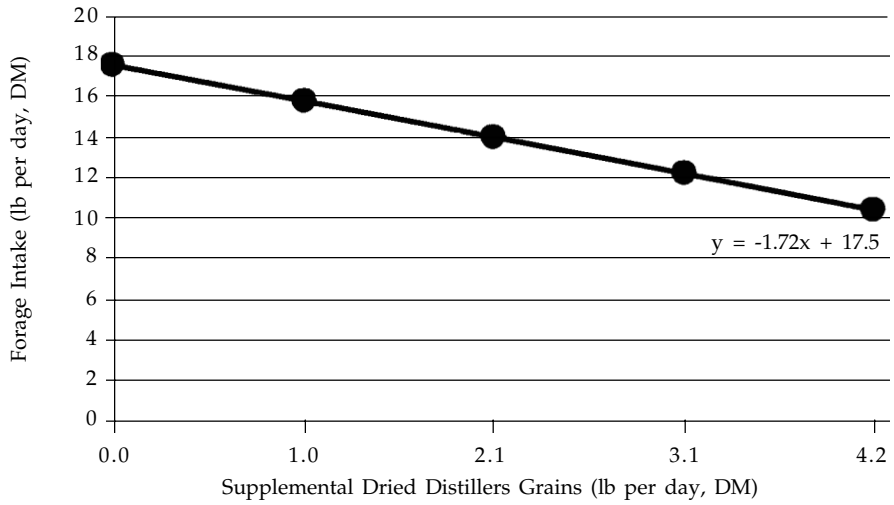

Figure 2. Effect of supplemental dried distillers grains on forage intake as predicted by the 1996 NRC model.

Table 1. Value of dried distillers grains (DDG) due to improved animal performance (IAP) and reduced forage intake(RFI).

Supplemental DDG, lb per d (DM):	0	1.0	2.1	3.1	4.2
Beginning wt, lb[a]	650	650	650	650	650
End wt, lb[b]	776	782	787	793	798
Sale price, $ per 100 lb[c]	74.30	74.14	73.98	73.82	73.66
Revenue, $[d]	576.52	579.42	582.32	585.23	588.15
DDG value from IAP, $ per ton[e]	—	65.97	66.04	66.12	66.20
DDG value from RFI, $ per ton[f]	—	109.68	109.68	109.68	109.68
Total DDG value, $ per ton[g]	—	175.65	175.73	175.80	175.88

[a]Average start weight for this trial.
[b]Expected weight after 84 days based on the equation $y = 0.06x + 1.50$ where y = ADG and x = DDG intake.
[c]Sale price per 100 lb determined from the equation $y = 0.00005x^2 - 0.1071x + 127.3$ where y = sale price and x = sale weight.
[d]Revenue determined by multiplying end weight and sale price/100.
[e]DDG value (DM) due to improved animal performance. Calculated from additional revenue over 0 DDG / level / days (84).
[f]DDG value (DM) due to reduced forage intake assuming a forage cost of $21.65 per animal unit month.
[g]Total DDG value (DM) from IAP + RFI. DDG value can be determined relative to forage cost with the equation $y = 5.07x + 66.08$ where y = DDG value and x = forage cost ($ per animal unit month).

is described by the equation y = -1.72x + 17.5 where y = forage intake (lb per day, DM) and x = supplemented DDG (lb per day, DM). This relationship suggests that one lb DDG will replace 1.72 lb forage in situations where unsupplemented cattle would be expected to consume 17.5 lb forage per day. By definition, there are 680 lb forage DM in one AUM. Therefore, 395 lb DDG will replace one AUM of forage or one ton DDG will replace 5.07 AUMs of forage. This relationship allows for DDG to be valued based on the forage it will replace. Table 1 shows the value of DDG as a result of increased animal performance and reduced forage intake. The additional gain of 0.06 lb per lb DDG supplemented results in an average additional value of DDG of $66.08 per ton(DM). Using these relationships, the value of DDG can be calculated from the cost of forage using the equation y = 5.07x + 66.08 where y = the value of DDG ($ per ton, DM) and x = the value of forage ($ per AUM). Using the 10-year average price of forage in Nebraska of $21.65 per AUM, the value of DDG is $175.84 per ton (DM).

It is appropriate to consider several points of discussion regarding these data. First, it is important to note that this value for DDG does not include a charge for delivery to the pasture because this cost is highly variable among producers. Second, DDG fed in this trial had a fat content of 8.5%. However, DDG may contain as much as 13% fat. Additional fat would supply more energy which would further increase gain or reduce forage intake. Thus, we feel these estimates are conservative. Finally, the highest level of supplemental DDG included in this data set was approaching 30% of dietary DM intake. This is a high level of supplementation and fat provided from DDG and forage above these levels may inhibit fiber digestibility. Therefore, we caution against extrapolating results of this data set beyond 4.2 lb of DDG supplementation. The process of determining the value of DDG relative to the price of forage suggests that supplementing DDG may be beneficial in many grazing situations.

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[1]Jim C. MacDonald, graduate student; Terry J. Klopfenstein, professor, Animal Science, Lincoln.

Effects of Corn Bran and Degradable Protein Source on Microbial Protein Estimated From Spot Urine Samples in Heifers

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Summary

A metabolism trial was conducted in finishing heifers to determine if allantoin in spot urine samples could be a predictor of microbial CP (MCP) supply. When corn bran replaced high moisture corn, ruminal pH was higher and microbial efficiency and flow were greater. Estimated microbial efficiency and flow were not different for SBM compared to urea as a source of degradable protein. Daily variation in intake was reflected in MCP estimates. Within day variation for MCP estimates was consistent and small. Estimates of MCP from allantoin in spot urine samples followed NRC estimates. Results demonstrate that allantoin is an effective predictor of MCP flow.

Introduction

Purines are one of the building blocks used in the synthesis of DNA and RNA. Feed purines are essentially totally degraded in the rumen leaving only purines of microbial origin for passage to the duodenum. Therefore, purines have commonly been used to estimate microbial crude protein (MCP) flow in studies assessing protein status of beef cattle. However, this requires duodenal fistulation resulting in laborious experiments with few cattle. Urinary allantoin is derived from the breakdown of purines. Recent research (2001 Nebraska Beef Report, pp. 115-116) has shown a strong linear relationship between allantoin excretion and purine flow to the duodenum. Previous research analyzed urine samples from total daily collections. This technique is noninvasive but is still laborious and limits cattle numbers because it requires total collection. Creatinine may be used as a marker of urine volume because it is excreted at a constant rate relative to body weight. Using creatinine, spot sampling of urine could be used in a larger number of cattle in typical production settings. Our primary objective was to feed diets that would create differences in MCP supply and determine if allantoin to creatinine ratios in spot urine samples could predict these differences.

Procedure

Six ruminally cannulated crossbred yearling heifers (1311 ± 103 lb BW) were used in a 3 x 6 Latin rectangle. Each of three periods consisted of 9 day for adaptation to diet and 5 day for collection. Base diets (Table 1) were a high-moisture corn (HMC) diet and a diet with corn bran (BRAN) replacing 20% (DM basis) HMC. Urea was added to base diets at 0.9% of diet DM. Addition of corn bran provided a highly digestible fiber source that was expected to increase ruminal pH and subsequently increase microbial efficiency and flow. The BRAN diet also was fed with 7.8% soybean meal (SBM) (DM basis) replacing HMC. The levels of urea and SBM were calculated to provide equal amounts of degrable intake protein (DIP). The SBM diet was included to provide microbes a source of true protein and amino acids that was not available when using urea as the supplemental DIP source. The hypothesis was that true protein and amino acids would increase microbial efficiency resulting in increased MCP flow. Heifers were fed for ad libitum

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

	Diet[a]		
Ingredient	HMC	BRAN	SBM
High-moisture corn	88.3	68.3	60.5
Corn bran	—	20.0	20.0
Soybean meal	—	—	7.8
Cottonseed hulls	6.7	6.7	6.7
Dry supplement[b]	5.0	5.0	5.0
Fine ground milo	1.68	1.67	2.98
Limestone	1.50	1.49	1.36
Urea	0.90	0.90	—
Potassium Chloride	0.43	0.45	0.17
Salt	0.30	0.30	0.30
Tallow	0.10	0.10	0.10
Trace mineral premix	0.05	0.05	0.05
Rumensin premix	0.02	0.02	0.02
Tylan premix	0.01	0.01	0.01
Vitamin premix	0.01	0.01	0.01

[a]HMC=high-moisture corn diet, BRAN=corn bran diet, SBM=soybean meal diet.
[b]All diets supplemented to contain a minimum of 0.6% Ca, 0.24% P, 0.6% K, and 0.1% S (DM basis). All diets contained 32 g/ton monensin and 11 g/ton tylosin (DM basis).

Table 2. Effect of HMC replacement with corn bran or supplemental degradable protein source on digestion, ruminal pH, and microbial estimates.

	Diet[a]				Contrasts[b]	
Item	HMC	BRAN	SBM	SEM	1	2
DMI, lb/day	22.2	25.1	23.8	1.5	0.14	0.35
Digestible DMI, lb/day	18.7	20.5	18.7	1.3	0.49	0.22
Ruminal pH	5.44	5.78	5.88	0.18	0.01	0.46
Time pH below 5.6, min	887	576	428	212	0.09	0.49
A:C[c]	1.05	1.30	1.23	0.09	0.02	0.38
Urine volume, L/day[d]	31.6	32.2	25.8	9.4	0.71	0.38
MCP, g/day[e]	740	966	913	88	0.02	0.47
Microbial efficiency[f]	38.8	46.0	48.6	4.0	0.05	0.54

[a]HMC=high-moisture corn diet, BRAN=corn bran diet, SBM=soybean meal diet.
[b]Contrast 1 is comparison of HMC to average of both corn bran containing diets; Contrast 2 is comparison of BRAN and SBM.
[c]Molar ratio of allantoin to creatinine.
[d]Urine volume calculated from creatinine output.
[e]Microbial crude protein.
[f]Microbial efficiency calculated as g MCP/lb digestible DMI.

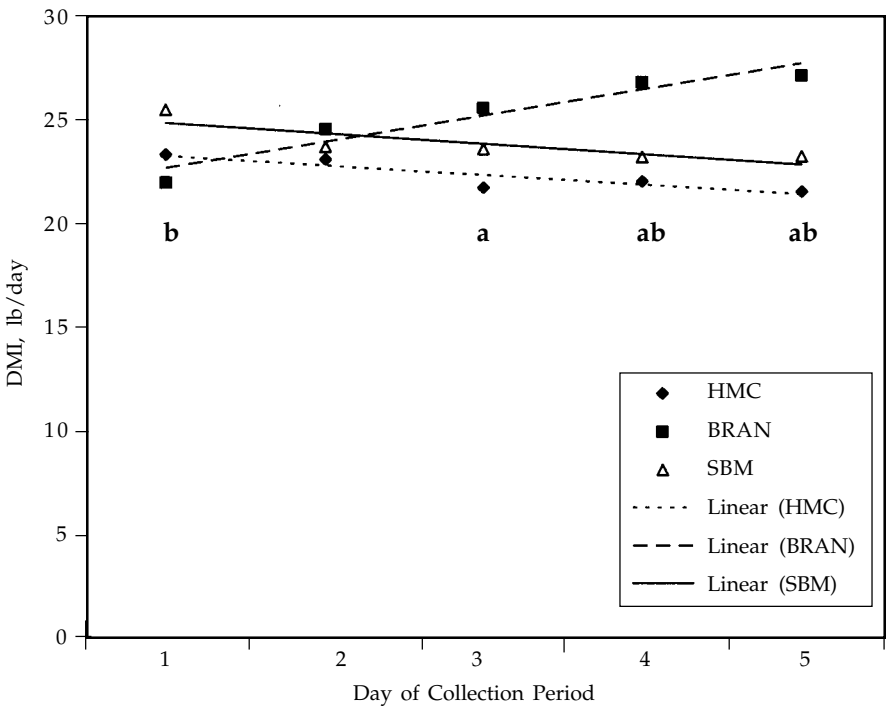

Figure 1. Daily variation in dry matter intake. SEM=1.5. Treatment x day (*P*<0.01). Linear effect of day within HMC (*P*=0.19). Linear effect of day within BRAN (*P*<0.01). Linear effect of day within SBM (*P*=0.13). Differences in means on a particular sampling day are denoted by letters beneath points: [a] Contrast comparing HMC to both corn bran containing diets (*P*<0.10) and [b] Contrast comparing BRAN and SBM (*P*<0.10).

intake once daily at 0900. Chromic oxide was used as an indigestible marker to calculate total-tract digestion and was administered through the ruminal cannula twice daily at 0800 and 1700. Feed intake and ruminal pH were monitored continuously with feed weight and ruminal pH recorded every minute during the 5 day collection period.

Spot urine and fecal grab samples were obtained on each collection day at 0800, 1100, 1400, and 1700. The molar ratio of allantoin to creatinine was calculated for each urine sample. We assumed daily urinary creatinine output was equal to 16.4 mg/lb BW. To calculate daily allantoin output (moles/day), the allantoin to creatinine ratio was multiplied by assumed daily creatinine output. Estimated MCP flow was calculated from daily allantoin output according to equations outlined previously (2002 Nebraska Beef Report, pp. 66-68). Estimates of microbial efficiency (g/lb DM) were calculated by dividing estimated MCP supply by digestible DMI.

Data were analyzed as repeated measures using the Mixed procedure of SAS. For intake and ruminal pH analyses, collection day represented repeated observations. For urine data analyses, collection day and time of collection were the repeated observations. To determine the effect of corn bran addition, a contrast was used to compare the HMC diet to both of the corn bran containing diets. To determine the effect of supplemental DIP source, a contrast was used to compare the BRAN and SBM diets. Additionally, linear and quadratic effects of time and day were tested with orthogonal contrasts. The REG procedure of SAS was used to compare MCP estimates from urinary allantoin to estimates from Level 1 of the NRC (1996) model.

Results

Ruminal pH below 5.6 is generally used to define subacute acidosis. Results of the current trial indicate the presence of subacute acidosis. Heifers consuming the HMC diet had an average ruminal pH of 5.44 (Table 2). Additionally, those heifers spent almost 15 hours of each 24-hour collection below a pH of 5.6 (Table 2). Intakes were variable and treatment and collection day interacted (*P*<0.01) with

(Continued on next page)

DMI increasing linearly ($P<0.01$) for the BRAN diet (Figure 1). This may be an indication that the adaptation period was not long enough. The significance of differences in DMI for HMC compared to corn bran containing diets increased toward the end of the collection period (day 3, $P=0.09$; day 4, $P=0.08$; day 5, $P=0.04$).

Estimates of MCP flow and microbial efficiency from allantoin to creatinine ratios in spot urine samples followed the pH and intake responses for dietary addition of corn bran. Treatment effects for estimates of MCP interacted with collection day ($P=0.02$), and MCP was lower on day 2 ($P=0.02$), day 4 ($P=0.01$), and day 5 ($P<0.01$) for HMC versus the average of the corn bran containing diets (Figure 2). On average, corn bran addition increased MCP estimates by 27% ($P=0.02$; Table 2). The interaction for MCP estimates is explained by the interaction found for intake. When intake variation was taken into account by calculating microbial efficiency, the interaction was no longer present ($P=0.28$), and there was no main effect of collection day. However, microbial efficiency increased ($P=0.05$) by 22% with corn bran addition (Table 2). Because there were no differences in digestible DMI (Table 2), the lower MCP value for HMC is attributable to lower microbial efficiency as a result of lower ruminal pH.

The present study also was designed to evaluate supplementing SBM versus urea based on the hypothesis that providing microbes a source of true protein and amino acids would increase microbial efficiency and flow. There was no effect on DMI, digestible DMI, or ruminal pH when SBM was supplemented relative to urea (Table 2). Evaluation of the treatment by collection day interactions discussed previously for intake (Figure 1) showed that DMI was higher for SBM relative to BRAN on day 1 ($P=0.05$) and lower on day 4 ($P=0.05$), and day 5 ($P=0.03$). Evaluation of the treatment by collection day interaction for MCP estimates (Figure 2) indicates that MCP was higher ($P=0.05$) only on day 5 of the collection period for BRAN compared to SBM. Microbial efficiency did not differ between SBM and BRAN (Table 2) treatments. These results are in conflict with some previous reports that indicated MCP flow and efficiency were higher for SBM versus urea supple-

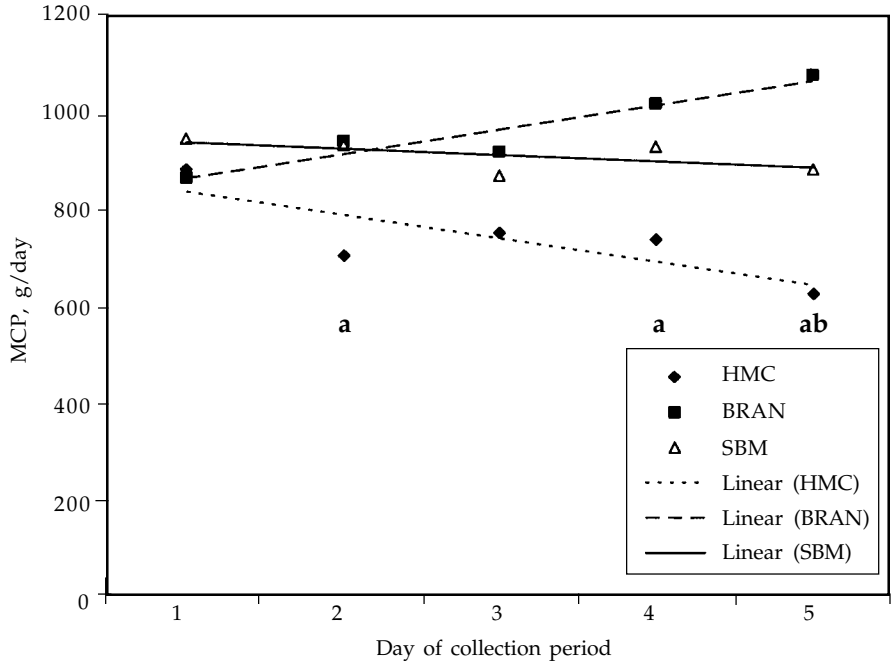

Figure 2. Daily variation in microbial protein estimates. SEM=103. Treatment x day ($P=0.02$). Linear effect of day within HMC ($P=0.01$). Linear effect of day within BRAN ($P<0.01$). Linear effect of day within SBM ($P=0.45$). Differences in means on a particular sampling day are denoted by letters beneath points: [a] contrast comparing HMC to both corn bran containing diets ($P<0.10$) and [b] contrast comparing BRAN and SBM ($P<0.10$).

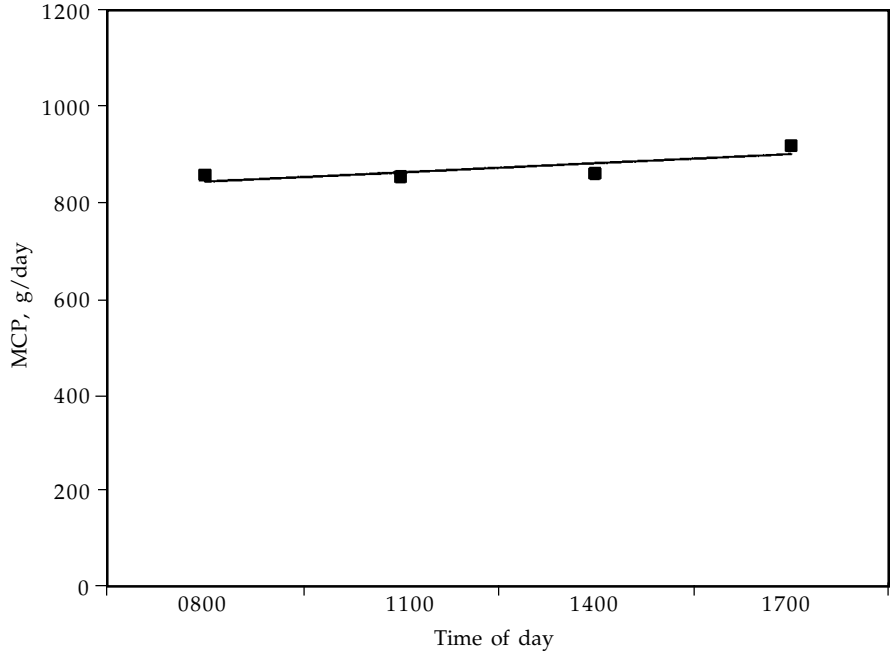

Figure 3. Diurnal variation in microbial protein estimates. SEM=75. Treatment x time ($P=0.19$). Main effect of time ($P=0.10$). Linear effect of time ($P=0.06$).

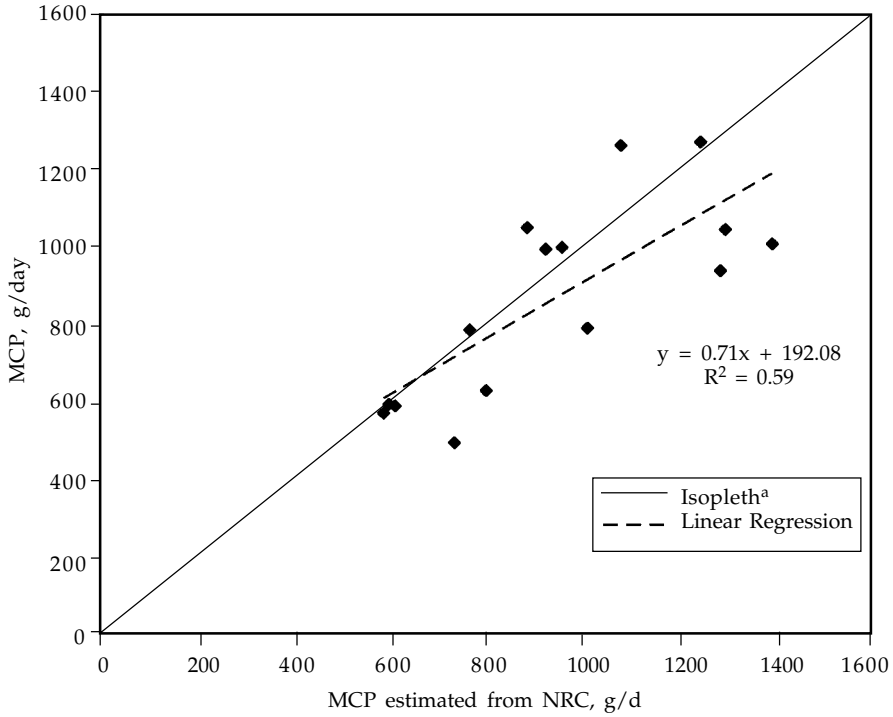

Figure 4. Relationship between allantoin and NRC estimates of microbial protein. [a] Isopleth is the line where estimates are equal and r^2 is equal to 1. Intercept (SE=161; *P*=0.25). Slope (SE=0.16; *P*<0.01).

mented diets. However, those trials were conducted with DRC-based finishing diets, and it seems plausible that the higher DIP value for HMC relative to DRC would provide microbes with more true protein and amino acids decreasing the response to SBM as a supplemental DIP source. Additionally, this trial compared SBM and urea in corn bran containing diets where risk of acidosis had been reduced.

Estimates of urine volume (L/day) did not differ with treatment and were comparable to estimates found in other research trials. The allantoin to creatinine ratio was only different (*P*=0.02) when comparing HMC to the corn bran containing diets representing the increased MCP flow. Some previous studies have found allantoin to creatinine ratios and estimates of MCP display diurnal variability. This variability is acceptable as long as it is consistent and predictable. Our most important finding in this regard is that there was no time of day by collection day interaction for estimates of MCP (*P*=0.22). We did show some diurnal variability with a MCP estimates increasing linearly (*P*=0.06) from 0800 to 1700 (Figure 3). However, MCP estimates only increased by 63 g or 7% from the first sampling time to the last. In addition, there was no treatment x time of day interaction for MCP estimates. Using an assumed creatinine output of 16.4 mg/lb BW resulted in MCP estimates that were in agreement with estimates from the NRC (1996) model (Figure 4).

In conclusion, we observed an increase in MCP flow and efficiency estimated from allantoin excretion in spot urine samples when average ruminal pH was increased by adding corn bran to HMC-based finishing diets. Additionally, there were no differences in ruminal pH, intake, or digestibility between diets containing corn bran that were supplemented with urea or SBM resulting in no differences in MCP flow or efficiency. There was little diurnal variation in MCP estimates, and daily variation due to changes in intake was removed when microbial efficiency was calculated. Estimates of MCP followed NRC (1996) estimates, but creatinine outputs may need to be adjusted on an individual animal basis to more accurately and precisely estimate MCP. This trial was conducted in a metabolism setting with a small number of animals. However, the goal of developing a spot sampling technique is to be capable of sampling large numbers of animals in a more typical production setting. Results of a companion finishing trial are also reported in this publication (pp. 32). In that trial, 120 head of heifers were fed the same diets and spot sampled across the feeding period.

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Effects of Corn Bran and Degradable Protein Source on Finishing Heifer Performance and Estimates of Microbial Protein Supply in High Moisture Corn Finishing Diets

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Summary

A feeding trial was conducted to evaluate performance and estimates of microbial CP (MCP) supply in high moisture corn finishing diets with corn bran addition and different sources of degradable protein. Corn bran increased intake throughout the feeding period but decreased performance after day 42. Microbial efficiency and MCP were unaffected by corn bran addition, but MCP increased with increasing urea level. Performance was increased for the first 42 days when SBM was fed relative to urea, but microbial efficiency and MCP were unaffected. Supplemental DIP level did not affect MCP estimates. Estimates of MCP from allantoin were low and variable but did reflect differences that could be explained with performance.

Introduction

Purine flow to the duodenum is commonly used to estimate microbial CP (MCP) supply in ruminants. Previous research (2001 Nebraska Beef Report, pp. 115-116) has shown a strong linear relationship between urinary excretion of allantoin and purine flow to the duodenum. Several studies in calves, sheep and lactating dairy cows have compared MCP estimates from purine derivative excretion in total urine collections to values estimated using allantoin to creatinine ratios in spot urine samples. The two methods have been shown to yield similar results but have not been studied in finishing cattle.

Corn bran contains highly digestible NDF and can reduce the incidence of subacute acidosis in finishing diets resulting in increased DMI and ADG and improved feed conversion (1997 Nebraska Beef Report, pp. 72-74). In vitro research has demonstrated that lower ruminal pH decreased microbial efficiency and MCP flow. Ruminant bacteria can use a non-protein nitrogen source like urea, but some microbes may have a requirement for true protein and amino acids. As a result, addition of a true protein source like soybean meal (SBM) would increase microbial efficiency and flow relative to urea. The objective of this trial was to evaluate estimates of MCP flow from allantoin to creatinine ratios in spot urine samples by formulating diets that were expected to result in different MCP flows. In addition, this was done in a typical production setting with a larger number of animals than can be used in a metabolism setting.

Procedure

One hundred-twenty crossbred yearling heifers averaging 768 ± 44 lb (initial BW) were used in a randomized complete block design. Heifers were split into four blocks by initial weight, stratified by weight within block and assigned randomly to one of 15 dietary treatments (8 heifers/treatment). Base diets were a high-moisture corn (HMC) diet and a diet with corn bran (BRAN) replacing 20% HMC (DM basis) (Table 1). Five levels of urea were added to the HMC and

Table 1. Composition of experimental diets (% of DM).

	Level of Supplemental DIP[b]				
Diet/Ingredient[a]	0	25	50	75	100
HMC					
High-moisture corn	88.3	88.3	88.3	88.3	88.3
Cottonseed hulls	6.7	6.7	6.7	6.7	6.7
Dry supplement[c]	5.0	5.0	5.0	5.0	5.0
Urea	0.00	0.45	0.90	1.35	1.80
BRAN					
High-moisture corn	68.3	68.3	68.3	68.3	68.3
Corn bran	20.0	20.0	20.0	20.0	20.0
Cottonseed hulls	6.7	6.7	6.7	6.7	6.7
Dry supplement[c]	5.0	5.0	5.0	5.0	5.0
Urea	0.00	0.45	0.90	1.35	1.80
SBM					
High-moisture corn	68.3	64.4	60.5	56.6	52.7
Corn bran	20.0	20.0	20.0	20.0	20.0
Soybean meal	0.0	3.9	7.8	11.7	15.6
Cottonseed hulls	6.7	6.7	6.7	6.7	6.7
Dry supplement[c]	5.0	5.0	5.0	5.0	5.0

[a]HMC=high-moisture corn diet, BRAN=corn bran diet, SBM=soybean meal diet.
[b]Level is the % of maximum supplemental DIP (i.e. 100=1.8% urea or 15.6% SBM).
[c]All diets supplemented to contain a minimum of 0.6% Ca, 0.24% P, 0.6% K, and 0.1% S. All diets contained 32 g/ton monensin and 11 g/ton tylosin and provided 0.05 mg/head/day MGA.

Table 2. Effect of corn bran inclusion and dietary urea level on finishing performance and carcass traits of finishing heifers.

Diet:	BRAN					HMC						*P*-value[b]		
Level:[a]	0	25	50	75	100	0	25	50	75	100	SEM	D	L	D x L
Day 0 – 42														
DMI, lb[c]	17.2	19.1	20.2	20.2	18.7	18.5	18.3	18.9	18.3	18.9	0.4	0.04	0.01	0.01
ADG, lb[d]	2.09	2.77	3.04	2.97	2.90	2.35	2.53	2.64	2.71	3.12	0.20	0.44	<0.01	0.27
feed/gain[d]	8.26	6.94	6.71	6.85	6.67	8.00	7.25	7.19	6.76	6.10	0.49	0.86	<0.01	0.62
Day 42 – end														
DMI, lb	17.8	18.9	20.5	20.9	18.9	18.9	17.4	18.5	18.0	18.9	0.9	0.06	0.35	0.13
ADG, lb	2.42	2.49	2.62	2.64	2.29	3.06	2.88	3.01	2.82	2.66	0.26	0.01	0.70	0.93
feed/gain	7.30	7.52	7.87	7.87	8.26	6.29	5.99	6.13	6.49	7.09	1.00	<0.01	0.46	0.95
Day 0 – end														
DMI, lb[c]	17.6	18.9	20.5	20.7	18.9	17.6	17.6	18.7	18.0	18.9	0.7	0.03	0.13	0.03
ADG, lb	2.27	2.62	2.77	2.75	2.49	2.77	2.75	2.88	2.79	2.88	0.20	0.04	0.51	0.64
feed/gain	7.75	7.19	7.41	7.52	7.57	6.85	6.41	6.49	6.58	6.53	0.45	<0.01	0.77	0.99
A:C ratio[e]	0.97	1.09	1.19	1.11	1.04	1.04	1.05	1.20	1.05	1.24	0.07	0.44	0.13	0.42
Urine volume, L/day	38.7	39.3	29.0	34.7	31.8	32.1	25.7	46.1	32.1	64.0	9.5	0.38	0.49	0.10
MCP, g/day[fg]	431	583	630	571	494	528	512	639	517	561	52	0.77	0.05	0.41
MCP/DMI, g/lb[f]	22.7	29.2	28.3	26.2	24.0	26.4	26.8	30.9	24.7	27.1	6.9	0.47	0.22	0.62
MCP/TDNI, g/lb[fh]	25.6	33.4	32.4	29.8	27.1	28.6	29.2	34.0	26.7	29.5	12.7	0.96	0.21	0.62

[a]Urea levels for each diet represent % of maximum amount of urea (i.e. 100=1.8% of diet DM).
[b]D=diet effect, L=effect of urea level, D x L=interaction of diet and level.
[c]Quadratic effect of urea level within BRAN ($P<0.01$).
[d]Linear effect of urea level ($P<0.01$).
[e]Allantoin to creatinine ratio.
[f]MCP=microbial crude protein.
[g]Quadratic effect of urea level (P<0.01).
[h]TDNI=TDN intake.

BRAN diets at 0, 0.45, 0.90, 1.35, and 1.80% of the diet DM. Additionally, the BRAN diet was fed with five levels of SBM at 0, 3.9, 7.8, 11.7, and 15.6% of the diet DM (Table 1) replacing HMC. Levels of SBM were calculated to be equal in degradable intake protein (DIP) to levels of urea.

Heifers were individually fed once daily using electronic Calan gates. Heifers were adapted to their respective finishing diet by gradually increasing the amount of feed offered until heifers reached ad libitum intake. Initially, intake was limited to 1.5% (DM basis) of average initial BW (11.4 lb DM). Feed offered was subsequently increased by 0.5 lb/day (DM basis) until ad libitum intake was reached (approximately 20 days).

Each weight block was implanted with Synovex-Plus approximately 100 days before slaughter with the heaviest block being fed 86 days, the two intermediate blocks being fed 114 days and the lightest block being fed 129 days. Final weight was calculated from hot carcass weight based on a common dress (62%) and used to calculate ADG and feed efficiency.

Spot urine samples were collected on days 19 to 21, days 61 to 63 and days 103 to 105. The molar ratio of allantoin to creatinine was calculated for each urine sample. We assumed daily urinary creatinine output was equal to 16.4 mg/lb BW. To calculate daily allantoin output (moles/day), the allantoin to creatinine ratio was multiplied by assumed daily creatinine output. A set of equations outlined previously (2002 Nebraska Beef Report, pp. 66-68) were used to calculate MCP production (g/day) based on daily urinary allantoin output. Microbial efficiency (g/lb) was calculated by dividing the estimate of MCP by the DMI for the day prior to urine collection. In a companion metabolism trial (2004 Nebraska Beef Report, pp. 28), the HMC and BRAN diets were fed with the mid-level (0.9%) of urea and the BRAN diet was fed with the mid-level (7.8%) of SBM. That trial found total-tract DM digestibilities of 85.1, 81.8, and 80.2% for the HMC, BRAN, and SBM diets, respectively. These values were used to calculate microbial efficiency based on TDN intake.

Performance data were analyzed using the Mixed procedure of SAS. Two separate 2 x 5 factorial treatment structures were analyzed. The first analysis compared corn bran inclusion and five levels of urea. The second analysis compared effects of source of supplemental DIP (urea or SBM) at five levels. Urine data were averaged across each 3 day collection period for individual animals. These average values were termed time 1 (T1), time 2 (T2), and time 3 (T3). Data were analyzed as repeated measures using the Mixed procedure of SAS in both of the treatment structures previously discussed. Time period represented repeated observations.

Results

Previous research (1997 Nebraska Beef Report, pp. 72-74) found that replacing dry-rolled corn (DRC) with 15% corn bran resulted in increased DMI and ADG with improved feed conversion. In the current trial, 20% corn bran addition to a HMC-based diet resulted in a 6% increase (P=0.03) in DMI, 8% decrease (P=0.04) in ADG, and 14% decrease (P<0.01) in

(Continued on next page)

Table 3. Effect of supplemental degradable protein source and level in diets containing corn bran on finishing performance and carcass traits of finishing heifers.

Diet:	Urea					SBM						*P*-value[b]		
Level:[a]	0	25	50	75	100	0	25	50	75	100	SEM	D	L	D x L
Day 0 – 42														
DMI, lb[c]	17.2	19.1	20.2	20.2	19.4	19.1	19.6	20.0	20.2	18.7	0.4	0.34	<0.01	0.10
ADG, lb[c]	2.09	2.77	3.04	2.97	2.90	2.71	2.75	3.70	3.48	3.30	0.22	<0.01	<0.01	0.47
feed/gain[d]	8.26	6.94	6.71	6.85	6.67	7.19	7.14	5.40	5.78	5.68	0.48	<0.01	<0.01	0.24
Day 42 – end														
DMI, lb	17.8	18.9	20.5	20.9	18.9	20.9	19.6	20.9	19.8	18.3	0.9	0.30	0.11	0.18
ADG, lb	2.42	2.49	2.62	2.64	2.29	2.60	2.71	2.86	2.53	2.62	0.20	0.15	0.64	0.81
feed/gain	7.30	7.52	7.87	7.87	8.26	7.94	7.19	7.30	7.94	6.99	0.60	0.34	0.87	0.46
Day 0 – end														
DMI, lb[c]	17.6	18.9	20.5	20.7	18.9	20.2	19.6	20.5	20.0	18.9	0.7	0.21	0.05	0.16
ADG, lb[c]	2.27	2.62	2.77	2.75	2.49	2.64	2.71	3.19	2.84	2.90	0.15	<0.01	0.01	0.64
feed/gain[e]	7.75	7.19	7.41	7.52	7.57	7.63	7.25	6.41	7.04	6.41	0.33	<0.01	0.06	0.10
A:C ratio[f]	0.98	1.10	1.20	1.12	1.05	1.08	1.05	1.03	0.92	1.03	0.08	0.20	0.75	0.33
Urine volume, L/day	39.1	39.7	29.4	35.0	32.2	22.3	36.8	28.2	26.8	30.7	10.0	0.30	0.88	0.91
MCP, g/day[g]	437	590	635	577	500	519	548	518	465	498	58	0.26	0.26	0.31
MCP/DMI, g/lb[g]	24.3	30.7	29.8	27.8	25.7	24.4	28.0	25.0	22.4	25.0	3.0	0.13	0.35	0.81
MCP/TDNI, g/lb[gh]	29.8	37.7	36.5	34.1	31.4	30.5	34.9	31.2	28.0	31.3	3.7	0.21	0.35	0.82

[a]Supplemental DIP levels represent % of maximum amount of urea or SBM in diet (i.e. 100=1.8% urea or 15.6% SBM).
[b]S=source effect, L=effect of supplemental DIP level, S x L=interaction of source and level.
[c]Quadratic effect of supplemental DIP level ($P<0.01$).
[d]Quadratic effect of supplemental DIP level ($P=0.04$).
[e]Linear effect of supplemental DIP level ($P=0.03$).
[f]Allantoin to creatinine ratio.
[g]MCP=microbial crude protein.
[h]TDNI=TDN intake.

feed conversion across the entire feeding period (Table 2). These effects occurred from day 42 to the end of feeding period, because corn bran addition resulted in a 3% increase ($P=0.04$) in DMI with no difference in ADG or feed conversion during the first 42 d (Table 2). Corn bran could be more effective when fed in HMC instead of DRC-based finishing diets because more starch would be degraded in the rumen at a faster rate for HMC. Perhaps our failure to observe a benefit of corn bran was due to relatively low feed intake. Our results did show that corn bran was more effective early in the feeding period when cattle were being adapted to a HMC-based finishing diet, and subacute acidosis may have been more prominent.

The hypothesis for this trial was that corn bran would reduce the incidence of acidosis and increase microbial efficiency and MCP flow. Based on results discussed previously, acidosis may not have been an issue. As a result, corn bran addition did not change microbial efficiency or MCP estimates (Table 2.). Microbial efficiencies were calculated by dividing MCP estimates by TDN intake which is a measure of total-tract digestibility. We were unable to calculate microbial efficiency based on rumen available energy intake, but these efficiencies would have been higher than those reported because they would only account for ruminal digestion instead of total-tract digestion. Additionally, microbial efficiency based on ruminal available energy would probably have been higher for the BRAN diet because ruminal digestion of corn bran would be lower than HMC. Preliminary results of a current research trial have shown ruminal digestibility of corn bran to be half of HMC. This difference in ruminal digestibility would result in a 10% increase in our reported microbial efficiencies for the BRAN diet (i.e. 20% inclusion x 50% lower digestibility). Much of the energy value assigned to corn bran is attributed to its value in reducing the incidence of acidosis. Therefore, corn bran may have only increased microbial efficiency by enough to offset the decrease in energy intake. Increased performance for the HMC diet was a result of total dietary energy content.

Results in this Nebraska Beef Report (pp. 28) from a companion metabolism trial conflict with results of the current study showing corn bran addition increased ruminal pH resulting in increased estimates of microbial efficiency and flow. The companion study was conducted with six heifers having an average weight of 1311 lb while the current study evaluated heifers across the feeding period. Corn bran increased DMI by approximately 13% in the metabolism trial compared to 6% in the current trial.

Previous research (2001 Nebraska Beef Report, pp. 54-57) determined that 10.1% (DM basis) dietary DIP resulted in the lowest feed conversion for steers fed HMC-based finishing diets. In contrast, the current trial showed no effect of increasing DIP level on performance across the entire feeding period implying DIP requirements were met with no added urea. How-

ever, ADG increased by 36% and feed conversion decreased by 21% from the lowest to highest level of urea during the first 42 days of the feeding period (Table 2). Our highest level of urea resulted in dietary DIP values of 10.6 and 11.6% for HMC and BRAN diets, respectively. Therefore, our results were in agreement with previous work only for the first 42 days heifers were on feed.

Estimates of MCP flow to the duodenum increased quadratically ($P<0.01$) across levels of urea reaching a maximum at 0.9% (DM basis) which represented 8.1 and 9.1% dietary DIP (DM basis) for HMC and BRAN diets, respectively (Table 2). These values for dietary DIP are lower than those determined based on performance for the first 42 days of the feeding period but higher than those based on performance from day 42 to the end; however, they represent the midpoint of these two extremes.

Across the entire feeding period in the current trial, ADG increased ($P<0.01$) and feed conversion decreased ($P<0.01$) by 11 and 7%, respectively, when SBM was the source of supplemental DIP (Table 3). We found an increase of 16% in ADG ($P<0.01$) and a decrease of 12% in feed conversion ($P<0.01$) for SBM relative to urea from day 0 to 42 with no differences from day 42 to the end of the feeding period (Table 3). The reason for a response only during the first 42 days may have been due to the undegradable intake protein (UIP) in SBM and its contribution to metabolizable protein (MP). The MP balance (data not shown) for both sources of supplemental DIP was negative at the two lowest levels. The balance was only marginally positive across the three highest levels of urea. Compared to urea, SBM improved ADG and feed conversion at the three highest levels of supplemental protein.

We hypothesized replacing urea with SBM would increase microbial efficiency and MCP flow. We saw no effect of source of supplemental DIP on microbial efficiency or MCP estimates (Table 3). These results are in agreement with research reported in this publication (pp. 28) from a companion metabolism trial, but are in conflict with other reported research results. The conflicting studies were conducted with DRC-based diets. It seems plausible that the higher DIP value for HMC relative to DRC would provide microbes with more true protein decreasing the response to SBM as a supplemental DIP source. Additionally, in the present trial, SBM and urea were compared in corn bran containing diets where risk of acidosis had been reduced. These results are in agreement with the possibility that performance differences were a response to UIP in SBM and not to true protein increasing microbial efficiency.

From day 0 to 42 of the feeding period, ADG ($P<0.01$) and feed efficiency ($P=0.04$) showed a quadratic response to increasing supplemental DIP level (Table 3). The lowest value for feed conversion was at the mid-level which represented 9.1 and 8.8% dietary DIP (DM basis) for the urea and SBM sources, respectively. The problem with using performance to determine when the DIP requirement was met is that performance responses were potentially confounded with UIP supplied by SBM. There was no effect of supplemental DIP level on estimates of MCP flow (Table 3). It is not clear why estimates of MCP did not respond to increasing levels of supplemental DIP. Estimates of MCP across levels of SBM were variable and seem to be the limiting factor in finding an overall effect of level. It is important to remember that SBM replaced HMC in the diet while urea replaced supplement carrier. Increasing levels of SBM may have decreased ruminal available energy limiting the need for DIP. This still argues that increased performance for SBM was a response to UIP, but it does not explain why estimates of MCP were not lower for SBM versus urea. However, if microbial efficiency were calculated based on ruminal available energy, it may have been higher for SBM.

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Influence of Implant Regimen on Performance and Carcass Characteristics in Feedlot Steers

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Summary

A feedlot experiment was conducted to evaluate initial and terminal implant combinations in finishing steers. Implant strategies including Synovex Choice increased average daily gain and rib eye area when compared to strategies including Revalor-IS. Steers implanted initially and terminally with Synovex Choice also had increased performance compared to steers implanted initially and terminally with Revalor-IS; however, performance was not different when comparing Synovex Choice verses Revelor-IS as an initial implant (Revalor-S terminal implant). Marbling was similar across implant strategies, indicating the observed increase in performance with Synovex Choice was achieved without negatively influencing carcass quality.

Introduction

Anabolic implants have been extensively used in the cattle industry to increase gain and protein deposition and to improve feed conversion. Combinations of initial and terminal implants and their effects on animal performance and carcass quality are important to consider when selecting an implant strategy. Ralgro is an estrogenic implant which contains 36 mg zeranol. Revalor-S (24 mg estradiol 17β + 120 mg TBA) and Synovex Plus (28 mg estradiol benzoate + 200 mg TBA) are combination implants. Revalor-IS (16 mg estradiol 17β + 80 mg TBA) and Synovex Choice (14 mg estradiol benzoate and 100 mg TBA) are new combination implants. In this trial six implant strategies were selected to: 1) evaluate the influence of implant strategies in calf-feds during the finishing phase on performance and carcass characteristics and 2) determine the impact of implant strategies on carcass quality changes with additional days on feed.

Procedure

Four hundred eighty crossbred steers (619 lb) were stratified by weight and assigned randomly to one of six treatments in a feedlot trial at the University of Nebraska Agricultural Research and Development Center (Ithaca, NE). Treatments were assigned randomly to pens (4 pens/treatment) with 20 steers/pen. Initial weights were taken on two consecutive days at the beginning of the trial, and initial implants were administered at the initiation of the trial. A series of step-up diets containing 35%, 25%, 15%, and 5% alfalfa hay (DM basis) were fed for 3, 4, 7, and 7 days, respectively with high moisture corn replacing alfalfa. All treatments received the same finishing diet consisting of 10% corn silage, 43.5% high moisture corn, 40% wet corn gluten feed, 3.5% tallow, and 3% supplement, formulated to contain 14.5% CP. Rumensin and Tylan were included in the diet at 30 g/ton and 11 g/ton (DM basis), respectively.

Steers implanted originally with Ralgro were reimplanted on day 63 with their respective terminal implant. Steers implanted with Synovex Choice or Revalor-IS initially were reimplanted with their terminal implants on day 83. Steers were serially slaughtered so 10 steers from each pen were slaughtered after 155 days on feed (early slaughter), while the remaining 10 steers in each pen were slaughtered after 174 days on feed (late slaughter). Serial slaughter was used to evaluate changes in carcass characteristics late in the feeding period and to determine whether these changes are influenced by implant strategy. Feed conversion for the first 155 days on feed (early slaughter group) was calculated using the DMI based on 20 steers per pen. Feed conversion for the late slaughter group (174 days on feed) was calculated using the DMI from 20 steers per pen for the first 155 days plus the DMI of the remaining 10 steers per pen for the final 19 days. Final live weights were recorded for both slaughter groups prior to shipment and were pencil shrunk 4%. Hot carcass weights (HCW) were recorded on the respective slaughter day and were used to calculate gain and feed conversion on a carcass-adjusted basis (HCW adjusted to a 63 common dressing percentage). Carcass fat thickness, rib eye area (REA), and USDA quality and yield grade (YG) were recorded following a 24-hour chill. Yield grade was calculated based on fat thickness, hot carcass weight and rib eye area measurements. Empty body fat (EBF) was calculated using fat thickness, HCW, marbling and

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

	Implant Strategies									Contrasts			
	Choice/ Choice	RevIS/ RevIS	Choice/ RevS	RevIS/ RevS	Ralgro/ RevS	Ralgro/ Syn+	SEM[a]	Implant* Kill	Implant F-test	Choice/ Choice RevIS/ RevIS	RevS Syn+	Choice RevIS	Initial Choice Initial RevIS
Initial BW	619	619	618	620	620	619	<1	0.25	0.48	0.67	0.40	0.30	0.06
DMI	20.8	20.6	20.9	20.5	20.5	20.7	0.2	0.99	0.35	0.33	0.70	0.06	0.10
Live Performance													
Final BW[b]	1224	1202	1216	1207	1187	1212	7	0.56	0.01	0.02	0.01	0.02	0.30
ADG	3.67	3.55	3.64	3.57	3.46	3.61	0.04	0.64	0.01	0.03	0.01	0.02	0.21
F:G	5.74	5.84	5.79	5.81	6.03	5.79	0.07	0.71	0.07	0.28	0.02	0.37	0.86
Carcass Performance													
Final BW[c]	1254	1228	1241	1236	1218	1246	7	0.27	0.01	0.01	0.01	0.03	0.59
ADG	3.85	3.70	3.79	3.74	3.64	3.81	0.04	0.37	0.01	0.01	0.01	0.02	0.43
F:G	5.44	5.60	5.57	5.54	5.73	5.49	0.06	0.31	0.05	0.09	0.01	0.32	0.73
Carcass Characteristics													
HCW	790	774	782	779	768	785	4	0.27	0.01	0.01	0.01	0.03	0.59
Fat (in)	0.58	0.59	0.61	0.59	0.62	0.58	0.02	0.99	0.65	0.64	0.17	0.86	0.47
Marbling[d]	517	520	518	508	519	524	9	0.29	0.86	0.85	0.69	0.67	0.43
REA (sq in)	13.1	12.7	13.1	13.0	12.8	13.0	0.1	0.82	0.24	0.06	0.18	0.10	0.68
REA-100lb HCW	1.66	1.65	1.68	1.67	1.67	1.67	0.02	0.98	0.93	0.60	0.93	0.69	0.97
YG[e]	3.16	3.25	3.19	3.18	3.27	3.13	0.08	0.99	0.82	0.43	0.23	0.64	0.89
YG1	5.0	2.6	1.6	3.8	3.9	1.4	2.2	0.81	0.84	0.45	0.43	0.95	0.50
YG2	33.8	33.8	34.8	31.9	35.9	46.0	6.7	0.98	0.72	1.00	0.29	0.83	0.76
YG3	55.6	50.9	51.0	56.9	46.0	44.6	5.9	0.93	0.63	0.57	0.87	0.92	0.49
YG4	4.0	11.5	12.9	7.5	13.0	5.5	3.1	0.48	0.20	0.10	0.10	0.74	0.23
YG5	1.6	1.3	0	0	1.3	2.6	1.2	0.64	0.66	0.83	0.44	0.88	1.00
EBF, %[f]	30.13	30.36	30.36	30.15	30.55	30.06	0.32	0.96	0.89	0.62	0.29	0.98	0.64
Choice[g]	62.9	61.3	64.9	63.0	62.0	68.1	6.5	0.55	0.98	0.86	0.52	0.79	0.84
Select[h]	37.3	37.8	35.1	37.0	38.0	32.0	6.5	0.55	0.98	0.87	0.52	0.80	0.84

[a]Standard error of the mean
[b]Final weight = live weight * 0.96
[c]Final weight = hot carcass weight/0.63 common dressing percentage
[d]Marbling score: 450 = Slight 50; 500 = Small 0; 550 = Small 50; 600 = Modest 0; etc.
[e]Calculated Yield Grade = 2.5 + 2.5(FT) + 0.2(%KPH) + 0.0038* HCW - (0.32 *REA). %KPH was not measured but assumed to be 2% for all steers.
[f]Empty Body Fat calculated from Guiroy et al., 2002 (*J. Anim. Sci*): EBF = 17.76207 + (4.68142*Fat) + (0.01945*HCW) + (0.81855 * QG) - (0.06754 * REA)
[g]Choice and above
[h]Select and below

REA from Guiroy et al., 2002 (*J. Anim. Sci.*).

Treatments were analyzed in a 2 x 6 factorial with implant strategy (Choice/Choice, Revalor-IS/Revalor-IS, Choice/Revalor-IS, Revalor-IS/Revalor-S, Ralgro-Revalor-S, and Ragro/Synovex Plus) and slaughter time (early slaughter and late slaughter) as factors. Contrasts were constructed to compare specific implant strategies including: 1) Choice/Choice vs. Revalor-IS/Revalor-IS, 2) Ralgro/Revalor-S vs. Ralgro/Synovex Plus, 3) Choice vs. Revalor-IS, and 4) initial Choice vs. initial Revalor-IS. Interaction between implant strategy and slaughter time was tested first for all variables. Main effects are presented when the interaction was not significant.

Results

There was no significant interaction between implant strategy and slaughter time for any of the performance or carcass variables; therefore, main effects of implant strategy on performance and carcass characteristics are shown in Table 1. ADG and final weight were different for the six implant strategies ($P < 0.05$) on a live as well as a carcass basis. Steers in the Choice/Choice implant strategy had higher final weights and ADG than steers implanted with Revalor-IS/Revalor-IS. Feed conversion was improved (carcass adjusted basis) for Choice/Choice compared to Revalor-IS/Revalor-IS ($P = 0.09$), presumably related to hormone levels. Steers implanted with Choice/Choice also had larger REA than steers implanted with Revalor-IS/Revalor-IS ($P = 0.06$). Ralgro/Synovex Plus steers gained more than Ralgro/Revalor-S steers and had heavier final and carcass weights ($P < 0.05$). Treatments including Choice had higher ADG and increased final weights (live and carcass). REA tended to be larger for steers implanted with Choice compared to treatments that included Revalor-IS ($P = 0.09$). Comparing Choice and Revalor-IS as initial implants (Revalor-S terminal implant), however, showed no differences in performance between the two implants. Fat thickness and marbling were not different for any of the treatments. Steers were fed to the same end-point as indicated by

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similar empty body fat and calculated yield grade among treatments.

The main effect of slaughter time is shown in Table 2. Initial weight and dry matter intake were not different for the early and late slaughter group. Based on live performance, steers in the late slaughter group were 63 lb heavier than steers in the early group ($P < 0.05$); however, live ADG and feed conversion were not different for the early and late slaughter groups. Based on the carcass adjusted final weight (HCW divided by 0.63), steers in the late group weighed 84 lb more than steers in the early group and hot carcass weight increased by 53 lb for the late verses early slaughter group ($P < 0.05$). ADG was improved for the late slaughter group on a carcass adjusted basis ($P < 0.05$) compared to the early slaughter group as more of the gain was deposited on the carcass late in the finishing period. Feed conversion (carcass adjusted basis) also was improved for the late slaughter group compared to the early group ($P = 0.06$) as a result of an increase in dressing percentage with additional days on feed from 64.0% in the early slaughter to 64.9% in the late slaughter group ($P < 0.01$).

REA tended to be greater for the late group than the early group ($P = 0.08$). Calculated YG was greater for steers in the late slaughter group than steers in the early group as a result of increased HCW and fat thickness. EBF was also greater for the late slaughter group than the early slaughter group; however, both groups were above 28% EBF which is the predicted EBF to reach low Choice quality grade. Interestingly, the early slaughter group tended to have a greater percentage of carcasses grading Choice than the late group — 68% and 60%, respectively ($P = 0.12$).

Table 2. Effect of slaughter time (days on feed) on performance and carcass characteristics in finishing steers for the entire feeding period.

	Slaughter Time			Slaughter
	Early	Late	SEM[a]	P-value
Days on feed	155	174	–	–
Initial BW	619	620	<1	0.21
DMI	20.6	20.7	0.1	0.61
Live Performance				
Final BW[b]	1176	1240	4	<0.01
ADG	3.59	3.57	0.02	0.44
F:G	5.81	5.86	0.04	0.33
Carcass Performance				
Final BW[c]	1195	1280	4	<0.01
ADG	3.72	3.79	0.02	0.04
F:G	5.62	5.51	0.04	0.05
Carcass Characteristics				
Dressing %	64.0	64.9	0.1	<0.01
HCW	753	806	3	<0.01
Fat (in)	0.57	0.62	0.01	0.01
Marbling[d]	521	515	5	0.45
REA (sq in)	12.8	13.0	0.1	0.08
REA-100 lb HCW	1.71	1.62	0.01	<0.01
YG[e]	3.07	3.32	0.05	<0.01
YG1	5.7	0.4	1.3	<0.01
YG2	40.0	32.0	3.9	0.15
YG3	47.0	54.7	3.4	0.12
YG4	6.5	11.6	1.8	0.06
YG5	0.8	1.4	0.7	0.57
EBF, %[f]	29.82	30.71	0.19	<0.01
Choice[g]	68.5	58.8	3.8	0.08
Select[h]	31.5	41.3	3.7	0.08

[a]Standard error of the mean
[b]Final weight = live weight * 0.96
[c]Final weight = hot carcass weight/0.63 common dressing percentage
[d]Marbling score: 450 = Slight 50; 500 = Small 0; 550 = Small 50; 600 = Modest 0; etc.
[e]Calculated Yield Grade = 2.5 + 2.5(FT) + 0.2(%KPH) + 0.0038* HCW - (0.32 *REA). %KPH was not measured but assumed to be 2% for all steers.
[f]Empty Body Fat calculated from Guiroy et al., 2002 (*J. Anim. Sci.*). EBF = 17.76207 + (4.68142*Fat) + (0.01945*HCW) + (0.81855 * QG) - (0.06754 * REA)
[g]Choice and above
[h]Select and below

Changes in carcass characteristics late in the finishing period were not influenced by implant strategy. Rate of REA change during the final 19 days was 0.01 sq in/day ± 0.03 across all implant strategies. The rate of fat deposition (fat thickness) was 0.0025 in/day ± 0.0037. Rate of yield grade change (0.0129/day ± 0.0159) was also similar across all implant strategies. Empty body fat increased 0.0451%/day ± 0.0626 with additional days on feed as a result of increased fat thickness and HCW. Despite the increase in fat thickness, quality as indicated by marbling did not increase with additional days on feed. Intramuscular fat still may have been increasing late in the finishing period but perhaps at a slower rate than the increase in REA. Clearly, any increases in intramuscular fat deposition were not great enough to change the overall marbling score.

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Delayed Implanting Improves Quality Grade in Steer Calves

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Summary

One hundred steer calves were used to evaluate the effect of delaying initial implanting on feedlot and carcass characteristics. One-half the steers were implanted with Synovex S® after a 14 day acclimation period, the remainder were implanted 30 days after the 14 day acclimation period. All calves were re-implanted 112 days after the beginning of the study with Synovex Choice® and harvested 100 days later. Neither final weight (1269 lb) nor ADG (3.74 lb/day) were affected by implant regimen. Delayed implant steers had a higher percentage grading Choice (92 vs 68%). Delaying implanting resulted in a 24% increase in cattle grading Choice at harvest without compromising feedlot performance.

Introduction

A common perception is feedlot cattle have to be fed for a certain length of time before they will grade Choice, suggesting marbling develops late in the feeding period. However, it appears management factors early in an animal's life can impact the development of marbling. Hypertrophy of adipocytes begins after 100 to 200 days of age (Vernon, R.G., 1980, Prog. Lipid Res. 19:23). Additionally, the age lipogenesis and adipocyte growth occurs is highly related to the age cattle are started on a high concentrate diet. Number of days on a high concentrate diet and a proprionate fermentation are likely major determining factors (Fluharty, F.L., http://beef.osu.edu/library/mgtdiet.html). Early weaned calves fed a high concentrate ration tend to grade better than later weaned calves. Numerous reports have also demonstrated calves treated for respiratory disease have lower final quality grades and this respiratory illness generally occurs early in the feeding period. Implanting with a low dose initial implant or delaying implanting has been shown to improve quality grade as well. Many of these studies have been conducted with yearling cattle or with calves receiving a single delayed implant. The objective of this study was to determine if delaying the initial feedlot implant would influence feedlot and carcass characteristics in steer calves implanted twice during the finishing period.

Procedure

One hundred crossbred (5/8 Red Angus, 3/8 Continental) steer calves (454 lb) from the Gudmundsen Sandhills Laboratory were transported to the feedlot at the West Central Research and Extension Center, North Platte, NE, in late September. Cattle were dewormed and immunized against Clostridial diseases, Haemophilus sominus, bovine rhinotracheitis, parainfluenza, and respiratory syncytial virus. Steers were acclimated together on a receiving ration for 14 days and then allotted to implant and antibiotic treatment by body weight. One-half the steers were implanted with Synovex S® after the acclimation period (day 0) and then divided into two pens and received identical diets without antibiotic for an additional 20 days. They were then fed either Rumensin®/Tylan® or Bovatec®/Terramycin® for the remainder of the feeding period. Equal numbers of animals from each implant treatment were represented in each pen. Thirty days after the acclimation period, the other half of the steers were implanted with Synovex S®. All calves were re-implanted on the same day (112) with a terminal implant (Synovex Choice®) and harvested on the same day (212).

The receiving diet consisted of 20% corn, 40% wet corn gluten feed, 35% ground alfalfa hay and 5% supplement. Steers were gradually (50 days) stepped up to the final finishing diet (Table 1) consisting of 48% corn, 40% wet corn gluten feed, 7% ground alfalfa hay and 5% supplement. Basal supplements are presented in Table 1, and also provided (gram/ton ration dry matter) either Rumensin® (28) and Tylan® (10) or Bovatec® (28) and Terramycin® (7.5).

Initial weights were the average of two consecutive early morning weights taken before feeding.

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Interim body weights were taken at the time the second group received their first implant (30 days), at re-implant (112 days), and near harvest (203 days). Final weights were calculated using hot carcass weight adjusted to a common dressing percentage (63). This adjusted final weight was also used to calculate ADG. Steers were harvested (May 10) at a commercial packing plant and carcass characteristics were determined following a 24-hour chill. Carcass measurements included hot carcass weight, marbling score, KPH fat, 12th rib fat thickness, and ribeye area.

Table 1. Finishing diet and ingredient composition.

Item	% of Dry Matter
Corn	48
Wet corn gluten feed	40
Alfalfa Hay	7
Supplement	5
Supplement	
Corn	58.25
Limestone	29.60
Salt	5.60
Ammonium Chloride	4.65
Trace Mineral Premix	.93
Thiamine	.238
Vitamin Premix	.214

Table 2. Effect of implant strategy on feedlot and carcass characteristics of steer calves.

Item	Delayed	Not Delayed	SEM	P-value
Initial BW, lb	475	477	6.63	.76
30 day BW, lb	591	618	7.36	.01
Re-Implant BW, lb	914	930	10.7	.27
Final BW, lb	1266	1273	14.6	.73
ADG	3.73	3.75	.05	.73
HCWT	797	802	9.2	.73
Ribeye area, sq.in.	12.85	12.73	.18	.63
Fat thickness, in.	.48	.49	.02	.69
KPH[a]fat, %	2.84	2.84	.05	.96
Yield grade	3.18	3.26	.09	.49
Marbling score[b]	570	527	13.00	.02
Choice, %	92	68	.06	.004

[a]KPH=kidney, pelvic and heart.
[b]500=small 0

Results

The effects of delaying initial implant on feedlot and carcass characteristics are presented in Table 2. Steers receiving a delayed initial implant were lighter (P<0.01) at the time of their first implant, but had reached similar live weights at the time of terminal implant. Final body weight and carcass weights were not different (P>0.10) between the two treatments. Carcass characteristics were similar between the two treatments with the exception of marbling score and percentage of animals grading Choice. Delaying implanting improved marbling score (Table 2) and increased the percentage grading choice (92 vs 68% for delayed and not delayed, respectively). The type of antibiotic regimen (Rumensin®/Tylan® vs Bovatec®/Terramycin®) had no effect on any characteristics measured. There was also no implant x antibiotic interaction for any feedlot or carcass trait measured.

Delaying the administration of Synovex S® until 30 days on feed improved marbling score and percentage of steers grading Choice and did not compromise feedlot (although feed intake was not determined) or carcass characteristics.

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Basis Variability on the Feeder Cattle Contract Versus the Failed Stocker Contract

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Summary

Basis variability was compared in 10 markets for 550 and 750 pound steers using the Chicago Mercantile Exchange (CME) stocker and feeder indexes as a proxy for futures prices. Basis variability for 550 pound steers was significantly greater than basis variability for 750 pound steers. As market volume decreased and as volume variability increased, basis variability also increased. The failed CME stocker contract never attracted enough volume to remain a viable contract. One possible explanation for this contract failure is the basis risk associated with it was large enough to discourage producers from using the contract to hedge calves.

Introduction

The Chicago Mercantile Exchange (CME) first introduced a feeder cattle contract in 1971. It was a deliverable contract for 600-800 lb steers. On Sept. 1, 1986, the contract changed to a cash-settled contract using the U.S. Feeder Steer Price for a settlement. Beginning Jan. 1, 1993 the settlement price was changed to the CME Composite Weighted Average Price for feeder steers. This index had a different regionally and volume-weighted scheme and the weight range was narrowed to 700-800 pounds. In November 1998, the CME introduced a new cash settled stocker contract for 500-600 pound steers. The weight range for feeder cattle was also increased to 700-849 pounds. Each of these changes was designed to reduce hedging risk by reducing basis variability, and thus, to improve the ability of producers to hedge feeder cattle and stocker cattle.

Feeder cattle prices, and hence basis, varies with cattle type, lot characteristics and location. Producers need to consider these factors when estimating their basis. However, there still remains variability in prices due to volume, or more likely lack of volume, in a particular weight class or in some cases for an entire market. The volume of stocker cattle being traded is quite seasonal in most markets. Feeder cattle volume may also fluctuate seasonally, but generally will not be as extreme as stocker volume. The overall objective of this paper is to analyze stocker and feeder cattle basis variability as a function of the volume of stocker or feeder cattle being sold. Specific objectives are: 1) to compare basis variability across markets, over time, and between stocker (550 lb) and feeder (750 lb) cattle; and 2) to analyze basis variability as a function of market volume and price level.

Procedure

Feeder cattle auction market price and volume data were obtained from January 1993 until September 2001 from the CME for the following markets: Ada, OK; Billings, MT; Clovis, NM; Dodge City, KS; Kearney, NE; La Junta, CO; St. Joseph, MO; Torrington, WY; Vienna, MO; and West Fargo, ND. These auctions contribute to the CME stocker and feeder indexes, occur on Wednesday, and represent a broad range of overall auction volume. Weekly basis was determined for each weight category and market by subtracting the CME stocker index and feeder index from the market price for 500-600 and 700-800 lb steers, respectively.

Basis variability was compared across markets and within markets between the two weight classes. The mean and standard deviation of volume for each market and weight class also were determined. As volume varies considerably throughout the year for some markets and weight classes, the mean and standard deviation of volume were determined on a quarterly basis in addition to the overall mean and standard deviation.

A 10-week rolling average for basis and volume in each market and weight class and the corresponding standard deviation for basis and volume were calculated. The following equation was then estimated for each market and for each weight class using Ordinary Least Squares regression:

$$SDBasis_{ij} = \beta_o + \beta_1 Cash_{ij} + \beta_2 Volume_{ij} + \beta_3 SDVolume_{ij} + \beta_4 SDWeight + \beta_5 Contract + \varepsilon$$

Where $SDBasis_{ij}$ is the 10-week standard deviation of basis;

Cash is the 10-week rolling average cash price;

Volume is the 10-week rolling average number of head sold;

SDVolume is the 10-week standard deviation of volume;

SDWeight is the 10-week standard deviation of the average weight;

Contract is a 0/1 dummy equal to 1 if the week is in a contract month;

I is the market (Ada, Billings, Clovis, Dodge City, Kearney, La Junta, St. Joseph, Torrington, Vienna, and West Fargo); and

j is the weight class (500-599 and 700-799 lb).

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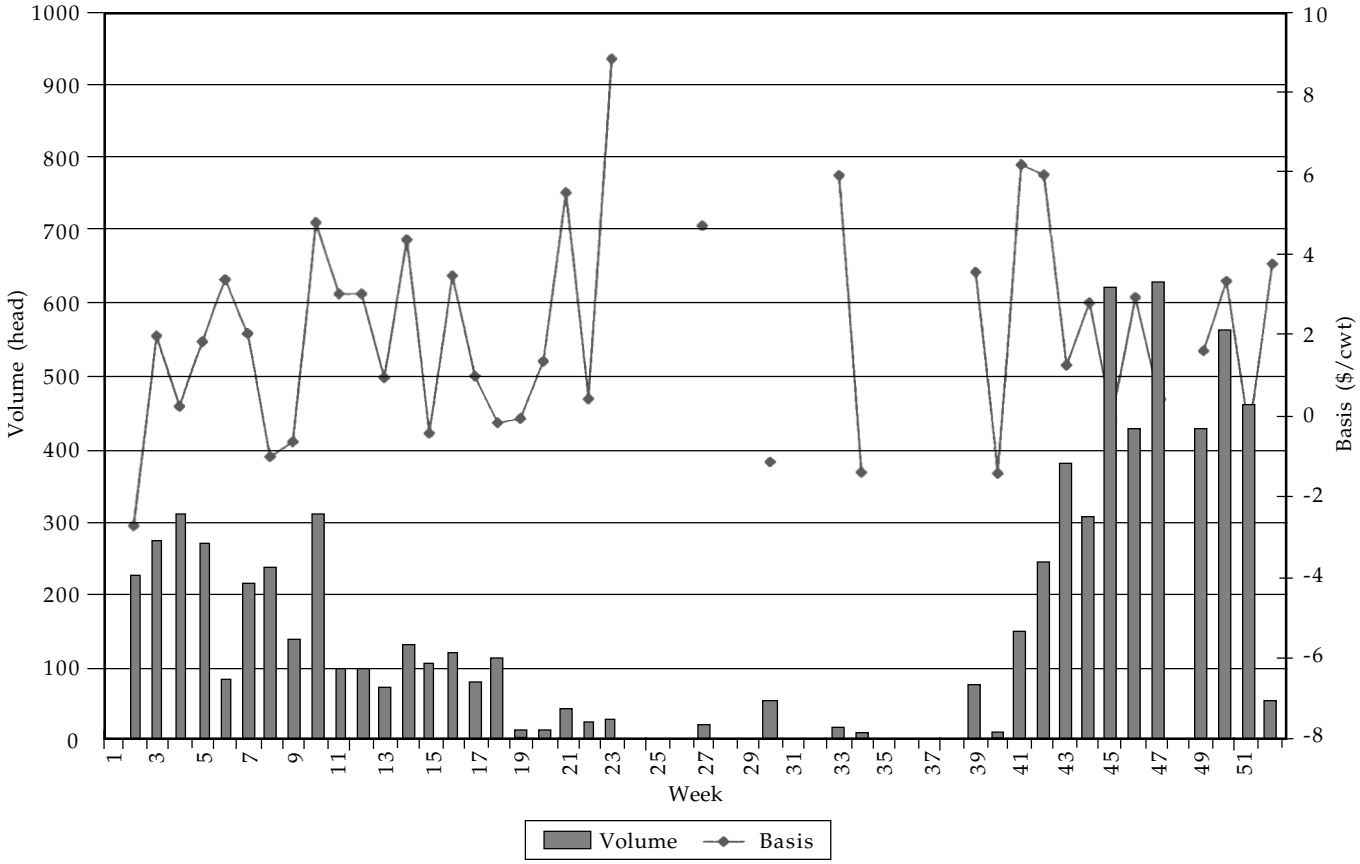

Figure 1. Weekly stocker basis and weekly volume for one market and year.

Results

Samples of the data for one year and one specific market are displayed in Figures 1 and 2. It is apparent that volume varies seasonally for both stocker and feeder cattle and that there is considerable variability in basis week to week. Plots of each market and year would show similarities and differences. The similarities are variability in volume and basis, and differences are in the magnitudes of the variability and the seasonal patterns.

Summary statistics on basis and volume for each market for stocker and feeder cattle are presented in Table 1. In all 10 markets, stocker basis variability exceeded feeder basis variability ($P < 0.05$). There is more risk to producers who hedge stocker cattle than to producers who hedge feeder cattle. Basis variability also differed significantly

Table 1. Basis and volume mean and standard deviation (bottom number) for stocker and feeder cattle in ten different markets from Jan. 1993 to Sep. 2001.

	Stocker		Feeder	
Market	Basis ($/cwt.)	Volume (head)	Basis ($/cwt.)	Volume (head)
Ada, OK	-0.99	136.27	-0.94	41.17
	3.2487[ef]	73.3676	2.1291[bc]	38.1525
Billings, MT	0.54	76.01	-0.95	42.86
	3.6607[g]	90.6556	2.3073[cd]	54.1965
Clovis, NM	-1.98	55.91	-3.01	68.45
	3.5674[fg]	47.6163	2.4311[d]	72.7774
Dodge City, KS	-0.73	122.76	0.27	122.76
	3.3424[efg]	117.0532	1.6609[a]	117.0532
Kearney, NE	2.99	180.53	1.98	374.76
	3.4671[fg]	179.3316	1.6382[a]	317.9758
La Junta, CO	1.39	223.04	-0.69	200.45
	4.1110[h]	220.7821	2.3391[cd]	192.8533
St Joseph, MO	-0.16	154.42	0.61	207.08
	4.1148[h]	158.9697	1.9363[b]	158.4756
Torrington, WY	3.90	396.50	1.58	451.02
	3.1142[e]	309.7550	2.0775[b]	315.3478
Vienna, MO	-2.05	56.61	-1.35	22.75
	3.5661[fg]	40.2587	2.4287[d]	29.6083
W Fargo, ND	-0.19	97.51	0.29	227.14
	3.2935[ef]	106.2327	2.0635[b]	231.0242

Note: Increasing superscripts (a-h) denotes that basis variability is significantly greater at the 0.05 level of confidence.

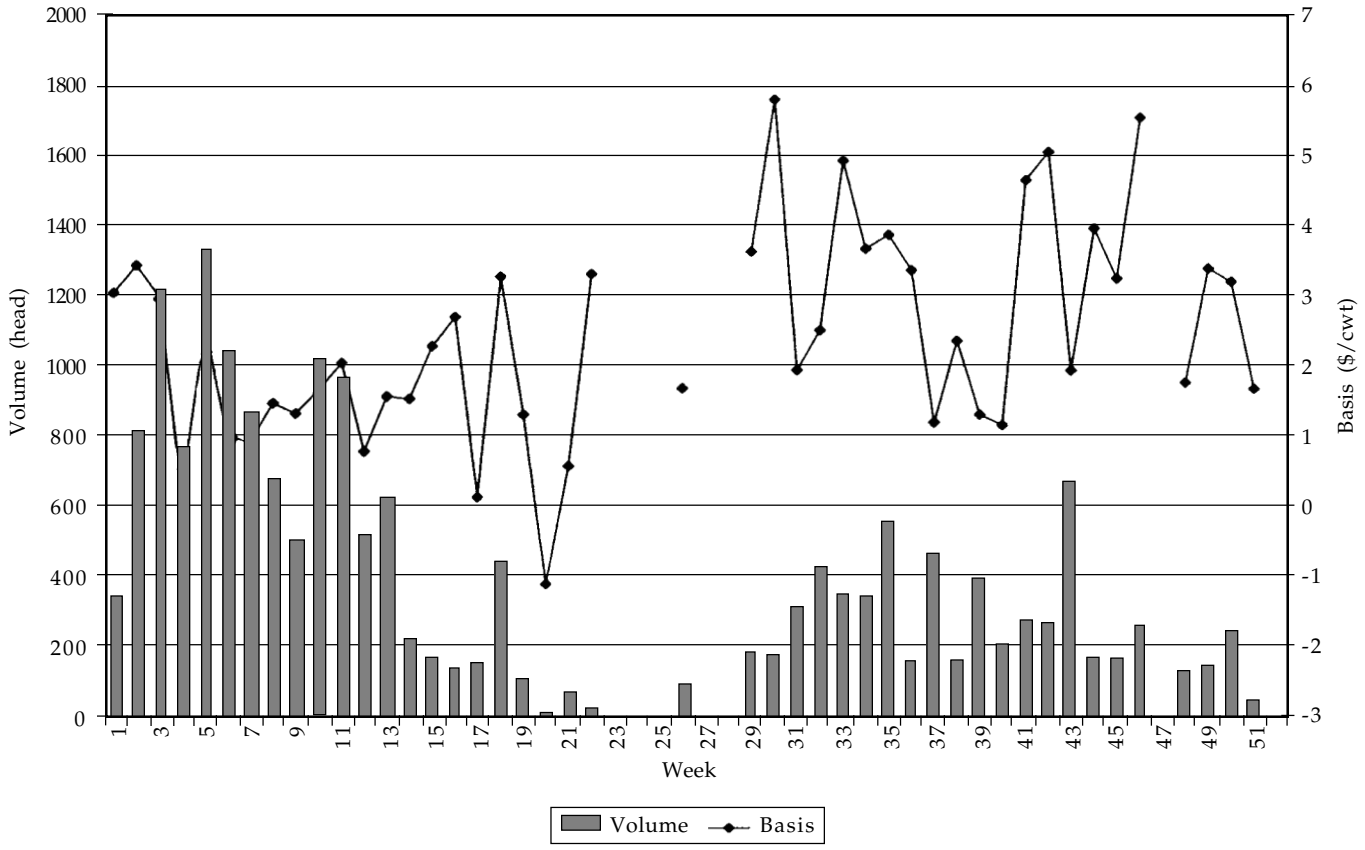

Figure 2. Weekly feeder basis and weekly volume for one market and year.

across markets. Dodge City, KS and Kearney, NE had the least amount of basis variability for feeder cattle. Clovis, NM and Vienna, MO had the greatest amount of basis variability for feeder cattle. However, feeder basis variability in these two markets is still significantly less than stocker basis variability in Torrington, WY, the least variable stocker market. La Junta, CO and St. Joseph, MO, have the greatest amount of stocker basis variability.

Torrington, WY, had the largest average stocker volume which may explain the reduction in basis variability, but this market also has the greatest variability in stocker volume. The two stocker markets with the smallest average weekly volume, Clovis and Vienna, had basis variability in the mid range of all 10 markets. Basis variability for the feeder markets also appears to be related to the level of volume. Clovis and Vienna are two of the smaller markets and they had the greatest feeder basis variability. Kearney is one of the larger markets with the smallest feeder basis variability.

Results of the regression equation to explain basis variability are displayed in Table 2 for stocker cattle and Table 3 for feeder cattle. The adjusted R^2 values ranged from 0.13 to 0.36 for stocker cattle and from 0.09 to 0.34 for feeder cattle.

The cash variable was significant and positive in nine out of 10 markets for stocker cattle. The implication is that as the cash market level increases, basis variability increases. Volume was significant and negative in eight markets and standard deviation of volume was significant and positive in seven stocker markets. This would substantiate our hypothesis that as the level of volume increases, basis variability decreases but as volume variability increases, basis variability also increases. Increases in weight variability led to a significant increase in basis variability in seven markets, as we hypothesized. Basis variability decreased significantly for a stocker contract month in only two markets. Basis variability actually increased significantly for a contract month for one market. The implications are that the effect of contract month on stocker basis variability is inconclusive.

Feeder cattle basis variability increased significantly with a higher cash price level in eight of ten feeder cattle markets. An increase in volume decreased basis variability in six markets while an increase in volume variability only significantly increased basis variability in half of the markets. Basis

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Table 2. Results of regression of selected independent variables on the standard deviation of basis against the CME stocker contract for ten different markets. Standard errors of the estimated coefficients are in parentheses.

	Ada	Billings	Clovis	Dodge City	Kearney	La Junta	St Joseph	Torrington	Vienna	W Fargo
Intercept	-0.717	1.990*	1.055*	0.275	-0.195	0.122	3.116*	-1.704*	0.236	0.884*
	(0.3860)	(0.5827)	(0.4290)	(0.4627)	(0.4342)	(0.7989)	(0.7594)	(0.4695)	(0.3101)	(0.4124)
Cash	0.029*	0.010*	0.023*	0.019*	0.036*	0.028*	0.001	0.053*	0.028*	0.018*
	(0.0032)	(0.0052)	(0.0039)	(0.0040)	(0.0039)	(0.0070)	(0.0077)	(0.0045)	(0.0028)	(0.0043)
Volume	-0.000	-0.016*	-0.009*	-0.008*	-0.004*	-0.006*	-0.002	-0.003*	-0.016*	-0.004*
	(0.0010)	(0.0037)	(0.0041)	(0.0023)	(0.0009)	(0.0015)	(0.0024)	(0.0006)	(0.0038)	(0.0014)
SDVolume	0.001	0.011*	-0.006	0.007*	0.003*	0.005*	-0.005*	0.002*	0.008*	0.009*
	(0.0026)	(0.0042)	(0.0041)	(0.0022)	(0.0013)	(0.0018)	(0.0031)	(0.0008)	(0.0030)	(0.0018)
SDWeight	0.030*	0.033*	0.054*	0.074*	0.013	0.043*	0.049	-0.017	0.057*	0.022*
	(0.0148)	(0.0099)	(0.0115)	(0.0121)	(0.0081)	(0.0179)	(0.0260)	(0.0092)	(0.0106)	(0.0079)
Contract	0.080	-0.048	0.148	0.225	-0.468*	0.938*	-0.232	0.267	0.098	-0.705
	(0.0790)	(0.1653)	(0.1275)	(0.1518)	(0.1745)	(0.2812)	(0.3339)	(0.1688)	(0.0755)	(0.1592)
Adj R^2	0.17	0.20	0.22	0.27	0.36	0.13	0.14	0.35	0.30	0.20

Note: An asterisk denotes the coefficient is significant at the 0.05 level.

Table 3. Results of regression of selected independent variables on the standard deviation of basis against the CME feeder contract for ten different markets. Standard errors of the estimated coefficients are in parentheses.

	Ada	Billings	Clovis	Dodge City	Kearney	La Junta	St Joseph	Torrington	Vienna	W Fargo
Intercept	1.178*	-1.973*	0.562*	0.551*	0.451*	3.124*	0.378	1.816*	-0.614	-0.613*
	(0.2600)	(0.3982)	(0.2484)	(0.2435)	(0.2170)	(0.3552)	(0.3252)	(0.4386)	(.3279)	(0.2638)
Cash	0.008*	0.044*	0.014*	0.012*	0.007*	-0.012*	0.013*	0.006	0.029*	0.028*
	(0.0029)	(0.0050)	(0.0033)	(0.0029)	(0.0027)	(0.0043)	(0.0034)	(0.0045)	(0.0040)	(0.0030)
Volume	-0.013*	-0.008*	-0.004*	0.001	-0.001*	-0.003*	-0.001	-0.002*	0.003	-0.000
	(0.0027)	(0.0035)	(0.0015)	(0.0008)	(0.0002)	(0.0008)	(0.0006)	(0.0002)	(0.0060)	(0.0004)
SDVolume	0.015*	0.007*	0.004*	-0.003*	0.002*	0.000	-0.002*	0.001*	-0.002	-0.000
	(0.0026)	(0.0026)	(0.0017)	(0.0010)	(0.0004)	(0.0010)	(0.0008)	(0.0004)	(0.0042)	(0.0006)
SDWeight	-0.004	0.022*	0.025*	0.004	0.030*	0.016*	0.036*	-0.005	0.016*	0.022*
	(0.0042)	(0.0047)	(0.0050)	(0.0066)	(0.0045)	(0.0046)	(0.0065)	(0.0059)	(0.0042)	(0.0041)
Contract	0.025	-0.053	-0.246*	-0.110*	-0.337*	0.010	0.021	-0.107	-0.005	-0.236*
	(0.0545)	(0.1011)	(0.0609)	(0.0551)	(0.0520)	(0.0904)	(0.0659)	(0.0916)	(0.0756)	(0.0616)
Adj R^2	0.09	0.22	0.17	0.09	0.34	0.19	0.31	0.15	0.12	0.33

Note: An asterisk denotes the coefficient is significant at the 0.05 level.

variability increased as weight variability increased in seven of the feeder cattle markets. Basis variability during feeder cattle contract months decreased in four of the markets.

Compared to stocker cattle, feeder cattle basis variability appears to be a little less sensitive to volume in some markets. This does not appear to be related to the size of the market.

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Effect of Wet and Dry Distillers Grains Plus Solubles and Supplemental Fat Level on Performance of Yearling Finishing Cattle

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Summary

Two finishing trials were conducted to compare the addition of fat from either wet or dry distillers byproducts (WDGS; DDGS) to that provided from one of two commercially available fat sources (corn oil, Trial 1; tallow, Trial 2). In Trial 1, feed conversion and ADG decreased linearly as level of corn oil increased, while feed conversion and ADG were improved numerically as the level of WDGS increased in the diet. In Trial 2, no differences in performance were observed comparing cattle fed dry distillers grains plus solubles to cattle fed diets containing tallow. WDGS provided 12 and 17% more net energy for gain when fed at 20 and 40% of the diet compared to a dry rolled/high moisture corn mix.

Introduction

Ethanol production in the United States has expanded over the past few decades. A recent USDA report indicated that U.S. ethanol production has grown from just a few million gallons in the mid-1970s to over 1.8 billion gallons in 2002. Corn dry milling is the primary mechanism for producing fuel ethanol; however, ethanol can be produced from the dry milling of other cereal grains (sorghum, wheat, etc.) or from wet milling corn. About 2/3 of the grain being milled is recovered as ethanol or carbon dioxide (i.e, the starch); the other 1/3 is referred to as distillers byproducts. Therefore, nutrients within distillers byproducts are concentrated three-fold compared to the cereal grain from which it was produced.

In past research trials, distillers byproducts have shown a higher energy value than dry-rolled corn (1994 Nebraska Beef Report, pp. 38-40; 1996 Nebraska Beef Report, pp. 63-64). However, at this point it is unclear why the energy value of distillers byproducts is higher. Possibilities include: higher fat and protein content of distillers byproducts, less subacute acidosis, or overall increased energy utilization.

The objectives of these research trials were to determine if the additional energy provided from distillers byproducts when replacing corn in finishing diets is related to the higher fat content of the byproducts or their ability to minimize subacute acidosis.

Procedure

Trial 1

Sixty crossbred yearling heifers (765 lb) were individually fed one of six treatment diets in a 2 x 3 factorial design. Factors consisted of two sources of additional fat and level of fat (Table 1). Supplemental fat was provided at 0, 2.5, or 5% of diet DM from either corn oil or wet distillers grain plus solubles (WDGS) (0, 20, or 40% of diet DM). Alfalfa hay was included in all diets at 7.5% of diet DM, and high-moisture corn and dry-rolled corn were fed at a 1:1 ratio (DM-basis). Dietary treatments consisted of 0% WDGS (0DG), 20% WDGS (20DG), 40% WDGS (40DG), 0% corn oil (0FAT), 2.5% corn oil (2.5FAT), or 5% corn oil (5FAT). The 20DG and 2.5FAT diets as well as the 40DG and 5FAT diets were formulated to contain the same amount of ether extract (EE), as well as to ensure that all diets met or exceeded the metabolizable protein requirements of the heifers. Initial weights were based on a 5-day limit fed weight, where heifers were fed a 50% alfalfa hay:50% wet corn gluten feed diet (DM basis) at 2% of body weight, with weights taken for three consecutive days. Dietary adaptation consisted of limit feeding, DM offered increased 0.50 lb/day from 12 lb/day DM (1.6% BW) until ad libitum intakes were achieved (~21 days). Heifers were weighed every 28 days, and were implanted on day 28 with Synovex-Plus®. Heifers were slaughtered on day 113 at a commercial packing plant (IBP, West Point, NE), and livers were scored and hot carcass weights were recorded. Fat thickness, ribeye area, USDA called yield grade and marbling score were recorded after a 24- hour chill. Performance was

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calculated based on hot carcass weights adjusted to a common dressing percentage (62% for heifers). Net energy for gain (NE_g) for the diets and ingredients were calculated based on animal performance inputs (Owens et al., 2002, in J. Anim. Sci. 80(Suppl.1):273 (Abstr.).

Corn distillers grains and distillers solubles were produced at a commercial ethanol plant (Abengoa Bioenergy, York, NE). Distillers grains and distillers solubles were brought in separately and fed at a 65:35 ratio (DM basis) to provide a constant ratio.

Trial 2

Two hundred thirty-four crossbred yearling steers (775 lb) were utilized in 2 x 2 plus 1 experimental design. Factors consisted of source; dry distillers grains plus solubles (DDGS) and tallow, and level of fat source; zero, medium, and high. Dietary treatments (Table 1) consisted of zero tallow/zero DDGS (CON), 20% DDGS (20DG), 1.3% tallow (1.3TAL), 40% DDGS (40DG), and 2.6% tallow, with tallow or DDGS replacing corn. Wet corn gluten feed (WCGF; Sweet Bran®, Cargill Corn Milling, Blair, NE) a product of the corn wet-milling industry was included in all diets at 20% of diet DM to minimize subacute acidosis. The 20DG and 1.3TAL diets as well as the 40DG and 2.6TAL diets were formulated to provide the same amount of fat. Steers were weighed for two consecutive days prior to the initiation of the trial following a 5-d limit feeding period. Steers were stratified by weight and assigned randomly to pen (9-10 steers/pen; 9 steers rep 1, 10 steers rep 2-4), pen was then assigned randomly to treatment, with a total of 24 pens (4 pens for the TAL and DG diets and 8 pens for the CON diet). Steers were adapted to the finishing diet utilizing four diets where corn silage replaced high-moisture corn or DDGS at levels decreasing by 10% for 3, 4, 7, and 7 days, respectively. Steers were implanted with Revelor-S® on day 21 and slaughtered on day 118 at IBP (West Point, NE) on which hot carcass weights and liver abscess scores were recorded. Fat thickness, ribeye area and USDA called marbling score were taken after a 24 hour chill. Performance was calculated based on hot carcass weights adjusted to a common dressing percentage of 63, since this trial utilized steers.

The NE_g values for the diets, as well as, the DDGS were calculated similar to that in Trial 1. Corn DDGS were produced at a commercial ethanol plant (Abengoa Bioenergy, York, Neb.) and were received at the research facility on an as-needed basis.

Table 1. Diets for wet and dry distillers byproducts finishing trials (values presented as a percentage of dietary DM).

Trial 1

	0DG	0FAT	20DG	2.5FAT	40DG	5FAT
High-Moisture Corn	43.75	43.75	33.75	42.5	23.75	41.25
Dry-Rolled Corn	43.75	43.75	33.75	42.5	23.75	41.25
Distillers Grains	——	——	13.0	——	26.0	——
Distillers Solubles	——	——	7.0	——	14.0	——
Corn Oil	——	——	——	2.5	——	5.0
Alfalfa Hay	7.5	7.5	7.5	7.5	7.5	7.5
Dry Supplement	5.0	5.0	5.0	5.0	5.0	5.0
Total Lipid [a]	3.98	3.98	6.39	6.37	8.80	8.76

[a]Ether extract analysis, calculated from individual ingredient analysis and the corresponding inclusion rate in the diet.

Trial 2

	CON	20DG	1.3TAL	40DG	2.6TAL
High-Moisture Corn	67.0	47.0	65.7	27.0	64.4
Wet Corn Gluten Feed	20.0	20.0	20.0	20.0	20.0
Dry Distillers Grains/Solubles	——	20.0	——	40.0	——
Tallow	——	——	1.3	——	2.6
Corn Silage	10.0	10.0	10.0	10.0	10.0
Dry Supplement	3.0	3.0	3.0	3.0	3.0
Total Lipid [a]	3.50	4.25	4.74	5.00	5.98

[a]Ether extract analysis, calculated from individual ingredient analysis and the corresponding inclusion rate in the diet.

Results

Trial 1

No significant differences ($P > 0.10$) were observed for the interaction or main effects for dry matter intake (DMI) (Table 2). Dry matter intake tended ($P = 0.13$) to decrease linearly as fat provided from WDGS or corn oil in the diet increased. A significant source x level interaction was observed for both ADG and feed:gain. Average daily gain decreased linearly and feed:gain increased linearly as the amount of corn oil in the diet increased, with heifers on the 5FAT treatment having the lowest ADG and highest feed:gain than heifers on any other treatment. For dietary NE_g concentrations, there was a tendency for a source by level interaction to be significant ($P = 0.16$), with dietary NE_g concentration tending to decrease linearly as the amount of corn oil in the diet increased.

No significant differences were observed for the main effects or interaction on 12th rib fat thickness, ribeye area, yield grade, or liver abscess score (Table 2). Because no significant differences were observed for 12th rib fat thickness and yield grade values, it appears that heifers were equally finished. However, there was a significant difference ($P = 0.03$) observed for

Table 2. Performance measurements and carcass characteristics for wet distillers byproducts finishing trial.

	Treatment[a]									Main Effects			Simple Effects	
Item	0F	2.5F	5F	0DG	20DG	40DG	SE	Cov[b]	Int.[c]	S[d]	Lev. lin.[e]	Lev. quad.[f]	DG lin[g]	Fat lin[h]
DMI, lb/day	20.0	20.0	18.0	19.8	20.0	19.6	0.9	NS [k]	NS	NS	.13	NS	—	—
ADG, lb	3.04	3.01	2.49	3.04	3.04	3.19	0.18	NS	.09	—	—	—	NS	.04
F:G, lb/lb	6.52	6.59	7.25	6.58	6.52	6.15	0.28	.05	.10	—	—	—	NS	.10
Diet NE_g [j] Mcal/cwt	63.8	64.1	59.7	63.1	64.7	67.4	2.3	NS	.16	—	—	—	NS	.20
Carcass Wt, lb	693	691	647	680	693	689	20	< .01	NS	NS	NS	NS	—	—
Marbling score [j]	524	519	496	547	536	538	16	.08	NS	.03	.15	NS	—	—
Ribeye area, in^2	11.8	11.6	11.3	11.8	11.7	11.5	0.3	NS	NS	NS	NS	NS	—	—
Fat thickness, in	0.54	0.69	0.47	0.44	0.59	0.60	0.06	.03	NS	NS	NS	.13	—	—

[a]0F = 0% corn oil diet, 2.5F = 2.5% corn oil diet, 5F = 5% corn oil diet, 0DG = 0% WDGS diet, 20DG = 20% WDGS diet, and 40DG = 40% WDGS diet.
[b]Covariate P-Value.
[c]Source x Level Interaction P-Value.
[d]Main effect of Source P-Value.
[e]Contrast for the presence of a linear effect of Level P-Value.
[f]Contrast for the presence of a quadratic effect of Level P-Value.
[g]Linear effect of wet distillers grains plus solubles P-Value.
[h]Linear effect of corn oil P-Value.
[i]Mcal/cwt, based on cattle performance (NRC, 1996).
[j]400 = Slight 0, 500 = Small 0.
[k]NS, P-Value > 0.20.

Table 3. Performance measurements for dry distillers byproducts finishing trial.

	Treatment [a]						Simple Effects	
Item	CON	1.3TAL	2.6TAL	20DG	40DG	SE	DG lin[b]	Tal lin [c]
Initial BW, lb	774	774	774	776	775	2	NS [f]	NS
Final BW, lb [d]	1358	1350	1370	1359	1375	12	NS	NS
DMI, lb/day	27.0	26.6	27.0	27.1	27.0	0.4	NS	NS
ADG, lb/day	4.94	4.87	5.05	4.94	5.08	0.10	NS	NS
F:G, lbs/lb	5.51	5.56	5.41	5.54	5.36	0.05	0.20	NS
Diet NE_g, Mcal/cwt [e]	64.84	64.79	66.08	64.49	66.77	0.12	NS	0.18

[a]CON = control diet, 1.3TAL = 1.3% tallow diet, 2.6TAL = 2.6% tallow diet, 20DG = 20% DDGS diet, 40DG = 40% DG diet.
[b]Linear effect of dry distillers grains plus solubles P-Value.
[c]Linear effect of tallow P-Value.
[d]Calculated from carcass weight, adjusted to a 63% common yield.
[e]Mcal/cwt, based on cattle performance (NRC, 1996).
[f]NS, P-Value > 0.20.

the main effect of source on marbling score, with heifers on the corn oil treatments having significantly lower marbling scores than heifers on the WDGS treatments.

The 20DG, and 40DG diets provided 2.5% and 6.8% more NE_g than the 0DG diet, when calculated from animal performance. Net energy for gain values calculated from animal performance for WDGS in this trial were 73.1 and 75.9 Mcal/cwt when included at 20 and 40% of the diet, respectively, compared to that of the corn in the 0DG diet, which had an NE_g 65.3 Mcal/cwt, which is lower than the reported tabular value of 70 Mcal/cwt (NRC, 1996). This equated to the WDGS contributing 12 and 17% more energy than dry-rolled/high-moisture corn in this trial when fed to yearling heifers at 20 and 40% of the diet DM.

Within level of supplemental fat, all diets appeared to be similar in total lipid content (Table 1). Throughout the trial, distillers grains and distillers solubles were sampled and analyzed for lipid content, with the distillers grains samples averaging 9.5% total lipid (DM basis), and the distillers solubles averaging 29.5% total lipid (DM basis). The distillers solubles were the ingredient primarily responsible for the higher lipid content of the 20DG and 40DG diets. Past research (Zinn, 1994; in The Prof. Anim. Sci. 67:1038-1049) has suggested an upper limit of dietary lipid intake (0.73 g/lb of body weight), which was indeed surpassed for animals consuming the 40DG and 5FAT diets. However, performance was not affected negatively for cattle consuming the 40DG diet, while it was for cattle consuming the 5FAT diet. This may suggest that the fat within the WDGS product may be less available in the rumen compared to corn oil.

(Continued on next page)

Trial 2

No significant differences were observed for any performance parameter or carcass characteristic measurement (Table 3). All cattle gained very well (~4.98 lb/day), with cattle fed the 40DG or 2.6TAL diets having the highest ADG (5.08 and 5.05 lb). Feed conversion followed a similar response to ADG. Cattle fed the 40DG or 2.6TAL diets were the most efficient (5.36 and 5.41).

Net energy for gain, calculated from performance (Owens et al., 2002), indicated that DDGS when fed at 20% of the diet was 97.3% that of high-moisture corn, and when fed at 40% of the diet was 107.4% that of high-moisture corn. The overall diet NE_g values were 64.5 and 66.8 Mcal/cwt for the 20DG and 40DG diets respectively.

Within level of supplemental fat, diets appear to contain the same amount of total lipid (Table 1). Dry distillers grains plus solubles were sampled periodically throughout the trial and averaged 8.1% total lipid (DM basis) while the wet distillers grains and solubles mixture from trial 1 averaged 16.5% total lipid. Therefore, corn oil supplementation was higher in trial 1 because of the higher lipid content of the WDGS, where tallow supplementation in trial 2 was less, because of the lower lipid content of the DDGS compared to that of WDGS. Further, cattle did not surpass the total lipid intake threshold of 0.73 g/lb BW, in trial 2.

Results from Trial 1 indicate that feeding WDGS at 20 and 40% of the diet DM will increase ADG and feed conversion above a high-moisture/dry-rolled corn control. It appears that adding 5% supplemental corn oil to a feedlot finishing diet will have negative impacts on ADG and feed conversion. Wet distillers grains plus solubles in Trial 1 provided 12 and 17% more NE_g than a high-moisture/dry-rolled corn control when fed at 20 and 40% of the diet. Results from Trial 2 indicate that incorporating tallow in feedlot diets equal to that provided from DDGS results in similar performance of yearling finishing steers. Controlling acidosis by feeding WCGF at 20% of DM allowed tallow supplementation to produce similar results as feeding DDGS. Conclusions from Trial 2 indicate that part of the additional energy provided from DDGS is a result of subacute acidosis control.

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Phosphorus Requirement for Finishing Heifers

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Summary

Sixty head of crossbred heifers (614 lb initial BW) were individually fed one of five levels of phosphorus of 0.10, 0.17, 0.24, 0.31, 0.38 % of diet DM with supplemental P from mono-sodium phosphate. Heifers were fed an energy-dense diet composed primarily of corn starch and corn fiber to minimize P from corn. When compared to the other four levels, heifers fed at the 0.10 % P level had lower DMI, ADG and final BW. Heifers fed 0.10%P had lower plasma P concentration. Break-point analysis of ADG suggests that the P requirement for finishing heifers is 0.115% P of diet DM within the range of 8.2 to 10.3g P/day (0.104 and 0.127% P on a DM basis).

Introduction

Current recommendations on the P requirement may be over-estimated for finishing cattle. Previous research suggests the P requirement for yearling steers is less than 0.14% (DM basis; 1996 Nebraska Beef Report, pp. 78-80), and steer calves is less than 0.16% (DM basis; 2002 Nebraska Beef Report, pp. 45-48). In both experiments, P requirements were not determined because performance was similar across all levels of P fed. The objective of our experiment was to determine the P requirement for calf-fed heifers.

Procedure

The experiment used 60 crossbred, large framed heifers (initial BW= 614 lb). Two heifers were taken off of the trial due to pregnancy. Heifers were fed individually using Calan gates from Nov. 14, 2002 to May 15, 2003 (180 days). Heifers were stratified by weight and assigned randomly to one of five treatments. The treatments consisted of five different P levels of 0.10, 0.17, 0.24, 0.31, 0.38 % of DM. The five P levels were achieved by feeding one base diet (0.10 % P) and top dressing mono-sodium phosphate at feeding. The diet consisted of 50% coarse brewers grits, 15% high moisture corn, 15% corn bran, 10% sorghum silage, 5% tallow, and 5% supplement. Limestone was fed at 1.4% of diet DM to meet the Ca requirement. In order to formulate a diet low in P, coarse brewers grits (0.05% P DM basis) replaced corn (0.30% P DM basis). The diet was balanced to 12.5% CP, and it also contained 28 g/ton DM Rumensin, 10g/ton DM Tylan, and .46 mg/head/day MGA. Heifers were adapted to treatment diets by limiting intake at 1.5% of BW and increasing 0.5 lb/day until ad libitum intakes were achieved (approximately 21 days). They were implanted on day 1 with Revalor IH and re-implanted with Revalor 200 on day 84.

Heifers were weighed three consecutive days following a 5-day limit feeding period and averaged for initial BW. Samples of blood also were collected on day 0 and every 28 days throughout the feeding period. Blood was collected in the morning, prior to feeding, in 10 ml vacutainers containing sodium heparin. Samples were centrifuged at 2500 RPM for 15 minutes. Plasma was removed from the top of the sample. Plasma was transferred into 2 ml conicles then frozen at -20 degrees C for later analysis. Plasma was analyzed using a commercial kit (Diagnostic Chemicals Limited) for plasma P concentration.

Final weights were calculated from hot carcass weight using a common dressing percentage of 62. After a 24 hour chill 12th rib fat thickness and marbling scores were taken.

Results

Performance

Heifer performance data are shown in Table 1. Significant quadratic ($P<0.01$) effects were present for DMI and ADG. Cattle on treatments 0.10 and 0.38 had lower DMI and consequently lower ADG compared to cattle on the 0.17, 0.24, and 0.31 treatments. This indicates that the heifers on the 0.10 treatment were experiencing a P deficiency.

There were no significant quadratic or linear effects in feed conversion, despite differences in DMI and ADG. No differences were found in marbling score or 12th rib fat thickness; however, heifers fed 0.10% P had numerically lower marbling scores (linear effect: $P=0.10$).

When calculated using non-linear regression analysis for % P of diet DM, the requirement for P was estimated to be 0.115%, ranging between 0.104 and 0.127% P of diet

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Table 1. Performance data for heifers consuming different levels of P.

	P Intake (% of DM)						P- value	
	0.10	0.17	0.24	0.31	0.38	SEM	Linear	Quadratic
P Intake (g/day)	7.40	14.2	20.5	25.9	29.6	0.71	<.01	<.01
Initial BW (lb)	619	613	616	617	612	12.0	0.77	0.98
Final BW (lb)	1086	1167	1163	1158	1114	24.00	0.52	<.001
DMI (lb/day)	16.2	18.3	18.7	18.3	17.0	0.60	0.38	<.01
ADG (lb/day)	2.58	3.06	3.03	2.99	2.78	0.09	0.26	<.01
F:G	6.24	5.94	6.15	6.10	6.13	0.12	0.85	0.35
HCW[c]	674	723	721	718	691	14.8	0.52	<.01
Marbling[a]	486	565	529	546	554	22.4	0.10	0.28
12th Rib[b]	0.35	0.38	0.42	0.34	0.39	0.03	0.76	0.42

[a]Marbling Scores: 400=Slight, 500=Small, 600 =Modest .
[b]12th Rib: Back fat thickness at the 12th rib measured in inches.
[C]HCW: Calculated hot carcass weight using a common dressing percent of 62, measured in pounds.

DM (Figure 1). When feed conversion was plotted against P intake (g/day), no significant differences (P>0.05) were observed (Figure 2). P intake was positively correlated to ADG (r = 0.13, P<0.01) and DMI (r = 0.14, P<0.01). It was not correlated to feed efficiency (r = 0.049, P>.60).

Plasma P Concentration

There were no significant differences among treatments on day 0 (P>0.30), indicating all heifers were at the same plasma P concentration of 7.12mg/dL. A significant treatment by time interaction (P<0.10) occurred because the heifers fed 0.10% P had lower concentrations from day 28 to market (Figure 3). The heifers on the 0.10% P treatment were different from the other 4 treatments on day 28 to slaughter time (P<0.10). Heifers on the 0.10% P treatments had an initial plasma concentration of 6.98 mg/dL. Plasma P concentrations for heifers fed 0.10% P on day 28, 56, 84, 112, 140, and 180 were 4.49, 3.93, 4.82, 5.33, 4.32, and 4.18 mg/dL respectively. Plasma P concentration below 4.5 mg/dL are indicative of a P deficiency (Minerals Levels in Animal Health, R. Puls, p. 167). These results indicate heifers on the 0.10 treatment were P deficient. The plasma P concentration of cattle on

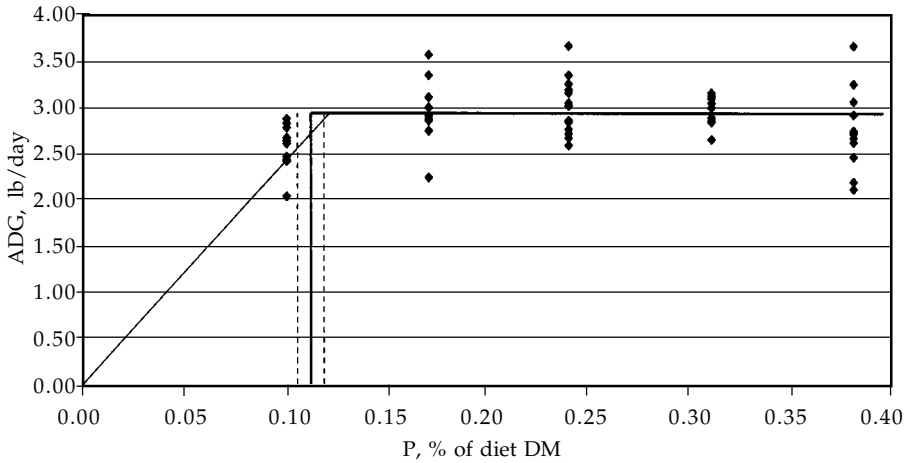

Figure 1. Non-linear effect of P% of diet DM on ADG of heifers. Breakpoint determined at 0.115% P (0.104 to 0.127% P). Solid line is the breakpoint (0.115% P) with the dashed line as the 95% confidence interval (0.104 to 0.127% P). Maximum ADG was 2.96 lb/day and the points represent ADG over entire 180 days for 58 heifers.

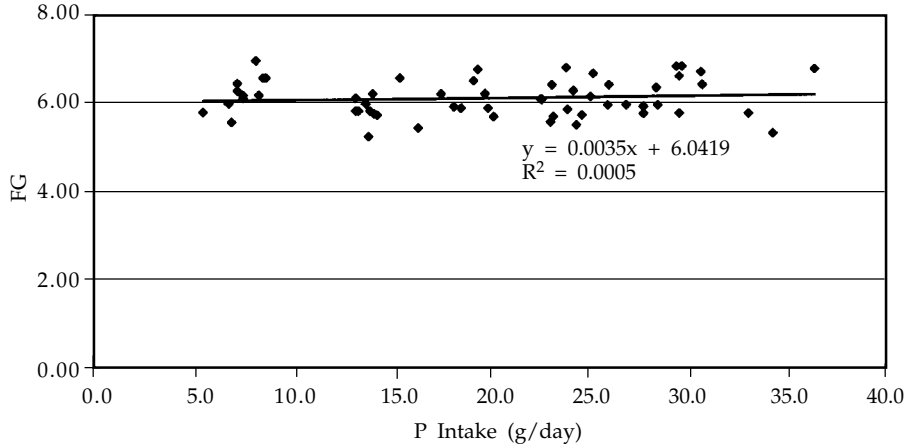

Figure 2. Scatter plot of feed conversion of heifers fed different levels of P for 180 days.

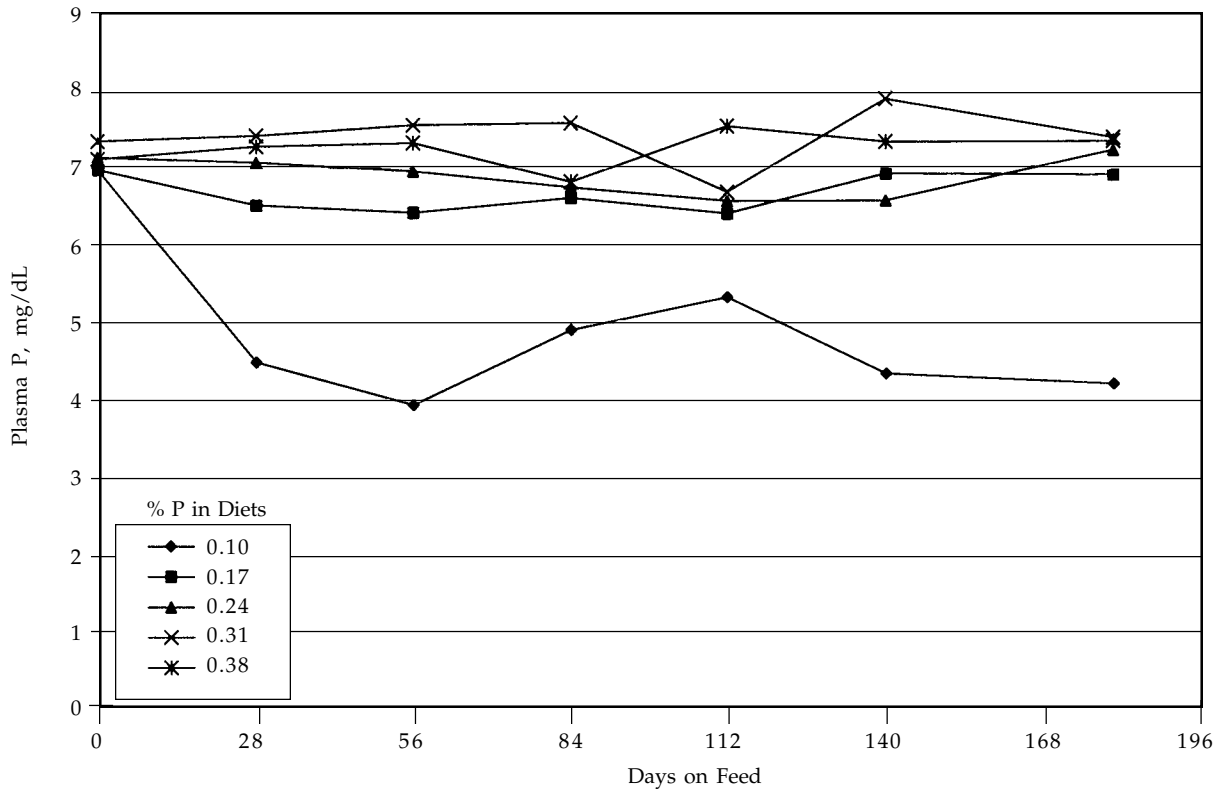

Figure 3. Plasma P concentration of heifers fed different levels of P. Significant treatment by time interaction (P<0.01).

the 0.17% treatment on day 28, 56, 84, 112, 140, and 180 were 6.52, 6.42, 6.61, 6.91, and 6.90, respectively, indicating that they were not experiencing a P deficiency. The other treatments stayed at approximately 7.07 mg/dL throughout the entire feeding period. There were no significant differences within the other four P levels over time (P>0.05)

Previous research indicates cattle can tolerate Ca:P ratios of 1:1 to 7:1. The Ca level in these diets was set at 0.70% of diet DM. The Ca:P ratios for these diets ranged form 1.8:1 to 7:1, suggesting the Ca:P ratio did not effect DMI and ADG. The performance and plasma P concentration results indicate the P requirement for finishing heifers is between 8.2 and 10.3 g/day, or 0.10 and 0.17% P of diet DM. This is supported by results from Erickson et. al (2002 Nebraska Beef Report, pp. 45-48), which indicated the P requirement for calf-fed steers was below 0.16% P of diet DM. There were no differences in steer performance in their study. However, steers on the 0.16% P treatment did have significantly lower plasma P concentrations (4.6 mg/dL) on day 56. However, by day 112 the blood plasma concentrations raised to above 5.5 mg/dL for the remainder of the trial. The results of our trials indicate corn-based finishing rations supply adequate P levels for finishing cattle and P supplementation is unnecessary.

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Sodium Chloride Levels for Finishing Feedlot Heifers

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Summary

A trial was conducted to establish a NaCl level that maximizes intake and performance while minimizing excretion of Na to the environment. Fifty-nine individually fed yearling heifers (803 lb) were fed 113 days. NaCl was added to a corn-based feedlot diet at levels of 0, 0.125, 0.25, 0.375 and 0.5 % of diet DM. No difference in ADG, DMI or F/G were observed with different levels of NaCl. Results suggest NaCl inclusion in the diet likely is not necessary to maintain acceptable feedlot performance.

Introduction

Sodium chloride is commonly supplemented in feedlot diets at .3 to .5% of diet DM. This level of supplementation has been assumed to aid in improving DMI and performance. With NaCl addition to the diet the level of Na excretion in feces and urine also is increased. The increase in Na in animal waste may cause long term problems in manure or compost applications and runoff application areas. Sodium accumulation in the soil profile will inhibit water infiltration and inhibit the absorption of nutrients in cropping systems. Determining the optimal amount of NaCl to be included in feedlot rations will be vital to long term environmental sustainablility. The objective of this trial was to evaluate NaCl levels to obtain a level that maximizes intake and performance while minimizing excretion of Na to the environment.

Procedure

Fifty-nine spayed yearling heifers (803 lb) were individually fed for 113 days. Heifers were assigned randomly to treatment and weighed on three consecutive days. Revalor-H® implants were administered at the beginning of the trial. Heifers were individually fed once daily using Calan electronic gates. Adaptation to concentrate was attained by increasing intake (0.5 lb/day) from 1.5 % of BW on the treatment diet until ad libitum consumption was attained, approximately 21 days. The basal diet was initially formulated to produce a sodium deficiency. The diet included 42.5% high moisture corn, 42.5% dry rolled corn, 7.5% grass hay, 3% tallow and 5% supplement. Iodine was added to the diet at 1.5 ppm. Five treatments (12 heifers/treatment) were formulated to provide increasing levels of NaCl; 0, 0.125, 0.25, 0.375 and 0.5 % of diet DM. Treatments bracketed 1996 NRC minimum Na requirements (0.08% of DM or 0.20% NaCl). Sodium chloride level in the supplement was increased by replacing fine ground corn (Table 1). Treatments then were mixed before feeding by combining low and high NaCl supplements to attain proper treatment levels. Water intake was measured using water meters on a group basis to evaluate average Na intake from water. Feeds and supplements were sampled weekly and composited for Na analysis. Feces and urine were sampled every 28 days and composited to evaluate Na excretion. Fecal output was determined by multiplying DMI by the estimated dry matter indigestibility of the diet (14.7%, 85.3% DMD). Urine volume was estimated assuming creatinine excretion is 12.7 mg/lb of BW and dividing by the creatinine concentration in the urine. Urine creatinine concentration was determined using laboratory analysis (Sigma Procedure No. 558, Sigma Diagnostics, St. Louis, MO.). Na analysis was performed on all samples by a commercial laboratory using atomic absorption spectroscopy. Results were analyzed using the mixed procedure of SAS.

Results

Ingredient and water analysis showed increasing levels of Na

Table 1. Supplement composition.

Ingredients (DM%)	Low Supplement[a]	High Supplement[a]
Limestone	27.6	27.5
Fine Ground Corn	24.3	13.8
Urea	24.2	24.6
Potassium Chloride	11.5	11.5
Calcium Sulfate	5.2	5.2
Salt	0.0	10.0
Tallow	3.0	3.0
Dicalcium Phosphate	2.4	2.5
Trace mineral[b]	1.0	1.0
Vitamin A-D-E[c]	.2	.2
Rumensin-80[d]	.35	.35
Tylan-40[e]	.25	.25

[a]Low represents no NaCl in the diet DM, High represents 0.5% NaCl in the diet DM.
[b]Trace mineral composition;10% Mg, 6% Zn, 4.5% Fe, 2% Mn, .5% Cu, .3% I, and .05% Co.
[c]Vitamin A-D-E; 15,000 IU of vitamin A, 3,000 IU of vitamin D, and 3.75 IU of vitamin E/g of premix.
[d]Rumensin-80; 27.1 g/ton of diet DM.
[e]Tylan-40; 9.7 g/ton of diet DM.

Table 2. Performance of heifers fed finishing diets with different levels of NaCl inclusion.

Level	0%	0.125%	0.25%	0.375%	0.5%	SEM	P-value[a]
Initial BW, lb	801	808	802	800	805	23	0.99
Final BW[b], lb	1150	1171	1164	1155	1180	30	0.95
ADG lb/day	3.09	3.21	3.28	3.14	3.31	0.13	0.71
DMI lb/day	21.1	21.4	21.9	20.7	21.5	0.6	0.71
F/G	6.87	6.69	6.73	6.67	6.56	0.19	0.83
Marbling[c]	517	521	521	507	532	14	0.77
Fat thickness (in)[d]	0.46	0.64	0.55	0.53	0.47	0.04	0.03
Ribeye Area (in^2)	14.1	13.3	13.6	13.8	13.6	0.4	0.63

[a]F-test statistic P-value.
[b]Final BW based on dressing percentage of 62.
[c]Marbling score: 400 = Traces; 500 = Small 0; 600 = Modest.
[d]Significant quadratic response to Na (P = 0.01).

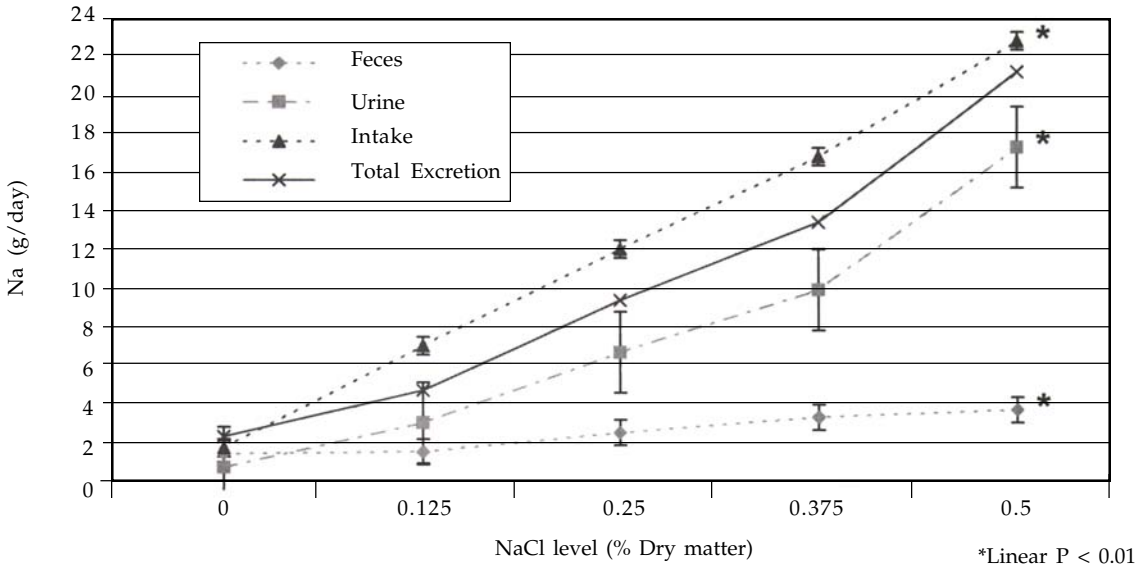

Figure 1. Na intake and excretion in feces and urine with different levels of NaCl inclusion.

intake from 1.9, 7.2, 12.2, 17.0 and 22.9 ± 0.46 g/heifer/day with an average of .65 g/day from water. Analyzed Na levels in the diet were 0.01, 0.07, 0.12, 0.18 and 0.23 % of DM. This provides NaCl levels of 0.03, 0.18, 0.31, 0.46 and 0.59 % of diet DM. Analysis of performance data showed no significant difference in ADG, DMI or F/G with different levels of NaCl (Table 2). Overall, NaCl supplementation was not effective in increasing ADG, F/G or DMI. Heifer performance averaged 3.21 ± 0.13 lb ADG with F/G averaging 6.7 ± 0.19. No significant effects were detected for marbling, yield grade or ribeye area (P > 0.10) across all treatments (Table 2). A significant quadratic effect for fat thickness was detected (P = 0.01). The quadratic response was a result of higher fat thickness in the 0.125% and 0.25% NaCl levels compared to lower fat thickness in the 0% and 0.5% NaCl levels. Fecal and urine analysis showed increasing levels of Na in waste with increased feeding levels (Figure 1).

These results suggest that NaCl inclusion in diets at current NRC recommendations or less would be adequate. In an attempt to produce a sodium deficiency, feedstuffs with low sodium contents were used in this trial. In commercial cattle feeding situations some ingredients would contain more sodium than those used here. Alfalfa contains about 0.12 % Na, beet molasses contains 1.48 % Na, corn gluten feed 0.26 % Na and distillers grains 0.30 %Na. Because most commercial diets in Nebraska contain alfalfa and a byproduct or molasses, most diets likely contain 0.05 to 0.07% Na or more and NaCl is likely not needed. Reducing NaCl supplementation in feedlot operations would reduce the excretion of Na to the environment and minimize Na buildup on acres receiving manure and runoff water.

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The Influence of Corn Kernel Traits on Feedlot Cattle Performance

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Summary

Seven commercially available corn hybrids representing a range within and among kernel traits were used in a finishing trial to evaluate effects of corn kernel traits on feedlot animal performance. Average daily gain, DMI, and hot carcass weight were similar among all corn hybrids. A significant difference in feed conversion of 8.4% from lowest to highest among hybrids was observed. Kernel traits correlated with feed conversion were 1,000 grain weight, stenvert time to grind, and stenvert proportion of soft to coarse particles. Efficiency of finishing cattle gain can be significantly improved by selection of corn hybrids with more desirable kernel traits.

Introduction

Much work has been done to examine effects of corn processing on digestibility and feedlot animal performance. However, studies examining the influence of chemical and physical properties of corn on performance are small in number. If performance differences relating to physical and/or chemical properties can be identified, they would be useful for discriminating among grain sources when purchasing feed. Physical (i.e. test weight, kernel size) and chemical properties (i.e. percentage protein, oil, and starch) are generally very consistent within a corn hybrid yet variable over corn hybrids, making them useful as a tool for predicting feed efficiency differences among hybrids. Some additional kernel traits include total starch content, vitreousness, ratio of amylose to amylopectin, 1,000 kernel weight and kernel hardness. Ruminal digestibility can be predicted by vitreousness (r^2=.89) of the kernel (Philippeau et al., 1999 JAS). In addition, Philippeau also found that ruminal starch degradability could be more easily and just as accurately predicted by combining apparent density and 1,000 grain weight (r^2=.91) compared to vitreousness. However, this second study did not examine animal performance. The objective of this research was to examine seven different commercially available corn hybrids varying in chemical and physical properties and determine the impact of these traits on finishing cattle performance.

Procedure

Corn Grain Production, Hybrids, Harvest, and Storage

Seven different commercially available dent corn hybrids representing a wide range in physical and chemical kernel traits were planted and grown under center pivot irrigation in two similar fields at the Agricultural Research and Development Center during the 2002 growing season. The seven different hybrids consisted of Golden Harvest H-9164Bt (1), H-9235Bt/RR (2), H-9230Bt (3), Pioneer 33B51 (4), and 33P67 (5), and Golden Harvest H-8562 (6), and H-9533Bt (7). Each hybrid was represented equally in the two fields. The grain was harvested between 14 and 18% moisture (variance was across, not within hybrids) within a two-day period and stored in separate grain bins and dried in preparation for the feeding trial. Whole corn was transported to the feed mill facility as needed, dry-rolled and placed in separate commodity bays until fed. At harvest, two raw grain samples were taken of each hybrid from each field and stored separately for laboratory analysis. Samples were placed in nylon mesh bags in the same room for 2 months to allow for moisture to equilibrate between the different hybrids, prior to analysis.

Grain Analyses

Tests were conducted to detect differences in kernel traits among hybrids. Kernel traits analyzed included percentage starch, DM, CP and amylose. Test weight, weight of 1,000 kernels, kernel size, *in-vitro* starch disappearance (IVSD), *in-situ* rate and extent of disappearance, and three different hardness tests were also conducted. Samples were analyzed by replicate within field (n=4) for each hybrid based on samples that were taken at harvest. The *in-situ* procedure used a simulated masticate grind designed to have a particle size similar to masticated dry rolled corn. This grind was produced using a Wiley mill with a 1/4 inch screen. Time points for the *in-situ* procedure were 0, 8, 16, 24, and 72 hours. The IVSD procedure was a 12-hour digestion which utilized two different sized grinds, a fine grind (2mm) and the masticate grind as discussed for the *in-situ* procedure. The hardness tests conducted were floating index, stenvert hardness test and the tangential abrasive dehulling device (TADD).

Table 1. Differences in kernel crude protein and amylose among hybrids within a field.

									P-values[b]		
Hybrid[a]	1	2	3	4	5	6	7	SEM	Corn*Field	Corn	Field
Crude Protein, %								0.06	0.05	<0.01	0.10
Field 1	8.04[c]	8.88[e]	8.19[c]	8.48[d]	8.97[ef]	9.12[f]	8.52[d]				
Field 2	8.07[c]	8.83[e]	8.24[c]	8.56[d]	8.96[e]	8.94[e]	8.19[c]				
Amylose,%								1.3	0.04	<0.01	0.04
Field 1	25.6[c]	23.1[c]	24.6[c]	30.5[e]	29.9[e]	29.1[de]	26.0[cd]				
Field 2	27.2[de]	25.7[cde]	24.0[c]	25.3[cd]	28.6[e]	25.2[cd]	22.7[c]				

[a]Hybrids consisted of Golden Harvest H-9164-Bt (1), H-9235Bt/RR (2), H-9230-Bt (3), Pioneer 33B51 (4), and 33P67 (5), and Golden Harvest H-8562 (6), and H-9533Bt (7).
[b]F-test statistic for the effect of hybrid.
[c,d,e,f]Means within a row with unlike superscripts differ (P<0.05).

Table 2. Differences in kernel characteristics among hybrids.

									P-values[b]
Hybrid[a]	1	2	3	4	5	6	7	SEM	Corn
Starch,%	80.2[k]	77.7[klm]	78.8[kl]	79.2[kl]	76.8[lm]	74.8[m]	69.6[n]	1.2	<0.01
1,000 grain wt., g	324.1[n]	322.5[n]	323.3[n]	317.2[o]	332.4[m]	354.5[k]	348.5[l]	1.3	<0.01
Test weight, lb/bu	60.2[o]	62.1[l]	62.1[l]	62.5[l]	63.7[k]	60.8[n]	61.6[m]	0.2	<0.01
Fine IVSD [c]	72.3	72.2	73.3	72.7	70.7	72.8	74.6	0.9	0.15
Masticate IVSD [c]	58.5	57.8	56.0	53.3	54.4	57.0	61.2	2.5	0.37
In-situ rate, %/hr[d]	3.63[kl]	3.74[kl]	3.16[k]	4.15[l]	3.17[k]	3.63[kl]	3.24[k]	0.2	0.02
% Floaters [e]	96.7[k]	82.5[l]	70.7[m]	70.5[m]	12.7[p]	49.0[n]	35.3[o]	2.2	<0.01
Tadd, % removed [f]	80.3[k]	71.9[mn]	74.5[lm]	82.7[k]	70.5[n]	75.8[l]	73.2[lmn]	1.0	<0.01
Stenvert, % hard (g)[g]	26.9[kl]	27.6[k]	28.5[k]	22.6[m]	26.1[kl]	20.9[m]	23.9[lm]	1.0	<0.01
Stenvert, RPM [h]	294.5[kl]	292.1[n]	293.3[klm]	294.5[k]	292.6[mn]	293.3[mn]	293.3[lmn]	0.4	<0.01
Stenvert time, s [i]	7.59[no]	7.82[mn]	9.68[k]	8.07[m]	8.68[l]	7.31[o]	7.90[mn]	0.1	<0.01
Stenvert, % soft ht.[j]	71.6[k]	67.4[l]	64.0[m]	67.9[l]	63.0[m]	72.6[k]	71.0[k]	0.8	<0.01

[a]Hybrids consisted of Golden Harvest H-9164-Bt (1), H-9235Bt/RR (2), H-9230-Bt (3), Pioneer 33B51 (4), and 33P67 (5), and Golden Harvest H-8562 (6), and H-9533Bt (7).
[b] F-test statistic for the effect of hybrid.
[c]Percent starch disappearance.
[d]Rate of DM disappearance.
[e]Measured as % kernels floating in a solution of 31.3 Baume' sodium nitrate solution which responds to a specific gravity of 1.275.
[f]Measured as percentage of original sample weight removed following abrasion by the TADD.
[g]Measured as weight of 425 micrometer overs divided by total sample weight.
[h]Reduction in hammermill speed from 360 RPM.
[i]Measured time to grind 17 ml of sample.
[j]Measured as height in cm and calculated as a percentage of total height.
[k,l,m,n,o,p]Means within a row with unlike superscripts differ (P<0.05).

Feedlot Experiment

Two hundred twenty-four crossbred steer calves (609 lb) were stratified by weight and assigned randomly to 1 of 28 pens (8 steers/pen). Pens were assigned randomly to 1 of 7 hybrids. Diets were formulated to meet or exceed NRC (1996) recommendations. All diets among the seven treatment groups were identical except for the hybrid fed as dry-rolled corn. Cattle were adapted to grain by feeding 35, 25, 15, and 5% alfalfa hay (DM basis) replacing corn in each treatment diet and fed for 3, 4, 7 and 7 days; respectively. The final diet consisted of 66.0% dry-rolled corn, 20.0% wet corn gluten feed, 10.0% corn silage and 4.0% supplement (DM basis). Rumensin® and Tylan® were included at 29 and 10 g/ton of diet DM, respectively.

Initial weights were determined using an average of two consecutive morning weights taken before feeding at the beginning of the trial, following a 5-day limit-feeding period. During the experiment, cattle were fed once daily and allowed ad libitum access to feed and water. Steers were implanted with Synovex-S on day 1 and reimplanted with Revalor-S on day 71. Cattle were fed for 167 days and harvested at a commercial packing plant (IBP, West Point, Neb.) where carcass data were collected. Hot carcass weight and liver abscess scores were taken on the day of slaughter. Following a 24-hour chill, 12th rib fat thickness, USDA called marbling score, and yield grade data were collected.

Results

Corn Grain Production and Analyses

The average yield for each of the test hybrids 1 through 7 were 229, 208, 221, 209, 222, 203 and 207 (15.5% corrected moisture) bushels per acre, respectively. However, growing production was not designed to test for yield differ-

ences. As expected, a wide range of values for the analyses existed. The average values across all hybrids for percentage CP, and amylose were 8.6%, and 26.2% respectively. There was a hybrid by field interaction for CP, and percentage amylose (Table 1). *In-vitro* starch disappearance was not different among hybrids which averaged 72.7% disappearance for the fine grind and 56.9% for the masticate grind. There were significant differences among hybrids for all other traits measured (Table 2). The percent floaters ranged from 12.7 to 96.7%, with hybrid 5 as the softest and hybrid 1 the hardest. However, results from the Tadd loss indicate hybrid 4 as the softest (82.7% loss), while hybrid 5 is the hardest (70.5% loss). Additionally, the measurements from the stenvert hardness test conflict with the floating and Tadd test. The stenvert hardness test measurements for % hard, grinding time, and % soft height all indicate that hybrid 6 is the softest.

Table 3. Differences in *In-situ* percentage DMD at various time points among hybrids.

Hybrid[a]	1	2	3	4	5	6	7	SEM	P-values[b]
Time 0	9.95^{c}	7.90^{de}	5.81^{f}	9.16^{cd}	6.55^{ef}	9.76^{c}	6.85^{ef}	0.50	<0.01
8	38.2^{c}	34.2^{cd}	31.8^{d}	36.0^{cd}	33.5^{d}	36.0^{cd}	32.0^{d}	1.60	0.06
16	50.3^{cd}	47.4^{de}	45.8^{e}	50.4^{cd}	47.1^{de}	53.1^{c}	47.5^{de}	1.38	<0.01
24	63.7^{c}	60.4^{cde}	56.9^{de}	59.0^{cde}	55.3^{e}	61.9^{cd}	61.9^{cd}	2.04	0.06
72	91.9^{cde}	94.8^{c}	90.0^{de}	94.9^{c}	89.6^{de}	93.1^{cd}	89.1^{e}	1.40	0.01

[a]Hybrids consisted of Golden Harvest H-9164-Bt (1), H-9235Bt/RR (2), H-9230-Bt (3), Pioneer 33B51 (4), and 33P67 (5), and Golden Harvest H-8562 (6), and H-9533Bt (7).
[b] F-test statistic for the effect of hybrid.
[c,d,e,f]Means within a row with unlike superscripts differ (P<0.05).

Table 4. Effects of corn hybrid on steer performance and carcass characteristics.

Hybrid[a]	1	2	3	4	5	6	7	SEM	P-values[b]
DMI, lb/day	21.8	22.0	22.5	21.9	21.3	21.5	21.2	0.4	0.23
ADG, lb	3.90	3.83	3.81	3.80	3.72	3.97	3.79	0.07	0.37
Feed:gain[c]	5.63^{fg}	5.77^{ef}	5.95^{e}	5.84^{ef}	5.77^{ef}	5.45^{g}	5.62^{fg}	0.08	<0.01
Hot carcass weight, lb	794	788	785	784	775	802	783	8	0.33
Marbling score[d]	575	552	525	563	546	543	516	14	0.10
12th rib fat, in.	0.56	0.58	0.49	0.56	0.49	0.53	0.51	0.03	0.20

[a]Hybrids consisted of Golden Harvest H-9164-Bt (1), H-9235Bt/RR (2), H-9230-Bt (3), Pioneer 33B51 (4), and 33P67 (5), and Golden Harvest H-8562 (6), and H-9533Bt (7).
[b]F-test statistic for the effect of hybrid.
[c]Statistically analyzed as gain:feed, which is the reciprocal of feed:gain.
[d]450 = Slight^{50}, 500 = Small^{0}, 550 = Small^{50}, etc.
[e,f,g]Means within a row with unlike superscripts differ (P<0.05).

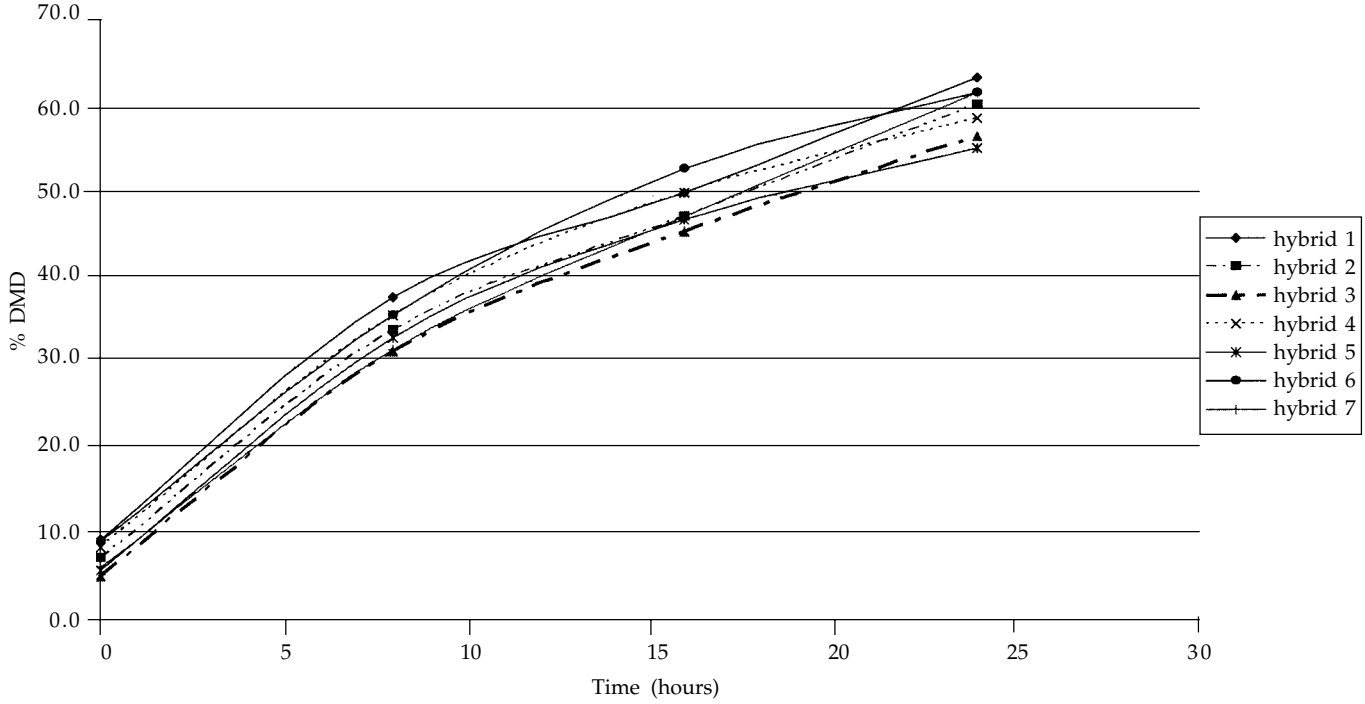

Figure 1. Twenty-four hour *In-Situ* dry matter disappearance by hybrid.

Percentage starch averaged 76.7%, while test weight and 1,000 grain weight averaged 61.9 lb/bu and 331.8 g across all hybrids after the air drying process. There was a significant difference in disappearance rates from the *in-situ* procedure (P=0.02). The hybrid that had the slowest disappearance rate was hybrid 5 (3.17%/hour) while the hybrid with the fastest rate was number 4 with a rate of 4.15%/hour. The improvement in overall disappearance rate of hybrid 4 over hybrid 5 was 31.3%. This difference may be due to differences in extent of digestion, because a greater extent of digestion generally results in an increased rate of digestion. The extent of digestion was calculated using the 72-hour time point. Additionally, differences in percentage DMD among hybrids at each of the individual time points were observed. When examining the DMD from the *in-situ,* there is no single hybrid that separates itself from the rest at all of the 5 different timepoints (Table 3). However, the DMD at the 16-hour time point may be the best indicator of actual DMD in a commercial feedlot setting, since this is the most realistic retention time when compared with the other time points from the *in-situ* procedure. A diagram depicting the percentage DMD over 24 hours by hybrid is shown in Figure 1.

Feedlot Experiment

Animal performance and carcass data are shown in Table 4. The average across all hybrids for DMI and ADG were 21.7 and 3.8 lb/day respectively, and were similar across all hybrids. There was a significant difference in feed conversion (P<0.01) among hybrids. Cattle fed hybrid 6 had the lowest feed conversion while hybrid 3 had the highest among the seven hybrids. The improvement in feed conversion of hybrid 6 over hybrid 3 was 8.4%. Carcass characteristics did not differ among hybrids.

There was no relationship between feed conversion and in situ DMD, which conflicts with previous research (Ladely et al., 1994 JAS). However, there was a highly correlated relationship of F/G with 1,000 grain weight (r = -0.81). As 1,000 grain weight increases, the ratio of F/G declines. Interestingly, hybrid 6 produced the lowest F/G and had the highest 1,000 grain weight. However, the increased 1,000 grain weight does not appear to be related to increased density (weight/volume) because hybrid 6 was also one of the lower test weight hybrids. Perhaps kernels from this hybrid are larger and softer resulting in greater 1,000 grain weight without increased test weight.

A similar relationship is evident between the ratio of stenvert soft to coarse particle height and feed conversion (r = -0.83). As the proportion of soft particles increase, F/G decreases. Stenvert grinding time and feed conversion were related; as time to grind the corn increases, feed conversion increases (r = 0.83). The stenvert time to grind is related to kernel hardness, with a longer grinding time being indicative of harder kernels. Additionally, the ratio of soft to coarse particles is an indicator of hardness, with the higher proportion of coarse particles representing a harder kernel. The relationships from this study between cattle performance and kernel traits imply that cattle fed hybrids with higher proportions of soft endosperm and higher 1,000 grain weight gain more efficiently than cattle receiving corn hybrids with a harder endosperm or a low thousand grain weight in a dry rolled corn based diet.

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Evaluation of Initial Implants for Finishing Heifers

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Summary

A commercial feedyard experiment evaluated initial implant strategies for feedlot heifers. Heifers were administered either Revalor-IH or Synovex-H at initial processing, with both treatment groups receiving Revalor-200 as a common terminal implant. Implanting heifers initially with Revalor-IH improved feed efficiency and ADG compared to heifers implanted initially with Synovex-H. In addition, Revalor-IH implanted heifers had higher marbling scores while 58% more carcasses achieved the upper two-thirds Choice category. There were no differences in USDA yield grades. Selling Revalor-IH implanted heifers on a carcass merit basis returned $14.22/head more than Synovex-H implanted heifers. New reduced-dose initial implants can improve both feed efficiency and marbling scores, suggesting carcass quality can be positively influenced with no negative impact on growth performance.

Introduction

Growth-promoting implants have proven to be safe and effective management tools in the production of meat from beef feedlot cattle. Implanting improves feed conversion and, increases growth rate (i.e., daily gain) and finished body weight compared to non-implanted cattle. If cattle are not sold at the same fat endpoint, this increase in growth rate and lean deposition may occur at the expense of meat quality (reduction in marbling score). However, depressions in quality grade or marbling of implanted cattle when compared to non-implanted cattle results in unfair comparisons unless cattle are fed to the same end-point (fat composition). Determining proper implant strategy (number of days exposed and dosage, or combination of dosages) is important so effects on quality grade can be minimized. Such accomplishments will be economically important as the marketing of beef continues to develop into a value-based grid marketing system. New reduced-dose initial implant combinations of estradiol and trenbolone acetate (E+TBA) are available for heifers and may have different effects on animal performance and carcass quality when compared to more traditional (higher dose) initial implant products. Objectives of this study were to: 1) determine whether a reduced-dose combination of E+TBA is effective in maintaining animal performance, and 2) measure the impact of different doses of E+TBA as initial implants on carcass quality, yield grade and feeding economics of feedlot heifers.

Procedure

Crossbred beef heifers (614 lb initial BW) were received at a commercial feedlot in Western Nebraska and were allotted randomly to one of two implant regimens at initial processing (within 72 hours after arrival). Each group of incoming cattle represented a treatment replication for a total of six replications per treatment (12 pens total; 1,124 heifers). Heifers were kept separate by arrival date and assigned randomly to pens by sorting every other animal as they exited the processing chute during initial processing. Within a replication, all heifers were from the same source and arrived to the feedyard at the same time. At initial processing, heifers were individually weighed, vaccinated and treated for internal and external parasites. A lot-tag for pen identification was also administered and contained a number to allow for individual animal identification. Initial implant treatments were either Revalor-IH (8 mg estradiol, 80 mg TBA) or Synovex-H (20 mg estradiol benzoate, 200 mg testosterone propionate). After processing, heifers were group weighed to obtain an initial pen weight, just before being moved into their home pen. Number of animals in a pen ranged from 80 to 120 head, but were equal across replications.

Heifers were fed a common finishing diet twice daily throughout the study. Cattle were adapted to the finishing diet over an 18- to 21-day step-up period starting with 45% roughage and progressively replacing roughage with corn. Heifers were fed a finishing diet containing 61.3% steam-flaked corn, 10.5% dry-rolled corn, 10% wet distillers grains, 7.5% alfalfa hay, 5% liquid supplement, 3%

Table 1. Effects of Revalor-IH or Synovex-H as initial implants for feedlot heifers on carcass adjusted performance.

	Initial Implant[a]			
Item	Revalor-IH	Synovex-H	SEM	*P* - value
Number of pens	6	6	—	—
Number of heifers	535	546	—	—
Initial weight, lb	614	614	11	0.99
Final weight, lb[b]	1256	1243	7	0.15
DMI, lb	19.1	19.2	0.5	0.63
ADG, lb[c]	3.65	3.57	0.1	0.10
Feed/gain[c]	5.26	5.39	0.03	0.03

[a]All heifers implanted with Revalor-200 as the common terminal implant.
[b]Calculated as hot carcass weight ÷ 63% (common dressing percentage).
[c]Calculated using carcass adjusted final weight.

Table 2. Effects of Revalor-IH or Synovex-H as initial implants on heifer carcass characteristics.

	Initial Implant[a]			
Item	Revalor-IH	Synovex-H	SEM	*P* - value
Hot carcass weight, lb	792	783	4.6	0.15
Dressing percentage	65.2	65.5	0.1	0.23
12th rib fat, in.	0.53	0.52	0.02	0.60
Empty body fat, %[b]	29.4	29.0	0.2	0.12
Ribeye area, sq. in.	14.1	14.3	0.1	0.26
Dark cutters, %	1.12	2.73	0.87	0.14
USDA Yield grade, %				
1	5.0	5.4	1.0	0.64
2	28.3	29.8	3.5	0.62
3	51.9	46.4	2.9	0.16
4	14.4	17.0	2.7	0.37
5	0.4	1.4	0.5	0.15
Calculated yield grade[c]	2.71	2.60	0.06	0.09
USDA Quality grade, %				
Prime	1.4	1.1	0.6	0.74
Upper 2/3 Choice	23.6	14.9	2.5	0.02
Low Choice	43.7	50.3	3.3	0.11
Select	30.4	32.7	2.9	0.55
Standard	0.89	0.79	0.52	0.87
Marbling score[d]	552	533	8.2	0.07
Total Choice carcasses, %	67.3	65.2	2.9	0.59

[a]All heifers implanted with Revalor-200 as the common terminal implant.
[b]Calculated from Guiroy et al., 2002 (*J. Anim. Sci.*), where empty body fat = 17.76207 + (4.68142 × FT) + (0.01945 × HCW) + (0.81855 × QG) - (0.06754 × LMA).
[c]Calculated YG = 2.5 + 2.5(FT) + 0.2(%KPH) + 0.0038 × HCW - 0.32 × REA.
[d]Marbling score: 450 = Slight ^{50}; 500 = Small ^{0}; 550 = Small ^{50}; 600 = Modest ^{0}; etc.

corn steep liquor and 2.7% tallow, and was formulated to contain 13.9% CP, 0.71% Ca, and 0.39% P. The finishing diet also provided 0.4 mg/head/day MGA, 28 g/ton DM Rumensin and 9 g/ton DM Tylan.

Replications of heifers were reimplanted with Revalor-200 (20 mg estradiol, 200 mg TBA) as the common terminal implant 81 days (range 69 to 85) before slaughter. At reimplant time heifers were removed from their pens and immediately weighed to obtain a pen weight. Heifers were then re-vaccinated, individually weighed, and reimplanted prior to being sent back to their home pen for the remainder of the feeding period. Heifers were fed an average of 177 days (range 147 to 202). All pens within a replication were marketed under identical conditions at the same commercial abattoir. Hot carcass weights were recorded on the day of harvest. Carcass fat thickness, longissimus muscle area and USDA called marbling score and yield grades were recorded following a 24 hour chill.

The economic influence of the initial implant treatment on profit/loss returns of heifers sold on a value-based pricing grid was determined based upon the commodity grid proposed by Feuz (*2002 Nebraska Beef Report*, pp. 39-41). Carcass value was calculated based on USDA quality and yield grade, carcass weight and nonconformance (i.e., dark cutters and heavy carcasses). A carcass base price of $109.84/cwt (10 year average dressed weight price) was used for low Choice, yield grade 3 carcasses weighing 550 to 950 lb. Discounts were calculated as: $7 Select; $17 Standard; $25 dark cutters; $15 light (<550 lb) and heavy (>950 lb) carcasses; and $15 yield grades 4 and 5. Premiums were calculated as: $6 Prime; $1.50 upper 2/3 Choice; $1 yield grade 2; and $2 yield grade 1. Ration cost was calculated using 10-year average corn and alfalfa hay price. Non-feed costs were $0.28/head/day yardage, $30/head miscellaneous (medicine, processing, shipping, etc.) and 7% animal and feed interest. Initial animal cost was based upon the 10 year average 600 to 700 lb feeder heifer price of $77.43/cwt.

Animal performance, carcass data and economics were analyzed using the Mixed procedure of SAS for a randomized complete block design where pen served as the experimental unit. Model effects were initial implant treatment, while replication of cattle was treated as a blocking factor and placed into the random statement. Least squares means were separated using the PDIFF statement of SAS.

Results

Data are presented with deads and railers removed from the analysis. Feed intake and head days were adjusted accordingly for the time of removal from the pen. Feed intake was figured according to feedyard close-out information on each individual pen of cattle. Because all heifers received a common terminal

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implant, initial implant treatment will be referenced when comparing treatments.

At reimplant time, initial implant checks were conducted by trained personnel for determination of abscessed, missing, crushed, or cartilage placed implants. Only 2.0 % of heifers administered Revalor-IH and 2.6 % of heifers administered Synovex-H were found to have implants that fell within these criteria. This would indicate that implants were properly administered.

Heifer performance is presented in Table 1 and is expressed on a carcass-adjusted basis using a common dressing percentage (63%). Dry matter intake was similar between treatments. Heifers implanted initially with Revalor-IH tended ($P = 0.10$) to gain faster and had improved feed efficiencies ($P < 0.03$). Carcass merit is shown in Table 2. Revalor-IH implanted heifers had 9 lb heavier ($P = 0.15$) hot carcass weights, with similar dressing percentages, 12th rib fat thickness, and longissimus muscle area when compared to Synovex-H implanted heifers. Empty body fat and USDA Yield grades were similar between treatments indicating heifers were fed to the same body fat end-point. Only calculated yield grades tended ($P = 0.09$) to be higher for heifers implanted with Revalor-IH (2.71 vs. 2.60 for Revalor-IH and Synovex-H, respectively) as a result of heavier hot carcass weights used in the calculation. Total carcasses grading Choice was not different between initial implant treatments. However, heifers administered Revalor-IH had improved ($P = 0.07$) marbling scores with 58% more carcasses ($P = 0.02$) achieving the upper 2/3 category of Choice quality grade. These data suggest that a low-dose combination E + TBA initial implant may improve carcass quality when cattle are fed the same number of days. Presumably, feeding cattle which are implanted initially with a less aggressive implant may be required.

Table 3. Feeding economics of heifers implanted with Revalor-IH or Synovex-H.

	Initial Implant[a]			
Item	Revalor-IH	Synovex-H	SEM	*P* - value
Ration cost, $/ton DM	126.00	126.00	—	—
Initial implant cost, $/head	1.95	0.80	—	—
Initial animal cost, $/cwt[b]	77.43	77.43	—	—
Total misc. cost, $/head[c]	101.36	100.17	—	—
Commodity grid profit(loss), $/head[d]	44.49	30.27	6.5	<0.05

[a]All heifers implanted with Revalor-200 as the common terminal implant.
[b]10 yr average 600 to 700 lb feeder heifer price.
[c]Includes $0.28/day yardage, 7% animal and feed interest, and $30/head misc. cost (processing, health, terminal implant, shipping, etc.)
[d]Calculated using $109.84/cwt carcass base price: discounts = $7 Select, $17 Standard, $15 yield grade 4&5, $25 dark cutter, $15 light & heavy carcasses; premiums = $6 Prime, $1.50 Upper 2/3 Choice, $2 Yield grade 1, $1 Yield grade 2.

The simulated economic analysis of marketing cattle on a value-based carcass merit basis is presented in Table 3. Ration cost was calculated to be $126/ton (DM basis). The added cost of Revalor-IH over that of Synovex-H implants also was included in the analysis. Initial animal cost and total miscellaneous costs were similar between treatments. Heifers implanted initially with Revalor-IH returned $14.22/head more ($P < 0.05$) than those heifers initially implanted with Synovex-H. The higher number of upper 2/3 Choice carcasses along with 9 lb heavier hot carcass weights translated into greater returns for heifers implanted with Revalor-IH.

The relatively large number of cattle grading yield grade 4 or higher would suggest that heifers in the trial may have been fed too long. However, it is not known what implications degree of finish may have on the treatments in this study.

This study provides evidence that Revalor-IH as an initial implant for feedlot heifers appears equal or better in performance to traditional heifer implants (Synovex-H), and does improve marbling, carcasses grading high Choice and feeding economics when heifers are sold on a value-based grid marketing system.

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Wet Corn Gluten Feed and Alfalfa Hay Levels in Dry-Rolled Corn Finishing Diets

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Summary

One hundred ninety-two yearling steers were fed 132 days (June to October) to determine if roughage levels could be reduced in dry-rolled corn finishing diets containing wet corn gluten feed (WCGF) and to evaluate the effects on N volatilization. Finishing diets contained either 0 or 35% WCGF and 0, 3.75, or 7.5% alfalfa hay. Intake, ADG, and carcass weight increased as level of alfalfa hay increased, or when WCGF was fed. Feed conversions of cattle fed 35% WCGF were improved 4.4% compared to conversions of cattle fed no WCGF at 0% alfalfa hay. Within 35% WCGF diets, efficiency decreased as alfalfa hay inclusion increased. Nitrogen loss from pens with cattle fed 0 and 35% WCGF was not different, averaging nearly 80%. These data suggest alfalfa hay can be decreased from conventional levels when diets contain WCGF.

Introduction

Roughages such as alfalfa hay (AH) are used to control acidosis in finishing diets. Typically, finishing diets contain 5-10% roughage (DM basis). However, due to their cost per unit of energy and high potential for shrink, roughages are burdensome in finishing diets. Due to a reduced starch load and the positive attributes of feeding WCGF relative to acidosis, conventional levels of roughage may not be necessary when WCGF is included in finishing diets.

Feeding corn bran has reduced N volatilization during the winter/spring (i.e., November to May) feeding months by increasing OM excretion onto the pen surface (2002 Nebraska Beef Report, pp. 54-57; 2003 Nebraska Beef Report, pp. 54-58). However, decreasing diet digestibility with corn bran may also depress animal performance. The combination of steep liquor and corn bran in WCGF may allow performance to be maintained while helping to reduce N loss by increasing OM excretion onto the pen surface. The objectives of this research were to determine 1) if WCGF can be effectively utilized as an energy source and reduce the need for conventional levels of roughage in dry-rolled corn based diets due to acidosis control, and 2) if feeding WCGF will increase OM excretion onto the pen surface and widen the C:N ratio of manure thereby increasing manure N and reducing N volatilization losses.

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

	0% WCGF			35% WCGF		
AH level, % DM	0	3.75	7.5	0	3.75	7.5
Dry-rolled corn	87.0	83.25	79.5	52.0	48.25	44.5
Wet corn gluten feed[a]	—	—	—	35.0	35.0	35.0
Alfalfa hay	—	3.75	7.5	—	3.75	7.5
Molasses	5.0	5.0	5.0	5.0	5.0	5.0
Tallow	3.0	3.0	3.0	3.0	3.0	3.0
Supplement[b]	5.0	5.0	5.0	5.0	5.0	5.0
Urea	1.23	1.12	1.01	0.21	0.11	—
Nutrient Composition[c]						
CP, %	13.1	13.1	13.1	13.5	13.5	13.5
Ca. %	0.70	0.70	0.70	0.70	0.70	0.70
P, %	0.38	0.38	0.38	0.49	0.49	0.48

[a]Wet corn gluten feed from ADM, Columbus, NE.
[b]Supplement provided 28 g/ton Rumensin and 10 g/ton Tylan (90% air-dry basis).
[c]Crude protein and P were analyzed (after trial), Ca was calculated based on formulation; all are expressed as a percentage of diet DM.

Procedure

Feedlot Experiment

One-hundred ninety two yearling steers (initial BW = 774 $\pm$ 24 lb) were fed 132 days from June to October 2002. Steers were weighed initially on two consecutive days after being limit fed (2% BW) for 5 days to minimize gut fill differences. Cattle were stratified by weight and assigned randomly to 1 of 24 pens (2 x 3 factorial treatment structure; 4 pens/ treatment). Adaptation to finishing diets consisted of a 23-day step-up period where dry-rolled corn progressively replaced AH. Cattle were implanted on day 1 with Synovex-C and re-implanted on day 30 with Revalor-S.

Finishing diets contained either 0 or 35% WCGF (ADM, Columbus, NE) and 0, 3.75, or 7.5% AH (Table 1). Experimental diets were formulated to meet or exceed metabolizable protein requirements (1996 NRC) and be iso-nitrogenous based

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upon the 35% WCGF and 7.5% AH treatment. Urea was used as the supplemental protein source to make diets equal in CP. Upon completion of the feeding trial, cattle were harvested at a commercial abattoir and carcass data were collected. Final weights were calculated from hot carcass weights using a common dressing percentage (63%).

Nutrient Balance

Mass balance for N was conducted as previously outlined (2002 Nebraska Beef Report, pp. 54-57; 2003 Nebraska Beef Report, pp. 54-58). Stocking density in all pens was maintained at 332 ft^2/steer. Throughout the feeding period, feed refusals were collected when necessary to accurately assess DMI. After cattle were removed from pens, manure was scraped and piled into one central pile within each pen. As the manure was being loaded out of pens, manure samples were taken. Manure was weighed on an as-is basis and hauled to the University of Nebraska compost yard.

Manure N was calculated by multiplying manure N concentration by pounds of manure removed (DM) from the pen surface. Soil core N was used to correct manure N for manure left in the pen or soil removed at cleaning. Runoff N was the N concentration of the runoff times pounds of water collected. The manure C:N ratio was calculated by taking amount of manure OM multiplied by 0.49 (assuming OM contains 49% C) and divided by amount of N in the manure.

Nitrogen excretion was determined by difference between N intake and N retention. Nitrogen intake was calculated using analyzed dietary N concentration multiplied by DMI and corrected for N content of feed refusals. Steer N retention was calculated according to the retained energy and protein equations established by the 1996 Beef Cattle NRC. Nitrogen excreted was calculated by subtracting N retention from N intake. Total N lost was calculated by subtracting manure N (corrected for soil N content) and runoff N from excreted N. Percentage of N lost was calculated as N lost divided by total N excretion. All N values were expressed on a lb/steer basis. Phosphorus intake, retention and excretion were calculated similar to N.

Statistical analyses were conducted using the Mixed procedures of SAS. Pen served as the experimental unit. Model effects were AH level, WCGF level and the interaction of the two. Simple effects are expressed when a significant interaction occurred, whereas main effects of AH and WCGF level are expressed when no interaction was observed.

Table 2. Effects of wet corn gluten feed and alfalfa hay on steer performance and carcass characteristics.

	WCGF level			AH level			
Item	0%	35%	*P*-value	0%	3.75%	7.5%	Linear[a]
Final wt., lb[b]	1288	1308	0.09	1279	1308	1308	0.04
DMI, lb/day	23.6	24.6	<0.01	23.1	24.4	24.8	<0.01
ADG, lb	3.90	4.03	0.10	3.81	4.04	4.05	0.03
Marbling score[c]	502	495	0.50	496	496	502	0.63
Ribeye area, sq. in.	13.6	14.3	<0.01	13.6	14.4	13.8	0.57
12th rib fat, in.	0.49	0.54	0.01	0.49	0.51	0.53	0.05
Liver abscesses, %	4.2	3.1	0.73	4.7	4.7	1.6	0.41

[a]*P*-value for linear effect of alfalfa hay level.
[b]Calculated as hot carcass weight ÷ 63% (common dressing percentage).
[c]450 = Slight^{50}, 500 = Small^{0}, 550 = Small^{50}, etc.

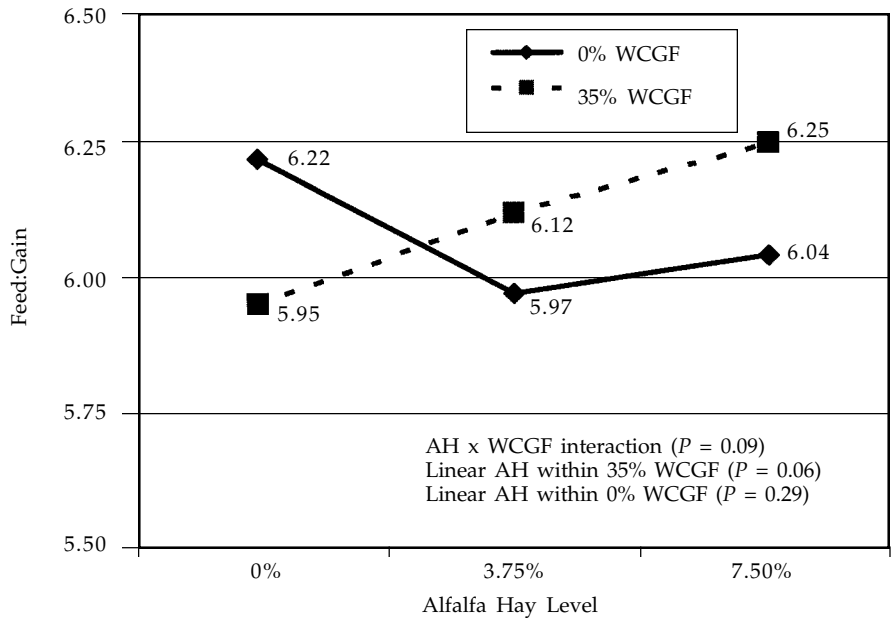

Figure 1. Interaction between alfalfa hay (AH) level and wet corn gluten feed (WCGF) inclusion on feed conversion of feedlot steers.

Results

Steers fed 35% WCGF had a higher DMI ($P < 0.01$) and ADG ($P = 0.10$) compared to those fed no WCGF (Table 2). Ribeye area and 12th rib fat thickness were also greater ($P < 0.01$) for steers fed WCGF. A linear effect ($P < 0.05$) of AH level was observed for DMI and ADG. An interaction occurred between AH level and WCGF inclusion for feed conversion (Figure 1). Feed conversions were not signifi-

Table 3. Effect of alfalfa hay level on N mass balance (values expressed as lb/steer over the entire feeding period).

Item	0% AH	3.75% AH	7.5% AH	SEM	Linear[a]
N intake[a]	65.6	69.3	70.4	0.7	<0.01
N retention[ab]	9.6	10.2	10.2	0.2	<0.05
N excretion[ac]	56.1	59.1	60.2	0.6	<0.01
DM wt. removed	736	814	772	123	0.83
OM wt. removed	143	179	183	16.2	<0.10
Manure N[d]	7.7	9.9	11.5	1.9	0.16
Runoff N	2.60	2.12	2.45	0.22	0.65
N lost[e]	45.8	47.1	46.2	1.8	0.88
N loss, %[f]	81.9	79.8	76.6	3.0	0.23
Manure C:N ratio	8.7	9.1	9.3	0.2	0.05

[a]*P*-value for linear effect of alfalfa hay level.
[b]Calculated using NRC (1996) net protein and net energy equations.
[c]Calculated as N intake — N retention.
[d]Corrected for soil N concentration before and after trial.
[e]Calculated as N excretion — manure N — runoff N.
[f]Calculated as N lost ÷ N excretion.

Table 4. Effect of wet corn gluten feed level on N mass balance (values expressed as lb/steer over the entire feeding period).

Item	0% WCGF	35% WCGF	SEM	*P*-value
N intake	65.9	71.0	0.6	<0.01
N retention[a]	9.8	10.2	0.1	0.10
N excretion[b]	56.1	60.8	0.5	<0.01
DM wt. removed	656	893	100	0.11
OM wt. removed	132	204	13	<0.01
Manure N[c]	8.6	10.8	1.5	0.33
Runoff N	3.05	1.73	0.18	<0.01
N lost[d]	44.4	48.3	1.5	0.08
N loss, %[e]	79.2	79.6	2.5	0.92
Manure C:N ratio	8.8	9.3	0.2	0.02

[a]Calculated using NRC (1996) net protein and net energy equations.
[b]Calculated as N intake — N retention.
[c]Corrected for soil N concentration before and after trial.
[d]Calculated as N excretion — manure N — runoff N.
[e]Calculated as N lost ÷ N excretion.

cantly different ($P > 0.2$) across AH inclusion levels when 0% WCGF was fed; however, feed conversions improved ($P = 0.06$) as AH was removed in diets containing 35% WCGF. This observation suggests AH had less value when diets contained WCGF. Furthermore, feed conversions of steers fed WCGF and 0% AH were improved 4.4% compared to conversions of steers fed no WCGF and 0% AH ($P = 0.10$).

Interactions between AH and WCGF were not observed for feedlot N mass balance; therefore, only main effects of AH and WCGF are shown (Tables 3 and 4, respectively). As level of alfalfa hay increased, N intake, N retention and N excretion increased linearly ($P < 0.05$). Steers fed WCGF consumed and excreted more N ($P < 0.01$) than those fed no WCGF. Amount of N lost (lb/steer) was greater when steers were fed WCGF ($P = 0.08$), but because WCGF fed steers excreted more N, there was no difference in the percentage N loss. When expressed as a percentage of N excretion, loss of N from pens where steers were fed 0 and 35% WCGF was not different, averaging 79.2 and 79.6%, respectively. More manure DM ($P = 0.11$) and OM ($P < 0.01$) were removed from pens with cattle consuming WCGF. The higher OM excretion from steers fed 35% WCGF translated into an elevated manure C:N ratio ($P = 0.02$) as compared to steers fed no WCGF; however, only a numerical increase was observed in the amount of N in manure (8.6 vs. 10.8 lb/steer for 0 and 35% WCGF diets, respectively). Runoff N was greater from pens where cattle were fed no WCGF ($P < 0.01$) compared to those pens where cattle were fed 35% WCGF.

Substituting 35% WCGF in place of dry-rolled corn resulted in a 0.11% increase in dietary P concentration (DM basis). The combination of a higher DMI for WCGF fed steers and greater P concentration in WCGF diets translated into a 4 lb/steer difference in P intake over the 132 day feeding period and a subsequent 3.9 lb/steer increase (42%) in P excretion (data not shown).

These data suggest AH has less value when diets contain WCGF, and can be reduced from conventional levels. Presumably, this effect is due to reduction in ruminal starch load and subsequent reduced ruminal acidosis when dry-rolled corn is partially replaced with WCGF. Previous research has provided evidence that feeding WCGF reduces the severity of acidosis compared with cattle consuming dry-rolled corn (1995 Nebraska Beef Report, pp. 34-36). However, the response to lower AH may change if corn is processed differently.

Loss of N from open feedlots is higher during the summer months than those of the winter/spring months (2003 Nebraska Beef Report, pp. 54-58); therefore, the additional OM excretion from feeding WCGF may not reduce N loss during the summer feeding months. Feeding WCGF will increase the amount of manure removed from pens. Evaluating the effects of feeding WCGF on N losses during the winter/spring months is warranted.

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Prediction of Net Energy Adjuster for Feedlot Cattle When Using the 1996 Beef Cattle NRC Model

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Summary

Data from 277 treatment means in 15 previous beef cattle studies were used to develop equations to predict net energy adjusters throughout the feeding period to better predict gain with the National Research Council's 1996 Nutrient Requirements of Beef Cattle model. Early in the feeding period the net energy adjuster reduces the energy to correct for overprediction of gain and late in the feeding period the net energy adjuster increases energy to correct for underprediction of gain. The average NE adjusters were 0.88 and 1.08 for the beginning and end of the feeding period.

Introduction

The National Research Council's (NRC) 1996 Nutrient Requirements of Beef Cattle model has previously been shown to overpredict gain early and underpredict gain late in the finishing period of beef cattle. Level 1 of the NRC model contains net energy (NE) adjusters that can be used to achieve accurate prediction of gain by altering the net energy values of the diets. Predicting gain accurately is absolutely essential before the protein requirements and supplies can be accurately predicted. Accurate determination of protein requirements are important early in the finishing period to ensure metabolizable protein requirements are met and late in the finishing period to avoid overfeeding protein. The objective of this study was to use previous feeding data from the University of Nebraska to determine equations to accurately predict gain throughout the feeding period.

Procedure

Data from 277 treatment means in 15 previous beef cattle feeding studies were used to develop equations to predict NE adjusters throughout the feeding period. The feeding studies were conducted with calf-feds, short yearlings and long yearlings. Calf-feds were placed on feed in the fall months and harvested in spring (4 studies over 3 years). Short yearlings were placed on feed in late-spring months and harvested in early-fall months (7 studies over 5 years). Long yearlings were placed on feed in early-fall and harvested in the early winter months (4 studies over 2 years).

The feeding studies used had 5-day limit fed initial weights on 2 consecutive days, interim weights, and final weights calculated from hot carcass weights divided by 0.63. Interim weights were shrunk 4%. Daily feed delivery records were used to determine DMI for a pen. Regression analysis using the initial, interim and final weights was used to estimate beginning (first day on feed), midpoint, and ending (last day on feed) weights for each pen. Regression analysis was also used to determine intake for the beginning, midpoint, and end of the feeding period. Data for each pen then were used in the NRC model to determine the NE adjustments needed to obtain the correct daily gains given the observed feed intakes. Actual intake data for each pen also were compared to DMI predicted by the NRC model.

The inputs used in the NRC model were cattle implanted, fed an ionophore, under thermal neutral conditions (68° F and no mud), body condition score of 5, and fed a diet that contained 1.36 Mcal/lb ME. All cattle in the data were steers and were from crossbred cattle with no need to adjust breed maintenance requirement. Mature weight was adjusted for each pen based on fat thickness and hot carcass weight.

Results

Data showed that on average for a feeding study, daily gain is constant through the feeding period. In Figure 1, data for one of the feeding studies is shown. In all feeding studies evaluated, the R^2 was in the range of 0.98 to 0.99. Under our research conditions, these data indicate that cattle gain did not decline throughout the feeding period and this observation is supported by recent serial slaughter data (2004 Nebraska Beef Report, pp. 37-39). Implant programs may prevent the decline in gain throughout the feeding period as they increase mature weight. In this data set, cattle were harvested at about 28% body fat or when finished to Choice grade. Cattle were not overfed in these studies thus data are not available to determine gain when cattle are fed beyond 28% body fat. With gains highly correlated to days on feed, we felt that using regression equations to predict weights at the beginning, midpoint, and end of the feeding period was appropriate.

The fit of DMI on days on feed was not as good. Dry matter intake fluctuated throughout the feeding period and is shown for one feeding study in Figure 2. In all feeding studies evaluated, the R^2 was in the range of 0.08 to 0.61. With this movement in DMI, regressing DMI on days on feed was the best way to

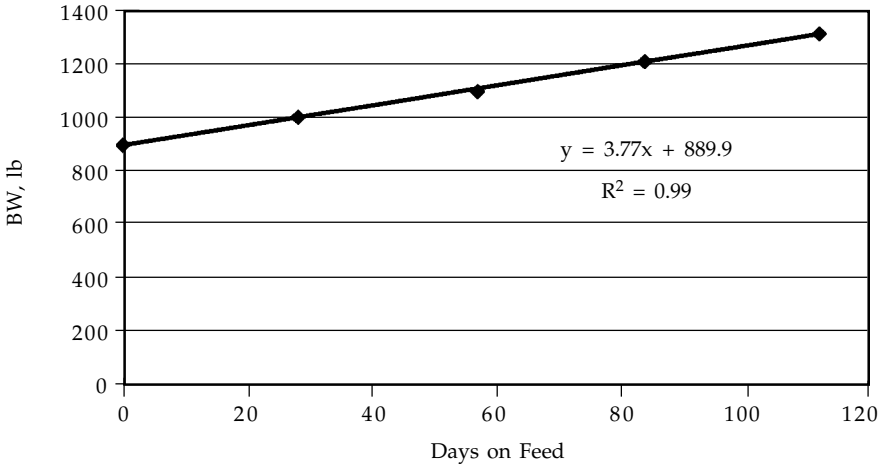

Figure 1. The average body weight for one feeding experiment throughout the finishing period for beef cattle (pens = 20).

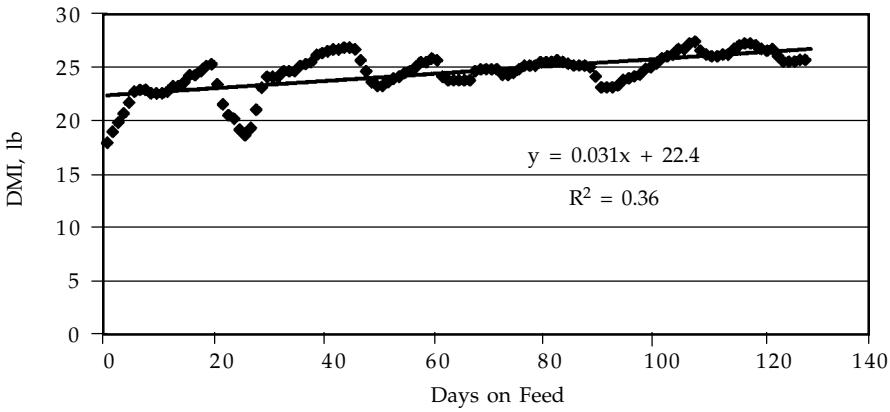

Figure 2. Average dry matter intake for one feeding expermient throughout the finishing period for beef cattle (pens = 17).

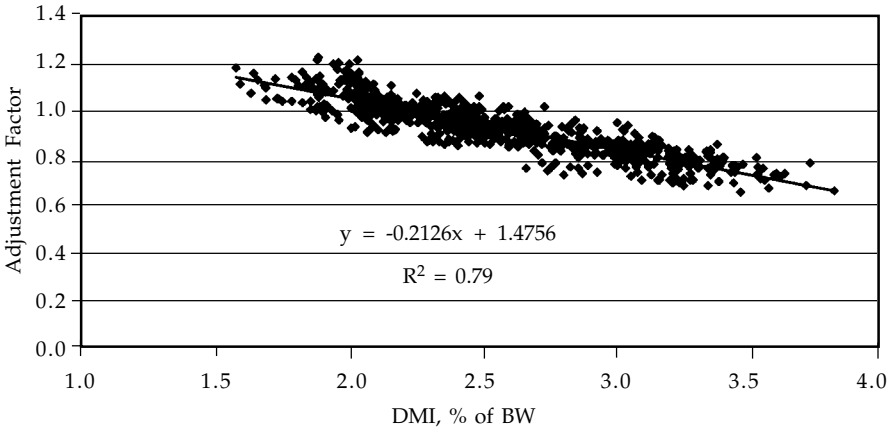

Figure 3. NE_m and NE_g adjustments factors (NRC) related to intake (pens = 277) for all three types of cattle (calf-feds, short yearlings, and long yearlings).

predict feed intake at the beginning, midpoint, and end of the feed period. Also there was variation during the step-up period and the regression equation was able to predict a number for the beginning of the feeding period.

Using the predicted weights and DMI for beginning, midpoint and end, these variables were inputted into the NRC model to get predicted performance and calculate the NE adjuster needed to correct to the observed performance. The NE adjusters were regressed on feed intake as a percentage of BW. The relationship of intake as a % of BW was good (R^2 = 0.79) when all pens were included in the analysis (Figure 3). Analyzing by cattle type as either short yearlings or long yearlings improved the relationships of intake as a % of BW to NE adjuster (R^2 = 0.92 and 0.83, respectively). However, analyzing calf-feds, the relationship of intake as a % of BW to NE adjuster decreased (R^2 = 0.75). This decrease in relationship may be created when thermal neutral conditions are used in the NRC model as it does not account for the increased maintenance requirement that occurs during environmental stress over different years. In Nebraska, cold and muddy conditions occur during the winter/spring months for the calf-fed data. This period may have a larger impact on cattle maintenance requirements than heat stress, as shown with the relationship being greatest for the short yearlings and least for the calf-feds.

In evaluation of the regression equations, the slopes and intercepts did not change between the three types of cattle. Using data from all pens of cattle defined the relationship as: NE adjuster = -0.2126 * DMI (as a % of BW) + 1.4756. Early in the feeding period when there were high intakes as a % BW, the need to adjust energy down occurs to correct the overprediction in gain. The opposite occurs late in the feeding period when low intakes as a % of BW occur and energy must be adjusted up to correct for the underprediction in gain.

Cattle consumed more throughout the feeding period (Table 1), resulting in a worsening in feed conversions from 5.80 at the beginning to 6.90 at the end. Intake as a percentage of BW decreased as the feeding period progresses from 3.0 to 2.1% of BW on average. Both weight and intake increased but

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weight increased at a more rapid rate. As cattle become heavier, the maintenance requirement increases and less of the total feed consumed is going to gain worsening feed conversion. Also as BW increases during the feeding period, the cattle become increasingly fatter. The extra fat explains part of the decrease in intake as a percentage of BW. The cattle were marketed at about 28% fat. The NRC and other literature suggest the cattle were about 15% body fat at the start of the feeding period. If final weights are adjusted to 15% body fat (1083 lb), then intake would be 2.5% of lean BW instead of 2.1% (1278 lb at 28% body fat). Average initial intakes were 3.0% of BW so there still was a reduction in intake (calculated as percentage of lean BW) as the feeding period progressed. In the data set, intakes as % of BW were 3.0% at the beginning of the feeding period, 2.5% at the midpoint of the feeding period, and 2.1% at the end of the feeding period (Table 1). Intake at 2.5% of BW for the midpoint is above commercial feedlot average (2.0% of BW; eMerge Interactive; Weathford, OK). However, the same principles apply as intakes as % of BW decline during the feeding period.

Is intake as % of BW the cause of the change in the NE adjuster from the start of the feeding period to the end? The lower feed intake as percentage of BW potentially would give greater digestion and less subacute acidosis. This may not explain all of the change in NE adjusters from 0.83 at the beginning of the feeding period to 1.04 at the end. There may be an artifact in the development of the original NE system because it was developed with feeding period means and did not directly account for the changes occurring during the feeding period as presented here.

The NE adjuster at the average weight of the cattle was 0.946. Because runs were made assuming thermo-neutral conditions, this value compared to 1.00, probably represents reduced energetic efficiency from some cold stress. If environmental conditions are inputted into the model, then 0.054 needs to be added to the intercept of the NE adjuster equation giving the following equation: NE adjuster = -0.2126 * DMI (as a % of BW) + 1.5296. With this modification, the NE adjuster at the beginning of the feeding period was 0.88 and at the end of the feeding period was 1.08. These values appear to be reasonable guidelines to use even with lower intakes.

Predicted intakes by the NRC compared to those observed with the regression equations for each pen at the beginning, midpoint, and ending of the feeding period had a fair relationship ($R^2 = 0.50$; Figure 4). Our observed intakes were greater than what was predicted by the NRC model. However, compared to industry averages (19.6 lb/day; eMerge Interactive; Weatherford, OK) our DMI appeared to be greater and NRC may be able to predict industry DMI. However, the beginning and end of the feeding period are not well predicted with the NRC model. If the NRC model predictions were accurate, the slope of the line would be 1 and intercept would be 0 and our observed equation has a slope of 0.73 and an intercept of 9.3. Feed intake was underpredicted at the beginning of the feeding period and overpredicted at the end of the feeding period.

Table 1. Summary of means for pens of cattle at the beginning, midpoint, and end of the feeding period.

Item	BW, lb	ADG, lb	DMI, lb/day	NE adjusters	DMI as % BW
Beginning					
Calf-fed	642	3.47	19.9	0.78	3.10
Short yearling	779	3.86	22.7	0.84	2.95
Long yearling	801	4.41	25.0	0.85	3.15
Total	756	3.93	22.8	0.83	3.04
Midpoint					
Calf-fed	945	3.47	21.9	0.95	2.32
Short yearling	1024	3.86	24.6	0.95	2.41
Long yearling	1060	4.41	27.8	0.94	2.63
Total	1017	3.93	24.9	0.95	2.45
End					
Calf-fed	1248	3.47	23.9	1.07	1.92
Short yearling	1268	3.86	26.5	1.04	2.09
Long yearling	1317	4.41	30.5	1.01	2.32
Total	1278	3.93	27.1	1.04	2.12

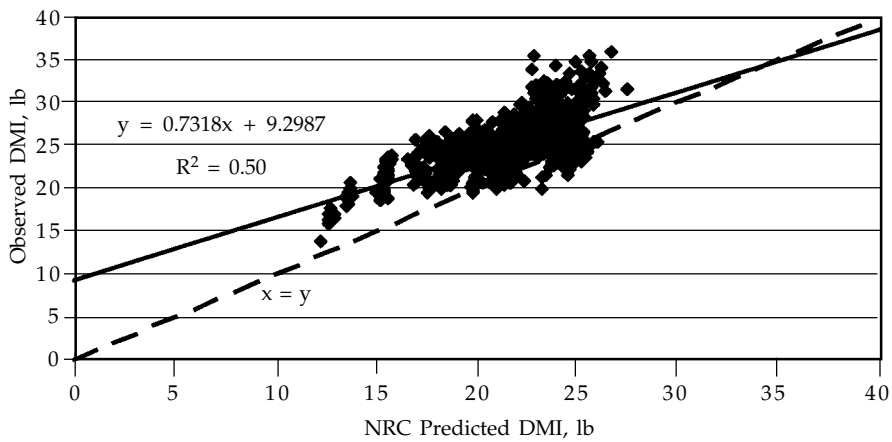

Figure 4. Observed DMI compared to the predicted NRC DMI (pens = 277).

[1]Casey N. Macken, research technician, Rob J. Cooper, former graduate student, Terry J. Klopfenstein, Professor, Galen E. Erickson, Assistant Professor, Animal Science, Lincoln.

[2]Acknowledgments: Shawn Walter at eMerge Interactive for suppling eight years of industry data (P.O. Box 1767, Weatherford, OK 73096; (800) 654-4580).

Vaccination and Direct Fed Microbials as Intervention Strategies for Reduction of *E. coli* O157:H7 in Feedlot Steers

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Summary

A clinical trial was conducted to evaluate effects of two intervention strategies on the prevalence of E. coli O157:H7 shedding by feedlot steers using 384 steers and 48 pens. Intervention strategies were a direct fed microbial or vaccination against E. coli O157:H7. No differences in performance or carcass yield were observed for direct fed microbial or vaccination treatments, compared to the control. Vaccination significantly reduced the prevalence of E. coli O157:H7. In addition, we also observed a non-significant decrease in the prevalence of E. coli O157:H7 with inclusion of the direct fed microbial.

Introduction

Preliminary Nebraska research has indicated inclusion of direct fed microbials such as (Lactobacillus spp.) in the diet of beef animals, may reduce numbers of *E. coli* O157:H7 shed in the feces (Moxley, et al., 2000, unpublished observations; Brashears et al., 2003, Journal of Food Protection 66:748-754). Also, previous research indicated vaccination against *E. coli* O157:H7 type III secreted proteins reduced fecal shedding of this organism in experimentally inoculated cattle (6-month old calves and adult yearlings; Potter, et al., 2001 unpublished observations). Therefore, an experiment was conducted to evaluate effects of vaccination, and or inclusion of a direct fed microbial as intervention strategies on the prevalence and of *E. coli* O157:H7 being shed in the feces.

Procedure

Three hundred eighty-four medium framed steer calves (768 lb) were used in a feedlot finishing experiment. Steers were blocked into three weight groups and stratified by weight within block and assigned randomly into forty-eight pens (8 steers / pen). Pens within each block were assigned randomly to a 2 x 2 factorial treatment design; factors being with or without direct fed microbial (NPC 747) (Nutrition Physiology Corp.), or with or without vaccination treatment. Direct fed microbial product was mixed with water and applied to the feed truck mixing box and fed at a rate of $1x10^9$ colony forming units / steer / day. Steers were fed once daily with the control steers fed with a control feed truck and treatment steers fed with another treatment feed truck to minimize cross contamination. The finishing diet dry matter composition was 55% high moisture corn, 35% wet corn gluten feed, 5%corn silage, 2% alfalfa hay, 2 % supplement, and 1 % water (used to mix the direct fed microbial) (Table 1). Steer weights were taken for two consecutive days at the start of the experiment after a 3-day period of limit-feeding to equalize gut fill. Steers were fed for an average of 121 days. Steers were sampled one block per week in three-week experimental periods, resulting in one pre-treatment period and 5 experimental periods. Rectal fecal grab samples were obtained from each steer in each period. Vaccinations were given three times, beginning with the pre-treatment sampling and twice more during the first two experimental period samplings.

Table 1. *E. coli* O157:H7 intervention experiment finishing diets.

Ingredient (% DM basis)	
Wet Corn Gluten Feed	35.0
High Moisture Corn	55.0
Corn Silage	5.0
Alfalfa Hay	2.0
Supplement[a]	2.0
Water[b]	1.0
Nutrient Composition, % of DM[c]	
Crude Protein	12.5
Calcium	0.7
Potassium	0.7
Phosphorus	0.3

[a]Supplement formulated to deliver 30 g/ton Rumensin® and 10g/ton Tylan® and meet NRC requirements for trace minerals and vitamins.
[b]Used to mix the direct fed microbial.
[c]Calculated from 1996 NRC Model.

All fecal samples were taken immediately to the UNL *E. coli* lab and analyzed for presence of *E. coli* O157:H7 using procedures previously described (Smith, et al., 1999) with modifications. Ten-gram fecal samples were incubated 6 hr in Gram Negative (GN) broth containing vancomycin, cefixime and cefsulodin. An aliquot of culture material was then subjected to immunomagnetic bead separation and plated onto sorbitol-MacConkey agar containing cefixime and tellurite (CT-SMAC). After an 18-24 hr incubation, three non-sorbitol-fermenting colonies were picked and subcultured onto CT-SMAC to ensure purity then were subcultured onto MacConkey and Fluorocult agars. After an 18-24 hr incubation, lactose-fermenting colonies that yielded a negative MUG (4-methylumbelliferyl-β-D-glucuronide) reaction were streaked for isolation on blood agar. After an overnight incubation, one colony per isolate on blood agar was tested for *E. coli* O157 and H7 antigens by latex agglutination. Isolates that

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were positive for O157 antigen, regardless of H7 results, were tested in a 5-primer-pair multiplex polymerase chain reaction (PCR) assay that detected genes for E. coli O157, H7 Shigatoxins 1 and 2, and intimin. Detection of genes for O157, H7 and at least one other target in the assay was considered to be confirmation of an isolate as *E. coli* O157:H7.

Pen was considered the experimental unit, and the performance and proportion of culture-positive animals per pen during the period were the outcomes of interest. *E. coli* O157:H7 data were analyzed on a pen basis using repeated measures in the Mixed procedure of SAS assuming random block and compound symmetry. Performance data were statistically analyzed with the mixed procedures of SAS.

Results

E. coli Results

During the pre-treatment sampling period, the prevalence of *E. coli* O157:H7 was 31.0% (Table 2) and there were no significant (P=.19) differences among treatment groups. Average pen prevalence by treatment and period is summarized in Figure 1. During the experimental periods prevalence varied significantly over time (P=0.01), with period 1 having an overall prevalence of 18.5%. Period 2 declined in overall prevalence with 10.2%. Period 3 was static having an overall prevalence of 11.7%. Prevalence again declined in period four having an overall prevalence of 4.4%. However in period 5 we observed an increase in overall prevalence with 18.8% of the steers being positive at market time. There were no significant interactions between time and treatment.

Table 2. *E. coli* O157:H7 results over time and treatment.

Experiment Periods	Prevalence, %
Pre-Treatment	31.0
Experimental Periods	
Period 1	18.5
Period 2	10.2
Period 3	11.7
Period 4	4.4
Period 5	18.8
Treatment	**Prevalence, %**
Control	21.3
DFM[a]	13.3
Vacc.[b]	8.8
DFM + Vacc.	7.7

[a]DFM = Direct fed microbial treatment.
[b]Vacc. = Vaccination treatment.

Table 3. Steer finishing and carcass performance.

Item	Vacc.[a]	DFM[b]	Vacc.+ DFM	Control	SE	DFM P[c]	Vacc. x DFM[d]
Daily Gain, lb	3.94	4.03	3.94	3.98	.05	0.72	0.70
Feed / Gain	6.20	6.04	6.16	6.15	.07	0.37	0.55
DMI lb/d	24.3	24.3	24.2	24.5	.2	0.39	0.80
Fat, in	0.50	0.50	0.50	0.47	.13	0.81	0.84
Marbling[e]	476	471	477	478	6	0.60	0.47

[a]Vacc. = Vaccination treatment.
[b]DFM = Direct fed microbial treatment.
[c]DFM P = P-value for main effect of DFM.
[d]Vacc by DFM interaction.
[e]Marbling = Marbling score = 400 = Slight^{0}, 450 = Slight^{50}, 500 = Small^{0}, etc.

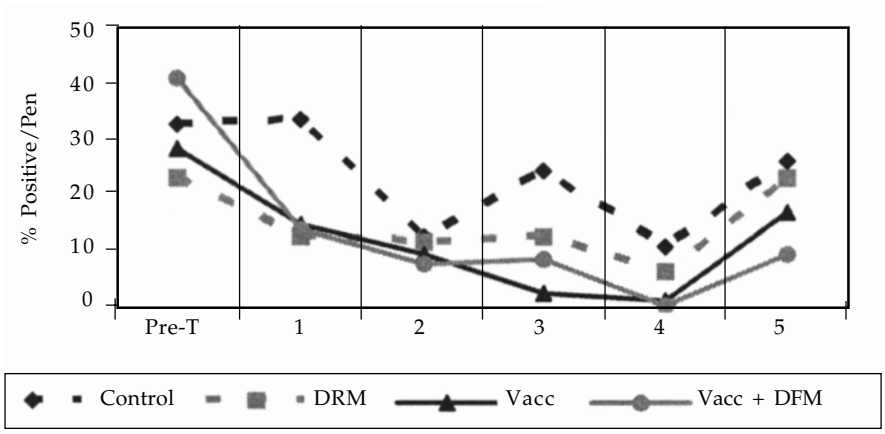

Figure 1. Prevalence of *E. coli* O157:H7 with treatment over time.

Over the five experimental periods, control steers averaged 21.3% (Table 2) positive for *E. coli* O157:H7. Steers treated with direct-fed microbials showed decreased prevalence with 13.3% of the steers positive, but the response was non-significant (P=.21). However, steers vaccinated with three injections of vaccine displayed a significant decrease (P=.03) in prevalence of *E. coli* O157:H7 with an average of 8.8% positive. The addition of the direct fed microbial treatment to the vaccinated cattle showed slight, but not significant improvement with an average prevalence of 7.7%. There was no interaction between vaccination and direct fed microbial.

Finishing Performance

There were no effects of direct-fed microbial or vaccination on any aspect of steer finishing performance or carcass merit (Table 3).

In conclusion, vaccination of steers with three injections of *E. coli* O157:H7 vaccine significantly reduced fecal shedding of *E. coli* O157:H7. We observed a non-significant trend to decrease the prevalence of *E. coli* O157:H7 in cattle feces, with the addition of a direct-fed microbial to the feed. A similar non-significant decrease in prevalence was observed in at least two recent experiments in other research facilities. This suggests the direct-fed microbial is effective in reducing prevalence. Therefore, because we saw no interaction we believe the two intervention strategies may be useful separately or in concert to reduce fecal shedding of *E. coli* O157:H7.

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Reducing Diet Digestibility and Increasing Pen Cleaning Frequency: Effects on Nitrogen Losses and Compost Nitrogen Recovery

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Summary

A finishing trial evaluated effects of diet and management on N losses from open feedlots and compost N recovery. Steer calves were fed in 12 pens from November to May. Nitrogen losses from pens were compared by feeding corn bran (30% diet DM) designed to increase OM excretion and by increasing pen cleaning frequency in a 2 x 2 factorial design. Pens were either cleaned monthly or once at the end of the feeding period. Corn bran negatively affected feed/gain by 8.1% and reduced ADG by 4.4%. Dietary treatment and pen cleaning frequency interacted for N balance in the feedlot. Nitrogen losses from pens decreased and manure N increased for steers fed corn bran if pens were cleaned monthly. Corn bran increased the amount of N remaining in composted manure regardless of cleaning frequency. Feeding corn bran and increasing pen cleaning frequency will reduce N losses from open feedlot pens and increase N recovery in compost.

Introduction

As environmental regulations concerning feedlot operations become more stringent, producers will need cost effective alternatives to become and remain compliant with air and water quality regulations. One alternative to reduce N loss is the manipulation of manure carbon to nitrogen (C:N) ratio. The C:N ratio of manure can be altered via dietary manipulations. Previous research at Nebraska has demonstrated feeding corn bran to reduce dietary digestibility reduces N volatilization losses when fed during the winter/spring months (2002 Nebraska Beef Report, pp. 54-57; 2003 Nebraska Beef Report, pp. 54-58). Another management alternative that may reduce N loss is to clean pens more frequently resulting in less exposure of manure N to surrounding air and subsequent volatilization.

The specific objectives of this research were to: 1) compare the effects of OM addition by feeding less digestible diets on N losses, 2) test the interaction between OM on the pen surface and cleaning frequency on N losses, and 3) determine if increasing pen cleaning frequency of open feedlot pens would decrease N losses from pen surfaces. Our hypothesis is that increasing the C:N ratio of manure by increasing OM excretion will reduce N losses and cleaning pens more frequently may reduce N losses even further.

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

Ingredient	CONTROL	BRAN
High moisture corn	45	45
Dry-rolled corn	30	—
Corn bran	—	30
Corn silage	15	15
Molasses	5	5
Supplement[a]	5	5
Urea	0.83	0.61
Feather meal	0.33	0.29
Blood meal	0.04	0.03
Nutrient composition[b]		
CP	12.7	12.8
DIP	7.9	8.9
P	0.32	0.26
K	0.60	0.60
Ca	0.65	0.65

[a]Weighted average of 2 phases of finishing supplements. Supplement provided 28 g/ton Rumensin and 10 g/ton Tylan (90% air-dry basis).
[b]Crude protein was analyzed, other nutrients were calculated; all are expressed as a percentage of diet DM.

Procedure

Ninety-six steer calves (741 ± 29 lb BW) were fed 166 days from November to May to evaluate impacts of feeding diets designed to increase OM excretion onto the pen surface and pen cleaning frequency on N balance in open feedlots. Treatments (diet and pen cleaning frequency) were arranged in a 2 x 2 factorial design. Steers were weighed initially on two consecutive days after being limit fed (2% BW) for 5 days to minimize gut fill differences. Steers were stratified by weight and assigned randomly to 12 pens (8 head/pen, 3 pens/treatment).

Two dietary treatments were fed (Table 1). One was designed to mimic a "typical" feedlot diet and was dry-rolled and high moisture corn based (CONTROL). The second was designed to increase OM excretion onto the pen surface (BRAN). In this diet, corn bran replaced dry-rolled corn (30% diet DM) in order to reduce diet digestibility. In addition to diets, two pen cleaning frequency treatments were imposed. Pens were either cleaned monthly or once at the end of the 166 day feeding period. Monthly cleanings consisted of four pen cleanings during the feeding period and one at the end, immediately after steer removal, for a total of five cleanings. Pens cleaned once at the

(Continued on next page)

end were cleaned immediately after steer removal upon termination of the study.

Adaptation to finishing diets consisted of a 21 day step-up period. Steers initially were implanted with Synovex-S® and re-implanted with Revalor-S® on day 69. Finishing diets were formulated to meet metabolizable protein requirements to minimize excess protein fed above requirements (NRC, 1996). When steers were visually appraised as being finished, they were marketed at a commercial abattoir and carcass data were collected.

Nitrogen balance was conducted in 12 open feedlot pens as previously described (2002 Nebraska Beef Report, pp. 54-57; 2003 Nebraska Beef Report; pp. 54-58). Upon completion of the feeding period and during monthly pen cleanings, steers were removed from pens and manure was scraped and piled on the pen surface. As manure was removed from one central pile, manure samples were taken. Manure was weighed on an as-is basis immediately and transported to the University of Nebraska compost yard. Nitrogen intake was quantified by accounting for DMI and N concentration of dietary ingredients, corrected for N content of feed refusals. NRC (1996) net protein and net energy equations were used to calculate steer N retention. Nitrogen excretion (urine plus feces) was determined by difference between N intake and N retention. Manure N was calculated by multiplying manure N concentration by pounds of manure removed (DM) from the pen surface. Soil core N and OM were used to correct manure N and OM for manure left in the pen or soil removed at cleaning. Runoff N was the N concentration of runoff times pounds of water collected. Total N lost was calculated by subtracting soil corrected manure N and runoff N from N excreted. All N values are reported on a pound per steer basis. Percentage of N lost was calculated as N lost divided by N excretion. The manure C:N ratio was calculated by taking the amount of manure OM multiplied by 0.49 (assuming OM contains 49% C) and divided by amount of N in the manure. Organic matter values were all calculated in the same manner as N. Using ash as an internal marker, compost N and OM recoveries were calculated by dividing, N and OM in manure after composting, by N or OM removed from the pen at cleaning.

Performance, carcass and nutrient balance data were analyzed as a completely randomized design with pen as the experimental unit. Model effects were dietary treatment, pen cleaning frequency, and interaction of the two. Least squares means were separated using Least Significant Difference method when a significant ($P < 0.10$) F-test was detected. When a significant dietary treatment x pen cleaning frequency interaction was detected, simple effects are presented. Otherwise, main effects of treatment and pen cleaning frequency are presented.

Table 2. Growth performance and carcass characteristics.

Item	CONTROL	BRAN	SEM	P - value
Initial BW, lb	739	742	2	0.27
DMI, lb	22.9	23.7	0.2	0.01
ADG, lb	3.88	3.71	0.03	<0.01
Feed/gain	5.92	6.40	0.06	<0.01
Hot carcass weight, lb	871	856	3	<0.01
Marbling score[a]	520	501	6.7	0.09
Ribeye area, sq. in.	14.3	14.4	0.2	0.84
12th rib fat, cm	0.49	0.46	0.03	0.57

[a]Marbling score: 450 = Slight^{50}; 500 = Small^{0}; 550 = Small^{50}.

Table 3. Nitrogen mass balance (values expressed as lb/steer).

	Monthly Cleaning		End Cleaning			
Item	CONTROL	BRAN	CONTROL	BRAN	SEM	F-test[a]
N intake	80.2[g]	81.3[g]	76.4[h]	81.8[g]	0.8	0.04
N retention[b]	13.1[g]	12.3[h]	12.4[h]	12.1[h]	0.1	0.08
N excretion[c]	67.1[g]	69.1[g]	64.1[h]	69.7[g]	0.8	0.05
Manure N[d]	35.7[g]	50.6[h]	37.2[g]	35.5[g]	1.7	<0.01
Runoff N	1.15	1.00	1.34	0.88	0.09	0.14
N lost[e]	30.3[gh]	17.4[i]	25.5[h]	33.3[g]	1.8	<0.01
N loss, %[f]	45.1[gh]	25.2[i]	39.8[h]	47.9[g]	2.6	<0.01

[a]P-value for interaction between cleaning frequency and dietary treatment.
[b]Calculated using NRC (1996) net protein and net energy equations.
[c]Calculated as N intake - N retention.
[d]Corrected for soil N concentration before and after trial.
[e]Calculated as N excretion - manure N (corrected for soil) - runoff N.
[f]Calculated as N lost ÷ N excretion.
[g,h,i]Means within a row with different superscripts differ ($P < 0.10$).

Results

No interaction between dietary treatment and pen cleaning frequency occurred for feed conversion; therefore, only effects of dietary treatment on performance are presented (Table 2). Feeding corn bran resulted in a reduction in DMI and ADG, compared to CONTROL ($P < 0.01$). Steers fed BRAN were less efficient ($P < 0.01$) than those fed CONTROL, which is in agreement with previous reports (2002 Nebraska Beef Report, pp. 54-57; 2003 Nebraska Beef Report, pp. 54-58). Based on steer performance and dietary ingredient composition, corn bran was estimated to have 73% the net energy of DRC when diets contain 45% HMC. Calves fed BRAN had lighter hot carcass weights than those fed CONTROL ($P < 0.01$). Ribeye area and 12th rib fat were not different between dietary treatments; however, marbling scores of steers fed CONTROL were greater than those fed BRAN ($P = 0.09$).

Nitrogen intake and excretion were similar across treatments except calves fed CONTROL with pens cleaned at the end consumed and excreted less total N than the other treatments ($P < 0.05$; Table 3). However, N retention was rela-

Table 4. Manure and compost nutrient composition (values expressed as lb/steer).

	Monthly Cleaning		End Cleaning			*P*-values[a]		
Item	CONTROL	BRAN	CONTROL	BRAN	SEM	Diet*Clean	Diet	Clean
Manure								
As-is weight removed	3889[de]	5697[f]	3339[d]	4024[e]	260	0.06	<0.01	<0.01
DM, %	64.8	60.6	64.9	52.4	1.8	0.06	<0.01	0.06
DM weight removed	2519[d]	3454[e]	2169[d]	2111[d]	189	0.03	0.05	<0.01
N weight removed[b]	35.7[d]	50.6[e]	37.2[d]	35.5[d]	1.7	<0.01	<0.01	<0.01
OM, %	26.6	29.6	27.8	35.4	3.0	0.47	0.11	0.28
OM removed[c]	739[de]	1200[f]	689[d]	855[e]	60	0.04	<0.01	0.01
C:N ratio	10.1	11.6	9.1	11.8	0.3	0.12	<0.01	0.24
Compost								
N weight[b]	18.0	24.1	15.2	22.4	—	—	—	—
N recovery, %	50.4	47.6	40.9	63.2	—	—	—	—
OM weight[b]	304	385	252	382	—	—	—	—
OM recovery, %	41.1	32.4	36.6	44.7	—	—	—	—

[a]Diet*Clean = interaction between pen cleaning frequency and dietary treatment; Diet = main effect of dietary treatment; Clean = main effect of pen cleaning frequency.
[b]Corrected for soil N concentration before and after trial.
[c]Corrected for soil OM concentration before and after trial.
[d,e,f]Means in a row with different superscripts are different ($P < 0.05$).

tively small when expressed as a percentage of N intake, averaging 16.3 and 15.0% retained N for CONTROL and BRAN, respectively. An interaction occurred between diet and pen cleaning frequency on manure N and N losses from pens. Manure N was greatest with steers fed BRAN and pens cleaned monthly ($P < 0.05$) indicating OM from BRAN along with a more frequent pen cleaning was effective in retaining N. Higher manure N translated into a reduction in N lost when calves were fed BRAN and pens were cleaned monthly. Nitrogen losses were reduced ($P < 0.01$) from 45.1 to 25.2% of N excreted (44% reduction) by feeding BRAN if pens were cleaned monthly. However, if pens were cleaned once at the end, N losses from the pen surface were greater when steers were fed BRAN compared to CONTROL ($P = 0.06$). This was a result of greater N intake and N excretion, yet similar manure N for steers fed BRAN compared to CONTROL. It is not clear why; however, this observation of similar manure N with BRAN feeding contradicts trials with cattle fed during similar times of the year (2002 Nebraska Beef Report, pp. 54-57; 2003 Nebraska Beef Report, pp. 54-58). Runoff N was not different between treatments and accounted for less than 2% of N excreted. Results indicate more frequent cleaning of pens from steers fed BRAN reduced N losses from feedlot pens as opposed to allowing manure to collect on the pen surface during the entire feeding period. It appears that cleaning feedlot pens more frequently interacts with diet to increase N in manure and reduce N losses.

Effects of diet and pen cleaning frequency on DM, OM and C:N ratios of manure removed are presented in Table 4. Interactions existed between diets and cleaning frequency for the amount of DM and OM removed from pens. The C:N ratio of manure was increased with BRAN feeding regardless of pen cleaning frequency ($P < 0.01$). Feeding BRAN resulted in a higher percentage OM in manure ($P = 0.11$), whereas cleaning frequency did not alter OM percentage in manure. The total amount of OM removed was greater from pens with BRAN fed calves compared to CONTROL because of an increase in excreted manure.

Percentage N recovery in compost was similar between CONTROL and BRAN within monthly pen cleaning frequency (Table 4). However, manure N from BRAN fed calves was higher than CONTROL prior to composting, resulting in a 34% greater total N retention in compost from BRAN fed animals. When pens were cleaned at the end, BRAN compost had a 55% greater N recovery than CONTROL compost, resulting in 47% more N in finished compost although manure N prior to compost was not different. The greater N recovery suggests extra OM excreted from steers fed BRAN was effective in lowering N losses during the composting process. Presumably, the extra OM excretion from corn bran has value in "trapping" more N either in manure or compost.

Feeding corn bran will increase OM on the pen surface, thereby increasing the C:N ratio of feedlot manure. Increasing manure OM removal from the pen surface preserves excreted N and prevents volatile N losses from the pen surface (during the winter/spring months) or from composting. If diets lower in digestibility are fed, performance may be compromised. Cleaning frequency of feedlot pens appears to interact with diet and N losses. Feeding corn bran reduced N losses from pens cleaned monthly. Regardless of cleaning frequency, feeding corn bran resulted in more N retained in composted manure. Reduced N losses from the pen surface and/or composting process will reduce environmental concerns related to N and increase the value of manure when utilized as a crop fertilizer.

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Impact of Cleaning Frequency on Nitrogen Balance in Open Feedlot Pens

Casey B. Wilson
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Summary

Pen cleaning frequency of feedlot pens was evaluated during the summer of 2001 and 2002. Dry matter, organic matter and nitrogen recoveries were evaluated on a per head basis. Cleaning pens monthly compared to cleaning at the end of the feeding period resulted in significantly more DM, OM and N recovered. Cleaning pens every month increased N removal by 7.0 lb per steer (49.9% increase) above manure N removed at the end of the feeding period.

Introduction

Nitrogen losses or emissions from animal manure during collection, storage, and application are a concern for air quality, the environment and, potentially, human health. Methods that lower nitrogen (N) losses from manure will be important tools for producers in the future. One potential method to decrease N losses is to minimize protein fed in excess of requirements. By minimizing dietary protein to meet and not exceed requirements, N losses may be decreased (1999 Nebraska Beef Report, pp 60-63). Another potential method to lower N volatilization during manure storage is by manipulating the carbon to nitrogen (C:N) ratio.

Adding carbon to the manure increases microbial N immobilization, which reduces N losses. Carbon can be added in outdoor feedlot pens through bedding or by decreasing diet digestibility (2003 Nebraska Beef Report, pp 54-58). Losses of N with these various methods are not consistent across the year. Our hypothesis is that warm temperatures during the summer months results in rapid volatilization losses. The objective of this experiment was to evaluate pen cleaning frequency and the impact on N volatilization during the summer months when volatilization is the highest and during composting of manure.

Procedure

Cleaning frequency was evaluated during the summers of 2001 and 2002. Either monthly or end cleaning were evaluated. End cleaning refers to cleaning pens at the end of the feeding period. Monthly cleaning was performed every 28 days throughout the feeding period. In 2001, 432 yearling steers in 54 open feedlot pens receiving the same diet were utilized. The diet consisted of 40% wet corn gluten feed, 33% high-moisture corn, 7% alfalfa hay and 5% supplement. In 2002, 384 yearling steers in 48 pens were utilized with all pens receiving the same diet. The diet consisted of 35% wet corn gluten feed, 55% high moisture corn, 5% corn silage, 2% alfalfa hay and 3% supplement. The pen space per steer was equal in both years with 300 square feet per head. Pens were designated in each experiment as monthly cleaning or end cleaning. Within each cleaning frequency collected manure was composted.

Manure collected from pens was sampled at cleaning and weighed. Manure analysis was utilized to evaluate DM, OM and N recovery from the feedlot pen over the entire feeding period.

Nitrogen intake was calculated using dietary N concentration multiplied by DMI. Retained energy and protein equations established by the NRC (1996) were used to calculate steer N retention. Nitrogen excreted (urine plus feces) was determined by subtracting N retention from N intake. Manure N was calculated by multiplying DM removed per head by the percentage N in manure. Total N lost (lb/steer) was calculated by subtracting manure N from excreted N. Due to dry weather, little runoff occurred during either year of this experiment. However, runoff losses are generally small (2003 Nebraska Beef Report, pp 54-58) and were not quantified in these studies. Percentage of N lost was calculated as N lost divided by N excretion. All N values were converted to a lb/steer basis. Results were analyzed using the mixed procedure of SAS. Compost was sampled when composting was finished and OM and N recovery were evaluated based on cleaning frequency. Nitrogen recoveries in the compost were calculated using total ash as an internal marker and the following equation: Nitrogen recovery = 100 x [(% ash before ÷ % ash after) x (% N after ÷ % N before)]. Ash and N concentrations are on a DM basis. Dry matter and OM amounts were calculated similarly assuming no loss of ash, based on amounts removed at cleaning.

Results

The amounts of DM and N removed were increased if pens were cleaned monthly compared to cleaning at the end of the feeding period during summer (Table 1). By cleaning pens every month, N removal was increased 8.7 lb per steer or a 69.0% increase above manure N removed at the end of the feeding period in 2001. Monthly cleaning in 2002 increased manure N removal 5.5 lb per steer or a 34.8% increase above manure N

Table 1. Nitrogen mass balance per head in two years expressed in lb/steer.

	2001				2002			
Item	Monthly	End	SEM	P-value	Monthly	End	SEM	P-value
DM[a]	1464	803	64	<0.01	1529	1103	78	<0.01
OM[b]	440	230	10	<0.01	449	269	10	<0.01
N intake[c]	66.9	66.9	0.4	0.91	56.8	57.7	0.45	0.08
N retention[d]	8.7	8.7	0.1	0.73	8.8	8.4	0.1	<0.01
N excretion[e]	58.2	58.2	0.3	0.97	47.9	49.4	0.4	0.007
N manure	21.3	12.6	0.8	<0.01	21.3	15.8	1.0	<0.01
N loss[f]	36.9	45.6	0.7	<0.01	26.6	33.6	0.9	<0.01
N loss, %[g]	63.6	78.4	1.4	<0.01	55.5	68.0	1.7	<0.01

[a]DM manure recovered per steer over the entire period.
[b]OM manure recovered per steer over the entire period.
[c]Calculated using DMI and N concentration in the diet.
[d]Calculated using NRC (1996) net protein and net energy equations.
[e]Calculated as N intake minus N retention.
[f]Calculated as N excretion minus manure N.
[g]Calculated as N lost divided by N excretion.

Table 2. Compost analysis and nitrogen recovery for 2001 and 2002.

		Before Composting		After composting		
Frequency[a]	Date	N lb/head[b]	OM lb/head[b]	N lb/head[b]	OM lb/head[b]	N recovery
2001						
Monthly	June	5.3	128.3	3.1	67.4	58.8
Monthly	July	5.3	131.1	3.1	52.0	58.6
Monthly	August	4.0	97.8	2.2	32.4	53.6
Monthly	September	7.0	164.1	4.3	69.6	60.8
Total		21.6	521.3	12.7	221.4	58.0[c]
End	September	12.8	281.3	7.6	104.6	59.2
2002						
Monthly	June	4.9	129.6	2.7	50.1	56.5
Monthly	July	5.1	135.2	2.8	49.8	53.8
Monthly	August	5.9	154.2	2.9	54.2	49.0
Monthly	September	5.9	140.0	2.8	60.6	45.9
Total		21.8	559.0	11.2	214.7	51.8[c]
End	September	16.0	339.8	8.8	163.9	55.0

[a]Frequency signifies the pen cleaning frequency either monthly (28 day) or cleaning at the End.
[b]Values before and after composting have N and OM contributed from sawdust addition.
[c]Represents average recovery.

removed at the end of the feeding period. If manure is allowed to collect on pen surfaces during the entire feeding period, more N was exposed to the environment and available for volatilization. Intake of N was similar across treatments in both years ($P < 0.05$). Nitrogen retention in 2002 was lower for the end cleaning treatment than for monthly cleaning. Cattle on the end cleaning treatment consumed similar amounts of DM and gained less weight over the entire summer. Cattle on the end cleaning treatment started at significantly higher BW and had lower ADG. Lower ADG reduced N retention and impacted the total N excretion as well. Less nitrogen retention by steers with lower ADG and higher N intakes than steers on the 28 day cleaning treatment resulted in increased N excretion. Nitrogen excretion during the summer of 2001 was not different between treatments. The cattle allocation and performance were not part of this study. The cleaning frequency treatments were imposed on existing treatment blocks which led to differences in initial BW and ADG. We cannot conclude that cleaning frequency impacted performance. Manure N was significantly different between treatments for both years. Nitrogen loss was significantly higher for the end cleaning treatment than for the monthly cleaning treatment in both years. In conclusion, monthly cleaning was more effective in recovering N in manure and reducing the overall loss from the pen surface. Monthly cleaning reduced the total N loss to the environment by an average of 14%.

Nitrogen recovery percentages were evaluated after composting. N recovery was similar between pen cleaning treatments (Table 2). These data suggest if manure can be collected and windrowed to decrease surface area exposed to the atmosphere, cleaning pens more frequently may be a possible method to increase manure or compost N and decrease N losses. This method may be especially important during warm, summer months when volatilization losses are rapid and large.

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Hydrogen Sulfide Concentration in Vicinity of Beef Cattle Feedlots

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Summary

A field survey of Total Reduced Sulfur (TRS) concentrations in the vicinity of beef cattle feedlots was conducted to compare field observations against current regulatory thresholds. It was observed that TRS levels in the vicinity of beef cattle feedlots are not likely to exceed current regulatory thresholds used by Nebraska. It was further noted concentration of TRS varies with air temperature and time of day. However, wet feedlot surface conditions had almost no impact upon observed TRS concentrations. Feedlots typically do not contribute significant hydrogen sulfide emissions and are unlikely to produce concentrations in excess of current Nebraska Department of Environmental Quality regulatory limits.

Introduction

In 1997, the Nebraska Department of Environmental Quality amended Title 129 Air Quality Regulations to establish a regulatory threshold for Total Reduced Sulfur (TRS) concentrations under ambient conditions. These thresholds are set at "10.0 parts per million (10.0 PPM) maximum 1 minute average concentration or 0.10 parts per million (0.10 PPM) maximum 30-minute rolling average."

TRS emissions, including hydrogen sulfide (H_2S), from livestock systems increasingly are being implicated with community health concerns. The Agency for Toxic Substances and Disease Registry, the federal agency charged with evaluating possible general public health risks form chemicals released at waste sites recently published recommended Minimal Risk Levels for H_2S. An intermediate (15 to 364 day exposure) and an acute (1 to 15 day exposure) inhalation minimum risk level is defined at 30 and 70 ppb daily average exposure, respectively (ATSDR, 1999).

This growing scrutiny prompted a field survey of TRS levels in the vicinity of typical feedlots in central Nebraska. The intent of this research was to:

1. Compare field observations from the vicinity of beef cattle feedlots against current regulatory thresholds for Nebraska (0.1 ppm TRS 1/2 hour average), Minnesota (0.03 ppm H_2S 1/2 hour average), and Iowa (proposed to be 0.07 ppm H_2S 1 hour average);
2. Identify environmental factors that influence TRS concentration.

Procedure

Two Jerome 631-S analyzers with memory were used to survey TRS concentrations at 15-minute intervals approximately 1 meter from the ground surface. To evaluate field observations, Nebraska's 10.0 ppm maximum, 1-minute average concentration and 0.10 ppm maximum, 30-minute rolling average were used to evaluate regulatory compliance. An on-site meteorological weather station (MicroMet Station) was used to collect wind speed, wind direction, air temperature barometric pressure, and relative humidity at 15-minute intervals.

Surveys were conducted on three feedlots for one-week periods under spring, summer and fall conditions during 2000. A perimeter survey was conducted at 0.2-mile intervals on all four township mile lines surrounding the feedlot. Within the feedlot, data were collected at the center point within the feedlot among the animal pens, at the downwind edge of the feedlot, and at the downwind edge of the runoff holding pond. Typically, one Jerome meter was located at the center of the feedlot for the entire week and the second meter was moved among the three locations for two- to three-day intervals.

A second survey was conducted in 2001 to identify environmental factors that increased the emission of TRS. Two 9-week surveys were conducted during the spring (April 4 through June 9) and summer (July 9 through September 12) of 2001 at a single location at the center of one feedlot with one Jerome meter. During the sampling period, on-site weather data were collected at 15-minute intervals and were matched with TRS observations collected at similar time intervals.

Table 1. Summary of TRS[a] observations within three Nebraska feedlots.

	Feedlot #1			Feedlot #2			Feedlot #3					
	Spr	Sum 2000	Fall[c]	Spr	Sum 2000	Fall	Spr	Sum 2000	Fall	Spr 2001	Sum 2001	Total
Center of Feedlot												
TRS > 1.0 (single observ.)	0	0	0	0	0	0	0	0	0	0	0	0
TRS > 0.1 PPM												
Single observations:	7	3	0	17	3	10	1	13	3	3	3	63
Running Average:	6	0	0	17	1	2	0	8	3	0	0	37
3 consecutive observations[b]:	0	0	0	2	0	0	0	0	0	0	0	2
Average TRS concentration[a]	0.010	0.012	0.001	0.028	0.037	0.009	0.006	0.014	0.002	0.006	0.008	
Number of observations	902	320	190	904	683	640	1249	558	854	5803	6115	18,218
Feedlot Edge												
TRS > 1.0 (single observ.)	0	0	0	0	0		0	0				0
TRS > 0.1 PPM												
Single observations:	9	1	0	1	0		0	4				15
Running Average:	9	0	0	0	0		0	6				15
3 consecutive observations[b]:	0	0	0	0	0		0	0.008				0
Average TRS concentration[a]	0.013	0.009	0.005	0.007	0.006		0.008	0				
Number of observations	251	343	496	184	176		118	180				1748
Holding Pond Edge												
TRS > 1.0 (single observ.)	1	0		0	1	0	0	0				2
TRS > 0.1 PPM												
Single observations:	2	2		1	4	0	1	3				13
Running Average:	6	3		0	9	0	3	0				21
3 consecutive observations[b]:	0	0		0	0	0	0	0				0
Average TRS concentration[a]	0.001	0.009		0.009	0.006	0.002	0.012	0.0008				
Number of observations	228	255		355	283	353	283	185				1942

[a]TRS is reported as parts per million H_2S equivalent .
[b]Three consecutive observations at 15-minute intervals would approximate situations where TRS levels exceeded the 0.1 PPM 30-minute average regulatory threshold for Nebraska.
[c]Most observations occurred after a six-inch blowing snow.

Table 2. Summary of daily TRS[1] level relative to rainfall events at feedlot #3 in 2001.

Day	Event 1 April 7 - 16		Event 2 May 1 - 10		Event 3 May 17 - 26		Event 4 May 27 - June 5		Event 5 Aug. 11 - 20		Event 6 Aug. 20 - 29	
	Rainfall (mm)	Average TRS (PPM)	Rainfall (mm)	Average TRS (PPM)	Rainfall (mm)	Average TRS (PPM)	Rainfall (mm)	Average TRS (PPM)	Rainfall (mm)	Average TRS (PPM)	Rainfall (mm)	Average TRS (PPM)
-3	0.4	0.004	0.8	0.007		0.008		0.008		0.007		0.008
-2	0.1	0.003	14.9	0.006		0.007		0.007		0.008		0.008
-1		0.004	5.2	0.006	1.2	0.007	9.6	0.006		0.007		0.007
0	16.0	0.002	72.9	0.004	17.7	0.007	40.4	0.007	26.0	0.009	20.0	0.007
1	5.8	0.003	9.1	0.007		0.007		0.007		0.008		0.007
2		0.003		0.007	0.7	0.007	0.1	0.006		0.005		0.006
3		0.002		0.004		0.006		0.006		0.007		0.006
4		0.003			0.2	0.005	17.9	0.007		0.006		0.007
5						0.007	2.2	0.003		0.005		0.007
6	0.2	0.007				0.008	1.2	0.006		0.008		0.006

[1]TRS concentrations are reported as an H_2S equivalent. See Procedure section.

Results

Perimeter Observations

To determine the impact of feedlot TRS emissions on the community, a survey of neighborhood concentrations was completed on the township mile lines surrounding the feedlot. The average TRS levels at these locations ranged from 0.002 to 0.006 PPM (parts per million by volume) for all three feedlots. The peak observation was 0.030 PPM, well below the regulatory thresholds for Nebraska. The 0.030 PPM reading was observed at a location about one mile from the feedlot and based upon other observations and readings at nearby

(Continued on next page)

locations, it appeared to be an isolated observation not related to the feedlot. Other higher than normal values were from locations directly next to the feedlot facilities. However, the perimeter observations provided no indications of TRS levels that might exceed regulatory thresholds.

About 3,700 observations were made at a location a few meters immediately downwind (based on prevailing winds) from the feedlot and holding pond (Table 1). Only two observations exceeded Nebraska's 10 ppm, 1-minute standard, both at the edge of the holding pond. The 30-minute running averages exceeded Nebraska's 0.1 ppm, 30-minute standard on 36 occasions (15 and 21 occurrences at the edge of the feedlot and holding pond, respectively). However, the calculated running average from this survey was based upon 3 data points and often heavily influenced by a large single observation. No situations were observed where three consecutive readings exceeded Nebraska's 0.1 ppm, 30-minute standard.

Based on observations at the edge of the feedlot and holding pond, few differences were observed among the three feedlots. Average TRS concentrations were similar with most averages being less than 0.01 ppm. Feedlot 1 experienced more single point observations above common regulatory thresholds at the feedlot edge location. Feedlot 2 experienced higher rates of observations above these thresholds at the holding pond edge. However, average TRS concentrations were similar among all three feedlots and all were low relative to regulatory thresholds and ATSDR defined minimum risk levels based upon inhalation.

Feedlot Center Observations

At the center of the feedlot, spikes in TRS concentration that may exceed a property line threshold were common, but sustained levels (30 minute periods) were not. More than 18,200 observations were made at the center of the feedlots. Sixty-three single point observations exceeded a 0.1 PPM level. However, even at the center of the feedlot sustained TRS levels exceeding the 0.1 ppm (2 occurrences or 0.01 % of observations).

Several environmental factors have the potential to impact TRS concentrations. TRS levels increased linearly with air temperature between 0 and 35°C (Figure 1). A 20°C rise in air temperature correlated to a doubling of observed TRS concentration. Increased soil temperatures should contribute to increased soil microbial activity and greater production of volatile sulfur compounds. Soil temperature, not measured in this experiment, would be expected to track changes in air temperature.

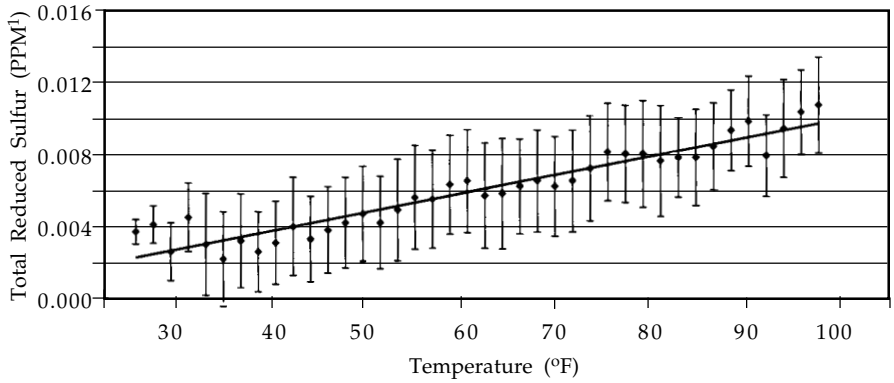

Figure 1. Average TRS concentration (± one standard deviation) vs. Air Temprature for Feedlot #3 during Spring 2001.

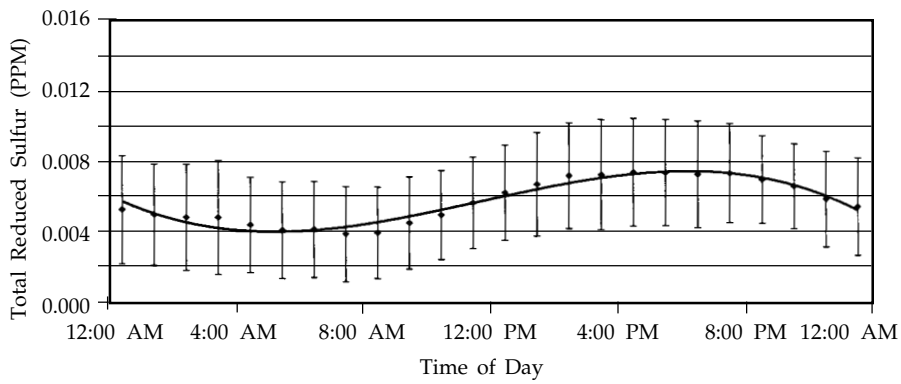

Figure 2. Average TRS concentration (reported as an H_2S equivalent) vs. time of day for feedlot #3 during Spring 2001.

A strong diurnal pattern was observed for TRS concentration (Figure 2). Peak concentrations were observed during mid-afternoon and the lowest concentrations occurred during early morning hours. Afternoon concentrations were approximately twice those observed during the early morning. Several factors will impact daily TRS concentrations.

Soil temperature and animal activity may provide the most plausible explanation of this diurnal pattern. Soil surface temperature, which impacts microbial action and TRS production, would increase during daylight and decline during the night similar to the pattern observed for TRS. Animal activity would tend to increase during the morning hours as a result of feeding practices and during late afternoon and evening

hours as temperatures cool. The late afternoon TRS peak is at a similar time as the late afternoon peak in animal activity. Peaks in animal activity commonly are correlated with feedlot dust emissions (Auverman, 2001). Thus, soil temperature and animal activity are potential factors contributing to the observed diurnal TRS levels at the feedlot's center.

It was anticipated that feedlot surface moisture level would influence TRS concentration. Wet feedlot conditions, conducive to bacterial activity, and anaerobic conditions should result in greater TRS production. Feedlot surface conditions in Nebraska vary dramatically based upon weather conditions. The extended sampling during the spring and summer of 2001 was conducted in hopes of capturing the effects of volatile sulfur production under muddy feedlot surface conditions.

Six rainfall events occurred during the spring and summer 2001 sampling periods. TRS levels between 3 days before and 6 days after significant (>15mm) rainfall events are summarized in Table 2. For much of the early spring 2001, wet feedlot conditions were common. Summer feedlot surface conditions were typically very dry with short wet periods following a rainfall event. The TRS concentration for the days following rainfall events did not rise above the levels observed before or on the day of rainfall events (see Table 2). No increase in TRS levels could be attributed to wet feedlot conditions.

Based upon the observations made in this survey of Total Reduced Sulfur (TRS) concentrations (expressed as a hydrogen sulfide equivalent) in the vicinity of cattle finishing feedlots, the following conclusions were drawn:

- Sustained levels of TRS at the township mile lines and prevailing downwind edge of the feedlot and holding pond above the regulatory thresholds for Nebraska, Iowa (proposed) and Minnesota, were extremely rare. TRS concentration in the vicinity of beef cattle feedlots are unlikely to exceed common regulatory thresholds or health risk levels identified by ATSDR.
- TRS levels increase linearly with increasing air temperature. It is anticipated that warming of feedlot surface is partially responsible for the increased production of TRS.
- A diurnal pattern was observed for TRS concentrations with peak levels occurring in mid-afternoon. This pattern is also likely attributable to varying feedlot surface temperature and possibly animal activity.
- TRS level was not influenced by rainfall events or wind speed. Transiently wet feedlot surface conditions do not appear to increase TRS emissions.

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Crop Performance and Soil Properties of Sites Previously Used for Production of Beef Cattle Manure Compost

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Summary

This study was established on sites that had three or seven years of compost production history. Corn, wheat, barley, sorghum and alfalfa were planted in 2001. In the first year, wheat, barley and sorghum performed better than corn in the windrow areas while alfalfa did not even establish because of excessive salt in the soil. Soil electrical conductivity, K and Na in the 0-6 inch depth under windrows were high and caused soil crusting and poor germination and crop yields. Growing salt tolerant crops, such as barley, can rehabilitate sites used for composting and the process can be accelerated by appropriate field cultural practices.

Introduction

Composting manure is a useful method of producing a stabilized product that can be stored or spread with little odor or fly breeding potential. The other advantages of composting include killing pathogens and weed seeds, and improving handling characteristics of manure by reducing its volume and weight. Composting also has some disadvantages, which include nutrient and C loss during composting, the cost of land, equipment and labor required for composting, and odor associated with composting.

Composting manure on earthen sites can increase nitrate, phosphorus and salt levels in the soil under the compost windrows. When the composting operation is terminated, there is a need to reclaim the sites for agricultural crops. Salt tolerant crops such as barley or wheat can be established for one or two years before the site is ready for alfalfa establishment. Alfalfa has deep roots that can extract nitrate from deeper in the soil profile. The objective of this study was to evaluate soil properties and performance of corn, sorghum, barley, winter wheat and alfalfa on land previously used as composting sites, and to arrive at recommendations on how to best return such composting sites to agricultural production.

Procedure

Two sites identified as 3Y and 7Y had been used for 3 and 7 years of beef cattle manure composting, respectively. Every year, the composted manure was removed from the windrows and replaced with fresh beef cattle feedlot manure on the same area. Prior to initiation of the study in 2001, all compost windrows were removed from the sites. The 3Y and 7Y sites were made into 18 and 14 plots, respectively, with each plot 78 feet long and 15 feet wide). Each plot had length perpendicular to the windrows and inter-windrows and included 3 windrows and 4 inter-windrows. The windrows (12 to 15 feet wide, 300 to 400 feet long, and 4 to 5 feet high) were separated by inter-windrow alleys, 12 to 14 feet wide.

In the spring 2001 prior to disking and planting crops, soil samples from 0-3 feet depth were collected from 7 locations that were 13 feet apart in each plot (4 inter-windrows and 3 windrows). Deep soil samples to 12 feet also were taken from the windrows of three plots for sites 3Y and 7Y. Soil cores were divided into 6 or 12-inch depth increments.

Deep soil samples also were collected from four locations in an adjacent field (300 feet east of site 3Y) that has never been used for composting and could be considered as control. Deep samples were also taken from a site (30 feet south of 3Y) identified as 1Y that had been used for one year of composting. Soil samples were dried and ground and analyzed for K, Na, nitrate and electrical conductivity (EC). Electrical conductivity indicates the salt level in the soil.

Site 3Y and 7Y were assigned to two replications of 9 and 7 cropping sequences, respectively (Table 1). In spring 2001 (after soil sampling), each plot was field cultivated for seedbed preparation before planting. In spring 2002, all

Table 1. Crop sequences on abandon compost sites with a history of 3 and 7 year windrow composting at Mead, NE.

Treatment	Site 3 year Cropping system			Site 7 year Cropping system		
	2001	2002	2003	2001	2002	2003
1	A	A	A	A	A	A
2	B	A	A	B	A	A
3	B	B	A	B	B	A
4	C	A	A	S	A	A
5	C	C	A	S	S	A
6	S	A	A	W	A	A
7	S	S	A	W	W	A
8	W	A	A			
9	W	W	A			

A, alfalfa; B, Barley; C, corn; S, sorghum; W, wheat

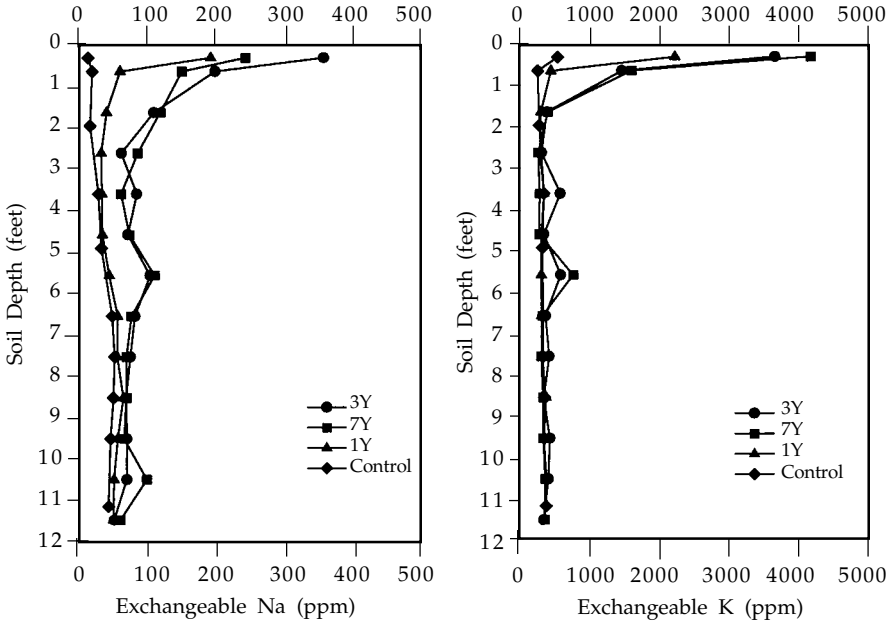

Figure 1. Exchangeable K and Na concentrations in soil under 3 and 7 years of composting beef cattle manure at various soil depths prior to planting crops. Horizontal bars are standard deviations of the means.

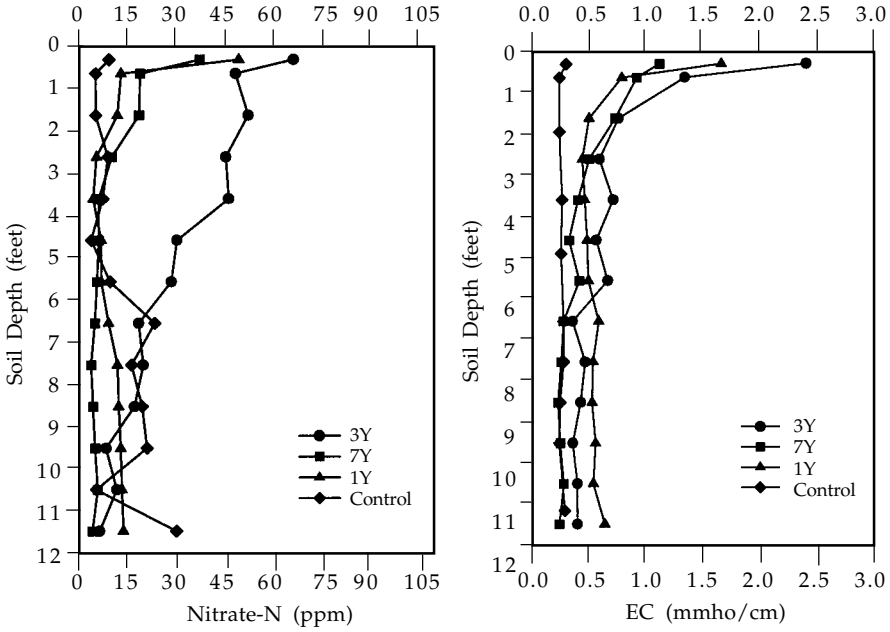

Figure 2. Nitrate-N and electrical conductivity (EC) in soil under 3 and 7 years of composting beef cattle manure at various soil depths prior to planting crops. Horizontal bars are standard deviations of the means.

plots were disked and field cultivated prior to crop planting. Replanting of alfalfa also was conducted to improve alfalfa stands. Each grain crop was planted for either a one- or two-year period. Alfalfa was planted on all plots after the last grain crop was harvested. Both sites were under dryland conditions.

Results

Soil variables

Exchangeable K was similar among the control, 1Y, 3Y and 7Y sites at soil depths > 1 foot (Figure 1). The effect of one year composting was limited within the top 6 inches of soil. The K levels of the 3Y and 7Y were extremely high (>0.35%) in the top 6 inches soil of the compost windrow areas. Soil exchangeable K in the 3Y and 7Y were similar. Sodium leaching in the soil was deeper than K and was to 3 feet soil depth in the 1Y and to 8 feet in the 3Y composting area. Soil exchangeable Na in the first 6-inch depth was higher in the 3Y than the 7Y. The high K and Na contents of the surface soil apparently dispersed the soil and resulted in low crop germination and growth.

Variability of soil nitrate for the 1Y and 3Ysites was high for the first 6-inch depth (Figure 2). Nitrate contents of the control, 1Y and 7Y sites were similar to 6 feet soil depth. Nitrate-N in the control site was higher than the 1Y and 7Y sites for soil depths > 6 feet due to nitrate leaching from applied N fertilizer. Nitrate in the 3Y site was greater than the other sites in the top 6 feet of soil. Analysis of soil stable nitrogen (^{15}N) indicated that the source of nitrate in the deep soil profile of 3Y site was manure, while this was inorganic fertilizer N in the 1Y and control cropland sites.

The EC of the control did not vary with soil depth (Figure 2). The EC of the 1Y did not vary with soil depth beyond 1 foot. The EC level of the 3Y area was higher than other sites to a soil depth of 6 feet.

Soil K, Na, Nitrate-N and EC levels in the windrow areas were significantly higher than those in the inter-windrows at 6 inch depth (Table 2). Extreme levels of K and Na cause soil surface dispersion and crusting, thus hindering seed germination, plant growth, and grain yield. Poor plant growth caused low grain yield in the windrows to less than 50% of those in the inter-windrows in 2001 (Table 3).

Crop response

The grain yields of all crops were reduced in the areas that were under composting windrows compared to inter-windrows areas (Table 3). Corn growth in the windrow areas was severely stunted, as grain yield was only 2.1 bu/acre,

(Continued on next page)

Table 2. Analysis of surface soil (6 inch depth) prior to planting crops for the windrows and inter-windrows of sites used for 3 or 7 years of windrow composting at Mead, NE.

Soil analysis	Windrow (R)	Inter-windrow (I)	R/I ratio
	Site 3 year		
Exchangeable K, ppm	3554 ± 121	2261 ± 91	1.6
Exchangeable Na, ppm	318 ± 14	159 ± 10	2.0
Nitrate-N, ppm	73 ± 15	35 ± 4	2.1
Electrical conductivity, mmho/cm	2.21 ± 0.15	0.92 ± 0.07	2.4
	Site 7 year		
Exchangeable K, ppm	4078 ± 178	3137 ± 180	1.3
Exchangeable Na, ppm	242 ± 12	181 ± 11	1.3
Nitrate-N, ppm	49 ± 7	20 ± 3	2.4
Electrical conductivity, mmho/cm	1.23 ± 0.07	0.77 ± 0.05	1.6

Table 3. Comparison of grain yield of windrow (WR) and inter-windrow (IWR) areas for the first year (2001) and the second year (2002) cropping.

Crop sequence	2001 WR (R)	2001 IWR (I)	2001 R/I	2002 WR (R)	2002 IWR (I)	2002 R/I
	bu/acre			bu/acre		
			Site 3 year composting			
B-B	5.4[b]	18.4[a]	0.29	47.8[a]	48.4[a]	0.99
C-C	2.1[b]	57.2[a]	0.04	61.1[a]	45.8[a]	1.34
S-S[c]	26.0[b]	56.0[a]	0.46	—	—	—
W-W	5.5[b]	22.2[a]	0.25	25.9[a]	23.8[a]	1.09
			Site 7 year composting			
B-B	8.4[b]	20.5[a]	0.40	51.2[a]	55.8[a]	0.92
S-S[c]	14.7[b]	63.5[a]	0.23	—	—	—
W-W	4.8[b]	10.6[a]	0.45	20.4[a]	28.4[a]	0.72

B, barley; C, corn; S, sorghum; W, wheat.
[a,b]Values with different superscripts within each row and each year are significantly different at 0.05 probability level.
[c]Excessive temperature during the reproductive stage and the subsequent diseases reduced the sorghum yield to near zero in 2002.

Table 4. Effect of previous cropping on alfalfa dry matter of the windrows (WR) and inter-windrows (IWR) for the second year (2002) cropping.

Previous crop	Alfalfa dry weight WR (R)	IWR (I)	R/I ratio
	ton/acre		
		Site 3 year composting	
Alfalfa	0.88[a]	1.02[a]	0.87
Barley	1.04[a]	0.95[a]	1.09
Corn	1.15[a]	1.05[a]	1.09
Sorghum	1.14[a]	1.16[a]	0.98
Wheat	0.89[a]	0.90[a]	0.98
		Site 7 year composting	
Alfalfa	0.46[a]	0.52[a]	0.87
Barley	0.46[a]	0.53[a]	0.86
Corn	0.55[a]	0.46[a]	1.21
Wheat	0.66[a]	1.64[a]	0.90

[a]Values with the same superscript within each column and each site are not significantly different at 0.05 probability level.

while grain yield in inter-windrows was 57.2 bu/acre. Barley, wheat and sorghum provided better grain yields than corn in the windrow areas. Alfalfa was not even established in the windrow areas in the first year of planting. Excess salt in the soil as indicated by EC values (Figure 2) negatively influenced alfalfa germination. It must be noted that 2001 was a very dry year.

In the second year of cropping (2002), previous-year plant residue after harvest, fall disking, winter cover-crop, spring disking and spring field cultivation resulted in dilution of K, Na, Nitrate-N and EC, which improved soil surface structure. Yields of grain crops and alfalfa dry matter were similar between the windrows and inter-windrows in 2002 (Tables 3 and 4). Previous-year crops affected alfalfa dry matter equally in 2002 (Table 4). Fall tillage of first-year-crop residue and planting winter cover-crops followed by spring tillage resulted in similar alfalfa yields in the windrows and inter-windrows for plots under all grain crops.

Summary

Significant amounts of nitrate-N can be released when a soil under composting is tilled, and thus crops will be needed to extract this nitrate. Areas used for composting can be rehabilitated by using tillage and growing crops for at least one year before alfalfa can be established to remove excess nitrate deep in the soil profile. Our sites were under rainfed conditions, and when irrigation is available, crop performance can improve. Leaching of K, Na, NO3 and salts (EC) were time dependent and they moved deeper into the soil profile with increasing years of composting. Increased levels of K and Na in the topsoil caused soil dispersion and crusting, poor germination, and lower first-year crop yields. Based on the first-year crop, it seems that barley, wheat or sorghum can be used. Corn does not seem to be a good crop for the first year of cropping after cessation of composting. In the second year of cropping, the grain crops and alfalfa resulted in similar yields in the windrow and inter-windrow areas indicated effectiveness of cropping and field cultural practices in rehabilitating these sites.

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Consumer Preference and Value of Beef with Country-Of-Origin Labeling

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Summary

The 2002 Farm Bill mandates country-of-origin labeling for beef and other items by 2004. A majority (69.2%) of consumers in Denver and Chicago preferred a fresh beef strip steak with a label guaranteeing the meat came from a U.S. animal over an unlabeled steak. On average, consumers were willing to pay 18.7% more ($0.81/lb) for labeled product. When 17 attributes were rated for their desirability when purchasing beef, country-of-origin labeling ranked ninth; "freshness" and "inspected for food safety" were the most popular selection criteria. Food safety concerns were the primary reason consumers preferred beef labeled with country of origin.

Introduction

Many countries require country-of-origin labeling of perishable agricultural products. Until recently, the United States did not. Mandatory country-of-origin labeling for fresh and frozen meat in the United States will be required by Sept. 30, 2004, with the recent passage of the Farm Security and Rural Investment Act of 2002. Meat products may increase in price to alleviate the cost of country-of-origin labeling. This research was conducted to determine the extent to which consumers might prefer country-of-origin labeling in isolation of other beef attributes. It was also designed to learn the relative importance of country-of-origin labeling to other product selection criteria and why consumers might prefer their beef to be so labeled.

Procedure

Consumers in Denver and Chicago who were participating in a larger study involving sensory evaluation of beef completed an attitudinal survey and then visually evaluated two steaks during June and July, 2002. A one-inch thick steak was divided in the center to create two, identical, 1/2-inch thick steaks. The steaks were individually placed on foam trays, cut side up, and overwrapped with oxygen permeable film. The steaks were kept refrigerated and allowed to bloom. One steak remained unlabeled, while a 3.3 x 2.3 inch label, guaranteeing the animal from which the steak was taken was born and raised in the United States, was placed on the other steak. The label contained a red, white, and blue American flag with the words "U.S.A. Guaranteed" across the flag, and "Born and Raised in the United States of America" on the label.

Two hundred seventy-three consumers participated in the study (n = 132 for Denver, n = 141 for Chicago). To qualify for the study, panelists had to be the primary shopper of the household, between the ages of 19 and 60, with no food allergies, and willing to consume beef. A dialogue explaining the design of the evaluation session and auction methods was read to the panelists. A moderator explained to the panelists that both steaks were inspected and passed by the USDA. The moderator clarified the only difference between the steaks was the labeled steak was guaranteed to be born and raised in the United States, while the unlabeled steak may or may not have been born, raised, or both in the United States. A reference price of $7 for an unlabeled steak was given. The panelists were asked to write a hypothetical monetary value they would be willing to pay for the unlabeled and labeled steaks. The steaks were only visually evaluated and not sold in the auction process.

Results

When consumers were asked on a survey if they would be willing to purchase a steak labeled with the country of origin of the animal, 74.7% indicated they would. Surprisingly, 22.3% did not care and 3% claimed to prefer unlabeled over labeled beef. Consumers preferring to purchase a labeled product were asked to indicate why they preferred the label. Their responses were grouped into six categories (followed by the percentage of consumers who made such comments): safety and health of meat (45.0%), freshness of meat (4.5%), meat quality (11.0%), support of producers (21.0%), support of location (12.5%), and general information (31.8%). Concerns about food safety were the primary reason for consumer support of country-of-origin labeling.

Those consumers preferring a labeled product were asked to volunteer how much they would be willing to pay for such information. About 20% were unwilling to pay a premium (Table 1). More than 50% were willing to pay a premium of $0.25/lb or more. This was true whether the product was steak or ground beef. The mean premium for the label was $0.42/lb for the steak

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and $0.36 for the hamburger, which equated to an 11% and a 24% premium, respectively.

Consumers were asked to rank products in the order they would most prefer to have a country-of-origin label. In order of preference, they ranked hamburger, steak, roast, pre-prepared beef products and processed beef products. Given public concern over the safety of ground beef, these results are consistent with the food safety issues identified in their comments.

In the survey, consumers were asked to rate 17 items on their desirability when purchasing beef. Table 2 indicates that "freshness" and "inspected for food safety" were the top two concerns. In ninth place was country-of-origin labeling. This suggests consumers would use country-of-origin labeling information as an indicator of food safety.

The data discussed so far came from the survey. Such data can be used to explore consumer attitudes about topics but cannot be used to actually predict how consumers would respond to country-of-origin labels in the marketplace.

After completing the survey, consumers were shown the two steaks (one with a label and one without) and asked to volunteer a price they might be willing to pay for each package. It should be noted the label provided considerable focus on just the country-of-origin labeling, excluding all of the other criteria consumers often used to make purchase decisions. As such, the data likely inflates the value of the label. It does, however, give another indication of consumer willingness to pay for labeling information.

After viewing the steaks, 69.2% of consumers indicated a willingness to pay a premium for a steak guaranteed to be from an animal born and raised in the U.S.A. This is comparable to the 74.7% who indicated an interest in country-of-origin labeling on the written survey. On average, consumers were willing to pay 18.7% more ($0.81/lb) for labeled product (Table 3).

Table 1. Percentage of consumers willing to pay a voluntary premium for country of origin labeling information on beef.

Premium/lb	Steaks	Ground Beef
No premium	21.2	20.6
$0.10 - $0.20	22.5	28.4
$0.25 - $0.50	34.3	30.9
> $0.50	21.7	19.8

Table 2. Ratings for desirability of characteristics people may look for when purchasing beef, where 1=extremely desirable and 5=not at all desirable.

Rank	Characteristic	Relative rating
1	Freshness	1.23
2	Inspected for food safety	1.45
3	Color	1.60
4	Price	1.72
5	Leanness	1.76
6	High quality grade	1.79
7	Tender	1.86
8	Nutritional value	2.20
9	Country-of-origin label	2.41
10	Marbling	2.43
11	Brand name	2.53
12	Source assurance	2.56
13	Environmentally friendly production methods	2.61
14	Beef raised in your region of the country	2.64
15	Convenience	2.66
16	Fat content	2.75
17	Organic/natural	3.01

Table 3. Auction data (bids, $/lb) for visual evaluation of country-of-origin labeling.

Visual Evaluation	Overall	Chicago	Denver
U.S.A. Label	5.14	5.56	4.69
No Label	4.33	4.53	4.12
Difference	0.81	1.03	0.57
Significance (P-value)	.0001	.0001	.0001

Consumers in Chicago were willing to pay more for labeling information than consumers in Denver.

Advocates for country-of-origin labeling assume consumers want information about the source of their beef and are willing to pay for such information. Our results would agree with this assumption. However, not all consumers placed a higher value on the labeled steak. Nearly one quarter of the consumers (24.2%) were indifferent in their preference for the labeled or unlabeled product, while 6.6% of consumers were willing to pay more for the unlabeled product. Consideration should be given to consumers who are indifferent in their preference or preferred unlabeled steak, as these consumers may be unwilling to pay for country-of-origin labeling.

A majority of consumers appear willing to pay a premium for country-of-origin information. Many appear to use the information as an indication of food safety. By itself, country-of-origin labeling was judged to be intermediate in importance, following issues of freshness and safety.

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Consumer Acceptance and Value of Beef from Various Countries of Origin

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Summary

To determine consumer acceptance and value of beef from various countries, 12 taste panels were conducted in each of two cities. Two pairs of beef strip steaks were evaluated - domestic versus Australian grass-fed and domestic versus Canadian. Consumers gave significantly higher scores for flavor, tenderness and overall acceptability to domestic steaks compared to Australian grass-fed steaks and Canadian steaks. A significantly higher value also was placed on the domestic samples compared to Australian grass-fed steaks ($3.68/lb versus $2.48/lb) and Canadian steaks ($3.95/lb versus $3.57/lb). U.S. consumers preferred and were willing to pay significantly more for domestic steaks than Australian and Canadian steaks.

Introduction

With the increasing trend of global trade, more meat products from various countries are imported into the United States. The imported fresh meat may include grain-finished or grass-finished beef, depending on the country of origin. Flavor differences may exist because of the different production systems and different lengths of cooler aging. Previous research (2001 Nebraska Beef Report, pp. 96-98) showed consumers detected sensory differences and placed greater value on steaks with moderate or modest marbling compared to steaks with slight marbling, even when tenderness was held constant. The following research was conducted to determine sensory differences and consumer value of domestic grain-fed beef steaks compared to steaks from grass-fed beef in Australia and grain-fed beef in Cananda.

Procedure

Steak Preparation

Fresh (unfrozen) Australian grass-fed and Canadian AAA beef strip loins (IMPS #180) were purchased from a beef importing company and domestic strip loins were purchased from a commercial meat plant in Nebraska. Two pairs of loins were compared by each taste panel: 1) Australian grass-fed versus domestic and 2) Canadian versus domestic. To the extent possible, steaks were paired to similar Warner-Bratzler tenderness scores and visual marbling scores to reduce variation within the pair. The aging period varied for each category, due to shipping. The aging period for this study was defined as the time from the vacuum packing date to the date the steaks were frozen for storage. The domestic strip loins were aged for 8 to 11 days to simulate the average storage time of fresh beef from the packing plant to the meat counter. The Australian grass-fed strip loins were aged the longest, for 67 to 73 days. The Canadian strip loins were aged for 24 days. Although the aging times were not consistent, they do reflect actual periods of aging available for these products in the marketplace.

The strip loins were cut into one-inch thick steaks. The first steak was used for marbling score and proximate analysis. The second steak from the anterior end of the loin was used to determine Warner-Bratzler shear value. The third and fourth steaks were evaluated by the taste panels. The remaining steaks were sold in an auction, in which the consumers could participate. After cutting, the steaks were stored in a -8°F freezer. The steaks were shipped frozen via airmail to the host facilities in Denver and Chicago.

Auction Procedures

Immediately before the panel, panelists received a $50 participation payment, which the panelists could use to bid on steaks they tasted. Panelists were not required to bid. However, if panelists chose to bid and won a non-practice auction, the panelist was required to pay for the beef. A dialogue explaining the auction procedure was read. Steaks, approximately one pound, which the panelists bought, were taken from the same strip loin as the taste sample. A reference price of $7/lb was given prior to auctions. One steak from each pair was a binding auction, although the panelists did not know which auctions were binding. The panelist tasted a pair of samples, rated them for several sensory properties, and then submitted silent, sealed bids on each steak.

A variation (the number of winners per sample was randomly assigned) of the Vickery (uniform-price) auction was utilized. An nth

(Continued on next page)

price auction (n = 2, 3, or 4) determined the purchase price, or the amount the winner(s) paid, for the steak. In a 2nd price auction, the second highest bid was the purchase price the highest bidder paid for the steak. For a 3rd price auction, the third highest bid set the purchase price for the steak, and the highest and second highest bidder paid only the price of the third highest bid. The 4th price auction resulted in three winners.

Since the winners of the auctions do not pay the amount they bid, it is in the best interest of the consumer to bid the exact amount he or she is willing to pay for a sample. Consumers who underbid risk the chance of losing the auction, while consumers who overbid risk overpaying for the item. The best strategy is to bid the highest value the panelist is willing to pay for each item.

Three practice auctions were conducted to familiarize the panelists with the auction procedure. The third practice auction had a warm-up sensory sample to familiarize the panelists with the sensory evaluation process and flavor, juiciness and tenderness traits. If a panelist chose to bid "$0" for a sample, the panelist was asked to provide a written explanation of why he or she chose not to bid.

Taste Panels

Taste panel steaks were thawed in a 40°F refrigerator for 24 hours prior to taste panels. The steaks were trimmed of excess fat and cooked to an internal temperature of 158°F on Farberware Open Hearth Broilers (Farberware Co., Bronx, NY). After cooking, the steaks were cut into 0.4 x 0.4 x 1 inch cubes, wrapped in aluminum packets and labeled appropriately. Samples were held in a double broiler at approximately 104°F for 20 minutes or less until served. A single piece of steak was served to each panelist on a labeled plate. Water and unsalted saltine crackers were provided to the panelists to cleanse their palates between samples.

Samples were rated on an 8-point hedonic scale, where 1 = extremely undesirable and 8 = extremely desirable. One sample from the pair was served and evaluated for desirability of flavor, juiciness, tenderness and overall acceptability. The second sample of the pair then was served and evaluated for sensory traits. After both samples had been evaluated for

Table 1. Taste panel ratings[a] for domestic, Australian, and Canadian strip steaks matched by shear force and marbling

Pair	Flavor	Juiciness	Tenderness	Overall Acceptability
Australian	4.58	4.49	4.38	4.34
Domestic	5.67	5.20	5.17	5.37
Difference	-1.09	-0.71	-0.79	-1.03
Significance (P-value)	.01	.01	.01	.01
Canadian	5.64	5.36	5.37	5.49
Domestic	5.94	5.53	5.67	5.79
Difference	-0.30	-0.17	-0.30	-0.30
Significance (P-value)	.01	.09	.01	.01

[a]Taste panel scores (n = 273) were based on an eight-point hedonic scale, where 1 = Extremely undesirable, 2 = Very undesirable, 3 = Moderately undesirable, 4 = Slightly undesirable, 5 = Slightly desirable, 6 = Moderately desirable, 7 = Very desirable, and 8 = Extremely desirable.

Table 2. Auction data[a] for taste panel evaluations for domestic, Australian, and Canadian strip steaks matched by shear force and marbling.

Pair	Bid ($/lb)
Australian	2.48
Domestic	3.68
Difference	-1.20
Significance (P-value)	.01
Canadian	3.57
Domestic	3.95
Difference	-0.38
Significance (P-value)	.01

[a]Consumers (n = 40) who bid $0 for all samples were removed from the bid data set (n = 233).

Table 3. Bids from consumers[a] with different preferences for domestic, Australian grass-fed, and Canadian steaks.

	Preference		
	Australian ($/lb)	Domestic($/lb)	No Preference($/lb)
Australian	3.53	2.03	3.12
Domestic	2.15	4.26	3.05
Difference	1.38	-2.23	0.07
Significance (P-value)	.01	.01	.85
	Preference		
	Canadian ($/lb)	Domestic($/lb)	No Preference($/lb)
Canadian	4.57	2.85	3.67
Domestic	3.20	4.48	3.92
Difference	1.37	-1.63	-0.25
Significance (P-value)	.01	.01	.29

[a]Consumers (n=40) who bid $0 for all samples were removed from the bid data set (n = 233). Preference based on overall acceptability ratings.

sensory traits, the panelists bid on both samples at the same time. At the end of the auction, panelists were informed of the "purchase price" and whether they had won or lost the auction. This procedure was repeated for the remaining pairs of steaks.

The steaks to be sold (which auctions were binding) were announced after the entire taste panel was completed.

Statistical Analysis

All 273 panelists were included in the sensory evaluation portion of the analysis. If a panelist bid $0 per pound for all of the samples, the panelist was removed from the auction portion of the analysis, leaving 233 panelists for the analysis. Differences in sensory panel evaluation and auction data were analyzed using the PROC MIXED procedure of SAS.

Results

Consumers rated domestic beef significantly higher ($P < .01$) than Australian grass-fed beef for desirability of flavor, juiciness, tenderness and overall acceptability (Table 1), even though there were no differences in shear force. The largest sensory difference for the Australian and domestic pair was flavor. Consumers' comments frequently included reference to off-flavors and off-odors, possibly due to the longer aging periods for the Australian samples. Aging beef for 10 days in a study by Xiong et al. (Food Res. Internat., 29:27) caused frequency of off-flavors to double. Since the Australian samples were vacuum-aged for 67 to 73 days during shipping and storage, significant flavors could have developed. The diet of the animal also influences the flavor of beef. Xiong et al. also noted grassy flavors and off-flavors were significantly more pronounced in grass-fed steers than grain-supplemented steers. Higher beef flavor intensity was observed for corn-fed steers than steers finished on grass (J. Anim. Sci., 66:892). Due to the overwhelming predominance of corn-fed beef harvested in Nebraska packing plants, the domestic strip loins were assumed to be corn-fed, possibly influencing the preferred flavor of the domestic steaks. Even though marbling score was matched as closely as possible, the average percent fat for Australian samples was 2.46% less ($P < 0.01$) than the average domestic samples (8.58 versus 6.12%, respectively), which may have influenced higher juiciness scores for domestic samples.

Consumers placed a significantly higher ($P < 0.01$) value on domestic samples than Australian samples (Table 2). On average, consumers were willing to pay $3.68/lb for domestic steaks, while Australian steaks were valued at $2.68/lb. When consumer preference was defined as the highest overall acceptability score within a pair, a majority of the 273 consumers preferred domestic to Australian grass-fed samples. More consumers favored domestic (64.5%) than Australian grass-fed (19.0%) beef; however, 16.5% of the consumers did not have a preference. Consumers were willing to pay significantly for their preference, whether Australian grass-fed or domestic samples (Table 3).

More barley than corn is produced in Canada. Over 14 million metric tons of barley were produced in Canada in 2000 to 2001. Since only 8.23 million metric tons of corn were produced in Canada the same year, the beef from the Canadian supplier was assumed to be barley-fed.

Ratings for desirability of domestic beef flavor, tenderness and overall acceptability were significantly higher ($P < 0.01$) than Canadian beef (Table 1). Significant flavor differences ($P < 0.01$) between domestic and Canadian beef agrees with results from a study (Can. J. Anim. Sci., 78:271) in which barley-fed beef was rated higher for undesirable flavor compared to corn-fed beef. They also agree with results of a trained flavor profile panel that observed corn-fed beef to have slightly, but significantly, better well-balanced and well-blended flavor attributes (J. Anim. Sci., 78:1837), although the magnitude of differences were relatively small. The difference in value between domestic and Canadian samples was not as great as between domestic and Australian samples (Table 2). Consumers valued domestic beef at $3.95/lb, while $3.57/lb was the average bid for Canadian samples. When consumers were divided according to preference (Table 3), 44% of the consumers preferred the domestic samples, while 29.3% favored the Canadian samples; 26.7% of consumers had no preference. Consumers were willing to pay significantly more for their preference.

American consumers favor domestic beef compared to Australian grass-fed or Canadian beef. Overall acceptability and willingness-to-pay for domestic samples were significantly higher than Australian samples and Canadian samples. Different feeding regimes of the countries, various aging periods, or cattle breed may impact the flavor and overall acceptability for Australian grass-fed and Canadian samples. Since a steady supply of corn-fed beef is available to most consumers in the United States, consumers may have become accustomed to and prefer the flavor of corn-fed beef.

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Consumer Acceptance and Value of Wet Aged and Dry Aged Beef Steaks

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Summary

Beef aged in air (dry aging) develops a different flavor profile than beef aged in vacuum bags (wet aging). This research compared wet versus dry aged beef. At similar tenderness and marbling, no differences in desirability or value were found for wet versus dry aged Choice beef. For Prime, wet aged steaks were rated more desirable in flavor, juiciness, and overall acceptability and valued more than dry aged Prime. A significant proportion (27-30%) of consumers preferred dry aged beef and were willing to pay > $1.90/lb more for it. Consumers can detect sensory differences in beef and are willing to pay for their preference.

Introduction

Fresh meat is aged to enhance the palatability of the product. Unique flavors and increased tenderness are common characteristics of aged meat. Whole carcasses, primal cuts, and steaks benefit from aging.

Wet and dry aging are common aging techniques. Meat that is vacuum packaged in a sealed barrier film and held at a temperature above the freezing point of the meat is classified as wet or vacuum aged, which can occur during shipping and storage. Dry aging is the process of aging unpackaged meat in a cooler, while humidity is controlled. Dry aging, while more expensive than wet aging, can also be used for entire carcasses or individual subprimal cuts.

Results differ from studies on the magnitude of difference in sensory traits between wet and dry aging. One study (J. Food Sci., 56:601) showed minute palatability differences between dry and wet aged loins. In another, significantly more beef flavor and dry aged flavor were perceived for steaks dry aged than steaks wet aged (Meat Ind. 30:12). However, wet aged loins resulted in increased juiciness and flavor scores when strip loins were aged (J. Anim. Sci., 61:584; J. Food Sci., 44:140). This research was conducted to compare wet versus dry-aged beef for palatability and value.

Procedure

Steak Preparation

Fresh strip loins (IMPS #180) were purchased unfrozen from Excel Corporation, Schuyler, NE, and from Buckhead Beef, a commercial, dry-aging beef facility in Atlanta, GA. Prime and Choice strip loins from Excel Corporation were vacuum aged in a 4°F cooler for 37 days. Loins were dry aged for 30 days at the aging facility prior to shipping and vacuum aged for 7 days during shipping prior to cutting. Two pairs of loins were matched for taste panels: 1) wet aged Prime versus dry aged Prime and 2) wet aged Choice versus dry aged Choice. The steaks were paired to similar Warner-Bratzler tenderness scores and visual marbling scores to reduce variation within the pair. The aging periods were similar (37days) for each category. The aging period for this study was defined as the time from the vacuum packing date to the date the steaks were frozen for storage.

The strip loins were cut into one-inch steaks. The first steak from the anterior end of the loin was used for marbling score and proximate analysis. The second steak was used to determine Warner-Bratzler shear value. The third and fourth steaks were evaluated by the taste panels. The remaining steaks were sold in an auction, in which the consumers could participate. After cutting, the steaks were stored in a -8°F freezer. The steaks were shipped frozen via airmail to the host facilities in Denver and Chicago.

Auction Procedures

Immediately prior to the panel, panelists received a $50 participation payment, which they could use to bid with. Panelists were not required to bid; however, if a panelist chose to bid and won a non-practice auction, the panelist would pay for the auction from the participation payment. A dialogue explaining the auction procedure was read. Steaks, approximately one pound, which the panelists bought, were taken from the same strip loin as the sample taste. A reference price of $7/lb was given prior to auctions. One steak from each pair was a binding auction, although the panelists did not know which steaks were to be sold. The panelist tasted a pair of samples, then submitted silent, sealed bids on both steaks.

A variation (the number of winners per sample was randomly assigned) of the Vickery (uniform-price) auction was used. A nth price auction determined the purchase price, or the amount the winner(s) pay, for the auction (n = 2, 3, or 4). In a 2nd price auction, the second highest bid was the purchase price the highest bidder paid for the steak. For a 3rd price auction, the

Table 1. Taste panel evaluations ratings[a] for wet aged and dry aged strip steaks matched by shear force and marbling

Pair	Flavor	Juiciness	Tenderness	Overall Acceptability
Dry aged choice	5.77	5.30	5.59	5.56
Wet aged choice	5.91	5.39	5.68	5.72
Difference	-0.14	-0.09	-0.09	-0.16
Significance (P-value)	.18	.37	.38	.09
Dry aged prime	5.70	5.66	5.61	5.55
Wet aged prime	6.08	5.82	6.00	5.94
Difference	-0.38	-0.16	-0.39	-0.39
Significance (P-value)	.01	.10	.01	.01

[a]Taste panel scores (n = 273) were based on an eight point hedonic scale, where 1 = Extremely undesirable, 2 = Very undesirable, 3 = Moderately undesirable, 4 = Slightly undesirable, 5 = Slightly desirable, 6 = Moderately desirable, 7 = Very desirable, and 8 = Extremely desirable.

third highest bid set the purchase price for the steak, and the highest and second highest bidder would only pay the price of the third highest bid. The 4th price auction resulted in three winners.

Since the winners of the auctions do not pay the amount they bid, it is in the best interest of the consumer to bid the exact amount he or she is willing to pay for a sample (J. Finance, 16:8). Consumers who underbid risk the chance of losing the auction, while consumers who overbid risk overpaying for the item. The best strategy is to bid the highest value the panelist is willing to pay for each item.

Three practice auctions were conducted to familiarize the panelists with the auction procedure. The third practice auction had a warm-up sensory sample to familiarize the panelists with the sensory evaluation process and flavor, juiciness and tenderness traits. If a panelist chose to bid "$0" for a sample, the panelist was asked to provide a written explanation of why he or she chose not to bid.

Taste Panels

Taste panel steaks were thawed for 24 hours before taste panels in a 40°F refrigerator. The steaks were trimmed of excess fat and cooked to an internal temperature of 158°F on Farberware Open Hearth Broilers (Farberware Co., Bronx, NY). After cooking, the steaks were cut into 0.4 x 0.4 x 1 inch cubes, wrapped in aluminum packets and labeled appropriately. Samples were held in a double broiler at approximately 104°F for 20 minutes or less until served. A single piece of steak was served to the panelists on a labeled plate. Water and unsalted, saltine crackers were provided to the panelists to cleanse their palates between samples.

Samples were rated on an 8-point hedonic scale, where 1 = extremely undesirable and 8 = extremely desirable. One sample from the pair was served and evaluated for desirability of flavor, juiciness, tenderness and overall acceptability. The second sample of the pair was then served and evaluated. After both samples had been evaluated for sensory traits, the panelists bid on both samples at the same time. The panelists were informed of the "purchase price" and if they had won or lost the auction. This procedure was repeated for the remaining pairs of steaks.

The steaks to be sold were announced after the taste panel was completed. Panelists who had won the auction remained to pay for their steaks and were given change and a receipt, if needed.

Statistical Analysis

All 273 panelists were contained in the sensory evaluation portion of the analysis. If a panelist bid $0 per pound for all the samples, the panelist was removed from the auction portion of the analysis, leaving 233 panelists for the auction portion of the analysis. Differences in sensory panel evaluation and auction data were analyzed using the PROC MIXED procedure of SAS.

Results

No significant differences for flavor, juiciness, tenderness and overall acceptability were detected between dry aged Choice strip loins and wet aged Choice strip loins (Table 1). This agrees with results by Parrish et al. (J. Food Sci., 56:601), who reported minute differences in juiciness, flavor intensity, and flavor desirability between 21 day dry and wet aged loins. Consumers valued the wet aged Choice numerically, but not significantly, over the dry aged Choice steaks by $0.25/lb (Table 2). The average value for wet aged Choice and dry aged Choice samples were $3.82/lb and $3.57/lb.

Wet aged Prime strip loins were rated significantly higher ($P < 0.01$) for flavor, tenderness and overall acceptability than dry aged Prime strip loins (Table 1). Even though the strip loins in a pair were matched to similar marbling scores ($P > 0.05$), the fat content of the wet aged Prime steaks was significantly higher ($P < 0.01$) than the dry aged Prime steaks. The 4.6% higher fat content in the wet aged Prime steaks (16.16 versus 11.56%, respectively) could account for higher juiciness rating. Consumers in this study valued wet aged Prime strip loins significantly higher than dry aged Prime strip loins (Table 2). Consumers placed a value of $4.02/lb for wet aged Prime steaks and $3.58/lb for the dry aged Prime steaks.

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When consumers were grouped according to their preference (sample in the pair with the highest overall acceptability score), 39.2% of consumers preferred wet aged Choice, 29.3% preferred dry aged Choice, and 31.5% of the consumers had no preference. Consumers who preferred the dry aged Choice steaks were willing to bid a $1.99/lb premium ($P < 0.01$) for their preference, while consumers with a preference for wet aged Choice steaks were willing to bid $1.77/lb more ($P < 0.01$) for wet aged Choice samples (Table 3). Although more consumers preferred wet aged Prime steaks (45.8%), 27.5% of the consumers preferred the dry aged Prime steaks, and 26.7% did not indicate a preference in the pair of steaks. Consumers paid $1.92/lb more for their preference (Table 3), whether wet aged or dry aged.

Dry aging beef is an expensive method, requiring extra storage time and yield loss due to evaporation. Results from this study indicate consumers who prefer dry aged beef are willing to pay more for the dry aged steaks. Since wet aged beef usually is consumed by the average consumer, consumers may not be accustomed to the unique flavor profile of dry aged beef. While the market exists for dry aged beef, the less expensive alternative of wet aging may be more economical with acceptable sensory qualities.

Table 2. Auction data[a] for taste panel evaluations of wet aged and dry aged steaks matched by shear force and marbling.

Pair	Bid ($/lb)
Dry aged choice	3.57
Wet aged choice	3.82
Difference	-0.25
Significance (P-value)	.12
Dry aged prime	3.58
Wet aged prime	4.02
Difference	-0.44
Significance (P-value)	.01

[a]Consumers (n = 40) who bid $0 for all samples were removed from the bid data set (n = 233).

Table 3. Consumers' bids based on overall preference placed on wet aged or dry aged strip steaks.

	Prime		
	Dry Aged ($/lb)	Preference Wet Aged ($/lb)	No Preference ($/lb)
Dry aged	4.75	2.93	3.33
Wet aged	2.76	4.70	3.53
n	80	107	86
Significance (P-value)	.01	.01	.41
Percentage of total	29.3	45.8	26.7
	Choice		
	Dry Aged ($/lb)	Preference Wet Aged ($/lb)	No Preference ($/lb)
Dry aged	4.38	2.99	4.14
Wet aged	2.46	4.91	4.04
n	75	125	73
Significance (P-value)	.01	.73	.01
Percentage of total	27.5	45.8	26.7

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Cow Muscle Profiling: A Comparison of Chemical and Physical Properties of 21 Muscles from Beef and Dairy Cow Carcasses

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Summary

About 43% of the meat from cow carcasses is sold into the boxed beef trade. This research was conducted to compare muscles from beef and dairy cows in an effort to identify optimal uses for cow muscles. Twenty-one muscles from beef and dairy cow carcasses were analyzed for objective color, total heme-iron, total collagen, pH, expressible moisture and proximate composition. Wide variation was observed for all properties measured. Effects of breed type on all measured traits were minimal except in the case of percent moisture. These results indicate muscles from beef and dairy cows are similar in chemical and physical properties. Opportunities exist to upgrade the value of selected cow muscles.

Introduction

Market cows and bulls represent an estimated 25% of the nation's beef production. Nearly 68% of the non-fed cow population consists of beef cows while just over 31% are dairy cows. Previous research has revealed that 43% of the cow carcass is sold as boxed beef, the remaining 57% being merchandised primarily as beef trim for grinding and processing. Though palatability of beef from mature animals has been studied, little research has been performed evaluating chemical and physical properties of a wide variety of muscles from both beef and dairy cow carcasses. Earlier studies have compared carcass traits and meat palatability of beef from animals of beef and dairy breeds. However, research comparing the chemical and physical properties of numerous muscles from both beef and dairy cow carcasses is scarce. Therefore, the objectives of this study were to determine the chemical and physical properties of muscles from beef and dairy cow carcasses and to determine effects of breed type, 12th rib fat thickness, muscling level and skeletal maturity on these properties.

Procedure

One hundred and forty-five cow carcasses (74 beef and 71 dairy) were selected over a 5-month period in 4 geographic locations (Green Bay, WI, Gering, NE, Phoenix, AZ, and Central, FL). Carcasses of a similar weight class were selected based upon breed type (beef or dairy), 12th rib fat thickness (< .1 inch > .1 inch), muscling level (heavy/medium or light) and skeletal maturity (C/D or E). Approximately 5 carcasses were selected for each breed type-fat thickness-muscling level-skeletal maturity combination, of which 21 muscles per carcass were harvested for analysis (see Table 1 for muscle abbreviations). Muscles from 2 carcasses were evaluated for objective color using a Hunter Lab[7] Mini Scan XE plus colorimeter with a 1-inch port. Chemical analysis was performed on muscles from 3 carcasses per cell. A pH meter with spear tip combination electrode was used to determine muscle pH. Water holding capacity was determined as expressible moisture and was measured as the percentage of moisture loss due to centrifugation. Muscle total collagen content is related to the amount of hydroxyproline found in a given muscle

Table 1. Muscle names and three letter abbreviations

Adductor	ADD
Biceps femoris	BIF
Complexus	COM
Deep pectoral	DEP
Gluteus medius	GLM
Infraspinatus	INF
Latissimus dorsi	LAT
Longissimus dorsi	LOD
Multifidus/Spinalis dorsi	MSD
Psoas major	PSO
Rectus femoris	REF
Semimembranosus	SEM
Semitendinosus	SET
Serratus ventralis	SEV
Supraspinatus	SUP
Teres major	TER
Tensor facia latae	TFL
Triceps brachii	TRB
Vastus intermedius	VAT
Vastus lateralis	VAL
Vastus medialis	VAM

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Table 2. Least square means and standard errors for objective color, total heme-iron, and total collagen of beef and dairy market cow muscles.

	L*		a*		b*		Heme-iron, ppm		Total Collagen, mg/g	
Muscle[1]	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
ADD	35.46^{nopq}	(0.59)	30.38^{m}	(0.37)	23.42^{m}	(0.44)	36.67^{mn}	(1.28)	7.65^{mnop}	(1.07)
BIF	35.64^{no}	(0.59)	29.38^{mnop}	(0.37)	22.69^{mnop}	(0.44)	32.90^{opqrs}	(1.28)	12.28^{s}	(1.07)
COM	33.93^{pqrst}	(0.59)	28.98^{opqr}	(0.37)	21.67^{opqr}	(0.44)	35.75^{mnop}	(1.27)	10.69^{qrs}	(1.07)
DEP	34.35^{opqrs}	(0.59)	28.07^{rst}	(0.37)	21.24^{rst}	(0.44)	20.60^{rst}	(1.29)	10.36^{pqrs}	(1.07)
GLM	32.60^{t}	(0.59)	28.34^{qrst}	(0.37)	21.66^{qrst}	(0.44)	35.14^{mnopq}	(1.31)	11.81^{s}	(1.03)
INF	32.70^{t}	(0.58)	30.04^{mn}	(0.37)	23.42^{mn}	(0.44)	35.70^{mnop}	(1.27)	21.66^{u}	(1.07)
LAT	33.10st	(0.60)	27.87^{stu}	(0.38)	20.35^{stu}	(0.45)	31.21^{rst}	(1.32)	8.55^{mnopqr}	(1.17)
LOD	34.75^{opqr}	(0.58)	28.44^{opqrst}	(0.37)	21.96^{opqrst}	(0.44)	30.21st	(1.27)	9.75^{mn}	(1.03)
MSD	32.40^{t}	(0.59)	28.79^{opqrs}	(0.37)	21.74^{opqrs}	(0.44)	37.43^{m}	(1.28)	15.60^{t}	(1.07)
PSO	35.38^{nopq}	(0.59)	26.92^{u}	(0.37)	20.21^{u}	(0.44)	32.75^{opqrs}	(1.34)	6.08^{m}	(1.07)
REF	35.50^{nop}	(0.59)	29.45^{mno}	(0.37)	22.65^{mno}	(0.44)	31.74^{qrs}	(1.29)	8.63^{mnopqr}	(1.03)
SEM	33.39^{rst}	(0.58)	29.01^{opqr}	(0.37)	22.31^{opqr}	(0.44)	32.22^{pqrs}	(1.29)	7.78^{mnopq}	(1.03)
SET	38.43^{m}	(0.59)	28.67^{opqrs}	(0.37)	22.19^{opqrs}	(0.44)	27.64^{t}	(1.28)	8.56^{mnopqr}	(1.12)
SEV	33.85^{qrst}	(0.60)	30.12^{mn}	(0.38)	23.47^{mn}	(0.45)	35.98^{mno}	(1.28)	9.75^{opqrs}	(1.07)
SUP	34.04^{opqrst}	(0.61)	29.33^{nopq}	(0.38)	22.23^{nopq}	(0.46)	34.12^{mnopqr}	(1.28)	10.95^{rs}	(1.17)
TER	36.58^{n}	(0.59)	28.23^{rst}	(0.37)	21.20^{rst}	(0.44)	30.85^{rst}	(1.34)	10.09^{pqrs}	(1.12)
TFL	33.22^{rst}	(0.59)	27.62^{tu}	(0.37)	20.45^{tu}	(0.44)	30.58^{rst}	(1.31)	8.24^{mnopqr}	(1.07)
TRB	32.95st	(0.59)	29.40^{mnop}	(0.37)	22.87^{mnop}	(0.44)	36.95^{m}	(1.28)	9.66^{nopqrs}	(1.07)
VAL	34.54^{opqrs}	(0.58)	28.40^{pqrst}	(0.37)	21.66^{pqrst}	(0.44)	33.32^{nopqrs}	(1.28)	6.98^{mno}	(1.03)
VAM	33.03st	(0.60)	27.76^{stu}	(0.38)	21.31^{stu}	(0.45)	36.63^{mn}	(1.28)	6.15^{m}	(1.03)
VAT	35.40^{nopq}	(0.59)	28.99^{opqr}	(0.37)	22.37^{opqr}	(0.44)	37.12^{m}	(1.29)	9.34^{nopqrs}	(1.07)

[1]Refer to Table 1 for muscle abbreviations.
Values in the same column having different superscripts are significant at $P < 0.05$ level.

Table 3. Least square means and standard errors for pH, expressible moisture, and proximate composition of beef and dairy market cow muscles.

	pH		Expressible Moisture, %		Moisture, %		Fat, %		Ash, %	
Muscle[1]	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
ADD	5.64^{tu}	(0.03)	47.19^{m}	(0.70)	74.78^{pq}	(0.25)	3.57^{qrs}	(0.29)	1.61^{m}	(0.04)
BIF	5.68^{tu}	(0.03)	43.32^{qr}	(0.70)	74.56^{qr}	(0.25)	4.62^{p}	(0.29)	1.54^{mno}	(0.04)
COM	5.92^{pq}	(0.03)	41.74^{stuv}	(0.70)	74.85^{pq}	(0.26)	4.88^{p}	(0.29)	1.36^{tuvw}	(0.05)
DEP	5.67^{tu}	(0.03)	42.88^{rstuv}	(0.70)	75.80^{mno}	(0.25)	3.66^{qr}	(0.29)	1.46^{nopqrst}	(0.04)
GLM	5.67^{tu}	(0.03)	46.30^{mno}	(0.70)	73.71^{s}	(0.25)	5.28^{op}	(0.29)	4.57^{mn}	(0.04)
INF	6.06^{n}	(0.03)	40.96^{uv}	(0.70)	73.85^{s}	(0.26)	5.88^{no}	(0.29)	1.25^{wx}	(0.05)
LAT	5.83^{rs}	(0.03)	43.06^{rst}	(0.73)	76.25^{mn}	(0.27)	3.20^{qrst}	(0.29)	1.43^{opqrstu}	(0.05)
LOD	5.63^{tu}	(0.03)	44.70^{opqr}	(0.69)	73.64^{s}	(0.26)	4.89^{p}	(0.30)	1.52^{mnopqr}	(0.05)
MSD	6.09^{n}	(0.03)	37.42^{w}	(0.70)	72.24^{t}	(0.27)	8.61^{m}	(0.29)	1.20^{x}	(0.05)
PSO	5.77^{s}	(0.03)	44.76^{opqr}	(0.71)	73.70^{s}	(0.25)	6.32^{n}	(0.29)	1.53^{mnopq}	(0.04)
REF	5.85^{qrs}	(0.03)	43.97^{qr}	(0.69)	75.61^{no}	(0.25)	3.40^{qrs}	(0.29)	1.38^{stuv}	(0.04)
SEM	5.60^{u}	(0.03)	46.82^{mn}	(0.70)	74.63^{qr}	(0.25)	3.79^{q}	(0.29)	1.57^{mn}	(0.04)
SET	5.69^{t}	(0.03)	45.07^{nopq}	(0.70)	75.63^{no}	(0.25)	2.84st	(0.29)	1.33^{uvw}	(0.04)
SEV	6.01^{no}	(0.03)	40.81^{v}	(0.70)	73.99^{rs}	(0.26)	6.33^{n}	(0.29)	1.29^{vwx}	(0.05)
SUP	5.96^{op}	(0.03)	42.93^{rst}	(0.70)	76.27mn	(0.26)	3.66^{qr}	(0.29)	1.44^{opqrstu}	(0.05)
TER	5.90^{pqr}	(0.03)	46.32^{mno}	(0.71)	76.35^{m}	(0.25)	3.31^{qrst}	(0.29)	1.41^{qrstuv}	(0.04)
TFL	5.78^{s}	(0.03)	41.12^{tuv}	(0.70)	74.59^{qr}	(0.25)	4.74^{p}	(0.29)	1.42^{pqrstu}	(0.04)
TRB	5.78^{s}	(0.03)	44.16^{pqr}	(0.70)	75.46^{op}	(0.26)	3.57^{qrs}	(0.29)	1.50^{mnopqrst}	(0.05)
VAL	5.78^{s}	(0.03)	45.92^{mnop}	(0.70)	75.75^{mno}	(0.25)	2.89^{rst}	(0.29)	1.53^{mnop}	(0.04)
VAM	5.93^{opq}	(0.03)	43.69^{qr}	(0.70)	77.11^{m}	(0.26)	2.55^{t}	(0.29)	1.40^{qrstuv}	(0.05)
VAT	6.30^{m}	(0.03)	43.39^{qr}	(0.70)	75.89^{mn}	(0.26)	7.45^{p}	(0.29)	1.40^{rstuv}	(0.05)

[1]Refer to Table 1 for muscle abbreviations.
Values in the same column having different superscripts are significant at $P < 0.05$ level.

sample. Hydrochloric acid is added to a sample and subjected to a combination of high pressure and heat to denature the proteins in the sample. Hydroxyproline content then is assayed using a spectrophotometer. Total collagen content is expressed as mg of collagen/g of lean tissue. Total heme-iron is a measurement of pigment (myoglobin and hemoglobin) in a muscle sample. Pigments are extracted using acetone and hydrochloric acid. The total heme content then is quantified using a spectrophotometer and reported in parts per million. Proximate composition consisted of fat, moisture and ash determination and was measured by Soxhlet ether extraction (fat) and a LECO Thermogravimetric Analyzer (moisture and ash). Fat, moisture and ash were reported as a percentage of lean tissue. Data were analyzed using the general linear model procedure of Statistical Analysis System (SAS).

Results

The results of this project are given in Tables 2 and 3. These data indicate large variation in all measured characteristics among the 21 muscles studied. Objective color was represented by three quantitative values, L*, a*, and b*, representing lightness (0 = black to 100 = white), redness(-60 = green to +60 = red), and yellowness (-60 = blue to +60 = yellow) respectively. The measurements ranged from 32.40 (MSD) to 38.43 (SET), 26.92 (PSO) to 30.38 (ADD), and 20.21 (PSO) to 23.42 (ADD) for L*, a*, and b*, respectively. Breed type had minimal effects on objective color measurement influencing L* values of only four muscles ($P < 0.05$).

Expressible moisture provides information pertaining to the water holding capacity of various muscles. Low expressible moisture values correspond to greater water holding capacity. Expressible moisture values varied significantly ($P < 0.05$) among muscles ranging from 37.42 (MSD) to 47.19 (ADD). Differences in expressible moisture between muscles from beef and dairy carcasses were observed in only one of the 21 muscles studied ($P < 0.05$).

A wide range of values was observed for all components of proximate analysis. The MSD muscle had the lowest percentage moisture (73.71) and highest percentage fat (8.61). Conversely, VAM had the highest percentage moisture (77.11) and lowest percentage fat (2.55). Ash content ranged from 1.20 (MSD) to 1.61 (ADD and TRB). Eight muscles exhibited significant variation in percentage moisture due to breed type, while the percentage fat and ash of just two and one muscles, respectively, showed significant differences. For all muscles influenced by breed type, percentages of moisture, fat and ash were greater in muscles from beef cows compared to those from dairy cows.

Muscle pH is an indicator of meat quality affecting muscle color, protein functionality and water-holding capacity. Muscles with higher pH values generally exhibit improved water holding capacity, as well as darker color, with the side effect of shorter shelf life. The results of this study show that muscle pH is variable from one muscle to another. A range in values was observed from a low of 5.6 (SEM) to a high of 6.30 (VAT); differences were found to be significant ($P < 0.05$). Muscle pH is dependent on the amount of glycogen present in the muscle at the time of slaughter and can be influenced by animal diet. No significant differences in muscle pH were observed between muscles from beef and dairy cows.

Collagen is a protein found in connective tissues. Large amounts of connective tissue have adverse effects on the tenderness and palatability of meat. In this study a wide range of collagen content was observed. Of the 21 muscles studied, the PSO had the lowest total collagen content (6.08 mg/g) while the INF exhibited the greatest amount (21.66). Collagen has been shown to vary from animal to animal and with animal age. However, only one of the 21 muscles studied showed an effect of either carcass maturity or breed type in this study.

Heme-iron is a measurement of the total pigment (both myoglobin and hemoglobin) in a muscle sample. Heme-iron has been shown to have an effect on muscle color. With the emphasis being placed on enhancing the color stability of fresh meat products, heme-iron is an important property to measure. The concentration of heme-iron varied significantly among the muscles studied ($P < 0.05$), ranging from 27.64 (SET) to 37.43 (MSD). Differences among muscles may be related to the amount of residual blood remaining in the muscle post slaughter, as well as muscle type and function. In general, breed type had little influence on heme-iron content of market cow muscles, significantly affecting only one of the 21 muscles studied.

The results of this study indicate minimal differences exist among muscles from beef and dairy cow carcasses. In general, sorting cow carcasses based on breed type will not alter the mean muscle values of the 10 muscle characteristics studied. A large variation was observed in the chemical and physical attributes of beef and dairy cow muscles. Processors may use these data to identify muscles which exhibit characteristics they desire for certain value-added applications.

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Carcass Traits and Palatability Attributes of Herdmates Finished as Calves or Yearling Steers

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Summary

A two-year study compared steers from the same herd finished as calves or yearlings at a fat thickness endpoint of 0.5 in. Yearlings yielded heavier carcasses with larger ribeye areas, lower marbling scores and lower quality grades. Calves produced more tender steaks measured by shear force and a consumer taste panel. The probability of a tough steak (based on shear force) from calf-fed steers was 1.9 and 0.02% for 7 and 21 days of aging, respectively, while the risk for yearlings was 29.2 and 4.0%, respectively. Calf-fed steers produced more tender steaks and, after 21 days of aging, steaks from yearlings were similar.

Introduction

Beef calves are fed in a variety of systems that supply finished beef every week of the year. Thirty to 35% of the calves are placed on-feed soon after weaning (calf-feds). Others are grown or backgrounded for various time periods before being placed on feed. Yearlings that graze green grass in the summer before entering the feedlot are at the other end of the spectrum from calf-feds. Yearling systems are more extensive, growing calves for a longer period of time on forage before being fed a high concentrate diet for a short period prior to harvest. Although this reduction of days on a high concentrate diet may reduce costs, it has been associated with higher quality grades and less tender beef. Regardless of the management practice used to increase profitability, cattle produced must be acceptable for the feedlot and yield a final product desirable to the consumer.

Variable results exist within the literature when comparing meat quality from finished calves and yearlings. Most studies do not use herdmates in the various production systems, may have varied slaughter end points of age or weight, and use small populations. Therefore, this study compared carcass characteristics and meat palatability of contemporary steers produced in calf-fed and yearling systems to a constant fat thickness endpoint.

Procedure

Steers (3/4 British, 1/4 Continental) were randomly assigned to be finished as calves or yearlings at weaning. Thirty-five and 41 calves and 42 and 41 yearlings were designated in years 1 and 2, respectively.

Each year at weaning, steers to be finished as calves were implanted (Synovex-S©) and were adapted from a 50% concentrate diet to a 92.5% concentrate finishing diet (TDN 84%, CP 12%) fed until harvest. Reimplantation (Revalor-S©) occurred after 90 days on feed. All steers were fed to an estimated 12th-rib fat thickness endpoint of 0.5 in. To achieve this, Year 1 steers were on feed for 203 days and Year 2 steers were fed for 180 days. The calf-fed steers were about 13 to 14 months old at the time of harvest.

Steers to be finished as yearlings were drylotted for 60 days, until corn stalks became available for grazing. While in drylot, these steers were fed ammoniated wheat straw ad libitum and supplemented with mineral and 5 lb/head/day (DM basis) of wet corn gluten feed. Steers then grazed corn stalks for 78 days in Year 1 and 91 days in Year 2. While on corn stalks, these steers were supplemented with mineral and 5 lb/head/day (DM basis) corn gluten feed. Hay was supplemented during heavy snow cover. After grazing corn stalks, steers were again drylotted for the remainder of the wintering period until pasture was available for spring and summer grazing. Spring drylot was 64 days in Year 1 and 50 days in Year 2. Following the spring drylotting period, steers grazed pastures for 96 days in Year 1 and 103 days in Year 2. Steers were implanted (Revalor-G©) before summer grazing. Spring grazing pastures consisted of smooth bromegrass. Summer grazing pastures consisted of big bluestem, indiangrass and switchgrass. Following the summer grazing period, steers entered the feedlot, were reimplanted (Revalor-S©), blocked by weight and assigned randomly to one of two pens. Steers then were fed similarly to the calves for receiving and finishing periods. This final finishing period consisted of 93 days in Year 1 and 90 days in Year 2. Yearling steers were approximately 19 to 20 months old at the time of harvest.

Steers were harvested in a commercial slaughter facility. Shortly after being bled, carcasses were electrically stimulated with 8 to 10 low voltage (40 V) pulses. Hot carcass weights were obtained from all

Table 1. Comparison of means for carcass characteristics from calf- and yearling-finished steers.

	Calves		Yearlings	
Trait	Mean	SE	Mean	SE
Hot carcass weight, lb	695.7[b]	7.42	828.0[c]	7.00
Fat thickness, in	0.55	0.018	0.51	0.017
Adjusted fat thickness, in	0.59	0.015	0.56	0.015
Longissimus muscle area, in^2	11.28[b]	0.10	12.56[c]	0.10
Kidney, pelvic, and heart fat, %	2.33[b]	0.053	2.07[c]	0.050
Yield grade	3.49	0.054	3.46	0.050
Marbling score[a]	454.1[b]	8.80	346.1[c]	8.28

[a]Marbling score: modest = 500-599; small = 400-499; slight 300-399.
[bc]Means on the same row without a common superscript are different (P < 0.01).

Table 2. Mean shear force values, in pounds for steaks aged 7, 14, or 21 days from calf- and yearling-finished steers.

	Calves		Yearlings	
Age, d	Mean	SE	Mean	SE
7	7.27[c]	0.196	9.00[e]	0.240
14	6.76[b]	0.196	8.24[d]	0.240
21	6.15[a]	0.196	7.49[c]	0.240

[abcde]Means without a common superscript are different (P < 0.05).

Table 3. Mean sensory panel ratings[a] for steaks aged 7 or 14 days from calf- or yearling-finished steers.

		Calves		Yearlings	
Age, day	Trait	Mean	SE	Mean	SE
7	Juiciness	5.08[e]	0.032	4.88[f]	0.039
	Tenderness	5.46[b]	0.034	4.56[d]	0.043
	Flavor	4.96[e]	0.033	4.64[f]	0.041
	Overall acceptability	5.07[e]	0.032	4.47[f]	0.039
14	Juiciness	4.86[f]	0.032	4.61[g]	0.039
	Tenderness	5.59[c]	0.034	4.63[d]	0.043
	Flavor	4.99[e]	0.033	4.70[f]	0.041
	Overall acceptability	5.03[e]	0.032	4.49[f]	0.039

[a]Evaluated on an 8-point scale where 4 = slightly undesirable and 5 = slightly desirable.
[bcd]Means for a given trait without a common superscript are different (P < 0.05).
[efg]Means for a given trait without a common superscript are different (P < 0.01).

steers at the time of slaughter. In Year 1, carcasses were chilled for an extended 48 hour weekend chill period. Carcasses in Year 2 were chilled for approximately 42 hours. After the chill period, carcasses were ribbed to expose the 12th rib interface and allowed to bloom for approximately 20 minutes. A marbling score was assigned to the carcass by the USDA grader. Other carcass data were measured and evaluated by experienced University of Nebraska personnel. Carcass measurements were used to calculate yield and quality grades. A boneless beef strip loin was collected from the left side of each carcass. Two strip loins from calf-fed cattle were lost during the fabrication process, so additional data analysis continued on 34 and 40 strip loins in Year 1 and Year 2, respectively.

At 7 d postmortem, strip loins were cut into one-inch steaks for proximate analysis, Warner-Bratzler shear force and sensory panel evaluation. After the designated aging time, shear force and sensory steaks were frozen at -8°F.

Steaks were broiled to an internal temperature of 158°F. After cooling, 8 to 10 cores (1/2-inch in diameter) were removed and sheared using a Warner-Bratzler shear attachment to an Instron Universal testing machine. The mean peak shear force (lb) of at least 6 cores was calculated for each steak.

Steaks for sensory evaluation were cooked by the same procedure as described for shear force. After cooking they were cut into 1 x 2 x 1 cm pieces for evaluation. Samples were served to a consumer sensory panel (n≥30). An 8-point Hedonic scale (8 = extremely desirable; 1 = extremely undesirable) was used to evaluate tenderness, juiciness, flavor and overall acceptability.

Results

Carcass characteristics for calf-finished and yearling-finished steers are summarized in Table 1. Yearling steers yielded heavier (P<0.01) carcass weights with larger (P<0.01) longissimus muscle areas, and less (P<0.01) kidney, pelvic and heart fat. They also had lower (P<0.01) marbling scores, USDA quality grades and percentage of carcasses grading USDA Choice or higher when compared to carcasses of calf-fed steers. The differences in marbling scores were confirmed with chemical analysis (8.5 versus 5.5% fat). Production data from this experiment are in the 2003 Nebraska Beef Report, pp. 3-5.

Steaks from calves had lower (P < 0.01) shear force values at 7, 14 and 21 days of age (Table 2) than steaks from yearlings. They were also rated higher (P<0.01) for tenderness, as well as juiciness, flavor, and overall acceptability (Table 3) after 7 and 14 days of aging. As

(Continued on next page)

expected, increased aging time from 7 to 14 to 21 days produced steaks with lower (P<0.10) shear force values, regardless of production system (Table 3). Yearlings produced steaks that, after aging 21 days, had similar shear force values to calf-fed steaks aged 7 days.

When quality grades were grouped to compare palatability traits at equal quality grades, USDA Choice steaks from calf-fed steers had lower shear forces and were more desirable for all palatability attributes (P<0.05) than Choice steaks (Table 4) from yearlings. The same was true for USDA Select grade steaks; differences in palatability and tenderness were not due solely to differences in marbling.

Wheeler et al. (Proceedings, Recip. Meat Conf. 50:68-77) categorized "tender," "intermediate," and "tough" steaks as having less than 6.6 lb, between 6.6 and 10.5 lb, and greater than 10.5 lb of shear force. Using these limits, the risk probability was calculated for steaks from calf-fed and yearling systems at 7, 14 and 21 days of aging (Table 5). Steaks from calves had a very low risk of being "tough" at 7 days (1.92%) and relatively no risk (0.02%) by 21 d. Steaks from yearlings showed a much higher risk (29.2%) of being "tough" after 7 days of aging than steaks from calves. This risk decreased substantially with increasing aging time to 11.89% (14 days) and 4.02% (21 days). Previous research (1995 Nebraska Beef Report, pp. 53-56) revealed less risk of tough (high shear force) beef from yearlings. It is unclear why the results of this study are of greater magnitude.

Growing steers for a longer period of time on forage with a short finishing period resulted in heavier carcasses with lower quality grades and beef that was less tender than calf-fed steers. Steers finished as calves spent more days in the feedlot and in this study produced beef that was more tender with more acceptable eating characteristics than yearlings. Objective tenderness differences that were evident after 7 days of aging were similar after 21 days of aging.

Table 4. Mean sensory ratings for USDA Choice and Select steaks from calf- and yearling-finished steers.

		Calves		Yearlings	
Grade	Trait[a]	Mean	SE	Mean	SE
Choice	Juiciness	5.07[b]	0.026	4.93[c]	0.051
	Tenderness	5.62[e]	0.028	4.77[g]	0.055
	Flavor	5.01[e]	0.027	4.76[f]	0.053
	Overall acceptability	5.11[e]	0.026	4.65[g]	0.051
Select	Juiciness	4.87[c]	0.036	4.57[d]	0.022
	Tenderness	5.43[f]	0.039	4.41[h]	0.024
	Flavor	4.94[e]	0.038	4.58[g]	0.023
	Overall acceptability	4.99[f]	0.036	4.32[h]	0.022

[a]Evaluated on an 8-point scale where 4 = slightly undesirable and 5 = slight desirable.
[bcd]Means for a given trait without a common superscript are different (P < 0.05).
[efgh]Means for a given trait without a common superscript are different (P < 0.01).

Table 5. Risk probability for shear force values of loin (longissimus muscle) steaks from calf- and yearling-finished steers (percentages).

	Calves			Yearlings		
Age	tender	intermediate	tough	tender	intermediate	tough
7	41.00	57.08	1.92	8.11	62.68	29.20
14	52.81	46.52	0.67	12.67	75.44	11.89
21	69.68	30.30	0.02	21.08	74.90	4.02

[a]Shear force rate: <6.6 lb = tender; between 6.6 and 10.5 lb = intermediate; >10.5 lb = tough.

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Effect of Conjugated Linoleic Acid on Cell Death in Adipose Tissue

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Summary

Mice fed conjugated linoleic acid (CLA) lose body fat. This loss of body fat is accompanied by an increase in DNA fragmentation, indicative of apoptosis or programmed cell death. Adipose apoptosis was observed in mice fed the trans-10,cis-12 isomer or a mixture of isomers but not the cis-9,trans-11 isomer. The trans-10,cis-12 isomer also induced DNA fragmentation in preadipocytes in vitro, *but not mature adipocytes. The cis-9,trans-11 CLA isomer, the predonimant isomer in ruminant-derived products, was reported to induce apoptosis of cancer cells. Determining the mechanism of action of CLA will improve our understanding of body fat regulation.*

Introduction

Conjugated linoleic acid (CLA) refers to a group of isomers of linoleic acid. One of these isomers, cis-9,trans-11, is produced naturally and found in the fat of ruminant animals. The cis-9,trans-11 isomer has anti-cancer properties while the other main commercially produced isomer, trans-10,cis-12, can induce a loss of body fat. One mechanism by which the cis-9,trans-11 isomer is beneficial in cancer is by inducing apoptosis, or programmed cell death, of malignant cells. It is possible that different isomers result in different effects through similar mechanisms. Moreover, before practices that will allow for alterations in fat deposition can be developed the regulation of body fat must be understood. Determining the mechanism by which CLA induces a loss of body fat may give insight into that regulation. The objective of these experiments was to determine if the loss of body fat induced by CLA was accompanied by an increase in apoptosis in the adipose tissue. Secondly, we determined if preadipocytes and mature adipocytes, both present in adipose tissue, were sensitive to CLA-induced apoptosis.

Procedure

Experiment 1

Seventy-two male mice (12 weeks old) were allotted to either a control (7% soy oil), mCLA (6% soy oil + 1% CLA mixture), CLA10/12 (6.5% soy oil + 0.5% trans-10,cis-12 CLA), or CLA9/11 (6.5% soy oil + 0.5% cis-9,trans-11 CLA) diet for 2 weeks. The CLA mixture contained 50% cis-9,trans-11 and 50% trans-10, cis-12 CLA. Mice were killed, body fat was determined with dual x-ray densitometry, and fat pads were weighed and collected. Apoptosis was determined in retroperitoneal fat pads by differentially precipitating fragmented and non-fragmented DNA and is expressed as a ratio of fragmented DNA:total DNA.

Experiment 2

3T3-L1 mouse fibroblasts were seeded into 12-well plates at a density of 4,000 — 5,000 cells per cm^2. For analysis of preadipocytes, the cells were allowed to attach to the plates overnight. Either 0, 50, 100, or 200 µM linoleic acid or trans-10,cis-12 CLA, complexed to albumin (6.6:1), or 50 nM staurosporine (a positive control for apoptosis) was then added to the basal medium (DMEM + 10% calf serum + 1% antibiotics). Cells were collected following 2 (proliferating) and 4 days (confluent). On day 6 of fatty acid treatment, cells were stimulated to differentiate with DMEM + 10% fetal bovine serum + 5 µg/ml insulin + 1 µM dexamethasone + 0.5 mM IBMX. Cells were also collected following 8, 10, and 12 (differentiating) days of fatty acid treatment. The experiment was replicated 3 times. Cell number was determined using a hemacytometer. Cellular triacylglycerol content was determined with a commercially available kit (Sigma). DNA fragmentation was determined as described in Experiment 1. For adipocytes, cells were grown to confluence, stimulated to differentiate, and allowed 7 — 9 days to accumulate lipid. Either 0, 50, 100, or 200 mM linoleic acid or trans-10,cis-12 CLA, complexed to albumin (6.6:1), or 50, 500, or 1000 nM staurosporine was then added to the medium (DMEM + 10% fetal bovine serum). Cells were collected

(Continued on next page)

following 2, 4, and 6 days of fatty acid treatment. The experiment was replicated 3 times. Cell number, cellular triacylglycerol and media glycerol content and DNA fragmentation were determined.

Results

Experiment 1

The CLA10/12 and mCLA diets caused a reduction ($P < 0.05$) in feed intake in both weeks. This reduction in feed intake, however, did not relate to a reduction in body weight. It is unlikely that the reduction in feed intake influenced either body fatness or DNA fragmentation. We previously reported (2002 Nebraska Beef Report, pp 92-93) mice fed a control diet at the intake level of CLA-fed mice did not lose body fat while the CLA-fed mice did. The addition of the trans-10,cis-12 isomer, either alone or in the CLA mixture, reduced ($P < 0.001$) the percentage body fat of the mice (Figure 1). Similar reductions ($P < 0.001$) in the weight of the retroperitoneal (74.4 and 51.5% for CLA10/12 and mCLA, respectively) and epididymal (57.6 and 29.7% for CLA10/12 and mCLA, respectively) fat pads compared to the control were observed. Paralleling the reduction in body fat was an increase ($P < 0.001$) in DNA fragmentation (Figure 2).

Experiment 2

In preadipocytes, both linoleic acid and trans-10,cis-12 CLA reduced ($P < 0.01$) the number of cells per well starting on day 4 for linoleic acid and every day for CLA. However, only 200 µM CLA caused an increase ($P < 0.05$) in DNA fragmentation. In the first replication of the experiment only cells that were not confluent or differentiating underwent apoptosis (Figure 3). In subsequent replications cells did not become fully confluent by day 4 and therefore DNA fragmentation was detected in later stages.

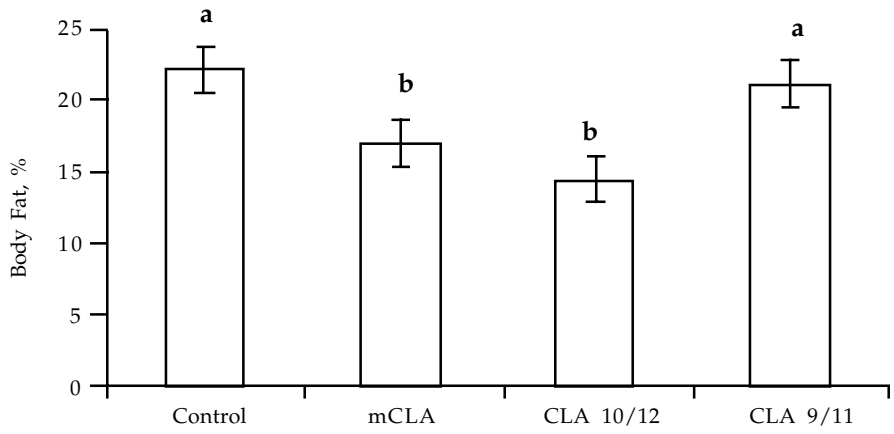

Figure 1. Effect of diets containing individual, or a mixture of, conjugated linoleic acid (CLA) isomers on body fat of mice, experiment 1. Control (7% soy oil), mCLA (6% soy oil + 1% CLA mixture), CLA10/12 (6.5% soy oil + 0.5% trans-10,cis-12 CLA), and CLA9/11 (6.5% soy oil + 0.5% cis-9,trans-11 CLA). [ab]Letters indicate differences, $P < 0.001$.

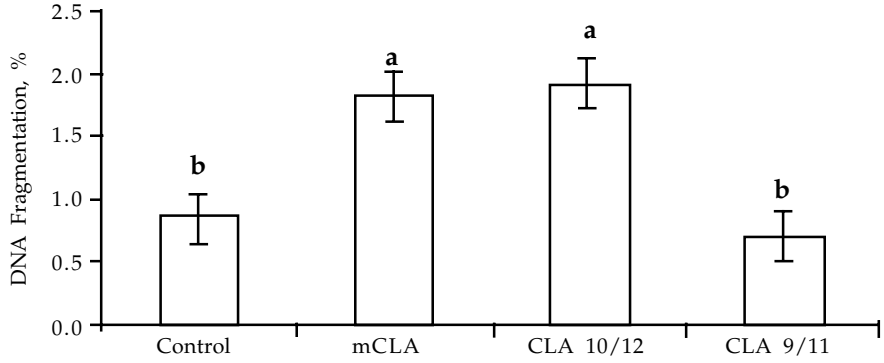

Figure 2. Effect of diets containing individual, or a mixture of, conjugated linoleic acid (CLA) isomers on DNA fragmentation in adipose tissue of mice, experiment 1. Control (7% soy oil), mCLA (6% soy oil + 1% CLA mixture), CLA10/12 (6.5% soy oil + 0.5% trans-10,cis-12 CLA), and CLA9/11 (6.5% soy oil + 0.5% cis-9,trans-11 CLA). [ab]Letters indicate differences, $P < 0.001$.

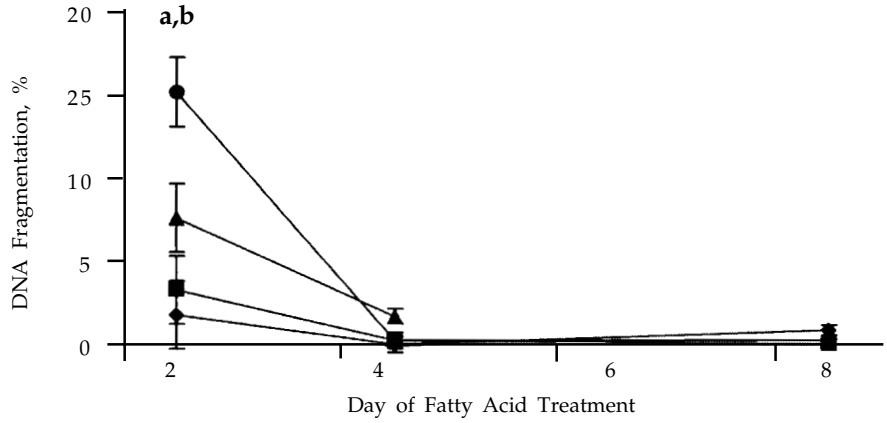

Figure 3. Effect of linoleic acid or trans-10,cis-12-conjugated linoleic acid (CLA) on DNA fragmentation of preadipocytes in culture. Circle — CLA (200 mM), triangle — staurosporine (50 nM), square — linoleic acid (200 mM), and diamond — control. [a]CLA differs from control, $P < 0.05$. [b]CLA differs from linoleic acid, $P < 0.05$.

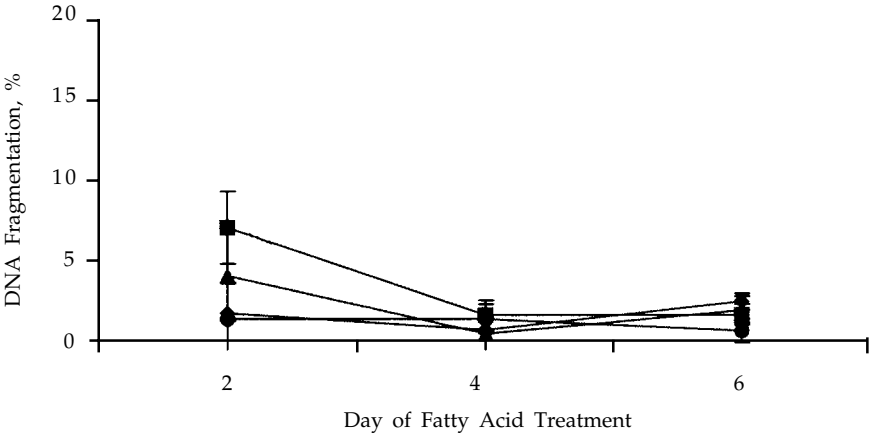

Figure 4. Effect of linoleic acid or trans-10,cis-12-conjugated linoleic acid (CLA) on DNA fragmentation of adipocytes in culture. Circle — CLA (200 mM) , triangle — staurosporine (1000 nM), square — linoleic acid (200 mM), and diamond — control.

In adipocytes, 50 and 100 µM CLA, but not linoleic acid, reduced ($P < 0.05$) cell number on day 2 of fatty acid treatment. On no day was there an effect of treatment on DNA fragmentation in adipocytes (Figure 4). Additionally, CLA had no effect on either cellular triacylglycerol content, or the content of glycerol in the media. These data indicate that the CLA supplementation did not alter lipid filling or lipolysis.

In conclusion, the trans-10,cis-12 isomer of CLA can induce apoptosis, as measured by DNA fragmentation, in adipose tissue of mice as well as cause a loss of body fat. The cis-9,trans-11 isomer appears to have no effect on either phenomenon. The increase in DNA fragmentation due to trans-10,cis-12 CLA supplementation was only observed in preadipocytes *in vitro* and it remains to be seen if the same holds true *in vivo*. Perhaps only cells that are dividing are susceptible to the apoptotic effect of CLA. Although both isomers of CLA can cause apoptosis, only the trans-10,cis-12 isomer does so in adipose tissue. These results may indicate that alterations in fat deposition need to be made prior to differentiation of preadipocytes.

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[1]Kim Hargrave, graduate student; Brett Meyer, former undergraduate student; Jess Miner, associate professor Animal Science, Lincoln.

Conjugated Linoleic Acid Metabolism and Body Fat Loss in Mice

Kim M. Hargrave
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Summary

Mice were fed conjugated linoleic acid (CLA) with or without fish oil or aspirin, which deplete tissue arachidonic acid and block arachidonic acid metabolism, respectively. Mice fed fish oil did not lose body fat when supplemented with CLA but mice fed soy oil did. Aspirin did not alter CLA-induced body fat loss. CLA may be metabolized to an isomer of arachidonic acid to induce a loss of body fat. However, this body fat loss is apparently not mediated via alteration of prostaglandin synthesis. Understanding the regulation of body fat by CLA may offer insight into the mechanisms of body fat regulation in cattle.

Introduction

Conjugated linoleic acid (CLA) refers to a group of isomers of linoleic acid which have multiple health benefits. The cis-9,trans-11 isomer is produced naturally and deposited in the fat of ruminant animals. The CLA isomers can be metabolized like linoleic acid to longer-chain conjugated fatty acids including isomers of arachidonic acid. We previously reported (2002 Nebraska Beef Report, pp 92-93) that mice consuming a diet deficient in essential fatty acids (linoleic and linolenic acids) lost more body fat when supplemented with CLA than did control mice. While the cis-9,trans-11 isomer has no effect on body fatness, it does have other health benefits including prevention and treatment of certain cancers. Since this isomer can be metabolized similarly to the trans-10,cis-12 isomer responsible for the loss of body fat, understanding the metabolism of one isomer may contribute to our knowledge of how several of the isomers induce biological effects. In addition, the regulation of body fat deposition is largely not understood but essential to our ability to alter that deposition. Therefore, our first objective was to determine the effect of modulating the dietary concentration of essential fatty acids (linoleic, linolenic, and arachidonic acids) on CLA-induced body fat loss.

Arachidonic acid is a precursor to the series 2 prostaglandins via metabolism by cyclooxygenase and the series 4 leukotrienes via metabolism by lipoxygenase. It is unknown if CLA, metabolized to a conjugated isomer of arachidonic acid, interferes with the normal conversion of arachidonic acid to prostaglandins or leukotrienes, or if conjugated eicosanoids are formed. Aspirin is a known inhibitor of cyclooxygenase. Our second objective was to determine if altering arachidonic acid metabolism by inhibiting cyclooxygenase would alter CLA-induced body fat loss.

Procedure

Experiment 1

Eighty newly weaned male mice were fed either a control diet (20% soy oil) or a fish oil diet (20% menhaden fish oil) for 6 weeks. Half of each group was subsequently supplemented with 0.5% CLA, replacing either soy or fish oil, for an additional 2 weeks. The mice then were killed and the retroperitoneal fat pads, epididymal fat pads and livers were weighed and collected. Body fat and lean mass were determined by dual x-ray densitometry.

Experiment 2

Eighty male mice (9 weeks of age) were fed either a control (7% soy oil), CLA (6% soy oil + 1% CLA), aspirin (control + 400 mg/kg diet aspirin), or aspirin+CLA (CLA diet + 400 mg/kg diet aspirin) diet for 2 weeks. Mice were killed and tissues were collected as in Experiment 1.

Results

Experiment 1

Adipose tissue from mice fed fish oil had a greater concentration of long-chain n-3 polyunsaturated fatty acids and arachidonic acid and less linoleic and linolenic acids than those fed soy oil (Table 1). Neither fish oil feeding nor the addition of CLA affected feed intake or body weight. Feeding either fish oil or CLA reduced ($P < 0.05$) body fat compared to control (Figure 1). However, fat source by CLA interaction was observed ($P < 0.01$); mice fed fish oil + CLA were not leaner than mice fed fish oil or CLA alone. Similar results were observed in fat pad weights. Fish oil-fed mice also had heavier ($P < 0.001$) livers and greater ($P < 0.05$) lean mass than soy oil-fed mice.

We hypothesized that feeding a basal fat source with altered essential fatty acid concentrations would alter the sensitivity to CLA-induced body fat loss. We previously reported support of this hypothesis, in that a greater loss of body fat was

Table 1. Effect of fish oil and/or conjugated linoleic acid (CLA) on fatty acid concentrations in retroperitoneal fat pads, Experiment 1.

Fatty Acid, %[a]	Control[b]	CLA[b]	Fish Oil[b]	Fish Oil+ CLA[b]	SEM[c]
C18:2 n-6	50.67[d]	48.30[d]	8.94[e]	10.98[e]	1.701
C18:3 n-3	3.43[d]	2.48[e]	1.67[f]	1.78[f]	0.107
C20:4 n-6	0.08[e]	0.06[e]	0.29[d]	0.28[d]	0.021
C20:5 n-3	0.02[e]	0.10[e]	1.22[d]	1.13[d]	0.121
C22:6 n-3	0.01[e]	0.02[e]	0.38[d]	0.38[d]	0.040
cis-9,trans-11 CLA	0.02[e]	0.34[d]	0.07[e]	0.48[d]	0.061
trans-10,cis-12 CLA	0.00[e]	0.30[e]	0.96[d]	0.89[d]	0.110

[a]Fatty acids were analyzed by gas chromatography and expressed as a percentage of total fatty acids.
[b]Control (20% soy oil); CLA (19.5% soy oil + 0.5% CLA); Fish oil (20% menhaden fish oil); Fish oil+CLA (19.5% menhaden fish oil + 0.5% CLA).
[c]SEM = Standard error of the means.
[def]Different letters within a row indicate differences, $P < 0.05$.

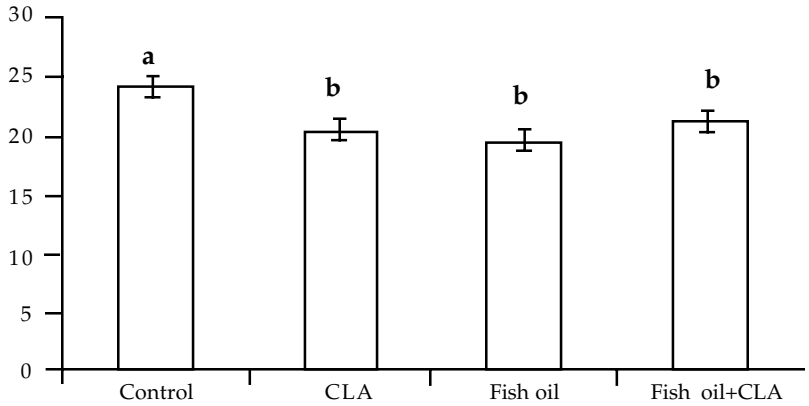

Figure 1. Effect of fish oil and (or) conjugated linoleic acid (CLA) on body fat, Experiment 1. Control (20% soy oil), CLA (19.5% soy oil + 0.5% CLA), Fish oil (20% menhaden fish oil), and Fish oil+CLA (19.5% menhaden fish oil + 0.5% CLA). [ab]Means with different superscripts differ, $P < 0.01$.

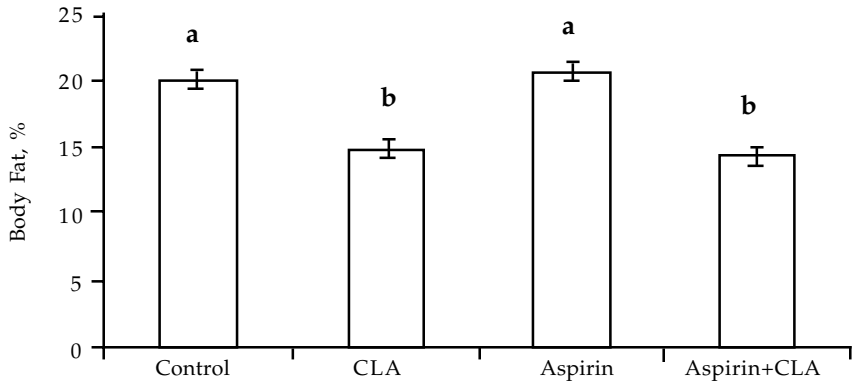

Figure 2. Effect of aspirin and (or) conjugated linoleic acid (CLA) on body fat, Experiment 2. Control (7% soy oil), CLA (6% soy oil + 1% CLA), Aspirin (control diet + 400 mg/kg aspirin), Aspirin+CLA (CLA diet + 400 mg/kg aspirin). [ab]Means with different superscripts differ, $P < 0.001$.

observed in mice when both linoleic and arachidonic acids were reduced by feeding coconut oil (2002 Nebraska Beef Report, pp. 92-93). However in this experiment, no CLA-induced loss of body fat was observed when arachidonic acid concentration was increased by feeding fish oil, although this diet also reduced linoleic acid concentration. Therefore, CLA may be metabolized to a conjugated isomer of arachidonic acid that then results in the body fat loss observed in mice.

Experiment 2

The addition of CLA to the diet of mice resulted in reduced feed intake ($P < 0.05$) during both weeks and reduced body weight following week 2 ($P < 0.01$). Aspirin feeding increased week 2-body weight ($P < 0.01$). CLA supplementation reduced body fat by 26% ($P < 0.001$) while aspirin had no effect (Figure 2). Similar results were observed in fat pad weights. CLA also increased liver weight ($P < 0.001$) and lean mass ($P < 0.01$) regardless of aspirin supplementation.

In our previous report and with Experiment 1 in this report, we indicated adipose tissue arachidonic acid concentration may be negatively correlated with the CLA-induced loss of body fat in mice. However, inhibition of arachidonic acid metabolism to the series 2 prostaglandins via cyclooxygenase did not affect CLA-induced body fat loss. Arachidonic acid is also metabolized to leukotrienes via lipoxygenase. Therefore a conjugated isomer of arachidonic acid may still interfere with arachidonic acid metabolism, but not at the level of cyclooxygenase.

Although the CLA isomer present in ruminant products, cis-9,trans-11, does not result in altered body fatness it does block cancer growth. This isomer can also be metabolized similarly to linoleic acid and the trans-10,cis-12 isomer that is responsible for the loss of body fat. Therefore, determining the pathway through which one CLA isomer induces a biological effect will give insight into the mechanism by which other isomers function.

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[1]Kim Hargrave, graduate student; Brett Meyer, former undergraduate student; Jess Miner, associate professor, Animal Science, Lincoln.

Effect of Age, Pregnancy, and Diet on Urinary Creatinine Excretion in Heifers and Cows

Kimberly M. Whittet
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Galen E. Erickson
Tim W. Loy
R. Allen McDonald[1]

Summary

A series of total urine collections was conducted to evaluate effect of age, pregnancy and diet on creatinine excretion in heifers and cows. To test effect of age on creatinine excretion, 31 animals ranging from 5 to 104 months of age were fed a hay diet supplemented with dried distillers grains (DDG). There was no difference in creatinine excretion across age. Cows fed the same diet were sampled to determine effect of pregnancy on creatinine excretion. Pregnancy did not affect daily creatinine excretion. Two collection periods were conducted to determine if diet alters creatinine excretion. In period 1, heifers were fed a hay diet supplemented with DDG; in period 2, heifers were fed a finishing diet. Creatinine excretion was lower in heifers on the finishing diet. Age and pregnancy did not influence creatinine excretion; however, diet may affect creatinine excretion in growing heifers.

Introduction

Since the introduction of the metabolizable protein system, it has become essential to quantify microbial protein supply in cattle. Purines are products of microbial protein degradation, and can be detected in duodenal flow and used to estimate microbial production. Further degradation products, purine derivatives, can be found in the urine of cattle and also used to estimate microbial production. For this latter technique to accurately estimate daily microbial production, 24-hour urine volume must be determined. This can be accomplished with total urine collections with urinary catherization or urine funnels or by collecting a random "spot" sample and calculating the 24-hour urine volume with a urinary marker. This latter technique is less invasive and can be used in a production setting. Creatinine, a urine metabolite, has been shown to be effective at estimating daily urine output. As product of muscle metabolism, creatinine is directly related to muscle mass, and has been significantly correlated to live weight. To calculate urine volume, 24-hour creatinine excretion must be determined. The constancy of 24-hour creatinine excretion must be evaluated for it to be a viable marker of urine output. Therefore, the objectives of this study were to test the effects of age, pregnancy and diet on the constancy of creatinine excretion.

Procedure

A series of total urine collections was conducted to evaluate the effect of age, pregnancy and diet on creatinine excretion in heifers and cows. Thirty-one heifers and cows (BW range = 216-1479 lb) were fed either a hay diet supplemented with dried-distillers grains or a finishing diet that was 90% concentrate and 10% forage. Animals were fitted with indwelling urethral catheters, housed in individual stanchions, and intake was limited to 2.0% of body weight. Urethral catheters were attached at each animal's hip and connected to tubing that led to a 2 L urine collection bag. Urine from each animal's bag was drained at 2 hour intervals from 6:00 a.m. to 6:00 p.m. Urine was allowed to accumulate from 6:00 p.m. to 6:00 a.m. then drained. Drainage was measured and recorded to the nearest 10 mL, and a 45 mL sub-sample was taken. Sub-samples then were composited by animal within day according to sample volume at each 2-hour interval, diluted for analysis, and stored at -4°F.

For each collection, urine was collected continuously over a 5-day period. Daily composite samples for each animal were analyzed for creatinine using the Jaffe Reaction (Sigma Diagnostics, Procedure

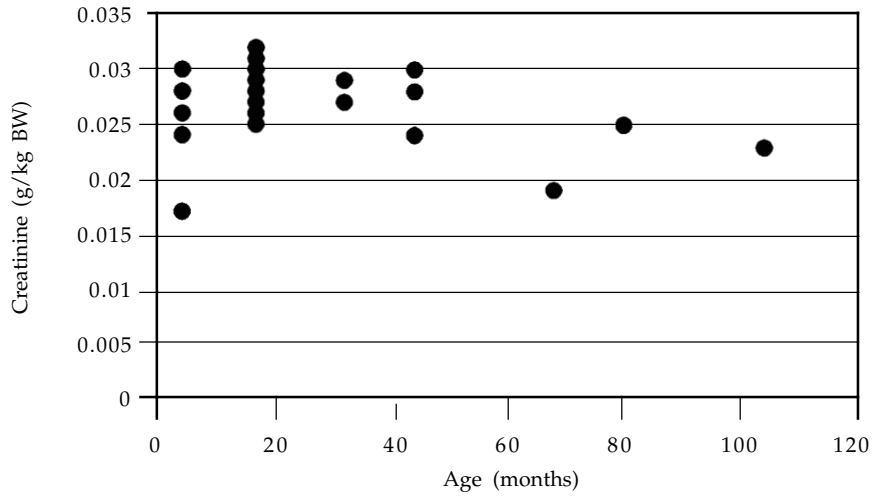

Figure 1. Relationship between average daily creatinine excretion and age of heifers and cows ranging from 5 to 104 months of age.

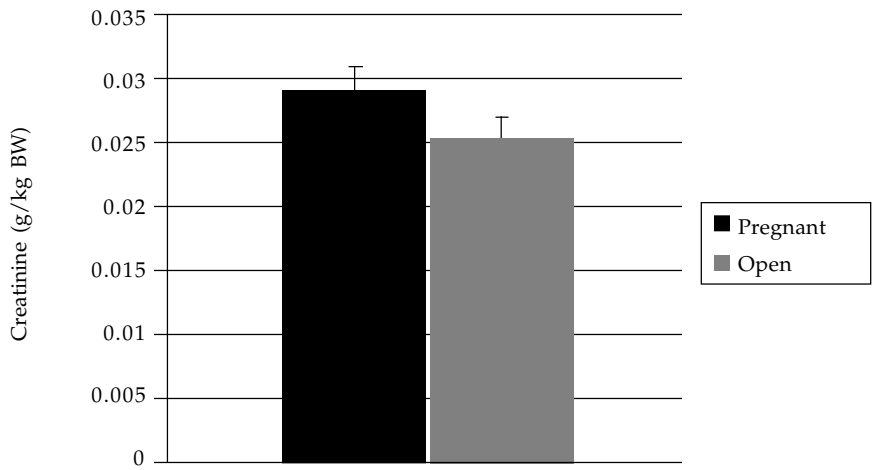

Figure 2. Average daily creatinine excretion of pregnant and open cows. SE = 0.0016 g/kg BW. Pregnant not different from open (*P* > 0.05).

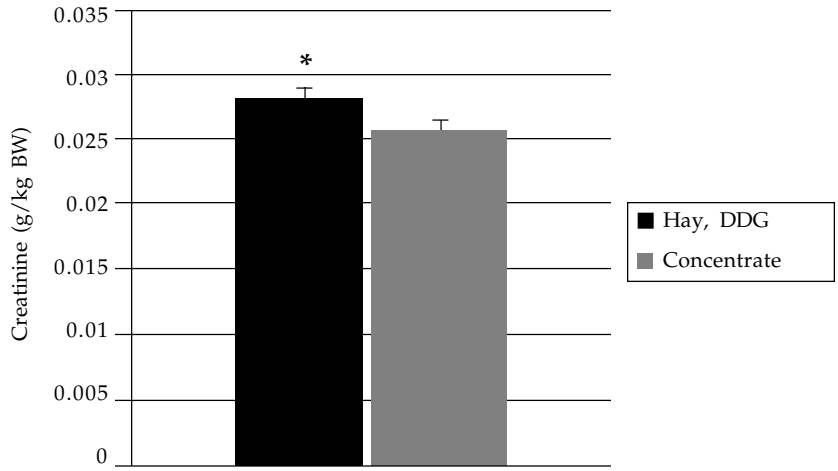

Figure 3. Average daily creatinine excretion of heifers fed either a hay diet supplemented with dried distillers grains or a finishing ration (90% concentrate: 10% roughage). SE = 0.0006 g/kg BW. * Treatments differ (*P* < 0.05).

#558). Each animal then was averaged over the 5-day period and creatinine values were expressed as g/kg BW by multiplying creatinine concentration by measured 24-hour volume and dividing by individual animal body weight.

To test the effect of age on creatinine excretion, 23 animals (BW range = 216-1479 lb) ranging from 5 to 104 months of age were fed a hay diet supplemented with dried distillers grains (DDG). Five pregnant and 8 open cows (BW = 1258 $\pm$ 129 lb) fed a hay diet supplemented with DDG were sampled to determine the effect of pregnancy on creatinine excretion. To determine if diet alters creatinine excretion, 8 heifers (BW = 970 $\pm$ 107 lb) were sampled for 2 urine collection periods. In period 1, heifers were fed a hay diet supplemented with DDG. In period 2, heifers were fed a finishing diet containing 90% concentrate and 10% forage.

Results

Results for the effect of age on creatinine excretion are presented in Figure 1. It was anticipated, due to differences in body composition over age, animals would excrete differing amounts of creatinine. There was no difference in creatinine excretion across all animals with respect to month of age ($P = 0.16$). Range of creatinine excretion across all cows and heifers was 0.017 to 0.032 g/kg BW, demonstrating variation in creatinine excretion across all animals.

Pregnancy had no effect on creatinine excretion in cows ($P = 0.09$; Figure 2). Pregnant cows excreted an average of 0.029 g/kg BW of creatinine compared to 0.026 g/kg BW for open cows. Excretion of creatinine across cows was variable and could account for the inability for a difference to be detected between open and pregnant cows.

Heifers consuming the hay diet supplemented with DDG excreted more creatinine than when

(Continued on next page)

consuming the finishing diet ($P < 0.05$; Figure 3). When heifers were fed the hay diet, they excreted an average of 0.028 g/kg BW, compared to 0.026 g/kg BW when fed the finishing diet. The two diets were formulated to be quite different. The hay/DDG diet would be expected to give 1 lb/day gain, while the finishing diet would give 3+ lb/day gain. Further, the hay diet supplies fiber as the primary energy source for the rumen microbes and the resulting end-products to the heifer. The finishing diet is starched-based, producing a different microbial population and different endproducts. These two diets represent the extremes, yet the difference produced in creatinine excretion was only 9.6%. Using the NRC, the heifers were estimated to be approximately 15% fat when consuming the hay diet. After the adaptation and treatment period, heifers were estimated to be approximately 18% fat when fed the finishing ration. If 30-40% of the diet difference can be explained by greater percentage fat when the heifers were fed the finishing ration compared to the hay ration, then the impact of diet on creatinine is small.

For creatinine to be a viable marker for urine output, creatinine excretion must be independent of any physiological and environmental factors or we must be able to account for their influence. Animal-to-animal variation will require that either numerous animals be used for experiments or that latin square or switchbacks designs be used.

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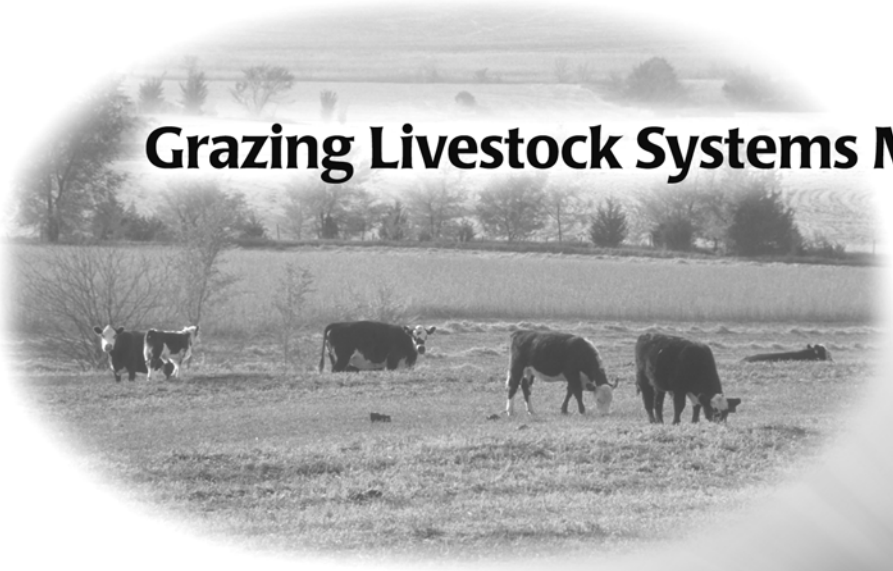
[1]Kimberly M. Whittet, research technician; Terry J. Klopfenstein, professor; Galen E. Erickson, assistant professor; Tim W. Loy, research technician, R. Allen McDonald, graduate student, Animal Science, Lincoln.



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