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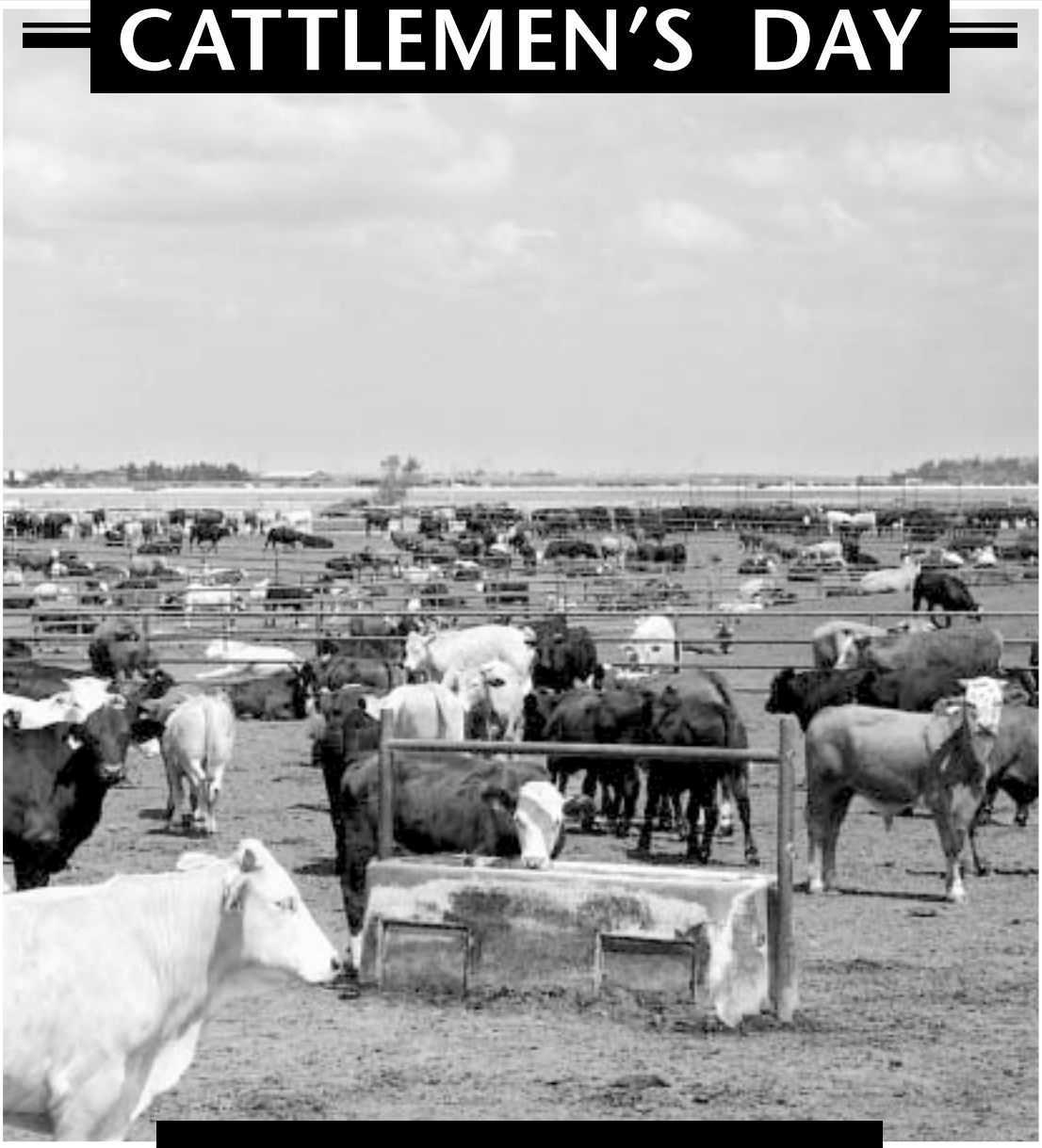

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Agricultural Experiment Station and
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EFFECTS OF NONPROTEIN NITROGEN SOURCE IN BLOCKS ON INTAKE AND DIGESTION OF PRAIRIE HAY BY STEERS

C. A. Löest, E. C. Titgemeyer, J. S. Drouillard, B. D. Lambert, and A. M. Trater

Summary

This intake and digestion study evaluated source of nonprotein nitrogen in cooked molasses blocks supplemented to 18 steers (590 lb) with ad libitum access to prairie hay, Treatments were 1) control (no block), 2) a block containing 60% crude protein with 83% from urea (UREA block), and 3) a block containing 60% crude protein with 42% from urea and 42% from biuret (UREA/BIURET block). Blocks were broken into small pieces to facilitate rapid consumption and fed once daily at .125% of body weight. Forage intake increased by 22%, total intakes (forage plus block) increased by 28%, and digestible organic matter intakes increased by 52% when either UREA or UREA/BIURET blocks were fed. Total diet digestibilities also increased with block supplementation. Intakes and digestibilities were similar for the UREA and UREA/BIURET blocks. Supplementing prairie hay with cooked molasses blocks containing high levels of nonprotein nitrogen increased intake and digestion, but replacing half of the urea with biuret had little effect.

(Key Words: Steers, Forages, Urea, Biuret.)

Introduction

Dormant range forages are often low in important nutrients, particularly protein. Providing supplemental crude protein, such as nonprotein nitrogen (NPN) or rumen-degradable protein, to cattle consuming these low-quality forages improves animal performance and forage utilization. Urea, the most common supplemental NPN source, releases its nitrogen rather rapidly in the rumen and thus is not well synchronized with the slower release of fermentable energy from forages. A more slowly released NPN source, such as biuret (a compound formed by thermal treatment of urea), might improve ruminal fermentation and forage utilization. Our objective was to evaluate the effects of NPN source (urea or biuret) in cooked molasses blocks on intake and digestion of low-quality forage by steers.

Experimental Procedures

Eighteen steers (590 lb initial body weight) were used in a complete block design. Steers were housed in individual pens with drinking water available at all times. Each steer received 20 grams of plain salt daily and had ad libitum access to coarsely chopped prairie hay; offered at 120% of the average intake for the previous 5 days. Treatments were 1) control (no supplementation), 2) a cooked molasses block containing 60% crude protein with 83% from urea (UREA block), and 3) a cooked molasses block containing 60% crude protein with 42% from urea and 42% from biuret (UREA/BIURET block). The cooked molasses blocks were broken into small pieces and fed daily at 0.74 lb as is (.125% of initial body weight). The experiment lasted 21 days; 15 days for adaptation and 6 days for the collection of orts (feed refusals) and feces (fecal collection bags).

Results and Discussion

The prairie hay contained (dry basis) 5.5% crude protein and 69.5% neutral detergent fiber (NDF). Crude protein in the UREA and UREA/BIURET blocks averaged 61.6% (dry basis), which was close to the expected values (60% as fed).

Intakes of forage organic matter, NDF, and crude protein increased (P<.08) by 22%, and total intakes (forage plus cooked molasses blocks) of organic matter and NDF increased (P#.05) by 28% and 23%, respectively, when either UREA or UREA/BIURET blocks were fed (Table 1). Total crude protein intakes nearly doubled (P<.01) when blocks were provided. Digestible intakes of organic matter increased by 52% (P<.01) and those of NDF by 47% (P<.01) when blocks were fed. Increased digestible organic matter intake, an indication of the available energy intake, was due partly to increased dry matter intakes and partly to an 18% improvement (P<.01) in organic matter digestibility when steers received blocks (Table 1). The improvement in organic matter digestion appeared to be due to greater (P<.01) NDF digestibilities.

Steers receiving UREA blocks had greater digestible crude protein intakes than steers receiving the UREA/BIURET block, but this difference has limited biological significance. Organic matter and NDF intakes and digestibilities were not significantly different between blocks. Although steers receiving the UREA block tended to have greater intakes and digestibilities, these differences were small and not statistically significant (P$.12).

Providing cooked molasses blocks containing 60% crude protein and high levels of NPN increased intake and digestion of prairie hay fed, but replacing half of the urea in the blocks with biuret affected neither intake nor digestion.

Table 1. Effects of Supplementation on Intake and Digestion by Steers

	Treatment[a]			
Item	Control	Urea	Urea/Biuret	SEM
Forage intake, lb/day				
Organic matter	9.6	11.8	11.6	.82
Neutral detergent fiber	7.2	8.9	8.8	.61
Crude protein	.58	.71	.70	.051
Total intake, lb/day				
Organic matter[b]	9.6	12.4	12.2	.82
Neutral detergent fiber	7.2	8.9	8.8	.61
Crude protein[b]	.58	1.15	1.12	.051
Digestible intake, lb/day				
Organic matter[b]	5.0	7.7	7.4	.44
Neutral detergent fiber[b]	3.5	5.3	5.1	.31
Crude protein[bc]	.20	.63	.57	.021
Digestion, %				
Organic matter[b]	52	63	61	1.5
Neutral detergent fiber[b]	49	60	58	1.9
Crude protein[b]	34	55	51	1.8

[a]Urea = cooked molasses block containing 60% crude protein with 83% from urea; Urea/Biuret = cooked molasses block containing 60% crude protein with 42% from urea and 42% from biuret.
[b]Average of blocks different than control (P<.05).
[c]Urea block different than Urea/Biuret block (P<.05).

EFFECTS OF NONPROTEIN NITROGEN SOURCE IN BLOCKS ON RUMEN PARAMETERS OF STEERS FED PRAIRIE HAY

C. A. Löest, E. C. Titgemeyer, J. S. Drouillard, B. D. Lambert, and A. M. Trater

Summary

Six ruminally cannulated steers (1012 lb) were fed prairie hay ad libitum supplemented with cooked molasses blocks that contained either 60% crude protein 83% of which came from urea (UREA block) or 60% crude protein with 42% from urea and 42% from biuret (UREA/BIURET block). Blocks were broken into small pieces to facilitate consumption and were fed once daily at .125% of body weight. Rumen samples were collected on days 3, 7, 14, and 21 at 0, 1, 2, 4, 6, 8, 12, and 16 hours after feeding blocks. Averaged over time, ruminal ammonia and total volatile fatty acid concentrations and plasma urea concentrations were lower ($P<.05$) for steers fed the UREA/-BIURET block than for those fed the UREA block. Acetate and propionate concentrations followed patterns similar to those of total volatile fatty acids, whereas butyrate increased rapidly after block consumption. Release of ammonia from biuret was not demonstrated clearly. Ruminal ammonia concentrations were no greater with the UREA/BIURET block at times distant from feeding than with the UREA block.

(Key Words: Steers, Forages, Urea, Biuret.)

Introduction

Cattle consuming dormant range often are supplemented with crude protein as nonprotein nitrogen (NPN) or ruminal degradable protein. Although a common NPN source is urea, its release of nitrogen in the rumen is rather rapid and not well synchronized with the slower release of fermentable energy from forages. This rapid nitrogen release can result in toxic levels of ammonia. A more slowly released NPN source, such as biuret (a compound formed by thermal treatment of urea), might reduce the risk of ammonia toxicity and also improve synchronization of nitrogen release and carbohydrate fermentation. Our objective was to evaluate the effects of NPN source (urea or a urea/biuret combination) in cooked molasses blocks on ruminal parameters and plasma urea concentrations.

Experimental Procedures

Six ruminally cannulated steers (1012 lb initial body weight) were used in a completely randomized design. Steers were housed in individual tie-stalls where they had free access to fresh water. Each steer received 20 grams of plain salt daily and was offered coarsely chopped prairie hay at 120% of the average intake for the previous 5 days. Treatments were 1) a cooked molasses block that contained 60% crude protein, 83% of which came from urea (UREA block) and 2) a cooked molasses block that contained 60% crude protein with 42% from urea and 42% from biuret (UREA/BIURET block). The cooked molasses blocks were broken into small pieces and fed daily at 1.26 lb (.125% of initial body weight). On sampling days, steers were allowed 30 minutes to consume their block. Any unconsumed block was then placed directly into the rumen via rumen cannulae. The experiment lasted 21 days. Rumen contents were sampled via the rumen cannula on days 3, 7, 14, and 21 at 0, 1, 2, 4, 6, 8, 12, and 16 hours after blocks were fed. Jugular blood samples were collected on each of the sampling days at 5 hours after blocks were fed.

Results and Discussion

The prairie hay contained (dry basis) 5.5% crude protein and 69.5% neutral detergent fiber (NDF). Crude protein in both UREA and UREA/BIURRT blocks averaged 61.6% (dry basis), which was close to the expected values (60% as fed).

Ruminal parameters remained similar on the different sampling days (days 3, 7, 14, and 21), suggesting that adaptation to biuret was either rapid (within 3 days) or had not occurred before the end of the 2 1 -day study. Rumen ammonia concentrations were similar with UREA and UREA/BIURET blocks at 1 hour postfeeding and at 12 hours or more postfeeding, but were lower for the UREA/BIURET block at 2,4, and 8 hours after block feeding (Figure 1). As a result, ruminal ammonia concentrations, averaged over time, were lower (P<.05) for steers receiving the UREA/BIURET block (10.0 mM) than those receiving UREA block (15.1 mM). Furthermore, plasma urea concentrations averaged 3.14 mM for steers receiving the UREA/BIURET block vs. 4.12 mM for steers supplemented with a UREA block (P<.05). These differences may indicate that less ammonia was produced from microbial fermentation of blocks containing biuret. Because biuret is considered a slowly released source of ammonia, greater ruminal ammonia 'concentrations at 8 hours or more postfeeding would have been expected if the total supplies of ammonia from the two blocks were similar.

For steers fed UREA blocks, ruminal pH was higher at 2 and 4 hours postfeeding, corresponding to higher ruminal ammonia concentrations. A lower pH at 16 hours may have been due to higher totai VFA concentrations (Figure 1). Rumen total VFA concentrations averaged over time were 92.8 mM for the UREA block vs. 89.1 mM for the UREA/BIURET block (P<.05). Values were similar up to 6 hours after feeding, but differed thereafter. This may indicate a shift in ruminal fermentation from differences in nitrogen availability. Patterns of ruminal acetate and propionate concentrations were similar to those for total VFA concentrations. Ruminal butyrate concentrations increased rapidly after the feeding of either block because of the fermentation of sugars in the molasses component.

Steers fed UREA/BIURET blocks had lower rumen ammonia and plasma urea levels, indicating a reduced risk of ammonia toxicity. In fact, our data do not clearly demonstrate the release of ammonia from biuret. It is possible that reducing urea rather than replacing a portion with biuret would yield similar results.

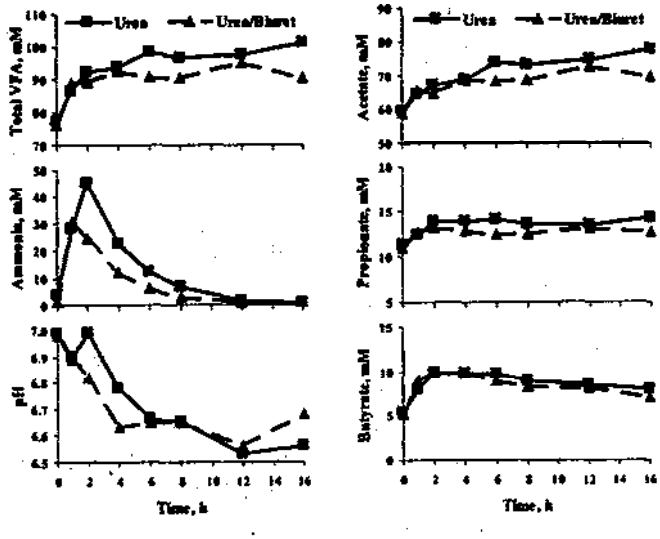

Figure 1. Effect of Supplementation on Ruminal Parameters of Steers

EFFECTS OF FREQUENCY OF SUPPLEMENTATION ON PERFORMANCE OF BEEF COWS GRAZING WINTER PASTURE

C. G. Farmer, R. C. Cochran, D. D. Simms[1], E. A. Klevesahl, and T. A. Wickersham

Summary

One hundred twenty spring-calving Hereford × Angus cows grazing low-quality tallgrass-prairie forage during the winter of 1998 were fed a 43% crude protein supplement 2, 3, 5, or 7 days a week. Supplement was fed at 4 lb/head daily to cows supplemented daily. The other cows still received 28 lb per week but divided equally among feedings. Cumulative performance (measured by changes in body condition score and body weight) was slightly better with increased supplementation frequency. However, the magnitude of differences in body condition and body weight changes, even for the most extreme treatment comparisons, were relatively small.

(Key Words: Forage, Supplementation, Frequency.)

Introduction

Where time allows and beef cows are easily accessible, they often are supplemented daily. However, long traveling distances and scarcity of time and/or labor make less frequent supplementation attractive. Previous research at Kansas State University indicated that reducing supplementation frequency from daily to three times weekly caused only slight decreases in body weight and body condition scores. Our objective was to evaluate the impact of several supplementation frequencies on winter performance of range beef cows.

Experimental Procedures

During the winter of 1998-99, supplementation frequency was studied with spring-calving cows grazing low-quality, tallgrass-prairie range. One hundred twenty Hereford × Angus cows were weighed and body condition was scored (1 to 9 scale) on December 7, 1998. Initial condition score averaged 5.3, and initial body weight averaged 1183 lbs. Cows were stratified by body condition score and body weight and assigned randomly within the strata to one of three pastures. Within each pasture, cows were assigned randomly to one of four supplementation frequencies: 1) supplementation 2 days a week (Tuesday and Friday); 2) supplementation 3 days a week (Monday, Wednesday, and Friday); 3) supplementation 5 days a week (Monday-Friday); and 4) supplementation 7 days a week. The supplement contained 43% crude protein and was fed at 4 lbs/head daily (as-fed) to cows that received daily supplement. Cows in other treatments were offered 28 lb of supplement per week but evenly split among the supplementation events. For example, cows that were offered supplement 2 days a week received their total weekly allotment of supplement in two 14 lb portions. There was no supplement wastage even when 14 lbs of supplement was presented at once. All cows were gathered daily and sorted into their respective treatment groups regardless of their supplementation schedule. For statistical purposes, treatment group within a pasture was the experimental unit. Cows were weighed and body condition was scored again on January 8, on February 8, and

[1]Consolidated Nutrition, Omaha, NE.

within 48 hours after calving. Calves were weighed within 48 hours after birth.

Results and Discussion

Cows lost less (linear, P=.02) body condition from trial initiation to February 8 as supplementation became more frequent (Table 1). During the same period, cows gained more (linear, P=.02) as supplementation frequency increased (Table 2). Regression equations were used to describe the relationships between supplementation frequency and changes in both body condition and body weight. For each increase in weekly supplementation frequency, body condition score improved by .05 units (i.e., reduced loss) and body weight increased by 4.4 lbs. However, body condition changes in the period before calving lessened the magnitude of cumulative change from the beginning of the study through calving. Calf birth weights were not affected by treatment (Table 3).

This experiment indicated that more frequent supplementation of beef cows will improve the response only slightly. The small performance differences with changing frequencies suggest that reducing supplementation frequency is a viable practice, particularly if cows enter the wintering period in reasonably good condition, and if the intervals between supplementation events are not extreme.

Table 1. Influence of Frequency of Supplementation on Beef Cow Body Condition (BC)

	Treatment[a]					Contrasts (P-Values)[b]		
Item	2-day	3-day	5-day	7-day	SEM	L	Q	C
No. of cows	30	30	30	30				
Initial BC score	5.27	5.30	5.27	5.30	.024	.61	.81	.26
Period BC changes								
7 Dec – 8 Jan	.06	.13	.16	.19	.044	.09	.56	.57
8 Jan – 8 Feb	-.44	-.34	-.29	-.27	.054	.07	.40	.64
8 Feb – Calving	-.31	-.39	-.62	-.54	.088	.06	.20	.52
Cumulative BC changes								
7 Dec – 8 Feb	-.38	-.21	-.13	-.08	.068	.02	.30	.47
7 Dec – Calving	-.73	-.63	-.75	-.66	.050	.81	.70	.11
Ending BC score	4.53	4.69	4.52	4.63	.043	.76	.80	.02

[a]Treatment: The number of days per week when supplement was offered: 2-day=2 days a week; 3-day=3 days a week; 5-day=5 days a week; 7-day=7 days a week.
[b]Contrasts: L=Linear; Q=Quadratic; C=Cubic.

Table 2. Influence of Frequency of Supplementation on Beef Cow Body Weight

	Treatment[a]					Contrasts (P-Values)[b]		
Item	2-day	3-day	5-day	7-day	SEM	L	Q	C
No. of cows	30	30	30	30				
Initial wt.,lb	1198	1168	1192	1172	12.3	.44	.97	.10
Period weight changes, lb								
7 Dec - 8 Jan	32.0	45.4	47.1	51.1	3.95	.02	.24	.23
8 Jan - 8 Feb	-12.8	-16.3	-5.0	-10.2	5.55	.44	.59	.31
8 Feb - Calving	-182.6	-182.1	-190.8	-177.8	6.91	.82	.29	.47
Cumulative weight changes, lb								
7 Dec - 8 Feb	19.2	29.0	42.2	40.9	5.55	.02	.19	.88
7 Dec - Calving	-163.9	-148.6	-148.7	-131.3	6.60	.02	.94	.22
Ending wt., lb	1032	1032	1044	1045	14.4	.44	.89	.79

[a]Treatment: The number of days per week when supplement was offered: 2-day=2 days a week; 3-day=3 days a week; 5-day=5 days a week; 7-day=7 days a week.
[b]Contrasts: L=Linear; Q=Quadratic; C=Cubic.

Table 3. Influence of Frequency of Supplementation on Birth Weight of Calves

	Treatment[a]					Contrasts[b]		
Item	2-day	3-day	5-day	7-day	SEM	L	Q	C
Birth weight, lb	85	85	87	87	2.01	.42	.82	.78

[a]Treatment: The number of days per week when supplement was offered: 2-day=2 days a week; 3 day=3 days a week; 5-day=5 days a week; 7-day=7 days a week.
[b]Contrasts: L=Linear; Q=Quadratic; C=Cubic.

EFFECTS OF FREQUENCY OF SUPPLEMENTATION ON THE INTAKE AND DIGESTION OF LOW-QUALITY FORAGE BY BEEF STEERS

C. G. Farmer, R. C. Cochran, D. D. Simms[1], E. A. Klevesahl, and T. A. Wickersham

Summary

A 43% CP (dry basis) supplement was fed to 16 ruminally fistulated steers on 2, 3, 5, or 7 days a week. Supplement was offered at .36% BW (dry basis) daily for steers that received supplement every day. For other treatments, the same amount of supplement was split equally among supplementation events. Forage intake and digestibility increased with increasing supplementation frequency. However, the difference in forage intake tended (cubic, P=.07) to be most prominent for the two extremes; the 3- and 5-days-a-week treatments tended to be similar. Forage intake for steers supplemented on 2 days a week decreased on the days when they were supplemented. Although forage utilization may improve with increasing frequency of supplementation, the impact on performance is likely to be small unless differences in frequency of supplementation are extreme.

(Key Words: Steers, Forage, Intake, Digestion, Supplementation Frequency.)

Introduction

Supplementing low-quality forages with protein, particularly highly degradable protein, improves performance. Producers with sufficient time and labor frequently supplement daily. Unfortunately, time and labor constraints in some cow/calf operations make such frequent supplementation infeasible. If effective, less frequent supplementation would be an advantage where time and labor are scarce. A previous study at Kansas State University revealed that daily supplementation resulted in a slight improvement in digestible diet intake over three-times-weekly supplementation. Our objective was to see the effects of an array of supplementation frequencies on forage intake, digestion, and selected ruminal fermentation characteristics.

Experimental Procedures

Sixteen ruminally fistulated Hereford × Angus steers (avg. BW=565 lb) were blocked by weight and assigned randomly to receive a 43% crude protein (CP) supplement 2 (Tuesday and Friday); 3 (Monday, Wednesday, and Friday); 5 (Monday-Friday); and 7 days a week.

Each steer was offered tallgrass-prairie hay (4.8% CP; 73.5% neutral detergent fiber, NDF) at 130% of the average voluntary intake for the preceding 5-day period. The amount of supplement fed was similar to that provided to grazing beef cows in a companion trial (.36% BW per day, dry basis).

All treatments received the same amount of supplement on a weekly basis, but the weekly allotments were divided into equal portions fed at the different frequencies. For instance, steers supplemented on 2 days a week received their total weekly allotment of supplement in two portions.

Forage intake and digestion were determined in a 7-day intake and total fecal collection period following a 14-day adaptation period. Following the fecal collection pe-

[1]Consolidated Nutrition, Omaha, NE.

riod, two separate fermentation profiles were conducted; one on a day when only the steers that received supplement every day were supplemented and the other on a day when all steers were supplemented. Ruminal fluid was sampled just before feeding and at 3, 6, 9, and 12 hours postfeeding.

Results and Discussions

Forage organic matter (OM) intake, total OM intake, and total digestible OM intake increased (linear, P<.01) as frequency of supplementation increased (Table 1). However, the response to increasing frequency tended to be cubic (P=.07) for forage OM intake and total OM intake.

A large difference in intakes occurred for the daily versus twice weekly supplementation. The three- and five-times-weekly groups were similar to each other and intermediate to the extremes. Digestibilities of OM and NDF also increased (P#.02) as supplementation frequency increased, with some evidence of a more substantive difference for the two highest frequencies (cubic, P=.05 and P=.12, respectively).

A treatment × day interaction (P<.01) was observed for daily DM intake. Steers supplemented on 2 days a week had a sharp decrease in forage DM intake on days when they received supplement.

Ruminal pH increased (P#.05) as frequency of supplementation increased (Table 2), but the differences were small. All ruminal pH's were well within the range acceptable for uninhibited fiber digestion.

On the day when only the daily treatment group was supplemented, the supplemented steers had higher ruminal ammonia concentrations than steers that were not supplemented (quadratic, P=.01). Ruminal ammonia decreased linearly (P=.01) with frequency of supplementation on the day that all steers received supplement. Clearly, this was because steers supplemented less frequently received more supplement each time. Interestingly, steers supplemented on 2 days a week had their peak ruminal ammonia concentration and the lowest pH later (6 hours after feeding) than other groups on the day that all groups were supplemented. This may indicate microbial adaptation in response to receiving large amounts of supplemental protein only twice per week.

In addition, on days when they were supplemented, steers supplemented twice per week had a slower rate of liquid passage (4.75 %/hr) than those supplemented 3 (6.72 %/hr), 5 (6.15 %/hr), or 7 (6.61 %/hr) days per week. No significant differences in liquid passage rates occurred on the day when only 7-day steers received supplement.

Increasing supplementation frequency likely will maximize the proportion of nutrients derived from low-quality forage. However, our treatment differences suggest that only with extreme differences in supplementation frequency (twice weekly vs. daily) will performance be impacted.

Table 1. Influence of Frequency of Supplementation on Intake and Digestion by Beef Steers

	Treatment[a]					Contrasts (P-Values)[b]		
Item	2-day	3-day	5-day	7-day	SEM	L	Q	C
Forage OM intake								
g/kg $BW^{.75}$	63.2	74.2	70.7	84.0	3.71	<.01	.74	.07
% BW	1.58	1.86	1.77	2.10	.093	<.01	.70	.07
Total OM intake								
g/kg $BW^{.75}$	75.9	86.9	83.3	96.7	3.71	<.01	.72	.07
% BW	1.90	2.17	2.08	2.41	.092	<.01	.70	.07
Digestible OM intake								
g/kg $BW^{.75}$	40.6	45.5	46.1	53.5	1.90	<.01	.68	.15
% BW	1.01	1.14	1.15	1.34	.048	<.01	.66	.16
OM digestion, %	53.5	52.5	55.3	55.4	.62	.01	.96	.05
NDF digestion, %	51.0	50.4	53.7	53.5	.86	.02	.55	.12

[a]Treatment: The number of days per week where supplement was offered: 2-day=2 days a week; 3-day=3 days a week; 5-day=5 days a week; 7-day=7 days a week.
[b]Contrasts: L=Linear; Q=Quadratic; C=Cubic.

Table 2. Influence of Frequency of Supplementation on Ruminal Fermentation Characteristics on Supplemented and Unsupplemented Days

	Treatment[a]					Contrasts (P-Values)[b]		
Item	2-day	3-day	5-day	7-day	SEM	L	Q	C
pH								
only 7-day group supplemented	6.69	6.75	6.70	6.56	.052	.05	.13	.62
all groups supplemented	6.48	6.53	6.59	6.64	.033	<.01	.57	.81
Ammonia, mM								
only 7-day group supplemented	.20	.12	.16	.57	.080	<.01	.01	.86
all groups supplemented	1.18	.91	1.06	.53	.146	.01	.33	.10

[a]Treatment: The number of days per week where supplement was offered: 2-day=2 days a week; 3 day=3 days a week; 5-day=5 days a week; 7-day=7 days a week.
[b]Contrasts: L=Linear; Q=Quadratic; C=Cubic.

EFFECTS OF GRAZING SYSTEM ON PERFORMANCE OF COW-CALF PAIRS GRAZING BERMUDAGRASS PASTURES INTERSEEDED WITH WHEAT AND LEGUMES

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Summary

A total of 96 fall-calving cows and 64 calves grazed bermudagrass interseeded with wheat and legumes during 1996, 1997, and 1998 in either a continuous or rotational system stocked at equal rates. Legume cover, available forage dry matter, residual hay production, gains of cows and calves grazing wheat interseeded into bermudagrass, and gains of cows grazing bermudagrass interseeded with legumes were measured. Grazing system had no effect on legume cover, available forage dry matter, gains of cows and calves (wheat phase), and gains of cows (legume phase); however, rotationally grazed pastures produced more residual hay than those grazed continuously.

(Key Words: Interseeding, Wheat, Legumes, Grazing.)

Introduction

Short-duration rotational grazing at higher than normal stocking rates has been used to improve forage utilization of underutilized pastures. Most of the previous research has evaluated rotationally grazed pastures stocked at a higher rate than the continuously grazed pastures, resulting in higher gain per acre and lower individual grazing gains for the rotational system. Because stocking rates were different for each grazing system, it is difficult to determine whether the performance differences were due to grazing system or stocking rate. Rotational grazing also may be beneficial for establishment of legumes. This study was conducted to compare legume establishment, available forage, and grazing performance of fall-calving cows and calves grazing bermudagrass pasture interseeded with wheat, red clover, ladino clover, and Korean lespedeza and managed by either continuous or rotational grazing. Cattle numbers and land area were equal for each grazing system.

Experimental Procedures

Four 10-acre 'Hardie' bermudagrass pastures were used in a completely randomized design with two replications per grazing system. 'Jagger' wheat was no-till interseeded into the bermuda at 90 lb/acre in the falls of 1995, 1996, and 1997. Pastures were interseeded in the springs of 1996 and 1997 with 'Kenland' red clover, 'Regal' ladino clover, and Korean lespedeza. All pastures were fertilized with N, P and K in mid-May of 1996, 1997, and 1998 followed by 50 lb of N per acre in late July. Eight fall-calving cows were allotted randomly to each pasture on May 21, 1996, and 8 fall-calving cow-calf pairs were assigned randomly to each pasture on March 21, 1997 and April 7, 1998. Rotationally grazed units were subdivided into eight paddocks that were grazed for 3.5-day (1996 and 1997) or 2-day intervals (1998). In 1997 and 1998, cows and calves initially grazed the interseeded wheat for 56 days. Then calves were removed, and cows grazed bermudagrass interseeded with legumes for the remainder of the summer.

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Wheat was not available for grazing in 1996 because of below normal precipitation, so grazing was initiated with cows at the beginning of the bermudagrass-legume phase. Cows grazed bermudagrass interseeded with legumes for 113 days in 1996, 88 days in 1997, and 91 days in 1998. Hay was harvested from all pastures in late July of each year to maintain the bermudagrass in a vegetative state. We measured legume cover, available forage dry matter, gains of cows and calves grazing interseeded wheat and gains of cows grazing bermudagrass interseeded with legumes.

Results and Discussion

Grazing performance is presented in Table 1. No significant (P>.05) year by treatment interactions were observed. Legume cover and available forage dry matter were similar (P>.05) between grazing systems during both the interseeded wheat and legume/bermudagrass phases. However, residual hay production was higher (P<.05) from rotationally grazed pastures than from pastures grazed continuously. Available dry matter during the wheat phase was higher (P<.05) in 1998 than in 1997. Legume cover did not differ during the wheat phase in 1997 and 1998. Legume cover and hay production during the bermudagrass phase were higher (P<.05) in 1997 than in 1998. Grazing system had no effect (P>.05) on gains of cows and calves grazing interseeded wheat or gains of cows grazing bermudagrass interseeded with legumes. Because legume cover and available dry matter did not differ between grazing systems, differences in grazing performance would not be expected. On interseeded wheat, calves gained 2.78 lb/day and cows gained 1.29 lb/day. Cows grazing bermudagrass interseeded with legumes gained 1.63 lb per day. Although differences (P<.05) occurred in cattle weights between years, cow and calf gains were similar (P>.05) between years.

Table 1. Effects of Grazing System on Performance of Cow-Calf Pairs Grazing Bermudagrass Pastures Interseeded with Wheat and Legumes

	Grazing System		Year		
Item	Continuous	Rotation	1996	1997	1998
Interseeded Wheat Phase					
No. of cow-calf pairs	32	32	-	32	32
No. of days	56	56	-	56	56
Calf initial wt., lb	508	509	-	468[a]	549
Calf final wt., lb	666	662	-	628[a]	701[b]
Calf gain, lb	158	153	-	160	152
Calf daily gain, lb	2.82	2.74	-	2.85	2.71
Cow initial wt., lb	1341	1343	-	1272[a]	1412[b]
Cow final wt., lb	1415	1414	-	1344[a]	1485[b]
Cow gain, lb	73	71	-	72	73
Cow daily gain, lb	1.31	1.27	-	1.28	1.30
Legume cover, %	19.9	18.8	-	23.2	15.5
Available dry matter, lb/acre	1630	1555	-	1392[a]	1792[b]
Bermudagrass/Legume Phase					
No. of cows	48	48	32	32	32
No. of days	97	97	113	88	91
Cow initial wt., lb	1307	1300	1081[a]	1344[b]	1485[c]
Cow final wt., lb	1459	1468	1289[a]	1516[b]	1585[c]
Cow gain, lb	153	168	208[a]	172[a,b]	100[b]
Cow daily gain, lb	1.56	1.70	1.84	1.95	1.10
Legume cover, %	7.0	10.0	6.5[a,b]	16.2[a]	2.9[b]
Available dry matter, lb/acre	3667	3868	3850	3830	3622
Hay production, lb of dry matter/acre	1727[a]	3075[b]	2200[a,b]	3087[a]	1917[b]

[a,b,c]Grazing system and year means within a row with the same letter are not significantly different (P<.05).

THE EFFECT OF LONG-TERM MANAGEMENT OF NATIVE GRASS PASTURES ON STEER GAINS[1]

F. K. Brazle[2], D. L. Lanham, and J. L. Davidson

Summary

Three hundred thirteen mixed breed steers (558 lb) were used to determine the effect of long-term management of native grass pastures on gain. Steers were allotted randomly to eight pastures previously grazed for 1/2 season (1 steer/2 acres from April to July 15, 81 days) or 3/4 season (1 steer/3 acres from April to August 15, 112 days) from 1990 to 1998. In 1999, all pastures were stocked at 1 steer/2 acres and grazed 83 days until July 15 or 16. The steers received free-choice mineral and were supplemented six times with 2 lb of 20% crude protein range cubes to aid in gathering. The steers on pastures previously grazed for 3/4 season gained faster (P<.01) than those on pastures previously grazed for 1/2 season. The 1/2-season pastures appeared to have taller, more mature grass left after the 1999 grazing season than those previously grazed for 3/4 season. The 1999 season was extremely wet until July 15, which may have been a factor in the gain difference. This study clearly showed that gains were good following either system of grazing. However, under these environmental conditions, pastures previously grazed for 3/4 season had the advantage.

(Key Words: Stocker Cattle, Grazing Cattle, Native Grass.)

Introduction

When pastures are overstocked for years, grass composition can change, which affects future stocking rates and animal performance. Late-cut, native-grass hay meadows can yield less the following year. Therefore, our purpose was to find out how long-term grass management (9 years) influenced cattle gains.

Experimental Procedures

Three hundred thirteen mixed breed steers (558 lb) were allotted randomly to pastures that had been grazed for 1/2 season (1 steer/2 acres from April to July 15, 81 days) or for 3/4 season (1 steer/3 acres from April to August 15, 112 days) from 1990-1998. Four pastures were used per treatment. The steers grazed for 83 days and were removed on July 15 or 16, 1999. They had free-choice access to a mineral mixture and were fed (six times) 2 lb of a 20% crude protein cube to aid in gathering. All pastures were burned in April. Steers were weighed individually at the start and end of the grazing period.

Results and Discussion

The steers grazing the 3/4-season pastures gained faster (P<.01) than the steers grazing the 1/2-season pastures. The 9-year summary showed greater grass regrowth on the pastures grazed for 1/2 vs. 3/4 season. At the end of the 1999 grazing season (July 15), visual appraisal of the pastures showed that those previously

[1]Appreciation is extended to the Bressner Pasture Committee.

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grazed for 1/2 season (to July 15) had taller, more mature grass. The early summer of 1999 had above-average precipitation, so the pastures previously grazed to July 15 may have had more early growth. The resulting taller, more mature grass could explain the lower steer gains on those pastures. Normally, a late-cut, native-grass hay field yields less the next year. A pasture that is grazed later could show the same result, which might affect gain. However, the late-season grazing in the 9 preceding years had a positive rather than a negative effect on gains. Both grazing systems resulted in excellent steer gains in the year following 9 years of grazing. Either system, properly managed, should maintain future grazing potential. However, differences may occur because of environmental conditions of a given year.

Table 1. Steer Gains (Short Season) on Native Grass Pastures Grazed for 1/2 Season or 3/4 Season for the Previous 9 Years

Items	1/2 Season	3/4 Season
No. steers	156	157
Starting wt, lb	556	561
Daily gain, lb	3.35[a]	3.50[b]
Days grazed	83	83

[a,b]Means in the same row with unlike superscripts are different (P<.01).

INTEGRATED CONTROL OF SERICEA LESPEDEZA IN KANSAS

W. H. Fick[1]

Summary

Two experiments were conducted near Maple Hill, KS in 1998 to compare the effectiveness of herbicides and mowing used alone and in combination for control of sericea lespedeza (*Lespedeza cuneata*). Remedy® at 0.5 lb/acre was more effective when applied during the vegetative growth stage (>87%) than during flowering or seed production. Ally® at 0.4 oz/acre provided control equivalent to Remedy and was equally effective at both the vegetative and bloom stages. Both herbicides provided less than 60% control when applied during seed production. A single mowing on July 8 was not effective. Mowing followed in 6 weeks by Remedy at 0.25 lb/acre or Ally at 0.2 oz/acre provided control equivalent to that with the higher rates of Remedy or Ally alone.

(Key Words: Sericea Lespedeza, Integrated Control, Remedy®, Ally®, Rangeland.)

Introduction

Sericea lespedeza is an introduced perennial legume that is invading rangeland in Kansas. Its high tannin content and woody nature make it unpalatable. On July 1, 2000, sericea lespedeza will become a noxious weed statewide. Finding effective methods for management and control of this invasive species is necessary. The objective of this study was to compare the effectiveness of herbicides and mowing used alone and in combination for control of sericea lespedeza.

Experimental Procedures

Two experiments were conducted near Maple Hill, KS during 1998. All herbicides were applied in 20 gal/acre spray volumes using a CO_2-powered backpack sprayer. Application conditions are noted in Table 1. Individual plots were 6.7 by 25 feet. All treatments were replicated three or four times. Reduction in sericea lespedeza cover was estimated visually (% control).

Experiment 1. Remedy (triclopyr) at 0.125, 0.25, and 0.5 lb/acre and Ally (metsulfuron) at 0.4 oz/acre were applied on July 8 and September 18, 1998 and evaluated for control on July 28, 1999. Data were analyzed as a split plot with date of application as the whole plot and treatments as the subplots. Means were separated using the Least Significant Difference test ($P<0.10$).

Experiment 2. Remedy (0.5 lb/acre) or Ally (0.4 oz/acre) were applied on July 8 and October 12, 1998. Additional plots were mowed on July 8, and 0.25 lb/acre Remedy or 0.2 oz/acre Ally were applied about 6 weeks later (August 22). All plots were evaluated for control on July 8, 1999. Data were subjected to analysis of variance and means separated using the Least Significant Difference test ($P<0.10$).

Results and Discussion

Experiment 1. Sericea lespedeza control depended on date of herbicide application (Table 2). Remedy at 0.5 lb/acre was more effective when applied on July 8 when

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sericea lespedeza was still in a vegetative stage than on September 18 when it was blooming. Ally applied at 0.4 oz/acre was equally effective at both stages of plant development. Remedy at 0.25 or 0.5 lb/acre and Ally at 0.4 oz/acre provided equal control when applied on July 8. However, Ally at 0.4 oz/acre was more effective than any rate of Remedy when applied during the bloom stage.

Experiment 2. Control of sericea lespedeza was less than 60% when either herbi-cide was used during seed production (October 12) (Table 3). A single mowing on July 8 was not effective (6% control). Mowing followed in 6 weeks (August 22) by either 0.25 lb/acre Remedy or 0.2 oz/acre Ally provided control equal to that with 0.5 lb/acre Remedy applied on July 8.

Table 1. Environmental Conditions during Herbicide Application at Maple Hill, KS

Date	Temperature (°F)	Relative Humidity (%)	Wind Speed (mph)
July 8, 1998	89	52-67	0-8
August 22, 1998	89	49	4-6
September 18, 1998	89	41	0-2
October 12, 1998	65	50	4-6

Table 2. Percent Sericea Lespedeza Control - Experiment 1, Maple Hill, KS

Herbicide	Rate	Application Date	
		July 8, 1998 (Vegetative)	Sept 18, 1998 (Bloom)
		- - - - - - - - % Control----------	
Remedy	0.125 lb/acre	8^{cd}	25^{d}
Remedy	0.25 lb/acre	82^{ab}	68^{bc}
Remedy	0.5 lb/acre	90^{ab}	60^{c}
Ally	0.4 oz/acre	79^{ab}	92^{a}
Control (no treatment)	–	0^{d}	8^{d}

^{a,b,c,d}Means within a row or column with different superscripts are different (P<0.10).

Table 3. Percent Sericea Lespedeza Control - Experiment 2, Maple Hill, KS

Treatment	Date	% Control
Remedy 0.5 lb/acre	July 8	87^{a}
Ally 0.4 oz/acre	July 8	64^{bc}
Remedy 0.5 lb/acre	October 12	46^{c}
Ally 0.4 oz/acre	October 12	58^{bc}
Mow	July 8	6^{d}
Mow + Remedy 0.25 lb/acre	July 8 August 22	68^{ab}
Mow + Ally 0.2 oz/acre	July 8 August 22	70^{ab}
Control (no treatment)		6^{d}

^{a,b,c,d}Means with different superscripts are different (P<0.10).

EFFECTS OF CATTLE GRAZING CROP RESIDUES ON SOIL BULK DENSITY[1]

R. K. Taylor[2] and J. W. Slocombe[2]

Summary

Effects of cattle grazing on soil bulk density were measured at two sites in central Kansas. Samples were taken at depths of 0 to 3 in. and 3 to 6 in. from grazed and ungrazed areas at five locations in each field. No statistical difference ($P>0.01$) between bulk densities of the two areas occurred at the 3 to 6 in. depth for either site. However, soil in the grazed areas had significantly higher ($P<0.01$) bulk density than that in the ungrazed areas at the 0 to 3 in. depth at both sites.

(Key Words: Soil Compaction, Stocker Cattle, Grazing, Forage.)

Introduction

Grazing cattle on crop residues can be economical for producers. However, the impact of cattle on soil properties can affect subsequent crops planted in fields that have been grazed. In a Texas study, trampling during rotational grazing reduced water infiltration rate and increased sediment production, resulting in a silty clay surface devoid of vegetation.

In a 3-year study, cattle grazing wheat pastures in late fall and winter resulted in soil bulk densities greater than 1.5 g/cm^3 and soil cone penetrometer readings greater than 290 psi at 2 to 4.8 in. below the soil surface at planting time in the following year. This compaction may have been associated with reductions of forage and grain yields in the following year's wheat crop.

Our objective was to evaluate the effects of stocker cattle grazing grain sorghum stalks on soil bulk density.

Experimental Procedures

This study was conducted on two fields in central Kansas, one in Rice County (near Lyons) and one in Smith County (near Smith Center). The Rice County field consisted primarily of Crete silt loam and Smolan silty clay loam, was planted to grain sorghum in the spring of 1998, and was harvested in late October. The stocker cattle had access to approximately 75 acres of winter wheat pasture as well as the grain sorghum stalks. The Smith County field consisted of Harney silt loam, was planted to grain sorghum in the spring of 1998, and was harvested in early November. Table 1 shows the stocking rates and durations of grazing for each of the two fields.

[1]K-State Forages Task Force Project. The authors appreciate the cooperation of Todd Whitney, Rice County Extension Office; Sandra Wick, Smith County Extension Office; Knight Feedlot, Lyons, KS; and Gary Gerstenkorn, Smith Center, KS.

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Table 1. Field Sizes, Stocking Rates, and Grazing Duration

County	Field Size (acres)	Starting Date	Ending Date	Animal Units
Rice	108[a]	11/17/98	3/30/99	83[b]
Smith	45	11/11/98	12/26/98	37[c]

[a]The field consists of 33 acres of grain sorghum stubble and 75 acres of wheat pasture.
[b]83 stocker calves weighing approximately 600 lbs each.
[c]33 weaned cows, 2 bulls, and 2 yearling calves.

To facilitate a comparative analysis of bulk density between grazed and ungrazed soil, sets of three 16-ft livestock panels were erected to form triangles (110 sq ft) at five randomly selected locations in each field before the fields were stocked. At the conclusion of the grazing period, soil samples were taken at the five locations in each field prior to tillage in the spring of 1999. A slide hammer, double ring, 3-in.-diameter core sampler was used to take five samples each from the grazed and ungrazed (protected by the livestock panels) areas at each location in the field. Each sample was divided into depths of 0 to 3 in. and 3 to 6 in. This resulted in 100 samples per site. The soil samples were transported to a laboratory, weighed, oven dried at 100°C for 24 hours, and then weighed again to determine bulk density.

Results and Discussion

Soil samples were composited for each location within a field for both treatments (grazed and ungrazed) and depths. Textural analyses were run on the composited samples (Table 2). The soil texture was very similar across each field.

Table 2. Soil Texture Analyses from the Five Sample Locations of the Two Sites

County	Location	Sand %	Silt %	Clay %
Rice	A	20	30	51
	B	17	33	51
	C	23	37	41
	D	26	26	49
	E	26	28	47
Smith	A	19	62	19
	B	23	59	18
	C	22	51	28
	D	21	60	20
	E	18	62	21

Table 3 shows soil bulk densities and water contents for grazed and ungrazed areas by depth. Bulk density was greater for the grazed areas at both depths in both fields. The magnitude of variation was significant ($P<0.01$) at the 0 to 3 in. depth, but not statistically significant at the 3 to 6 in. depth. Higher bulk density indicates a more compacted soil. Soils with a higher bulk density have less pore space for air and water to occupy, which is confirmed by the higher water content in the ungrazed areas. Comparatively, water content was greater at both depths in the ungrazed areas. The water content differences were significant ($P<0.01$) at the 0 to 3 in. depth for both sites and significant ($P<0.01$) at the 3 to 6 in. depth in Rice County.

These results suggest that compaction by cattle was confined to the 0 to 3 in. depth, as was the depleted water content. Compaction in this zone is manageable for producers, because it is easily removed with spring tillage. In northern areas of the state, a freeze/thaw cycle may eliminate this shallow compaction. This study dealt only with the effects of cattle grazing on soil compaction as measured by soil bulk density. It made no attempt to quantify subsequent impact on grain or forage yield.

Table 3. Bulk Density and Water Content Data Separated by Site and Depth

		Bulk Density, gms/cm^3		Water Content, gms/gm	
County	Depth	Grazed	Ungrazed	Grazed	Ungrazed
Rice	3 inches	1.43[a]	1.35[b]	0.189[a]	0.212[b]
	6 inches	1.52	1.51	0.220[a]	0.228[b]
Smith	3 inches	1.51[a]	1.41[b]	0.217[a]	0.249[b]
	6 inches	1.61	1.60	0.238[a]	0.244[a]

[a,b]Bulk density and water content values within each row that are followed by different letters are significantly different ($P<0.01$).

EFFECTS OF STAGE OF MATURITY AT HARVEST AND KERNEL PROCESSING ON THE NUTRIENT DIGESTIBILITY OF CORN SILAGE

T. J. Wistuba, L. A. Whitlock, M. K. Siefers, R. V. Pope, and K. K. Bolsen

Summary

Twelve ruminally cannulated crossbred steers were used to evaluate the effects of stage of maturity and kernel processing (rolling) of whole-plant corn silage on nutrient digestibilities. The six silage rations were: 50% milkline, 80% milkline, and 7 days after-black layer (7BL) each ensiled processed (rolled) or unprocessed. Steers consuming the 80% milkline and 7BL processed rations had numerically higher DM and OM digestibilities, and all processed rations had numerically higher starch digestibilities. However, the three processed rations had numerically lower fiber digestibilities (NDF and/or ADF). Steers consuming the 80% milkline rations had numerically higher nutrient digestibilities than those fed the less or more mature silages. Yield data taken at each of the three harvests showed that whole-plant DM and grain yields increased with advancing maturity. The data indicate that harvesting at the 80% milkline stage of maturity and processing the whole-plant maximized DM yield and nutrient utilization.

(Key Words: Mechanically Processed, Corn Silage, Stage of Maturity, Growing Cattle.)

Introduction

Improving the digestibility of whole-plant corn (both the stover and grain) would have a positive impact on the performance of growing cattle. An earlier trial (1998 Cattlemen's Day, pg 25) showed that using a kernel processor on the forage harvester could improve nutrient digestibilities. The objective of this study was to evaluate the effect of stage of maturity at harvest and kernel processing on the utilization of corn silage-based rations by growing cattle.

Experimental Procedures

Pioneer 3394 corn hybrid was grown under irrigation during the summer of 1997. A three-row, self propelled, precision chop, forage harvester (FieldQueen®) was used to harvest the whole plants at three stages of maturity; 50 and 80% milkline and 7 days after-black layer (7BL). Dry matter (DM) contents were 32, 38, and 42%, respectively. The forage was chopped to a 10 mm particle length, and four concrete pilot-scale silos were filled at each harvest date. Two silos were filled with chopped forage that was put through a stationary kernel processor (Roskamp® roller mill), and two silos were filled without further processing. At each stage of maturity, three, 20-foot rows of whole-plant corn were hand-harvested and separated into stover and grain portions, which were dried and weighed for determinations of yield and plant parts.

The nutrient digestibilities of the six corn silage rations (three maturity stages processed and unprocessed) were determined using 12 ruminally cannulated, yearling steers in a Latin square metabolism trial. All rations contained 90% silage and 10% supplement on a dry basis. The steers were housed in a climate-controlled barn, where they were tethered in individual tie stalls. The 21-day periods consisted of four phases: a 10-day ration adaptation, an 8-day total fecal collection (two, 4-day periods), a 2-day ruminal fermentation, and a 1-day ruminal evacuation.

Results and Discussion

The pre-ensiled stover increased in contents of DM, CP, NDF, and ADF as stage of maturity advanced, as did whole-plant DM yield and the proportion of grain in the whole plant (data not shown).

The effects of stage of maturity and processing whole-plant corn silage on nutrient digestibilities are shown in Table 1. Steers consuming the 80% milkline and 7BL processed silage rations had numerically higher DM and OM digestibilities than steers consuming their unprocessed counterparts, and starch digestibilities were numerically higher for all processed silage rations than for unprocessed rations. However, the three processed silage rations did have numerically lower fiber digestibilities (NDF and/or ADF). The 50 and 80% milkline silage rations had numerically higher DM, OM, CP, NDF, and ADF digestibilities than did the respective 7BL silage rations.

The improvements in starch digestibilities observed in the processed corn silage rations likely were due to an increased surface area of the kernel and more starch granules exposed to ruminal fermentation compared to the unprocessed corn silage rations. The slight negative impact of processing on fiber digestibilities could have been due to a carbohydrate effect on ruminal pH and ruminal bacteria activity.

Table 1. Nutrient Digestibilities of the Six Whole-Plant Corn Silage Rations by Growing Steers

	50% Milkline		80% Milkline		7 Days After-Black Layer		
Item	P	U	P	U	P	U	SE
	---------- % of the ration----------						
DM	72.9^{a}	73.8^{a}	74.3^{a}	73.9^{a}	71.8^{a,ab}	70.2^{b}	1.0
OM	74.7^{a}	76.2^{a}	77.0^{a}	76.2^{a}	73.5^{a,b}	72.3^{b}	1.0
Starch	96.4^{a}	94.6^{b}	96.4^{a}	94.0^{b}	94.9^{a,b}	93.3^{c}	.7
CP	71.9^{c}	78.1^{a}	80.5^{a}	76.9^{a,b}	71.4^{c}	74.1^{b}	1.4
NDF	50.4^{c}	53.5^{b}	54.1^{a}	55.8^{a}	50.2^{c}	51.2^{b,c}	1.2
ADF	48.6^{b,c}	53.7^{a}	52.3^{a,b}	53.3^{a}	46.6^{c,d}	45.5^{d}	1.8

^{a,b,c,d}Means within a row with different superscripts differ (P<.05).

P = processed, U = unprocessed.

EFFECT OF LEVEL OF SURFACE-SPOILED SILAGE ON THE NUTRITIVE VALUE OF CORN SILAGE-BASED RATIONS

L. A. Whitlock, T. Wistuba, M. K. Siefers, R. V. Pope, B. E. Brent, and K. K. Bolsen

Summary

Twelve ruminally cannulated crossbred steers were used to determine the effects of level of surface-spoiled silages on dry matter (DM) intake and nutrient digestibilities of corn silage-based rations. Irrigated corn was harvested at the 80% milkline stage of maturity and ensiled in 3-ft-deep, pilot-scale, bunker silos and a 9-ft-diameter AgBag®. After 90 days, the bunkers were sealed with a single sheet of polyethylene, and this silage was designated "spoiled". The silage in the AgBag was designated "normal". The four rations contained 90% silage and 10% supplement (DM basis). The silages in the rations were: A) 100% normal; B) 75% normal: 25% spoiled; C) 50% normal: 50% spoiled; and D) 25% normal: 75% spoiled. Dry matter intake decreased in a linear manner as the proportion of spoiled silage increased from 0 to 75%. Steers consuming the normal silage ration had higher DM, OM, CP, NDF, and ADF digestibilities than those fed the three rations that contained spoiled silage. The addition of spoiled silage also had negative associative effects on nutrient digestibilities, and the integrity of the forage mat in the rumen was destroyed partially by even the lowest level of surface spoilage.

(Key Words: Corn Silage, Surface Spoilage, Nutritive Value.)

Introduction

Whole-plant corn silage is a major source of energy in most rations for growing beef cattle and lactating dairy cattle in North America. Two silage management practices, which are in the control of cattle producers but often poorly implemented or overlooked entirely, are effective sealing of the exposed surface in bunker, trench, or drive-over pile silos and discarding spoiled silage. The objective of this study was to determine the effect of including three levels of "surface-spoiled silage" on the nutritive value of whole-plant corn silage-based rations.

Experimental Procedures

Twelve crossbred steers fitted with ruminal cannulas were used in the study. A single source of irrigated corn (Pioneer 3394) was harvested at the 80% milkline stage of maturity and chopped to a 10 mm particle length. Three pilot-scale bunker silos, which were approximately 3 feet deep, and a 30-ft section of a 9-ft-diameter AgBag® were filled with alternating loads of chopped forage. After 90 days, the bunkers were sealed with single sheets of 0.6 mil polyethylene, and these silages were designated "spoiled". The silage in the AgBag was designated as "normal". The four experimental rations contained 90% silage and 10% supplement (dry basis). The silages in the rations were: A) 100% normal, B) 75% normal:25% spoiled; C) 50% normal:50% spoiled, and D) 25% normal:75% spoiled. The rations were fed once daily at 7:00 a.m., and the amount fed was adjusted so that 5 to 10% of the as-fed ration was in the feed bunk at the end of each 24-h period.

Results and Discussion

The pHs and chemical compositions of the whole-plant corn silages fed are shown in Table 1. The composition of the spoiled silage is reported for each of the two distinct visual layers, designated as the original top 18 inches and bottom 18 inches and for a

composite of the two layers after they were mixed. The mixture represents the spoiled silage as it was actually fed in rations B, C, and D. With ash content as the internal marker, the estimated proportions of the original top 18-inch and bottom 18-inch spoilage layers in the spoiled composite silage were 23.8 and 76.2%, respectively. The normal corn silage had higher DM and OM contents and slightly lower starch and CP contents than the spoiled composite silage. The normal corn silage also had low NDF and ADF percentages, which reflect the high proportion of grain in the ensiled crop. The high ash and fiber contents of the spoiled composite silage are associated with poor preservation efficiency and very high OM losses during the aerobic, fermentation, and storage phases.

The original top 18-inch layer was visually quite typical of an unsealed layer of silage that has undergone several months of exposure to air and rainfall. It had a foul odor; was black in color; and had a slimy, "mud-like" texture. Its extensive deterioration during the 90-day storage also was reflected in very high values for pH, ash, and fiber. This slimy layer comprised 5.4, 10.7, and 16.0 % of the DM in rations B, C, and D, respectively. The original bottom 18-inch layer had an aroma and appearance usually associated with wet, high-acid, corn silage – a bright yellow to orange color, a low pH, and a very strong acetic acid smell.

The original depth of the packed, whole-plant corn in the bunker silos was about 36 inches; however, the final depth of the spoiled silage was only about 22 inches, with about 7 in. in the top layer and 15 in. in the bottom (Figure 1). This settling of the ensiled crop that occurred during the 90 days when the bunker silos remained unsealed – approximately 14 inches – is typical of settling depths observed in unsealed bunker, trench, or drive-over pile silages.

The addition of spoiled silage decreased CP digestibility in a linear manner, and surface spoilage had large negative associative effects on DM intake and DM, OM, NDF, and ADF digestibilities (Table 2). When the ruminal contents were evacuated, the spoiled silage had partially or totally destroyed the integrity of the forage mat in the rumen. These results clearly indicate that feeding surface-spoiled silage has greater negative impacts on the nutritive value of corn silage-based rations than were expected.

Table 1. pH and Chemical Compositions of the Whole-Plant Corn Silages Fed in the Metabolism Trial

Silage	pH	DM	OM	Starch	CP	NDF	ADF
		% ---------- % of the DM - - - - - - - - - -					
Normal	3.90	38.0	94.7	22.3	6.9	42.6	23.4
Spoiled top layer, composite of the original top 36 inches	4.79	26.4	90.9	24.3	9.9	48.9	31.0
Spoilage Layers							
Original top 0-18 inches (Slimy layer)	8.22	19.1	80.0	2.7	17.7	57.6	48.3
Original top 18-36 inches (acidic layer)	3.67	27.6	94.3	26.1	6.7	48.5	25.5

Table 2. Effect of the Level of Spoiled Silage on Nutrient Digestibilities for Steers Fed the Four Whole-Plant Corn Rations

	Ration			
Item % Spoiled silage (% Slimy layer)	0 (0)	25 (5.4)	50 (10.7)	75 (16.0)
DM intake, lb/day	17.5[a]	16.2[b]	15.3[b,c]	14.7[c]
DM intake, % of body weight	2.36[a]	2.22[a,b]	2.10[b,c]	2.04[c]
		Digestibility, %		
DM	74.4[a]	68.9[b]	67.2[b]	66.0[b]
OM	75.6[a]	70.6[b]	69.0[b]	67.8[b]
Starch	94.6	95.0	93.3	95.3
CP	74.6[a]	70.5[b]	68.0[b,c]	62.8[c]
NDF	63.2[x]	56.0[x,y]	52.5[y]	52.8[y]
ADF	56.1[a]	46.2[b]	41.3[b]	40.5[b]

[a,b,c]Means within a row with no common superscript differ (P<.05).

[x,y]Means within a row with no common superscript differ (P<.10).

Figure 1. Surface-Spoiled Silage with a Slimy Layer of 7 Inches (Top) and an Acidic Layer of 15 Inches (Bottom).

SUPPLEMENTATION STRATEGIES FOR FORAGE-FED BEEF STEERS[1]

J. S. Drouillard, R. D. Hunter, T. A Nutsch, and D. A. Blasi

Summary

A comparison was made of different supplementation strategies for steer calves wintered on brome hay for 109 days. Treatments consisted of no supplement, 1.33 lb/head daily of a 30% protein range cube, a commercially available free-choice block supplement containing 40% crude protein (19% as nonprotein nitrogen), and a soy-based block supplement containing soy solubles and full-fat soybeans with 40% crude protein (25% as nonprotein nitrogen). Following the backgrounding phase, steers were placed onto finishing rations and fed for an additional 152 days before being slaughtered. Gain during the growing phase was greater for all supplemented cattle than for unsupplemented controls. Cattle fed blocks or no supplement tended to compensate during the finishing phase, suggesting that differences in gastrointestinal tract fill may have impacted body weights at the end of the backgrounding phase. When performance was evaluated over the entire 261-day trial, cattle fed blocks were more efficient than controls, whereas efficiencies of cattle fed range cubes were essentially equal to those of cattle that previously received no supplement. Additionally, soybean solubles and full-fat soybeans were viable alternatives to traditional ingredients for manufacturing free-choice block supplements.

(Key Words: Growing Cattle, Forages, Blocks.)

Introduction

Free-choice block supplements are convenient and require little labor. Low-moisture blocks, which are manufactured by cooking molasses and other liquid ingredients to very low moisture levels, are particularly attractive because consumption is very consistent. The liquid ingredients used typically contain a high proportion of simple sugars. When exposed to air, sugars bind atmospheric moisture, producing a thin layer of syrup on the block surface that is readily consumed by cattle. Consumption is controlled as a result of the rate at which the softened, syrupy layer develops on the block surface. Using this process, it is possible to regulate intake of costly nutrients, such as protein, vitamins, and minerals, with a free-choice system.

Soy solubles contain approximately 50% sugars, 20% protein, and appreciable levels of several important minerals. The majority of the sugars is sucrose, which is similar to other liquid ingredients used in blocks, such as cane or beet molasses. Consequently, our interest was in comparing blocks manufactured with soy solubles and full-fat soybeans to range cubes and to commercially available blocks containing high proportions of molasses, feather meal, and blood meal.

Experimental Procedures

Crossbred steer calves (618 head) were purchased from sale barns in Florida, transported to the K-State Beef Cattle Research Center, and placed on a common receiving

[1]Partial funding for this project was provided by the Kansas Soybean Commission.

diet for 35 to 40 days prior to initiating the growing experiment. At the beginning of the growing period, calves were weighed individually and allocated to 12 pens, with a total of 48 to 53 head per pen, and three pens per treatment.

Treatments included blocks made with a high proportion of soy solubles and full-fat soybeans (SOYBLOCK; 40% crude protein with 25% as nonprotein nitrogen), commercially available molasses-based blocks (CBLOCK; 40% crude protein with 19% as non-protein nitrogen), and commercially available range cubes (CUBES; 30% crude protein). These supplementation strategies were compared to a negative control (CONTROL) group that received only hay and salt. Brome hay (7.85% crude protein, 69.7% NDF, .46% calcium, and .17% phosphorus) was processed in a tub grinder to a chop length of 3 to 4 inches. Cattle had free access to the brome hay, which was fed twice daily in fence-line feed bunks. Fresh water and white salt were available at all times. Steers fed CUBES were given 1.33 lb/head daily (as-fed basis) of the supplement in conjunction with the morning feeding of hay. SOYBLOCK and CBLOCK were provided free choice throughout the 109-day growing phase. At the end of the growing period, steers were stepped up to common finishing diets, fed for 152 days, and slaughtered at a commercial facility in Emporia, Kansas. Average daily gains during the finishing phase were based on shrunk (4%) weights computed using carcass weight adjusted to a common dressing percentage.

Results and Discussion

Intake of hay and supplements, daily gains, and efficiencies for the growing phase are shown in Table 1. Intake of the SOYBLOCK was somewhat higher than intake of the commercial 40% block supplement. We attributed this to the softer texture of the SOYBLOCK in comparison to the CBLOCK. Additional experience with processing of soy solubles in block supplements likely would make it feasible to produce harder blocks that would lower consumption. Cattle fed the block supplements tended to consume less hay than the cattle fed CUBES or no supplement. Gains for cattle fed the two blocks were very similar. Steers fed blocks tended to gain faster than unsupplemented cattle and slower than cattle fed range cubes. Efficiency of gain paralleled rate of gain.

During the finishing phase (Table 2), cattle previously fed the SOYBLOCK gained faster and were more efficient than the other treatment groups. Efficiency was poorest for cattle previously fed range cubes, indicating some compensation by cattle in the other dietary treatments. We interpret these data to suggest that different supplementation strategies vary in their impact on gastrointestinal tract fill.

When performances during the growing and finishing phases were combined (Table 3), cattle that were supplemented during the growing period gained more rapidly than unsupplemented controls. However, cattle fed either of the block supplements were more efficient than controls, whereas those fed range cubes were essentially identical to unsupplemented controls. Cattle fed the SOYBLOCK gained more rapidly than those fed the commercial block supplement, but the two block supplements yielded comparable efficiency overall.

Free-choice block supplements represent a feasible alternative to hand-fed range supplements. Additionally, we conclude that soybean solubles and full-fat soybeans can effectively substitute for traditional ingredients in cooked, self-fed, block supplements.

Table 1. Performance of Steers Backgrounded (109 Days) on Forage-Based Diets Using Different Supplementation Strategies

	Treatment [a]				
Item	CONTROL	SOYBLOCK	CBLOCK	CUBE	SEM
No. steers	157	153	155	153	
Initial weight, lb	551	549	550	552	9.7
Ending weight, lb	634	645	647	671	14
Dry matter intake, lb/day					
Supplement	---	.96[b]	.60[c]	1.18[d]	.032
Forage	15.1[b]	14.2[bc]	14.0[c]	14.8[bc]	.36
Total	15.1[bc]	15.1[bc]	14.6[c]	16.0[b]	.37
Average daily gain, lb	.76[b]	.88[b]	.89[b]	1.09[c]	.069
Gain:feed	.051[b]	.058[bc]	.061[c]	.068[c]	.0039

[a]CONTROL: no supplement; SOYBLOCK: free-choice block supplement containing 40% crude protein with 25% as nonprotein nitrogen, made from soybean solubles, urea, and full-fat soybeans; CBLOCK: commercially available cooked molasses block containing 40% crude protein with 19% as nonprotein nitrogen; CUBE: commercially available range cube containing 30% crude protein with no nonprotein nitrogen.

[b,c,d]Means in the same row without a common superscript are different (P<.1).

Table 2. Finishing Performance (152 Days) of Steers Previously Backgrounded on Forage-Based Diets Using Different Supplementation Strategies

	Treatment [a]				
Item	CONTROL	SOYBLOCK	CBLOCK	CUBE	SEM
No. steers	157	153	155	153	
Initial weight, lb	634	645	647	671	14
Final weight, lb	1165	1188	1174	1188	13
Average daily gain, lb	3.12[b]	3.25[c]	3.13[b]	3.06[b]	.056
Dry matter intake, lb/d	19.3	19.1	19.2	19.8	.29
Gain:feed	.162[bc]	.170[b]	.163[bc]	.155[c]	.0041
Hot carcass weight, lb	709	729	719	727	7.9
Dressing percentage	60.8	61.3	61.2	61.2	.27
Ribeye area, in^2	11.8	11.9	11.7	11.9	.19
Fat thickness, in	.41	.44	.44	.45	.024
Kidney, pelvic, & heart fat, %	2.1	2.1	2.1	2.1	.09
Yield grade 1, %	6	5	4	8	2.4
Yield grade 2, %	37	31	34	28	4.3
Yield grade 3, %	52	56	51	52	5.5
Yield grade 4&5, %	6	8	12	12	2.6
Marbling score	Sl[46]	Sl[59]	Sl[55]	Sl[47]	8.6
USDA Choice, %	27	29	32	25	5.6
USDA Select, %	60	58	54	59	5.1
USDA Standard, %	12	12	13	14	3.4
Liver abscess, %	5.2[b]	2[c]	1.9[c]	.7[c]	.66

[a]CONTROL = no supplement; SOYBLOCK = free-choice block supplement containing 40% crude protein with 25% as nonprotein nitrogen, made from soybean solubles, urea, and full-fat soybeans; CBLOCK = commercially available cooked molasses block containing 40% crude protein with 19% as nonprotein nitrogen; CUBE = commercially available range cube containing 30% crude protein with no nonprotein nitrogen.

[b,c]Means in the same row without a common superscript are different (P<.1).

[d]Sl = Slight, Sm=Small amount of marbling.

Table 3. Performance for the Combined Growing and Finishing Periods (261 Days) of Steers Backgrounded on Forage-Based Diets Using Different Supplementation Strategies

	Treatment [a]				
Item	CONTROL	SOYBLOCK	CBLOCK	CUBE	SEM
No. steers	157	153	155	153	
Gain, lb/day	2.13 [b]	2.26 [c]	2.19 [d]	2.24 [c]	.02
Dry matter intake, lb/day	16.9 [bc]	16.8 [bc]	16.5 [b]	17.6 [c]	.30
Gain:feed	.127 [b]	.134 [d]	.133 [cd]	.127 [bc]	.0021

[a]CONTROL: no supplement; SOYBLOCK: free-choice block supplement containing 40% crude protein with 25% as nonprotein nitrogen, made from soybean solubles, urea, and full-fat soybeans; CBLOCK: commercially available cooked molasses block containing 40% crude protein with 19% as nonprotein nitrogen; CUBE: commercially available range cube containing 30% crude protein with no nonprotein nitrogen.

[b,c,d]Means in the same row without a common superscript are different (P<.1).

ALFALFA HAY LEVELS IN LIMIT-FED, HIGH-ENERGY, GROWING DIETS FOR BEEF STEERS

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Summary

One hundred sixty-four crossbred beef steers were used in a 102-day growing study to determine optimum levels of alfalfa hay in limit-fed, high-energy, growing diets. Diets contained steam-flaked corn and 40% *Sweet Bran*® brand wet corn gluten feed (dry matter basis) with 0, 10, or 20% ground alfalfa hay. A fourth diet containing steam-flaked corn (no *Sweet Bran*) and 20% ground alfalfa hay was used as a control. Average daily gains and feed efficiencies in the growing phase were greater (P<.05) for cattle fed no alfalfa than for cattle fed the control, 10% alfalfa, or 20% alfalfa diets. Steers fed the control and 20% alfalfa diets had increased rates of dry matter intake (P<.05) compared to those fed no alfalfa. At the end of the growing phase, all cattle were placed on a common finishing diet and fed for 101 days. Dry matter intakes during the finishing phase for cattle previously fed no alfalfa were numerically less than intakes for cattle fed other diets and significantly less than intakes for cattle previously fed the control diet. Feed efficiencies were greater for cattle previously fed 20% alfalfa diets than those fed the control diet (P<.05). Average daily gains did not differ (P>.40) among diets during the finishing phase.

(Key Words: Wet Corn Gluten Feed, *Sweet Bran*®, Roughage, Limit Feeding.)

Introduction

Wet corn gluten feed is a by-product of the corn wet milling industry and traditionally has been used in cattle diets as a source of both protein and energy. Because it contains high levels of corn bran, wet corn gluten feed constitutes a valuable source of fermentable fiber in ruminant diets. This study was conducted to determine optimum levels of alfalfa hay in limit-fed, high-energy, growing diets containing steam-flaked corn and wet corn gluten feed.

Experimental Procedures

One hundred sixty-four crossbred beef steers averaging 576 lb were used in a randomized complete block design experiment. Steers had ad libitum access to a common diet for 14 days preceding the growing study to minimize differences in gastrointestinal tract fill. Steers then were blocked by weight and allotted to pens containing five to seven animals per pen, with nine pens per treatment. Treatments (Table 1) consisted of diets containing steam-flaked corn and 40% *Sweet Bran* (DM basis) with 0, 10, or 20% ground alfalfa hay. A fourth diet containing steam-flaked corn and 20% ground alfalfa hay was used as a control. All diets provided 30 grams of Rumensin® per ton of dry matter and were fed once daily at 1.8% of body weight for 88 days. On days 12, 25, 39, 55, 67, and 81, feed was removed 2 hours after feeding, immediately weighed, and returned to the respective feed bunk to measure intake

[1]Department of Statistics.
[2]Cargill Corn Milling, Blair, NE.

rate. Prior to obtaining final weights for the growing phase, cattle had ad libitum access to a common diet for 14 days. At the end of the growing phase, steers were placed onto a common finishing diet, fed for 101 days, and then slaughtered. The final finishing diet (Table 1) contained 82% steam-flaked corn, provided 30 grams per ton of Rumensin (DM basis), and was offered once daily for ad libitum feeding. Steers were weighed approximately every 28 days throughout the entire 203-day period.

Results and Discussion

Performance during the growing phase is shown in Table 2. Decreasing the level of alfalfa hay in limit-fed, high-energy growing diets containing 40% wet *Sweet Bran* (DM basis) increased average daily gain and feed efficiencies. Cattle fed no alfalfa had higher average daily gains and feed efficiencies ($P<.05$) than those fed 10 or 20% alfalfa or control diets. Steers fed the control and 20% alfalfa diets had greater dry matter intake ($P<.05$) than those fed no alfalfa (Table 3). However, no feed-related metabolic disorders such as acidosis or bloat were observed. During the finishing phase (Table 4), dry matter intake was higher for controls than cattle previously fed no alfalfa ($P<.05$), but feed efficiencies were greater for cattle previously fed 20% alfalfa than controls ($P<.05$). Finishing average daily gains did not differ among treatments ($P>.40$). The only significant difference for carcass data was a higher percentage of carcasses grading standard ($P<.10$) for cattle previously fed 10% alfalfa. This study suggests that additional roughage may not be required for beef steers that receive limit-fed, high-energy, growing diets containing 40% wet corn gluten feed.

Table 1. Experimental Diets (% of Dry Matter)

	Diet				
Ingredients	No Alfalfa	10% Alfalfa	20% Alfalfa	Control	Finishing[1]
Sweet Bran®	40.55	40.43	40.31	-	-
Alfalfa hay	-	10.19	20.31	20.53	6.57
Steam-flaked corn	53.93	44.63	35.39	65.08	81.98
Soybean meal	-	-	-	5.35	2.73
Cane molasses	-	-	-	3.77	3.70
Tallow	2.03	2.02	2.02	2.04	2.01
Urea	.39	.19	-	1.13	1.17
Limestone	1.92	1.60	1.27	.95	1.14
Sodium chloride	.39	.29	.19	.39	.28
Potassium chloride	.65	.51	.38	-	.04
Ammonium sulfate	-	-	-	.10	.19
Calcium phosphate	-	-	-	.56	.11
Vitamin/trace mineral premix[2]	.14	.14	.14	.10	.08
Crude protein, analyzed	16.5	17.0	17.6	16.7	14.5

[1]Contained 10 g/ton Tylan®.

[2]Vitamin/trace mineral premix formulated to provide (total diet dry matter): 1,490 IU/lb vitamin A, .05 ppm cobalt, 10 ppm copper, .62 ppm iodine, 60 ppm manganese, .30 ppm selenium, 10 ppm thiamin, 60 ppm zinc, and 30 g/ton Rumensin®.

Table 2. Performance during the Growing Phase for Cattle Limit-Fed Diets Containing 40% *Sweet Bran*® and 0, 10, or 20% Alfalfa Hay

	Diet				
Item	No Alfalfa	10% Alfalfa	20% Alfalfa	Control	SEM
No. of steers	53	55	56	56	
Initial weight, lb	578	577	573	575	7.4
Final weight, lb	873	855	846	855	10.3
Dry matter intake, lb/day	12.4	12.5	12.5	12.7	.15
Average daily gain, lb	2.90[a]	2.73[b]	2.68[b]	2.74[b]	.051
Gain:feed	.233[a]	.219[b]	.215[b]	.217[b]	.0039

[a,b]Means within same row with uncommon superscripts differ (P<.05).

Table 3. Rate of Experimental Dietary Dry Matter Intake as Measured 2 Hours after Feeding on Days 12, 25, 39, 55, 67, and 81

	Diet				
Item	No Alfalfa	10% Alfalfa	20% Alfalfa	Control	SEM
Rate of dry matter intake, lb	8.9[a]	10.2[a,b]	11.0[b]	11.6[b]	.55

[a,b]Means within same row without common superscripts differ (P<.05).

Table 4. Finishing Performance and Carcass Characteristics Following a Growing Period during Which Cattle Were Limit-Fed Diets Containing 40% *Sweet Bran*® and 0, 10, or 20% Alfalfa Hay

	Previous Growing Diet				
Item	No Alfalfa	10% Alfalfa	20% Alfalfa	Control	SEM
No. of steers	53	53	56	55	
Initial weight, lb	873	858	846	853	10.4
Dry matter intake, lb/day	19.9[a]	20.2[a,b]	20.4[a,b]	20.7[b]	.25
Average daily gain, lb	3.12	3.12	3.26	3.14	.068
Gain:feed	.156[a,b]	.154[a,b]	.160[a]	.152[b]	.0025
Hot carcass weight, lb	770	760	761	757	8.6
Ribeye area, in^2	13.3	12.7	13.0	12.7	.28
Fat thickness, in	.43	.43	.43	.44	.020
Kidney, pelvic & heart fat, %	2.1	2.2	2.1	2.2	.066
Liver abscesses, %	2	3	2	2	2.6
Yield grade 1, %	6	6	7	9	3.5
Yield grade 2, %	39	33	41	34	6.5
Yield grade 3, %	51	59	45	53	7.7
Yield grade 4 & 5, %	4	2	7	3	2.6
Marbling score[c]	Sl[97]	Sl[81]	Sl[79]	Sl[82]	8
USDA Choice, %	49	47	42	47	6.1
USDA Select, %	44	48	55	47	5.8
USDA Standard, %	.08[d]	4[e]	1[d,e]	2[d,e]	1.5
Dark cutters, %	7	2	2	4	2.7

[a,b]Means within same row without common superscripts differ (P<.05).
[c]Sl=Slight.
[d,e]Means within same row without common superscripts differ (P<.10).

EFFECTS OF FEEDING TWO MICROBIAL ADDITIVES IN SEQUENCE ON GROWTH PERFORMANCE AND CARCASS CHARACTERISTICS OF FINISHING HEIFERS

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Summary

Four hundred fifty heifers (846 lb) were used in a 126-day experiment to investigate the effects of feeding two microbial additives, *Lactobacillus acidophilus* BG2FO4 (MicroCell) and *Propionibacterium freudenreichii* P-63 (MicroCell PB), alone or in sequence, on feedlot growth performance and carcass characteristics. A 21-day step-up period preceded heifers being placed on a final finishing diet containing 10% corn silage, 42% steam-flaked corn, 42% high-moisture corn, 3% soybean meal, and 3% mineral supplement. Premeasured amounts of microbial additive were mixed with water before being mixed directly with the total ration. Treatments consisted of 1) no microbial additive; 2) MicroCell for the entire period; 3) MicroCell PB for the entire period; 4) MicroCell for 28 days then MicroCell PB for the remainder of the period; and 5) MicroCell PB for 28 days then MicroCell for the remainder of the period.

Feeding MicroCell for 28 days and then MicroCell PB for the remainder of the feeding period resulted in significant improvements (P<.10) in daily gain and feed efficiency.

(Key Words: *Lactobacillus acidophilus*, *Propionibacterium freudenreichii* , Microbial Feed Additives, Finishing, Carcass.)

Introduction

Research on the microbial feed additive *L. acidophilus* in feedlot diets has been conducted since the mid-1980's. In controlled studies, improvements in daily gain and feed efficiency are reported to be 2 to 3%. Its proposed mode of action is competitive exclusion in the lower gut. That is, *L. acidophilus* competes for attachment sites with pathogenic bacteria, thereby improving nutrient absorption and overall health.

Because feedlot cattle consume rapidly fermentable feeds like steam-flaked and high-moisture corn, they are inclined to develop ruminal acidosis. Acidotic conditions in the rumen occur when lactate is produced faster than the rumen environment can remove it. Because *P. freudenreichii* utilizes lactate, it might prevent these periodic bouts of lactic acidosis. Our objective was to determine during which phase of the finishing period these microbial feed additives would be most effective.

Experimental Procedures

This study was conducted at the Southwest Research and Extension Center in Garden City from September 9, 1998 to January 13, 1999. Prior to the experiment, heifers were fed a corn silage-based diet for approximately 7 months. Four hundred fifty heifers (846 lb) were allotted to 50 pens in a completely random manner, then blocked by location. Initial weight was based on the

[1]Southwest Area Extension Office.
[2]Biotal, West Point, NE.

average of two consecutive daily weights. Each pen within a block was allotted randomly to one of five treatments, defined by microbial additive or microbial additive sequence. Treatments were: 1) Control, no additive fed; 2) MicroCell during the entire period; 3) MicroCell PB during the entire period; 4) MicroCell for 28 days then MicroCell PB for the remainder; and 5) MicroCell PB for 28 days then MicroCell for the remainder of the feeding period. Cattle were stepped up in 21 days by feeding a diet containing (dry basis) 60% corn silage for 7 days, 40% corn silage for 7 days, and 20% corn silage for 7 days. The final diet contained 10% corn silage, 42% steam-flaked corn, 42% high-moisture corn, 3% soybean meal, and 3% mineral supplement. The diet was balanced to contain 12.5% crude protein (2.5% from urea), 30 grams/ton monensin, and 10 grams/ton tylosin. Heifers were implanted initially with Component E-H and reimplanted with Component E-H plus Component T-H on day 58.

Each microbial additive was mixed with about 2 gallons of tap water and added to the total mixed ration. Then each load was mixed for approximately 2 minutes longer. The microbial additive feeding levels were 5×10^8 colony forming units per head per day for MicroCell and 1×10^9 for MicroCell PB. At the end of the feeding period, all heifers were transported to Monfort, Inc. in Garden City for processing. Hot carcass weight, backfat thickness, and marbling score were collected at the processing plant. Final weight was determined by dividing hot carcass weight by the average dressing percent (62.6%).

Results and Discussion

The change in microbial additives occurred on day 29. Therefore, day 1 through 28 data reported in Table 1 reflect growth performance of heifers fed either no additive, MicroCell, or MicroCell PB. Although no significant differences in growth performance occurred during day 1 through 28, heifers fed MicroCell PB were out-performed numerically by control heifers and those fed MicroCell. This agrees with previous research conducted at Oklahoma State University. Heifers fed MicroCell had the lowest numerical intakes during the first 28 days, but they also had numerically better feed efficiency than heifers in other treatments.

Growth performance data for the entire feeding period also are shown in Table 1. Daily feed intake did not differ among treatments. Feeding either MicroCell or MicroCell PB alone throughout the entire period did not affect daily intake, daily gain, or feed efficiency. Feeding MicroCell PB followed by MicroCell significantly improved average daily gain ($P<.10$) but not feed efficiency, compared to controls. Heifers fed MicroCell followed by MicroCell PB did not differ from controls for daily feed intake, but gain was improved by 5.0% ($P<.10$) and feed efficiency was improved by 5.1% ($P<.10$).

An improvement ($P<.10$) in the percentage of carcasses grading U.S.D.A. Choice and Prime was observed when MicroCell PB was fed throughout the entire trial (Table 1). Because we did not observe a similar effect in heifers fed MicroCell PB for only 28 fewer days (MicroCell followed by MicroCell PB), this difference is difficult to explain.

This study indicates that growth performance of finishing cattle can be improved by targeting the appropriate microbial feed additive to a particular phase of production.

Table 1. Effects of Microbial Additive Treatment on Heifer Growth Performance and Carcass Characteristics

	Microbial Additive Treatment[a]					
Day 1 to 28:	None	MC	MC PB	MC	MC PB	
Item Day 29 to 126:	None	MC	MC PB	MC PB	MC	SEM
No. of heifers	90	90	90	90	90	
Performance, day 1 to 28						
Initial weight, lb	844	847	850	856	831	7.8
Final weight, lb	923	929	924	934	907	8.3
Dry matter intake, lb/day	19.6	19.2	19.9	19.0	19.5	.31
Average daily gain, lb	2.84	2.93	2.69	2.82	2.76	.13
Gain:feed	.144	.152	.135	.149	.142	.007
Performance, day 1 to 126						
Initial weight, lb	844	847	850	856	831	7.8
Adj. Final weight, lb	1176	1179	1176	1205	1178	8.7
Dry matter intake, lb/day	18.6	18.5	18.5	18.5	18.8	.22
Adj. average daily gain, lb	2.64	2.67	2.60	2.78[b]	2.76[b]	.04
Adj. gain:feed	.142	.144	.141	.150[b]	.147	.003
Hot carcass weight, lb	736	738	737	754	737	5.5
Dressing percentage	62.7	62.5	62.6	62.9	62.6	.2
Fat thickness, in	.45	.48	.46	.43	.45	.017
Yield grade 1, %	22	17	19	29	21	4.7
Yield grade 2, %	55	67	55	54	62	5.1
Yield grade 3, %	23	12	26	17	15	4.3
Yield grade 4 & 5, %	0	4	0	0	1	1.0
USDA Choice + Prime, %	64	60	77[b]	66	68	4.6
USDA Select, %	32	34	20	31	29	4.5
USDA Standard, %	4	6	3	3	3	2.1
Liver abscess, %	7.0	2.7	2.5	8.0	6.6	2.3

[a]MC=MicroCell (*Lactobacillus acidophilus* BG2FO4); MC PB=MicroCell PB (*Propionibacterium freudenreichii* P-63).

[b]Different from control (P<.10).

LIMITING AMINO ACIDS FOR HOLSTEIN STEERS FED SOYBEAN HULL-BASED DIETS

R. H. Greenwood and E. C. Titgemeyer

Summary

A study was conducted to determine the limiting amino acids for cattle fed soybean hull-based diets. Ruminally cannulated Holstein steers (335 lb) were maintained in metabolism crates, fed the same basal diet (73% soyhulls, 19% alfalfa), and given the same intraruminal infusions (400 g/day acetate to increase energy supply without increasing microbial protein supply). Steers were infused into the abomasum with a complete mixture of the 10 essential amino acids or the mixture with histidine; tryptophan; arginine; phenylalanine; or the three branched-chain amino acids (leucine, isoleucine, and valine) removed. Nitrogen retention was reduced by removal of either histidine or the branched-chain amino acids, suggesting that those amino acids were limiting.

(Key Words: Steers, Soybean Hulls, Amino Acids.)

Introduction

Previous research demonstrated that for cattle fed soybean hull-based diets, methionine was the first limiting amino acid, lysine was also limiting, but threonine was not limiting. The current study used similar methods to evaluate the possibility that other essential amino acids also limit lean growth of steers fed soybean hull-based diets.

Experimental Procedures

Six ruminally cannulated Holstein steers (335 lb initial body weight) were used in a 6 × 6 Latin square design. Steers were maintained in individual metabolism crates and fed 7.5 lb/day of the same diet (Table 1) in equal portions at 12-hour intervals.

Table 1. Diet Composition[a]

Ingredient	% of Dry Matter
Soybean hulls	72.4
Alfalfa	19.2
Molasses	4.7
Monocalcium phosphate	1.6
Sodium bicarbonate	.8
Magnesium oxide	.3
Limestone	.4
Trace mineralized salt[a]	.2
Vitamin mixture[b]	.2
Elemental sulfur	.2

[a]Composition (%): NaCl (95 to 99); Mn (>.24); Fe (>.24); Mg (>.05); Cu (>.032); Zn (>.032); I (>.007); Co (>.004).
[b]Supplied per lb diet dry matter: 2000 IU vitamin A, 1000 IU vitamin D, and 26 IU vitamin E.

All steers received intraruminal infusions of acetate (400 g/day) supplied through an infusion line terminating in the rumen, in order to increase the energy supply without increasing the microbial protein supply. Treatments (Table 2) were abomasal infusions of a complete mixture of the 10 essential amino acids or the same mixture with either the branched-chain amino acids (leucine, isoleucine, and valine); histidine; phenylalanine; tryptophan; or arginine removed. The abomasal amino acid infusions were supplied continuously by a peristaltic pump through tubing that passed through the ruminal cannula and into the abomasum. Each period was 7 days long with 3 days for

adaptation to treatments and 4 days for total collection of feces and urine.

Representative samples of the basal diet were collected in each period. During days 3 to 7, total fecal and urine outputs were collected daily, and samples were saved for later analysis. Diet, feces, and urine were analyzed for nitrogen to calculate nitrogen retention. On day 7 of each period at 3 hours postfeeding, jugular blood was collected and analyzed for plasma urea and amino acid concentrations.

Results and Discussion

Nitrogen balance data are presented in Table 3. Urinary and fecal nitrogen excretions were statistically similar among all treatments, but nitrogen retention decreased ($P<.05$) when histidine or branched-chain amino acids were removed from the infused mixture. This indicates that without those amino acids, less lean tissue was deposited. Nitrogen retention was depressed to similar magnitudes when either histidine or the branched-chain amino acids were removed, indicating that these amino acids were co-limiting.

Our report is among the first to directly implicate histidine as a limiting amino acid for growing cattle. Other researchers have reported that histidine was limiting for sheep when the sole source of metabolizable protein was microbial protein. Branched-chain amino acids have been studied little, so few data exist to indicate whether or not they are limiting.

Plasma urea nitrogen (Table 4) was numerically highest when histidine was removed from the infusate, reflecting the decrease in nitrogen retention. However, similar changes in plasma urea were not observed for branched-chain amino acids, whose removal also decreased nitrogen retention. As expected, plasma concentrations of individual amino acids (Table 4) decreased when they were removed from the infusate.

In previous studies, methionine was determined to be the first limiting amino acid for steers fed a soybean hull-based diet. In the current study, the similar reductions in nitrogen retention that occurred when histidine or branched-chain amino acids where removed from the infusate suggest that these amino acids were co-limiting. In an earlier study, reductions in nitrogen retention in response to deletion of lysine were of a magnitude similar to those observed when histidine and the branched-chain amino acids were deleted, suggesting that lysine also could be co-limiting. Further delineation of the limiting amino acid sequence will be difficult, because nitrogen retention responses to removal of lysine, histidine, and the branched-chain amino acids are so similar.

Our data suggest that growing cattle fed diets low in undegradable intake protein should benefit from the addition of feedstuffs that would increase the postruminal supply of these limiting amino acids.

Table 2. Amino Acid Treatments (g/day)

	Treatment					
Item	Control	-HIS	-PHE	-TRP	-BCAA	-ARG
L-Methionine	10	10	10	10	10	10
L-Lysine-HCl[a]	20	20	20	20	20	20
L-Threonine	10	10	10	10	10	10
L-Histidine-HCl-H_2O[b]	10	-	10	10	10	10
L-Phenylalanine	10	10	-	10	10	10
L-Tryptophan[c]	5	5	5	-	5	5
L-Leucine	20	20	20	20	-	20
L-Isoleucine	10	10	10	10	-	10
L-Valine	10	10	10	10	-	10
L-Arginine	10	10	10	10	10	-

[a]Feed grade, provided 15.8 g/day lysine. [b]Provided 7.4 g/day histidine. [c]Feed grade, provided 4.9 g/day tryptophan.

Table 3. Effects of Removing Amino Acids from Postruminal Infusions on Nitrogen Retention in Growing Cattle

	Treatment						
Nitrogen, g/day	Control[1]	-HIS[2]	-PHE[3]	-TRP[4]	-BCAA[5]	-ARG[6]	SEM
Total intake	76.5	74.6	75.3	75.9	71.9	72.8	
Fecal	29.2	30.5	29.8	28.7	29.0	27.7	1.0
Urinary	18.8	20.0	19.5	19.9	18.6	18.5	.9
Retained	28.5	24.1[a]	26.1	27.4	24.4[a]	26.6	1.0

[1]Mixture of 10 essential amino acids.
[2]Histidine removed.
[3]Phenylalanine removed.
[4]Tryptophan removed.
[5]Leucine, isoleucine, and valine (branched-chain amino acids) removed.
[6]Arginine removed.
[a]Different from control (P<.05).

Table 4. Effects of Removing Amino Acids from Postruminal Infusions on Plasma Amino Acid and Urea Concentrations in Growing Cattle

	Treatment						
Amino Acid, μ*M*	Control[1]	-HIS[2]	-PHE[3]	-TRP[4]	-BCAA[5]	-ARG[6]	SEM
Histidine	88	30[a]	79	81	94	87	4.1
Phenylalanine	66	70	34[a]	67	71	68	3.6
Tryptophan	36	31	34	18[a]	34	34	2.5
Leucine	175	181	173	177	53[a]	194	10.2
Isoleucine	141	139	142	148	90[a]	150	7.6
Valine	288	290	286	270	172[a]	313	12.1
Arginine	124	117	116	118	138[a]	72[a]	3.5
Urea N, m*M*	1.31	1.65	1.34	1.42	1.38	1.38	.14

[1]Received mixture of 10 essential amino acids.
[2]Histidine removed.
[3]Phenylalanine removed.
[4]Tryptophan removed.
[5]Leucine, isoleucine, and valine removed.
[6]Arginine removed.
[a]Different from control (P<.05).

EFFECTS OF CARNITINE ON PERFORMANCE OF FINISHING STEERS

R. H. Greenwood, E. C. Titgemeyer, J. S. Drouillard, and C. A. Löest

Summary

Ninety-five crossbred steers (787 lb initial body weight) were fed finishing diets (14.5% crude protein) for 129 days. Diets were based on steam-flaked corn and contained 6% alfalfa and 4% tallow. Steers were supplemented with 2 g per day of L-carnitine, or not supplemented (control). Feed intakes, gains, and feed efficiencies were not impacted by carnitine supplementation. However, steers receiving L-carnitine had fatter carcasses as indicated by tendencies (P<.2) for more subcutaneous fat, higher marbling scores, and higher yield grades. Carnitine supplementation may increase fat deposition and alter carcass quality of finishing cattle.

(Key Words: Steers, Carnitine, Performance, Carcass Quality.)

Introduction

Carnitine is a vitamin-like substance that facilitates fat oxidation. Research with swine has indicated that supplemental carnitine improves feed efficiency and alters carcass composition. However, little carnitine research has been conducted with finishing cattle and has not been conclusive. In one study, heifers fed a high-grain diet had lower quality grades when they received 1 g/day carnitine, whereas in another study, carnitine-supplemented steers and heifers had higher quality grades. Our objective was to evaluate the effects of 2 g per day of supplemental L-carnitine on the performance and carcass attributes of finishing cattle.

Experimental Procedures

This study was conducted during the spring and summer of 1999. Ninety-five crossbred yearling steers (average initial weight of 787 lb) were used in a randomized complete block design experiment. Steers were fed for 129 days on a typical finishing diet (Table 1) based on steam-flaked corn. Treatments were 0 or 2 g/day of L-carnitine top-dressed to the diets at feeding. This carnitine level was based on a previous metabolism experiment. Steers were implanted with Component TE-S®. Cattle were sorted into 12 pens with eight steers per pen (one pen contained only seven steers) to provide six pairs of pens as similar as possible in weight and breed characteristics. For each pair, one pen received carnitine and the other (control) did not. Feed was provided once daily and cattle had ad libitum access. After 129 days on feed, steers were shipped to a commercial slaughter facility. Except for hot carcass weights, carcass characteristics were obtained after a 24-hour chill. Final live weight of steers was calculated as carcass weight divided by a common dressing percent (64%).

Results and Discussion

No differences in feed intake, gain, or efficiency occurred between treatments (Table 2). However, carcasses of steers supplemented with carnitine appeared to be fatter than those of controls (Table 2). Backfat thickness (P=.12), marbling score (P=.14), and yield grade (P=.19) all tended to be increased by carnitine, which, in turn, led

to shifts in carcass quality and yield grades. Carnitine-supplemented steers had a numerically greater percentage of carcasses grading USDA Choice (73 versus 64%) and numerically lower percentage of carcasses with a yield grade of 1 or 2 (35 versus 58%; Table 2). Percent kidney, pelvic, and heart fat was not affected by treatment, suggesting that carnitine effects may be specific to particular fat depots.

If carnitine increased fatty acid oxidation (as we expected based on its metabolic function), lipid deposition should decrease. However, it is possible that 1) our measures of carcass fatness did not reflect whole-body lipid deposition and 2) the site of lipid deposition was impacted more than was the amount of lipid deposited.

Our data suggest that lipid, but not protein, deposition by cattle fed grain-based diets may be impacted by carnitine status.

Table 1. Composition of Diets for Finishing Steers

Ingredient	% of Dry Matter
Steam-flaked corn	79.08
Alfalfa hay	6.00
Cane molasses	4.00
Tallow	4.00
Soybean meal	3.77
Limestone	1.28
Urea	1.21
NaCl	.30
Ammonium sulfate	.20
Mineral premix[a]	.07
KCl	.05
Rumensin 80[b]	.02
Tylan 40[c]	.01
Vitamin A premix[d]	.01
Nutrient, analyzed	
Crude protein	14.5
Calcium	.62
Phosphorus	.27

[a]Provided 48 ppm Mn, 48 ppm Zn, 8.0 ppm Cu, .50 ppm I, .43 ppm Fe, .30 ppm Se, and .04 ppm Co to diet (dry basis).
[b]Provided 27 g/ton monensin (dry basis).
[c]Provided 9 g/ton tylosin (dry basis).
[d]Provided 1200 IU vitamin A per pound (dry basis).

Table 2. Performance and Carcass Characteristics of Finishing Steers

Item	Control	2 g/d Carnitine	SEM
No. of steers	47	48	
Initial weight, lb	788	787	5.0
Final weight[a], lb	1235	1233	8.9
Dry matter intake, lb/day	19.6	19.7	.12
Average daily gain[a], lb	3.47	3.45	.074
Gain:feed[a]	.177	.176	.0037
Hot carcass weight, lb	790	789	5.7
Ribeye area, in^2	13.1	13.2	.14
Fat thickness, in	.41	.45	.015
Kidney, pelvic & heart fat, %	2.07	2.08	.042
Average yield grade	2.38	2.63	.11
Yield grade 1, %	13	4	4.4
Yield grade 2, %	45	31	7.4
Yield grade 3, %	34	63	8.7
Yield grade 4, %	8	2	3.0
Marbling score[b]	Sm^{08}	Sm^{36}	12
USDA Choice, %	64	73	5.7
USDA Select, %	30	23	5.8
USDA Standard, %	6	2	1.9

[a] Final weight calculated as carcass weight /.64.
[b] Sm=Small.

BETAINE SUPPLEMENTATION FOR FINISHING CATTLE

C. A. Löest, E. C. Titgemeyer, J. S. Drouillard, C. M. Coetzer, R. D. Hunter, and B. D. Lambert

Summary

Crossbred heifers (756 lb) were used to evaluate the effects of feed-grade betaine on animal performance and carcass characteristics. Heifers had ad libitum access to a finishing diet without betaine or with 4, 8, or 12 g/day of feed-grade betaine top-dressed at feeding. Feed intakes, gains, and feed efficiencies were not significantly altered by feed-grade betaine. Hot carcass weights tended to increase with the betaine supplementation, but dressing percent; percentage of kidney, pelvic and heart fat; fat thickness; or ribeye area were not altered. Yield grades were numerically greater, and marbling scores significantly greater for heifers supplemented with 4 or 12 g/day of betaine. These results demonstrate that supplementation of feed-grade betaine may have minor effects on performance and carcass characteristics.

(Key Words: Betaine, Heifers, Performance, Carcass.)

Introduction

Previous research at Kansas State University has suggested that feed-grade betaine may improve feedlot performance and carcasses quality grades. Differences were more apparent with 10.5 g/day than 21 g/day, suggesting that the response to supplemental betaine may peak, and then decline.

Our objectives were to investigate the effects of feed-grade betaine supplementation on animal performance and carcass characteristics and to find the optimal level of supplementation.

Experimental Procedures

Three hundred twelve crossbred, non-pregnant heifers averaging 756 lb were used in a randomized block design. Heifers were individually weighed and implanted with Revalor-H®. Then they were allotted to one of three blocks based on weight and previous treatment and, within each block, were stratified by weight to one of eight pens (12 to 13 heifers per pen). Heifers were adapted to a common finishing diet before the start of the experiment. Treatments were a control without betaine and three levels of feed-grade betaine (4, 8, and 12 g/day) top-dressed onto the diet at feeding. The basal diet was provided once daily, and heifers had ad libitum access. The three blocks of heifers were fed for 117, 127, or 159 days before final pen weights were obtained and they were shipped to a commercial slaughter facility.

Results and Discussion

Top-dressing feed-grade betaine to the finishing diet had no effect on feed intakes (Table 2). Gains of heifers fed 12 g/day of betaine were 2.5% greater than those of controls, but the difference was not statistically significant. Similarly, feed efficiencies were not greatly affected by betaine addition. Hot carcass weights tended to increase (linear; P=.15) with the betaine supplementation; carcasses from heifers fed 12 g/day betaine weighed 7 lb more than those of controls. Dressing percent; percentage of kidney, pelvic and heart fat; twelfth rib back fat; and ribeye area also were not altered. Yield grades were numerically greater, and marbling score significantly greater (cubic, P<.05) for heifers fed 4 or 12 g/day of feed-

grade betaine. Carcasses grading USDA Choice averaged 77% for control heifers, which left little room for improvement in response to betaine.

The results of this study suggest that supplementing finishing heifers with feed-grade betaine has minor effects on performance and carcass characteristics. This study and a previous KSU study suggest that supplementing finishing cattle with 10 to 12 g/day of feed-grade betaine may improve carcass value.

Table 1. Ingredients and Nutrient Composition of the Finishing Diet

Item	% of Dry Matter
Ingredient	
Steam-flaked corn	81.61
Chopped alfalfa hay	7.00
Cane molasses	4.00
Feather meal	3.01
Bleachable tallow	2.00
Limestone	1.27
Urea	.55
Salt	.30
Potassium chloride	.15
Trace mineral mix[a]	.06
Rumensin-80[b]	.02
Tylan-40[c]	.01
Vitamin A premix[d]	.01
Nutrient, calculated	
Crude protein	13.0
Calcium	.65
Phosphorus	.28
Potassium	.65

[a]To provide (dry basis): 60 ppm Zn, 60 ppm Mn, 10 ppm Cu, 1.1 ppm Fe, .63 ppm I, .25 ppm Se, and .05 ppm Co to diet.

[b]To provide (dry basis): 30 g monensin per ton of diet.

[c]To provide (dry basis): 10 g tylosin per ton of diet.

[d]To provide (dry basis): 1200 IU vitamin A per lb of diet.

Table 2. Effects of Feed-Grade Betaine on the Performance and Carcass Characteristics of Finishing Heifers

	Betaine, g/day				
Item	0	4	8	12	SEM
No. of heifers	78	77	78	77	-
Performance Data					
Initial weight, lb	754	754	756	757	1.5
Final weight, lb[a]	1084	1075	1085	1093	7.7
Dry matter intake, lb/day	18.1	17.8	17.6	18.1	.30
Average daily gain, lb[a]	2.44	2.40	2.44	2.50	.058
Gain:feed[a]	.136	.135	.140	.139	.0032
Carcass Characteristics					
Hot carcass weight, lb	699	693	705	706	5.2
Dressing percentage	64.5	64.5	65.0	64.6	.17
Ribeye area, in^2	14.2	13.9	14.3	14.0	.22
Fat thickness, in	.40	.40	.40	.40	.021
KPH[b] fat, %	2.2	2.2	2.3	2.2	.066
Yield grade 1, %	18	22	19	10	3.7
Yield grade 2, %	38	34	37	44	5.2
Yield grade 3, %	40	36	37	41	5.7
Yield grade 4 & 5, %	4	8	6	5	2.6
Marbling score[cd]	Sl^{44}	Sl^{81}	Sl^{42}	Sl^{60}	13
USDA Prime, %	6	9	3	5	3.1
USDA Choice, %	71	69	71	73	4.7
USDA Select, %	19	18	24	20	4.5
USDA Standard, %	4	4	3	3	1.6
Liver abscesses, %	7	7	3	7	2.7

[a]Computed by applying a 4% shrink to the final weights.

[b]KPH = kidney, pelvic & heart.

[c]Sl = Slight.

[d]Cubic effect of betaine (P<.05).

IN VITRO DEGRADATION OF BETAINE BY RUMINAL MICROBES

C. A. Löest, C. K. Armendariz, and E. C. Titgemeyer

Summary

An in vitro study was conducted to evaluate the degradation of betaine sources by rumen microbes. Five sources of betaine (anhydrous betaine, betaine-HCl, feed-grade betaine, lipid-coated betaine, and concentrated separator by-product) were incubated in rumen fluid collected from steers fed grain- or forage-based diets. In vitro degradation of betaine was slower with the high roughage diet than the grain diet. Betaine from concentrated separator by-product was degraded most rapidly, but no large differences occurred among the other four sources. The disappearance of betaine from lipid-coated product indicates that it did not resist ruminal degradation. Although betaine from all sources was degraded, some still remained after 24 hours of incubation, suggesting that some betaine may bypass the rumen.

(Key Words: Rumen, Betaine, Degradation.)

Introduction

Research at Kansas State University has demonstrated that cattle may respond to supplemental betaine, possibly because of its role as a methyl group donor. However, betaine is likely to be degraded extensively by rumen microbes and may need to be protected from ruminal fermentation in order for appreciable amounts to reach the small intestine.

Our objective was to estimate how much betaine from various sources may escape ruminal degradation.

Experimental Procedures

Ruminal contents were collected from four ruminally cannulated Holstein steers. Two were fed a high-grain (corn) diet, and two were fed a forage-based (prairie hay) diet. Ruminal contents were strained through cheesecloth, maintained at 39°F, and mixed with an equal volume of warm McDougall's buffer. The buffer-ruminal fluid mixture (20 milliliters) was added to in vitro incubation tubes containing .2 grams (dry basis) of an energy source (corn for the grain diet and prairie hay for the forage diet) and 10 milligrams of betaine from one of five sources. The sources and their analyzed betaine concentrations were: 1) anhydrous betaine (95.7%); 2) betaine-HCl (75.3%); 3) feed-grade betaine (Finnsugar Bioproducts, Helsinki, Finland) (81.8%); 4) lipid-coated betaine (Finnsugar Bioproducts) (59.9%); and 5) concentrated separator by-product (American Crystal Sugar, Moorhead, MN) (6.2%). This by-product results when additional sugar is extracted from beet molasses. Tubes without betaine also were prepared to correct for background quantities of betaine in ruminal fluid and the energy source (corn or prairie hay). Tubes were prepared in duplicate, flushed with carbon dioxide, and sealed with one-way-valve rubber stoppers to maintain anaerobic conditions before being incubated for 2, 4, 8, 24, or 48 hours at 39°C. To stop fermentation at the end of each incubation period, ethanol (5 ml) was added, and tubes were placed in a boiling water bath and boiled for 5 minutes. Tubes were centrifuged (30,000 × g for 20 minutes) and the supernatant was analyzed for residual betaine.

Results and Discussion

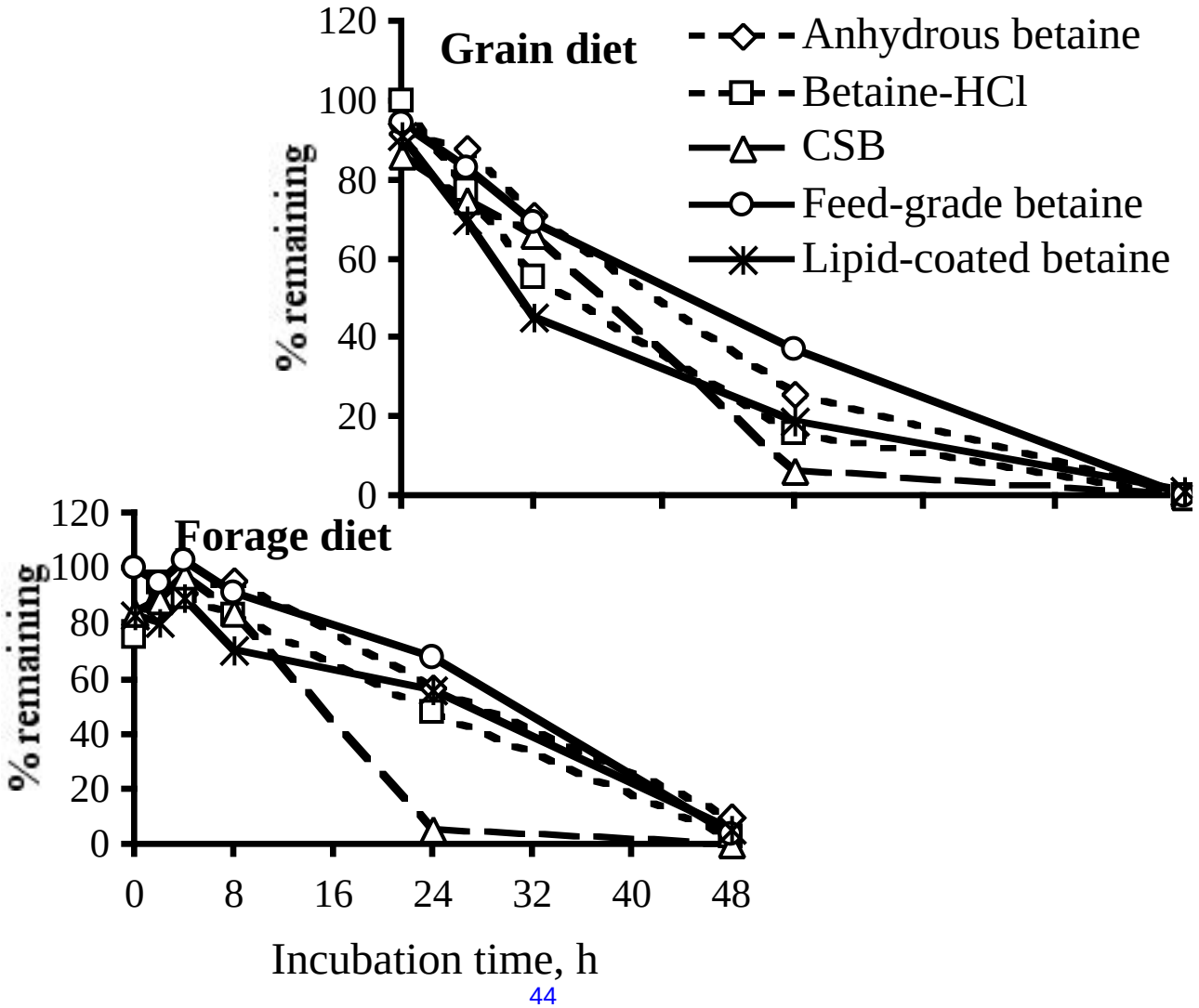
The betaine concentrations in some of the sources were slightly lower than label claims, likely because of moisture accumulation. The amounts of betaine remaining in the in vitro tubes before and after 2, 4, 8, 12, 24, and 48 hours of incubation are presented in Figure 1.

The grain diet generally led to faster betaine degradation than the forage diet, probably because of a faster fermentation rate. Among betaine sources, concentrated separator by-product appeared to be degraded most rapidly for both the forage and grain diets. Little remained after 24 h of incubation. Rapid degradation may occur because this source also provides additional sugar and may stimulate fermentation.

No large differences occurred between anhydrous betaine, betaine-HCl, feed-grade betaine, and lipid-coated betaine. The lipid-coated betaine was a mixture of a feed-grade betaine and calcium stearate designed to enhance flowability and potentially decrease ruminal degradation of betaine. The disappearance rate of betaine from lipid-coated betaine, however, was slightly greater than that from feed-grade betaine (Figure 1), indicating that lipid coating did not effectively decrease the metabolism of betaine by ruminal microorganisms.

Even though betaine was degraded by ruminal microbes, some of the betaine from all sources remained after 24 hours, which suggests that some betaine would escape ruminal degradation and thus pass to the small intestine.

Figure 1. Betaine Remaining after Incubation in Rumen Fluid from Steers Fed Grain- and Forage-Based Diets. CSB=concentrated separator by-product. SEM=7.4.



EFFECTS OF SUPPLEMENTATION OF LIMIT-FED GROWING DIETS WITH EITHER SOYBEAN MEAL OR NONENZYMATICALLY BROWNED SOYBEAN MEAL ON STEER PERFORMANCE

C. M. Coetzer, J. S. Drouillard, C. A. Löest, D. J. Bindel, H. LaBrune, R. D. Hunter, T. A. Nutsch, and J.J. Higgins[1]

Summary

Seventy two individually fed Angus × Hereford steers (642 lb) were used to evaluate the effects of supplementing limit-fed, growing diets with either soybean meal (SBM) or nonenzymatically browned soybean meal (NSBM). Eight steers were allotted to a control diet composed of 39.1% high-moisture corn, 42% cottonseed hulls, 10.4% ground corn, 5% cane molasses 2.25% urea, and 1.5% vitamins and minerals (dry basis). The remaining steers were allotted to diets that derived 100, 80, 60, or 40% of their supplemental protein from SBM or 60, 45, 30, or 15% of their supplemental protein from NSBN. The balance of supplemental protein came from urea. All diets were formulated to contain 13.0% crude protein (dry basis). Steers were fed once daily for 80 days at 2.25% of BW. Average daily gain and efficiency did not differ (P>.05) between sources (ADG=1.932 + .103 × (% CP from SBM) + .097 × (% CP from NSBM); gain:feed=.140 + .0058 × (% CP from SBM) + .0051 × (% CP from NSBM)). The lack of response to NBSBM supplementation above that for SBM suggests that either degradable intake protein was limiting in the basal diet or a large proportion of the amino acids in the NSBM were unavailable due to overprocessing.

(Key Words: Growing Cattle, Nonenzymatically Browned Soybean Meal, Undegraded Intake Protein.)

Introduction

Previous research at KSU has demonstrated that supplementation with nonenzymatically browned soybean meal (NSBM) improved performance of growing steers fed restricted amounts of wheat middling-based diets. Energy sources like high-moisture corn are characterized by relatively high levels of degradable intake protein and also might benefit from supplementation with NSBM.

The content of bypass protein is higher in NSBM than in untreated commercial soybean meal (SBM). Our objective was to compare the effects of supplementing limit-fed growing diets composed predominantly of high-moisture corn and cottonseed hulls with either SBM (28% bypass protein) or NSBM (82% bypass protein).

Experimental Procedures

Seventy two individually fed Angus × Hereford steers (642 lb) were stratified by weight and allotted randomly, within strata, to one of nine treatments. Eight steers were allotted to a control diet (Table 1), and the remaining steers were allotted to one of four soybean protein levels within each SBM source. Levels of SBM were 100 (6.5% CP), 80 (4.9% CP), 60 (3.2% CP), and 40% (1.6% CP) of supplemental CP with the balance as urea. Levels of NSBM were 60 (3.9% CP), 45 (2.9% CP), 30 (1.9% CP), and 15% (1% CP) of supplemental CP with the balance as

[1]Department of Statistics.

urea. All diets were formulated to contain 13.0% crude protein (dry basis). Steers were fed once daily for 80 days at 2.25% of BW. Data were analyzed by regression using supplementation level as a continuous variable nested within supplement source (SBM or NSBM).

Results and Discussion

Gain (Figure 1) and efficiency (Figure 2) did not differ (P>.05) among sources:

ADG (lb/day) = 1.932 + .103 × (%CP from SBM) + .097 × (%CP from NSBM)

Gain to feed = .140 + .0058 × (%CP from SBM) + .0051 × (%CP from NSBM).

In our model, we formulated the control diet to contain excess degradable intake protein (120% of requirement according to level 1 of the 1996 NRC) and, therefore, expected little response to SBM supplementation. However, the observed response to SBM supplementation suggests that the basal diet was still deficient in degradable protein.

Supplementing limit-fed growing diets based on high-moisture corn and cottonseed hulls with NSBM improve animal performance above that seen with SBM supplementation. This suggests that either degradable intake protein was limiting in the basal diet or that a large proportion of the amino acids in the NSBM were unavailable due to overprocessing.

Table 1. Compositions of Experimental Diets (dry basis)

		SBM[1]	SBM	SBM	SBM	NSBM[2]	NSBM	NSBM	NSBM
		% of supplemental protein							
Item	Control	40	60	80	100	15	30	45	60
High-moisture corn	39.10	39.10	39.10	39.10	39.10	39.10	39.10	39.10	39.10
Cottonseed hulls	42.00	42.00	42.00	42.00	42.00	42.00	42.00	42.00	42.00
Molasses	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
SBM[1]	-	4.90	7.40	9.90	12.40	-	-	-	-
NSBM[2]	-	-	-	-	-	1.80	3.80	5.60	7.40
Ground corn	10.40	6.00	4.00	2.00	-	8.90	7.30	5.70	4.10
Calcium phosphate	.23	.23	.23	.23	.23	.23	.23	.23	.23
Salt	.25	.25	.25	.25	.25	.25	.25	.25	.25
Limestone	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10
Urea	2.25	-	.52	1.04	1.56	.85	1.15	1.46	1.77
Vitamin/mineral mix[a]	.06	.06	.06	.06	.06	.06	.06	.06	.06

[a]Contains 8 ppm Cu, .04 ppm Co, .5 ppm I, .13 ppm Fe, 48 ppm Mn, .2 ppm Se, 47 ppm Zn, 1330 IU/lb vitamin A. Rumensin® and Tylan® were added at 30 g/ton and 10 g/ton of diet, respectively.

[1]SBM = soybean meal.

[2]NSBM = nonenzymatically browned soybean meal.

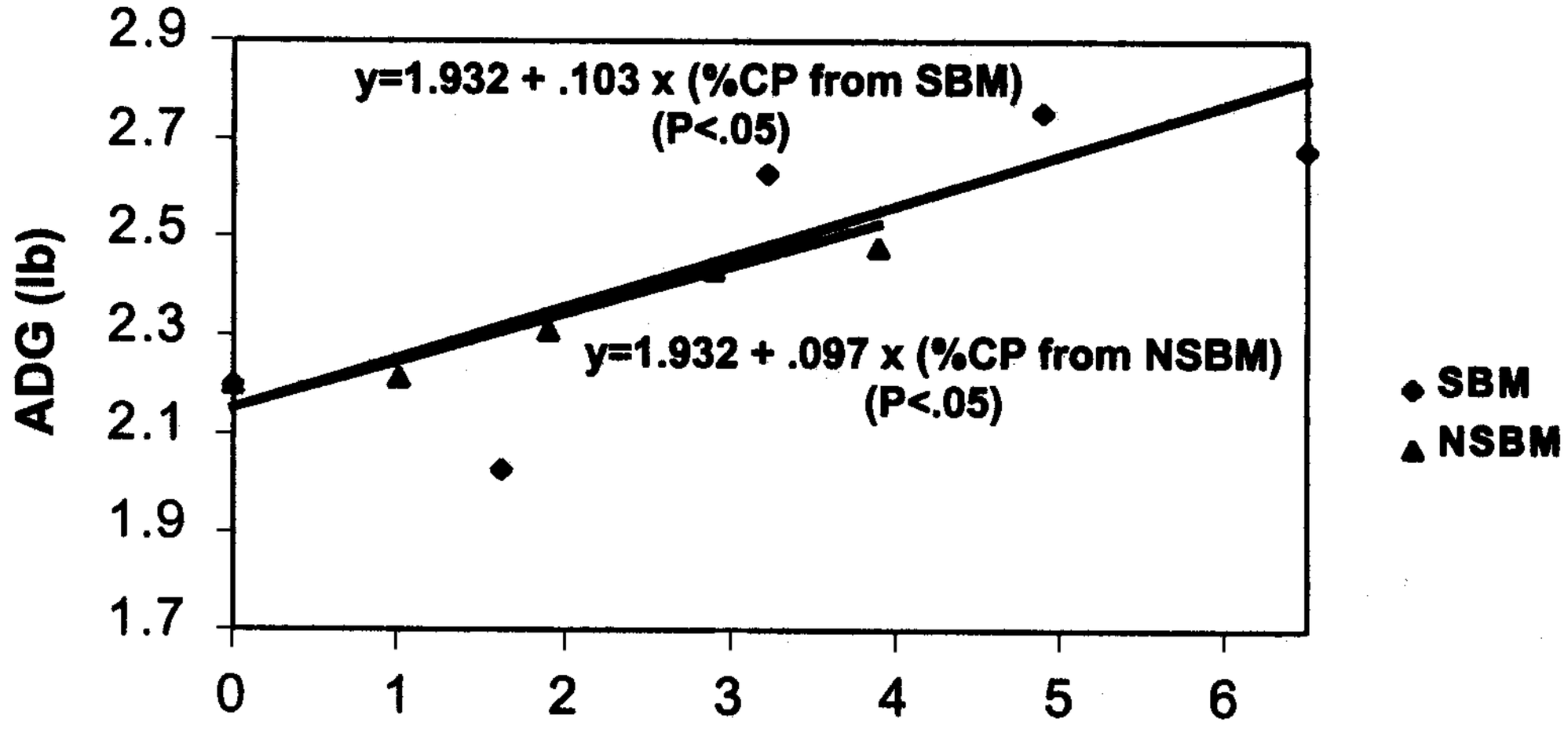


Figure 1. Effects of Supplementing Limit-Fed Growing Diets with Soybean Meal (SBM) or Nonenzymatically Browned Soybean Meal (NSBM) on Average Daily Gain (ADG)

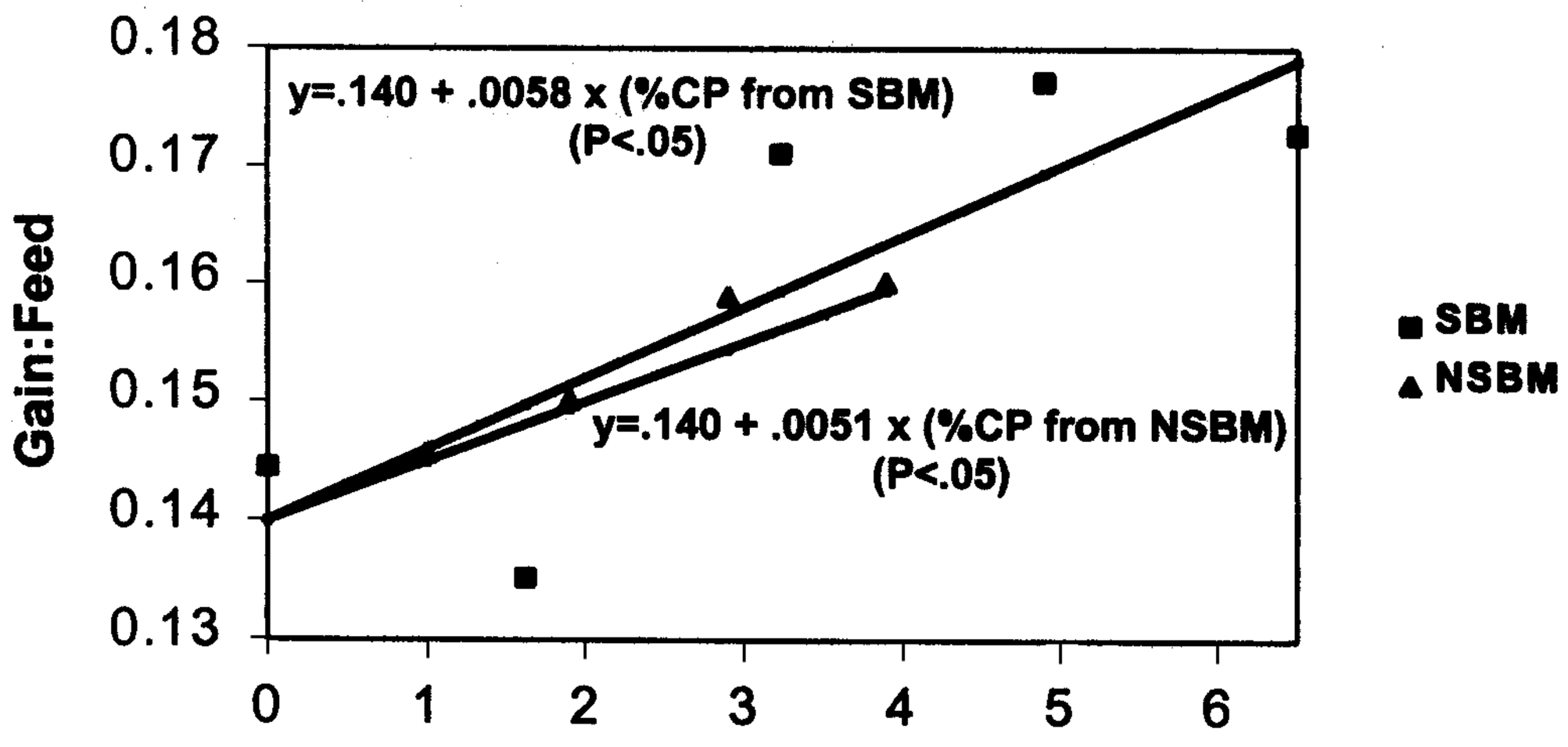


Figure 2. Effects of Supplementing Limit-Fed Growing Diets with Soybean Meal (SBM) or Nonenzymatically Browned Soybean Meal (NSBM) on Feed Efficiency (gain:feed)

COMBINATIONS OF WET CORN GLUTEN FEED AND STEAM FLAKED CORN IN FINISHING CATTLE DIETS

J. J. Sindt, J. S. Drouillard, S. P. Montgomery, T. B. Farran, H. J. LaBrune, R. D. Hunter, J. J. Higgins[1], R. T. Ethington[2], and R. U. Lindquist[2]

Summary

A 152-day experiment was conducted using 615 crossbred steers to evaluate cattle performance when steam-flaked corn in finishing diets was replaced partially with wet corn gluten feed (CGF). Finishing diets contained no wet CGF (0CGF) or 30 and 60% CGF on a dry matter basis (30CGF and 60CGF). Ruminal and fecal pH increased linearly (P<.01) as the proportion of wet corn gluten feed increased. Cattle fed 60CGF gained less than those fed 30CGF (P<.01) and were less efficient than cattle fed 0CGF or 30CGF (P<.05). Dressing percentage was lower (P<.03) for cattle fed 60CGF compared to cattle fed 30CGF. Incidence of liver abscesses increased linearly (P<.01) as the level of CGF increased. Replacing steam-flaked corn with wet CGF at 30% of the diet did not alter performance.

(Key Words: Wet Corn Gluten Feed, Steam-Flaked Corn, Finishing Cattle.)

Introduction

Corn gluten feed (CGF) is the major by-product produced from the wet milling of corn for production of starch and corn sweeteners. It contains a high percentage of fiber and, therefore is ideally suited for use in cattle diets. Previous studies have identified optimal substitution levels of gluten feed in finishing diets composed of dry rolled or high-moisture grain. In Kansas, however, steam flaking is the predominant method of grain processing in feedlots. Steam flaking improves energy availability of grains; however, the heat associated with flaking induces cross-linking reactions that reduce availability of grain protein. Therefore, high protein levels in CGF may be more complementary to flaked corn than to high-moisture or dry-rolled grain. Additionally, rapid ruminal degradation of steam-flaked corn predisposes cattle to digestive disorders such as acidosis. The fibrous nature of CGF and the resulting slower rates of digestion may provide an opportunity to minimize this condition.

Experimental Procedures

Six hundred fifteen crossbred beef steers (average wt 649 lb) were used in a 152-day experiment to evaluate finishing performance when steam-flaked corn was replaced partially with wet CGF. Steers were blocked by previous treatment and randomly allocated, within block, to each of three diets (4 pens per diet, 48 to 53 steers per pen). Dietary treatments included no CGF (0CGF) or 30 and 60% wet CGF on a dry matter basis (30CGF and 60CGF). Diet compositions are shown in Table 1.

Steers were implanted with Component® TE-S on day 1 and were adapted to the final finishing diets within 23 days. Respective diets were provided once daily, and cattle had ad libitum access. Unconsumed feed was collected, weighed, analyzed for dry matter content, and subtracted from the amount of feed offered to determine actual feed intakes.

[1]Department of Statistics.

[2]Minnesota Corn Processors, Inc., Marshall, MN.

On days 114 to 118, samples of rumen fluid and feces were collected from 180 steers (60 per treatment) for determination of ruminal and fecal pH. Rumen fluid was obtained via rumenocentesis using a 4-inch, 16-gauge needle. Fecal grab samples were collected concurrently.

Final shrunk weights were determined by dividing carcass weight by a common dressing percentage (64.0%). Ribeye area, fat thickness, percentage kidney, pelvic and heart fat, marbling score, incidence of dark cutters, and USDA quality and yield grades were evaluated 24 hours after slaughter.

Results and Discussion

A linear increase was observed for both ruminal and fecal pH as the proportion of wet CGF in the diet increased (Figure 1). This suggests that increasing the percentage of CGF in the diet potentially could reduce metabolic disorders by elevating ruminal pH.

Performance during the finishing trial is summarized in Table 2. Dry matter intake tended to increase (P<.14) as the proportion of CGF increased. Average daily gain during the finishing phase was greater (P<.01) for steers fed 30CGF than steers fed 60CGF. This resulted in more efficient (P<.05) gains for cattle fed 0CGF or 30CGF than cattle fed 60CGF. Dressing percentage was lower (P<.03) for cattle fed 60CGF compared to cattle fed 30CGF. Incidence of liver abscesses increased linearly (P<.05) as the level of CGF increased. This suggests that metabolic disorders may not be reduced by adding CGF to the diet, in spite of the observed differences in ruminal pH among the diets.

Replacing steam-flaked corn with wet CGF at 30% of the diet dry matter yielded performance similar to that with steam-flaked corn. However, when wet CGF was increased to 60% of the diet dry matter, performance was reduced modestly. Moderate levels of wet CGF are suitable as a replacement for steam-flaked corn in cattle finishing rations. Use of higher levels of wet CGF may be a justifiable alternative, if the opportunity is available to lower costs of gain.

Table 1. Composition of Experimental Diets (% of diet dry matter)

	Dietary Wet Corn Gluten Feed		
Ingredient	0%	30%	60%
Flaked corn	81.60	58.37	30.21
Alfalfa hay	6.71	6.82	6.97
Molasses	3.72	-	-
Tallow	2.01	2.05	2.09
Wet corn gluten feed	-	28.64	58.51
Soybean meal	2.83	1.44	-
Urea	1.21	.79	.36
Limestone	1.18	1.28	1.39
Sodium chloride	.29	.29	.30
Potassium chloride	.04	.02	-
Ammonium sulfate	.19	.10	.10
Calcium phosphate	.12	.06	.06
Vitamin/trace mineral premix[1]	.10	.10	.10
Nutrient			
Dry matter, %	83.4	65.0	53.0
Crude protein, %	14.9	15.2	15.4
Calcium, %	.66	.70	.75
Phosphorus, %	.29	.35	.41
Thiamin, ppm	-	7.5	15
Copper, ppm	8.3	12.2	16.0

[1]Vitamin/trace mineral premix formulated to provide (total diet dry matter): 1,200 IU/lb vitamin A, .10 ppm cobalt, .52 ppm iodine, 50 ppm manganese, .25 ppm selenium, 50 ppm zinc, 30 grams/ton Rumensin®, and10 grams/ton Tylan®.

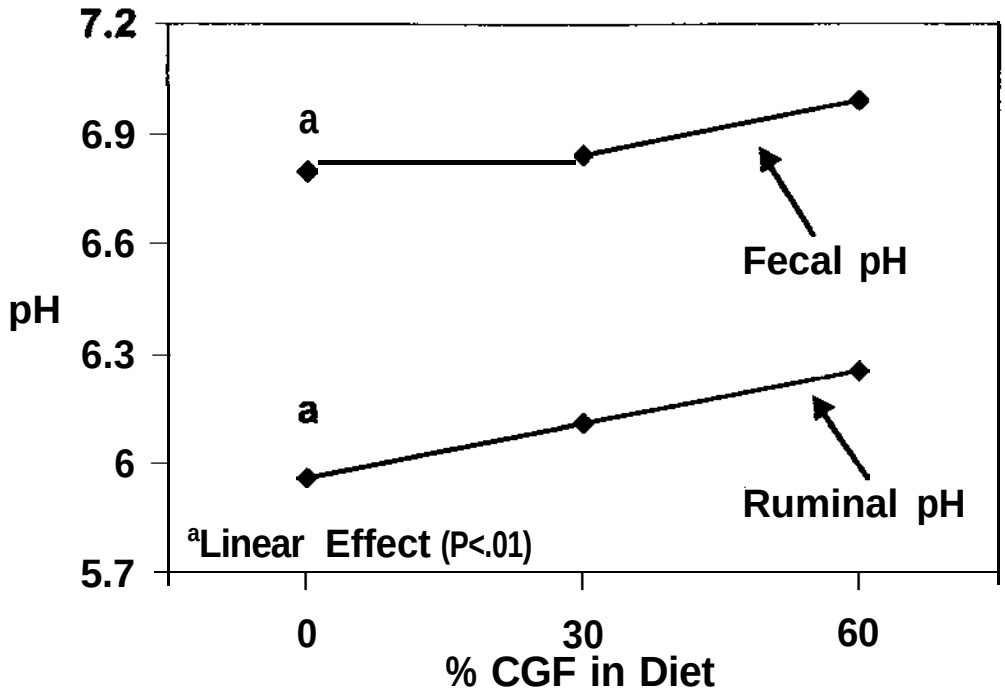


Figure 1. Effect of Increasing Dietary Proportions of Wet Corn Gluten Feed on Ruminal and Fecal pH of Finishing Cattle

Table 2. Finishing Performance and Carcass Characteristics of Steers Fed 0,30, or 60% Wet Corn Gluten Feed (dry matter basis)

	Dietary Wet Corn Gluten Feed			
Item	0%	30%	60%	SEM
No. of steers	206	202	207	
Initial weight, lb	655	645	647	12.8
Final weight, lb	1183	1181	1173	11
Dry matter intake, lb/day	19.1	19.2	19.9	.26
Average daily gain; lb	3.14[ab]	3.22[a]	3.05[b]	.032
Gain:feed	.165[a]	.168[a]	.154[b]	.0026
Hot carcass weight, lb	725	726	711	6.9
Dressing percentage	61.3[ab]	61.5[a]	60.7[b]	
Ribeye area, in^2	12.0	11.9	11.6	.17
Kidney, pelvic, & heart fat, %	2.1	2.1	2.1	.083
Fat thickness, in	.46	.42	.43	.020
% USDA yield grade l,%	5	7	5	2.2
% USDA yield grade 2,%	31	35	32	3.9
% USDA yield grade 3,%	56	47	56	4.1
% USDA yield grade 4 & 5,%	9	12	8	2.5
Marbling score[c]	SI[58]	SI[52]	SI[45]	8.0
USDA Choice, %	31	29	26	5.2
USDA Select, %	57	59	58	4.8
USDA Standard, %	12	13	14	3.2
Dark cutters, %	0	1	2	.50
Liver abcesses, %	1.5[a]	2.0[ab]	3.9[b]	.58

[a,b]Means within same row with uncommon superscripts differ (P<.05).
[c]Sl=Slight.

INCREASING LEVELS OF RUMENSIN® IN LIMIT-FED, HIGH ENERGY, GROWING DIETS FOR BEEF STEERS AND EFFECTS ON SUBSEQUENT FINISHING PERFORMANCE

S. P. Montgomery, J. S. Drouillard, J. J. Sindt, T. B. Farran, H. J. LaBrune, R. D. Hunter, J. J. Higgins[1], and T. A. Nutsch

Summary

One hundred sixty-four crossbred beef steers were used to determine optimal Rumensin® concentrations in limit-fed, high-energy, growing diets. Diets contained 30, 40, or 50 grams of Rumensin per ton of dry matter (R30, R40, and R50). Average daily gain and feed efficiency during the growing phase were not different (P>.80) among treatments. Steers that received R50 in the growing phase had the highest average daily gains during the finishing phase (P<.05). This resulted in heavier carcass weights for R50 than R30 (P<.05) and R40 (P<.12). Feed efficiencies during the finishing phase were not different among treatments (P>.40).

(Key Words: Rumensin, Limit Feeding, Finishing Cattle.)

Introduction

Currently, Food and Drug Administration regulations limit Rumensin to not more than 30 grams per ton of diet. Although this level is adequate to enhance growth and increase feed efficiency in cattle feeding ad libitum, it may be less than optimum when cattle are fed restricted amounts of high-concentrate growing diets. This study was to determine if levels of Rumensin higher than those currently approved by the FDA, when added to limit-fed, high-energy, growing diets, would increase average daily gain and feed efficiency of cattle during the growing phase and subsequent finishing period.

Experimental Procedures

One hundred sixty-four crossbred beef steers weighing 574 lb were used in a randomized complete block design experiment. They had ad libitum access to a common diet for 14 days preceding the growing study to minimize differences in gastrointestinal tract fill. Steers were blocked by weight and allotted to pens containing five to seven animals per pen, with nine pens per treatment. Growing diets (Table 1) provided 30, 40, or 50 grams of Rumensin per ton (DM basis). Diets were fed once daily at 1.8% of body weight (DM basis) for 88 days. Intakes were adjusted weekly, assuming an average gain of 2 lb per head daily. Prior to obtaining final weights for the growing phase, cattle had ad libitum access to a common diet for 14 days. At the end of the growing phase, steers were placed onto a common finishing diet, fed for 101 days, and then slaughtered. The final finishing diet (Table 1) contained 30 grams of Rumensin per ton (DM basis) and was offered once daily for ad libitum feeding. Steers were weighed approximately every 28 days throughout the entire 203-day growing-finishing trial.

Results and Discussion

Increasing the level of Rumensin in limit-fed, high-energy, growing diets did not affect weight gain or feed efficiency (P>.80) during the growing phase, which suggests that 30 grams of Rumensin per ton were sufficient to elicit maximal growth response.

[1]Department of Statistics.

During the finishing phase, average daily gain was greater (P>.05) for steers fed R50 during the growing phase than for steers fed R40 or R30. This resulted in heavier carcass weights for steers fed R50 than those fed R30 (P<.05) or R40 (P<.12). Feed efficiency during the finishing phase improved numerically as concentration of Rumensin during the prior growing phase increased, but these differences were not significant (P>.40). Including higher concentrations of Rumensin in limit-fed, high-energy, growing diets may increase subsequent average daily gain and carcass weight in the finishing period.

Table 1. Experimental Diets (% of Dry Matter)

	Growing Diet			
Ingredient	R30	R40	R50	Finishing
Steam-flaked corn	65.08	65.11	65.13	81.98
Alfalfa hay	20.53	20.54	20.55	6.57
Soybean meal	5.35	5.32	5.28	2.73
Cane molasses	3.77	3.77	3.77	3.70
Tallow	2.04	2.04	2.04	2.01
Urea	1.13	1.13	1.12	1.17
Limestone	.95	.94	.94	1.14
Sodium chloride	.39	.39	.39	.28
Potassium chloride	-	-	-	.04
Ammonium sulfate	.10	.10	.10	.19
Calcium phosphate	.58	.57	.57	.11
Vitamin/trace mineral premix[1]	.10	.10	.11	.08
Rumensin, grams/ton	30	40	50	30
Tylan, grams/ton	-	-	-	10
Crude protein, analyzed	16.7	16.7	16.7	14.5

[1]Vitamin/trace mineral premix formulated to provide (total diet dry matter): 1,470 IU/lb vitamin A, .05 p.m. cobalt, 10 p.m. copper, .62 p.m. iodine, 60 p.m. manganese, .30 p.m. selenium, and 60 p.m. zinc.

Table 2. Performance during the Growing Phase for Cattle Fed High Concentrate Diets Containing 30, 40, or 50 grams/ton Rumensin

	Growing Diet			
Item	R30	R40	R50	SEM
No. of steers	56	52	56	
Initial weight, lb	576	578	571	8.4
Final weight, lb	855	863	853	12.3
Dry matter intake, lb/day	12.7	12.7	12.6	.16
Average daily gain, lb	2.74	2.79	2.76	.056
Gain:feed	.217	.220	.220	.0036

Table 3. Finishing Performance and Carcass Characteristics Following a Growing Period during Which Cattle Were Fed Diets Containing 30, 40, or 50 grams/ton Rumensin

	Previous Growing Diet			
Item	R30	R40	R50	SEM
No. of steers	55	52	52	
Initial weight, lb	853	862	859	12
Dry matter intake, lb/day	20.7[a,b]	20.3[a]	21.5[b]	.38
Average daily gain, lb	3.14a	3.15[a]	3.38[b]	.059
Gain:feed	.152	.155	.158	.0034
Hot carcass weight, lb	758[a]	762[a,b]	778[b]	6.8
Ribeye area, in^2	12.8	12.8	13.1	.22
Fat thickness, in	.44	.45	.46	.021
Kidney, pelvic & heart fat, %	2.2	2.2	2.2	.053
Liver abscesses, %	2	11	2	3.8
Yield grade 1, %	9	10	3	3.7
Yield grade 2, %	34	37	35	5.2
Yield grade 3, %	53[a,b]	41[a]	57[b]	5.4
Yield grade 4 & 5, %	3[c]	14[d]	5[c,d]	4.3
Marbling score[e]	Sl[82]	Sl[75]	Sl[82]	6.0
USDA Choice, %	47	44	53	6.9
USDA Select, %	47	53	45	6.0
USDA Standard, %	2	2	2	2.0
Dark cutters, %	4	1	-	2.0

[a,b]Means within same row without a common superscript differ (P<.05).

[c,d]Means within same row without a common superscript differ (P<.10).

[e]Sl=Slight.

EFFECTS OF HIGH-GRAIN OR HIGH-ROUGHAGE TRANSITION DIETS ON FINISHING PERFORMANCE OF CATTLE PREVIOUSLY FED HIGH-CONCENTRATE GROWING DIETS

S. P. Montgomery, J. S. Drouillard, J. J. Sindt, T. B. Farran, H. J. LaBrune, R. D. Hunter, J. J. Higgins[1], and T. A. Nutsch

Summary

Three hundred twenty-eight crossbred beef steers previously fed high-concentrate growing diets had ad libitum access to one of two transition diets prior to initiation of the finishing phase. Transition diets consisted of 58% steam-flaked corn and 30% alfalfa hay or of 23% steam-flaked corn and 65% alfalfa hay (DM basis). Average daily gains, dry matter intakes, and feed efficiencies during the transition phase were greater for steers fed the high-grain diet than for steers fed the high-roughage diet (P<.01). This resulted in heavier carcass weights at the end of the subsequent finishing phase for steers fed the high-grain transition diet (P<.05). Average daily gains and feed efficiencies in the finishing phase were not affected by the type of diet fed during the transition phase (P>.20).

(Key Words: Transition Diet, Grain, Roughage, Finishing Cattle.)

Introduction

Previous research at Kansas State University has demonstrated that cattle fed high-concentrate growing diets typically exhibit lower dry matter intakes when initially provided ad libitum access to finishing diets. We speculated that lower intakes after limit feeding may be due to modifications of intake patterns during the limit-fed growing phase. Such modifications may consist of cattle becoming conditioned to consuming their daily ration during one meal period or simply a reduced capacity to accommodate large volumes of feed when it's available ad libitum. This study was conducted to determine the effects of roughage levels in transition diets on subsequent intakes and performance of finishing cattle previously fed high-concentrate growing diets.

Experimental Procedures

Three hundred twenty-eight crossbred beef steers averaging 575 lb were used. Steers were fed high-concentrate growing diets at 1.8% of body weight for 88 days. Then transition diets (Table 1) of 58% steam-flaked corn and 30% alfalfa hay (corn-based) or 23% steam-flaked corn and 65% alfalfa hay (alfalfa-based) were offered once daily for 14 days, and steers fed ad libitum At the end of the transition phase, steers were stepped up to a common finishing diet, fed for 101 days, and then slaughtered. The final finishing diet (Table 1) containing 82% steam-flaked corn was offered once daily, and steers fed ad libitum. All diets provided 30 grams per ton of Rumensin® and 10 grams per ton of Tylan®. Steers were weighed approximately every 28 days throughout the 101-day finishing period.

Results and Discussion

Steers fed corn-based transition diets had greater dry matter intakes, gained more, and were more efficient (P<.01) during the 14-day transition phase than those fed alfalfa-based diets (Table 2). The increased weight gain of steers fed the corn-based diet was maintained throughout the 101-day finishing phase (Table 3) as suggested by the heavier

[1]Department of Statistics.

carcass weights (P<.05) of cattle fed the corn-based diet during the transition phase. Cattle fed the alfalfa-based diet tended to have greater dry matter intakes (P<.10) during the finishing phase. Average daily gains and feed efficiencies were not affected by transition diet (P>.20).

The results of this study suggest that feeding high-grain transition diets to cattle previously fed high-concentrate growing diets will increase average daily gain and feed efficiency during the transition period. Furthermore, the advantage in weight gain will be maintained throughout the finishing phase.

Table 1. Experimental Diets (% of Dry Matter)

	Transition Phase Diet		
Ingredient	Corn-Based	Alfalfa-Based	Finishing
Steam flaked corn	57.97	22.77	81.98
Alfalfa hay	29.96	65.19	6.57
Soybean meal	2.88	2.88	2.73
Cane molasses	3.89	3.88	3.70
Tallow	2.10	2.10	2.01
Urea	1.24	1.23	1.17
Limestone	1.20	1.20	1.14
Sodium chloride	.30	.30	.28
Potassium chloride	.04	.04	.04
Ammonium sulfate	.20	.20	.19
Calcium phosphate	.12	.12	.11
Vitamin/trace mineral premix[1]	.10	.10	.08
Crude Protein, analyzed	17.8	21.4	14.5

[1]Vitamin/trace mineral premix formulated to provide (total diet dry matter): 1,200 IU/lb vitamin A, .10 ppm cobalt, 8 ppm copper, .52 ppm iodine, 50 ppm manganese, .25 ppm selenium, 50 ppm zinc, 30 g/ton Rumensin®, and 10 g/ton Tylan®.

Table 2. Performance during the Transition Phase for Cattle Feeding ad libitum on High-Grain or High-Roughage Diets Following an 88-Day Limit-Feeding Period

	Transition Phase Diet		
Item	Corn-Based	Alfalfa-Based	SEM[1]
No. of steers	177	151	
Initial weight, lb	785	783	6.7
Final weight, lb	873[a]	842[b]	6.9
Dry matter intake, lb/day	18.9[a]	18.2[b]	.19
Average daily gain, lb	6.29[a]	4.17[b]	.12
Gain:feed	.332[a]	.228[b]	.0051

[1]Pooled standard error.

[a,b]Means within same row with uncommon superscripts differ (P<.01).

Table 3. Finishing Performance and Carcass Characteristics of Cattle Feeding ad libitum on High-Grain or High-Roughage Diets during a Transition Period between Limit Feeding and Finishing

	Transition Phase Diet		
Item	Corn-Based	Alfalfa-Based	SEM[1]
No. of steers	173	148	
Initial weight, lb	873[a]	844[b]	6.7
Dry matter intake, lb/day	20.3[c]	20.7[d]	.19
Average daily gain, lb	3.19	3.20	.040
Gain:feed	.158	.154	.0017
Hot carcass weight, lb	774[e]	756[f]	4.8
Ribeye area, in^2	13.1	12.8	.15
Fat thickness, in	.45	.43	.013
Kidney, pelvic & heart fat, %	2.2[e]	2.1[f]	.036
Yield grade 1, %	7	6	2.0
Yield grade 2, %	35	37	3.8
Yield grade 3, %	48	54	4.1
Yield grade 4 & 5, %	9[c]	3[d]	2.1
Marbling score[g]	Sl[83]	Sl[83]	4.9
USDA Choice, %	48	46	4.2
USDA Select, %	48	49	4.0
USDA Standard, %	1	3	1.0
Dark Cutters, %	3	3	1.3

[1]Pooled standard error.

[a,b]Means within same row with uncommon superscripts differ (P<.01).

[c,d]Means within same row with uncommon superscripts differ (P<.10).

[e,f]Means within same row with uncommon superscripts differ (P<.05).

[g]Sl=Slight.

EFFECTS OF LATE-SUMMER PROTEIN SUPPLEMENTATION ON STOCKER CATTLE PERFORMANCE, FEEDLOT GAIN, AND CARCASS TRAITS [1]

T. T. Marston, D. O. Yauk [2], L. E. Wankel, and J. F. Gleghorn

Summary

A 2-year trial was conducted to study the effects of feeding an Arsoy™-based, 32% crude protein supplement to stocker cattle grazing late-summer native pastures. During about 90 days of late-summer/fall grazing, the steers efficiently converted the Arsoy supplement (5.3:1, as fed basis) into significantly greater weight gains (55 lb) relative to non-supplemented contemporaries. Both groups of steers then were finished and slaughtered in commercial facilities to determine if the supplementation program had any carryover effects. Late-summer supplementation did not influence steers' feedlot gain or carcass traits including ribeye area, fat thickness, and quality grade. However, average hot carcass weight and yield grade of pasture-supplemented steers were significantly greater than those of controls. Our study demonstrates that Arsoy makes an excellent protein supplement for growing cattle on maturing native grass pastures. In addition, the added stocker gains did not influence feedlot performance and had minimal effects on carcass traits.

(Key Words: Stocker Cattle, Protein, Supplementation.)

Introduction

During late summer, the crude protein content and energy digestibility of native grass declines, resulting in reduced performance of stocker cattle in season-long grazing programs. With the supplementation of about .5 to 1.0 lb of crude protein per day, researchers have reported dramatic increases of nearly 30% in intake of low-quality forage and digestion improvements of 5 to 10%. However, producers are unsure if the added stocker performance would influence subsequent feedlot performance and(or) carcass traits. This experiment was conducted to evaluate the response of grazing stocker cattle to late-summer protein supplementation and to determine if carryover effects on subsequent feedlot performance or carcass traits exist.

Experimental Procedures

A 2-year grazing trial was conducted using 149 crossbred steers (507 lb initial weight) and two native range pastures in Clark County, Kansas. Steers were allotted randomly to the pastures, and treatments were assigned randomly to the pastures in year 1. To reduce the effect of pastures, treatments were rotated between pastures in the second year. Treatments consisted of control (no protein supplement) and Arsoy, a soybean by-product protein supplement hand-fed at 3.2 lb/head/day. Supplementation began in mid to late July and ended in October each year. Both groups had access to a free-choice mineral supplement.

Steers were tagged, processed, weighed, and transported to their pastures to commence the trial each year. Supplements were group-fed in bunks after all animals were

[1]Appreciation is extended to ADM Protein Specialties Division, Decatur, IL, for support of this study.

[2]Clark County Extension Office.

called to the feeding facilities to minimize differences in supplement consumption. At the end of the grazing period each year, steers were gathered, transported to a commercial feeding facility, weighed, processed, and placed in a single drylot pen. In the feedlot, steers were fed step-up and finishing diets until the average of the pen was deemed ready for slaughter. Final live slaughter weight was calculated by dividing hot carcass weight by the average dressing percentage of the pen. Carcass data were collected following a 24-hour chill.

Results and Discussion

Late-summer stocker gains were enhanced 54.6 lb per head by feeding the Arsoy supplement (P<.01). Average daily gain improved dramatically from year 1 to year 2 (1.92 vs. 2.65 lb/day; P<.01). The difference between years is probably a reflection of weather, pasture conditions, and cattle type. Concurrently, a greater Arsoy supplementation response (P<.01) was recorded in year 2 (.76 lb/day) than year 1 (.38 lb/day). The overall conversion of supplemental feed to extra weight gain was calculated to be about 5.3:1. These results indicate that the Arsoy supplement is an attractive management tool for stocker operators wishing to increase grazing performance of growing cattle.

Steer feedlot gains were unaffected by previous pasture supplementation treatment (P>.32). About 80% of the additional gain achieved through supplementation apparently was retained through the feedlot. Feedlot gains were greater for year 1 than year 2 (3.05 vs 2.45 lb/day; P<.01), which was inversely related to pasture gains. Because steers from both treatments were fed in the same feedlot pen, feed efficiency differences during the finishing phase could not be determined. Corresponding to the heavier live weights, the Arsoy-supplemented steers had greater hot carcass weights and yield grades (P<.01). Marbling score and percentage of carcasses grading USDA Choice or higher were not influenced by summer supplementation (P>.59). Our data indicate that late-summer supplementation does not hinder feedlot performance and has minimal effects on carcass parameters.

Table 1. Effects of Grazing Supplementation Program on Steer Performance

Item	No Supplement	Arsoy Supplement	P-Value
No. steers	72	77	
Starting wt, lb	503	511	
Off-pasture wt, lb	694	741	
Slaughter wt, lb	1174	1214	
Pasture Performance			
Daily gain, lb:			
Year 1	1.72	2.11	.01
Year 2	2.28	3.04	.01
Overall	2.00	2.58	.01
Supplement efficiency	--	5.3:1	
Feedlot Performance			
Daily gain, lb:			
Year 1	3.10	3.01	.40
Year 2	2.47	2.44	.84
Overall	2.78	2.73	.48

Table 2. Effects of Late-Summer Stocker Supplementation on Carcass Trait

Item	No Supplement	Arsoy Supplement	P-Value
Hot carcass wt, lb	734	761	.01
Fat thickness, in.	.35	.36	.75
Ribeye area, sq in.	13.8	14.1	.29
KPH, %	2.3	2.4	.26
USDA yield grade	1.3	1.7	.01
USDA marbling score	Slight 76	Slight 81	.59
% USDA Choice or better	33	35	.92

RELATIONSHIP OF PLASMA GLUCOSE TO PERFORMANCE AND CARCASS TRAITS IN FINISHING CATTLE

H. J. LaBrune, J. S. Drouillard, D. J. Bindel, C. C. Coetzer, C. A. Löest, R. D. Hunter, and J. J. Higgins[1]

Summary

Blood glucose levels of finishing cattle were measured between 3 and 30 days prior to slaughter and compared to performance and carcass traits. In trial 1, blood samples were obtained from 318 heifers at 2 hours post-feeding at 30 days before slaughter. Plasma glucose levels were correlated positively with fat thickness (P<.01) and kidney, pelvic, and heart fat (P<.02). Trial 2 utilized 72 steers from which blood was collected at 15 hours post-feeding at 3 days before slaughter. Blood glucose was correlated positively with average daily gain (P<.01); dry matter intake (P<.01); hot carcass weight (P<.01); ribeye area (P<.01); fat thickness (P<.06); and kidney, pelvic, and heart fat (P<.01). A third trial was conducted with 77 individually fed steers to determine if blood glucose levels could be used to predict finishing performance and carcass traits. Contrary to trials 1 and 2, plasma glucose did not reflect performance or carcass traits except marbling score (P<.03).

(Key Words: Glucose, Finishing Cattle.)

Introduction

We have postulated that digestive disorders or decreased performance in cattle may be related to poor regulation of blood glucose. These studies were conducted in an effort to define relationships between glucose levels, performance, and carcass traits of finishing cattle.

Experimental Procedures

Experiment 1 utilized 318 heifers in a 120-day finishing trial. Heifers were allotted to pens of 11 to 12 animals each and were fed finishing diets containing different levels of fat and choline once daily at 8:00 a.m. On day 90, blood was collected via the jugular vein at 2 hours after feeding.

In Experiment 2, 72 steers were fed different sources and levels of protein in the diet for 107 days. Steers were allotted to individual pens and fed once daily at 3:00 p.m. Blood was collected at 20 hours after feeding 3 days prior to slaughter.

In Experiment 3, 77 Angus × Hereford crossbred beef steers (825 lb) were fed finishing diets containing various levels of tallow for 93 days. Steers were fed once daily at 3:00 p.m. On day 84, steers were weighed individually, and blood was collected 16 hours after feeding.

For all experiments, plasma glucose values were linearly regressed against performance and carcass traits to obtain correlation coefficients. The correlation coefficient explains the amount of variation in performance or carcass traits that is explained by differences in glucose concentration.

Results and Discussion

Table 1 summarizes data from Experiment 1. Plasma glucose values (postfeeding)

[1]Department of Statistics.

ranged from 62 to 279 mg/dl and averaged 110 mg/dl. Significant relationships occurred between plasma glucose and fat thickness and kidney-heart-pelvic fat. Hot carcass weight, ribeye area, and marbling score were not significantly related to plasma glucose.

Table 1. Coefficients of Correlation (R) Between Plasma Glucose and Carcass Traits in Finishing Heifers Fed Different Levels of Fat and Choline (Experiment 1)

Item	R	P-Value[a]
Hot carcass weight	.04	.50
Ribeye area	.00	.98
Fat thickness	.20	<.01
Kidney, pelvic, and heart fat	.14	.02
Marbling score	.12	.06
% USDA Choice	.04	.50

[a]P-value <.05 indicates a significant linear relationship between the variable and plasma glucose concentration.

Correlations of performance and carcass traits to plasma glucose of finishing steers that were fed different sources and levels of protein are shown in Table 2 (Experiment 2). Fasting plasma glucose values ranged from 38 to 104 mg/dl and averaged 67 mg/dl. Average daily gain, feed efficiency, and intake for the finishing period were significantly related to blood glucose. Carcass traits such as carcass weight, ribeye area, fat thickness, and kidney-heart-pelvic fat also were related significantly to blood glucose. These data led us to believe that plasma glucose concentration could be used as a predictor of performance and carcass traits.

In Experiment 3, fasting blood glucose levels ranged from 66 to 115 mg/dl and averaged 91 mg/dl. Marbling score was related negatively to plasma glucose levels (P<.03), but none of the other performance traits or carcass characteristics were related. This is contrary to our observations from Experiments 1 and 2 and may have been due to factors that influence glucose metabolism, such as health of the individual, feed consumption patterns, or other nutritional factors that need to be studied further.

Table 2. Coefficients of Correlation (R) among Plasma Glucose and Performance and Carcass Traits in Finishing Steers Fed Different Sources and Levels of Protein (Experiment 2)

Item	R	P-Value[a]
Average daily gain	.41	<.01
Gain:feed	.29	.02
Dry matter intake	.38	<.01
Hot carcass weight	.53	<.01
Ribeye area	.36	<.01
Fat thickness	.22	.06
Kidney, pelvic, and heart fat	.36	<.01
Marbling score	.15	.22
% USDA Choice	.16	.19

[a]P-value <.05 indicates a significant linear relationship between the variable and plasma glucose concentration.

Table 3. Coefficients of Correlation (R) among Plasma Glucose and Performance and Carcass Traits in Finishing Steers (Experiment 3)

Item	R	P-Value[a]
Average daily gain	.14	.21
Gain:feed	.20	.08
Dry matter intake	.02	.89
Hot carcass weight	.03	.82
Ribeye area	.04	.74
Kidney, pelvic, and heart fat	.05	.69
Marbling score	-.09	.03
% USDA Choice	.03	.78

[a]P-value <.05 indicates a significant linear relationship between the variable and plasma glucose concentration.

REFRACTIVE INDEX: A RAPID METHOD FOR DETERMINATION OF STARCH AVAILABILITY IN GRAINS

J. J. Sindt, J. S. Drouillard, S. P. Montgomery, and T. B. Farran

Summary

Steam-flaked corn samples were used in a series of experiments to determine if refractive index could be used as a rapid, inexpensive method to predict starch availability. Results were best when samples were incubated for 15 min with 500 to 600 active units of enzyme/gm of grain prior to measuring on a hand-held refractometer. Correlations to starch availability determined from gas production by a commercial lab were R=.64 for whole flakes and R=.79 when samples were ground. Samples of corn flaked to different densities produced estimates of solubility similar to an in situ dry matter disappearance assay (R^2 = .84, P < .01). Furthermore, refractive index yielded estimates of starch solubility that were well related to a commercial lab's measures of glucose release for samples of flaked corn that were stored for 0 to 48 hours subsequent to flaking.

(Key Words: Starch Availability, Steam-Flaked Corn, Refractive Index.)

Introduction

When grain is steam flaked, the starch matrix is disrupted and ultimately gelatinized, increasing its susceptibility to degradation by digestive enzymes and improving energy value. Current starch availability methods take too much time to be useful for making mill adjustments. Our objective was to develop a rapid, reliable, inexpensive procedure that could be used by mill operators to assess quality of flaked grains. If successful, the method could be used to determine the effects of milling and grain storage procedures on gelatinization and (or) extent of retrogradation of grains.

Experimental Procedures

Experiment 1 – Effect of Amyloglucosidase Concentration

A dose titration was performed to determine optimum concentration of amyloglucosidase required for measuring starch availability. Steam-flaked corn (26 lb/bu) was prepared using an 18-in × 24-in Ferrel-Ross flaker equipped with a 96-cubic ft steam cabinet. Grain was conditioned for approximately 45 min before being flaked. Samples were collected, packed in dry ice, transferred to the laboratory, and frozen. Grain was ground to pass through a 1-mm screen. Samples then were divided into 10-gm subsamples that were placed into Erlenmeyer flasks. Buffered-enzyme solutions (40 ml) containing amyloglucosidase (A3407, Sigma Chemical Company; 6,100 enzyme units per ml) were added at levels of 30, 60, 153, 305, or 610 active enzyme units/gm of grain. Samples were incubated for 15 min in a 130° F water bath and filtered through Whatman 541 filter paper. Several drops of the filtrate were placed on the prism of a hand-held refractometer, and the percentage of solubles in each sample was read from a Brix scale.

Experiment 2 – Effects of Enzyme Concentrations and Incubation Time

Samples from Exp.1 were used to further evaluate different enzyme concentrations and incubation times. Ground subsamples were incubated at 130°F for 10, 15, 20, or 30 min in 40 ml of buffered amyloglucosidase enzyme solution containing 153, 305, 610, or 1220 active enzyme units/gm of grain. Per

cent solubles was determined for each filtrate with a hand-held refractometer.

Experiment 3 – Refractive Index vs. Other Methods of Estimating Starch Availability

A series of grain samples was submitted to a commercial laboratory to obtain measures of in vitro gas production, total starch, and starch availability (by glucose release). Correlations were used to compare these procedures to the enzyme/refractive index method for both ground and whole-flaked grain samples.

Experiment 4 – Refractive Index vs. *in Situ* Ruminal Disappearance of Grains

Corn was conditioned for approximately 45 min and then flaked to densities of 20, 22, 23, 24, 25, 26, 27, 28, 29, 30, and 31 lb bu. After collection, samples were frozen immediately in liquid nitrogen, transferred to the laboratory, and incubated with buffered enzyme (610 active units/gm of grain) for 15 minutes at 130°F. Ruminal dry matter disappearance was measured by placing subsamples of each flake density in Dacron bags and suspending them in the rumen for 8 hrs. Samples were removed from the rumen, rinsed, dried, and weighed to determine in situ dry matter disappearance.

Experiment 5 – Solubility by Refractive Index vs. Starch Availability by Glucose Release

Approximately 6 tons of corn were steam conditioned for 45 min, flaked to a density of 26 lb/bu, and conveyed onto a concrete slab for storage for a period up to 48 hrs. Samples of grain were placed in permeable nylon bags and positioned in the flake pile. The interior of the pile maintained a temperature of 120°F or greater throughout the 48-hr storage period. Sample bags were removed from the core of the pile at 1, 2, 3, 4, 5, 6, 9, 12, 15, 18, 21, 24, 30, 36, 42, and 48 hrs after flaking and immediately placed into a freezer. Unground flake samples were incubated in enzyme solution as in Experiment 4. Percent available starch also was measured by a glucose release method.

Results and Discussion

Experiments 1 and 2 indicated that optimal results were achieved when enzyme was added at approximately 600 units per gm of grain (Figure 1). An incubation time of 15 min was adequate to produce concentrations of solubles that could be measured easily on a low-range refractometer (Figure 2). Correlations among various methods of estimating starch availability are shown in Table 1. Correlations between gas production and glucose release were very high. However, comparison of the refractive index method to the gas production technique gave a lower correlation of R=.64. Proteins and other solubles likely are measured in the refractive index procedure, whereas other procedures are more specific to carbohydrates. Grinding the flakes through a 1-mm screen improved the correlation with gas production. Flake density was correlated negatively to starch availability. In Exp. 4, the refractive index method yielded results similar to an in situ procedure for corn of different flake densities (Figure 3). The proportion of grain that was digested in situ decreased with increasing flake density. Exp. 5 examined length of storage vs. starch availability. The refractive index method followed a trend similar to the gas production procedure in determining starch availability (Figure 4). Available starch decreased in the early hours of storage and was lowest at 12-30 hours. From 30 to 48 hours, starch availability increased as measured by both procedures, but to a greater degree for the gas production procedure.

Applications

Estimating starch availability in grains by enzymatic starch hydrolyses/refractive index is inexpensive and rapid. We suggest that grain samples be incubated for 15 min using 500 to 600 enzyme units/gm of grain. After filtration, the resulting solubles can be measured easily using a simple hand-held refractometer under direct lighting. Starch availability can be assessed without further processing of flaked grain and requires as little as 15 to 20 min.

Table 1. Coefficients of Correlation (R) for Availability of Starch Measured by Various Methods[1] (Exp. 3)

Item	Gas Production	Glucose Release	Refractive Index, w[1]	Refractive Index, g[2]	Flake Density
Gas production	1.0	.97	.64	.79	-.64
Glucose release		1.0	.59	.80	-.65
Refractive index, w[2]			1.0	.75	-.72
Refractive index, g[2]				1.0	-.76
Flake density					1.0

[1]P<.01 for all correlations.
[2]Measured using whole flakes.
[3]Measured after grinding flakes through a 1-mm screen.

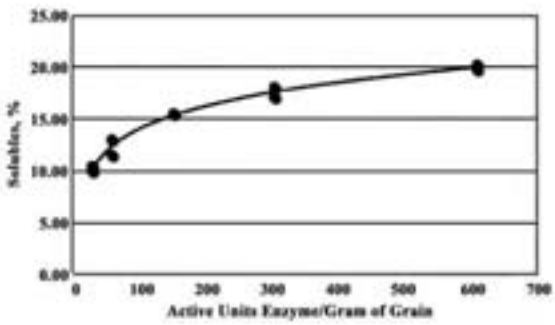


Figure 1. Effect of Enzyme Concentration on Solubles in Steam-Flaked Corn Incubated for 15 Min, as Measured by Refractive Index (Exp. 1).

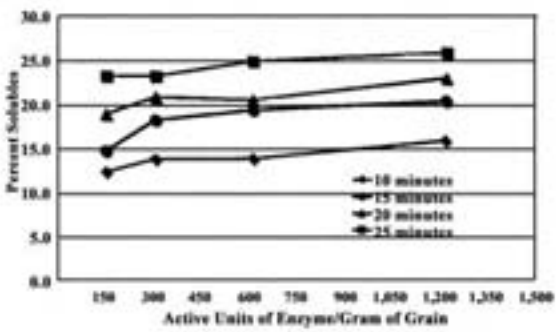


Figure 2. Effects of Incubation Time and Enzyme Concentration on Steam-Flaked Corn Solubility as Measured by Refractive Index (Exp. 2).

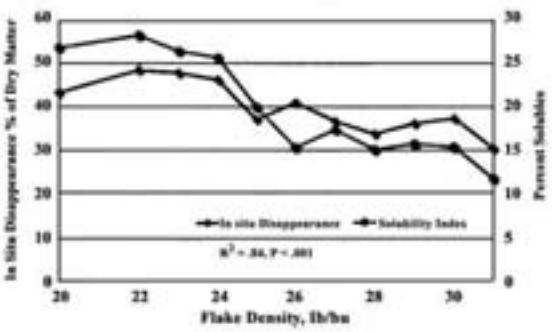


Figure 3. Flake Density Effects on Percent in Situ Dry Matter Disappearance and Percent Solubles Measured by Refractive Index (Exp. 4).

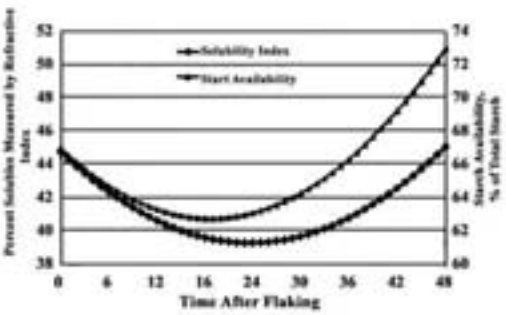


Figure 4. Comparison of Starch Availability Measured by Glucose Release and Solubility as Measured by Refractive Index for Steam-Flaked Corn Piled and Stored for Various Lengths of Time (Exp. 5).

DRYLOT RECEIVING PROGRAM VS PASTURE CONDITIONING WITH MICOTIL® METAPHYLAXIS FOR GRAZING STOCKER CALVES

S. I. Paisley[1], T. R. Falkner, F. K. Brazle[2], and G. L. Stokka

Summary

Three stocker cattle field studies were conducted comparing a traditional 4- to 5-week drylot receiving program with injectable antibiotics administered on a pull-and-treat basis versus a pasture-based conditioning program using an initial metaphylaxis with Micotil® followed by immediately placing cattle on grass. Although daily gains were similar (P=.80) for both receiving programs during the first 28 days, pasture conditioning reduced the number of cattle treated and increased (P<.01) daily gains during the subsequent grazing phase.

(Key Words: Stockers, Receiving, Metaphylaxis, Micotil®)

Introduction

Many forage-based stocker programs still utilize an initial 21- to 45-day drylot conditioning period to "straighten out" recently purchased and(or) commingled cattle. Confining cattle to a smaller area makes it easier to identify and treat sick animals. However, drylot programs may increase stress as calves are forced to cope with dusty or muddy pens, while adjusting to feedbunks, waterers, and new feeds. Additionally, the higher density likely facilitates the transmission of disease-causing organisms from animal to animal. Pasture conditioning programs have the potential to reduce stress, because cattle remain on a forage diet and are able to spread out, possibly reducing disease transmission. This study was conducted to compare two management strategies used in pasture-based stocker programs: traditional drylot receiving programs versus a pasture-based conditioning program that included metaphylaxis. Stocker morbidity and performance were measured during the receiving phase and subsequent grazing.

Experimental Procedures

Five hundred ninety three steers across three locations were assigned randomly to one of two treatments: 1) traditional drylot conditioning for 28 to 35 days (DRYLOT) or 2) pasture conditioning after a maximum of 48 hours in drylot (PASTURE). Basic processing on arrival was identical for all cattle, and in addition, PASTURE cattle received a metaphylactic dose (1.5 ml/cwt) of tilmicosin phospate (Micotil). Respiratory disease treatment protocol for both DRYLOT and PASTURE cattle was Micotil, followed by Nuflor. Cattle on the DRYLOT treatment received a conditioning ration free choice during the initial 30-day period. Management of PASTURE cattle depended on the type of forage grazed. Following the initial 30-day conditioning period, cattle were combined into a similar pasture for the remainder of the grazing period.

Site 1. (Chanute, KS). One hundred ninety eight heifers (initial wt 500 lb) originating from Missouri were received in two groups of 67 and 129 head. Each group was split, so 99 were in DRYLOT and 97 in

[1]South Central Area Extension Office, Hutchinson.
[2]Southeast Area Extension Office, Chanute.

PASTURE. Initial weights were recorded on December 2 and 8, 1998. Conditioning period weights were recorded on January 6, resulting in 29- and 35-day conditioning periods. Following the conditioning period, all heifers grazed fescue pastures with some additional dormant winter grass throughout the trial. The fescue was twice covered with ice during the receiving period. Heifers from both groups were stressed further by stray dogs during the receiving period. Final weights taken on April 19, 1999.

Site 2. (Emporia, KS). One hundred ninety nine steers (initial wt 488 lb) originating from Missouri were divided equally into two groups. Initial weights were taken on November 10 and 17, 1998. Conditioning period weights were recorded on December 8 and 17, respectively. Normal receiving management consisted of measuring rectal temperature twice, on day 1 and between days 4 and 6. On both days, steers received Micotil if rectal temperature was $103°F. Morbidity percentages depicted in Table 1 include those animals that were treated because of high rectal temperature. Steers grazed dormant native grass with minimal cool-season forages. Final weights were recorded on May 25, 1999.

Site 3. (Kingman, KS). One hundred ninety eight steers (initial wt 469 lb) originating from Southeast Colorado were either placed in drylot or immediately hauled to an irrigated winter wheat pasture. Initial weights were recorded on November 17, 1998 and following the conditioning phase on December 15. After the second weighing, all steers grazed the same irrigated wheat pasture for 70 days, and final weights were taken February 23, 1999.

Effects of conditioning-period management on performance were analyzed using site × treatment as the error term. Morbidity data are presented by site and whole trial averages but were not analyzed because of different management protocols across sites.

Results and Discussion

Daily gains during the conditioning phase were similar (P=.80) for both treatments, although the relative differences varied from site to site. Cattle grazing dormant forage gained less weight during the conditioning phase than cattle in drylot; however, steers grazing winter wheat outgained their drylot counterparts. Morbidity was dramatically lower for PASTURE cattle at all three field study sites, despite different receiving management. The magnitude of the decrease was considerably greater than reported in previous trials. Additionally, the number of cattle treated a second time was lower for PASTURE cattle. These results suggest that the benefits of pasture-based conditioning programs and the use of metaphylaxis may be additive.

Subsequent grazing performance was greater (P<.01) for PASTURE cattle. However, this difference may reflect either differences in fill between DRYLOT and PASTURE cattle at the end of the conditioning phase or a necessary adaptation back to a forage-based diet for DRYLOT cattle.

Table 1. Effects of Receiving Management on Initial Performance, Morbidity, and Subsequent Grazing Performance of Calves on Forage-Based Stocker Programs

Item	DRYLOT	PASTURE	P-Value
Site 1. Chanute, KS			
Number	99	97	
Conditioning daily gain, lb/day	.68	.60	
Morbidity, %	71	27	
Retreats, %[a]	38	12	
Subsequent daily gain, lb/day	.17	.30	
Site 2. Emporia, KS			
Number	100	99	
Conditioning daily gain, lb/day	2.38	1.45	
Morbidity, %[b]	90	6	
Retreats, %	8	0	
Subsequent daily gain, lb/day	.64	.77	
Site 3. Kingman, KS			
Number	99	99	
Conditioning daily gain, lb/day	1.60	2.22	
Morbidity, %	37	4	
Retreats, %	35	0	
Subsequent daily gain, lb/day	1.66	1.84	
Three-site average			
Number	298	295	
Conditioning daily gain, lb/day	1.42	1.55	.80
Morbidity, %	60	10	
Retreats, %	27	5	
Subsequent daily gain, lb/day	.82	.97	.01

[a]Expressed as a percent of cattle treated previously.

[b]Morbidity value for DRYLOT includes all steers treated based on temperatures > 103°F.

EFFECTS OF FLORFENICOL METAPHYLAXIS IN REDUCING MORBIDITY AND ASSOCIATED PERFORMANCE LOSSES IN STRESSED BEEF CALVES

G. L. Huck[1], G. L. Stokka, T. T. Marston, and T. R. Falkner

Summary

In February, 1998, 191 crossbred steers (885 lb) were used in a 28-day feeding trial to evaluate the effects of florfenicol (Nuflor®) on morbidity of newly weaned, lightweight cattle. No clinical signs of illness were observed in either the medicated or control group. No statistically significant differences in daily gain, feed intake, or feed efficiency were observed between treated and nontreated cattle.

(Keywords: Nuflor®, Metaphylaxis, Intake, Morbidity, Receiving.)

Introduction

Significant transportation stress occurs in most feeder cattle prior to arrival at backgrounding and feedlot facilities. Usually, these stress factors combine to ensure an overgrowth of *Pasteurella haemolytica*, depression of systemic immunity and lung protective mechanisms, and aerosolization of bacteria into the lungs. Nuflor® has proven to be a valuable antibiotic for use in the treatment of bronchopneumonia caused by *P. haemolytica* and other organisms in controlled research environments, clinical trials, and field studies. Metaphylaxis involves treating all animals with an antibiotic prior to an anticipated disease outbreak. Preliminary evaluations of Nuflor have been promising; results showed significant reductions in morbidity and mortality. The intent of this study was to further evaluate the utility of Nuflor metaphylaxis in stressed beef calves.

Experimental Procedures

Over a 5-day period, 220 steers were purchased from sale barns in Dodge City and Syracuse, KS, and Burlington, CO, and received into a weaning facility in Southwest Kansas. Cattle had ad libitum access to long-stemmed grass hay upon arrival and during their stay at the receiving facility. Vaccination history prior to purchase was not known. After all cattle had been purchased, they were transported to the Southwest Kansas Research-Extension Center, Garden City, KS. Cattle were vaccinated (Nasalgen®; 1cc/nostril); treated for parasites (Totalon®; 2.5cc/100 lb); individually tagged; and weighed within 24 hours of arrival. One hundred ninety two steers were selected for the trial. The 14 lightest and 14 heaviest were eliminated. On day 2, cattle designated for the trial were reweighed and either treated with a metaphylactic dose of florfenicol (Nuflor, 6cc/100 lb) or left untreated, then allotted to their respective pens (22 pens, 8 or 9 head per pen, 11 pens per treatment). The 28-day trial began on February 8 and ended on March 7, 1999. Cattle were fed one 70 lb bale of prairie hay per pen on the first 3 days, 1/2 bale per pen on days 4 and 5, and 1/3 bale per pen on days 6 through 8. Approximately 8 lb of a 60% corn silage-based growing diet was fed prior to hay on days 3 and 4, and 12 lb was fed on days 5 through 7; then cattle were stepped up to full feed (60% corn silage, 34% dry rolled corn, 3% soybean meal, 3% mineral supplement) on day 8. Cattle were fed once a day, and bunks were managed so that the entire bunk was empty at

[1]Southwest Area Extension Office, Garden City.

least once out of every 3 days. One feed call per pen was made each morning.

All animals were observed daily, and individual treatment records were maintained. One steer died from a joint infection (confirmed by postmortem) 2 days before the trial was completed. Feed intakes were adjusted for that pen by subtracting the average intake of a single animal from the total amount of feed fed to that pen prior to the animal's death.

Reported final weight is the average of two scale weights multiplied by .97 (3% pencil shrink). Daily gain and feed efficiency were based on initial unshrunk and final shrunk weights.

Results and Discussion

None of the cattle in this study showed clinical signs of illness during the 28-day experiment, so no conclusions could be made with regard to morbidity reduction. Performance data are shown in Table 1. No significant differences in daily gain or feed efficiency were observed ($P<.05$). Cattle receiving Nuflor consumed 2.9% more feed than controls, but the difference was not statistically significant ($P=.14$).

Table 1. Growth Performance Data of Weaned Untreated Steers or Steers Receiving Nuflor® upon Arrival

Item	Control	Treated	SE
Pens per treatment	11	11	
Head per treatment	95	96	
Initial wt., lb	442.8	441.7	4.69
Final wt., lb	520.8	520.4	5.48
Daily gain, lb	2.79	2.81	.10
Dry matter intake, lb/d	10.1	10.4	.15
Feed/gain	4.65	4.72	.23

EFFECTS OF A CLOSTRIDIAL BACTERIN-TOXOID ADMINISTERED SUBCUTANEOUSLY AT THE BASE OF THE EAR ON STOCKER HEIFER PERFORMANCE, TESTOSTERONE SERUM CONCENTRATIONS, AND INFRARED THERMAL CHARACTERISTICS OF THE INJECTION SITE AND ADJACENT TISSUES[1]

D. A. Blasi, J. M. Sargeant[2], M. F. Spire[2], S. I. Paisley[3], and J. E. Minton

Summary

A 129-day field study was conducted to evaluate the effects of a clostridial bacterin-toxoid administered subcutaneously at the base of the ear on heifer calf performance, surface-ear temperature, and testosterone concentration. Two hundred previously non-implanted heifers averaging 372 lb were assigned to one of four treatments: 1) Alpha-7 (clostridial toxoid) in left neck, Synovex-H in left ear (NL); 2) Alpha-7 in left neck, Synovex-H in right ear (NR); 3) Alpha-7 in right ear, Synovex-H in opposite ear (OP); and 4) Alpha-7 in right ear, Synovex-H in same ear (SM). On day 7, the right ear of each heifer was thermographically imaged. On trial days 7, 28, 59, and 87, jugular blood samples were collected to determine if placement of the clostridial vaccine reduced serum concentration of testosterone. Although vaccinating in the base of the ear increased (P<.01) ear temperature, daily gains through 59 days were similar (P$.44) for heifers injected in the neck (NL + NR) vs those injected in the base of the ear (SM + OP). Additionally, ear temperature and animal performance were similar (P$.11) for OP and SM placements of vaccine and implant. Testosterone concentrations were similar (P>.84) for heifers implanted in the right ear and vaccinated in the same side ear or neck.

(Key Words: Infrared, Injection Site, Growth Implant, Heifers.)

Introduction

Over the past 6 years, the beef industry has encouraged the use of alternative injection sites to reduce intramuscular injection-site blemishes and has discouraged the development of products whose label requires intramuscular injection. In response to this issue, two clostridial vaccines, Alpha-7® and Alpha-CD®, have received FDA approval for subcutaneous administration in the base of the ear. Although favorable immune responses are achieved with an ear injection, placing an implant in the same ear might alter the release characteristics. The middle third of the ear is the only approved site for placement of growth-promotant implants.

Identification tags and other biological products targeted for placement at the base of the ear also might have to be placed in the same ear as growth implants. Sustained absorption of the active ingredients from the surface of the implants is required, if they are to improve carcass gain and feed efficiency. Localized tissue reactions following vaccination or antimicrobial usage might alter blood and lymph drainage from the implant site.

Experimental Procedures

Two hundred forty eight heifers averaging 372 lbs were received from Mississippi in two truckloads. Upon arrival, all heifers were weighed individually, evaluated for abnormalities, and tagged in the left ear.

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[1]Sincere appreciation is expressed to Great Plains Cattle, Pratt, Kansas for providing cattle, facilities, and assistance and to Boehringer Ingelheim Animal Health for financial support.

[2]Food Animal Health and Management Center, KSU College of Veterinary Medicine.

[3]South Central Area Extension Office, Hutchinson.

Forty eight heifers were removed from the study because of horns, abnormalities, and extreme weights. The remaining heifers were allotted by weight within truck load on the basis of uniformity, breed type, frame size, body condition, and health to one of the following four treatments: 1) Alpha-7 (clostridial toxoid) in left neck, Synovex-H in left ear (NL, N = 33); 2) Alpha-7 in left neck, Synovex-H in right ear (NR, N = 33); 3) Alpha-7 in right ear, Synovex-H in opposite ear (OP, N = 67), and, 4) Alpha-7 in right ear, Synovex-H in same ear (SM, N = 67).

On the following day, each heifer received a Fusion-4® (killed/modified live IBR, BVD, PI3 and BRSV) and Bar Somnus + 2P bacterin vaccination, a vitamin ADE injection, and a mass medication with Micotil® (as per label); was wormed with Cydectin®; and was weighed and branded. All heifers were vaccinated and implanted according to treatment assignment on day 0. On day 7, all heifers were weighed individually and the back of the right ear was thermographically imaged. Each ear was examined physically to assess the presence of implants and any anatomical alteration at the site of implantation and/or vaccination. Then a second matching identification tag was placed in the right ear. All heifers were weighed individually on days 28, 56, 87, and 129 of the trial. On days 7, 28, 59, and 87, blood samples were obtained (left jugular vein) for testosterone analysis.

A one-way analysis of variance was used initially to model the effects of treatment on ear temperature, interim-weight, and daily-gain variables. Orthogonal contrasts were used to make direct comparisons of surface temperature and animal performance between the different combinations of implant and vaccine sites. This method was used to test: 1) the null hypothesis of no difference between neck (NL and NR) and ear (OP and SM) vaccination, 2) vaccination in the neck and implant in right vs. left ear (NL vs. NR), and 3) vaccination in the right ear and implant in the right vs. left ear (OP vs. SM).

Results and Discussion

Heifers injected in the ear had higher ear temperatures. No differences ($P>.44$) with regard to vaccination placement (neck vs. ear) occurred in weight gain from 0 to 28, 29 to 59, and 0 to 59 days. However, over the entire 129-day period, heifers injected in the neck gained faster ($P=.02$). Although ear temperatures were similar ($P=.28$) between the NL and NR treatments, weight gain was greater ($P<.04$) for calves implanted in the right ear (NR) over all weigh periods. With vaccination in the ear, ear temperature and growth performance were similar ($P>.11$) for calves implanted in either the left or right ear. We have no explanation for the significant gain response for the NR treatment relative to the other three treatments.

All blood samples came from the left jugular. Figure 1 shows that at all sampling times, serum testosterone was higher for heifers with the left ear implant (NL and OP vs NR and SM). The similar testosterone concentrations observed between treatments NR and SM suggest that serum testosterone was not affected by vaccination with Alpha-7 in the same ear as the growth implant. Serum testosterone values peaked at 28 days post-implantation. Implanting and vaccinating in the same ear did not alter performance when compared to implanting and vaccinating in opposite ears.

Table 1. Effect of Clostridium Bacterin-Toxoid Administered Subcutaneously at the Base of the Ear on Calf Performance and Infrared Thermal Characteristics of the Ear

	Treatments					Contrasts		
Item	NL	NR	OP	SM	SE	Neck vs Ear vacc (NL+NR) vs (OP+SM)	Neck vacc site (L) R vs L ear implant (NL vs NR)	Ear vacc site (R) R vs L ear implant (OP vs SM)
Ear temp. °C	28.6	29.1	29.4	29.8	0.24	<.01	.28	.16
Wt gain 0-29 d	28	36	30	31	2.2	.44	.04	.46
Wt gain 29-59 d	50	61	52	57	2.9	.84	.03	.16
Wt gain 0-59 d	78	97	82	89	3.7	.49	<.01	.11
ADG, 129-d	1.63	1.87	1.64	1.66	0.04	.02	<.01	.64

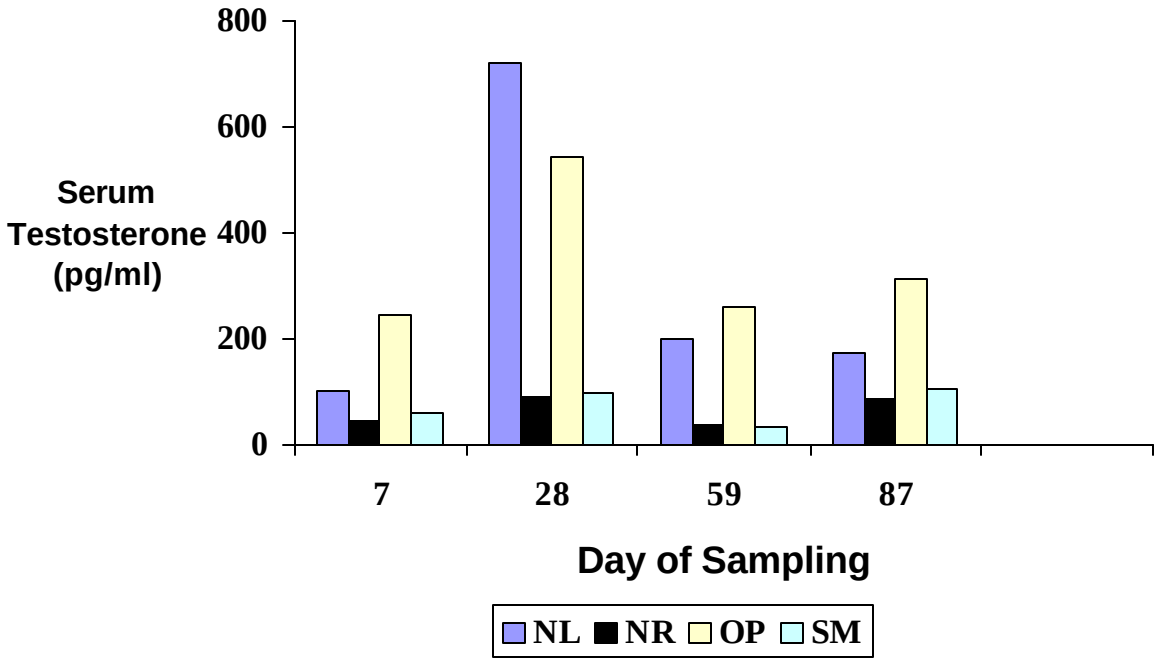


Figure 1. Testosterone Levels in Heifers from Serum Collected on the Same Side (NL and OP) or Opposite Side (NR and SM) from the Ear Bearing a Growth Implant.

EFFECTS OF SICKNESS ON WEIGHT GAIN AND RADIANT ENERGY LOSS IN RECENTLY RECEIVED FEEDER CATTLE[1]

M. F. Spire[2], J. S. Drouillard, and J. M. Sargeant[2]

Summary

Sickness from undifferentiated respiratory disease in recently received feeder cattle reduced weight gain and altered radiant energy loss. Over a 35-day receiving period, weight gains were reduced 26.3% if an animal was diagnosed as sick once and 48.1% if diagnosed sick more than once. Thermal profiles obtained 10 or more days following clinical illness were cooler than profiles of animals never diagnosed as being sick. Our data suggest that respiratory disease alters metabolic activity as evidenced by reduced weight gain and a detectable decrease in radiant energy loss from the body surface.

(Key Words: Infrared Thermography, Sickness, Feedlot Performance.)

Introduction

Respiratory disease is the most costly disease of feeder cattle and remains a major, ongoing concern for health care providers and feedlot operators. Death loss from respiratory disease was estimated to have cost the cattle industry nearly $500 million in 1996. Respiratory disease creates additional economic losses because of drug and vaccine costs, increased labor costs, poor feed efficiency, delayed animal marketing, poor weight gain, and decreased carcass grade. Marked physiological events associated with disease, adaptation to rations, and acute and chronic stresses occur during the early feedlot phase. These events can modify heat loss from the body surface. Scanning the animals with an infrared camera can monitor those changes in body surface temperature. This project was undertaken to evaluate the effects of acute respiratory disease shortly after arrival on animal performance and radiant energy loss after 33-35 days in a feedlot.

Experimental Procedures

A total of 224 British crossbred heifers (average weight 525 lb) was evaluated over a 35-day period for evidence of undifferentiated bovine-respiratory disease. Within 24 hours after arrival, each animal was treated for internal and external parasites; vaccinated against common viral and clostridial diseases; and received a subcutaneous injection of tilmicosin (Micotil®, Elanco Animal Health) at a dosage of 1.5 ml/100 lb body weight. During processing, the animals were sorted into groups of six head each. Cattle were fed a 60% concentrate diet during a 35-day receiving period. Seven days following arrival, the cattle were reweighed and re-vaccinated with a modified live viral product.

Once daily, on days 33-35 following arrival, cattle were thermally imaged using a short-wavelength, infrared radiometer. Based on thermal images, each animal were assigned a thermal score of 1 (coldest) to 4 (hottest). The 3-day average of assigned thermal scores was used as the thermal profile for each animal.

[1]The authors express their sincere appreciation to Steven Hogge, Food Animal Health and Management Center, for all his efforts in support of this project.

[2]Food Animal Health and Management Center, College of Veterinary Medicine.

Cattle were evaluated daily for clinical illness. Animals were assigned a clinical score ranging from 0 to 4 (0=no clinical signs of respiratory disease, 1=mild respiratory illness, 4=moribund), based on clinical signs, including depression, lethargy, anorexia, coughing, rapid breathing, and nasal and/or ocular discharge. Cattle were treated for respiratory disease if they had a clinical score $\geq$1 and a rectal temperature of $\geq$103.5°F. Animals not meeting those criteria remained untreated and were returned to their home pen. Animals requiring therapeutic treatment received a subcutaneous injection of tilmicosin (Micotil) at 1.5 ml/ 100 lb. Cattle were returned to their original pen following treatment. Retreatment was based upon a continuing clinical score of $\geq$1 and rectal temperature $\geq$103.5°F and commenced no sooner than 48 hours following initial treatment. It consisted of intramuscular injections of long-acting oxytetracycline (Liquamycin LA-200®, Pfizer Animal Health) at 6 ml/100 lb body weight and tylosin (Tylan 200®, Elanco Animal Health) at 5 ml/100 lb body weight.

Average daily gain and thermal profiles were analyzed as separate outcomes. For each outcome, differences between treatment groups (0, 1, and $\geq$2 treatments) were assessed using ANOVA with pen controlled as a random effect.

Results and Discussion

Forty-four percent of the cattle were treated for clinical respiratory disease within the first 35 days after arrival in the feedyard. Eight animals died prior to thermal profiling on days 33-35 and were not included in the analyses. Animals never identified as sick gained 3.16±0.10 SEM lb/day over the 35-day period, whereas animals requiring one or more treatments had a lower average daily gain ($P<0.001$, adjusted for pen effect). Cattle identified as sick once gained 2.33 ± 0.11 SEM lb/day, whereas those identified as sick more than one time gained 1.67 ± 0.16 SEM lb/day. Individual animal feed efficiency could not be evaluated, because the cattle were fed on a pen basis.

Ambient temperatures during the 3 days of thermal evaluation ranged from 46 to 61°F. Wind speed was calm except on day 2, when it ranged from 10 to 12 miles per hour. No animals were treated in the 10 days before thermal profiling. Animals treated one or more times had reduced average thermal profiles over days 33-35 ($P<0.01$). Thermal profiles of cattle not identified as sick averaged 2.06±0.07 SEM. Profiles for cattle identified as being sick once averaged 1.78 ± 0.09 SEM vs. 1.71 ± 0.11 for those sick more than once ($P>0.05$).

Thermal imaging measures the amount of infrared radiation from the surface of an animal, which is an exponential function of surface temperature. The body surface will come to equilibrium with skin temperature in an environment with static ambient temperatures. Heat flows to the body surface and dissipates by conduction, convection, radiation, and evaporation. Skin derives its heat from local circulation and tissue metabolism. Changes in an animal's skin temperature generally result from changes in perfusion of blood vessels, biorhythm, core body temperature, rate of metabolism, and environmental factors.

As evidenced by average daily gain, animal performance was altered significantly following clinical respiratory illness. This alteration in growth may reduce the amount of radiant energy released from the body surface as measured remotely by a thermal imaging unit. Animals having higher overall thermal profiles (warmer body surface) tend to be healthier and gain better. Radiant energy release from an animal, can be used to screen for conditions such as the effects of respiratory disease that may alter metabolism and, therefore, performance.

DIFFERENCES IN SERUM IMMUNOGLOBULIN G1 AND TOTAL PROTEIN CONCENTRATIONS IN NEONATAL CALVES ON DAYS 1, 5, AND 10

L. E. Wankel, T. T. Marston, G. L. Stokka, and T. G. Rozell

Summary

Immunoglobulin G1 (IgG1) serum concentrations are used to evaluate passive transfer of immunity in neonatal calves. Total serum proteins also can be measured to evaluate calf health. If IgG1 and total serum protein concentrations change with age, it becomes imperative to compare samples only from a narrow time period. Otherwise, differences might be due to age and not immune status. To help define this time period, blood was drawn from 10 beef calves when they were 1, 5, and 10 days of age. Serum samples were analyzed for IgG1 and total protein concentrations. Total protein concentrations decreased from days 1 to 5 ($P<.05$) or days 1 to 10 ($P<.05$), but not from days 5 to 10 ($P=.46$). IgG1 concentrations declined from days 1 to 10 ($P<.05$), but values from days 1 to 5 were similar ($P=.17$). Thus, it is important to collect serum on day 1 to guarantee correct results when evaluating IgG1 and total proteins collectively. However, if IgG1 alone is evaluated, serum can be collected between days 1 and 5.

(Key Words: Immunoglobulin G1, Total Protein, Calves.)

Introduction

Serum IgG1 concentration is a good indicator of passive immunity transfer in beef cattle. Total serum protein can be used as an indicator of health. However, when research is conducted involving these blood characteristics, collecting serum around 24 hours postpartum can be difficult. This experiment was designed to identify the calf age at which serum samples should be collected for evaluation of IgG1 and total serum protein.

Experimental Procedures

In January, 1999, blood was collected via jugular venipuncture at 1, 5, and 10 days of age from three Hereford, three Simmental, and four Angus calves born within 6 days of each other at the Kansas State Purebred Teaching Unit. Serum was analyzed for IgG1 using radial immunodiffusion kits specific for IgG1. Total serum protein was determined using a temperature-compensated hand-held refractometer. Results then were analyzed using the Proc Mixed procedure of SAS.

Results and Discussion

Serum total protein concentrations declined from days 1 to 5 ($P<.05$) and from days 1 to 10 ($P<.05$). However, concentrations on days 5 and 10 were not different ($P=.46$) (Figure 1). Serum IgG1 concentrations were similar from days 1 to 5 ($P=.17$), and the difference in values for days 5 vs. 10 approached significance ($P=.06$). Nonetheless, days 1 and 10 differed significantly ($P<.05$) (Figure 2). These results indicate that when research is conducted to assess passive transfer of immunity, IgG1 should be measured only at 1 to 5 days of age to secure accurate data. However, if both IgG1 and total serum protein are measured, blood should be drawn on day 1.

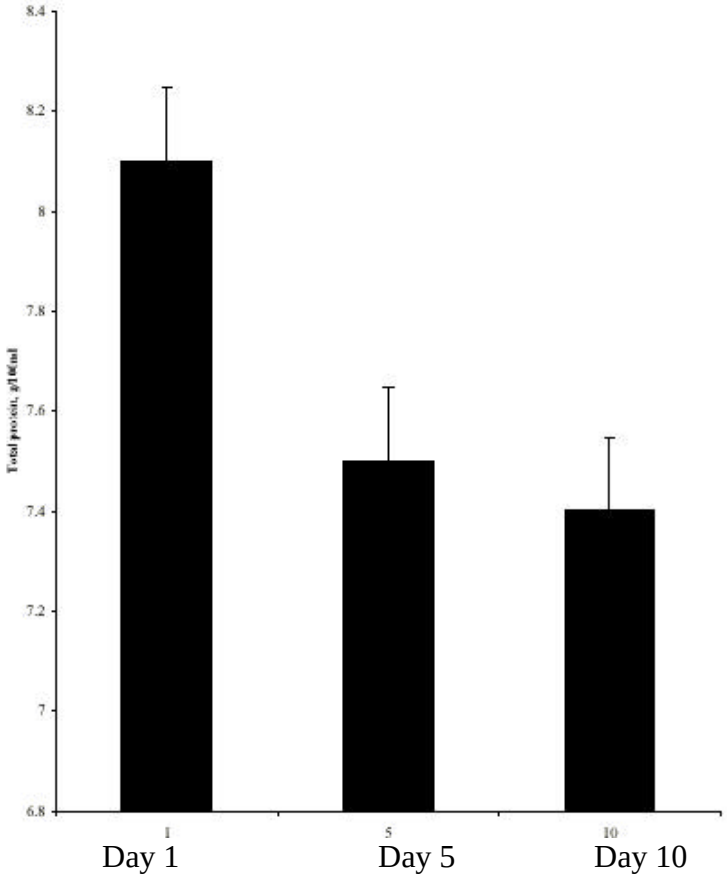


Figure 1. Total Protein Concentrations of Serum Samples from Calves 1, 5, and 10 Days of Age

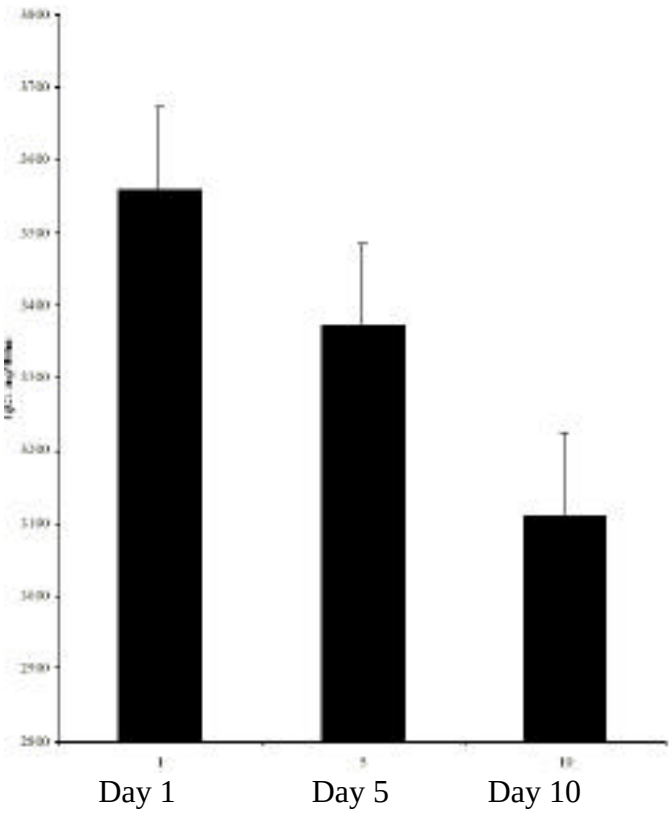


Figure 2. IgG1 Concentrations of Serum Samples from Calves 1, 5, and 10 Days of Age

EFFECTS OF DYSTOCIA AND CONFINED CALVING ON CALF-MORBIDITY RATE FROM BIRTH TO WEANING [1]

M. W. Sanderson [2] and D. A. Dargatz [3]

Summary

An analysis was performed on data from a national survey of US beef cow-calf producers to quantify the effects of management factors on calf-morbidity risk from birth to weaning. The analysis included 2,490 herds from 23 states. A high calf-morbidity herd was defined as one with greater than 10% morbidity. The rate of dystocia in the herd was categorized into five levels. All dystocia levels were associated significantly with increased risk of being a high calf-morbidity herd. Having greater than 70% of cows and heifers calve in confinement also was associated with increased risk of being a high calf-morbidity herd. Approximately 40% of herds experienced high morbidity from the effect of dystocia and approximately 10% from the effect of confined calving. This analysis indicates that dystocia and confined calving are important factors in determining a herd's calf-morbidity rate from birth to weaning.

(Key Words: Beef, Cow-Calf, Calf Morbidity, Calving, Dystocia.)

Introduction

Examination of individual-animal risk factors for morbidity and mortality from birth to 45 days of age has found increased morbidity among calves born to2-year-old heifers, and calves experiencing dystocia. A 35 lb reduction in weaning weight also has been shown among calves experiencing morbidity between birth and 45 days of age. Of all disease categories, diarrhea of unknown cause, predominately in calves, has the highest costs associated with treatment and labor. Over 75% of annual miscellaneous costs of disease may be due to lost weight gain. Clearly, calf morbidity is an important issue to the beef industry, resulting in reduced weight gains and expense and labor associated with treatment. The purpose of this study was to quantify the effect of herd management variables on herd risk for high calf morbidity.

Experimental Procedures

Data Source. Questionnaire data were collected from 2,490 beef, cow-calf operations between December 30, 1996, and February 3, 1997. Operations were selected from 23 states[4] by the USDA:National Agricultural Statistics Service (NASS) [5].

Producers were asked to estimate the number of calves experiencing morbidity from respiratory disease, diarrhea or "scours", bovine keratoconjunctivitis or "pinkeye", and infectious pododermatitis or "footrot" from birth to 3 weeks of age and

[1]The authors thank the NASS enumerators and state and federal statisticians for their roles in selecting and contacting this sample of beef producers and collecting the data for this analysis. In addition, none of this would have been possible without the cooperation of all the beef producers who participated in the survey.

[2]Department of Clinical Sciences.

[3]Centers for Epidemiology and Animal Health, USDA-Animal Plant Health Inspection Service-Veterinary Services, Ft. Collins, CO 80521.

from 3 weeks of age to weaning. Producers also were asked to estimate or use records to determine the number of dystocias in heifers and cows during 1996. Calvings were reported as "no assistance given", "easy pulls", "hard pulls", or "cesarean sections". Producers also provided estimates of the percent of cows and heifers calving in confined vs. extensive facilities, as well as an estimate of calving density. Confined calving was defined as cows calving in pens, sheds, or lots without access to grazing.

Data Analysis. A single morbidity rate was calculated for each herd by adding the estimates in each morbidity category and dividing by the total number of live-born calves in the herd. This calf morbidity value was used to categorize herds as high vs. low morbidity. High-morbidity herds were defined as having >= 10% morbidity.

Herd dystocia rate was calculated by summing the estimates for easy pulls, hard pulls, and cesarean sections and dividing by the number of calves born alive or dead. The combined dystocia rate for cows and heifers was categorized into five levels: no dystocia (reference group), >0 to 5% dystocia, >5% to 10% dystocia, >10% to 20% dystocia, and >20% dystocia. Data on whether or not cows were observed regularly during calving season also was collected.

Percentage of cows and heifers calving in confined facilities was classified into three categories; <=20% (reference group), >20 to 70%, and >70%.

Based on biological plausibility, all potential explanatory variables for which data were present for all herds were examined for association with calf morbidity. Variables associated with herd morbidity were included in an initial, multiple-logistic-regression model. The proportions of herd morbidity attributable to the identified management factors were calculated.

Results and Discussion

The estimate of mean morbidity prior to weaning was 5.8%, and mean mortality rate prior to weaning was 3.7%. The final odds ratios and confidence intervals (CI) for being classed a high calf-morbidity herd are summarized in Table 1. Odds ratios quantitate the risk of being a high calf-morbidity herd. Odds ratios for dystocia categories increased as the proportions of dystocia in the herds increased (P<0.01). Odds ratios for confined calving categories increased as the proportion of cows and heifers calving in confined facilities increased (P<0.01). No association was found between calf morbidity levels and regular observation of calving, specific dystocia categories such as dystocia in cows or hard dystocia (hard pull or cesarean section), or percent heifers in the herd.

In this data set, the mean dystocia rate for cows and heifers combined was 4% vs. 16.7% for heifers alone. Percentage of heifers in the herd was not associated significantly with high calf morbidity. Risk for morbidity in heifer's calves may be accounted for in the dystocia variable.

[4]California, Colorado, Montana, New Mexico, Oregon, Wyoming, Kansas, Nebraska, North Dakota, South Dakota, Oklahoma Texas, Arkansas, Illinois, Iowa, Missouri, Alabama, Florida, Georgia, Kentucky, Mississippi, Tennessee, and Virginia.

[5]This analysis is based on data from the USDA:APHIS:VS. Beef 97 survey. For complete results of the survey, contact the Centers for Epidemiology and Animal Health. Ft. Collins, CO. (970) 490-8000.

Table 1. Odds Ratios for Being Classified a High Calf-Morbidity Herd

Variable	Odds Ratio	95% CI
Dystocia class		
0%	1	
>0 to 5%	2.68***	1.8-3.99
>5% to 10%	2.68***	1.71-4.2
>10% to 20%	3.19***	1.77-5.77
>20%	5.46***	2.28-13.1
Confined calving		
0 to 20%	1	
>20% to 70%	1.34	0.67-2.65
>70%	1.8**	1.16-2.82

** P<0.01, *** P<0.001

Each category of dystocia was associated with increased risk of being a high morbidity herd. As dystocia rate increased from one category to the next, the associated point estimate for that odds ratio also increased. This relationship was particularly evident in herds with >20% dystocia, where the estimate of the odds ratio increased to 5.4. Failure to provide for adequate ingestion of colostrum and for maintenance of body temperature likely would increase morbidity significantly. As dystocia rate increased, the number of calves requiring additional support increased. Thus, available labor may be overwhelmed, resulting in increased risk of morbidity for individual calves.

The odds ratio for herds in which 20 to 70% of cows and heifers calved in confinement was numerically, but not significantly, greater than the ratio for herds in which less than 20% of cows and heifers calved in confinement. Herds in which >70% of cows and heifers calved in confinement were significantly more likely to be high morbidity herds (odds ratio=1.8). These estimates suggest a threshold where labor inputs are exceeded or environmental contamination reaches a level where disease transmission probability increases sufficiently to cause an outbreak.

The combined effects of dystocia and confined calving accounted for a significant proportion of high morbidity. Approximately 40% of herds experienced high calf-morbidity from effects associated with dystocia, and approximately 10% of herds experienced high calf-morbidity from effects associated with confined calving. Eliminating all dystocia would be unrealistic; nonetheless, the data reported here indicate the relative effects of dystocia and confined calving on calf morbidity.

CHARACTERIZATION OF SERUM HORMONE PROFILES IN GROWING HEIFERS IMPLANTED WITH ANABOLIC GROWTH PROMOTANTS[1]

D. A. Blasi, D. M. Henricks[2], J. S. Drouillard, G. L. Kuhl, and M. F. Spire[3]

Summary

A 147-day study was conducted to determine the sequential growth responses and serum hormone profiles of growing heifer calves implanted with anabolic growth promotants. Forty eight previously nonimplanted crossbred beef heifers averaging 396 lb were assigned to one of three treatments: 1) nonimplanted controls (NC), 2) Revalor®-G (REV-G), and 3) Synovex®-H (SYN-H). Accumulative gain response from day 84 through the end of the trial was significantly faster for both implant treatments than controls. Implant response was not consistent across time; heifers in both implant treatments gained faster than controls ($P<.05$) during the early (days 22-42) and later (days 64-84 and 85-105) weigh periods. By day 2, serum estradiol concentrations were increased in REV-G ($P<.05$) and SYN-H ($P<.01$) heifers relative to NC. Only REV-G contains trenbolone acetate, and none was detected in NC and SYN-H heifers, but serum levels in REV-G heifers were increased on days 2 ($P<.001$), 4 ($P<.05$), and 63 ($P<.001$). Only SYN-H contained testosterone; its level peaked by day 63 in SYN-H heifers. Throughout the study, progesterone was higher in NC heifers than in SYN-H or REV-G heifers, which suggests that the exogenous steroids reduced pituitary gonadotropin secretion and, thus, ovarian progesterone secretion. Our results suggest that the release of trenbolone and estradiol from REV-G implants is complete by 84 days after implanting.

(Key Words: Growth Promotants, Serum Hormones, Heifers.)

Introduction

Profit-minded cattle producers recognize that growth-promoting implants are indispensable tools for improving efficiency. Previous KSU field studies on stocker heifers showed that the gain response to implants depends on both implant type and the number of implants administered during the grazing period (Cattlemen's Day reports 1997 and 1998). Those studies also suggested that serum hormone concentrations vary between implant types over time. Hence, our objective was to characterize serum hormone profiles and performance of growing heifers implanted with Revalor®-G (40 mg trenbolone acetate and 8 mg estradiol) or Synovex®-H (20 mg estradiol benzoate and 200 mg testosterone propionate) compared to nonimplanted controls.

Experimental Procedures

This 147-day study was conducted from May through October, 1997, at the KSU Beef Cattle Research Center. A total of 48 British crossbred heifers averaging 396 lbs was assigned randomly to one of three treatments: 1) nonimplanted control (NC), 2) Revalor-G (REV-G) and 3) Synovex-H (SYN-H). All heifers were checked for previous implants, stratified by weight, and allotted randomly to treatment using the average of individual unshrunk weights on 2 previ-

[1]Sincere appreciation is expressed to Fort Dodge Animal Health for financial support.

[2]Animal and Veterinary Sciences Dept., Clemson University, Clemson, SC.

[3]Food Animal Health and Management Center, KSU College of Veterinary Medicine.

ous weigh days (days !2 and !1). All heifers were fed in one pen, once per day. The ration was 65% sorghum silage, 20% wheat middlings, 10% rolled corn, and 5% supplement (as-fed basis). Table 1 shows the same ration converted to a dry basis. The targeted gain of 2 lb/day was intended to be comparable to the gain in grazing studies conducted previously on smooth bromegrass and winter rye.

Table 1. Dry Matter Composition of Growing Diet[a]

Ingredient	% of DM
Sorghum silage	40.3
Wheat middlings	34.7
Dry-rolled corn	17.6
Supplement	7.4

[a]Formulated to provide 14.6% crude protein, .43 Mcal/lb Neg, 1.04% calcium, 0.53% phosphorus, and 25 g/ton Rumensin®.

On day 0, implants were administered according to manufacturers' recommendations. Unshrunk weights and blood samples for serum hormone analysis were collected on days 0, 2, 7, 14, 21, 42, 63, 84, 105, 126 and 147. Samples were analyzed for trenbolone acetate (TBA), testosterone (T2), estrogen (E2), and progesterone (P4).

Live weight gain data were analyzed as a completely randomized design with treatment as the sole source of variation. All hormone data were analyzed as a split-plot analysis for repeated measures. The model included the effect of treatment in the main plot (tested by the animal within treatment variance) and time and the treatment × time interaction in the subplot. Treatment × time means were compared only when a significant effect of the interaction term was found.

Results and Discussion

Table 2 presents heifer performance by treatment during successive weigh periods. Daily gains of REV-G and SYN-H heifers were similar (P>.05) to those of the NC heifers during the first 21 days. However, heifers in both implant treatments gained 10 to 27% faster than controls during the next five 20-day weigh periods. During the final two weigh periods, SYN-H heifers gained numerically faster than either REV-G or NC heifers.

Table 2. Effect of Implant Type on Heifer Daily Gains during Successive 20-Day Weigh Periods

	Treatment[a]		
Period of Study (Days)	NC	REV-G	SYN-H
0-21	2.10	2.26	2.01
22-42	2.49[b]	2.92[c]	2.91[c]
43-63	2.12	2.44	2.40
64-84	2.65[b]	3.11[c]	2.91[bc]
85-105	1.97[b]	2.34[bc]	2.50[c]
106-126	1.92	1.99	2.07
127-147	1.79	1.50	1.96

[a]NC = Nonimplanted control; REV-G = Revalor® -G; SYN-H = Synovex®-H. All implants were administered on day 0.
[b,c]Values in rows not sharing a common superscript are different (P<.05).

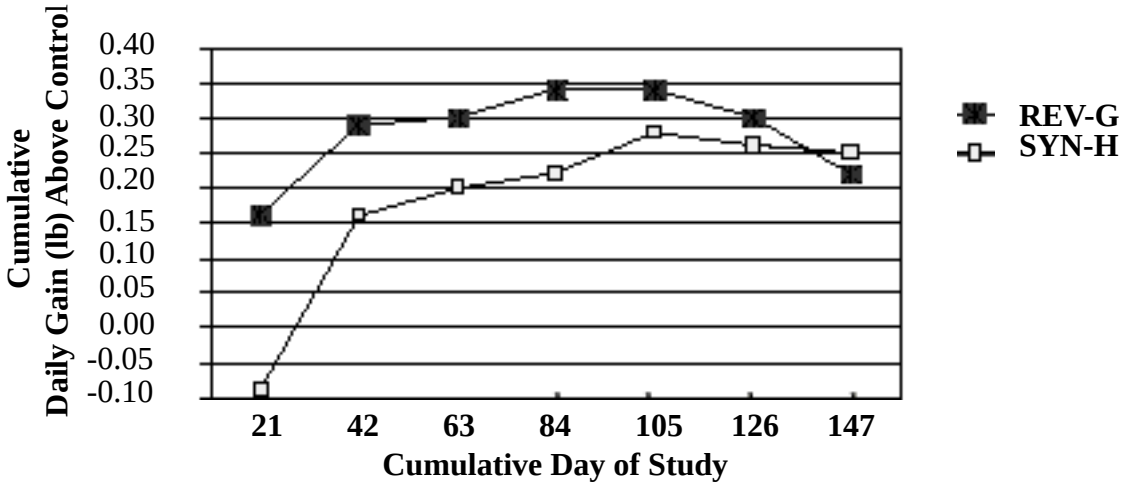
Figure 1 shows the accumulative growth responses of REV-G and SYN-H heifers relative to controls over the 147-day study. In contrast to earlier KSU studies where heifers responded rapidly to SYN-H and REV-G implantation, the implanted heifers in our study gained similarly (P>.05) to controls during the first 21 days. By day 42, the cumulative daily gains of both implanted groups were numerically greater than those of controls. From day 84 through the end of the study, cumulative daily gains of both implant groups were greater (P<.05) than those of controls. The lack of a significant gain response to the implants early in the study may have been related to intensive handling and blood sampling. Although the

amplitude of the growth response was higher for REV-G heifers, the gain response to SYN-H seemed to be sustained longer. These observations are consistent with previous KSU field trials.

Figure 2 shows the serum hormone concentrations of the heifers throughout the 147-day study. As expected, estradiol concentrations were similar among all treatments on day 0. But by day 2, estradiol levels were increased in both REV-G (P<.05) and SYN-H (P<.01) heifers. Serum estradiol declined rapidly in REV-G calves, and remained similar to the level in controls throughout the remainder of the study. Serum estradiol was higher in SYN-H heifers than in both control and REV-G heifers on days 7, 14, 42, and 105. The lack of a clear increase in serum estradiol in REV-G heifers likely reflects the lower estradiol concentration in that implant.

As expected, only the REV-G heifers contained measurable serum levels of trenbolone. All samples from NC and SYN-H heifers were below the detection limit of the assay (10.0 pg/mL). Trenbolone was elevated in REV-G heifers on days 2 (P<.001), 4 (P<.05), and 63 (P<.001). Thereafter, serum trenbolone levels were similar across the three treatments.

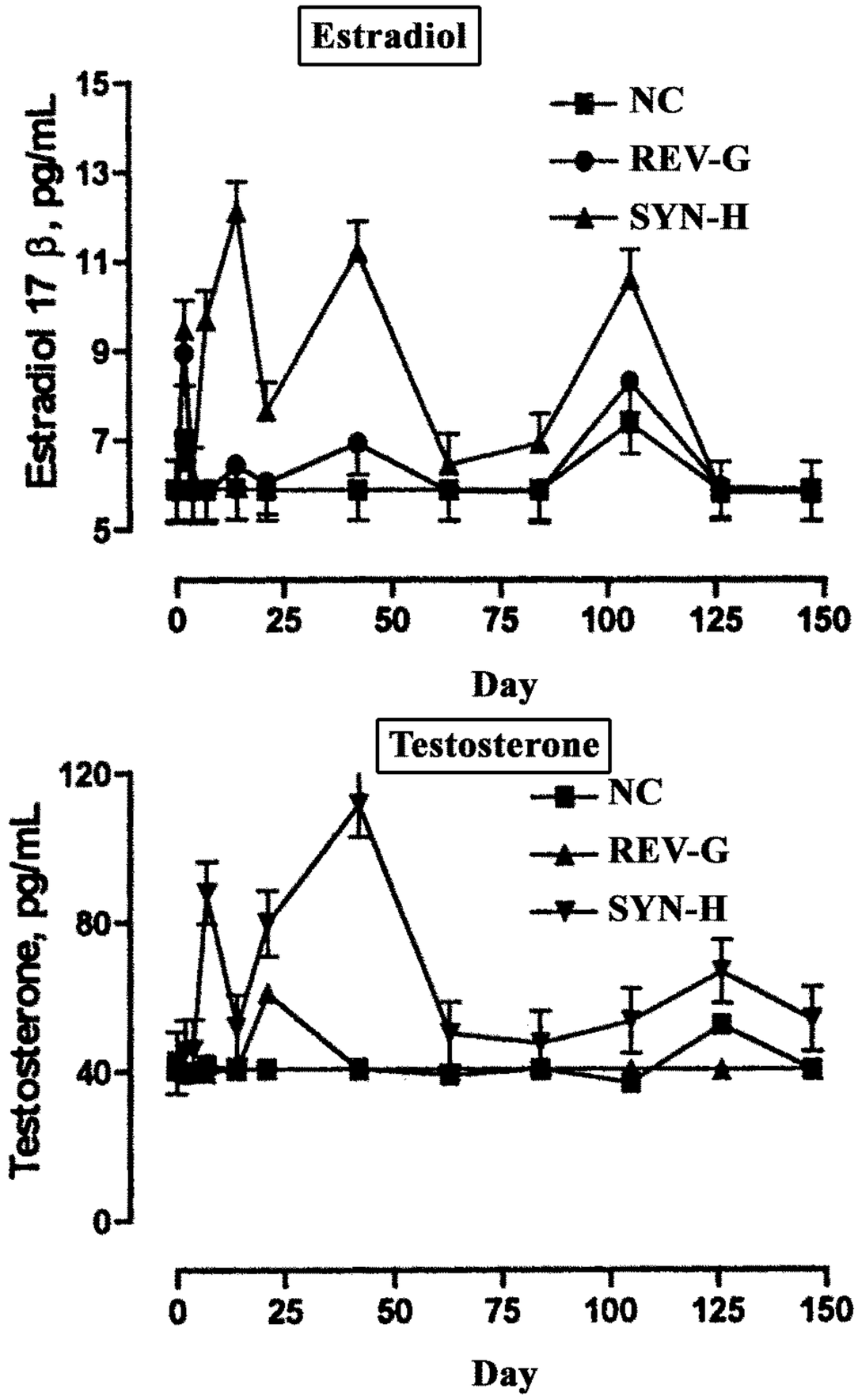
Averaged across the 147-day study, serum testosterone level was higher in SYN-H heifers (61.5+1.8 pg/mL) than in NC (41.2+6.9 pg/mL; P<.01) or REV-G (42.0+6.9 pg/mL; P<.01) calves. That was expected because only the SYN-H implant contained testosterone. Progesterone concentrations trended upward in all treatments as the study progressed, and this is reflected (P<.001) in a day of sampling effect. The most reasonable explanation is that, with increasing age, more heifers were becoming pubertal, and therefore exhibited luteal function and increased progesterone secretion. Averaged over all sampling days, progesterone was higher (P<.05) in NC heifers (1.3+.2 ng/mL) than in REV-G (.7+.2 ng/mL) or SYN-H (.7+.2 ng/mL) calves. That is diffi-cult to reconcile. However, the exogenous steroids may have decreased pituitary gonadotropin secretion, which, in turn, delayed puberty or at least resulted in reduced progesterone secretion.



a REV-G = Revalor-G; SYN-H = Synovex-H.

b Daily gain of implanted heifers significantly different from nonimplanted controls (P<.05).

Figure 1. Cumulative Growth Responses of Heifers to Growth Implants Relative to Nonimplanted Controls[a].



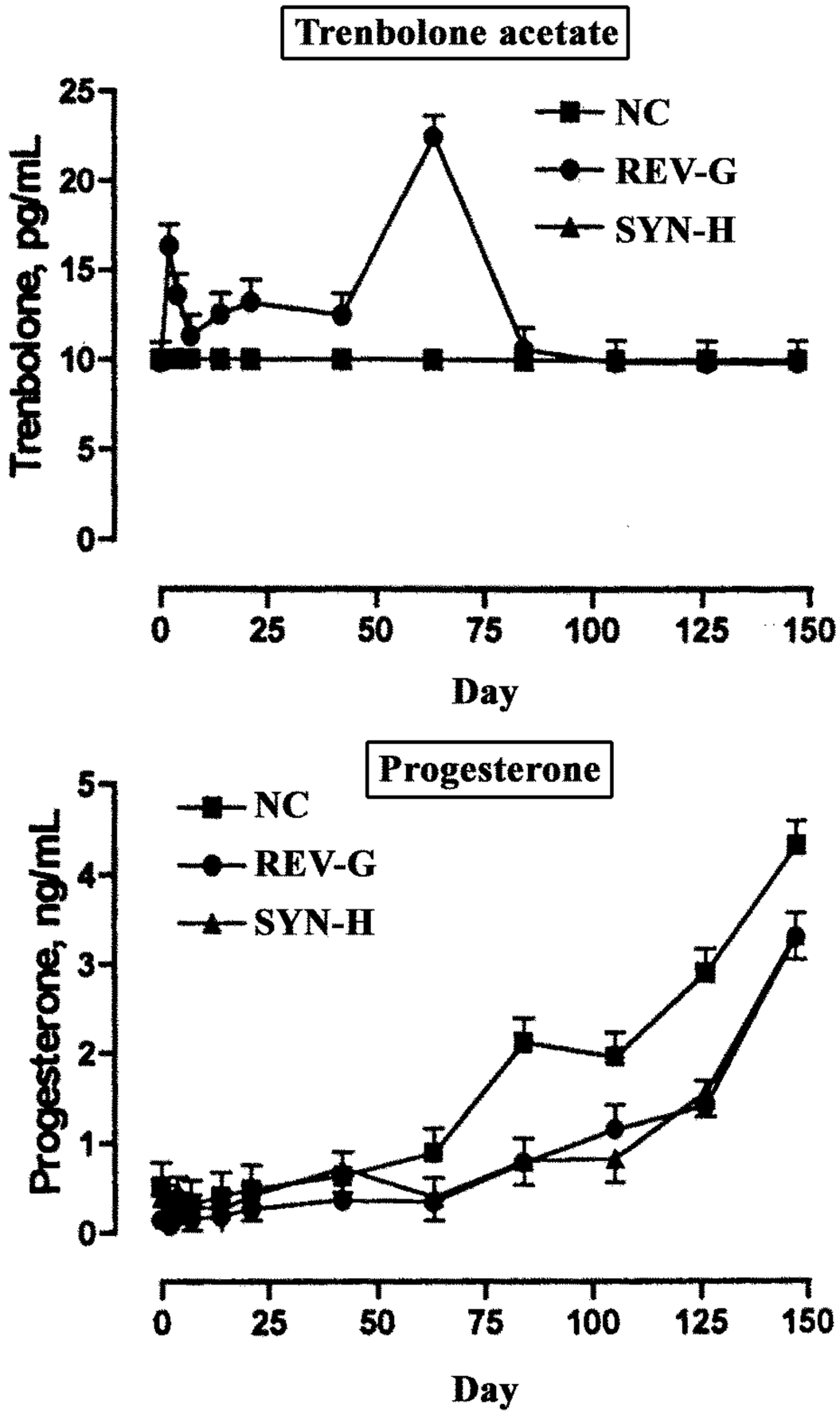


Figure 2. Serum Hormone Concentrations in Heifers Implanted with Revalor-G (REV-G) or Synovex-H (SYN-H) and in Nonimplanted Control (NC) Heifers over Time

MEASURING THE FINISHING PERFORMANCE OF STEERS AND HEIFERS

M. Langemeier[1], R. Jones[1], and G. Kuhl

Summary

This study examined improvements in the finishing performance of steers and heifers from 1990 to 1998 by measuring the rate of technological change. The rates of technological change were 0.58% per year for finishing steers and 1.01% per year for finishing heifers. The relatively higher rate for heifers indicates that technological change over the study period favored the performance of heifers.

(Key Words: Steer Finishing, Heifer Finishing, Technological Change.)

Introduction

The increase in production per unit of input for the cattle feeding industry has not kept up with that exhibited by the swine- and poultry-feeding industries over the last 15 to 30 years. This lack of growth in production per unit of input has impacted the relative prices among cattle, swine, and poultry and has contributed to changes in market shares. Given recent developments in the swine- and poultry-feeding industries, it is imperative that the cattle feeding industry continue to improve performance in the conversion of inputs to beef.

Several measures can be used to examine changes in the performance of finishing steers and heifers. For example, improvements in performance could be measured using growth rates in average daily gain; feed conversion; or the rate of technological change, which is commonly used to compare performance across industries. The rate of technological change represents the difference between output growth and input growth. A positive rate of technological change indicates that over time, the same level of output can be achieved with less input, or the same amount of input can produce more output. The rate of technological change can be used to measure the importance of changes in genetics, feeding systems, and management.

In order to gage the relative magnitude of future performance improvements, it is important to study past performance. Research that has examined improvements in cattle feeding performance over time is sparse. This study examines the improvements in the finishing performance of steers and heifers in Kansas from January 1990 to December 1998.

Experimental Procedures

The data in this study were obtained from monthly issues of *Focus on Feedlots*[2], a KSU newsletter that reports costs, performance data, and closeout data in the Kansas feedlot industry. Table 1 presents the summary statistics for feedlot gain, feed consumption, corn price, total feeding costs, average daily gain (ADG), and dry matter feed conversion efficiency (FCE) for steers and heifers during the study period. Total gain per head averaged 465 lb for steers and

[1]Department of Agricultural Economics.

[2]The authors acknowledge the generosity of the feedyard managers who provided data for the Focus on Feedlots newsletter.

409 lb for heifers. On average, steers had an ADG of 3.20 lb and an FCE of 6.45, whereas heifers had an ADG of 2.85 lb and an FCE of 6.66.

The rate of technological change was determined using regression analysis. Regression models were specified for steers, heifers, and the difference between steers and heifers. Gain per head represented the output from finishing and was used as the dependent variable for steers and heifers.

Independent variables for the steer and heifer regressions included feed consumed, a time trend, monthly dummy variables, and a dummy variable for closeouts from February 1993 to May 1993. The gain per head and feed variables were expressed in natural logarithms to facilitate computations of the rate of technological change and to allow for a nonlinear trend. The time trend was used to measure the monthly rate of technological change over the study period. To approximate the annual rate of technological change, the coefficient on the time trend variable was multiplied by 12. Monthly dummy variables were used to capture seasonality in performance. For example, if steers or heifers were finished in February, the February variable would have a value of one and the March through December variables would have a value of zero. Because January was used as the base month for comparisons, there was no variable for January. The performance for February through December thus was compared directly to January performance. A dummy variable for the February 1993 through May 1993 period was used to account for the unusually poor performance during these four closeout months resulting from a series of major snow storms. This dummy variable had a value of one if the closeout month for steers or heifers occurred during the February 1993 through May 1993 period and a value of zero otherwise.

Results and Discussion

Table 2 reports the regression values for steers, heifers, and the difference between steers and heifers. As expected, seasonality was quite pronounced, and the dummy vari-able for the early 1993 period was significant. Steer and heifer performance from the May to December closeouts was higher than performance from January. As evidenced by the significant coefficient on the early 1993 variable (2/93 to 5/93), that period had a large negative impact on performance. The regression results in the third column can be used to evaluate differences in seasonality between steers and heifers. Compared to heifer performance, steer performance tended to be higher for June, July, and August closeouts and lower in February.

The time trend was significant in each of the regressions. The regression that examines the difference between steers and heifers indicated that the rate of technological change was relatively higher for heifers than for steers during the study period. The annual rate of technological change can be found by multiplying the coefficient on the time trend variable by 12. The rates of technological change over the study period were 0.58% per year for finishing steers and 1.01% per year for finishing heifers. The cumulative rates over the entire study period were 5.3% for finishing steers and 9.4% for finishing heifers.

Even though technological change was significant over the study period, it was considerably lower than that experienced in U.S. agriculture as a whole. Relatively slow technological change in cattle finishing may have contributed to the deterioration in the competitive position of the beef industry during the 1990's. Research that directly compares technological change in the cattle, swine, and poultry industries is needed to address the relative competitiveness issue.

Table 1. Summary Statistics for Finishing Steers and Heifers

Variable	Unit	Mean	Standard Deviation
Steers			
Gain	lb/head	465.21	33.56
Feed	lb/head	2988.10	156.83
Corn price	$/bu	3.12	0.48
Total feeding costs	$/head	281.13	27.86
Average daily gain	lb/day	3.20	0.26
Feed conversion efficiency	lb feed/lb gain	6.45	0.45
Heifers			
Gain	lb/head	409.27	26.34
Feed	lb/head	2718.90	152.90
Corn price	$/bu	3.12	0.48
Total feeding costs	$/head	258.12	24.32
Average daily gain	lb/day	2.85	0.23
Feed conversion efficiency	lb feed/lb gain	6.66	0.46

Source: *Focus on Feedlots* newsletter, monthly issues from January 1990 to December 1998.
Note: Financial variables were converted to real 1998 dollars.

Table 2. Regression Analysis Examining Technological Changes for Finishing Steers and Heifers

Variable	Steers	Heifers	Difference
Intercept	-1.056785**	0.996367*	0.047894***
	(0.438195)	(0.517672)	(0.008337)
Feed consumed	0.880748***	0.583371***	0.895083***
	(0.060851)	(0.073189)	(0.043468)
Time	0.000485***	0.000843***	-0.000173***
	(0.000092)	(0.000106)	(0.000062)
February	-0.015129	0.003973	-0.016145**
	(0.013954)	(0.014840)	(0.008075)
March	-0.022245	0.001067	-0.011904
	(0.014061)	(0.015083)	(0.008075)
April	0.017246	0.027178*	0.007173
	(0.014221)	(0.015403)	(0.008083)
May	0.053396***	0.054597***	0.013034
	(0.014158)	(0.015233)	(0.008078)
June	0.066118***	0.051511***	0.025973***
	(0.013924)	(0.014970)	(0.008022)
July	0.071026***	0.056280***	0.022202***
	(0.014017)	(0.014836)	(0.008033)
August	0.067868***	0.045375** *	0.026803***
	(0.014065)	(0.014766)	(0.008100)
September	0.066755***	0.049666***	0.010346
	(0.013832)	(0.014808)	(0.008100)
October	0.063233***	0.055151***	-0.000996
	(0.013836)	(0.014882)	(0.008150)
November	0.043317***	0.038133**	-0.006662
	(0.013944)	(0.015015)	(0.008039)
December	0.026427*	0.032444**	-0.012527
	(0.013856)	(0.014826)	(0.008046)
2/93 to 5/93	-0.203049***	-0.174439***	-0.010479
	(0.015665)	(0.017154)	(0.009152)
Adjusted R^2	0.8471	0.7777	0.8839

Notes: Numbers in parentheses are standard errors. Single, double, and triple asterisks (*) denote significance at the 10%, 5%, and 1% levels, respectively.

IMPACTS OF CORN AND FED-CATTLE PRICES ON PRICE SLIDES FOR FEEDER CATTLE

K. C. Dhuyvetter[1] and T.C. Schroeder[1]

Summary

Several important determinants need to be considered when analyzing price slides (price-weight relationships) for feeder cattle. The two most economically important determinants of price-weight slides are expected fed-cattle price and corn price. Price-weight slides increase notably when corn prices decline (i.e., the premium for light-weight calves increases as feed prices decrease). Likewise, when expected fed-cattle prices increase, price-weight slides increase. Knowing this information can help producers who forward contract feeder cattle, backgrounders making decisions regarding feeding calves to various weights, and producers making feeder cattle purchase decisions.

(Key Words: Price Slides, Feeder Cattle Prices, Price Determinants.)

Introduction

Price determination and discovery for feeder cattle are complex, because many factors impact feeder cattle markets. Feeder cattle are inputs into a production process; therefore, feeder cattle demand is affected by all factors that affect future anticipated demand for fed cattle as well as expected cattle backgrounding and(or) feeding costs. Also, as feeder cattle weight varies, the relative importance of expected selling price and expected input costs changes. Thus, determinants of feeder cattle demand vary in importance over time as the cattle grow. A formidable task facing potential cattle buyers and sellers is how market prices are likely to change as the form of the product (i.e., cattle weight) and expected input and output prices change.

Our objective was to quantify how feeder cattle price changes as cattle weight, expected input costs, and expected selling prices change, and how these factors change in relative importance as feeder cattle weight varies. Results of this study are useful to cattle producers when making management decisions concerning alternative production strategies (e.g., creep feeding calves, rate of gain to pursue in backgrounding programs, length of grazing season) and timing of buy/sell decisions. Understanding how market conditions affect price slides (price-weight relationships) will allow producers to incorporate weight adjustments into price forecasts.

Experimental Procedures

Sale price, weight, number of head in sale lot, sex, and breed information were collected on individual sale lots of feeder cattle from the Winter Livestock Auction in Dodge City, Kansas from January 1987 through December 1996. The data included 46,123 individual lots with average weights of 300 to 900 lb representing five breed categories (English, mixed, Continental/ European, Longhorn, and Holstein). Slightly over half (55.5%) of the lots were steers, and the rest were heifers.

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[1]Department of Agricultural Economics. Appreciation is expressed to Marvin Fausett for supplying data necessary to complete this study.

In addition to the information on each individual lot of feeder cattle, weekly average futures prices for fed cattle and corn were collected to be used as proxies for expected fed-cattle price and expected corn price.

Summary statistics for feeder-cattle price and weight variables are given in Table 1. Average weight was 660 lb. Price averaged $80.64/cwt over the 10-year time period and ranged from a low of $40.10 to a high of $142.50 across weights and time. Weekly average corn price was $2.60/bu. (range, $1.52 to $4.38), and weekly average cattle futures price was $69.79/cwt (range, $54.25 to $78.00).

To quantify the price-weight relationship for feeder cattle while accounting for the major price determinants, feeder cattle price was regressed on weight, sex, live-cattle futures price, and corn futures price. Weight squared also was included to allow for nonlinear impacts of weight. Interaction terms between weight and each other variable were included.

Models including variables for breed, seasonality, profitability, and price variability also were estimated. Results with regards to the variables of interest here (fed cattle and corn prices) were similar, so the simpler model is presented to save space.

Results and Discussion

Regression results are reported in Table 2. The model explained 88.7% of the variability in feeder cattle prices. Every coefficient is statistically different from zero ($P<.05$), which is expected given the large number of observations. Because of the interaction and squared terms, the effects of each variable are difficult to decipher simply by examining the coefficients. Therefore, to enhance interpretation, graphical analysis is used to demonstrate the impacts of various price determinants.

Figure 1 shows the price-weight slide for feeder cattle as corn price varies from the mean of $2.60/bushel plus and minus two standard deviations and fed-cattle futures price is held steady at its mean. For lower corn prices, feeder cattle price increases more rapidly as feeder cattle weight decreases. This is as expected; when corn price is lower, lightweight feeder cattle are worth more relative to heavyweight cattle because cost of gain is low. For example, the price spread between 500 and 800 lb steers is almost $20/cwt when corn price is $1.68/bu but declines to just slightly over $8/cwt with a $3.52/bu corn price. An important implication is that price-weight slides should be adjusted for different corn prices.

Expected fed-cattle price also has a sizeable impact on the price-weight relationship (Figure 2). When the corn futures price is held at its mean, the price spread between 500 and 800 lb steers is about $19/cwt with a fed-cattle futures price (mean price plus a two standard deviations) of $79.37/cwt, whereas the spread is approximately $9/cwt with a fed-cattle futures price of $60.21/cwt (mean less two standard deviations). Price-weight slides clearly depend on both expected fed-cattle prices and corn prices.

Results here indicate that the relationship between feeder cattle prices and feeder cattle weights (i.e., price slides) vary as feed and fed cattle prices vary. Thus, it is important to account for current market conditions when estimating the impact that weight has on feeder cattle price.

Table 1. Summary Statistics of Feeder Cattle Sale Data and Futures Prices, January 1987 - December 1996 (46,123 head)

Variable	Mean	Std Dev	Minimum	Maximum
Price ($/cwt)	80.64	12.83	40.10	142.50
Weight (lbs.)	660	141	300	900
Corn futures price[a] ($/bu.)	2.60	0.46	1.52	4.38
Live cattle futures price[a] ($/cwt)	69.79	4.79	54.25	78.00

[a]Average of third, fourth, and fifth contracts out where the nearby contract is the first contract out.

Table 2. Regression Results (dependent variable is feeder cattle price, $/cwt)

Variable	Parameter Estimate	Standard Error	P-Value
Intercept	-45.5491	5.9043	0.0001
Live cattle futures (LC)	3.9149	0.0795	0.0001
Corn futures (CN)	-36.5803	0.9003	0.0001
Weight	0.0661	0.0199	0.0009
Weight squared	-3.8×10^{-5}	1.6×10^{-5}	0.0205
Heifer × weight	-0.0410	0.0004	0.0001
Heifer × weight squared	4.7×10^{-5}	5.6×10^{-7}	0.0001
LC × weight	-0.0048	0.0003	0.0001
LC × weight squared	2.4×10^{-6}	2.1×10^{-7}	0.0001
CN × weight	0.0621	0.0029	0.0001
CN × weight squared	-3.2×10^{-5}	2.3×10^{-6}	0.0001
R^2	88.7		

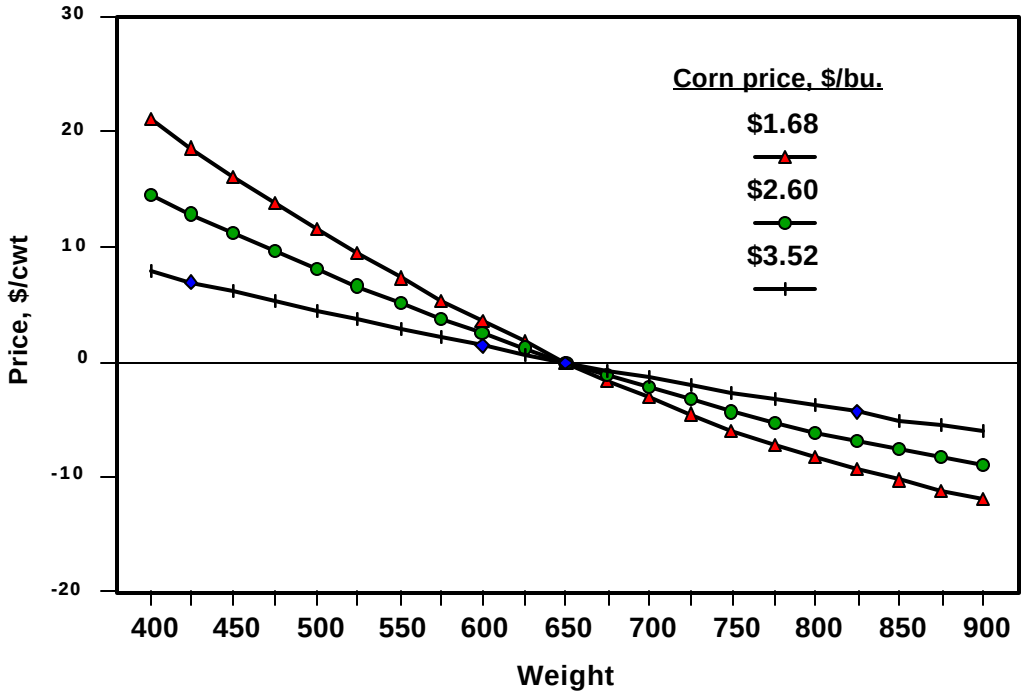

Figure 1. Impact of Corn Price on Feeder-Cattle Price Slide.

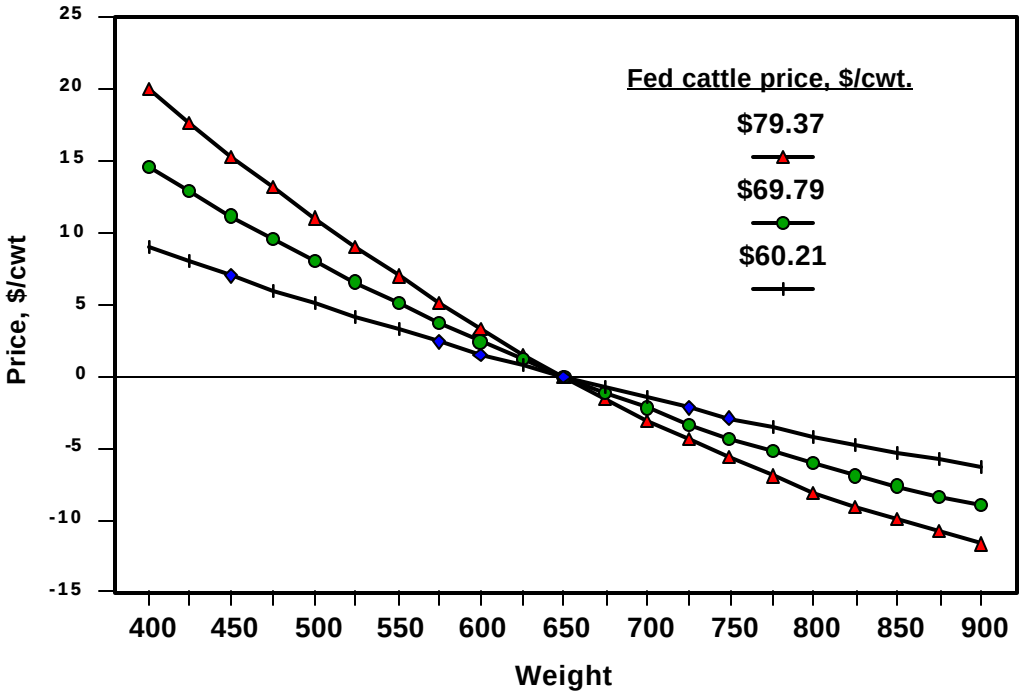

Figure 2. Impact of Fed-Cattle Price on Feeder-Cattle Price Slide.

ALTERNATIVES TO CASH PRICES IN FED-CATTLE PRICE DISCOVERY

T. C. Schroeder[1] and J. Mintert[1]

Summary

Price discovery in fed cattle markets is a significant concern as cash market volume declines and trade becomes more sporadic. Producers need to consider other sources of pricing information when negotiating cash trade and long-term marketing agreements. This study evaluated several alternative price sources for producers to consider. Live cattle futures and wholesale boxed-beef prices offer the most promise; however, both also have limitations associated with their use.

(Key Words: Cattle Price Discovery, Futures Markets, Wholesale Beef Prices.)

Introduction

What were once liquid, local, cash markets for fed cattle are being replaced with non-cash mechanisms including contracts, marketing agreements, alliances, and formula-pricing arrangements. As cash market volume declines, cash price data become less readily available, and the likelihood increases that publicly reported cash prices are not representative. If recent trends continue, USDA quotes of cash market prices for fed cattle could soon be of limited value. Consequently, producers need to consider other sources of market price information to use for price discovery and for base prices in marketing agreements and pricing formulas. This study reviewed and evaluated alternative market prices as sources of price discovery information.

Experimental Procedures

Kansas weekly prices for direct-trade fed cattle from January 1991 to July 1999 were compared with live cattle futures and wholesale boxed-beef prices. Relationships among these various markets were examined, and implications of using these alternative markets as price information sources are discussed.

Results and Discussion

Fed cattle pricing methods have changed considerably over the past decade, largely via formula prices. These formulas rely on some external reference price (such as USDA's Western KS direct cash price) as an adjustment mechanism when the market price fluctuates. However, as cash market volume declines, some market participants are considering new external reference prices, such as 1) average dressed or live prices from beef processing plants, 2) retail beef prices, 3) live-cattle futures prices, and 4) prices of wholesale boxed beef and by-products.

Average dressed or live prices from processing plants and retail beef prices are poor candidates for use as external reference prices, because they reflect varying quality levels over time, which can lead to perverse pricing results. Retail beef prices also are of limited value, because the relationship between retail and farm-level prices changes as processors and retailers add additional processing (e.g., trimming, cooking). Thus, formulas that rely on a retail-based, external,

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reference price may result in a farm-level price that does not represent actual farm value.

Live-cattle futures prices are appealing as an external reference. They typically have large volumes, reflect new information rapidly, and provide a viable source of price expectations. Future quotes are readily available, and futures are monitored closely to avoid manipulation. In addition, futures price-based formulas fix the basis level, which greatly reduces the risk of hedging.

Even with these advantages, concerns still exist regarding the use of a futures price as an external reference. First, futures prices have a 'time matching' problem. They represent specific delivery or expiration dates that do not necessarily match the cash market transaction date. Second, historical variability in basis (cash price minus futures price) needs to be accounted for. Finally, if a viable cash market for the underlying commodity does not exist, the viability of that futures contract itself may come into question.

The difference between the weekly Western Kansas fed-steer price and the nearby live-cattle futures price (nearby basis) is shown in Figure 1. The basis was quite variable, but had a statistically significant downward trend. The average Western Kansas fed-steer basis was $0.26/cwt during 1991 and 1995, but averaged $0.97/cwt below the nearby futures price from 1996 through mid-1999.

Exactly why Kansas fed-steer prices have declined relative to live cattle futures is not clear. One possibility is a change in the relative quality of cattle traded in the cash market. If higher quality cattle have moved away from the cash market trade toward marketing agreements and grade and yield pricing arrangements, then the relative decline in the cash market price may simply reflect a quality change.

The short-run implication for use of futures prices as external reference prices is clear. Formulas based on live-cattle basis levels from early in the decade would yield higher prices than formulas based on more recent basis levels. Thus, if live-cattle futures prices are to be used as an external reference, the formula needs to be adjusted periodically to account for changing basis.

Another possible external reference price is the value of wholesale boxed-beef cutout plus hide and offal. Wholesale prices are appealing because, conceptually, they represent the market supply and demand for all meat products whether they are going to retail, food service, or export markets, and as such, reflect the prices that meat processors are receiving for beef products.

Two factors make long-term use of wholesale prices as an external source of reference prices problematic. First, as in the fed cattle market, non-cash trade in the wholesale beef market is becoming commonplace. Consequently, USDA wholesale beef prices are based on a small percentage of all beef traded and may not represent the animal's true wholesale value. Second, as slaughter and processing costs change, the relationship between wholesale- and farm-level prices also changes.

During the period studied, values of boxed beef plus hide and offal ranged from less than $50 to more than $160 per head above live animal value. This variability in farm to wholesale beef prices is not necessarily a deterrent to using wholesale-based farm-level pricing when producers market cattle regularly; weekly "peaks" in the spread are offset by "troughs". However, it is more troublesome for producers marketing cattle infrequently.

More important than the week-to-week variability in the relationship between wholesale and live cattle values is the trend in this relationship. Figure 2 shows the ratio of the weekly values for Choice Western Kansas fed steers (1,000 lb. steer) versus the values for Choice boxed-beef cutout plus the hide and offal from January 1991 through July 1999. During the early 1990s, the fed steer value typically averaged 90 to 95% of the wholesale value. However, this ratio has trended downward and increased in variabil-

ity over time to the point where, during the 1996 1999 period, the live animal value generally ranged from 80 to 90% of the wholesale value.

The reason for this decline is not clear. It does not necessarily indicate that packer margins are increasing. Rather, as noted earlier, the cash fed-cattle market could be representing progressively lower quality cattle, as higher quality cattle get marketed using grids and marketing agreements. The key point is that using wholesale beef prices as external reference prices will result in lower fed-cattle prices today than would a similar formula just a few years ago. Additional research is needed to better explain this relationship.

Small- to medium-sized cattle producers may struggle in the current environment of price discovery. The daily fed-cattle market is characterized by spotty price quotes, small trade volume, few buyers and sellers, and concerns over the representativeness of publicly reported cash market prices. Thus producers may have difficulty negotiating prices that are reflective of market conditions. Producers in this predicament may want to consider developing formula pricing relationships with a processor. Negotiation of the formula, however, should not be taken lightly. In particular, settling for a formula based on plant averages is not recommended. In the long run, formulas using wholesale and (or) live-cattle futures prices as external reference prices appear to have promise.

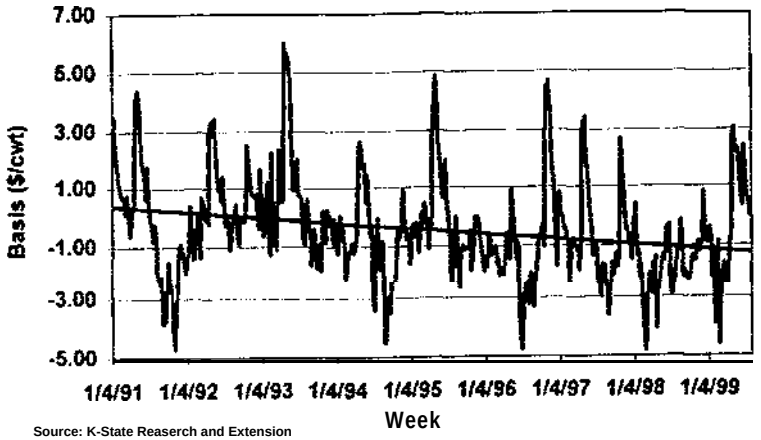


Figure 1. Weekly Choice Western Kansas Fed-Steer Basis (cash price minus nearby live cattle futures), 1991 through July 1999.

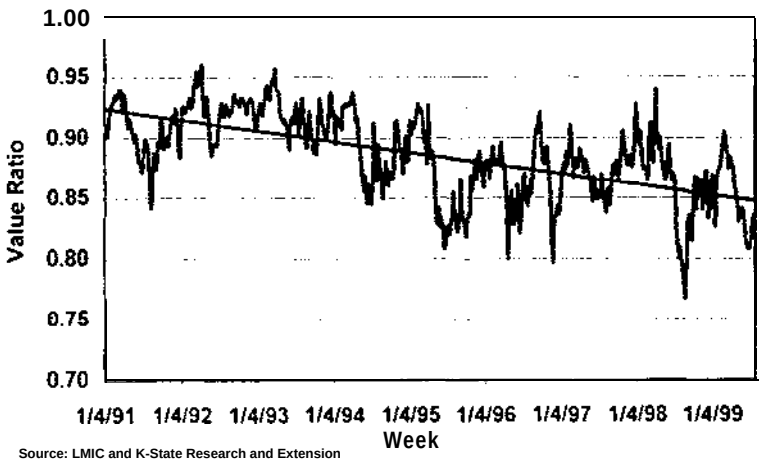


Figure 2. Ratio of Weekly Values for Western Kansas Fed Steers versus Boxed-Beef Cutout plus Hide and Offal per Head, 1991 through July 1999.

FACTORS INFLUENCING THE INITIATION OF ESTROUS CYCLES AND EXPRESSION OF ESTRUS IN BEEF COWS

J.S. Stevenson

Summary

Body condition, parity, and days postpartum at the onset of the breeding season determine the proportion of cows that initiated first postpartum ovarian activity and ovulated before the start of the breeding season. Hormonal treatments that included both GnRH and a source of progestin enhanced expression of estrus and led to greater pregnancy rates of suckled beef cows.

(Key Words: Suckled Cows, Body Condition, Parity, Days Postpartum, Estrus.)

Introduction

The factor most limiting early impregnation of suckled cows is the proportion of cows that are not cycling (anestrous) at the beginning of the breeding season. Continual presence of a suckling calf prolongs anestrus and delays the reinitiation of estrous cycles. Although insufficient energy and protein intake and insufficient body condition at calving are also limiting factors, temporary or permanent weaning of the calf usually initiates estrus within a few days. Younger cows nursing calves generally have more prolonged anestrus because of their additional growth requirement.

Nutrients are used by cows according to an established priority. The first priority is maintenance of essential body functions to preserve life. Once that maintenance requirement is met, remaining nutrients accommodate growth. Finally, lactation and the initiation of estrous cycles are supported. Because older cows have no growth requirement, nutrients are more likely to be available for milk synthesis and estrous cycle initiation. Because of this priority system, young, growing cows generally produce less milk and are anestrous longer after calving.

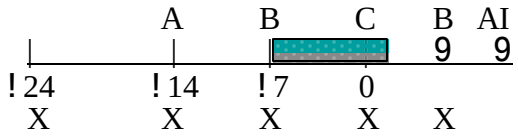
During the past 6 years, we have given more than 2,200 beef cows various hormonal treatments to synchronize estrus, ovulation, or both, in an attempt to achieve conception early in the breeding season and maximize the proportion of cows pregnant to genetically superior AI sires. As part of these studies, we measured the incidence of cyclicity at the beginning of the breeding season, both prior to hormonal treatments and in response to these treatments. This report summarizes the factors (body condition, parity, and days since calving) that influence the proportion of cows cycling before and in response to hormonal treatments.

Experimental Procedures

Five studies were conducted during the spring 1995-1999 breeding seasons on four private ranches and at the KSU Purebred Beef Unit.

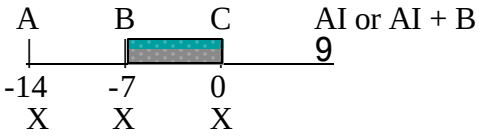
Study 1 (1994-1995). Purebred suckled cows (Simmental, Angus, and Hereford; n = 279) at KSU were used. Controls received two injections of Lutalyse® (25 mg of $PGF_{2\alpha}$; Pharmacia & Upjohn, Kalamazoo, MI) on days -14 and 0 and were inseminated at estrus, or in the absence of estrus, at 80 hr after the second Lutalyse. Treated cows received 25 mg of Lutalyse on days -14 and 0 plus 100 µg of Cystorelin® (GnRH; Merial Limited, Iselin, NJ) on day -7 and had a norgestomet (NORG) ear implant (Syncro-Mate-B®; Merial Limited, Iselin, NJ) in place for 8 days beginning on day -7. Treated

cows were inseminated at 72 hr after Lutalyse and 18 hr after a second injection of Cystorelin given at 54 hr after Lutalyse.



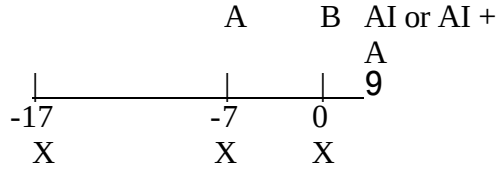
A = Lutalyse®
B = Cystorelin®
C = Lutalyse®
X = Blood sample
Norgestomet ear implant =

Study 2 (1996). Purebred suckled Angus, Gelbvieh, and Hereford cows and crossbred suckled cows (Simmental, Angus, and Hereford) (n = 890) on three private ranches were used. Control cows received two injections of Lutalyse on days !14 and 0. A second group of cows received Cystorelin on day !7 and Lutalyse on day 0 (Select Synch). Select Synch + NORG cows also had a norgestomet implant in place for 7 days beginning on day !7. Cows were inseminated after detected estrus. In addition, 164 purebred suckled cows received the Select Synch + NORG treatment at KSU. Cows were either inseminated after detected estrus (one-half) or at 48 hr after PGF_{2a} and given 100 *u*g of Cystorelin at the time of AI.



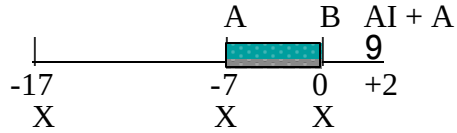
A = Lutalyse®
B = Cystorelin®
C = Lutalyse®
X = Blood sample
Norgestomet ear implant =

Study 3 (1997). Crossbred suckled cows (n = 406) (Simmental, Angus, and Hereford crosses) on two private ranches, plus 158 purebred Simmental, Angus, and Hereford suckled cows at KSU were used. Cows were treated with 100 *u*g of Cystorelin on day !7 and Lutalyse on day 0. They were inseminated after detected estrus, or in the absence of estrus, at 54 hr after Lutalyse and given 100 *u*g of Cystorelin at the time of AI.



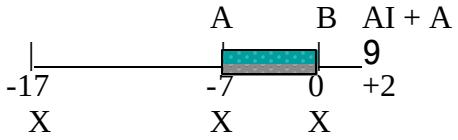
A = Cystorelin®
B = Lutalyse®
X = Blood sample

Study 4 (1998). Purebred Angus, Simmental, and Hereford cows (n = 187) at KSU were used. All cows received 100 *u*g of Cystorelin of day !7 and 25 mg of Lutalyse on day 0. Half of the cows also received an intravaginal progesterone insert (CIDR-B, InterAg, Hamilton, NZ) on day !7, which was removed on day 0. All were inseminated at 48 hr after Lutalyse and given 100 *u*g of Cystorelin at the time of AI.



A= Cystorelin®
B= Lutalyse®
X = Blood sample
CIDR® insert =

Study 5 (1999). Purebred Angus, Simmental, and Hereford cows (n = 187) at KSU were used. All cows received 100 *u*g of Cystorelin on day !7 and 25 mg of Lutalyse on day 0. Half also received an ear implant containing 6 mg of norgestomet on day !7. It was removed on day 0. All cows were inseminated 48 hr after Lutalyse and given 100 *u*g of Cystorelin at the time of AI.



A= Cystorelin®
B= Lutalyse®
X = Blood sample
Norgestomet implant =

Blood samples were collected prior to hormonal treatments to determine if cows had a functional corpus luteum. At least two blood samples were collected between 7 and 11 days before hormone administration and just prior to each hormone injection. Progesterone was measured by radioimmunoassay. If either or both samples contained one or more ng of progesterone per ml, then the cows were assumed to have ovulated and be cycling. If neither sample contained elevated progesterone, then the cow was anestrous. Further blood samples allowed us to determine if hormonal treatments induced ovulation in previously anestrous cows.

Body condition scores (1 = thin, 9 = fat) were assigned to cows on the first day of the breeding season, and days since calving were calculated for each cow.

The data were treated by analyses of variance to determine the effects of body condition score, parity, and days postpartum at the beginning of the breeding season on cyclicity. Further, the effects of various hormone treatments on the detection and expression of estrus were determined. In all analyses, herd and year were absorbed into the model.

Results and Discussion

Cyclicity

Body condition, parity, and days postpartum significantly affected the percentage of cows that were cycling before hormonal treatments and the beginning of the breeding season. Figure 1 illustrates the effect of body condition score. As body condition increased the percentage of cows cycling increased (P<.001) in a linear fashion. For every unit increase in body condition (range of 1 to 7), percentage of cows cycling increased (P<.01) by 18 ± 2%.

The literature indicates that beef cows should calve with a body condition score of at least 5 to prevent prolonged anestrus after calving. Cows may gain or lose body condition between calving and the beginning of the breeding season, depending on nutritional conditions, early grass growth, and supplementation. Clearly, body condition scores are predictive of cycling activity.

Percentage cycling was less (P<.001) for first-calf 2-year-olds than that for older cows even though the 2-year-olds calved 2 to 3 weeks earlier (Figure 2). The extra nutrient demand for growth clearly limits the proportion of 2-year-olds cycling at the beginning of the breeding season.

Estrus status also was influenced by days since calving (Figure 3). Percentage of cycling cows increased (P<.001) linearly before reaching a peak by 70 days postpartum. For every 10-day interval since calving (from <50 to 70 days), the percentage of cows cycling increased (P<.01) by 7.5 ± .7%. Thus, early calving is critical, because it allows more cows to be cycling by the start of the breeding season.

Estrus Expression

The percentage of cows expressing estrus during the first week of the breeding season is illustrated in Figure 4. A greater (P<.001) proportion of cycling cows than anestrous cows (70 vs. 40%) showed behavioral estrus early in the breeding season. However, an impressive proportion of anestrous cows was induced to show estrus by estrus-synchronization hormones.

The most effective hormonal treatments are those that include both Cystorelin and a progestin (Select Synch + NORG), compared to Cystorelin alone or injections of Lutalyse. Lutalyse is incapable of inducing estrus in noncycling cows, whereas norgestomet, Cystorelin, or both successfully induce cycling activity in suckled cows.

The percentage distribution of cows in estrus after treatment was influenced by a treatmentx cycling status interaction (P<.01; Figures 5 and 6).

The two treatments that included Cystorelin had similar distributions of estrus for cycling cows, with a peak percentage occurring between 49 and 60 hr. Estrus in the 2xPGF control occurred across a broad 144-hr period and lacked a defined peak.

The distribution of estrus among noncycling cows differed (P<.01) among treatments. The Select Synch cows were detected in estrus earlier than cows in the other treatments. A distinct peak in estrus of the Select Synch + NORG cows occurred between 37 and 48 hr, whereas estrus in the 2xPGF controls was distributed more broadly across the 144-hr period. The Select Synch + NORG treatment induced both the earliest and tightest synchrony of estrus. In that treatment, 50.5% showed estrus between 25 and 48 h after the PG_{F2a} injection, compared to 32.4% in the Select

Average interval from Lutalyse injection to estrus was affected by treatment (P<.01); location (P<.01); and cycling status at the beginning of the breeding season (anestrus vs. cycling; 54 ± 3 vs. 68 ± 3 hr; P<.001). Intervals to estrus for treatments that included Cystorelin + NORG (55 ± 4 hr) or Cystorelin alone (58 ± 4 hr) were similar but shorter (P<.05) than those in the 2xPGF controls (71 ± 5 hr). Body condition had no effect on interval to estrus, but for every 10-day increase in days between calving and the start of the breeding season (range of 22 to 120 days), a 2.2 ± 1 hr decrease (P=.05) occurred in the interval from Lutalyse to estrus.

Having more cycling cows at the beginning of the breeding season will maximize the proportion of cows that conceive to AI sires. More cows calving early during each successive calving season will enhance AI pregnancy rates, because more cows will be cycling before the breeding season begins. In addition, winter supplementation programs must maintain cows in body condition sufficient for cycling.

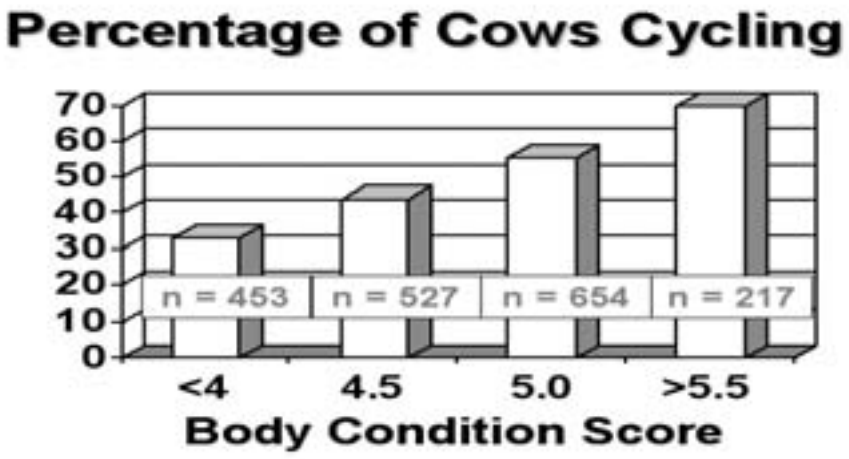


Figure 1. Effect of Body Condition Score on Percentage of Cows Cycling.

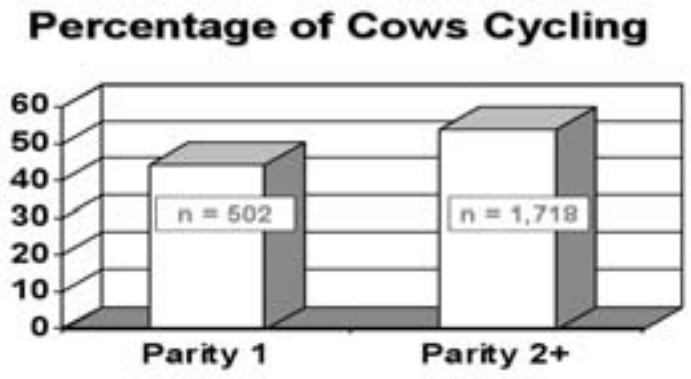


Figure 2. Effect of Parity on Percentage of Cows Cycling.

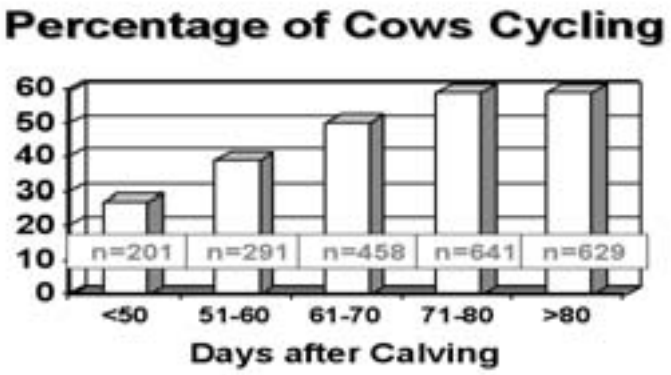


Figure 3. Effect of Days since Calving on Percentage of Cows Cycling.

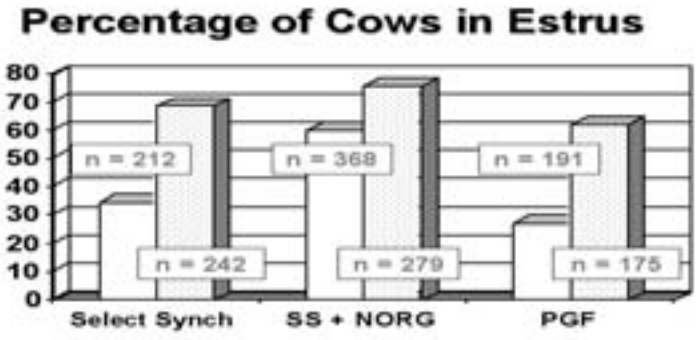


Figure 4. Effect of Hormonal Treatments on Percentage of Cows in Estrus during First Week of Breeding Season. (Open bars = anestrous; shaded bars = cycling.)

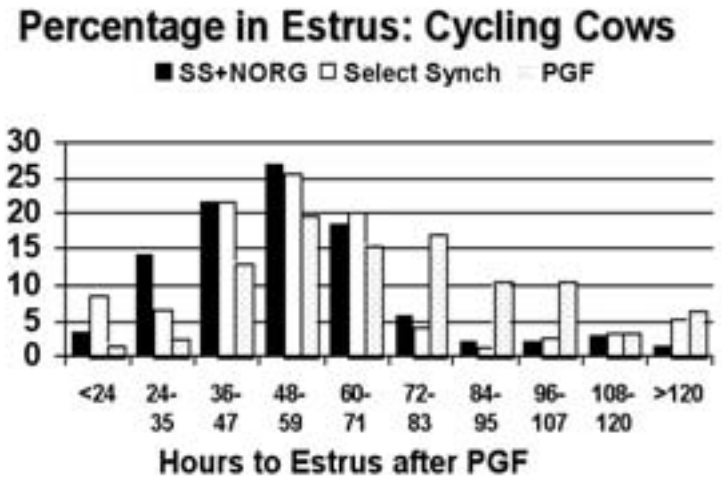


Figure 5. Effect of Hormonal Treatments on Percentage of Cycling Cows in Estrus.

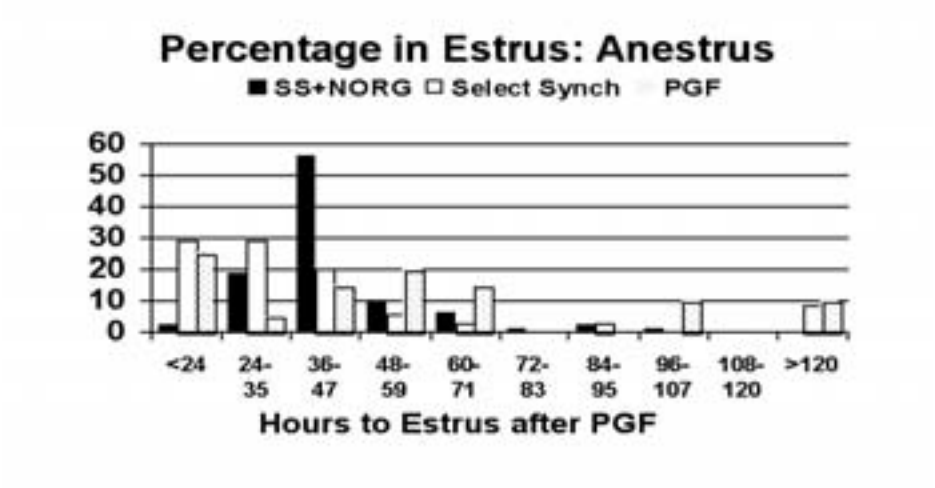


Figure 6. Effect of Hormonal Treatment on Percentage of Anestrous Cows in Estrus.

USE OF GNRH TO INCREASE THE PRECISION OF ESTRUS AND AUGMENT TIMED INSEMINATION IN HEIFERS TREATED WITH MELENGESTEROL ACETATE AND PGF$_{2\alpha}$[1]

S. K. Johnson[2], B. Broweleit, J. E. Huston[3], D. E. Grum[2], and M. L. Day[2]

Summary

We examined the potential of adding gonadotropin-releasing hormone (GnRH) to a synchrony system based on melengestrol acetate-prostaglandin F$_{2\alpha}$ (MGA-PGF$_{2\alpha}$) to increase the precision of synchronized estrus and augment timed artificial insemination (AI). Yearling heifers were fed MGA daily for 14 days. Nineteen days after the last feeding of MGA, all heifers were given PGF$_{2\alpha}$ (day 0). Heifers receiving no further treatment served as the untreated controls. In the second treatment, heifers also received an injection of GnRH on day –7. Both groups of heifers were artificially inseminated 12 hours after detected estrus. Heifers in the third treatment received GnRH on day –7 and day 2 and were inseminated (timed AI) at the time of the second GnRH injection. In comparison to a MGA-PGF$_{2\alpha}$ synchronization system, addition of GnRH on day –7 did not improve the synchrony of estrus. Adding two injections of GnRH (day –7 and day 2) facilitated timed AI. However, pregnancy rate for timed AI was lower than pregnancy rate for AI 12 hours after detection of estrus.

(Key Words: AI, Estrus Synchronization, Timed AI, GnRH, MGA, Heifers.)

Introduction

The MGA-PGF$_{2\alpha}$ synchronization system has been highly effective for facilitating the use of AI in heifers. Increasing the interval from the last feeding of MGA to the injection of PGF$_{2\alpha}$ from 17 days to 19 days seems to improve the synchrony of estrus (1998 Cattlemen's Day, pg. 31). Various permutations of timed AI and double insemination have been tried with the MGA-PGF$_{2\alpha}$ system. However, without controlling the timing of ovulation, results are variable. University of Missouri researchers found that an injection of GnRH prior to PGF$_{2\alpha}$ in a MGA- PGF$_{2\alpha}$ system, concentrated estrus during the synchrony period. The hypothesis for this study was that an injection of GnRH 1 week before PGF$_{2\alpha}$ in the MGA-PGF$_{2\alpha}$ system might synchronize follicle growth sufficiently to allow for timed AI.

Experimental Procedures

Yearling heifers from four herds (n=709) were used in the study. Herd A included 439 head of black and black baldy heifers; Herd B, 100 head of Angus cross, Angus×South Devon, and Angus× Limousin heifers; Herd C, 83 head of Angus and Angus × Simmental heifers; and Herd D, 87 head of Angus and Angus × Simmental heifers. All heifers were fed MGA (.5mg/head) daily for 14 days (days –32 to day –19 of the experiment). Nineteen days after the last feeding of MGA, all heifers were given 25 mg of PGF$_{2\alpha}$ (Lutalyse®; day 0). Heifers receiving no further treatment served as the untreated controls (control, n=253) and were inseminated artificially 12 hours after detection of estrus. In the second treatment, heifers

[1]We acknowledge the cooperation and participation of the KSU Agricultural Research Center, Hays, KS; Losey Bros., Agra, KS; and Shugert Farms, Lore City, OH.

[2]Northwest Area Extension Office, Colby.
[3]Ohio State University, Columbus, OH.

received an injection of GnRH (Cystorelin®;100mg) on day –7 (GnRH, n=260) and were inseminated artificially 12 hours after detected estrus. Heifers in the third treatment received GnRH on day –7 and day 2 (2xGnRH, n=196) and were inseminated at the time of the second GnRH injection (timed AI). Heifers in the 2xGnRH treatment that were detected in estrus early (before day 1.5) were bred 12 hours after detection. For purposes of data summary, we defined the synchrony period as days 0 to 7 after $PGF_{2\alpha}$.

The length of the total AI period varied with location. Heifers were exposed to bulls after AI for a total breeding season of approximately 60 days. Pregnancy diagnosis (ultrasound) occurred between 35 and 70 days after $PGF_{2\alpha}$. At all locations, heifers not diagnosed as pregnant at the first ultrasound, were re-evaluated 30 days or more after bulls were removed.

Results and Discussion

The onsets of estrus for heifers in the control and GnRH treatments for Herds A and B are shown in Figure 1. For both groups, the most heifers were detected in heat between 49 and 60 hours after $PGF_{2\alpha}$. Proportion of heifers exhibiting estrus from days 0 to 7 after $PGF_{2\alpha}$ (83.4 and 86.5%) and the average day of insemination during the synchrony period (days 3.0 ±.09 and 2.8 ±.08) did not differ between the control and GnRH treatments, respectively. In the 2xGnRH group, 18 of 196 (9.2%) heifers were detected in heat before day 1.5 and were bred 12 hours after detection of estrus. Timed insemination was performed on the remaining 178 heifers. Conception rate for this group was 72.2% (13/18). In Herds A, C, and D, heifers in the 2xGnRH group were observed for estrus after the timed AI. In Herd A, 23/107 (21.5%) heifers exhibited heat after the timed breeding between days 5-8. These heifers were bred 12 hours after detection of estrus, but the assumption was made that they did not conceive to the timed AI. Conception rate for 2xGnRH heifers that were bred between days 5 and 8 was 91.3%. In Herds C and D, no heifers were observed in heat during this time period.

Conception rates during the synchrony period for control (160/211; 75.8%) and GnRH (160/225; 71.1%) treatments did not differ and were greater ($P<.05$) than the conception rate following timed AI in the 2xGnRH treatment (83/178; 46.6%). Similarly, pregnancy rate during the synchrony period did not differ for the control and GnRH treatments (63.2 and 61.5%, respectively) but was greater ($P < .05$) than the pregnancy rate in the 2xGnRH treatment when only pregnancies resulting from timed AI were considered (83/196; 42.3%). If pregnancies in the 2xGnRH group that resulted from AI 12 hours after estrus, either before (13/18) the timed AI period or to a second AI after timed AI (21/23), are included, the pregnancy rate during the synchrony period in this treatment was 59.7%. Thus, a combination of timed AI and some heat detection resulted in a pregnancy rate not different from that of the control and GnRH treatments. Although some time was still spent on heat detection in this case, time spent sorting and resulting stress on the heifers were reduced. This time savings would be most relevant to producers synchronizing large groups of heifers and must be weighed against the cost of GnRH. Pregnancy rates for the entire breeding season did not differ among treatments.

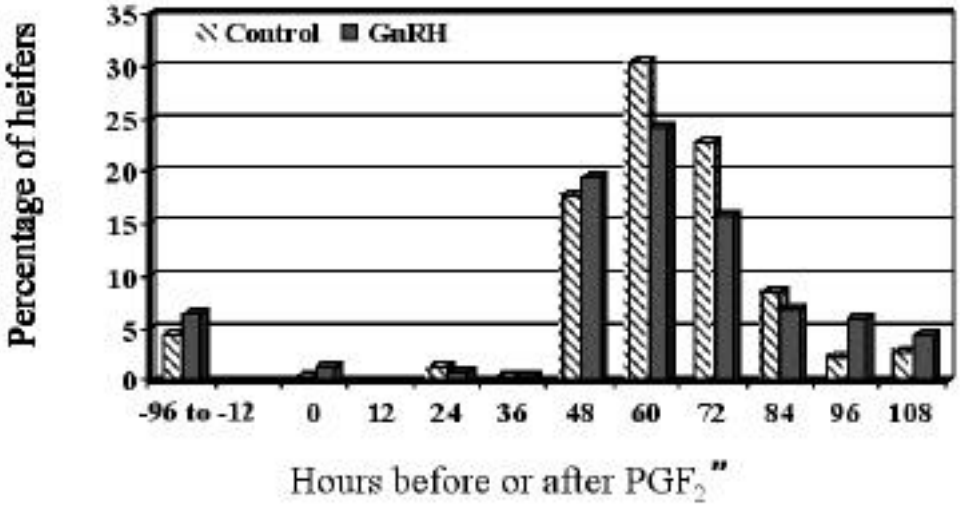
Table 1. Pregnancy Rate during the Synchrony Period and Breeding Season

Table 1. Pregnancy Rate during the Synchrony Period and Breeding Season

	Treatment		
Variable	Control	GnRH	2xGnRH
No. of heifers	253	260	196
Pregnancy rate (%)			
Days 0 - 7	63.2 [a]	61.5 [a]	42.3 [b*]
Breeding season	92.1	90.8	89.3

[a,b]Means with different superscripts differ (P<.05).
*Timed AI only.

Figure 1. Onset of Estrus for Heifers in Control and GnRH Treatments, Herds A and B combined.



SUPPLEMENTAL PROGESTIN INCREASES PREGNANCY RATES IN SUCKLED BEEF COWS[1]

J. S. Stevenson, G. C. Lamb, D. M. Grieger, J. A. Cartmill, B. A. Hensley, S. E. El-Zarkouny, and T. J. Marple

Summary

In two experiments, combining a source of progestin with the ovulation synchronization protocol using gonadotropin-releasing hormone plus prostaglandin $F_{2\alpha}$ (GnRH + $PGF_{2\alpha}$) tended to increase or statistically increase pregnancy rates in suckled cows compared to GnRH + $PGF_{2\alpha}$ alone. These improvements were accomplished without any detected estrus when cows were inseminated and received a second injection of GnRH at 48 hr after $PGF_{2\alpha}$.

(Key Words: Cows, AI, Estrus-Ovulation Synchronization, GnRH, $PGF_{2\alpha}$,Progestin.)

Introduction

Recent studies have identified the effectiveness of using GnRH + $PGF_{2\alpha}$ to synchronize estrus and ovulation in beef cattle (1998 Cattlemen's Day, pp 34-36). This protocol (known as Select Synch) requires an injection of GnRH 7 days before $PGF_{2\alpha}$ is given on the first day of the breeding season. Cows then are observed for estrus and inseminated. This protocol requires three separate trips through the working chute (two for hormone injections and one for AI). In other studies, pregnancy rates (number of pregnant cows/number of cows treated) have exceeded 50%.

The Select Synch protocol was refined further to allow for one fixed-time breeding of beef cows with only three trips through the working chute. Artificial insemination at 48 hr after $PGF_{2\alpha}$ was combined with a second injection of GnRH to induce ovulation; thus, it is referred to as Cosynch. Cosynch studies conducted in Colorado have consistently produced good pregnancy rates (approximately 50%), whereas our results in Kansas field trials were not quite as good (1999 Cattlemen's Day, pg. 61-64). We believe part of the difference is related to the better body condition of their cows. In addition, about 10% of the cows treated with GnRH + $PGF_{2\alpha}$ are observed in heat 1 or 2 days before the $PGF_{2\alpha}$ is administered or 6 to 7 days after the first GnRH injection. To prevent those cows from showing heat prematurely in our studies, we applied either an intravaginal progesterone insert or an implant containing a synthetic progestin (norgestomet; Syncro-Mate-B ear implants) during the 7-day interim between injections.

Our objective was to determine if adding progestin to the Cosynch protocol would enhance pregnancy rates.

Experimental Procedures

In 1998, purebred Simmental, Angus, and Hereford cows were assigned randomly to each of two treatments (Figure 1): 1) cows received (i.m.) 100 µg of GnRH (Fertagyl®; Intervet Inc. Millsboro, DE) followed in 7 days with 25 mg of $PGF_{2\alpha}$ (Lutalyse®; Pharmacia & Upjohn, Kalamazoo, MI), followed by a second injection of Fertagyl and one fixed time insemination (Cosynch) or 2) Cosynch plus one intravaginal progesterone insert (CIDR-B, InterAg, Hamilton, NZ) containing 1.9 g of progesterone during the 7 days between the first injection of Fertagyl and Lutalyse (Cosynch + CIDR).

[1]We acknowledge the assistance of student workers at the KSU Purebred Beef Unit.

Blood samples were collected 10 days before the first Fertagyl injection and at the time of each hormonal injection for progesterone assay. Pregnancy was diagnosed by trans-rectal ultrasound 35 days after the fixed-time insemination.

In 1999, Purebred Simmental, Angus, and Hereford cows were assigned randomly to each of two treatments (Figure 1): 1) cows received (i.m.) 100 µg of GnRH (Cystorelin; Merial Limited, Iselin, NJ), followed in 7 days with 25 mg of $PGF_{2\alpha}$ (Lutalyse), followed in 48 h by a second injection of Cystorelin and one fixed time insemination (Cosynch) or 2) Cosynch plus one 6-mg implant of norgestomet (Syncro-Mate-B ear implants only, Merial, Iselin, NJ) in place during the 7 days between the first injection of Cystorelin and Lutalyse (Cosynch + NORG). Blood samples for progesterone assay were collected 10 days before the first Cystorelin injection and prior to each hormonal injection. Pregnancy was diagnosed by transrectal ultrasound 35 days after the fixed-time insemination.

During 1998, blood serum samples were collected at least 1 hr after CIDR removal to allow progesterone released by the CIDR insert to clear from blood. Samples were assayed for progesterone to determine if cows were cycling or anestrus at the beginning of the breeding season.

Results and Discussion

Results of both experiments are summarized in Table 1. Based on serum progesterone levels, 78% of the cows in 1998 had ovulated at least once prior to the onset of treatments. Of those cows that were still anestrus on day -7, more ($P<0.05$) Cosynch than Cosynch + CIDR cows had high progesterone (≥1 ng/mL) on day 0 (CIDR removal and $PGF_{2\alpha}$ injection). More than 94% of the cows in both treatments had low progesterone prior to the timed insemination. Pregnancy rates tended ($P=0.09$) to be greater in all three breeds of cows receiving the CIDR inserts.

Based on changes in blood progesterone, about 60% of the cows in 1999 had ovulated at least once prior to the onset of treatments. As in 1998, of those cows that were still anestrus on day -7, more ($P<0.05$) Cosynch than Cosynch + NORG cows had high progesterone (≥1 ng/mL) on day 0 (norgestomet implant removal and $PGF_{2\alpha}$ injection). More than 94% of the cows in both treatments had low progesterone prior to the timed insemination. Pregnancy rates were increased ($P<0.01$) by the norgestomet implant even though cycling rates were less than those observed in 1998. Again, pregnancy rates were consistently better in all three breeds of cows.

Our results during 2 years indicate the need for progestin as part of a GnRH + $PGF_{2\alpha}$ ovulation synchronization protocol for suckled cows. Progestin combined with GnRH increased the proportion of cows detected in estrus in earlier experiments and usually increased pregnancy rates whether cows were inseminated after detected estrus or by appointment at 48 to 54 hr after $PGF_{2\alpha}$. In those studies, a second GnRH injection was administered at the time of the appointment insemination.

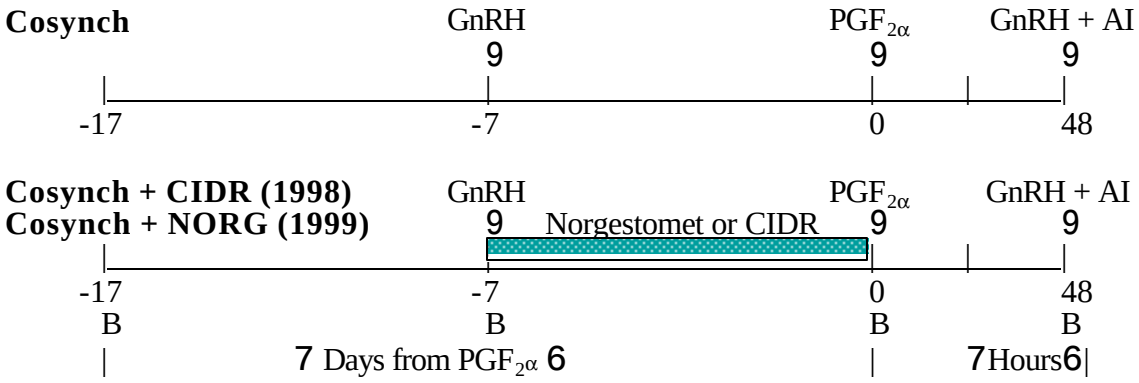


Figure 1. Protocols for Cosynch and Cosynch + NORG (1998) or Cosynch +CIDR (1999; B = blood collection for progesterone analyses; NORG = norgestomet; CIDR = progesterone-impregnated intravaginal insert).

Table 1. Comparison of Cosynch vs. Cosynch + Norgestomet or Cosynch + CIDR in Suckled Beef Cows

	Treatments			
	1998		1999	
Item	Cosynch	Cosynch + CIDR	Cosynch	Cosynch + NORG
No. of cows	92	95	91	92
Cycling by day -7, %	77.0	78.9	60.4	58.7
High progesterone on day 0, %	75.0	59.0[a]	73.6	47.8[a]
Low progesterone at +48 hr, %	94.6	98.9	98.9	94.6
Body condition score on day 0	-	-	4.8	4.6
Average days postpartum on day 0 (range)	71 (26-108)	70 (29-108)	76 (37-103)	78 (37-106)
Pregnancy rates, %	51.1	66.3[a]	30.7	51.1[b]
Breed				
Angus	58.8 (51)	62.2 (53)	37.0 (54)	56.6 (53)
Hereford	30.4 (23)	70.8 (24)	18.7 (16)	31.2 (16)
Simmental	55.6 (18)	72.2 (18)	23.8 (21)	52.1 (23)

[a]Different (P=0.05) from Cosynch within year.

[b]Different (P<0.09) from Cosynch within year.

THIAMIN AND RIBOFLAVIN RETENTION IN GROUND BEEF PATTIES PASTEURIZED BY ELECTRON BEAM

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Summary

This research focused on the effects of an electron beam irradiation treatment with the Repetitive High Energy Pulsed Power (PHEPP) accelerator at Sandia National Laboratories. Test variables included irradiation/storage temperatures (30 or 0°F), packaging environments (aerobic or nitrogen-flushed), and irradiation dose (0, 1.5, or 3.0 kGy). Ground beef patties formulated to a target fat level of 20% were packaged in barrier film under nitrogen (ca = 400 ppm residual oxygen) or sealed in aerobic packages (no vacuum), stored, and irradiated chilled or frozen. Thiamin and riboflavin levels were not affected (P>.05) by irradiation dose. Thiamin content of irradiated patties was greater for frozen vs. chilled and for nitrogen-packaged vs. aerobically packaged product. Riboflavin content was greater in frozen patties that were nitrogen packaged. Electron beam pasteurization by this method did not affect thiamin or riboflavin concentration of treated ground beef patties.

(Key Words: Ground Beef, Electron Beam, Thiamin, Riboflavin.)

Introduction

Ground beef is popular, economical, and widely used. Publicity from foodborne disease outbreaks involving meat products has increased consumer awareness of food contamination with pathogens, especially *Escherichia coli* O157:H7, *Salmonella*, and *Listeria*. Irradiation is a promising method to ensure meat safety; however, concerns have been raised about its possible effect on nutrients, especially thiamin and riboflavin.

Experimental Procedures

Beef knuckles (IMPS 167) obtained from a commercial processor within 5 days of carcass fabrication were trimmed of external and seam fat. Beef subcutaneous fat trim was obtained from the Kansas State University Meat Laboratory. Lean and fat sources were coarsely ground separately through a 3/8 in. plate. A sample of each source was ground using a 1/8 in. plate, mixed and analyzed for fat and moisture (CEM Corp., Matthews, NC). Lean and fat sources were mixed to obtain a targeted fat level of 20%, then mixed and ground twice through a 1/8 in. plate.

Twelve square, ground beef patties (1/4 lb, 4×4×1/2 in.) were made per replication per treatment. Patties were placed in a single layer on metal trays and crust frozen at –40°F for 20 min to facilitate handling. Half of the patties were packaged in barrier bags (3-6 cc O_2/m^2/24 hour at 40°F and 0% RH, Viskase Corp., Chicago, IL). The other half were sealed (not evacuated) in oxygen-permeable bags (Polyethylene; 3550 cc O_2/m^2/24 hour at 72°F and 50% RH).

Integrity of the nitrogen-flushed packaging was confirmed by using a gas analyzer to analyze residual gas in one nitrogen-flushed irradiated patty per treatment per replication. The probe was inserted into the package through a sticky rubber patch. The detection limit of the gas analyzer was 400 ppm O_2.

Patties were stored at 34±5°F (chilled) or !4±5°F (frozen) temperature. Packaged patties were packed into insulated ice chests and transported by air to Sandia National

Laboratories, Albuquerque, NM, for irradiation. Frozen cooler packs were used to control the temperature during transportation. Internal temperature was monitored using temperature loggers. Temperatures increased about 12°F in frozen product and 9°F in chilled product during shipment. After arrival, product temperature was stabilized overnight to !4 or 34°F. Control samples receiving no irradiation treatment were shipped and treated the same as product to be irradiated.

To measure actual irradiation, 48 calibrated dosimeters were placed on 1×1× 3/8 in. acrylic blocks on four corners of the patties. A total of 96 dosimeters was used to collect absorbed dose data. Minimum and maximum doses for each dose level and replication were determined. Because the ground beef patties were only 1/2 in. thick, a maximum to minimum ratio of <1.7 was our target.

Patties were placed on a 1/4 in.-thick aluminum base plate (18×53 in.). A refrigeration unit beneath the base plate maintained the required temperature. Each patty was irradiated with 1.5 or 3.0 kGy of non-radioactive electron beam, Repetitive High Energy Pulsed Power (RHEPP-II) at an energy level of 2 Mev, a power level of 200 kW, and an approximate dose rate of 10^{10} to 10^{11} kGy/sec at a conveyor speed of 1 in./sec. Patties irradiated at 1.5 kGy were exposed under the beam once, and patties irradiated to 3.0 kGy were exposed twice in one run. After each run, all patties and dosimeters were inverted and irradiated again in the same manner. Control (0 kGy) patties were placed on the conveyor and run through the unit with the electron beam turned off. Immediately after irradiation, patties were placed in ice chests (cooled with dry ice) and returned to two separate refrigeration units maintained at !4°F for frozen patties and 30°F for chilled patties.

After irradiation, samples for vitamin analysis were packed in Styrofoam boxes lined with dry ice and sent to Midwest Laboratories, Inc., Omaha, NE. During shipping, temperature was maintained at !13°F. Thiamin and riboflavin were measured using AOAC methods. The detection limit of each method was .02 mg/100 g. Duplicate values were averaged, and a statistical analysis was performed.

Results and Discussion

Maximum:minimum ratios for dose levels of irradiation ranged from 1.46 for 3.0 kGy frozen patties to 1.48 for 1.5 kGy chilled patties. Therefore, our target ratio of <1.70 was achieved.

Thiamin contents for control and after irradiation at 1.5, and 3.0 kGy were .077, .079, and .078 mg/100 g meat, respectively (Table 1). Corresponding riboflavin levels were .172, .174, and .172 mg/100 g. Thiamin was higher (P#.05) in nitrogen-flushed patties (.083 mg/100 g) than in aerobically packaged patties (.072 mg/100 g). Riboflavin was higher (P<.05) in nitrogen-flushed frozen (!4°F) patties than in nitrogen-flushed chilled (34°F) patties (.167 vs. .179 mg/100 g) (Table 2). Riboflavin in aerobically packaged ground beef patties at both chilled and frozen temperature was .172 mg/100 g.

Under our conditions, irradiating ground beef with electron beams generated from RHEPP-II resulted in no loss of either thiamin or riboflavin compared to nonirradiated controls. This encouraging observation could be due to low dose, packaging atmosphere, temperature, irradiation system, or a combination of those factors.

Table 1. Thiamin Content (mg/100 g) in Ground Beef Patties as Affected by Dose Level, Temperature, and Packaging Atmosphere

	Dose (kGy)				Temperature °F			Packaging		
Vitamin	0	1.5	3.0	SE	34	–4	SE	N_2	Air	SE
Thiamin	.077	.079	.078	.001	.074[a]	.82[b]	.001	.83[b]	.072[a]	.001

Detection limit: Thiamin .02 mg/100 g.

SE = Standard error.

[a,b]Means with the same or no superscript in the same row within a treatment parameter are not different (P>.05).

Table 2. Riboflavin Content (mg/100 g) in Ground Beef Patties as Affected by Temperature by Packaging Atmosphere (Standard Error = .005)

	Temperature °F	
Packaging	34	–4
Nitrogen	.167[a]	.179[b]
Aerobic	.172[a]	.172[a]

Detection limit: Riboflavin .02 mg/100 g.

[a,b]Means with the same superscript are not different (P>.05).

EFFECTS OF PH, MYOGLOBIN FORM, AND ENDPOINT TEMPERATURE ON COOKED GROUND BEEF COLOR

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Summary

Beef quadriceps muscles from nine pH groups (5.5 - 6.4 in .1 increments) were ground; mixed with fat (20%); formed into patties whose myoglobin was in either the oxy or deoxy state; and cooked to four endpoint temperatures (150, 160, 170, or 180°F). Internal cooked patty color was evaluated visually and instrumentally. Patties containing deoxymyoglobin with pH 6.2 or higher and cooked to 150 and 160°F were redder visually and instrumentally than those with a lower pH. Similar trends, but not as pronounced, were observed with patties containing oxymyoglobin. Deoxymyoglobin was more resistant to denaturation and, thus, made patties more susceptible to persistent red color and at a lower pH than those with oxymyoglobin.

(Key Words: Ground Beef, Cooked Color, pH, Myoglobin Form.)

Introduction

Persistent red color, a phenomenon in which product retains an undercooked, red to pink, internal color even when cooked beyond recommended endpoint temperatures, has become a very costly issue in the ground beef industry. Ground beef patties normally change from red to pink to brown, tan, or grey as endpoint temperatures increase. This color change can be attributed to the denaturation of muscle pigments. Ground beef displaying persistent red color progresses through the normal color changes less rapidly during cooking.

pH critically affects cooked meat color, especially persistent red color. Beef with higher ultimate pH values is more color stable than similar meat with lower pHs. Products with a high pH retain a reddish color despite thorough cooking. Our objective was to determine the effects of a pH continuum, pigment form, and endpoint temperature on cooked color in ground beef.

Experimental Procedures

We used the rectus femoris, vastus lateralis, and the vastus intermedius muscles from 24 peeled knuckles (IMPS 167A) of varying pH's (5.5-6.4). Individual muscles from the quadriceps were sorted into nine pH groups with a muscle pH range of not over 0.1 ± 0.05 pH units per group. Each pH group was coarsely ground separately through a 1/2 in. plate, blended to 20% fat, mixed and ground through a 1/8 in. plate, and formed into patties whose myoglobin was in either the oxy- or deoxy- state. The patties were rapidly crust frozen, individually vacuum packaged, and placed in a –40°F blast freezer. Patties were cooked from the frozen state to one of four endpoint temperatures (150, 160, 170, or 180°F). Internal temperatures of the patties were monitored using a hypodermic probe-type thermocouple inserted in the center. After cooking, patties were sliced in the center parallel to the flat surface and immediately evaluated for cooked color, both visually and instrumentally (a*, redness). The center (35 grams) of each patty was blended with two volumes of cold 40 mM phosphate buffer at pH 6.8 to quantitatively extract myoglobin. Data were analyzed using linear associations by correlation by PROC CORR of the Statistical Analysis System.

Results and Discussion

As expected, visual color scores for patties with higher pH values were redder than those for patties with a lower pH when cooked to the same endpoint temperature. As pH increased, ground beef patties maintained a persistent red color (lower visual scores, higher instrumental a* values) even with higher endpoint temperatures (Table 1). The visual score means of deoxymyoglobin pat-ties were lower (redder) than those for the oxymyoglobin patties. Myoglobin was protected more during cooking in the deoxygenated patties. A visual score of 4.5 and below indicates the presence of pink. Any patty that was cooked to or beyond the recommended cooking temperature (160°F) and continued to display a pink internal color was considered persistently red.

Many patties with pH as low as 5.9 (slightly higher than normal pH) were internally red when cooked to 160°F, the USDA-FSIS (1997) recommended endpoint temperature. The mean visual score for these patties was 4.38 (Table 1).

Our deoxymyoglobin patties at pH 6.1 and higher displayed persistent red color at all endpoint cooking temperatures (Table 1). The visual mean for pH 6.1 patties cooked to 180°F was 4.5. This indicates a slight pink color.

Oxymyoglobin patties cooked to 180°F never showed persistent red color visually, but when cooked to 170 or 160°F were red or pink at pH's 6.2 and 6.4. The patties cooked to the lowest endpoint temperature (150°F) displayed pink or red color at pH 5.9 and higher (Table 1). Premature brown cooked color was noted for oxymyoglobin patties cooked to 150°F from pH 5.6, 5.7, and 5.8 groups.

Both visual and instrumental color evaluation indicate that as pH increases, patties are more likely to retain red color even as temperatures increase. As pH is increased, myoglobin becomes more difficult to denature through cooking. Cooked patties with deoxymyoglobin retain the persistent red color at higher temperatures than cooked patties with oxymyoglobin.

More myoglobin denaturation was seen within the oxymyoglobin patties (Table 2), but myoglobin was protected from denaturation at higher pH levels with either pigment form.

Controlling muscle pH is a difficult task, but high-pH product can be identified prior to grinding. Effective handling practices might minimize persistent red color. Consumers of ground beef must be educated to use an accurate, rapid-response thermometer to determine endpoint temperature. If that temperature reaches 160°F, the ground beef is safe for consumption even if a pink color persists.

Table 1. pH and Maximum Internal Temperature Effects on Visual and Instrumental Redness (a*) of Ground Beef Patties

		Oxymyoglobin - pH								
Item	Temp °F	5.5	5.6	5.7	5.8	5.9	6.1	6.2	6.3	6.4
Visual	150	4.88	5.50	5.63	5.88	4.50	5.38	3.13	5.25	2.75
color	160	5.13	5.88	5.75	5.88	4.75	5.00	3.75	4.63	3.13
score[a]	170	5.88	6.38	6.38	6.50	5.63	5.88	4.50	5.25	4.38
	180	5.75	6.50	6.63	6.38	6.00	6.38	4.88	5.63	5.00
Instrumental	150	7.38	5.98	5.39	5.31	6.36	7.98	11.55	10.44	11.33
color[b]	160	5.56	6.00	5.60	5.31	5.88	8.91	9.19	9.10	11.39
(a*)	170	5.13	5.85	4.95	5.03	5.41	6.28	7.15	7.56	6.92
	180	5.15	5.52	5.26	5.33	5.15	6.40	6.41	7.27	6.53
		Deoxymyoglobin - pH								
	Temp °F	5.5	5.6	5.7	5.8	5.9	6.1	6.2	6.3	6.4
Visual	150	4.50	4.63	4.38	4.63	3.63	3.50	1.25	.63	1.25
color	160	4.63	5.00	5.12	5.00	4.38	4.13	1.38	1.63	.83
score[a]	170	4.88	5.75	5.13	5.00	4.50	4.38	3.00	2.75	3.63
	180	5.38	6.25	5.38	6.25	5.50	4.50	4.38	4.38	4.38
Instrumental	150	8.97	6.94	9.51	7.83	9.28	12.99	16.20	15.85	21.56
color[b]	160	6.29	5.84	8.66	6.40	8.23	10.38	16.31	19.23	16.10
(a*)	170	5.83	5.38	6.29	5.99	6.52	8.12	10.33	19.86	18.44
	180	6.25	5.33	6.57	5.71	5.64	7.09	7.68	18.71	18.02

[a]Color scale: 7-0, .5 increments; 7= grey, 6- brownish grey, 5=tannish brown, 4=tannish pink, 3=pink, 2=slightly reddish color, 1=reddish pink/raw, and 0=raw. Two patties per treatment (pH/temperature). Two visual evaluations per patty. Three instrumental evaluation per patty.
[b]a* is an instrumental value that increases with redness.

Table 2. Myoglobin Denaturation for Oxymyoglobin and Deoxymyoglobin Ground Beef Patties at Each Cooking Temperature Averaged over pH

Myoglobin	150°F		160°F		170°F		180°F	
Denaturation	Oxy	Deoxy	Oxy	Deoxy	Oxy	Deoxy	Oxy	Deoxy
Mean, %	73.5	62.5	78.9	67.0	80.1	75.3	84.8	82.6
Standard deviation, %	20.1	13.2	15.8	11.8	15.5	13.6	13.0	11.8

QUALITY AND DISPLAY LIFE OF CHILLED OR FROZEN ALL-NATURAL BEEF AND BEEF-BUFFALO FRANKFURTERS

R. Limsupavanich, E.A.E. Boyle, D. H. Kropf, K. A. Hachmeister, T. M. Loughin[1], and M. A. Boland[2]

Summary

Chilled (35±3°F) or frozen (0±3°F) all-natural beef and beef-buffalo frankfurters made with or without sodium nitrite ($NaNO_2$) were evaluated. Treatments included frankfurters made with: all-natural beef without $NaNO_2$ and displayed frozen (B0F); all-natural beef and buffalo without $NaNO_2$ and displayed frozen (BU0F); all-natural beef with $NaNO_2$ and displayed frozen (BNF) or chilled (BNC). Batter pH, smokehouse yield, and proximate analysis were determined. No differences (P>.05) were noted in batter pH, smokehouse yield, proximate analysis, or cooking yield. Day of display had no influence (P>.05) on oxidation. However, BU0F had the highest (P<.05) oxidation value, a measure of potential rancidity. For all treatments, instrumentally measured lightness increased during display, while redness decreased. Both B0F and BU0F had lower (P<.05) redness and nitrosoheme pigments than BNC. Purge loss increased (P<.05) with longer display. Microbial counts and pH of frozen products were not different (P>.05) during display. Nitrite-free frankfurters can be displayed frozen up to 90 days based on microbial counts, but display life may be limited to 60 days by product color. Inclusion of buffalo did not influence physical or microbiological quality of nitrite-free frozen frankfurters but may accelerate oxidative rancidity.

(Key Words: All-Natural Beef-Buffalo Frankfurters, Nitrite-Free, Chilled Display, Frozen Display.)

Introduction

About 834 million lb of frankfurters were sold at retail in the U.S. in 1998, with a value of $1.5 billion. Some consumers perceive "natural" foods as "health" foods. From 1987 to 1994, the sale of "natural" foods increased more than 100%, indicating increased demand. "Natural" beef is minimally processed and contains no artificial additives. Buffalo (*Bison bison*), an alternative red meat, is gaining acceptability in some foodservice settings. All-natural beef or beef-buffalo frankfurters may provide a niche market for meat processors and additional market opportunities for beef. Our objective was to evaluate chilled (35±3°F) or frozen (0±3°F) display life and quality of regular and nitrite-free all-natural beef and beef-buffalo frankfurters.

Experimental Procedures

Ground lean beef (80/20), ground fat beef (50/50), ground lean buffalo (90/10), and all-natural wiener seasonings were obtained from commercial suppliers. Frankfurters were processed by a very small commercial meat processor. They were made with all-natural beef without sodium nitrite ($NaNO_2$) and displayed frozen (B0F); all-natural beef and buffalo (10% of lean component) without $NaNO_2$ and displayed frozen (BU0F); all-natural beef with $NaNO_2$ and displayed frozen (BNF) or chilled (BNC). Each of three processing days represented one replication.

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Frozen raw meat materials, tempered overnight at 32°F, were chopped with seasoning mixes, ice, and $NaNO_2$ and sodium erythobate as appropriate to form a good batter. Batters were stuffed into sheep casing, hand linked (6-in. long), and hung. Frankfurters were smoked (45 min) to an internal temperature of 156°F. After smoking, frankfurters were cooked in hot water (162°F) to 158°F internally, cooled in 84°F water for 20 min, and dried at 32°F for 30 min. Frankfurters were vacuum packaged (5 per bag), labeled, and transferred in a cooler with ice packs to Kansas State University. One package per treatment was selected for instrumental color measurement. After the initial measurement, all samples were displayed under 150 ft-candles of deluxe warm white fluorescent light. The B0F, BU0F, and BNF were displayed frozen (0±3°F), and BNC was displayed chilled (35±3°F) in an open-top display case. Because of limited space, samples were shingle displayed, except those selected for instrumental color measurement.

Purge loss, cooking yield, 2-thiobarbituric acid reactive substances (TBARS), instrumental color, and nitrosoheme pigments were determined initially and at 3, 7, 14, 21, 30, 60, and 90 days. Aerobic plate count (APC), lactic acid bacteria (LAB), *Escherichia coli* (*E. coli*) and coliforms were evaluated initially before display and at 30, 60, and 90 days. Frankfurter pH was measured from the homogenate prepared for microbiological analysis. Data were analyzed as a randomized complete block design with repeated measures using ANOVA methods with the mixed procedure of SAS.

Results and Discussion

No differences ($P>.05$) were noted in batter pH (5.86-5.98), smokehouse yield (95.8-96.3%), protein (13.0-13.4%), fat (18.1-18.9%), or moisture (61.1-61.8%). Day of display had no influence ($P>.05$) on oxidative rancidity measured by TBARS (Fig. 1). Up to 30 days, BU0F had the highest ($P<.05$) TBARS. This might be due to the higher amount of unsaturated fatty acids in buffalo meat compared to beef. At days 60 and 90, the levels were lower and similar to those of B0F. In all treatments, L* (instrumentally determined lighter color) increased with display (Fig. 2). After 14 days, the frozen treatments (B0F, BU0F, and BNF) tended to be much lighter than the chilled treatment (BNC). Instrumentally determined a* decreased (less red) with display (Fig. 3). Treatments with $NaNO_2$ (BNF and BNC) were redder ($P<.05$) than those without $NaNO_2$ (B0F and BU0F). Instrumentally determined b* of frozen treatments decreased (less yellow) with display (Fig. 4). As expected, treatments with $NaNO_2$ had higher cured color intensity than those without $NaNO_2$ (data not shown, reflectance ratio of 650/570). Cured color intensity decreased with display. Cured color of treatments with $NaNO_2$, whether displayed frozen or chilled, was not different. In all treatments, purge loss increased ($P<.05$) with display (Fig. 5). Cooking yield (100.1-100.6%) was not influenced ($P>.05$) by treatment or day. Through 90 days, all frozen treatments had low APCs (1.3-1.5 log CFU/g, Fig. 6). After 30 days, BNC had higher ($P<.05$) APC than frozen treatments. Similarly, lactic acid bacteria of BNC were high ($P<.05$) after 30 days but low (1.0 log CFU/g) in all frozen treatments up to 90 days (Fig. 7). *E. coli*/coliforms of all treatments were estimated <1.0 log CFU/g. Frozen treatments had no differences in pH (6.20-6.36) during 90 days (data not shown). pH of BNC started to drop after 21 days because of the acids produced by LAB.

Nitrite-free beef or beef-buffalo frankfurters can be displayed frozen up to 90 days, based on microbial counts; however, display life was limited to 60 days by product color. Inclusion of buffalo in the formulation did not improve or adversely affect physical or microbiological quality of nitrite-free frozen frankfurters. However, the addition of buffalo meat may accelerate oxidative rancidity increases of nitrite-free frozen frankfurters.

Table 1. Frankfurter Formulation

Item	BOF & BUOF	BNF & BNC
Lean (%)	47.8	47.5
Fat (%)	28.5	28.5
Ice (%)	19.1	19.0
Non meat materials (%)	4.6	5.0

BOF = Beef without $NaNO_2$ and displayed frozen.
BUOF = Beef-buffalo without $NaNO_2$ and displayed frozen.
BNF = Beef with $NaNO_2$ and displayed frozen.
BNC = Beef with $NaNO_2$ and displayed chilled.

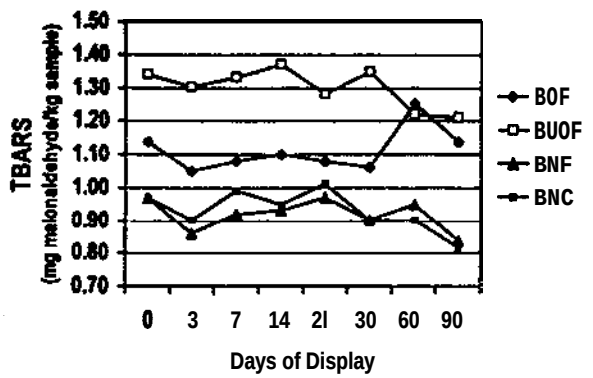


Figure 1. TBARS of Frankfurters during Display.

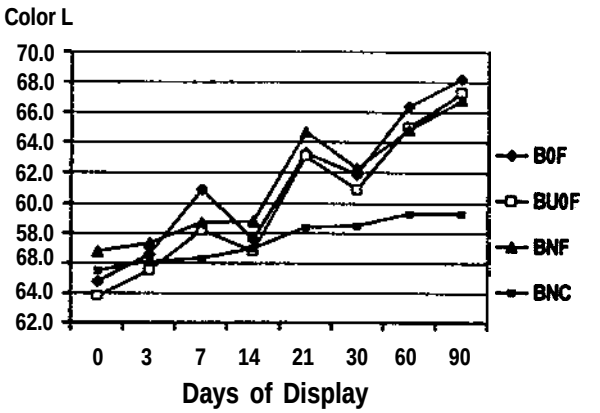


Figure 2. Color L* of Frankfurters during Display.

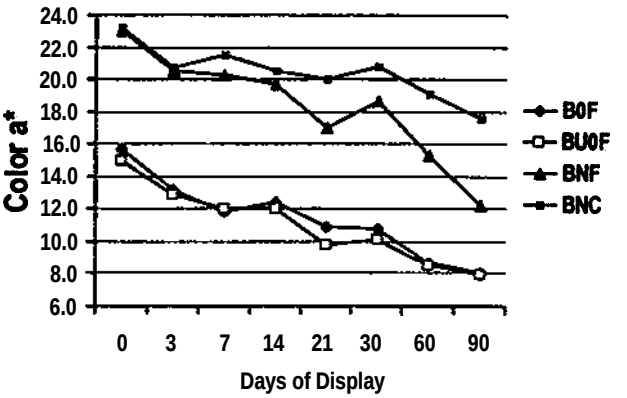


Figure 3. Color a* of Frankfurters during Display.

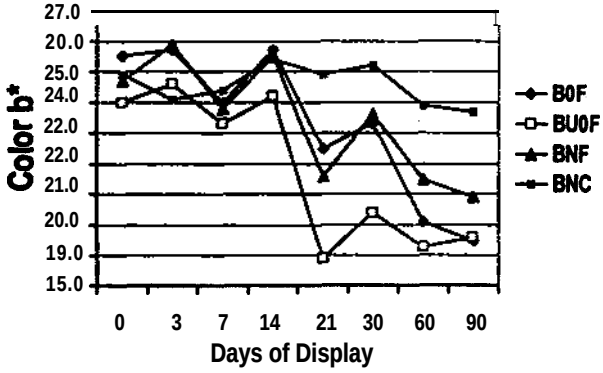


Figure 4. Color b* of Frankfurters during Display.

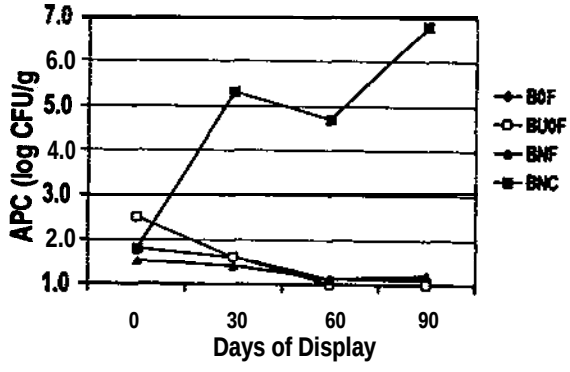


Figure 6. Aerobic Plate Count (APC) of Frankfurters during Display.

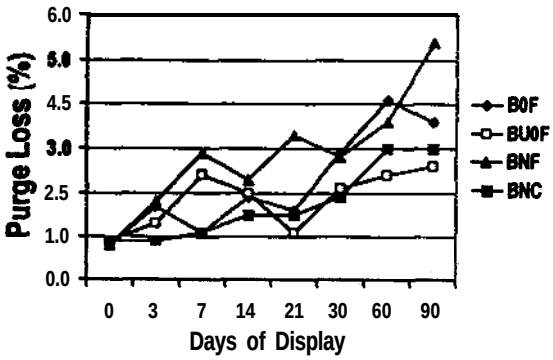


Figure 5. Purge Loss of Frankfurters during Display.

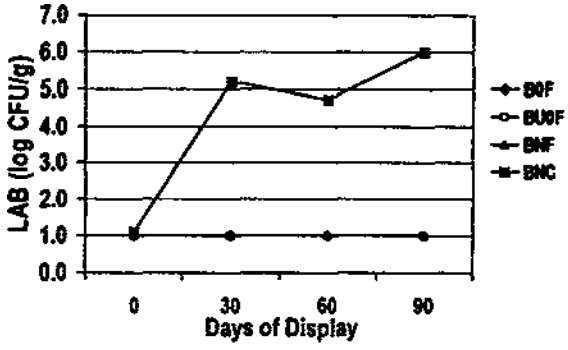


Figure 7. Lactic Acid Bacteria (LAB) Count of Frankfurters during Display.

ESCHERICHIA COLI O157:H7 RISK ASSESSMENT FOR BLADE-TENDERIZED BEEF STEAKS

R. K. Phebus, H. Thippareddi, S. Sporing, J. L. Marsden, and C. L. Kastner

Summary

The potential translocation of *E. coli* O157:H7 from the surface to the interior of whole muscle by blade tenderization was evaluated. Beef top sirloin subprimals were inoculated with 10^6 or 10^3 cfu/cm^2 and passed once through a Ross blade tenderization unit. Core samples showed a translocation of 3 to 4% of surface inoculum to the geometric center of the subprimal. A second study evaluated thermal destruction of *E. coli* O157:H7 in blade tenderized (BT) steaks compared to nontenderized (NT) steaks of three thicknesses when oven-broiled. Subprimal surfaces were inoculated to a level of 10^7 cfu/cm^2 and blade tenderized. Steaks cut from these subprimals were oven-broiled to internal temperatures from 120 to 170°F, then analyzed for surviving *E. coli* O157:H7. At internal steak temperatures of 140°F and higher, all *E. coli* O157:H7 were killed in both BT and NT steaks of all thicknesses. At 130°F, about 5 log reductions were noted for both BT and NT. With oven broiling to even moderate internal temperatures, BT steaks pose no greater risk of *E. coli* O157:H7 infection than NT steaks.

(Key Words: Blade Tenderization, Beef Steaks, Risk Assessment, *E. coli* O157:H7.)

Introduction

Blade tenderization of subprimals offers a cost-effective way to achieve uniform and acceptable tenderness in beef cuts. However, microbiological quality and associated health risks have not been researched thoroughly. Ground beef generally is cooked medium to well-done, because restaurants and consumers now realize that *E. coli* O157:H7 and other pathogens may be present in the product. However, consumers generally perceive that intact muscle steaks, even when blade tenderized, require cooking to lesser doneness. Mechanically tenderized steaks could harbor pathogenic bacteria internally, thereby increasing risk of foodborne infection if not thoroughly cooked. Our objectives were to determine the extent to which blade tenderization translocates microbial contamination from the surface to the interior of subprimals and to determine cooking parameters required to eliminate *E. coli* O157:H7 from the interior of blade tenderized steaks.

Experimental Procedures

Penetration of *E. coli* O157:H7 during Blade Tenderization

A rifampicin-resistant strain of *E. coli* O157:H7 (USDA-FSIS 011-82) was grown and diluted to provide inocula levels of 10^3 and 10^6 cfu/ml. Vacuum-packaged top butt subprimals (caps removed) were removed from packaging, and the inoculum was misted onto their surfaces in an airtight chamber. The inoculated subprimals were stored at 39°F for 30 min to allow attachment. Then each subprimal was passed once through a blade tenderizer (Ross TC700M, Midland, VA), which produced 32 blade penetrations per sq in. The unit was disassembled, cleaned and sanitized after passage of each subprimal. Tenderized suprimals were stored in a freezer at 0°F for 3 hours to crust the surface and facilitate accurate removal of core samples.

Tenderized subprimals were transferred aseptically to clean butcher's paper with the inoculated side down. Four cores were excised from each subprimal using sterile coring devices (4 in. long, 2 in. diameter),

beginning from the noninoculated surface. Meat cores were removed carefully through the back opening of the coring device to prevent artificial contamination of the core surface. Approximately 2 mm of the noninoculated surface of each core was trimmed aseptically, and the cores were sliced aseptically into four cross-sections of 2, 2, 1, and 1 cm. Cross-sectional strips were homogenized in 0.1% peptone diluent (1:5;w:v) in a sterile blender jar. Serial dilutions were plated onto TSA-rif agar to enumerate *E. coli* O157:H7 at each core depth.

Determining Adequate Cooking Temperatures for BT Steaks

Five strains of *E. coli* O157:H7 were grown, and a mixed-strain inoculum was prepared in 0.1% peptone water. Six top butt subprimals were mist-inoculated in a sealed chamber to provide 10^7 cfu/cm^2 on the top exterior surface. After a 1-hour attachment period at 39°F, three subprimals were blade tenderized (BT), and the other three served as inoculated but nontenderized (NT) controls. Steaks were cut from each subprimal at thicknesses of 0.5, 0.75, and 1.25 in, and the noninoculated edge of each steak was trimmed to provide weights of 5, 8, and 12 oz, respectively. Steaks of each thickness were assigned randomly to one of six target internal temperatures (120, 130, 140, 150, 160, or 170°F) and cooked under a typical kitchen oven broiling element set at 500°F, which provided an ambient temperature of about 300°F. Steaks were turned after reaching the mid-point temperature. Internal temperatures were monitored at 10-sec intervals using a thermocouple threaded through the steak edge to the geometric center. After reaching the target internal temperature, steaks were sealed in sterile stomacher bags, and placed into an ice bath.

After chilling, a cross-section strip was excised aseptically from the center of each steak, parallel to the blade penetrations and representing both the inoculated surface and the steak interior. These samples were placed into sterile blender jars with 0.1% peptone water (1:5 w:v) and homogenized for 30 sec. Surviving *E. coli* O157:H7 were enumerated on MacConkey Sorbitol Agar (MSA) and Phenol Red Sorbitol Agar (PRSA; to enumerate injured cells). Log reductions were calculated based on analysis of uncooked steaks from each treatment group. Samples testing negative by plating were selectively enriched and qualitatively analyzed by plating enrichments onto MSA agar. Presumptive *E. coli* O157:H7 colonies were confirmed biochemically and serologically. Three replications were completed.

Results and Discussion

Penetration of *E. coli* O157:H7 during Blade Tenderization

Blade tenderization translocated surface *E. coli* O157:H7 throughout the muscle interior. The high-level surface inoculum (10^6 cfu/cm^2) resulted in about 3 logs of *E. coli* O157:H7 being translocated to a depth of 6 cm into the subprimal. The geometric center of each core sample harbored 4 log cfu/g. The low-level inoculum (10^3 cfu/cm^2) produced similar trends; approximately 1.8 logs were transferred to the center of the steaks. Blade tenderization carried 3 to 4% of surface contamination to the center of the subprimals, regardless of initial surface contamination level.

Determining Adequate Cooking Temperatures for BT Steaks

Steaks were oven broiled to internal temperatures from undercooked (120°F) to well-done (170°F). No difference ($P>0.05$) was noted between BT and NT steaks in *E. coli* O157:H7 survival, except at 120°F internal temperature, where BT steaks showed less bacterial reduction than NT steaks (3.2 and 5.2 log cfu/g respectively). At an internal temperature of 130°F, mean log reductions of 5.6 and 5.0 cfu/g for BT and NT steaks, respectively, were not different ($P>0.05$). However, evaluation of individual steaks indicated significant variability in degree of kill, particularly in thinner (lower weight) steaks. This variability in cooking to 130°F could increase the risks associated with BT steaks potentially contaminated internally with *E. coli* O157:H7. At temperatures of 140°F and higher, all *E. coli* O157:H7 were eliminated by oven broiling.

A SURVEY ON THE USE OF BLADE TENDERIZERS BY BEEF FABRICATION PLANTS

C. D. George-Evins, J. A. Unruh, J. L. Marsden, and C. L. Kastner

Summary

A questionnaire to determine the use of blade tenderizers in beef fabrication facilities was sent to 241 members of the North American Meat Processors Association (NAMP). Eighty-four percent of the 90 respondents used blade tenderizers. These subprimals were at least sometimes tenderized by the following percentages of respondents: tenderloins, 7.9; chuck cuts, 18; round cuts, 36; ribeyes, 38; strip loins, 56; and top sirloin butts, 62. If a processor blade-tenderized a particular cut, they tenderized a majority of their production for that cut, generally with multiple passes through the tenderizer. For example, the 62% of respondents who tenderized top sirloin butts tenderized 87% of their production of that cut with an average of 1.6 passes. Cuts were aged by 70.7% of respondents that used blade tenderizers. The average aging period was 20 days, and the range was 7 to 60 days. Our respondents fabricated 75.1% of their beef products for the hotel/restaurant industry, 13.3% for retail, and 6.0% for other markets such as export or warehouse distributors. Blade tenderization is used widely by NAMP members, most often on ribeyes, strip loins, and top sirloin butts, and often combined with aging.

(Key Words: Beef, Blade Tenderization.)

Introduction

Blade tenderizers, often used by meat purveyors to improve tenderness, pass small, thin blades vertically through subprimal cuts to sever connective tissue and muscle fibers. The extent of blade tenderization use in the industry has not been surveyed since 1975. The purpose of our survey was to determine the current use of blade tenderizers for beef by meat purveyors, which beef cuts are tenderized, and the extent of aging prior to tenderization.

Experimental Procedures

With cooperation of the North American Meat Processors Association (NAMP), a questionnaire was sent to their 241 members listed in the 1998 NAMP membership directory, along with a cover letter describing the purpose of the survey. Care was taken to ensure confidentiality among respondents. A pre-addressed, stamped envelope was provided to encourage response. The questionnaire consisted of the following five questions.

1. Which of the following does your company use to tenderize beef products? (Blade Tenderizer, Cuber, Dicer, Other (please specify), Do not use)

2. On which cuts/muscle systems do you use a mechanical blade tenderizer, how many passes through the system occur for each cut/muscle system, and what percentage of each cut/muscle system is subjected to mechanical blade tenderization? (Chuck muscles, Ribeye, Tenderloin, Strip Loin, Top Sirloin Butt, Round muscles, Do not use)

3. Is product aged prior to blade tenderization?

4. Which USDA quality grades do you blade tenderize? (Prime, Premium Choice, Lower Choice, Select, Standard, Other)

5. What percentage of your customer base is Hotel/Restaurant/Institution, Retail, Other?

Results and Discussion

Out of 241 questionnaires sent, 90 were returned for a 37.3% return rate. Of the processors that responded, 84% used blade tenderization. In addition, 87% of the respondents used other forms of tenderization, including dicers (16%) and cubers (61%).

Eighteen percent of the respondents blade tenderized 79.6% of their chuck cuts with an average of 2.1 passes (range, 1 to 5 passes) through the blade tenderizer (Table 1). Thirty eight percent blade tenderized 80.8% of their rib cuts with an average of 1.4 passes (range, 1 to 3 passes); 7.9% blade tenderized 80% of their tenderloins an average of 1.6 passes (range, 1 to 3 passes); and 56.2% blade tenderized 85.1% of their strip loins with an average of 1.3 passes (range, 1 to 3 passes). However, the majority blade tenderized strip loins with only 1 pass. Sixty two percent blade tenderized 86.9% of their top sirloin butts with an average of 1.6 passes (range, 1 to 3 passes); and 36% blade tenderized 69.6% of their round product with an average 1.9 passes (range, 1 to 8 passes).

Of respondents that blade tenderized beef, 71% aged product before it was tenderized for an average of 20 days (SD=5.8), (range, 7 to 60 days). Grade and percent blade tenderized were: Prime, 35; Upper Choice, 73.8; Lower 1/3 of Choice, 88.5; Select, 86.8; and Standard, 86.8. These responses often reflected the quality grades sold by a particular purveyor, but a higher percentage of their Select and Choice products was blade tenderized. For respondents, 75.1% of their product was processed for the hotel/restaurant/institution industry, 13.3% for the retail industry, and about 6.0% was directed toward other markets such as export or wholesale warehouses.

Blade tenderization and aging often are used to improve beef tenderness and consistency. Top sirloin butts and strip loins were the cuts most often blade tenderized because of customer expectation of tenderness. Because top sirloin butt steaks are common menu items in restaurants and are inherently less tender than steaks from the rib, loin, and tenderloin, blade tenderization logically was used more often for this subprimal. The number of blade tenderization passes used for different cuts varied greatly among plants. Research should establish the number of blade tenderization passes and aging periods needed to produce tender, uniform products from different subprimals and quality grades.

Table 1. Results of Blade Tenderization Survey[a]

	Cut/Muscle System											
	Chuck		Rib		Tender-loin		Strip Loin		Top Sirloin Butt		Round	
Item	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Respondents who use blade tenderization, %	17.9	-	38.2	-	7.9	-	56.2	-	61.8	-	36.0	-
Product processed, %[b]	79.6	31.0	80.8	29.7	80.0	31.0	85.1	27.3	86.9	25.1	69.6	37.3
Number of passes[b]	2.1	1.1	1.4	.6	1.6	.79	1.3	.5	1.6	.6	1.9	1.4
Maximum number of passes	5	-	3	-	3	-	3	-	3	-	8	-

[a]Responses from 90 returned questionnaires.

[b]Averages derived from respondents who blade tenderized this subprimal.

EFFECTS OF POSTMORTEM AGING PERIOD AND BLADE TENDERIZATION ON SENSORY TRAITS OF BEEF STEAKS

C. D. George-Evins, J. A. Unruh, J. L. Marsden, and C. L. Kastner

Abstract

We used 54 strip loins, 54 top sirloin butts, and 54 inside rounds, all USDA Choice grade, to determine the influence of different postmortem aging periods and blade tenderization passes on sensory panel traits. Cuts were aged for 7, 14, or 21 days and not tenderized (0X) or blade tenderized one (1X) or two (2X) times. All steaks were cooked to 160°F internally, and samples were evaluated by a trained sensory panel for flavor intensity, juiciness, myofibrillar tenderness, connective tissue amount, and overall tenderness. Both longer aging periods and blade tenderization passes improved tenderness of strip loin and top sirloin butt steaks without affecting either flavor or juiciness, but did not affect tenderness of top round steaks. Therefore, meat purveyors should use these technologies to improve tenderness and consistency of strip loin and top sirloin butt steaks.

(Key Words: Beef, Sensory Panel, Blade Tenderization, Aging, Steak Cuts.)

Introduction

Tenderness, flavor, and juiciness of beef are important palatability factors to consumers. They are willing to pay a premium for cuts they know will be tender, flavorful, and juicy. A challenge of the beef industry is to reduce variation and improve tenderness through ante- and postmortem technologies. Of beef steaks regularly offered on higher class restaurant menus, the top sirloin steak is less tender and more variable in tenderness, but has the lowest price. Increased aging is a common postmortem technology used to increase beef tenderness. Blade tenderization is another technology that can improve the tenderness of beef through disruption of the connective and muscle tissue. Our objective was to determine the influence of different postmortem aging periods and blade tenderization passes on sensory panel ratings of Choice strip loin, top sirloin butt, and inside round steaks.

Experimental Procedures

We purchased 54 each of strip loins (IMPS 180), top sirloins butts (IMPS 184A), and inside rounds (IMPS 168), all USDA Choice, from a commercial packing facility. Loins were aged for 7, 14, or 21days at 32 to 34°F. After aging, cuts were not tenderized (0X) or passed through a blade tenderizer (model T7001, Ross Industries Inc., Midland, VA) one (1X) or two (2X) times. After tenderizing, cuts were wrapped in plastic and crust frozen at -35°F for 30 to 40 min in a spiral freezer. Longissimus, gluteus medius, and semimembranosus muscles were cut into 1-inch-thick steaks, which were vacuum packaged individually. The steaks were frozen for 30 to 40 min at -35°F in a spiral freezer, transported to the Kansas State University Meat Laboratory, and stored at -20°F until analysis.

A steak from each cut was thawed for 24 hours at 37°F. Steaks were cooked to 160°F internally in a Blodgett dual-air-flow gas convection oven preheated to 325°F. Temperature was monitored by 30-gauge, type-T thermocouples inserted into the geometric center of the steak and attached to a temperature recorder. Each steak was cut into cubes of ½ in. × ½ in. × thickness of the cooked steak. Sensory panel evaluations were conducted in an environmentally controlled

room partitioned into booths with a controlled mixture of red light and green light. One orientation sample was evaluated and discussed at the beginning of each session. For each session, duplicate samples for each of the nine treatments of a single cut were served warm and evaluated by a six-member trained sensory panel. Order of presentation was randomized for each panelist within each session. Samples were assessed for six sensory attributes using an 8-point numerical scale evaluated to the nearest .5. Sensory traits evaluated were flavor intensity (1=extremely bland to 8=extremely intense), juiciness (1=extremely dry to 8=extremely juicy), myofibrillar tenderness (1=extremely tough to 8=extremely tender), connective tissue amount (1=abundant to 8=none), and overall tenderness (1=extremely tough to 8=extremely tender). Data were analyzed as a 3 × 3 factorial design with main effects of aging period and blade tenderization passes using the GLM procedure of SAS (1998). All interaction and main effect means were separated (P<.05) using the Least Significant Difference procedure when the respective F-tests were significant (P<.05).

Results and Discussion

Ratings for flavor and juiciness for strip loin (longissimus) steaks were similar (P>.05) for all treatments (data not shown). An interaction (P<.05) of aging period × blade tenderization was observed for the tenderness traits evaluated (Table 1). For steaks aged 7 days, those tenderized 1X and 2X had higher (P<.05) ratings for myofibrillar and overall tenderness than steaks not tenderized. For steaks aged 14 days, those blade tenderized 2X had higher (P<.05) ratings for myofibrillar and overall tenderness than those in the 0X and 1X groups. For steaks aged 7 and 14 days, connective tissue amount ratings were similar (P<.05) across all blade tenderization treatments. For steaks aged 21 days, those blade tenderized 2X had higher (more tender, P<.05) ratings for myofibrillar and overall tenderness and connective tissue amount (less connective tissue) than those blade tenderized 1X. For steaks not tenderized, those aged 21 days were rated higher (P<.05) for myofibrillar tenderness than those aged 7 and 14 days. For steaks blade tenderized 1X, those aged 7 days higher (P<.05) sensory panel ratings for myofibrillar and overall tenderness than those aged 14 days. For steaks in the either 0X or 1X group, ratings of connective tissue amount were similar (P>.05) across all postmortem aging periods (P>.05). For steaks blade tenderized 2X, those aged 21 days had higher (P<.05) panel ratings for myofibrillar and overall tenderness than those aged 14 days and had less detectable connective tissue than those aged 7 or 14 days. Overall, blade tenderization and longer aging improved tenderness of strip loin steaks.

Sensory panel ratings for top sirloin steak (gluteus medius) flavor and juiciness were similar (P>.05) for all postmortem aging and blade tenderization treatments (Table 2). Myofibrillar tenderness ratings were similar (P>.05) for all postmortem aging periods. However, connective tissue amount and overall tenderness ratings were higher (P<.05) (less connective tissue and more tender) for steaks aged 21 days compared to 7 days. Steaks blade tenderized 1X and 2X had higher (P<.05) scores for (more tender) myofibrillar and overall tenderness than steaks not tenderized. Blade tenderization treatments had similar (P>.05) ratings for connective tissue amount. Steaks aged 21 days had higher (P<.05) ratings for overall tenderness than steaks aged 7 days. Both blade tenderization and longer aging could be used to improve tenderness and consistency of top sirloin butt steaks.

Sensory panel ratings for flavor were higher (P<.05) for inside round (semimembranosus) steaks aged 14 days than 7 days and lower (P<.05) for steaks blade tenderized 2X than not tenderized (Table 3). Juiciness ratings for steaks in the 0X and 1X groups were higher (P<.05) than ratings for those blade tenderized 2X. This may have been due partially to disruption of muscle tissue and subsequent moisture loss during either holding before cutting or cooking. Neither postmortem aging nor blade tenderization affected (P>.05) sensory panel ratings for myofibrillar tenderness or overall

tenderness. Steaks that were blade tenderized 2X tended (P<.08) to have less detectable connective tissue than steaks that were not blade tenderized. This suggests that blade tenderization of inside round steaks may provide a small benefit by disrupting some connective tissue. However, neither increasing the aging time nor blade tenderization passes provided any substantial benefit in sensory panel traits for inside round steaks.

Table 1. Sensory Panel Means for Strip Loin Steaks as Affected by Interaction of Different Postmortem Aging Periods and Blade Tenderization Passes

	Treatment[a]									
	7 days			14 days			21 days			
Trait[b]	0X	1X	2X	0X	1X	2X	0X	1X	2X	SE
Myofibrillar	5.47^{e}	6.36^{cd}	6.28^{cd}	5.43^{e}	5.39^{e}	6.11^{d}	6.26^{cd}	5.67^{de}	6.74^{c}	.19
CT amount	6.54^{de}	7.07^{cd}	6.83^{d}	6.69^{d}	6.22^{de}	6.93^{d}	7.04^{cd}	6.72^{d}	7.23^{c}	.15
Overall tenderness	5.63^{f}	6.45^{cd}	6.31^{cde}	5.64^{f}	5.46^{f}	6.25^{de}	6.35^{cde}	5.88^{ef}	6.81^{c}	.19

[a]Postmortem aging period (days); blade tenderization passes: 0X=not blade tenderized, 1X=1 time, 2X=2 times.

[b]Sensory traits were evaluated on an 8-point scale; (myofibrillar tenderness, 1=extremely tough, 8=extremely tender; connective tissue amount, 1=abundant, 8=none; overall, 1=extremely tough, 8=extremely tender).

[c,d,e,f]Means within a row with same superscript letter do not differ (P>.05).

Table 2. Sensory Panel Means for Top Sirloin Steaks with Different Postmortem Aging Periods and Blade Tenderization Passes

	Aging Period			Blade Tenderization[a]			
Trait[b]	7 days	14 days	21 days	0X	1X	2X	SE
Flavor	5.68	5.75	5.61	5.74	5.69	5.60	.04
Juiciness	5.12	5.27	4.94	5.04	5.13	5.15	.13
Myofibrillar	4.74	5.15	5.27	4.57^{e}	5.33^{f}	5.26^{f}	.17
CT amount	5.71^{c}	6.09^{cd}	6.29^{d}	5.77	6.18	6.16	.15
Overall tenderness	5.76^{c}	5.21^{cd}	5.42^{d}	4.68^{e}	5.37^{f}	5.34^{f}	.18

[a]0X=not blade tenderized, 1X=blade tenderized one time, 2X=blade tenderized two times.

[b]Sensory traits were evaluated on an 8-point scale: flavor, 1=extremely bland, 8=extremely intense; juiciness, 1=extremely dry, 8=extremely juicy; myofibrillar tenderness, 1=extremely tough, 8=extremely tender; connective tissue amount, 1=abundant, 8=none; overall tenderness, 1=extremely tough, 8=extremely tender.

[c,d]Means within a row and aging period with same superscript letter do not differ (P>.05).

[e,f]Means within a row and blade tenderization with different superscripts differ (P<.05).

Table 3. Effects of Aging Period and Blade Tenderization Passes on Sensory Panel Traits of Inside Round Steaks

	Aging Period			Blade Tenderization[a]			
Trait[b]	7 days	14 days	21 days	0X	1X	2X	SE
Flavor	5.51[d]	5.67[c]	5.60[cd]	5.67[e]	5.60[ef]	5.51[f]	.04
Juiciness	5.17	5.09	5.06	5.27[e]	5.23[e]	4.83[f]	.12
Myofibrillar	4.62	4.70	4.88	4.53	4.76	4.90	.17
CT amount	4.82	4.93	5.31	4.90	4.87	5.28	.15
Overall tenderness	4.43	4.53	4.83	4.45	4.57	4.78	.17

[a]0X=not blade tenderized, 1X=blade tenderized one time, 2X=blade tenderized two times.

[b]Sensory traits were evaluated on an 8-point scale: (flavor, 1=extremely bland, 8=extremely intense; juiciness, 1=extremely dry, 8=extremely juicy; myofibrillar tenderness, 1=extremely tough, 8=extremely tender; connective tissue amount, 1=abundant, 8=none; overall, 1=extremely tough, 8=extremely tender).

[c,d]Means within a row and aging period with same superscript letter do not differ (P>.05).

[e,f]Means within a row and blade tenderization with different superscripts differ (P>.05).

TRANSLOCATION OF NATURAL MICROFLORA FROM MUSCLE SURFACE TO INTERIOR BY BLADE TENDERIZATION

M. N. Hajmeer, E. Ceylan, J. L. Marsden, and R. K. Phebus

Summary

The effect of blade tenderization on translocation of natural microflora from the surface to the interior of *longissimus dorsi* steaks aged for 7, 14, and 21 days was evaluated. Samples from the exterior and interior of steaks from blade-tenderized (BT) and non-blade-tenderized (N-BT) strip loins were analyzed for aerobic plate, coliform, and *Escherichia coli* counts. Results showed that BT translocated microorganisms (aerobic plate counts) from the exterior to the interior of muscle. Microorganism numbers increased with extended storage ($P<.05$). Counts of coliforms and *Escherichia coli* recovered from BT steaks were comparable to those from N-BT steaks because of very low exterior counts, showing the importance of good hygiene.

(Key Words: Blade Tenderization, Beef Steaks, Microflora Translocation.)

Introduction

The meat industry utilizes several tenderization techniques including aging, application of proteolytic enzymes, marination, electrical stimulation, flaking and forming, and mechanical or blade tenderization. Blade tenderization improves tenderness of meat, especially low grade or cheaper cuts, without changing other sensory or quality attributes. Other tenderization techniques can affect sensory and textural characteristics of products.

Blade tenderization disrupts the muscle structure by cutting through muscle tissues, fibers, and connective tissue with sharp-edged blades. This penetrating action can increase tenderness, especially for meat high in connective tissue and improve overall product uniformity. More passes or larger blade size may increase tenderness without adverse sensory or bacteriological effects. Product life of vacuum-packaged or frozen, blade-tenderized (BT) meat has been comparable to that of non-blade-tenderized (N-BT) meat when high hygienic standards were maintained. Microbiological aspects of blade tenderization need further investigation, because it violates the surface of intact muscle, and contamination may be carried from the surface to the interior of cuts. This experiment examined the effects of blade tenderization on translocation of natural microflora from the surface to the interior of *longissimus dorsi* steaks.

Experimental Procedures

Strip loins (IMPS 180; NAMP, 1997) conforming to Certified Angus Beef™ (CAB) specifications were purchased from a commercial beef packing facility. The loins (n=27) were separated into three groups of nine and aged for 7, 14, or 21 days at 34°F. After aging, loins from each group were divided randomly into three sets of three. One set of loins was BT using a Ross™ tenderizer (model T7001, Ross Industries Inc., Midland, VA) by passing each of the loins one time (1X) through the tenderizer, another set was passed two times (2X), and the third served as the N-BT control (0X; no blade passes). The tenderizer gave an average penetration density of 32-36 punctures per square inch per blade pass. Following treatment, the loins were crust frozen for 30-40 min at –35°F in a spiral freezer. Loins were fabricated into 1-inch-thick steaks using

an automatic spiral slicer. Steaks were vacuum-packaged individually and stored at –20°F until microbial analyses.

Longissimus dorsi (LD) steaks were thawed at 40°F for 12 hours prior to microbiological analyses. Each steak was removed aseptically from its package, and a 1-inch-thick sample at a cutting angle perpendicular to the muscle grain was removed using a sterile stainless steel coring device (2-in. diameter). The sample was cut horizontally into three equal portions (each 1/3-in. thick); top, mid, and bottom. The top and bottom portions represented the upper and lower exterior surfaces of the steak that had been exposed to the packaging material. The middle portion represented muscle interior that was not exposed to the outside environment until removed for microbial analyses. Each sample was homogenized in 50 ml of 0.1% peptone water for 2 min using a stomacher. Serial dilutions were made using 9 ml of 0.1% peptone water. Aerobic plate counts were determined using 3M Petrifilm™ Aerobic Count Plates (3M, St. Paul, MN) incubated at 95°F for 48 hrs. Coliforms and *E. coli* were determined using 3M Petrifilm™ *E. coli* Count Plates incubated at 95°F for 24 hrs.

A split plot experimental design was used to select for treatments in which storage time and number of blade passes represented the whole plot, and sampling location was the split plot. Data were analyzed using PROC GLM and MIXED of the Statistical Analysis System. Differences among least square means were determined at P<.05. All experiments were replicated three times.

Results and Discussion

Aerobic plate (APC), coliform, and *E. coli* counts increased (P<.05) with aging time (Table 1). Also, APC, coliform, and *E. coli* counts from the exterior (upper plus lower) of muscle were higher (P<.05) than those from the interior, but very low. Counts of *E. coli* and coliforms recovered from BT steaks (1X and 2X) at 7, 14, or 21 d of aging were comparable (P<.05) to counts recovered from non-tenderized (0X; N-BT) steaks. Total APC indicated some translocation of microorganisms from the exterior to the interior (P<.05), and this translocation was more pronounced with longer aging. No interactions (P>.05) were found among storage time, treatment (tenderization), and sampling location. Sanitation, proper handling, and good hygiene practices, which result in low surface microbial counts and clean tenderizer blades, are important to avoid translocation of bacteria during blade tenderization.

Table 1. Average Microbial Counts (log_{10} CFU/cm^2) for Blade Tenderized (1X, 2X) and Non-Tenderized (0X) *longissimus dorsi* Steaks[1,2]

Aging (Days)	Blade Passes	APC		*E. coli*		Coliforms	
		Exterior	Interior	Exterior	Interior	Exterior	Interior
7	0x	1.36 ±1.92	0.82 ±1.15	NG	NG	0.29 ±0.0	0.58 ±0.35
	1x	1.54 ±0.41	0.48 ±0.03	0.15 ±0.21	0.12 ±0.16	0.36 ±0.51	0.21 ±0.30
	2x	1.80 ±1.57	1.21 ±1.25	NG	NG	NG	0.24 ±0.34
14	0x	1.21 ±0.23	0.67 ±0.02	NG	NG	NG	0.13 ±0.0
	1x	1.88 ±0.07	1.03 ±0.33	0.18 ±0.18	NG	0.15 ±0.21	NG
	2x	2.36 ±0.34	1.32 ±0.27	NG	NG	0.07 ±0.09	NG
21	0x	2.65 ±0.17	0.92 ±0.42	0.18 ±0.25	NG	0.12 ±0.16	NG
	1x	2.17 ±0.78	0.89 ±0.33	NG	NG	0.18 ±0.26	NG
	2x	2.67 ±0.08	1.74 ±0.54	NG	NG	0.35 ±0.30	NG
Standard Error (STD)		0.60	0.45	0.09	0.14	0.14	0.14

[1] = Microbial counts reported are means ± standard deviations (n=3).

[2] = NG: No Growth.

Cattlemen's Day 2000

EFFECTS OF QUALITY GRADE, AGING PERIOD, BLADE TENDERIZATION, AND DEGREE OF DONENESS ON TENDERNESS OF STRIP LOIN

C. D. George-Evins, J. A. Unruh, J. L. Marsden, and C. L. Kastner

Summary

We used 162 strip loins to determine the influence of different quality grades, aging periods, blade tenderization passes, and degree of doneness on thawing and cooking loss and Warner-Bratzler shear force (WBS, tenderness). Select (SEL), Choice (CHO), and Certified Angus Beef™ (CAB) strip loins were aged for 7, 14, or 21 days and not tenderized (0X) or blade tenderized one (1X) or two (2X) times. Steaks from each strip loin were assigned randomly to final endpoint cooking temperatures of 150, 160, and 170°F. For steaks aged 7 days, all quality grade and blade tenderization treatments had similar (P>.05) WBS. For steaks aged 14 days, CHO steaks had lower (P<.05) WBS than SEL steaks, CAB tended (P=.07) to have lower WBS than SEL, 2X steaks had lower (P<.05) WBS than 1X steaks, and 1X steaks had lower (P<.05) WBS than 0X steaks. For steaks aged 21 days, CAB steaks had lower (P<.05) WBS than CHO steaks, CHO steaks had lower (P<.05) WBS than SEL steaks, and 2X steaks had lower (P<.05) WBS than 1X steaks. Among the 0X and 2X groups, CAB and CHO steaks had lower (P<.05) WBS than SEL steaks. For the 1X group, only CAB steaks had lower (P<.05) WBS than SEL steaks. Blade tenderization improved tenderness of strip steaks but should be combined with high quality grades, increased aging, and lower endpoint cooking temperatures to achieve maximum tenderness.

(Key Words: Beef, Tenderness, Blade Tenderization, Aging, Quality Grade.)

Introduction

Tenderness is one of the most important palatability factors to beef consumers. Inconsistent and inadequate tenderness is a major concern of the beef industry. A challenge of the industry is to incorporate technologies that reduce variation and improve tenderness. Different quality grades, aging periods, blade tenderization passes, and endpoint cooking temperatures can affect tenderness. Our objective was to determine the influence of these variables on tenderness of strip loin steaks.

Experimental Procedures

We purchased 162 strip loins (IMPS 180) from a commercial packing facility, 54 USDA Select (SEL), 54 USDA Choice (CHO), and 54 Certified Angus Beef (CAB). They were aged for approximately 7, 14, or 21days at 32 to 34°F. After aging, strip loins were not tenderized (0X) or passed through a blade tenderizer (model T7001, Ross Industries Inc., Midland, VA) one (1X) or two (2X) times, then wrapped in film and crust frozen at -35°F for 30 to 40 min in a spiral freezer. Strip loins were cut into 1-inch- thick strip loin (longissimus muscle) steaks, individually vacuum packaged, and frozen for 30 to 40 min at -35°F in the spiral freezer. Frozen steaks were transported to the Kansas State University Meat Laboratory and stored at -20°F until analysis.

Steaks from each strip loin were assigned to endpoint cooking temperatures of 150, 160 and 170°F, representing medium rare, medium, and well done. Steaks were thawed for 24 hours at 37°F and cooked in a Blodgett dual-air-flow gas convection oven

preheated to 325°F. Temperature was monitored by 30-gauge, type-T thermocouples inserted into the geometric center of steaks and attached to a temperature recorder. After cooking, steaks were stored overnight at 37°F. A minimum of six 1/2-inch-diameter cores were taken parallel to the muscle fiber orientation. Cores were sheared perpendicular to the muscle fiber orientation using an Instron Universal Testing Machine with a V-shaped blade on a Warner-Bratzler Shear (WBS) attachment. Thaw weight loss was analyzed as a 3×3×3 factorial design using the GLM procedure of SAS (1998). Cooking loss and WBS were analyzed as a 3×3×3 factorial design with a split plot using the Mixed procedure of SAS (1998). Main effects were grade, aging period, and blade tenderization passes with endpoint cooking temperature serving as the split plot. All interaction and main effect means were separated (P<.05) using the Least Significant Difference procedure when the respective F-tests were significant (P<.05).

Results and Discussion

Percentages of thawing loss were slightly higher (P<.05) for SEL steaks than CHO or CAB steaks and for steaks aged for 14 days than 7 and 21 days (data not shown). As endpoint temperature increased (Table 1), percentage of cooking loss increased (P<.05). A quality grade × blade tenderization interaction (P<.05) was observed for cooking loss (Table 2). For CAB steaks, steaks blade tenderized 2X had more (P<.05) cooking loss than steaks blade tenderized 1X and tended to have more (P=.05) cooking loss than untenderized steaks. However, number of passes through the blade tenderizer did not (P>.05) influence cooking loss for SEL and CHO steaks. For the 0X group, CHO steaks had more (P<.05) cooking loss than CAB steaks. For the 1X group, SEL and CHO steaks had more (P<.05) cooking loss than CAB steaks. For the 2X group, SEL steaks had more (P<.05) cooking loss than CHO steaks.

Interactions (P<.05) of USDA quality grade × blade tenderization × aging period, and aging period × blade tenderization (Table 2) were observed for WBS. Select steaks had similar (P>.05) WBS values regardless of treatment. Choice steaks blade tenderized 2X had lower (P<.05) WBS values than CHO steaks not tenderized or blade tenderized 1X. Furthermore, CAB steaks blade tenderized 2X had lower (P<.05) WBS values than CAB steaks not tenderized and tended (P=.08) to have lower WBS values than those tenderized 1X. Overall, CAB and CHO steaks blade tenderized 2X had lower (more tender) WBS values (<2.8 kg) than the other quality grade × blade tenderization combinations.

For steaks aged 7 days, WBS values were similar (P>.05) among all quality grades. For steaks aged 14 days, CHO steaks had lower (P<.05) WBS values than SEL steaks, and CAB steaks tended (P=.07) to have lower WBS values than SEL steaks. Finally, for steaks aged 21 days, CAB steaks had lower (P<.05) WBS values than either CHO or SEL, and CHO steaks had lower (P<.05) WBS values than SEL steaks. The CAB steaks aged 21days had the lowest (most tender, P<.05) WBS values compared to all other quality grade × aging period means. Only the CAB and CHO steaks aged for 21 days had WBS values less than 6.6 lbs (3 kg). Overall, the higher quality grade steaks aged for 21 days had the highest probability of being tender.

Steaks aged 7 days had similar (P>.05) WBS values for all treatments. For steaks aged 14 days, the 2X group had lower (P<.05) WBS values than the 0X and 1X groups, and the 1X group had lower (P<.05) WBS values than the 0X group. For steaks aged 21 days, the 2X group had lower (P<.05) WBS values than the 1X group. Overall, the improvement in WBS for increased blade tenderization was observed only for steaks aged 14 days. However, steaks blade tenderized 2X and aged for 21 days had the lowest (most tender) WBS mean.

As endpoint cooking temperature increased (Table 1), WBS values increased (P<.05). Our results indicate a strong relationship between increasing endpoint cook-

ing temperature and increased toughness of strip steaks. When muscle is heated, the muscle fibers shrink and become tougher.

A WBS value of 6.6 lbs (3 kg) or less will have a 100% consumer acceptance rating for tenderness. Certified Angus Beef™ steaks aged 21 days and blade tenderized 2X included only one above 6.6 lbs
(3 kg) at any endpoint temperature studied (Table 3). High quality (CAB) combined with longer aging (21 days) and also high quality grades (CHO and CAB) combined with blade tenderizing 2X maximized tenderness of loin strip steaks. Purveyors could select CAB strip loins, age them for at least 21 days, and blade tenderize them 2X to guarantee tenderness. This combination could justify an "always tender" statement on the product.

Table 1. Cooking Loss and Warner-Bratzler Shear (WBS) Force Means of Strip Loin Steaks at Different Endpoint Cooking Temperatures

Item	Endpoint Cooking Temperature, °F			
	150	160	170	SE
Cooking loss, %	20.34[b]	24.13[c]	29.71[d]	.27
WBS, kg	2.74[b]	3.04[c]	3.41[d]	.05

[a]Blade tenderization*endpoint cooking temperature interaction.
[b,c,d]Means within a row with different superscripts differ (P<.05).

Table 2. Cooking Loss (CL) and Warner-Bratzler Shear (WBS) Means of Strip Loin Steaks as Affected by Interactions (P<.05) of Different Quality Grades, Aging Periods, and Blade Tenderization Passes[a]

	Quality Grade / Blade Tenderization Passes									
	SEL			CHO			CAB			
Item	0X	1X	2X	0X	1X	2X	0X	1X	2X	SE
CL, %	24.6[cdef]	25.5[ef]	25.7[f]	25.4[ef]	24.9[def]	24.2[cde]	23.8[cd]	23.2[c]	25.2[def]	.52
WBS, kg	3.27[g]	3.24[fg]	3.28[g]	3.02[ef]	3.20[ef]	2.72[c]	3.06[ef]	2.98[de]	2.77[cd]	.09
	Quality Grade / Aging Period									
	SEL			CHO			CAB			
	7 d	14 d	21 d	7 d	14 d	21 d	7 d	14 d	21 d	SE
WBS, kg	3.10[e]	3.36[f]	3.33[f]	3.01[de]	3.10[e]	2.82[d]	3.07[e]	3.14[ef]	2.59[c]	.09
	Aging Period / Blade Tenderization Passes									
	7 days			14 days			21 days			
	0X	1X	2X	0X	1X	2X	0X	1X	2X	SE
WBS, kg	2.95[cd]	3.12[de]	3.11[de]	3.49[f]	3.20[e]	2.92[cd]	2.91[cd]	3.10[de]	2.74[c]	.09

[a]Quality Grades (SEL=Select, CHO=Choice, CAB=Certified Angus Beef™); Blade Tenderization (0X=not blade tenderized, 1X=blade tenderized one time, 2X=blade tenderized two times).
[c,d,e,f,g]Means within a row with different superscripts differ (P<.05).

Table 3. Number of Strip Loin Steaks with Warner-Bratzler Shear Force Values Greater than 6.6 lbs (3 kg)

Blade	Cooked	SEL[a]			CHO			CAB			
Tend.[b]	Temp., °F	7[c]	14	21	7	14	21	7	14	21	Total
OX	150	2[d]	4	2	3	3	1	2	3	1	21
	160	2	6	5	2	2	1	4	4	0	26
	170	2	6	5	4	6	3	2	6	2	36
1X	150	3	2	3	2	2	2	2	1	1	18
	160	3	4	4	2	5	4	4	4	1	31
	170	5	5	6	3	5	6	4	4	2	40
2X	150	1	2	2	1	0	0	3	1	0	10
	160	4	4	4	2	1	1	3	1	0	20
	170	4	5	4	4	4	3	5	3	1	33
Total		26	38	35	23	28	21	29	27	8	235

[a]SEL=Select, CHO=Choice, CAB=Certified Angus Beef Program™.

[b]0X=Not blade tenderized, 1X=Blade tenderized once, 2X=Blade tenderized twice.

[c]Aging Days.

[d]n=6 for each cell; a total of 486 steaks is represented in this table.

EFFECTS OF QUALITY GRADE, AGING PERIOD, BLADE TENDERIZATION, AND DEGREE OF DONENESS ON TENDERNESS OF TOP SIRLOIN BUTT STEAKS

C. D. George-Evins, J. A. Unruh, J. L. Marsden, and C. L. Kastner

Summary

We used 162 top sirloin butts to determine the influence of different quality grades, postmortem aging periods, blade tenderization passes, and degree of doneness on thawing and cooking losses and Warner-Bratzler shear force (WBS, tenderness). Select (SEL), Choice (CHO), and Certified Angus Beef™ (CAB) top sirloin butts (n=54 for each) were aged for 7, 14, or 21 days and not tenderized (OX) or blade tenderized one (1X) or two (2X) times. Steaks from each top sirloin butt were assigned randomly to final endpoint cooking temperatures of 150, 160, and 170°F. Each longer aging period resulted in lower (P<.05, more tender) WBS. In addition, steaks blade tenderized 2X had lower (P<.05) WBS than steaks not tenderized or blade tenderized 1X. Within each quality grade, WBS increased (P<.05) as endpoint cooking temperature increased. When cooked to 160 or 170°F, CHO and CAB steaks had lower (P<.05) WBS than SEL steaks. Increased aging periods and blade tenderization passes of top sirloin butt steaks improved tenderness. When cooking to higher endpoint temperatures, using higher quality grades will minimize toughness caused by cooking.

(Key Words: Beef, Tenderness, Blade Tenderization, Aging, Quality Grade.)

Introduction

Of beef steaks regularly offered on restaurant menus, the top sirloin steak is less tender and more variable in tenderness and generally has the lowest price. Different quality grades, aging periods, blade tenderization passes, and endpoint cooking temperatures can contribute to tenderness. Our objective was to determine the influence of these variables on tenderness of top sirloin butt steaks.

Experimental Procedures

The procedures for this study followed those described in the previous paper (strip loin, pg. 127), except we used 162 top sirloin butts (IMPS 184A) to obtain top butt (gluteus medius) steaks.

Results and Discussion

Thawing and cooking losses were similar (P>.05) for all quality grade and blade tenderization treatments (Table 1). However, steaks aged 7 days had greater (P<.05) thawing loss than steaks aged 21 days. Steaks aged 14 and 21 days had more (P<.05) cooking loss than those aged 7 days. In addition, for each increase in endpoint cooking temperature (150, 160 and 170°F), cooking losses increased (P<.05; 26.3, 31.0 and 35.1%, respectively). Steaks aged 21 days had lower (more tender, P<.05) WBS values than those aged 14 and 7 days (Table 1). Furthermore, steaks aged 14 days had lower (P<.05) WBS values than steaks aged 7 days. Steaks blade tenderized 2X had lower (P<.05) WBS values than steaks not tenderized or blade tenderized 1X. These results show that blade tenderization and aging can lower WBS. Our results suggest that for maximum tenderness, top sirloin butt steaks should be aged at least 21 days and blade tenderized 2X.

A quality grade × endpoint cooking temperature interaction (P=.05) was detected for WBS (Table 2). Within each quality

grade, as endpoint temperature increased, WBS values increased (P<.05). For steaks cooked to 150°F, WBS values were similar (P>.05) for all quality grades. For those cooked to 160 and 170°F, CHO and CAB steaks had lower (P<.05) WBS values than SEL steaks. Higher quality grades (CHO and CAB) provided some protection against toughening at higher degrees of doneness.

For foodservice, a WBS of 8.6 lbs (3.9 kg) has been used as a threshold to predict a rating of at least "slightly tender". Select steaks aged 14 or 21 days, blade tenderized 2X, and cooked to 150°F had no tough steaks with WBS values above 8.6 lbs (Table 2). Choice steaks aged 14 or 21 days, blade tenderized 2X, and cooked to either 150 or 160°F and CAB steaks aged 21 days and blade tenderized 1X or 2X, regardless of degree of doneness, had no steaks above 8.6 lbs WBS.

Top sirloin butt steaks cooked to lower endpoint temperatures (150°F) were more tender than those cooked to higher temperatures (160 and 170°F). Higher quality grades (CHO and CAB) minimized the toughening by higher endpoint cooking temperatures and provided tenderness "insurance". Longer aging and more blade tenderization passes improved tenderness and consistency of top sirloin butt steaks.

Table 1. Thawing Loss, Cooking Loss, and Warner-Bratzler Shear (WBS) Force Means of Top Sirloin Steaks for Different Quality Grades, Postmortem Aging Periods, and Blade Tenderization Passes[a]

	USDA Quality Grade			Aging, Days			Blade Tenderization			
Item	SEL	CHO	CAB	7	14	21	0X	1X	2X	SE
Thawing loss, %	1.96	1.84	1.70	2.17^{f}	1.82^{fg}	1.52^{g}	2.01	1.90	1.59	.13
Cooking loss, %	30.8	30.4	30.8	29.8^{f}	31.3^{g}	30.9^{g}	30.5	30.7	30.8	.30
WBS, kg[b]	*	*	*	3.96^{f}	3.64^{g}	3.47^{h}	3.87^{i}	3.76^{i}	3.43^{j}	.05

[a]Quality Grades (SEL=Select, CHO=Choice, CAB=Certified Angus Beef™); Blade Tenderization (0X=not blade tenderized, 1X=blade tenderized one time, 2X=blade tenderized two times).

[b]Quality Grade*Endpoint Cooking Temperature interaction.

[f,g,h]Means within a row and postmortem age with different superscripts differ (P<.05).

[i,j]Means within a row and blade tenderization with different superscripts differ (P<.05).

Table 2. Warner-Bratzler Shear (WBS) Force Means of Top Sirloin Butts as Affected by Interaction of Different USDA Quality Grades and Endpoint Cooking Temperatures

Grade[a]	150°F	160°F	170°F	SE
SEL	3.29[b]	4.12[ce]	4.31[de]	.07
CHO	3.25[b]	3.69[cf]	3.96[df]	.07
CAB	3.14[b]	3.56[cf]	3.90[df]	.07

[a]SEL=Select, CHO=Choice, CAB=Certified Angus Beef™.

[b,c,d]Means within a row with different superscripts differ (P<.05).

[e,f]Means within a column with different superscript differ (P<.05).

Table 3. Number of Top Sirloin Butt Steaks with Warner-Bratzler Shear Force Values Greater than 8.6 lbs (3.9 kg)

		SEL[a]			CHO			CAB			
BT Treatment[b]	Cooked Temp., °F	7[c]	14	21	7	14	21	7	14	21	Total
	150	3[d]	1	1	1	1	1	0	0	1	9
0X	160	6	5	5	3	0	2	3	0	1	25
	170	6	6	3	5	5	2	5	1	4	37
	150	0	1	1	1	1	0	1	1	0	6
1X	160	5	4	3	4	2	1	3	1	0	23
	170	4	5	3	4	2	3	1	2	0	24
	150	1	0	0	1	0	0	1	0	0	3
2X	160	4	3	1	1	0	0	2	1	0	12
	170	4	4	1	1	3	1	4	3	0	21
Total		33	29	18	21	14	10	20	9	6	160

[a]SEL=Select, CHO=Choice, CAB=Certified Angus Beef™.

[b]0X=Not blade tenderized, 1X=blade tenderized one time, 2X=blade tenderized two times.

[c]Day of postmortem aging.

[d]n=6 for each cell; a total of 486 steaks is represented in this table.

EFFECTS OF QUALITY GRADE, AGING PERIOD, BLADE TENDERIZATION, AND DEGREE OF DONENESS ON TENDERNESS OF INSIDE ROUND STEAKS

C. D. George-Evins, J. A. Unruh, J. L. Marsden, and C. L. Kastner

Summary

We used 162 inside rounds to determine the influence of different quality grades, postmortem aging periods, blade tenderization passes, and degree of doneness on thawing and cooking losses and Warner-Bratzler Shear force (WBS, tenderness). Select (SEL), Choice (CHO), and Certified Angus Beef™ (CAB) inside rounds were aged for 7, 14, or 21 days and not tenderized (0X) or blade tenderized one (1X) or two (2X) times. Steaks from each inside round were assigned randomly to final endpoint cooking temperatures of 150, 160, and 170°F. Percentage of thawing loss was higher (P<.05) for steaks aged 7 days than steaks aged 14 and 21 days. For CHO steaks only, cooking loss was higher (P<.05) for the 2X group compared to the 0X and 1X groups. Steaks aged 14 and 21 days had lower (P<.05) WBS than steaks aged 7 days. Cooking loss and WBS were higher (P<.05) with each increase in endpoint cooking temperature. Postmortem aging (14 or 21 days) and lower endpoint cooking temperatures were the most effective methods to improve WBS of inside round steaks.

(Key Words: Beef, Tenderness, Blade Tenderization, Aging, Quality Grade.)

Introduction

Cuts from the round are generally less tender than those from the rib and loin. This presents a merchandising challenge. Different quality grades, aging periods, blade tenderization passes, and endpoint cooking temperatures may affect tenderness. Our objective was to determine the influence of these variables on tenderness of inside round steaks.

Experimental Procedures

The procedures for this study followed those described in a previous article (strip loin, pg. 127), except we used 162 inside rounds (IMPS 168) to obtain inside round (semimembranosus) steaks.

Results and Discussion

Thawing losses were similar (P>.05) for steaks of all quality grades and blade tenderization treatments (Table 1). Steaks aged 14 and 21 days had less (P<.05) thawing loss than steaks aged 7 days. Cooking losses were similar (P>.05) for all postmortem aging periods. A USDA quality grade × blade tenderization interaction (P<.05) was observed for cooking loss (Table 2). For SEL and CAB steaks, cooking loss was similar (P>.05) among blade tenderization treatments. However, CHO steaks tenderized 2X had greater (P<.05) cooking loss than CHO steaks not tenderized. For the 0X group, SEL steaks had more (P<.05) cooking loss than CHO and CAB steaks. However, quality grade treatments had similar (P>.05) percentages of cooking losses for steaks blade tenderized either 1X or 2X. Warner-Bratzler Shear values (WBS) were similar (P>.05) for quality grades and blade tenderization treatments (Table 1). Steaks aged 14 or 21 days had lower (P<.05) WBS values than those aged 7 days. As endpoint cooking temperature increased (Table 3), percentage of cooking loss and WBS increased (P<.05).

For foodservice, a WBS of 8.6 lbs (3.9 kg) has been used as a limit for a rating of at least "slightly tender". Although many treatment combinations had steaks that didn't meet this limit (Table 4), increasing endpoint temperatures resulted in increasing numbers of steaks with WBS over 8.6 lbs. The CAB grade had fewer steaks with WBS values above 8.6 lbs than CHO or SEL grades, and steaks blade tenderized 2X had fewer values above this limit than steaks in the 0X or 1X groups. Select and Choice steaks aged 14 or 21 days tended to have fewer steaks with WBS values above 8.6 lbs than steaks aged 7 days.

Quality grade and blade tenderization treatments had minimal effect on tenderness (WBS) of inside round (semimembranosus) steaks. Aging for at least 14 days and lower endpoint cooking temperatures (150°F) were the most effective ways to improve tenderness (WBS).

Table 1. Thawing Loss, Cooking Loss, and Warner-Bratzler Shear Force (WBS) Means of Inside Round Steaks for Different Quality Grades, Aging Periods, and Blade Tenderization Passes[a]

	Quality Grade			Aging Period, days			Blade Tenderization			
Item	SEL	CHO	CAB	7	14	21	0X	1X	2X	SE
Thawing loss, %	1.93	1.83	1.72	2.37[c]	1.62[b]	1.47[b]	2.07	1.72	1.68	.15
WBS, kg	3.69	3.71	3.58	3.84[c]	3.59[b]	3.55[b]	3.74	3.67	3.58	.06

[a]Quality Grades (SEL=Select, CHO=Choice, CAB=Certified Angus Beef™); Blade Tender-ization (0X=not blade tenderized, 1X=blade tenderized one time, 2X=blade tenderized two times).

[b,c]Means within a row within postmortem age with different superscripts differ (P<.05).

Table 2. Cooking Loss Means of Inside Round Steaks as Affected by Interaction of USDA Quality Grade and Blade Tenderization

	Blade Tenderization Treatment[a]			
Grade[b]	0X	1X	2X	SE
SEL	31.81[e]	31.09	30.80	.51
CHO	29.44[cf]	31.05[cd]	31.56[d]	.51
CAB	30.16[f]	30.68	31.29	.51

[a]0X= not blade tenderized, 1X=blade tenderized one time, 2X=blade tenderized two times.

[b]SEL=Select, CHO=Choice, CAB=Certified Angus Beef™.

[c,d]Means within CHO row with same superscript letter do not differ (P>.05).

[e,f]Means within a column with different superscripts differ (P<.05).

Table 3. Cooking Loss and Warner-Bratzler Shear Force (WBS) Means of Inside Round Steaks at Different Endpoint Cooking Temperatures

	Endpoint Cooking Temperature, °F			
Item	150	160	170	SE
Cooking loss, %	25.31[a]	31.11[b]	36.20[c]	.27
WBS, kg	3.28[a]	3.73[b]	3.97[c]	.05

[a,b,c]Means within a row with different superscripts differ (P<.05).

Table 4. Number of Inside Round Steaks with Warner-Bratzler Shear Force Values Greater than 8.6 lbs (3.9 kg)

BT	Cooked	SEL[a]			CHO			CAB			
Treatment[b]	Temp., °F	7[c]	14	21	7	14	21	7	14	21	Total
	150	0	2	0	1	0	0	0	1	1	5
0X	160	3	4	3	5	0	3	2	2	1	23
	170	4	4	3	5	4	3	3	4	2	32
	150	2	0	0	2	0	0	0	2	1	7
1X	160	2	2	4	3	4	2	1	2	2	22
	170	3	1	4	5	5	4	3	3	5	33
	150	0	0	0	3	1	0	1	0	0	5
2X	160	3	1	1	3	1	0	1	0	2	12
	170	5	2	3	3	2	1	2	1	1	20
Total		22	16	18	30	17	13	13	15	15	159

[a]SEL=Select, CHO=Choice, CAB=Certified Angus Beef™.

[b]0X = not blade tenderized, 1X = blade tenderized one time, 2X = blade tenderized two times.

[c]Days of postmortem aging.

INDEX OF KEY WORDS

Indexer's note: The numbers refer to the first pages of each article that uses the listed key word.

BIOLOGICAL VARIABILITY AND STATISTICAL EVALUATION OF DATA

The variability among individual animals in an experiment leads to problems in interpreting the results. Animals on treatment X may have a higher average daily gain than those on treatment Y, but variability within the groups may indicate that the difference between X and Y is not the result of the treatment alone. You can never be totally sure that the difference you observe is due to the treatment, but statistical analysis lets researchers calculate the probability that such differences are from chance rather than from the treatment.

In some articles, you will see the notation "P<.05." That means the probability that the observed difference was due to chance is less than 5%. If two averages are said to be "significantly different," the probability is less than 5% that the difference is due to change— the probability exceeds 95% that the difference is true and was caused by the treatment.

Some papers report correlations — measures of the relationship between traits. The relationship may be positive (both traits tend to get larger or smaller together) or negative (as one gets larger, the other gets smaller). A perfect correlation is either +1 or –1. If there is no relationship at all, the correlation is zero.

You may see an average given as 2.5 ± .1. The 2.5 is the average; .1 is the "standard error." That means there is a 68% probability that the "true" mean (based on an unlimited number of animals) will be between 2.4 and 2.6. "Standard deviation" is a measure of variability in a set of data. One standard deviation on each side of the mean is expected to contain 68% of the observations.

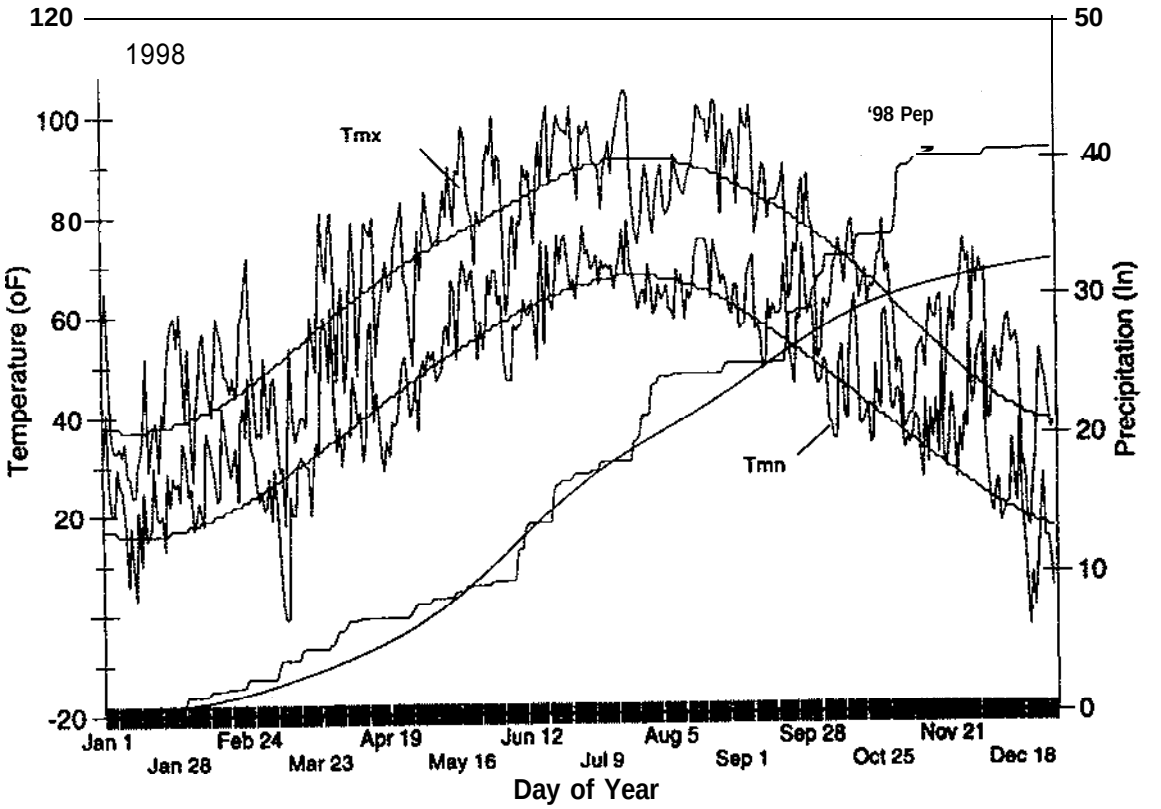
Many animals per treatment, replicating treatments several times, and using uniform animals all increase the probability of finding real differences when they actually exist. Statistical analysis allows more valid interpretation of the results, regardless of the number of animals in an experiment. In the research reported herein, statistical analyses are included to increase the confidence you can place in the results.

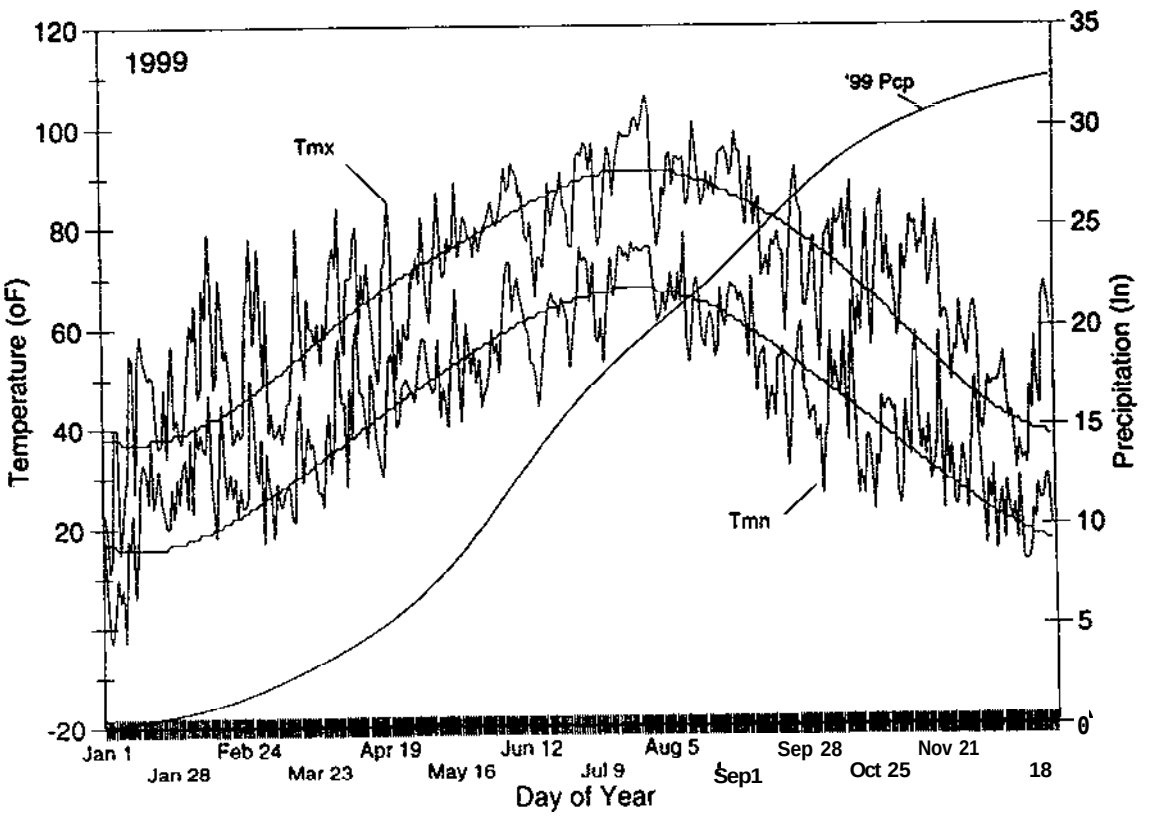
In most experiments, the statistical analysis is too complex to present in the space available. Contact the authors if you need further statistical information.

WEATHER DATA, 1998-1999

On the following page are graphs of the 1998 and 1999 Manhattan weather. They were produced by the Kansas State University Weather Data Library. The smooth line that starts in the lower left corner of each graph is the normal accumulated precipitation since January 1. The rough line starting in the lower left corner represents actual accumulated precipitation. A long horizontal section of that line represents time during which no precipitation fell. A vertical section represents precipitation. The other two smooth lines represent average daily high and low temperatures, and the rough lines represent actual highs and lows.

These graphs are included because much of the data in this publication, especially data on animal maintenance requirements and forage yields, can be influenced by weather. Weather graphs have been included in Cattlemen's Day publications since 1985.





Summaries of Weather in Manhattan, KS, 1998 and 1999

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Bressner Pasture Committee, Yates Center, Kansas
Brill Corporation, Norcross, Georgia
Cargill Corn Wet Milling Division, Blair, Nebraska
Cargill Flour Milling Division, Wichita, Kansas
Cargill Meat Sector, Minneapolis, Minnesota
Central City Scale, Central City, Nebraska
Consolidated Nutrition, Omaha, Nebraska
Dow Agrosciences, Indianapolis, Indiana
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Hoechst Roussel Vet, Summerville, New Jersey
ibp, inc., Emporia, Kansas
Iowa Limestone Company, Des Moines, Iowa
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Kansas Livestock Assn., Topeka, Kansas
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Kansas Grain Sorghum Commission, Topeka, Kansas
Kansas Soybean Commission, Topeka, Kansas
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Pharmacia and Upjohn, Kalamazoo, Michigan
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Rhone Poulenc Animal Nutrition, Atlanta, Georgia
Ross Industries, Midland, Virginia
Schering-Plough Animal Health, Kenilworth, New Jersey
Select Sires, Plain City, Ohio
Shugert Farms, Lore City, Ohio
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VetLife, Inc., Overland Park, Kansas
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