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Cattlemen's Day 1998

EFFECTS OF SUPPLEMENTAL DEGRADABLE INTAKE PROTEIN ON INTAKE AND DIGESTIBILITY OF LOW-QUALITY BROME HAY

C. P. Mathis, R. C. Cochran, J. S. Heldt, B. C. Woods, K. C. Olson, G. L. Stokka, and E. C. Titgemeyer

Summary

The effects of increasing levels of degradable intake protein (DIP) on intake and digestion of low-quality brome hay were evaluated using 16 ruminally fistulated beef steers. Trends were evident for small, positive changes in total intake and digestion with increasing level of DIP supplementation. As a result, total digestible OM intake (TDOMI) increased with DIP supplement-ation but tended to plateau below the highest supplementation level.

(Key Words: Steers, Forage, Intake, Digestion, Degradable Intake Protein.)

Introduction

Beef cattle in midwestern and plains states are commonly fed brome hay. When harvested at advanced stages of maturity, the quality of brome hay is similar to a number of low quality forages (such as winter range). Previous research with low-quality, tallgrass-prairie forage has demonstrated that supplementation with degradable intake protein (DIP) dramatically improves forage intake and utilization. In addition, the amount of DIP needed to maximize total digestible forage intake has been defined. Because information pertaining to the effects of DIP supplementation on low-quality brome hay is limited, our study was conducted to provide that information.

Experimental Procedures

Sixteen ruminally fistulated beef steers (average body weight, 675 lb) were blocked by weight and assigned to one of four increasing levels of DIP. Each steer was offered brome hay at 130% of the average voluntary intake for the preceding 5-day period. Supplemental DIP (sodium caseinate; 91.6% CP, 100% DIP) was ruminally infused at 7:00 AM, immediately prior to feeding forage to provide .041, .082, and .124% BW/day; controls received none. The forage contained 65.4% NDF and 5.9% CP, of which 49% was DIP. DIP was estimated using an in situ technique. Following a 10-day adaptation, feed offered, feed refused, and total fecal output were measured for 7 days to calculate digestibility coefficients and determine the intake response.

Results and Discussion

Total feed intake tended ($P \leq .15$) to increase in proportion to increasing level of DIP supplementation (Table 1). Because total diet organic matter digestion also exhibited a weak tendency to increase, when intake and digestion were combined, there was a linear increase (P=.06) in total digestible organic matter intake (TDOMI) as level of DIP supplementation increased. However, the DIP effect on TDOMI tended (P=.17) to diminish at the highest DIP intake. Peak TDOMI was observed at the .082% BW supplementation level, which is likely to be close to the amount of DIP needed to maximize TDOMI. Assuming that 49% of total

forage CP was DIP, total DIP consumed by steers on the .082% treatment was approximately 10% of TDOMI.

Table 1. Effects of Increasing Amounts of Degradable Intake Protein on DM and OM Intakes and Digestibilities in Beef Steers Fed Brome Hay

	DIP (% BW)					Contrasts[a]		
Item	0	.041	.082	.124	SEM[b]	L	Q	C
DM[c] intake	- - - - - - - - - - % BW - - - - - - - - - -							
Forage	2.69	2.89	2.97	2.84	.14	.42	.27	.88
Total	2.69	2.93	3.06	2.98	.14	.27	.27	.90
DM intake	- - - - - - - - - g/kg $BW^{.75}$ - - - - - - - -							
Forage	112.0	120.1	123.8	119.1	5.3	.32	.26	.87
Total	112.0	121.9	127.5	124.7	5.3	.10	.26	.87
OM[d] intake	- - - - - - - - - % BW - - - - - - - - - -							
Forage	2.55	2.72	2.80	2.68	.13	.45	.28	.88
Total	2.55	2.77	2.88	2.81	.13	.15	.27	.88
OM intake	- - - - - - - - - g/kg $BW^{.75}$ - - - - - - - -							
Forage	106.0	113.4	116.7	112.3	5.0	.34	.26	.87
Total	106.0	115.2	120.3	117.7	5.0	.10	.26	.87
Total DOMI[e]								
% BW	1.49	1.66	1.75	1.69	.08	.09	.18	.83
g/kg $BW^{.75}$	61.9	69.0	73.1	70.8	3.1	.06	.17	.81
Total OMD[f], %	58.4	60.0	60.8	60.1	.9	.19	.25	.88
Total NDFD[g], %	52.5	51.1	54.7	53.4	1.1	.55	.22	.85
Total DIPI[h]								
% BW	.081	.128	.172	.209	.004	<.01	.26	.82
g/kg $BW^{.75}$	3.38	5.34	7.19	8.77	.16	<.01	.27	.86

[a]L = Linear, Q = Quadratic, C = Cubic.
[b]Standard error of the mean (n=4).
[c]DM = dry matter.
[d]OM = organic matter.
[e]DOMI = digestible organic matter intake.
[f]OMD = organic matter digestion.
[g]NDFD = neutral detergent fiber digestion.
[h]DIPI = degradable intake protein intake.

EFFECTS OF SUPPLEMENTAL DEGRADABLE INTAKE PROTEIN ON INTAKE AND DIGESTIBILITY OF BERMUDA HAY

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Summary

A study with 16 ruminally fistulated beef steers fed Bermuda hay ad libitum showed that the intake and digestibility of hay was not influenced by increasing levels of supplemental degradable intake protein (DIP). However, the hay used in this study was of medium quality; lower quality Bermuda hay with lower CP may respond to supplemental DIP.

(Key Words: Steers, Forage, Intake, Digestion, Degradable Intake Protein.)

Introduction

Over the last decade, the approach to protein nutrition in ruminants has shifted from the traditional crude protein (CP) system to a metabolizable protein (MP) system described by the Natural Research Council in the 1996 Nutrient Requirements of Beef Cattle. Metabolizable protein is defined as the true protein absorbed by the small intestine. It is supplied by microorganisms passing out of the rumen and by undegradable intake protein (UIP) that escapes ruminal degradation. The MP system accounts for the degradation of protein in the rumen and separates protein requirements into degradable intake protein (DIP) which is needed by ruminal microorganisms and that needed by the animal (UIP). Crude protein = DIP + UIP.

Bermuda hay is a common roughage source for beef cattle in the southern United States, including portions of Oklahoma and Kansas. It typically contains 7 to 12% CP. Previous research on low-quality (CP<7%), tallgrass-prairie forage has demonstrated that DIP is the first-limiting nutrient for optimal forage utilization, and that DIP supplementation dramatically improves forage intake and digestion. Although the amount of DIP needed to maximize total digestible forage intake has been defined for tallgrass-prairie forage, information on the effects of DIP supplementation on medium-quality hay such as Bermuda is limited. Our study was conducted to determine the impact of DIP supplementation on Bermuda hay intake and digestion.

Experimental Procedures

Sixteen ruminally fistulated beef steers (average body weight, 653 lb) were blocked by weight and assigned to one of four treatments with increasing levels of DIP. Each steer was offered Bermuda hay at 130% of the average voluntary intake for the preceding 5 days. Supplemental DIP (sodium caseinate; 91.6% CP, 100% DIP) was infused ruminally at 7:00 AM, immediately prior to feeding forage. The forage contained 70.8% NDF and 8.2% CP, of which 60% was DIP. DIP was estimated using an in situ technique. The levels of supplemental DIP infused were .041, .082, and .124% BW/day. Controls received none. Following a 10-day adaptation, feed offered, feed refused, and total fecal output were measured for 7 days, in order to calculate intake response and digestibility coefficients.

Results and Discussion

Supplemental DIP exerted essentially no effect on forage or total OM intake, total OM digestion, or total digestible OM intake. Similarly, neither total NDF intake nor NDF digestibility were altered. We conclude that DIP was not significantly limiting the utilization of the Bermuda hay used in this study, in spite of the fact that the DIP in the Bermuda (about 8.3% of total digestible OM intake) was considerably less than the 11% previously demonstrated to maximize intake and digestion of lower quality (CP<7%) forages (such as winter tallgrass-prairie forage). The low level of DIP intake at which total diet intake and digestion were maximized is surprising and deserves additional evaluation. The Bermuda hay used in our study was of medium quality. Feeding Bermuda hay of lower quality (particularly with lower CP) might elicit a response to supplemental DIP.

Table 1. Effect of Increasing Amounts of Degradable Intake Protein on DM and OM Intakes and Digestibility in Beef Steers Fed Bermuda Hay

	DIP (% BW)					Contrasts[a]		
Item	0	.014	.082	.124	SEM[b]	L	Q	C
Dm[c] intake	- - - - - - - - - - % BW - - - - - - - - -							
Forage	2.45	2.21	2.28	2.27	.15	.45	.39	.50
Total	2.45	2.25	2.37	2.40	.15	.96	.39	.50
DM intake	- - - - - - - - g/kg $BW^{.75}$ - - - - - - - - -							
Forage	101.1	91.6	94.9	93.3	6.0	.43	.47	.46
Total	101.1	93.5	98.6	98.8	6.1	.94	.48	.45
Om[d] intake	- - - - - - - - - - % BW - - - - - - - - -							
Forage	2.30	2.06	2.33	2.11	.14	.41	.38	.48
Total	2.30	2.11	2.21	2.24	.14	.94	.38	.49
OM intake	- - - - - - - - g/kg $BW^{.75}$ - - - - - - - -							
Forage	94.4	85.7	88.7	86.9	5.5	.41	.49	.45
Total	94.4	87.5	92.3	92.2	5.5	.94	.49	.44
Total DOMI[e]								
% BW	1.45	1.27	1.42	1.43	.09	.84	.27	.21
g/kg $BW^{.75}$	59.8	52.5	59.1	58.7	3.9	.84	.35	.19
Total OMD[f], %	63.2	60.0	64.2	63.9	1.5	.35	.31	.07
Total NDFD[g], %	65.9	62.2	64.3	63.5	1.7	.49	.36	.20
Total DIPI[h]								
% BW	.120	.156	.193	.233	.008	<.01	.35	.37
g/kg $BW^{.75}$	4.83	5.98	7.96	9.50	.29	<.01	.47	.27

[a]L = Linear, Q = Quadratic, C = Cubic.
[b]Standard error of the mean (n=3).
[c]DM = dry matter.
[d]OM = organic matter.
[e]DOMI = digestible organic matter intake.
[f]OMD = organic matter digestion.
[g]NDFD = neutral detergent fiber digestion.
[h]DIPI = degradable intake protein intake.

EFFECTS OF INCREASING AMOUNTS OF SUPPLEMENTAL SOYBEAN MEAL ON INTAKE AND DIGESTIBILITY OF TALLGRASS-PRAIRIE HAY

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Summary

Twenty ruminally fistulated beef steers with free-choice access to prairie hay were used to evaluate the effect of increasing level of soybean meal (SBM) on forage intake and digestion. Forage intake, total organic matter intake, and organic matter digestion were enhanced with increasing level of SBM supplementation, although forage intake and digestion appeared to plateau at higher levels. The concomitant rises in intake and digestion as supplemental SBM increased resulted in an increase in total digestible organic matter intake, with the largest response to the initial increment of supplement.

(Key Words: Steers, Forage, Intake, Digestion, Soybean Meal.)

Introduction

Prairie hay is a common roughage source for beef cattle throughout Kansas and the midwest. Previous research conducted at Kansas State University demonstrated that supplementation with degradable intake protein (DIP) dramatically improves intake and digestion of low-quality, tallgrass-prairie forage, and demonstrated the amount of DIP needed to maximize total digestible forage. However, in those preliminary studies, DIP was supplied in a purified form, sodium caseinate. Therefore, to link previous work to a more practical setting, potential feedstuffs high in DIP must be identified, and their response evaluated. The present study was conducted to evaluate the impact of increasing levels of soybean meal (SBM), an oilseed by-product containing a relatively high concentration of DIP, on prairie hay intake and digestion.

Experimental Procedures

Twenty ruminally fistulated beef steers (average body weight, 813 lb) were blocked by weight and assigned to one of five treatments to evaluate the effect of increasing level of high-protein SBM on forage intake and digestion. Each steer was offered prairie hay at 130% of average voluntary intake for the preceding 5-day period. The forage contained 69.4% NDF, and 5.3% CP, 49% of which was DIP (single-point enzyme assay). Supplemental SBM (9.8% NDF, 53.4% CP) was fed at 6:30 AM and steers were fed forage at 7:00 AM. Supplemental SBM was offered at .08, .16, .33, and .50% BW/day, which provided .029, .058, .116, and .175% BW/day of DIP. Controls recieved none. The SBM crude protein was assumed to be 66% DIP (1996 National Research Council; Nutrient Requirements of Beef Cattle). We also used a single-point enzyme system to provide an alternate estimate. Following a 14-day adaptation, feed offered, feed refused, and fecal output were measured for 7 days, and the information was used to monitor intake response and calculate digestibility coefficients.

Results and Discussion

Forage and total organic matter intakes (FOMI and TOMI, respectively) increased (P<.01) with increasing SBM supplementation (Table 1). However, FOMI appeared to plateau (P=.02) once the level of SBM supplementation reached .16% BW/day. However, TOMI continued to increase up to the highest level fed (.5% BW/day). Organic matter digestibility (OMD) also increased (P<.01) with increasing supplemental SBM up to the highest level. Fiber digestion (NDF digestion) responded similarly. The concomitant rises in TOMI and OMD as supplemental SBM increased resulted in an increase in TOMI. The largest proportional response was observed with the initial increment of supplement. Thereafter, the response was smaller, and once the .16% BW/day level was reached, appeared to be due predominately to higher levels of highly digestible SBM. If the table values are used for SBM DIP (i.e., 66%), then the total DIP intake is 8.4% of the TOMI for the .16% BW treatment. If the enzymatic estimate of SBM DIP is used (84% of CP), that value is about 9.4%. We suspect that the breakpoint in response (which should be indicative of maximal forage utilization) would fall close to these values.

Table 1. Effects of Increasing Amounts of Soybean Meal on DM and OM Intakes and Digestibility in Beef Steers Fed Tallgrass-Prairie Hay

	Soybean Meal (% BW)						Contrast[a]		
Item	0	.08	.16	.33	.50	SEM	L	Q	C
DM[c] intake	- - - - - - - - - - - - - % BW - - - - - - - - - - - - -								
Forage	1.89	2.39	2.72	2.48	2.73	.13	<.01	.04	.02
Total	1.89	2.47	2.89	2.80	3.23	.13	<.01	.04	.02
DM intake	- - - - - - - - - - - - - - g/kg $BW^{.75}$ - - - - - - - - - - - - -								
Forage	81.9	105.2	119.1	108.6	118.6	5.2	<.01	.02	.01
Total	81.9	108.8	126.4	123.0	140.2	5.2	<.01	.02	.01
Om[d] intake	- - - - - - - - - - - - - - - $BW^{.75}$ - - - - - - - - - - - - - - -								
Forage	1.75	2.22	2.52	2.29	2.53	.12	<.01	.04	.02
Total	1.75	2.29	2.67	2.60	2.99	.12	<.01	.04	.02
OM intake	- - - - - - - - - - - - - - g/kg $BW^{.75}$ - - - - - - - - - - - - -								
Forage	75.7	97.5	110.3	100.5	110.0	4.9	<.01	.02	.01
Total	75.7	100.8	116.9	113.9	130.0	4.9	<.01	.02	.01
Total DOMI[e]									
% BW	.88	1.31	1.44	1.58	1.87	.09	<.01	.05	.03
g/kg $BW^{.75}$	37.9	57.4	67.3	69.5	81.6	3.7	<.01	.03	.03
Total OMD[f]	50.0	56.8	57.6	60.9	62.6	1.2	<.01	.02	.18
Total NDFD[g]	48.7	56.0	56.6	57.7	58.2	1.6	<.01	.03	.12
Total DIPI[h]									
% BW	.049	.091	.129	.180	.246	.003	<.01	.05	.01
g/kg $BW^{.75}$	2.12	4.00	5.63	7.90	10.69	.14	<.01	.02	.01
Total DIPI[i]									
% BW	.049	.099	.144	.211	.293	.003	<.01	.07	.02
g/kg $BW^{.75}$	2.12	4.34	6.31	9.26	12.74	.136	<.01	.02	.01

[a]L = Linear, Q = Quadratic, C = Cubic. [b]Standard error of the mean (n=4). [c]DM = dry matter. [d]OM = organic matter. [e]DOMI = digestible organic matter intake. [f]OMD = organic matter digestion. [g]NDFD = neutral detergent fiber digestion. [h]DIPI = degradable intake protein intake; SBM DIP estimate from 1996 Beef NRC.

IMPACT OF INCREASING AMOUNTS OF SUPPLEMENTAL HIGH-PROTEIN SOYBEAN MEAL ON PERFORMANCE OF RANGE BEEF COWS [1]

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Summary

One hundred and twenty spring-calving Hereford × Angus cows grazing low-quality, tallgrass-prairie forage were fed 1.0, 1.5, 2.0, 2.5, 3.0, 4.0, 5.0, or 6.0 lb soybean meal (SBM) per head daily. SBM as a source of supplemental degradable intake protein (DIP) can be effective in maintaining cow body weight and body condition during the winter grazing season. Performance as measured by changes in body weight and condition score was maximized when cows received approximately 3.5 to 3.8 lb/day. Below this level, cows lost about 48 lb (about .4 units of BCS) for every 1 lb decrease in the amount of supplemental SBM. The effect of amount of supplemental SBM on calf performance was minimal.

(Key Words: Range Cows, Forage, Soybean Meal.)

Introduction

Protein supplementation to beef cattle grazing low-quality, tallgrass-prairie forage has been a long-standing practice. However, in recent years, the mechanisms by which that protein is utilized have become more clear. We now classify the protein that is degraded by microbes in the rumen as degradable intake protein (DIP) and the protein that escapes ruminal degradation and passes through the rumen to the small intestine without being altered as undegradable intake protein (UIP).

Research at Kansas State University demonstrates that DIP is the first-limiting nutrient for optimal intake and utilization of low-quality forage. However, that research was conducted by supplementing DIP in a purified form (sodium caseinate). Applying that research under production conditions requires identification of potential protein supplements that are high in DIP. Soybean meal (SBM), in which 66% of the protein is DIP, is a good candidate.

The objectives of this study were to identify the level of SBM that elicits maximum performance response and to define the rate of performance decline below the maximum response.

Experimental Procedures

A performance study was conducted during winter 1996-97 to evaluate the impact of level of supplemental SBM on body weight, body condition, and pregnancy rate of spring-calving beef cows grazing low-quality, tallgrass-prairie forage. Forage samples clipped from the pastures contained 76% NDF and 2.7% CP, with 49% of the CP as DIP. DIP was estimated using a single-point enzyme assay. The SBM was 10.1% NDF and 53.9% CP, with 66% of the CP as DIP (1996 Beef NRC). One hundred and twenty Hereford × Angus cows (average initial body weight, 1141 lb; average initial body condition score, 5.3) were allotted randomly to one of three pastures. Within each pasture, cows were assigned to one of eight levels of supplemental SBM; 1.0, 1.5, 2.0, 2.5, 3.0, 4.0,

[1]Appreciation is expressed to the Bunge Corporation for providing the soybean meal used and to Gary Ritter and Wayne Adolph for their assistance.

5.0, and 6.0 lb/head/day as-fed. Cattle in each pasture were gathered daily, sorted into their respective treatments, group-fed their supplement, and then returned to pasture. The treatment period began December 2, 1996 and was terminated on February 10, 1997, which was the first day of the calving season. After the calving season began, all cows were fed 3.8 lb/head/day until they calved. Following parturition, cows were fed 10 lb/head/day of alfalfa until sufficient new grass growth was available in the spring. Body weight and condition were measured at approximately 1-month intervals until the beginning of the calving season. Thus, measurements were obtained on December 2, January 6, and February 10, with additional measures postcalving (within 48 h after calving), shortly before the beginning of the breeding season (May 8), and at weaning (October 1). Cows were bred by natural service to Angus bulls.

Results and Discussion

Losses in cow body weight (BW) and body condition score (BCS) through the beginning of the calving season (Table 1) were reduced (linear $P<.01$) by increasing the level of supplemental soybean meal (SBM); however, both BW and BCS showed a clear plateau (quadratic $P<.01$). Maximal BW response to supplemental SBM was achieved at approximately 3.5 lb/head/ day, and BCS response was maximized at approximately 3.8 lb/head/day. Feeding SBM above these levels yielded no further reduction in BW or BCS loss. Below this point of maximal response (3.5 to 3.8 lb SBM/head/day), each 1 lb decrease in SBM fed daily resulted in a 48 lb reduction in BW and a .4 unit decrease in BCS.

The level of SBM fed from the beginning of the winter grazing season until the beginning of the calving season had no affect on calf birth date (Table 2; $P>.52$) or calf average daily gain ($P>.43$). However, there was a trend for level of supplemental SBM to affect calf birth weight (linear $P=.14$; quadratic $P=.16$) and weaning weight (quadratic $P=.12$). Pregnancy rate not influenced significantly ($P=.51$).

Knowledge of the amount of supplemental SBM at which performance is maximized and the rate of decline below that maximum can be used as a rough guideline for determining the amount of supplemental SBM necessary to achieve a specified level of BW or BCS change in spring-calving beef cows grazing winter range.

Table 1. Effects of Increasing Amounts of Supplemental Soybean Meal (SBM) on Cumulative and Period Body Weight (BW) and Condition Score[a] (BCS) Change, Pregnancy Rate, and Calf Performance of Beef Cows Grazing Dormant, Tallgrass-Prairie Forage

	Supplemental SBM, lb									
Item	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0	SEM	Contrasts[b]
No. of cows	15	15	15	15	15	15	15	15		
Initial BW, lb	1138	1152	1136	1153	1125	1137	1132	1160	27.6	NS
Period BW change, lb										
2 Dec - 6 Jan	-60	-43	-31	-21	-8	-2	4	8	8.5	L, Q
7 Jan - 10 Feb[c]	-49	-16	-15	-13	11	15	17	30	6.7	L, Q
11 Feb - 8 May[d]	-146	-166	-184	-199	-210	-226	-244	-232	15.3	L, Q
8 May - 1 Oct[e]	259	238	261	192	198	216	213	173	19.1	L
Cumulative BW change, lb										
2 Dec - 10 Feb	-255	-212	-193	-201	-185	-140	-162	-	13.6	L, Q
2 Dec- 8 May	-255	-266	-228	-224	-206	-209	-223	-	18.0	L
2 Dec - 1 Oct	3	31	32	-32	-8	7	-10	-23	19.5	NS
Initial BCS	5.28	5.22	5.28	5.17	5.33	5.22	5.30	5.3	.15	NS
Period BCS change										
2 Dec - 6 Jan	-.82	-.58	-.75	-.45	-.18	-.23	-.15	-.23	.095	L, Q
7 Jan - 10 Feb	-.42	-.15	-.17	-.08	-.17	.17	.07	.25	.097	L
11 Feb - 8 May	-.33	-.50	-.43	-.43	-.38	-.77	-.73	-.91	.108	L
8 May - 1 Oct	1.21	1.15	1.24	.93	.63	.70	.78	.73	.133	L
Cumulative BCS change										
2 Dec - 10 Feb	-1.23	-.74	-.86	-.53	-.35	-.07	-.08	.02	.099	L, Q
2 Dec - 8 May	-1.58	-1.23	-1.29	-.98	-.73	-.83	-.82	-.93	.135	L, Q
2 Dec - 1 Oct	-.28	0	-.05	0	-.10	-.13	-.03	-.22	.121	NS
% Pregnant[f]										
rate, %	93	93	93	100	87	93	93	87	-	-
Birth wt, lb	84.4	83.1	83.2	89.3	88.3	85.3	93.6	84.	3.1	NS
Weaning wt, lb	513	489	512	537	519	527	515	503	17.8	NS
Calf ADG[g], lb	2.1	2.0	2.1	2.1	2.1	2.1	2.1	2.0	.1	NS

[a]Body condition scale: 1=extremely emaciated; 9=extremely obese.
[b]L=linear P<.05; Q=quadratic P<.05; NS=Not significant.
[c]10 February=calving.
[d]8 May=breeding.
[e]1 October=weaning.
[f]Chi-square P=.51.
[g]ADG=average daily gain; calculated as (weaning weight-birth weight)/age at weaning.

EFFECT OF SUPPLEMENTAL CARBOHYDRATE SOURCE ON THE UTILIZATION OF LOW-QUALITY TALLGRASS-PRAIRIE HAY BY BEEF STEERS

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Summary

Twenty ruminally fistulated steers were used in two experiments to evaluate the effects of supplemental carbohydrate source (starch, glucose, fructose, or sucrose) fed at .3% BW/day on the utilization of low-quality tallgrass-prairie hay. In Experiment 1, all supplemental carbohydrates were fed with a low level of supplemental degradable intake protein. In Experiment 2, the level of supplemental degradable intake protein was high. Intake of the tallgrass-prairie hay was not affected significantly by supplementation in either experiment, but as a result of the added carbohydrate, total intake was increased. When supplemental protein intake was inadequate, supplemental carbohydrates depressed digestion, but when supplemental protein was higher, fiber digestion was not depressed. Because of increased total intake (forage plus supplement) and increased digestion in Experiment 2, total digestible organic matter intake was greater in the supplemented animals, with little difference among carbohydrate sources.

(Key Words: Steers, Forage, Starch, Sugar.)

Introduction

Feeding supplements with a high concentration of degradable intake protein (DIP) has been shown to increase intake and digestion of low-quality forages. In contrast, the effects of feeding large amounts of highly digestible carbohydrate (CHO) may depend on the source of CHO and the amount of DIP provided. Supplemental starch has been shown to decrease the utilization of low-quality forages, whereas nonstarch CHO sources such as fiber and sugars have produced variable results. Our study was designed to provide additional insight into the specific effects of supplemental starch and various sugars, when fed with different amounts of DIP, on intake and digestion of low-quality tallgrass-prairie hay.

Experimental Procedures

Twenty Hereford × Angus steers with ruminal fistulas were housed in individual tie stalls and used in two experiments. In both experiments, steers had free-choice access to low-quality tallgrass-prairie hay (5.2% CP and 72.7% NDF in Exp. 1 and 5.2% CP and 76.0% NDF in Exp. 2). Steers were randomly assigned to treatments at the beginning of each experiment. Treatments were either no-supplement negative control (NC) or supplemental starch, glucose (supplied as dextrose), fructose, or sucrose fed at .30% BW/daily. Sucrose is a disaccharide composed of two monosaccharides, glucose and fructose. We were interested in sugars because of their presence in molasses-based liquid supplements and blocks. Supplemented steers also received degradable intake protein (DIP; sodium caseinate) fed at .031% BW/day in Exp. 1 and .122% BW/day in Exp. 2. Both experiments included a 14-day adaptation period followed by a 7-day intake and fecal collection period. Fecal grab samples were collected every day during the collection period and analyzed for acid detergent insoluble ash, which served as an internal marker to determine total fecal output. Feed offered, feed refused, and fecal output were used to monitor intake response and calculate organic matter (OM) and neutral detergent fiber (NDF) digestibilities.

Results and Discussion

Supplements did not significantly stimulate forage intake compared with the negative control in either experiment (Tables 1 and 2). This was expected when DIP was low (Exp. 1) but not when supplemental DIP was higher (Exp. 2). Because forage intake was similar among treatments, total intake was obviously increased by provision of the supplement.

When limited DIP was provided (Exp. 1), fiber digestion was depressed by supplemental carbohydrate, particularly glucose and sucrose. However, because the supplemental carbohydrate was more digestible than the basal forage, total diet digestibilities for the supple- mented groups did not differ from that of the negative control. In contrast, when a higher level of DIP was fed in Exp. 2, supplemental carbohydrates had no negative effect on fiber digestion. In fact, fiber digestion increased when glucose or fructose was fed. Because fiber digestion was not harmed in Exp. 2, the supplemented groups all had a higher total diet digestion than the negative control.

When the combined effects of intake and digestion were considered, total digestible OM intake increased with carbohydrate supplementation in both experiments. However, little difference occurred among the different carbohydrate sources. In contrast to supplemental DIP, which can stimulate forage intake and digestion, the response to supplemental carbohydrate sources appeared to be limited mostly to the nutrients provided in the supplements themselves.

Table 1. Influence of Supplementation on Intake and Digestibility (Experiment 1)

	Carbohydrates Fed with Low Degradable Intake Protein					
Component	Control	Starch	Glucose	Fructose	Sucrose	SEM
Intake, g/kg $BW^{.75}$						
Forage OM[a]	46.5	54.5	56.1	50.5	52.4	5.13
Total OM	46.5[c]	71.3[d]	72.8[d]	65.8[d]	67.7[d]	5.18
Digestible OM Intake,						
Digestibility, %						
OM	58.7	63.3	58.7	62.6	55.5	3.54
NDF[b]	60.0[d]	52.5[cd]	45.1[c]	52.0[cd]	41.9[c]	4.11

[a] OM = Organic matter.

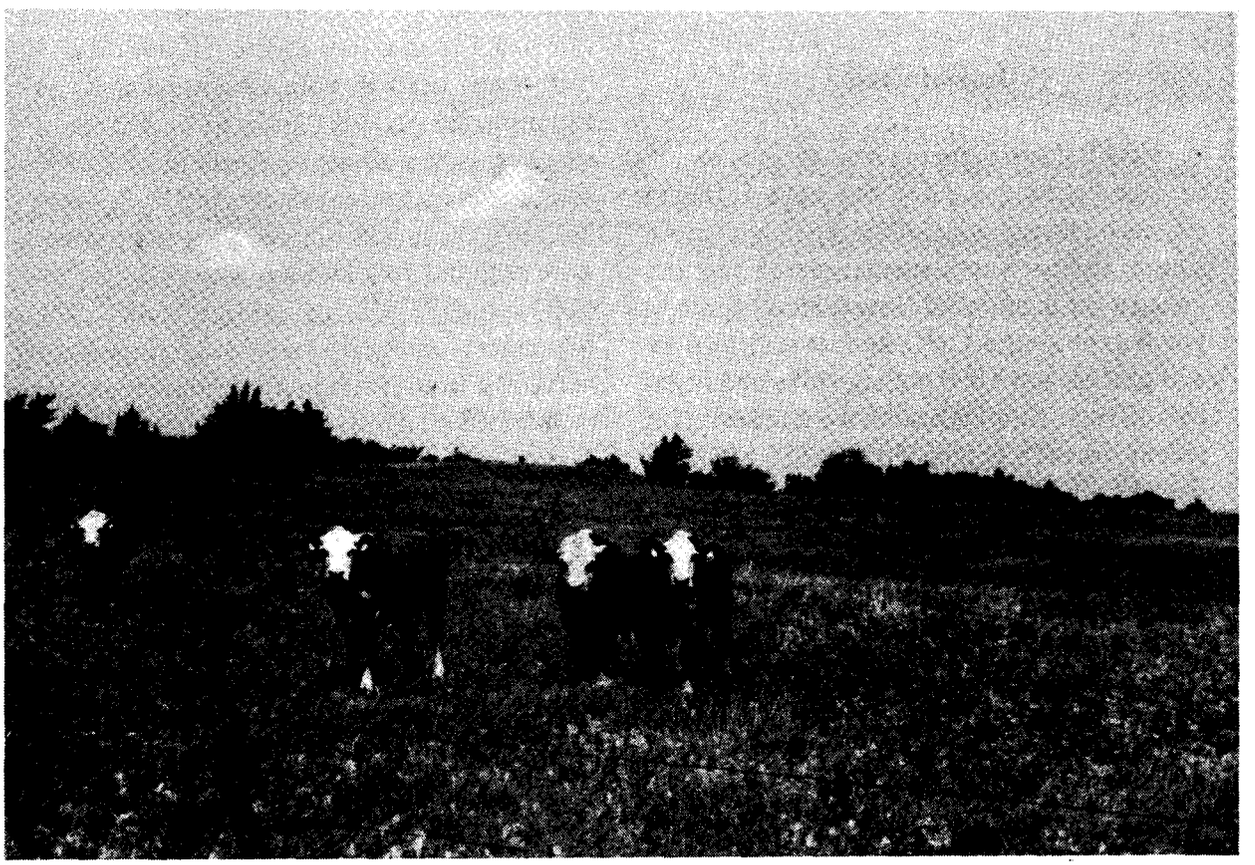
[b] NDF = Neutral detergent fiber.

[c,d] Least squares means in a row with uncommon superscripts differ ($P \leq .06$).

Table 2. Influence of Supplementation on Intake and Digestibility (Experiment 2)

	Carbohydrates Fed with High Degradable Intake Protein					
Component	Control	Starch	Glucose	Fructose	Sucrose	SEM
Intake, g/kg $BW^{.75}$						
Forage OM[a]	67.1	78.6	76.2	75.8	78.2	4.18
Total OM	67.1[c]	99.6[d]	97.1[d]	95.1[d]	97.6[d]	4.14
Digestible OM intake, g/kg $BW^{.75}$	38.7[c]	66.2[d]	70.9[d]	71.4[d]	66.1[d]	2.52
Digestibility, %						
OM	57.9[c]	66.7[d]	73.1[ef]	75.2[f]	67.7[de]	2.04
NDF[b]	59.3[c]	61.2[c]	68.1[de]	71.3[e]	62.3[cd]	2.41

[a] OM = Organic matter.
[b] NDF = Neutral detergent fiber.
[c,d,e,f] Least squares means in a row with uncommon superscripts differ ($P \leq .06$).



EFFECTS OF VARIOUS CARBOHYDRATE SOURCES ON THE UTILIZATION OF LOW-QUALITY TALLGRASS-PRAIRIE HAY IN CONTINUOUS CULTURE

J. S. Heldt, R. C. Cochran, C. P. Mathis, E. C. Titgemeyer, and T. G. Nagaraja

Summary

We evaluated the effects of supplemental carbohydrate sources on the utilization of low-quality forage in continuous "artificial rumen" culture. Providing readily digestible carbohydrates (starch, glucose, and fiber) did not improve total diet digestion. In fact, starch and glucose depressed fiber digestion. Response to other simple sugars was variable.

(Key Words: Digestion, Carbohydrate, Forage, Continuous Culture.)

Introduction

Feeding supplements with a large amount of carbohydrate (CHO) can have different effects on forage utilization, depending on the source used. Supplemental starch has decreased utilization of low-quality forages, whereas nonstarch CHO sources such as fiber and glucose have had both positive and negative effects. Similar results were observed in recent research conducted at KSU, although the impact of CHO source tended to be dependent on the amount of supplemental degradable intake protein provided. The present study was designed to provide additional insight into the specific effects of various CHO sources on digestion and fermentation characteristics of low-quality tallgrass-prairie hay.

Experimental Procedures

In experiment 1, eight dual-flow contin- uous-culture flasks were used for two periods in a randomized complete block design. The four dietary treatments were forage only (negative control; NC) and forage plus either starch; glucose (supplied as commercial dextrose); or digestible fiber (FIBER; supplied as alkaline hydrogen peroxide-treated oat hulls). In experiment 2, nine dual-flow continuous-culture flasks were used for three periods in a randomized complete block design. The nine dietary treatments were forage only (NC), and forage plus pentoses (arabinose and xylose); hexoses (glucose, fructose, and galactose); or disaccharides (lactose, maltose, and sucrose). The same prairie hay (5.4% CP and 65.7% NDF) was used in both experiments. The experimental periods consisted of 5 days of adaptation and 3 days of sampling. The continuous-culture fermenters (554 mL) were designed to simulate ruminal fermentation and were each fed 16 g DM/day with a forage-to-CHO ratio of 4:1 (g DM/g DM). The fermenters contained ruminal microorganisms harvested from a ruminally cannulated steer maintained on a low-quality, prairie-hay diet. They were held at rumen temperature, and pH was maintained within levels that allowed for continuous growth and digestion by the microorganisms. A constant amount of nitrogen (urea) was infused into each flask each day as part of the buffer solution.

Results and Discussion

The source of supplemental CHO did not affect ($P \geq .49$) either apparent or true organic matter digestion (Table 1). However, starch and dextrose tended ($P \leq .11$) to decrease neutral detergent fiber (NDF) digestion compared to NC and FIBER. Part of the reason why supplemental

FIBER may not have affected NDF digestion was that the treated oat hulls were very digestible fiber sources. All supplemental CHO sources decreased ($P \leq .10$) flask pH below 6.2, which may have depressed forage digestion (Table 2). Including starch and dextrose both increased ($P \leq .08$) total VFA concentration and decreased ($P \leq .10$) the molar proportion of acetate, indicative of the fermentation of a highly available CHO. Propionate, acetate: propionate ratio, and butyrate were unaffected ($P \geq .10$) by supplemental CHO. The quantity of ammonia detected in the ruminal fluid was less than that for NC when starch was supplemented and was intermediate and similar to that for NC with the dextrose and fiber treatments.

In experiment 2 (Table 2), diet digestion was greater ($P \leq .10$) when sucrose was supplemented compared to NC. Most of the remaining supplemental sugars resulted in digestibilities intermediate between those for NC and sucrose. The only exceptions were arabinose and lactose, which provided values lower than sucrose. No differences ($P \geq .10$) occurred in NDF digestion between the pentoses or among the disaccharides. However, within the hexoses, glucose decreased ($P \leq .10$) NDF digestion compared to NC, whereas galactose and fructose did not. Two of the eight supplemental sugars decreased ($P \leq .10$) flask pH (Table 4) and four increased total VFA concentration compared with NC. Also, all supplemental sugars, except the pentoses, decreased acetate and increased butyrate proportions compared with NC. It is apparent that supplemental sugars differ in their effects on forage utilization. Clarifying those differences is necessary to effectively plan their incorporation into supplementation programs.

Table 1. Effects of Carbohydrate Source on OM and NDF Digestion in Continuous- Culture Fermenters

		Digestion, %			
Item	Control	Dextrose	Starch	Fiber	SEM
Apparent OM[c]	68.8	67.0	66.6	70.2	3.30
True OM	74.7	72.6	73.2	75.8	3.18
NDF[d]	72.4[ab]	64.0[a]	64.0[a]	73.7[b]	3.38

[a,b]Means in a row with uncommon superscripts differ ($P \leq .10$).
[c]OM = organic matter.
[d]NDF = neutral detergent fiber.

Table 2. Effect of Carbohydrate Source on pH, Total VFA Concentrations, and VFA Proportions in Continuous-Culture Fermenters

		Carbohydrate			
Item	Control	Dextrose	Starch	Fiber	SEM
pH	6.55[b]	5.91[a]	5.94[a]	6.02[a]	.11
Ammonia N, m*M*	17.6[b]	14.4[ab]	10.2[a]	13.8[ab]	1.81
Total VFA, m*M*	28.3[a]	36.5[b]	34.7[b]	33.9[ab]	1.76
	----------mol/100 mol----------				
Acetate	64.3[b]	51.0[a]	51.5[a]	59.3[ab]	3.85
Propionate	21.0	21.2	23.8	22.9	3.70
Acetate:Propionate	3.15	2.53	2.43	2.77	.51
Butyrate	13.7	23.5	22.4	16.7	4.24

[a,b]Means in a row with uncommon superscripts differ (P ≤ .10).

Table 3. Effects of Sugar Source on OM and NDF Digestion in Continuous-Culture Fermenters

	Digestion, %		
Treatment	Apparent OM[d]	True OM	NDF[e]
Control	71.4	76.1[a]	70.6[c]
Arabinose	72.0	76.7[a]	67.0[abc]
Xylose	71.7	78.7[ab]	63.4[ab]
Fructose	72.7	79.4[ab]	69.2[abc]
Galactose	74.8	79.6[ab]	71.4[c]
Glucose	71.9	78.6[ab]	62.8[a]
Lactose	73.6	77.2[a]	65.7[abc]
Maltose	73.2	79.2[ab]	68.4[abc]
Sucrose	74.7	82.7[b]	66.0[abc]
SEM	2.53	1.77	2.90

[a,b,c]Means in a column with uncommon superscripts differ (P ≤ .10).

[d]OM = organic matter.

[e]NDF = neutral detergent fiber.

Table 4. Effect of Sugar Source on pH, Total VFA Concentrations, and VFA Proportions in Continuous Culture Fermenters

Treatment	pH	NH_3-N, mM	Total VFA, mM	Acetate	Propionate	Acetate: Propionate	Butyrate
				- - - - - - - - - - mol/100 mol - - - - - - - - - -			
Control	6.88[b]	10.6[b]	35.7[a]	68.5[d]	17.2[a]	4.15[b]	12.8[a]
Arabinose	6.04[a]	73.[a]	53.5[b]	63.3[cd]	19.8[ab]	3.21[ab]	15.5[a]
Xylose	6.09[a]	6.6[a]	51.5[b]	57.4[bc]	21.4[b]	2.74[a]	17.1[a]
Fructose	6.22[a]	7.4[a]	47.7[b]	48.4[a]	17.0[a]	2.99[a]	32.1[cd]
Galactose	6.28[a]	7.4[a]	46.9[b]	55.2[abc]	19.0[ab]	2.99[a]	24.6[b]
Glucose	6.51[ab]	8.3[a]	43.2[ab]	52.9[ab]	16.9[a]	3.32[ab]	29.1[bc]
Lactose	6.33[a]	7.5[a]	45.8[ab]	48.0[a]	16.8[a]	3.04[a]	30.4[cd]
Maltose	6.37[ab]	8.1[a]	45.0[ab]	50.7[ab]	18.5[ab]	2.88[a]	29.1[bc]
Sucrose	6.20[a]	6.9[a]	45.9[ab]	47.1[a]	16.6[a]	3.05[a]	34.6[d]
SEM	.21	.87	4.53	3.33	1.69	.43	2.17

[a,b,c,d]Means in a column with uncommon superscripts differ (P ≤ .10).

EFFECTS OF BASE INGREDIENT IN COOKED MOLASSES BLOCKS ON INTAKE AND DIGESTION OF PRAIRIE HAY BY BEEF STEERS

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

Summary

Blocks based on cooked beet molasses, cane molasses, or concentrated separator by-product, CSB) were tested to compare their effects on intake and digestion of prairie hay by beef steers. All blocks contained at least 30% crude protein. Steers fed the cooked molasses blocks consumed 22% more forage than control steers, but forage intakes were not different among the three different blocks. Intakes of digestible organic matter and neutral detergent fiber, indicators of energy available to the steers, were increased 38 and 29% respectively, by block supple-mentation but were not different among the three blocks. However, total tract organic matter and neutral detergent fiber digestibilities, expressed as a percent of intake, were slightly higher for steers fed the beet molasses block than those fed the cane molasses block or the CSB block. In summary, supplementation with cooked molasses blocks that contained adequate degradable protein increased forage intake and digestion. Generally, blocks made from the different by-products elicited similar responses, though steers fed the beet molasses product tended to have greater digestibilities than those fed blocks made from cane molasses or concentrated separator by-product.

(Key Words: Steers, Forage, Intake, Digestibility, Cooked Molasses Blocks.)

Introduction

Deficiencies of degradable intake protein can reduce digestion of dormant forage, which, in turn, can limit forage intake and reduce the energy available to grazing cattle. To increase forage intake and digestion and, thus, energy available to cattle, supplements containing ruminally degradable protein are often fed. Previously, we demonstrated that cooked molasses blocks (based on beet molasses) containing 30% crude protein (12% from nonprotein nitrogen) increased forage intake and digestion.

Various molasses products including beet molasses, cane molasses, and concentrated separator by-product (CSB, desugared beet molasses) are available for use as base ingredients in cooked molasses blocks. Composition of cooked molasses blocks may vary with availability and(or) cost of base ingredients. Alterations in base ingredients will affect the source and quantity of carbohydrates, protein, and minerals added to blocks. Our objective was to evaluate effects of blocks with similar nutrient composition but different ingredient composition on intake and digestion of prairie hay by beef steers.

Experimental Procedures

Twelve steers (730 lb) were used in three simultaneous 4×3 incomplete Latin squares. The cooked molasses blocks were formulated to be not less than 30% crude protein, of which not more than 12% equivalent crude protein was provided by nonprotein nitrogen (urea). Predominant ingredients were beet molasses, cane molasses, or CSB; animal fat; plant and animal proteins; and processed grain by-products. The cooked molasses blocks were fed daily at a level of .92 lb (as-is basis) which provided .28 lb crude protein. Control steers did not receive molasses blocks. Steers were provided 20 grams of salt daily and ad libitum access to

water and prairie hay. Hay contained 5.9% crude protein and 69.4% neutral detergent fiber (NDF) (dry matter basis). Experimental periods were 18 days with a 12-day adaptation period followed by 6-day intake and total fecal collection period. Orts and fecal samples were collected daily in the morning in order to calculate forage intake and digestion. On day 12, ruminal fluid was collected at feeding and 2, 4, 6, 8, 10, and 12 hours post-feeding for analysis of ammonia and volatile fatty acids (VFA).

Results and Discussion

Forage intakes, digestible organic matter intakes, and total tract organic matter digestibilities (% of intake) were greater (P<.05) for steers fed any of the three cooked molasses blocks than for control steers (Table 1). The increase in digestible organic matter intake, an indicator of energy available to the steers, was likely a response to increased degradable intake protein provided by the cooked molasses blocks. Forage intakes and digestible organic matter intakes were not different among steers fed the three different blocks. Total tract organic matter and NDF digestions (percent of intake) were slightly higher for steers fed the beet molasses block than for steers fed the cane molasses or CSB block. The lack of difference in digestible organic matter intakes and the relatively small differences in digestibilities among the steers fed the three different blocks indicates that the blocks containing different base ingredients had similar attributes.

Ruminal ammonia concentrations increased (P<.05) when steers were fed any of the three blocks (average of .89 vs .21 mM for control steers), reflecting the additional degradable protein that the cooked molasses blocks supplied. Total ruminal fluid VFA concentrations were greater (P<.05) for steers fed the beet molasses or CSB block than for control steers, whereas those for steers fed the cane molasses block were intermediate. The elevation in total ruminal fluid VFA among steers fed the cooked molasses blocks was primarily a function of the increase in forage fermentation, which was shown by the increase in digestible organic matter and NDF intakes. However, some VFA could be attributed to sugar in the blocks.

In conclusion, supplementation with cooked molasses blocks increased forage intake and digestion, ruminal ammonia, and total ruminal VFA. Digestible organic matter increased by an average of 38% when steers were fed the cooked molasses blocks, probably because they supplied additional ruminally degradable protein, which allowed for increased forage digestion. Generally, the blocks based on beet molasses, cane molasses, and CSB elicited similar responses, although steers fed the beet molasses block tended to have greater digestibilities.

Table 1. Effects of Different Base Ingredients in Cooked Molasses Blocks on Intake and Digestion of Prairie Hay by Steers and Ruminal Parameters

		Base Ingredient			
Item	Control	Beet	Cane	CSB[1]	SEM
Organic matter					
Forage intake, lb/day	10.7[a]	13.2[b]	12.8[b]	13.3[b]	.37
Digestible intake, lb/day	5.2[a]	7.4[b]	7.0[b]	7.3[b]	.18
Digestibility, % of intake	48.7[a]	54.0[c]	52.2[bc]	52.1[b]	.62
Neutral detergent fiber					
Forage intake, lb/day	8.1[a]	9.9[b]	9.6[b]	10.0[b]	.26
Digestible intake, lb/day	3.8[a]	5.1[b]	4.7[b]	5.0[b]	.13
Digestibility, % of intake	46.9[a]	51.9[b]	49.3[a]	49.3[a]	.84
Ruminal parameters					
Ammonia, m*M*	.21[b]	.95[a]	.84[a]	.87[a]	.08
Total VFA, m*M*	80.3[c]	92.7[a]	85.4[bc]	88.1[ab]	2.1

[1]Concentrated separator by-product.

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

EFFECT OF DATE OF HARVEST ON THE NUTRITIONAL QUALITY OF NATIVE GRASS HAY

J. C. Baker, D. E. Kehler, S. R. Tonn[2], and D. A. Blasi

Summary

Native grass hay meadows in three Kansas Flint Hills counties were sampled at 2-week intervals during the growing season to determine the effect of harvest date on forage quality. Each sample was analyzed for crude protein (CP), acid detergent fiber (ADF), and phosphorus (PHOS). CP and PHOS contents declined, and ADF increased as harvest date progressed into the growing season. Both CP and ADF were related highly to harvest date. PHOS content was associated only moderately with harvest date. Harvest date of native grass hay can significantly influence supplemental protein needs for beef cows.

(Key Words: Native Grass, Hay, Forage Quality, Cows.)

Introduction

Native grass hay serves as an important roughage source for wintering beef cattle in Kansas. Harvest date is the most important management factor for native grass hay meadows, because it has a major impact on dry matter (DM) yield, forage quality, and plant vigor in the following year. Native hay harvest in the Flint Hills region normally occurs in mid-July, although it can take place from late June through September.

Because forage quality declines and DM yield per acre increases with advancing plant maturity, the optimum harvest date for native grass hay involves a compromise between yield (tons/acre) and forage quality. Additionally, sufficient time must be permitted for perennial, warm-season grasses to replenish their root carbohydrate reserves prior to winter dormancy.

Our objective was to document and develop prediction equations for the rate of decline in nutritional value of grass hay harvested at progressively later dates throughout the growing season.

Experimental Procedures

Native grass hay meadows in Butler, Cowley, and Marion counties were used in this study. Meadows consisted of mixed species of perennial, warm-season grasses and forbs that are dominant in the Flint Hills region of Kansas.

A 35 ft. long by 3 ft. wide plot was established at each county location. Within each plot, 12 blocks corresponding to harvest date were established. A 30-in.×30-in. sample was hand-clipped from the center of each block leaving a 4-in. stubble height. Samples were harvested from each block at 2-week intervals beginning on June 3, 1997 and concluding on November 4, 1997.

[2]County Extension Agricultural Agents in Cowley, Butler, and Marion Counties, respectively.

Immediately after clipping, forage samples were sealed in an airtight bag and submitted to a commercial forage testing laboratory for chemical analysis. Samples for each harvest date were analyzed for DM, crude protein (CP), acid detergent fiber (ADF), and phosphorus (PHOS) contents and regression equations were developed to describe their relationship with harvest date. Julian calendar date (JCD) was included as the independent variable (June 3 = day 155, November 4 = day 309). Feed costs were estimated for lactating beef cows consuming native grass hay of various CP content.

Results and Discussion

Individual county data were pooled into one overall regression equation for each indicator of forage quality evaluated. Harvest date accounted for the majority of the variation for CP (R^2 =.89) and ADF (R^2 = .81). As anticipated, CP content declined with advancing maturity throughout the growing season (Figure 1), where % CP = 30.13 - (.1753 x JCD)+(.00029 x JCD^2). Conversely, ADF content increased by 1 percentage unit every 12 days (% ADF = 21.75 + .0836x JCD) within the window of the sampling period (Figure 2). Harvest date was less effective for predicting PHOS content (R^2 = .36) (Figure 3). However, the PHOS content of the native grass hay sampled in this study did tend to decline with advancing maturity and ranged from .18 to .05% (% PHOS = .1822 - [.00036xJCD]).

The CP content of the base forage influences the amount of supplemental protein needed to meet nutritional requirements. Therefore, beef cows or stockers that consume forages harvested beyond the optimum date will require more supplemental protein to attain requirements. Table 1 illustrates the influence of harvest date and CP content of native hay on the supplemental protein requirements for a 1,100 lb lactating beef cow. In this example, cows consuming 4.0% CP native grass hay would require an additional .88 lb of supplemental protein at an added cost of $.30/day, compared to cows consuming 8.0% CP hay. Represented another way, there is an approximate cost savings of $4.43 per cow per percentage unit improvement in CP from 4.0 to 8.0% in the native grass hay. Based on the results of this study, native hay meadows should be harvested by mid-July in order to optimize forage quality, while allowing adequate time for range grasses to replenish root carbohydrate reserves prior to fall dormancy.

Table 1. Influence of Harvest Date and Crude Protein Content of Native Grass Hay on Supplemental Protein Cost'

Harvest Date	%CP Content of Native Grass Hay	Pounds of Supplemental CP Required[2]	Cost/day of Supplemental CP Source[3]	Total Supplement Cost[4]
7/1	8.0	.84	$.27	$15.93
7/15	7.0	1.06	.35	20.65
7/29	6.0	1.28	.42	24.78
8/26	5.0	1.50	.49	28.91
9/23	4.0	1.72	.57	33.63

[1]CP requirements for 1,100 lb mature, lactating beef cow of superior milk production (20 lb/day), 3-4 months postpartum=2.6 lb CP/day.
[2]After accounting for CP content in native grass hay; assuming dry matter intake=22 lb/day
[3]38% commercial protein cube ($250/ton).
[4]For the postcalving period February 15 to April 15 (59 days).

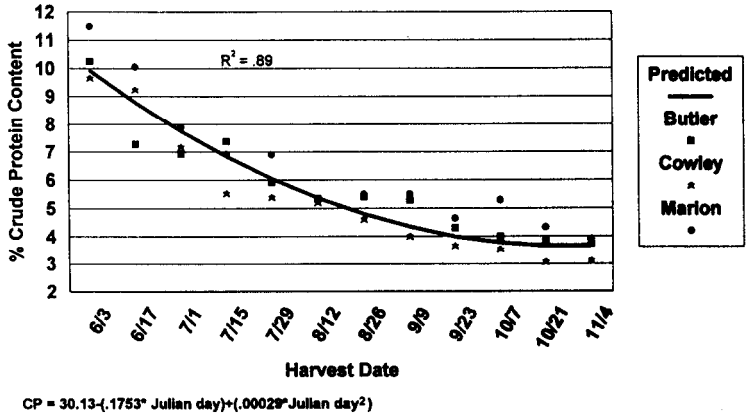


Figure 1. Crude Protein Content of Native Grass Hay.

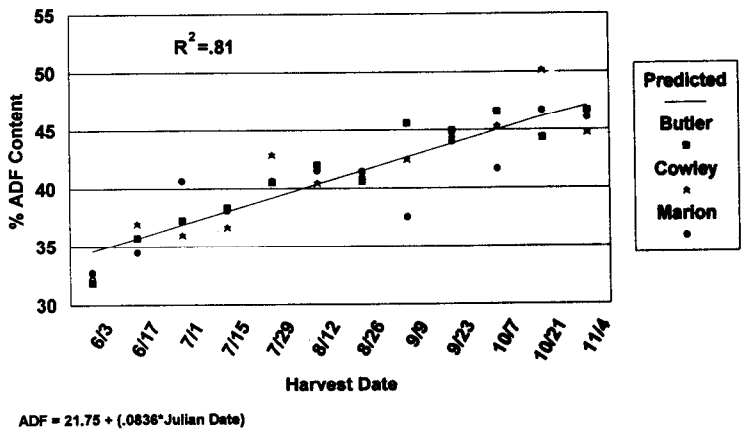


Figure 2. Acid Detergent Fiber Content of Native Grass Hay.

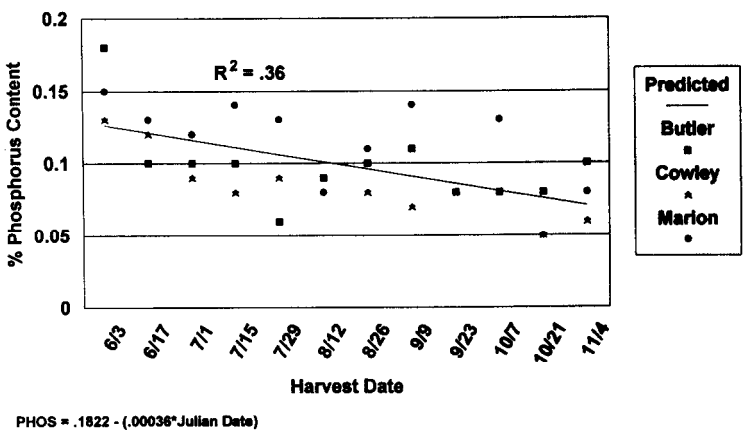


Figure 3. Phosphorus Content of Native Grass Hay.

PREDICTING VOLUNTARY FORAGE INTAKE IN CATTLE

C. A. Bandyk and R. C. Cochran

Summary

A large database was compiled of forage intake observations published during the past 20 years. Inputs included a wide range of factors believed to be related to voluntary intake. An analysis was designed to pinpoint which feed and animal characteristics were most valuable in predicting voluntary intake across a range of feeding situations and to compare the ability of different models to predict intake. Results emphasized the complexity of intake prediction. A wide range was evident in the variables included in the optimal models for predicting intake within different data subsets. In many cases, we observed that ratios between feed values (e.g., forage acid detergent fiber:forage crude protein) were more useful in predicting intake than the measures themselves.

(Key Words: Forage Intake, Multiple Regression, Prediction Models.)

Introduction

Accurate estimation of an animal's feed intake is necessary to formulate diets or predict performance on a particular diet. However, current intake prediction models are not sufficiently accurate, especially when applied across varied feeds, cattle types, and supplementation programs. To address these limitations, we compiled a large diverse data set of intake observations published during the past 20 years, then identified which variables consistently exerted the greatest impact on voluntary intake. In addition, this data set was used to evaluate whether models that would improve intake prediction could be constructed from currently available data.

Experimental Procedures

Intake observations were included from published data sets that reported measured voluntary intake, animal type and body weight, forage crude protein (CP), and diet digestibility. In addition, all information listed in Table 1 was recorded or, if necessary, estimated, based on predetermined standards.

The complete database included 240 treatment means from 42 published papers. The majority of the observations were made with growing cattle, and 80% of the test animals were steers. Nutrient contents of the forages ranged from 1.9 (dormat prairie hay) to 27.8 (fresh-cut wheat forage) % CP, 42 to 82% NDF, and 37 to 78% OMD.

Once the data set was complete, statistically significant correlations between the variables were identified. Simple regressions were run with pairs of intake and predictor variables that showed significant correlations. Stepwise multiple regressions were conducted, both on the entire set and within selected feed and animal groupings, to evaluate the potential for improving predictive accuracy. Several measures of intake were considered: dry matter intake (DMI), organic matter intake (OMI), and total digestible organic matter intake (TDOMI). All intake values were expressed both as a percentage of body weight (BW) and per unit of metabolic body weight ($BW^{.75}$). In

addition, we also evaluated the changes in forage and total intakes seen with supplementation when compared with unsupplemented cattle in the same trial and eating the same forage.

Results and Discussion

Unsupplemented Cattle. We identified five forage variables that in a single-variable regression model, could explain approximately half the variation seen within this data set in intake per unit of $BW^{.75}$:OMD, OMD:CP; and the squares of values for CP, DIP (expressed as a percent of CP), and OMD:NDF. A "best fit" multiple regression utilizing OMD:CP, ADF, DIP, DIP^2, CP^2, and OMD:NDF was able to account for nearly 75% of the variation observed in voluntary forage intake. From a practical viewpoint, it would be beneficial to limit predictor variables to those available from typical feed analysis. Multiple regression using simple feed analysis values yielded a model with CP, ADF, and NDF. Lignin content was not found to be a useful predictor. However, this model had an R^2 of just .41 (that is, it only explained 41% of the observed variation in intake). This was increased to nearly 60% with the addition of ADF:CP.

Supplemented Cattle. The best single predictor of forage intake in cattle fed supplement in conjunction with forage was the ratio between forage ADF and forage CP, which explained about 33% of the variation in forage intake. No other single-variable model had an R^2 greater than .25. A multiple regression using a combination of forage factors (NDF, CP^2); supplement factors (DIP, NDF, CP, % supplement in total diet); and one ratio (forage ADF:forage CP) was able to explain nearly 50% of the variation in forage intake. Subsequent work showed that the ability to predict intake of supplemented cattle depended upon the forage quality and supplementation approach. For example, predicted intake deviated more from actual intake when animals were receiving energy (i.e., grain) supplements compared with high-fiber or protein supplements. When the data were grouped by supplementation level (low, medium,or high), R^2 values were lower for diets containing intermediate amounts of supplement but were higher at either extreme. Similarly, intake prediction was more effective in diets based on high (>60%) or low (<45%) digestibility forages and less accurate with roughages of moderate quality. In the case of low-quality forages, the three highly significant variables in the model were forage CP^2, diet digestibility, and forage ADF. Predictions with high-quality hays were tied most closely to forage CP, forage ADF, and forage DIP.

All Cattle. Regression analysis was conducted on the entire data set (including both supplemented and unsupplemented cattle) and gave results very similar to those seen with supplemented cattle. Forage ADF:forage CP was the most powerful single predictive variable, but by itself, it could account for only 30% of the observed variation in forage intake. The best multiple regression developed for the complete data set had an R^2 of just .30, with virtually no improvement over the simple ADF:CP model. Improvements were not seen when the data were sorted by forage digestibility, but separate analysis of the information collected on dairy breed animals allowed development of a model that accounted for about 75% of the variation seen in that subset. Although none of these analyses generated a highly successful prediction model, the complexities of intake prediction were illustrated, and some key interrelationships were identified. In addition, several ratios between key feed characteristics, most notably forage crude protein and forage ADF levels, were identified as effective predictor variables.

Table 1. Additional Data Included in the Intake Data Set to Determine Variables Affecting Prediction of Voluntary Forage Intake in Cattle

Geographic location	Forage form
Confinement; yes or no	Forage dry matter (DM); organic matter (OM); CP degradable intake protein (DIP); neutral detergent fiber (NDF); acid detergent fiber (ADF); lignin OM digestibility (OMD); DM digestibility (DMD)
Class; breeding or growing	
Age; weanling, yearling or mature	
Sex	
Lactating; yes or no	
Breed or breed type	
Days on trial	
Season of year	Supplement type
Ionophore use; yes or no	Supplement ingredients
Daily gains	Supplement form
Name of forage	Supplement DM; OM; CP; DIP; NPN; NDF; ADF; starch
Forage type; grass or legume	
Forage type; C3 or C4	Diet DMD
Forage stage of growth	Diet OMD
	Diet NDF digestibility

EFFECTS OF PROCESSING WHOLE-PLANT CORN SILAGE ON GROWTH PERFORMANCE AND NUTRIENT DIGESTIBILITY IN FEEDLOT CATTLE

M. A. Young, T. J. Wistuba, M. K. Siefers, J. E. Turner, G. L. Huck, R. V. Pope, and K. K. Bolsen

Summary

Sixty crossbred heifers and 12 crossbred steers were used to evaluate the effects of mechanically processing (crushing the kernels of) whole-plant corn silage on feedlot performance and nutrient digestibility. The three treatments were: preensiled processed, postensiled processed, and nonprocessed corn silages. Heifers fed the processed corn silages grew faster and were more efficient than those fed nonprocessed silage. Steers consuming the two processed silage rations had numerically higher DM, OM, NDF, and ADF digestibilities and significantly higher starch digestibilities than those fed the nonprocessed silage ration. These data suggest that processing whole-plant corn silage before or after ensiling has a positive effect on both rate and efficiency of gain and nutrient utilization, particularly when the kernels approach the black layer stage of maturity.

(Key Words: Mechanically Processed, Corn Silage, Growing Cattle, Feedlot.)

Introduction

Corn silage is important in growing cattle rations throughout the High Plains. It has been suggested recently that processing the whole-plant corn through a forage harvester equipped with a kernel processor could improve growth performance and nutrient digestibility in feedlot cattle. The objective of this study was to evaluate the effect of corn silage processed either at the time of harvest or when removed from the silo in high-silage rations for backgrounding cattle.

Experimental Procedures

Trial 1. Sixty mixed breed, crossbred heifers (avg wt, 591 lb) were used in a completely randomized designed, 80-day growth trial. Three whole-plant corn silage treatments were compared: preensiled processed (PRE), postensiled processed (POST), and nonprocessed (control). The heifers were allocated randomly to one of 15 pens (four head per pen), and the treatments were assigned randomly to blocks of three pens. Dry matter intake, ADG, and feed efficiency were measured. The heifers were weighed individually on 2 consecutive days (February 19 and 20, 1997), and the average was used as the initial weight. Final weights were obtained in the same manner on May 9 and 10, 1997. Each ration contained 90% of the appropriate corn silage and 10% supplement (DM basis). Rations were formulated to provide 13.5% crude protein.

The corn hybrid was Pioneer 3394, which was grown under irrigation during the summer of 1996. A six-row, self-propelled forage harvester (CLAAS Jaguar 880, provided by Taylor Implement, Hoxie, KS) was equipped with an in-line kernel processor, and the corn was harvested in 18-row blocks to remove field variation among the three silage treatments. The whole-plant corn was in the 90% milkline to black layer stage of kernel maturity and contained about 36%

DM. The forage was chopped to a 3/8-inch particle length. Three, 10 × 50 ft concrete stave silos were filled on August 17. One was filled with chopped forage that was put through the kernel processor. Two silos were filled with chopped forage without further processing. Silage from one of them was put through a Roskamp roller mill before feeding (postensiled, processed silage).

Trial 2. Nutrient digestibilities of the three corn silage rations from Trial 1 were determined using 12 ruminally cannulated, yearling steers in a 21-day metabolism study. The steers were tethered via a collar in individual tie stalls in a climate-controlled, metabolism barn. The trial consisted of a 10-day ration adaptation phase and an 8-day total fecal collection phase (two 4-day periods). Each ration was fed once daily ad libitum to four steers.

Results and Discussion

Trial 1. The effect of processing whole-plant corn silage on growth performance of the feedlot heifers is shown in Table 1. DM intake was numerically highest for heifers fed the PRE processed silage and lowest for those fed the POST processed silage. These differences were significant at P<.10 but not at P<.05. Heifers fed either the PRE or POST processed silages had higher (P<.05) ADGs than those fed the control silage. Feed efficiency (F/G) also was significantly improved by processing the corn silage, either PRE or POST ensiling, with a slight advantage to PRE processing.

Trial 2. The effect of processing whole-plant corn silage on nutrient digestibility in the feedlot steers is shown in Table 2. Steers fed either PRE or POST corn silage rations had numerical improvements in DM, OM, NDF, and ADF disappearance versus those fed the control silage ration. Starch disappearance was significantly higher for the POST silage ration (96.7%) compared to the PRE (94.9%) and control (93.1%) silage rations.

The slight improvement in feed efficiency (Trial 1) and greater starch disappearance (Trial 2) observed for the POST processed versus PRE processed silage were likely due to an increased surface area of the kernel and more starch granules exposed to ruminal degradation in the POST corn silage. Although all kernels were disrupted in both processed corn silages, those in the POST silage had a more "flake-like" appearance.

Table 1. Effect of Processing Whole-Plant Corn Silage on Growth Performance of Feedlot Heifers

Corn Silage Treatment	No. of Heifers	Initial Wt, lb	Daily DM Intake, lb	ADG, lb	Feed/lb of Gain, lb[1]
Pre	20	591	21.2[x]	3.21[a]	6.6[a]
Post	20	591	20.0[y]	3.12[a]	6.4[a]
Control	20	590	20.6[x,y]	2.93[b]	7.0[b]

[1]100% DM basis.
[a,b]Means within a column with different superscripts differ (P<.05).
[x,y]Means within a column with different superscripts differ (P<.10).

Table 2. Effect of Processing Whole-Plant Corn Silage on Nutrient Digestibility in Feedlot Steers

	Digestibility[1]					
Corn Silage Treatment	DM	OM	NDF	ADF	CP	Starch
Pre	75.7	77.5	59.4	54.4	78.8	94.9[b]
Post	75.5	76.7	57.6	54.6	76.5	96.7[a]
Control	74.7	76.3	55.7	54.2	77.4	93.1[b]

[1]DM = dry matter, OM = organic matter, NDF = neutral detergent fiber, ADF = acid detergent fiber, and CP = crude protein.
[a,b]Means within a column with different superscripts differ (P<.05).

MILKING TWO OR FIVE TIMES DAILY IN THE PRESENCE OF A COW'S OWN NONSUCKLING CALF FAILS TO PROLONG POSTPARTUM ANOVULATION

G. C. Lamb, K. E. Thompson [1], J. S. Heldt, C. A. Löest, and J. S. Stevenson

Summary

Three treatments were initiated at approximately 15 days after calving and continued for 4 weeks: 1) cows were suckled ad libitum by their calves (calf present [CP]); 2) calves were present but nonsuckling 24 hr/day and cows were milked twice daily (CR+2×M); 3) or same as CR+2×M but cows were milked five times daily (CR+5×M). Interval to the first postpartum ovulation was similar between CR+2×M and CR+5×M cows but about 2 weeks less than that in cows suckled ad libitum by their own calves. Cows in the CR+5×M treatment produced more milk than cows in the CR+2×M treatment, whereas only slight differences occurred in the percentages of milk fat, protein, lactose, and solids-not-fat. Prior to initiation of treatments, CR+2×M cows yielded more milk than either CR+5×M or CP cows, but by the end of 4 weeks of treatment, milk yields were similar among treatments. We conclude that mechanical milking either two or five times daily in the presence of a cow's own nonsuckling calf fails to prolong postpartum anovulation to the extent of ad libitum suckling. However, increasing milking frequency to 5× daily enhanced milk yield.

(Key Words: Cows, Milking, Suckling, Calf Presence, Anestrus.)

Introduction

Reproduction is a major factor limiting efficiency of production in beef cattle enterprises. Duration of postpartum anestrus largely determines the likelihood of pregnancy during the breeding season and maintenance of a yearly calving interval. Suckling and cow nutrition are two critical components that alter duration of postpartum anestrus. The suckling mechanism is key to maintaining anovulation; cows suckled continuously have longer postpartum intervals to first estrus than cows whose calves are weaned.

Dairy cows that are milked 3× daily tend to have longer postpartum anestrus intervals than cows only milked 2× daily, whereas those milked 6× daily remain anestrus even longer. We previously demonstrated (1997 Cattleman's Day; KAES Report of Progress 783:99) that milking cows 2× daily in the presence of their own calves failed to prolong anovulation, whereas 2× daily suckling was sufficient to prolong anovulation. Our objectives were to determine whether milking a beef cow 5× daily in the presence of her nonsuckling calf would alter the postpartum interval to first ovulation and to evaluate the effects of milking beef cows 2× or 5× daily on milk yield and composition.

[1]Farmland Industries, 2102 Kirby Lee, Waco, Texas 76712.

Experimental Procedures

During the spring of 1997, 30 Angus × Hereford cow-calf pairs were assigned randomly on day 15 postpartum to three treatments of 10 pairs each; 1) calf was present continuously with its dam (CP); 2) calves were present but nonsuckling 24 hr/day, plus cows were milked twice daily (6:00 AM and 6:00 PM) (CR+2×M); and 3) calves were present 24 hr/day, plus cows were milked at 6:00 AM, 10:00 AM, 2:00 PM, 6:00 PM, and 10:00 PM) daily (CR+5×M). Cows remained on treatments for 4 weeks, after which calves were allowed to nurse until weaning at 205 days of age. During treatments, daily blood samples were collected from cows for serum progesterone analysis. Ovulation occurred 1 to 2 days before serum progesterone exceeded .5 ng/ml for at least 2 days.

Cow-calf pairs were housed individually in pens located in two separate open-front barns. After initiating treatments on day 15 postpartum and throughout the treatment period, calves in the CR+2×M and CR+5×M treatments were confined to a hutch within their dam's pen. The hutch permitted head and neck contact between cow and calf, but no contact with the udder. Cows were fed individually to meet or exceed NRC recommendations for superior milk producers, and intakes were adjusted weekly according to changes in individual body weight and condition.

Cows assigned to the two milking treatments were milked in an enclosed restraining chute, using a portable milking machine. Milk yield was recorded at each milking, and weekly samples were collected for measurements of fat, protein, lactose, solids-not-fat (SNF), and somatic cell count (SCC). During each milking, the cow's own calf was shuttled from its hutch to the chute where cow and calf were permitted visual, audible, tactile, and olfactory contacts during milking. To establish milk production at the onset and termination of all three treatments, pairs were separated for 8 to 10 hr and cows were milked after a 40 I.U. injection of oxytocin. Milk yield was recorded and adjusted to a 24-hr period. Individual samples also were collected for component analysis.

Results and Discussion

Average daily milk yields for CR+2×M and CR+5×M cows during the 4-week treatment period are shown in Figure 1. Average daily milk yield was 17% greater ($P<.05$) for cows milked 5× daily than for cows milked 2× daily. Therefore, increasing the frequency of milk removal enhanced total daily milk yield, which has been observed also in dairy cows.

Intervals to the first postpartum increase in serum progesterone (1 to 2 days after ovulation) are summarized in Table 1. Cows in both CR+2×M and CR+5×M treatments had similar intervals to ovulation, which were shorter ($P < .05$) than that for cows in the CP treatment. Previously (1997 Cattlemen's Day; KAES Report of Progress 783:99), we demonstrated that milking cows 2× daily in the presence of their own nonsuckling calves (CR+2×M) failed to prolong postpartum anovulation to the extent observed in cows suckled 2× daily or ad libitum by their own calves. Moreover, increasing the frequency of milking from 2× to 5× daily also failed to prolong postpartum anestrus, unlike the situation in dairy cows. We conclude that milk removal by suckling is essential to prolong postpartum anestrus in beef cows.

Table 1. Days to First Postpartum Ovulation in Beef Cows Suckled Ad Libitum, Milked Twice Daily, or Milked Five Times Daily

		Days to First Postpartum Increase in Progesterone (Ovulation)[b]	
Treatment[a]	No. of cows	Range	Mean ± SE
Calf restricted + cows milked twice daily (CR+2xM)	10	9 to 44	23.6 ± 3.5[x]
Calf restricted + cows milked five times daily (CR+5xM)	9	8 to 40	26.1 ± 3.7[x]
Calf present continuously (CP)	9	20 to 56	37.7 ± 3.7[y]

[a]Cows were suckled by their own calf until 4-week treatments were initiated on day 15 postpartum.
[b]Days from initiation of treatments.
[x,y]Means with uncommon superscript letters differ (P < .01).

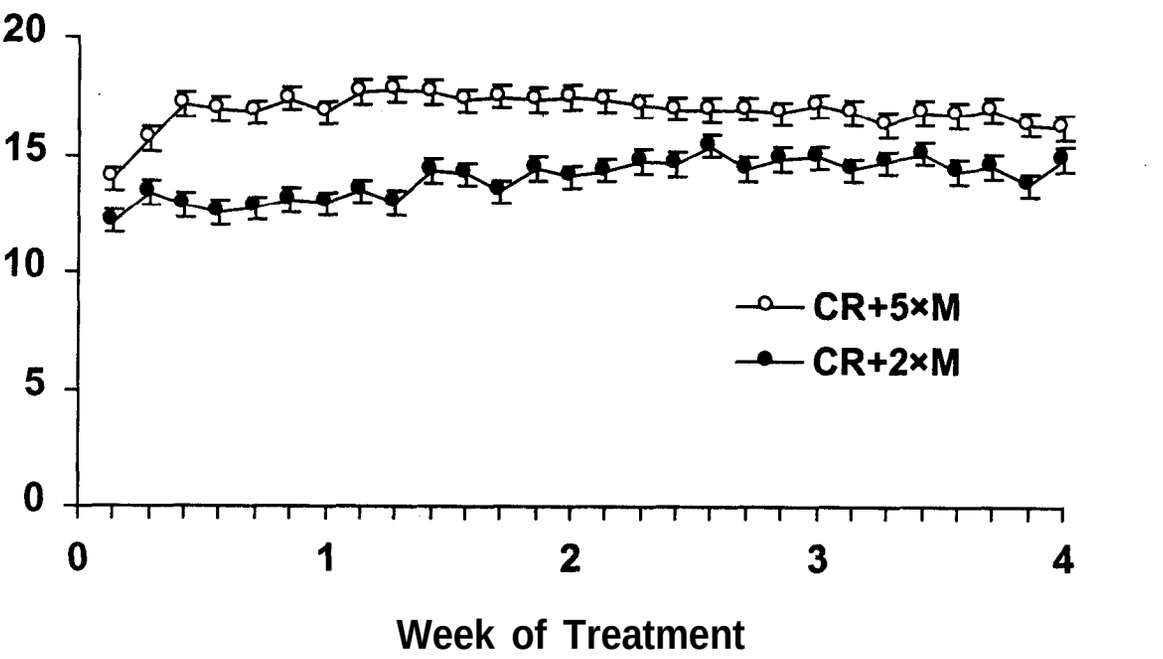


Figure 1. Average Daily Milk Yield in Cows that Were Milked during 4 Weeks Starting 15 Days Postpartum. Cows Were Suckled Ad Libitum by Their Own Calves until Treatments Began.

INCREASING INTERVAL TO PROSTAGLANDIN FROM 17 DAYS TO 19 DAYS IN AN MGA-PROSTAGLANDIN SYNCHRONIZATION SYSTEM FOR HEIFERS [1]

D. W. Nix, G. C. Lamb, V. Traffas [2], and L. R. Corah

Summary

Weanling Angus × Hereford heifers were purchased by a commercial heifer development operation from 12 sources. Heifers were fed a silage-based diet through an initial developmental period and then were retained or culled based on their average daily gain, pelvic area, or disposition. Of the original 591 heifers, 14% were culled. Estrus was synchronized using the Colorado MGA-Prostaglandin (PG) synchronization system with PG administered at either 17 days or 19 days after the 14th day of MGA feeding. Heifers were inseminated artificially (AI) during 30 days followed by 30 days of natural mating. Heifers given PG on day 17 after MGA had a first-service conception rate of 69.9% compared with 65.8% for heifers given PG on day 19. In the day 17 treatment, 64.2% of the heifers were inseminated artificially by 84 hr after the PG injection versus 75.1% for the day 19 treatment. Injections of PG 19 days after MGA tended to tighten synchrony of estrus. Based on source of purchase, first-service conception rates ranged from 50% to 85%, whereas overall pregnancy rates ranged from 65% to 95%. With early culling, accurate records, and pregnancy diagnosis, producers can identify reliable sources from which to purchase their replacement heifers, which should decrease costs and increase profit potential.

(Key Words: Replacement Heifers, Artificial Insemination, Synchronization, Culling.)

Introduction

Overall profitability of a beef cattle operation depends on proper selection and management of replacement females. Estrus synchronization and artificial insemination (AI) can increase the proportion of heifers bred early in their first breeding season and, thereby, increase their reproductive efficiency. A commonly accepted synchronization regimen is the Colorado MGA-PG system, which involves feeding MGA for 14 days, then injecting PG 17 days later. However, delaying the interval from MGA withdrawal to PG by an extra 2 days could result in a greater proportion of heifers displaying estrus within 72 hr following PG.

Stringent culling practices and monitoring the purchasing source from which heifers are obtained could increase efficiency of commercial heifer development programs. Our objectives were to: 1) evaluate the effects of administering PG to heifers on day 17 or day 19 after the 14th day of MGA feeding and 2) determine the influence of the source of replacement heifers on subsequent reproductive performance.

Experimental Procedures

[1]Appreciation is expressed to Losey Bros., Agra, Kansas for providing data for this study.

[2]Traffas Veterinary Service, Smith Center, Kansas.

A heifer development operation located in north-central Kansas purchased 591 weanling Angus × Hereford heifers from 12 sources. Number purchased from each source ranged from 13 to 100. Heifers were fed a common silage-based diet during the initial development period before a prebreeding exam was conducted in March, 1997. Heifers then were culled based on poor average daily gain (minimum of 1.4 lb per day), small pelvic area (minimum of 140 cm^2), poor reproductive tract scores, agressive disposition, or structural unsoundness. Eighty two culled heifers were either sold directly through a local sale barn or sent to a feedlot.

The remaining 509 heifers were used in an estrus synchronization program during March, 1997. Estrus was synchronized by feeding MGA (.5 mg per head per day for 14 days) then 260 head were given a PG injection 17 days after MGA withdrawal. The remaining 249 heifers were given PG on day 19 after MGA. Heifers were observed for estrus and inseminated artificially 12 hr after the first detected standing heat. Those not showing estrus were given a second PG injection 12 to 14 days after the first. The 30-day AI period was followed by 30 days of natural mating by clean-up bulls. All were tested for pregnancy using real-time intrarectal ultrasonography, approximately 30 days after insemination. Pregnancy rates after first AI service, 30 days of AI, and natural mating were determined.

In August 1997, all nonpregnant heifers were sold through a local sale barn. Pregnant heifers were moved to native prairie grass pasture after the breeding season. In early November, these heifers grazed cornstalk residue for 60 days and were supplemented with prairie hay when necessary. For 2 weeks in January, 1998, heifers were returned to drylot facilities and prepared for a special replacement heifer sale. Pregnancy was reconfirmed via uterine palpation to determine which heifers had aborted. Of the heifers that were previously diagnosed pregnant, 3% had lost their fetuses and were sold locally. The remaining pregnant heifers were sorted according to date of conception and sold at the replacement heifer sale.

Results and Discussion

Table 1 summarizes the conception and pregnancy rates of heifers given PG either 17 or 19 days after 14 days of MGA. First-service conception rates were similar between treatments. Thirty-day AI pregnancy rates and overall pregnancy rates were also similar between treatments. In contrast, distribution of estrus following PG administration tended (P=.14) to differ. Of those heifers in the 19-day treatment, 75.1% were inseminated by 84 hr after PG injection compared to 64.2% receiving PG at day 17 (Figure 1). Nineteen (7.3%) of day 17 heifers were inseminated between 96 and 120 hr after PG. Our results indicate that tighter synchrony may be possible when PG is administered 19 rather than 17 days after MGA, with little difference in fertility.

Our second objective was to evaluate the influence of purchasing source on reproductive efficiency. First-service conception rates calculated by heifer source ranged from 50% to 85% (mean, 67.5%). Following the 60-day breeding season, overall pregnancy rates by source ranged from 90.5% to 100% (mean, 95.8%). When expressed as a percentage of the total number of original heifers purchased from each source, pregnancy rates ranged from 69.9% to 96.0% (mean, 83.8%. These results indicate that source is critical to predicting performance of heifers.

Table 1. Fertility of Beef Heifers Synchronized with MGA Followed by Prostaglandin 17 or 19 Days Later

	No. of heifers	First-service AI conception rates (%)[a]	30 day AI pregnancy rates (%)[b]	Overall pregnancy rates (%)[c]
MGA + PG day 17	260	144 (69.9)	207 (79.6)	246 (94.6%)
MGA + PG day 19	249	129 (65.8)	200 (80.3)	239 (96.0%)
Total	509	273 (67.9)	407 (80.0)	485 (95.3%)

[a]Number of heifers pregnant divided by the number of heifers artificially inseminated.
[b]Number of heifers diagnosed pregnant after the 30-day AI breeding period.
[c]Number of heifers diagnosed pregnant after the 60-day breeding season (30 days of AI +30 days of natural mating).

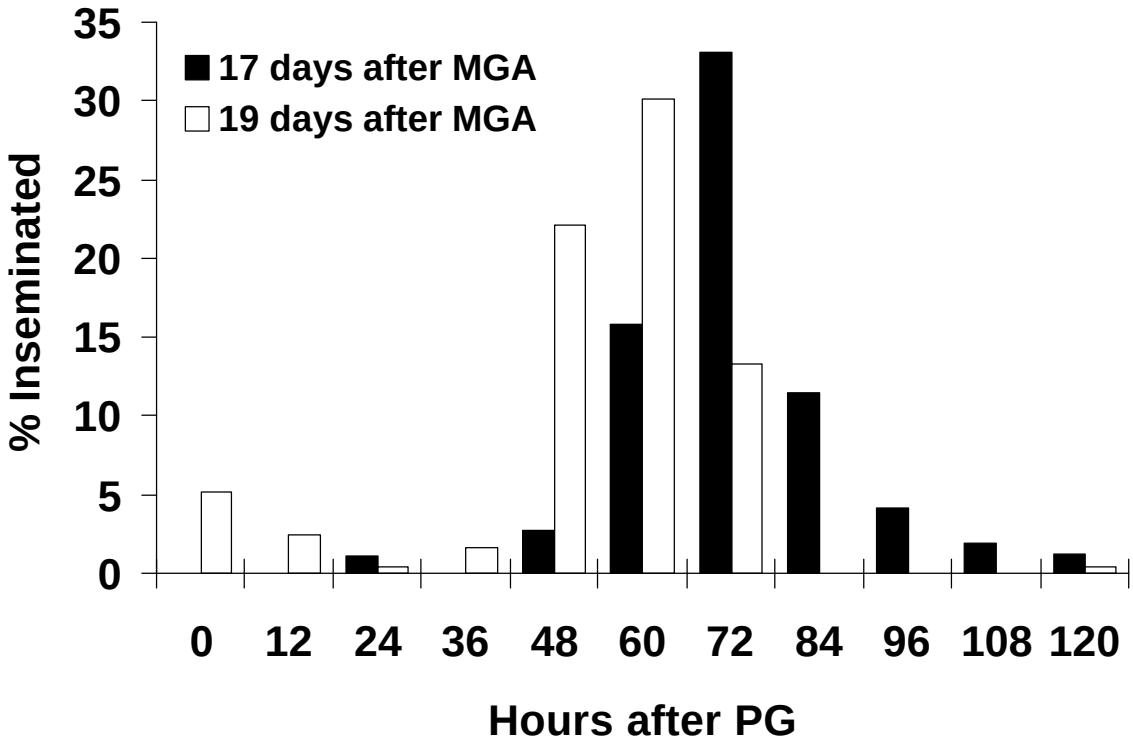


Figure 1. Distribution of AI Times in Heifers Given Prostaglandin (PG) on Day 17 or 19 after MGA.

SITE OF SEMEN DEPOSITION AND FERTILITY IN LACTATING BEEF COWS SYNCHRONIZED WITH GNRH AND $PGF_{2\alpha}$ [1]

D. M. Grieger, G. C. Lamb, T. G. Rozell, K. E. Thompson, J. S. Stevenson, and K. Anderson [2]

Summary

Our objective was to determine the effect of site of semen deposition on pregnancy rate in beef cows inseminated at a fixed time or after observed estrus. Cows were synchronized with a combination of gonadotropin-releasing hormone (GnRH) and prostaglandin-F_2 alpha (PGF). GnRH was injected 7 days before PGF (day 0; first day of breeding season). The trial was conducted at two locations, one in Kansas (147 cows) and one in Colorado (313 cows). At each location, cows were assigned to be inseminated after observed estrus (ESTRUS-AI) or at a fixed time (TIMED-AI). Within these two groups, cows either were inseminated in the uterine body (BODY-bred) or in both uterine horns (HORN-bred). Cows in the ESTRUS-AI group were observed for estrus each morning and evening until day 5 after PGF and then inseminated 12 hr after first detected estrus. Cows in the TIMED-AI group received a second dose of GnRH on day 2 and were inseminated at that time (48 to 56 hr after PGF). Heat response, AI conception rate, and pregnancy rate were analyzed for BODY-bred and HORN-bred cows within each treatment at each location. No differences in these variables occurred between locations, so the results were combined. Within the ESTRUS-AI group, neither conception rate (70% vs. 73%) nor pregnancy rate (39% vs. 40%) was different between BODY-bred and HORN-bred cows, respectively. Pregnancy rate within the TIMED-AI group tended (P=.09) to be greater for BODY-bred (53%) compared to HORN-bred (42%) cows. When BODY-bred and HORN-bred treatments were combined, the pregnancy rate of TIMED-AI cows (48%) tended (P=.07) to be greater than that of ESTRUS-AI cows (39%). Timed-insemination resulted in a greater pregnancy rate than inseminating cows according to estrus. No advantage was seen in conception rates when semen was deposited in the uterine horns compared to the uterine body.

(Key Words: AI, Timed Insemination, Horn Breeding, Estrous Synchronization, Cows.)

Introduction

The optimal site of semen deposition for artificial insemination (AI) of cattle is the body of the uterus. However, with the recent advances in breeding at a fixed time after synchronization with GnRH and prostaglandin (PGF), we questioned whether the deposition of semen into each uterine horn might improve conception. Therefore, our objective was to determine if the site of semen deposition would affect pregnancy rates in beef cows time-bred after being synchronized with a GnRH-PGF system

[1]Sincere appreciation is expressed to Rezak Land & Livestock Co., Onaga, Kansas and Lindner Ranches, Durango, Colorado.

[2]Current address: Y Cross Ranch, Horse Creek, Wyoming.

Experimental Procedures

The experiment was conducted in postpartum lactating beef cows on a ranch in Kansas (n=147) and a ranch in Colorado (n=313). At each location, cows were assigned to be inseminated after observed estrus (ESTRUS-AI) or at fixed time (TIMED-AI). The experimental design is shown in Figure 1. Cows in the ESTRUS-AI group were given 100 µg of GnRH (Fertagyl®) at day –7. On day 0 (first day of the breeding season), these cows were given 25 mg of PGF (Lutalyse®) and then observed for estrus each morning and evening until day 5. Cows observed in estrus were inseminated 12 hr later. Cows in the TIMED-AI group also were given GnRH at day –7 and PGF at day 0 but then received a second dose of GnRH on day 2 and were inseminated at that time (48 to 56 hr after PGF). All cows in the TIMED-AI group were inseminated, whereas only cows showing estrus were inseminated in the ESTRUS-AI group. At AI, semen was placed in the uterine body (BODY-bred) or in both uterine horns (HORN-bred). In BODY-bred cows, the entire contents of the straw were deposited in the uterine body just past the internal os of the cervix. In HORN-bred cows, one half of the semen was deposited 2 to 3 inches deep into one uterine horn. The AI gun then was pulled back and inserted 2 to 3 inches deep into the opposite horn, where the remaining semen was deposited. All inseminations at each ranch were divided equally between two technicians. Heat response, AI conception rate, and pregnancy rate were analyzed for BODY-bred and HORN-bred cows within each treatment at each location. Conception rates were determined by intrarectal ultrasonography at 30 to 50 days postbreeding.

Results and Discussion

At the Kansas location, 39 of 74 cows (53%) in the ESTRUS-AI group were observed in estrus and inseminated and 28 conceived (72%), resulting in a pregnancy rate of 38% (28 of 74). This did not differ from the pregnancy rate of 44% (32 of 73 cows) obtained in the TIMED-AI group at the Kansas ranch.

At the Colorado location, 91 of 163 cows (56%) in the ESTRUS-AI group were observed in estrus and inseminated and 65 conceived (71%), resulting in a 40% pregnancy rate. This was not statistically different than the 49% (74 of 150) pregnancy rate of cows in the TIMED-AI group at this location.

Because no statistical differences occurred between locations in heat response, conception rate, or pregnancy rate, these data were combined (Table 1). Within the ESTRUS-AI cows, no differences in conception rate (70% vs. 73%) or pregnancy rate (39% vs. 40%) were detected, whether BODY-bred or HORN-bred. In the TIMED-AI group, the pregnancy rate tended (P=.09) to be higher for BODY-bred cows (53%) than for HORN-bred cows (42%). Therefore, horn breeding in this study did not increase fertility and may have been detrimental. When the results for HORN-bred and BODY-bred cows were combined, the pregnancy rate tended (P=.07) to be greater for TIMED-AI cows (48%) than for ESTRUS-AI cows (39%).

To summarize, these results indicate no clear advantage to horn-breeding cows, whether inseminated at a fixed time or afterdetected estrus. These results indicate a potential increase in pregnancy rate with fixed-timed AI after a GnRH-PGF-GnRH estrus-synchronization program, compared to

breeding only cows that show estrus. Individual ranches must consider the advantages (no heat detection, increased AI pregnancy rate) and disadvantages (increased semen and hormone costs) before using timed AI in conjunction with this estrus-synchronization program.

Table 1. Heat Response, Conception Rate, and Pregnancy Rate of Cows Bred According to Estrus (ESTRUS-AI) or at One Fixed Time (TIMED-AI) with Semen Deposited in the Uterine Body (BODY) or in Both Uterine Horns (HORN)

	ESTRUS-AI		TIMED-AI	
Item	BODY	HORN	BODY	HORN
No. of cows	119	118	115	108
% in estrus	55%	54%	- - -	- - -
No. conceived to AI, %	46/66 (70%)	47/64 (73%)	61	45
No. pregnant, %	46/119 (39%)	47/118 (40%)	61/115 (53%)[a]	45/108 (42%)
Overall pregnancy rate	93/237 (39%)[b]		106/223 (48%)	

[a]Tended (P=.09) to differ from HORN-bred TIMED-AI cows.
[b]Tended (P=.07) to differ from TIMED-AI cows.

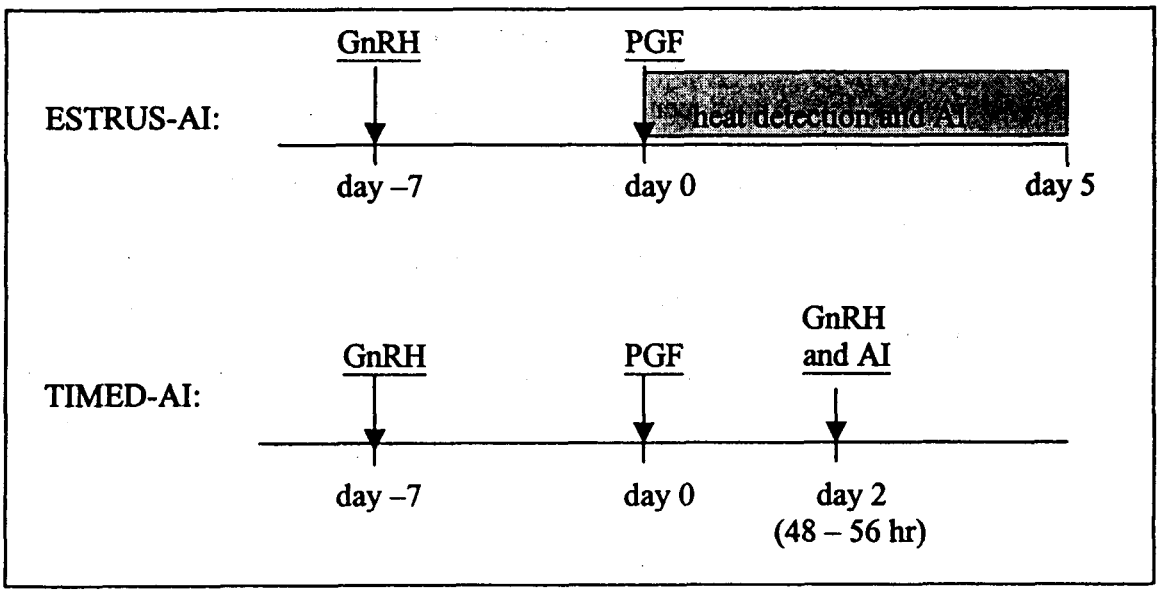


Figure 1. Experimental Design.

A THREE-YEAR ECONOMIC EVALUATION OF A COMMERCIAL HEIFER DEVELOPMENT PROGRAM [1]

G. C. Lamb, J. M. Lynch [2], B. L. Miller [3], V. Traffas [4], and L. R. Corah

Summary

In 1994, 1995, and 1996, a commercial heifer development operation purchased a total of 1542 potential replacement heifers. Heifers were purchased in the fall preceding the spring breeding season and fed a silage-based diet during the developmental period. Before the breeding season began, heifers that failed to meet minimum requirements for pelvic area, average daily gain, body weight, disposition, or structural soundness were culled. During the first year, 42% of 483 heifers were culled, 17% of 468 heifers were culled in the second year, and 14% of 591 heifers in the third year. Estrus was synchronized and heifers were inseminated artificially (AI) for 30 days followed by 30 days of natural mating by cleanup bulls. First-service AI conception rates averaged 68% and overall pregnancy rates (AI + natural mating) averaged 95.1% over the 3-year period. Heifers culled prior to the breeding season realized a net profit of $9 per head, whereas heifers diagnosed nonpregnant after the breeding season lost $86, and heifers that aborted lost $133. Profits for pregnant heifers sold were $163 for first-service AI, $138 for second-service AI, and $83 for bull bred.

(Key Words: Heifer Develpment, Economic Evaluation, Replacement Heifers.)

Introduction

The demand for genetically superior replacement heifers, artificially inseminated (AI) and synchronized to calve early in the calving season, has increased the popularity and size of commercial heifer development operations in recent years. Heifers purchased from these operations represent the future genetics and profit potential in many cow-calf operations. Therefore, our purposes were to: 1) evaluate the economic performance of all pregnant and nonpregnant heifers sold by a commercial heifer developer during a 3-year period and 2) determine any differences in profitability associated with genetic make-up.

Experimental Procedures

A commercial heifer development facility in north-central Kansas purchased 483 heifers in the fall of 1994, 468 in 1995, and 591 in 1996. Heifers were of either Angus (black) or Angus × Hereford (black-white-face; BWF). Each group was treated in a similar manner during the 3 years. Heifers were fed a similar silage-based diet to gain an average of 1.5 lb per day. Shortly before

[1]Appreciation is expressed to Losey Bros., Agra, Kansas for providing data for the study of this analysis.

[2]Heartland Cattle Co., RR3, Box 134, McCook, Nebraska.

[3]Virginia Extension Service, RR1, Box 30, Mt. Solon, Virginia.

[4]Traffas Veterinary Service, Smith Center, Kansas.

each spring breeding season (i.e., heifers purchased in the fall of 1994 were bred during the spring of 1995), a prebreeding exam was performed and heifers were culled on the basis of pelvic area, average daily gain, reproductive tract scores, disposition, or structural soundness. All culled heifers were sent to a feedlot, where the heifer development operator retained ownership until slaughter.

Estrus was synchronized in the remaining heifers by feeding MGA for 14 days, then injecting prostaglandin $F_{2\alpha}$ (PGF) 17 to 19 days after MGA withdrawal. Heifers were observed for estrus and inseminated 12 hr after first observed heat using semen from a sire with expected progeny differences (EPD) for small birth weights and above- average growth characteristics. Artificial insemination continued for 30 days followed by 30 days of natural mating by cleanup bulls. Conception rates at first- and second- service AI and overall pregnancy rates were calculated.

Heifers open after the breeding season were sold directly through a local sale barn. All pregnant heifers were wintered on native prairie grass or corn stalks until being returned to drylot facilities before a special replacement heifer sale during January of 1996, 1997, or 1998. At that time, pregnancy was reconfirmed to determine which heifers had aborted since the previous pregnancy diagnosis. Aborting heifers were sold locally, whereas pregnant heifers were sorted into groups according to their pregnancy status, genetic origin and expected calving dates.

Results and Discussion

Table 1 summarizes the culling percentage, first-service AI conception rates, and overall pregnancy rates over the 3-year period. During the first year, 42% of 483 heifers were culled. In the second year, 17% of 468 heifers were culled, and 14% of 591 heifers were culled in the third year. Decreased culling percentages from the first to third year indicate improvement in initial performance evaluation and heifer quality. Some heifer sources were used only once. First-service AI conception rates and overall pregnancy rates were similar among years and averaged 68.0% and 95.1%, respectively.

Net profit or loss for the heifers sold during the developmental period during all 3 years is summarized in Table 2. Heifers culled at the time of the prebreeding exams and finished in a feedlot had a 3-year average net profit of $9, whereas heifers diagnosed as nonpregnant shortly after the breeding season were sold for a net loss of $86. The loss for pregnant heifers that were then diagnosed nonpregnant after wintering on native pasture and sold at a local sale barn was $133 per head. Average profits were $163, $139, and $83, respectively, for heifers sold pregnant after first-service AI, second-service AI, or natural mating. The results emphasize the economic importance of early culling and early breeding to cut the losses associated with maintaining open heifers.

Heifers purchased during 1995 and 1996 and subsequently inseminated artificially during the spring of 1996 and 1997 were separated into first- or second-service AI groups according to their origin; Hereford × Angus (BWF) or Angus ([black). Profitability results are shown in Table 3. Among first AI service, pregnant heifers, BWF heifers were nearly twice as profitable ($P<.05$) as black heifers in both years. In contrast, profitability of second-service heifers did not seem to differ with genetic source.

Table 1. Culling, First-Service Conception, and Pregnancy Rates of Beef Heifers in a Heifer Development Operation

Purchase Year[a]	No. of Heifers	Culling Rates[a], %	First Service AI Conception Rates[b], %	Overall Pregnancy Rates[c], %
1994	483	42	66.8	93.8
1995	468	17	69.8	95.4
1996	591	14	67.5	95.8
Total	1542	24	68.0	95.1

[a]Culling rates = no. of heifers culled prior to breeding season/no. of heifers purchased.
[b]Conception rates = no. of pregnant heifers/no. of heifers inseminated.
[c]Pregnancy rates = no. of pregnant heifers/no. of heifers synchronized.

Table 2. Net Profit or Loss Associated with the Sale of Heifers at Various Stages of Development

	Purchase Year			
Stage	1994	1995	1996	Average
	))))))))))))))))))($/head)))))))))))))))))))			
Prebreeding culls	8	16	4	9
Postbreeding culls	-33	-144	-84	-86
Precalving culls[a]	-213	-61	-124	-133
First-service AI	160	164	164	163
Second-service AI	129	88	184	138
Naturally mated	89	72	86	83

[a]Heifers diagnosed pregnant but aborted during the winter.

Table 3. The Economic Effect of Genetics on Artificially Inseminated Heifers Over a Two-Year Period in a Heifer Development Operation

	First-Service AI Heifers		Second-service AI Heifers	
Purchase Year	No. of heifers	Profit, $/Head	No. of Heifers	Profit, $/Head
1995				
Black[a]	28	120[c]	13	133
BWF[b]	136	235[d]	29	175
1996				
Black[a]	108	112[c]	44	198
BWF[b]	147	201[d]	83	177

[a]Heifers of predominantly Angus origin.
[b]Heifers of predominantly Hereford × Angus origin.
[c,d]Profits within a column with uncommon superscript letters differ ($P < .05$).

FUSOBACTERIUM NECROPHORUM LEUKOTOXOID VACCINE FOR PREVENTION OF LIVER ABSCESSES [1]

T. G. Nagaraja, S. Saginala, M. M. Chengappa [2], K. F. Lechtenberg [3], K. E. Kemp [4], and P. M. Hine [5]

Summary

The efficacy of *Fusobacterium necrophorum* crude leukotoxoid vaccine to immunize and protect steers against experimentally induced liver abscesses was evaluated. The vaccine consisted of cell-free culture supernatant of a high leukotoxin-producing strain of *F. necrophorum*, inactivated with formalin and homogenized with an oil emulsion adjuvant. Vaccine was injected subcutaneously on days 0 and 21. Blood samples were collected weekly to monitor immune response. Three weeks after the second vaccination, steers were injected intraportally with *F. necrophorum* culture to induce liver abscesses. Three weeks later (day 63), steers were euthanatized and necropsied; livers were examined, and protection was assessed. Anti-leukotoxin antibody titers in the control steers generally did not differ from the baseline (week 0) titers. The titers in the vaccinated groups increased, more so after the second injection, and the increase was generally dose dependent. At necropsy, all steers in the control group had liver abscesses. In the vaccinated groups, two out of five steers in the 1.0 ml group and one each in the 2.0, 5.0, and 2.25 ml (concentrated) groups had liver abscesses. The difference suggests a protective effect of anti-leukotoxin antibodies against experimentally induced liver abscesses.

(Key Words**:** Liver Abscesses, *Fusobacterium necrophorum*, Leukotoxoid Vaccine.)

Introduction

Liver abscesses are of economic concern to the feedlot industry because they cause liver condemnation, reduced feed efficiency, and reduced weight gain. *Fusobacterium necrophorum*, is the primary causative agent of liver abscesses. The incidence of liver abscesses averages 18 to 32% in feedlot cattle and is related to feeding high grain diets. Rapid ruminal fermentation of grain in the rumen results in ruminal acidosis and rumenitis, which are considered to be predisposing factors for liver abscesses. *Fusobacterium necrophorum*, a normal inhabitant of the rumen, colonizes the ruminal epithelial wall, reaches the liver via the portal circulation, and sets up infection. The ability of *F. necrophorum* to colonize ruminal epithelium and establish infection in the liver is attributed mainly to a potent leukotoxin that is toxic to leukocytes, macrophages, ruminal epithelial cells, and hepatocytes. Therefore, immunizing the animal against the toxin may

[1]A detailed description of this study has been published in the Journal of Animal Sciences (volume 75, pages 1160-1166, 1997).

[2]Department of Diagnostic Medicine/Pathology and Microbiology.

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[4]Department of Statistics.

[5]Mallinckrodt Veterinary, Inc., Mundelein, Illinois.

prevent the onset of liver abscesses. Our objective was to determine the efficacy of *F. necrophorum* leukotoxoid vaccine to immunize steers and to provide protection against experimentally induced liver abscesses.

Experimental Procedures

Fusobacterium necrophorum, A25, a high leukotoxin producing strain, previously isolated from a liver abscess was used to prepare the vaccine, which consisted of cell-free supernatant (original or concentrated 5.2 fold) inactivated by adding formalin and homogenized with an oil emulsion adjuvant. The leukotoxicity of the original and concentrated culture supernatants, before and after formalin inactivation, was determined.

Twenty-five Holstein steers (mean body weight 860 lb), fed ad libitum a diet of alfalfa hay, were assigned randomly to five groups: control; three doses (1.0, 2.0, and 5.0 ml) of the culture supernatant; and a dose of the concentrated supernatant (2.25 ml) equivalent to the leukotoxin concentration in 4.5 ml of the original culture supernatant (Table 1). Each steer in the control group received 4.5 ml of phosphate buffer saline mixed with adjuvant. All injections were given subcutaneously on days 0 and 21.

Jugular blood samples were collected at weekly intervals after the first vaccination to monitor the immune response. Serum samples were assayed for anti-leukotoxin antibody titers. Three weeks after the second vaccination, steers were inoculated intraportally by an ultrasound-guided, percutaneous, catheterization procedure with *F. necrophorum* to induce liver abscesses Steers were euthanatized 21 days after the intraportal challenge and examined for abscesses and other gross lesions in the liver and other organs.

Results and Discussion

The leukotoxin concentration in the original culture supernatant was 27,020 units/ml. In the culture supernatant concentrated 5.2-fold, the leukotoxin concentration was 54,040 units/ml. Apparently, the process of concentration reduced the leukotoxin activity. Therefore, 2.25 ml of the concentrated supernatant was used to equal the leukotoxin concentration in the 4.5 ml dose.

Antibody titers in the control steers injected with phosphate-buffered saline generally did not differ from the baseline throughout the 6-week sampling period. The titers in the vaccinated steers increased ($P<.01$) following the first vaccination and increased much more after the second injection (Figure 1). A significant treatment x week interaction ($P < .01$) occurred. Generally, the antibody titers appeared to be related to the dose of leukotoxoid, with the 1.0 ml dose eliciting the lowest antibody titers and the 5.0 ml dose eliciting the highest. The purpose of using the concentrated supernatant was to determine whether concentrating the culture supernatant to reduce the injection volume would alter its immunogenicity or protective effect. Apparently, concentrating the culture supernatant reduced its immunogenicity as evidenced by lower antibody titers.

At necropsy, all five steers in the control group had liver abscesses as compared to two out of five steers in the 1.0-ml-vaccinated group and one each in the 2.0, 5.0, and 2.25 ml (concentrated) groups (Table 2). Based on Fisher's exact test (2-tail), the incidence of liver abscesses was lower ($P<0.01$) in the vaccinated groups (all four doses) than in the control. Steers that developed abscesses ($n=10$) had lower anti-leukotoxin titers ($P<0.05$) during wk 1 to 6 than those steers

(n=15) that did not develop abscesses in the liver, regardless of the treatment (Figure 2).

Our results indicate that *F. necrophorum* culture supernatant was capable' of eliciting anti-leukotoxin immunity that provided some degree of protection against experimentally induced liver abscesses. However, further studies are required to determine the efficacy of the vaccine in feedlot cattle with naturally developing liver abscesses.

Table 1. Treatment Groups and Leukotoxin Concentration in the Culture Supernatant

Treatment	Culture Supernatant (ml)	Concentrated Supernatant[a] (ml)	Phosphate Buffered-Saline (ml)	Adjuvant (ml)	Leukotoxin Titer per Dose
Control	–	–	4.5	.5	–
Culture supernatant, 1.0 ml	0.9	–		.l	24,318
Culture supernatant, 2.0 ml	1.8	–		.2	48,636
Culture supernatant, 5.0 ml	4.5	–		.5	121,590
Concentrated supernatant, 2.25 ml		2.25	2.25	.5	121,590

[a] Culture supernatant concentrated 5.2-fold

Table 2. Experimental Induction of Liver Abscesses in Control or Vaccinated Steers

		Liver Abscesses	
Treatment	No. of Steers	Necropsy[a]	Incidence (%)
Control	5	5/5	100
Culture supernatant, 1.0 ml	5	2/5	40
Culture supernatant, 2.0 ml	5	1/5	20
Culture supernatant, 5.0 ml	5	1/5	20
Concentrated supernatant, 2.25 ml[b]	5	1/5	20

[a]Fisher's exact test (2-tail), control vs. vaccinated $P < .01$.
[b]Culture supernatant concentrated 5.2-fold.

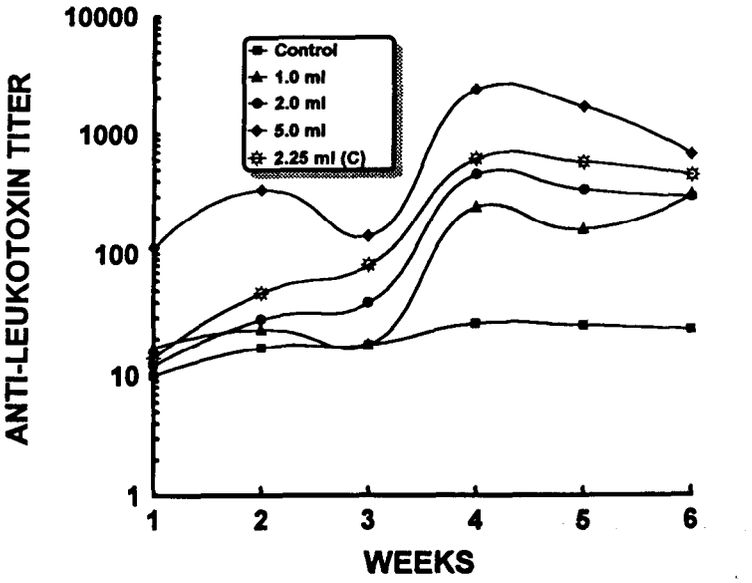

Figure 1. **Serum Leukotoxin-Neutralizing Antibody Titers in Controls or Steers Vaccinated with 1.0, 2.0, or 5.0 ml Culture Supernatant and 2.25 ml of the Concentrated (C) Supernatant. SEM = 1.6, Treatment Effect P<.0l, Week Effect P<.0l, and Treatment x Week Interaction P<.05.**

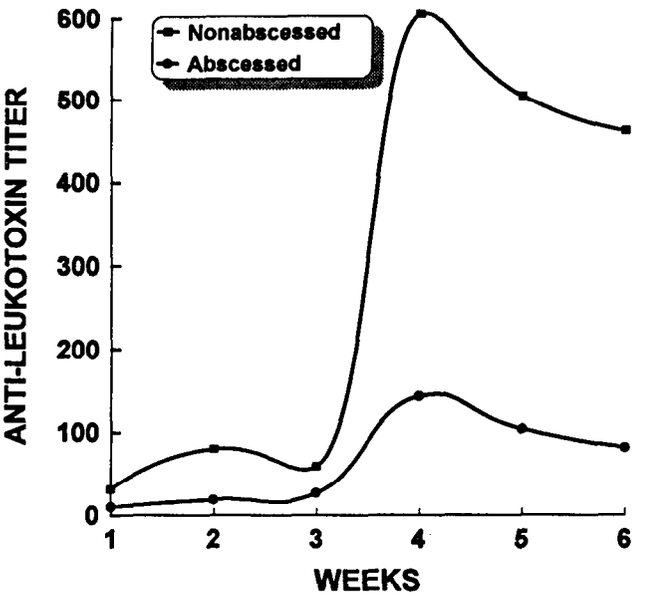

Figure 2. **Serum Leukotoxin-Neutralizing Antibody Titers in Steers that Developed (N=10) or Did Not Develop (N=15) Liver Abscesses. SEM=1.4, Abscess Effect P<.05, Week Effect P<.01).**

FUSOBACTERIUM NECROPHORUM IN RUMINAL CONTENTS AND ON THE RUMINAL WALL OF CATTLE

K. R. Bedwell, N. Wallace, and T. G. Nagaraja

Summary

Fusobacterium necrophorum was quantified from ruminal contents and ruminal wall tissue collected at slaughter. Livers were examined and scored for abscesses. The mean concentration of *F. necrophorum* on the ruminal wall ranged from 2.9×10^3 to 6.1×10^5 per cm^2. The dorsal sac had the lowest counts, and dorsal blind and ventral sacs had the highest counts of *F. necrophorum* adherent to the ruminal wall. The concentrations of *F. necrophorum* in ruminal contents and on the ruminal wall did not appear to be related to presence or absence of abscessed livers or to severity of abscesses.

(Key Words: *Fusobacterium necrophorum*, Ruminal Contents, Ruminal Wall.)

Introduction

Fusobacterium necrophorum is the primary causative agent of liver abscesses in feedlot cattle and is a normal inhabitant of the rumens of cattle. The concentration in the rumen ranges from 100,000 to a million cells per gram of contents. Additionally, the ruminal ecosystem includes 'epimural bacteria', which are adherent to the ruminal wall. Reports on the isolation of *F. necrophorum* from the ruminal wall are limited and are almost always in relation to ruminal lesions. Whether *F. necrophorum* is part of the normal component of the ruminal wall population is not known.

Two studies were conducted. One was to quantify *F. necrophorum* attached to the ruminal wall. The second was to determine whether the concentration of *F. necrophorum* in ruminal contents and on the ruminal wall was related to the occurrence of liver abscesses in cattle.

Experimental Procedures

In the first study, rumens were obtained immediately after slaughter from eight cattle fed a high-grain diet, and samples of ruminal contents and ruminal wall tissue were collected. Tissue sections were taken from the cranial sac, dorsal sac, dorsal blind sac, ventral sac, and ventral blind sac. The pH of ruminal contents was recorded.

In the second study, ruminal contents and ruminal wall sections (from the dorsal sac only) were collected from 76 grain-fed cattle at a slaughter house. Livers were examined for abscesses and scored on a scale of 0 to A+ with 0 being no abscess and A+ being one or two large or multiple small abscesses (Table 1). The pH of ruminal contents was measured immediately after collection. Samples were chilled and packed in ice and shipped by overnight delivery to the laboratory.

Ruminal contents were blended for 1 minute, strained through four layers of cheesecloth, and diluted anaerobically. Enumeration of *F. necrophorum* was by most-probable-number (MPN) technique using a selective culture medium dispensed in 96-well

microtiter plates and incubated in an anaerobic glove box. The plates were incubated for 48 hours and tested for indole production as evidence of *F. necrophorum* growth.

Ruminal wall tissues were cut into 8 mm circles with a biopsy punch, rinsed three times in anaerobic medium, and minced in a homogenizer. Serial dilutions of the suspension of homogenized ruminal wall tissue were made anaerobically, and *F. necrophorum* was enumerated as before.

Results and Discussion

In the first study, the mean pH was 5.57, and *F. necrophorum* counts of ruminal contents averaged 4.6 x 10^5/gram of DM. The mean concentration of *F. necrophorum* on the ruminal wall ranged from 2.9 x 10^3 to 6.1 x 10^5 per cm^2. Some ruminal wall tissue samples showed no *F. necrophorum* growth. The dorsal sac had the lowest counts, and the dorsal blind and ventral sacs had the highest counts of adherent *F. necrophorum* (Figure 1).

In the second study, 39 samples were from cattle with normal livers (liver score 0) and 37 samples were from cattle with liver abscesses (liver score A-, A, and A+). Mean pH of ruminal contents was similar between groups. Of the 39 ruminal wall samples from cattle with no liver abscesses, 14 samples yielded no *F. necrophorum* growth. Of the 37 rumen wall samples from cattle with liver abscesses, 17 exhibited no *F. necrophorum* growth. The mean *F. necrophorum* counts from ruminal contents were 2.4×10^6 and $.9 \times 10^6$ MPN/gram of DM from cattle with normal and abscessed livers, respectively (Table 1). Additionally, the mean *F. necrophorum* counts from ruminal wall were $2.6 \times 10^3/cm^2$ for samples collected from cattle with normal levels and $8.4 \times 10^3/cm^2$ for those with abscessed livers. None of the differences among groups for ruminal pH and *F. necrophorum* counts in ruminal contents and ruminal walls were statistically significant. However, it is interesting that counts of *F. necrophorum* adherent to the ruminal wall were numerically higher in cattle with abscessed livers than in cattle with normal livers. Further research is needed on *F. necrophorum* adherent to the ruminal wall in terms of factors affecting their presence or numbers and their role in causing liver abscesses.

Table 1. *Fusobacterium necrophorum* in Ruminal Contents and on the Ruminal Wall from Cattle with or without Liver Abscesses

			F. necrophorum	
Liver Abscess Score[a]	Number of Samples	Ruminal pH	Ruminal Contents, $\times 10^6$ MPN/g DM	Ruminal Wall, $\times 10^3$ MPN cm^2
0	39	6.15	2.4	2.6
A-	8	6.57	1.2	16.7
A	13	6.29	.4	2.3
A+	16	5.98	.2	6.3

[a]0 = normal liver; A- = Liver has one or two small abscesses or abscess scar; A = Liver has two to four well-organized abscesses under one inch in diameter; A+ = Liver has one or more large, or multiple small active abscesses with or without portions of the diaphragm adherent to the surface of the liver.

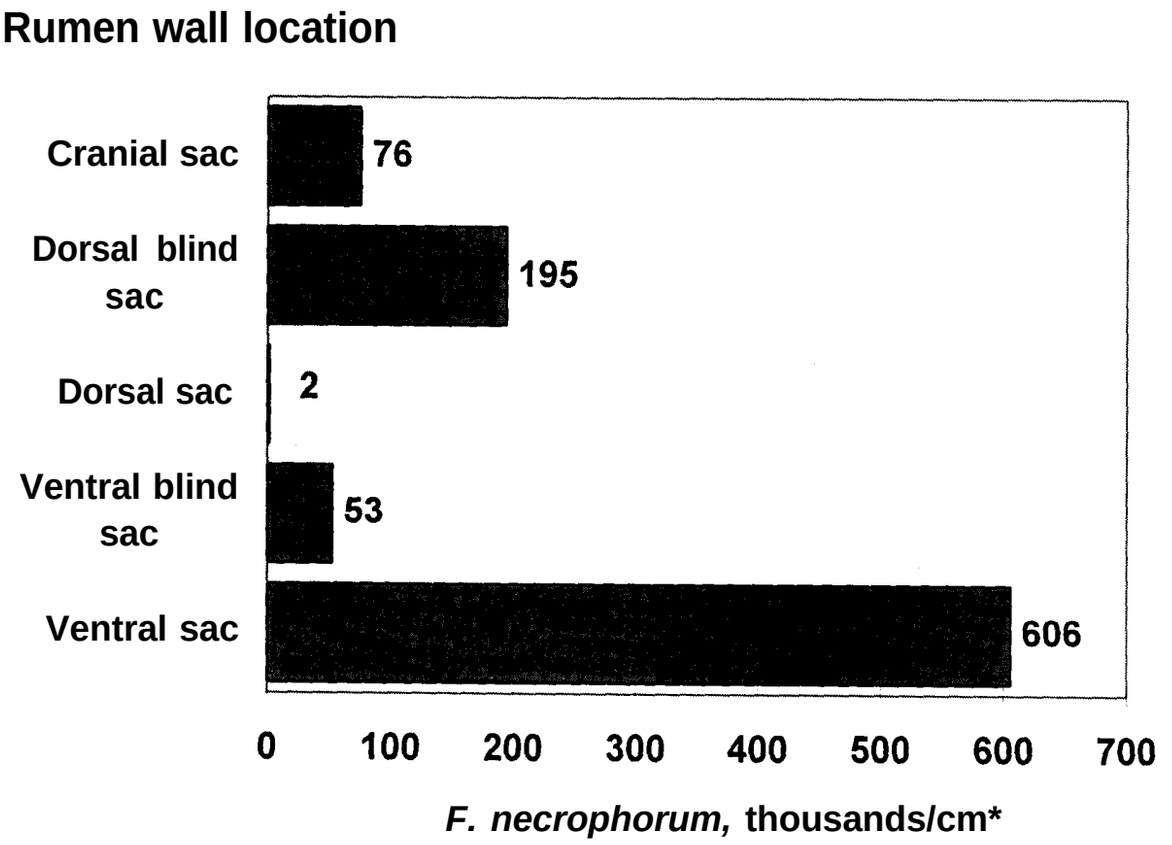

Figure 1. Counts of *Fusobacterium necrophorum* Adherent to the Ruminal Wall in Cattle Fed High Grain Diets.

COMPARISON OF *FUSOBACTERIUM NECROPHORUM* ISOLATES FROM LIVER ABSCESSES, RUMINAL WALLS, AND RUMINAL CONTENTS OF FEEDLOT CATTLE [1]

S. Narayanan, T. G. Nagaraja, O. Okwumabua [2], J. Staats [2], M. M. Chengappa [2], and R. D. Oberst [3]

Summary

DNA finger printing (restriction fragment length polymorphism analysis) was employed to genetically compare *Fusobacterium necrophorum* isolates of liver abscesses, ruminal wall, and ruminal contents from the same animal. *Fusobacterium necrophorum* isolates from liver abscesses were genetically identical to the corresponding isolates from the ruminal wall in eight of nine animals tested. This genetic similarity between the isolates supports the hypothesis that *F. necrophorum* in liver abscesses originates from the ruminal wall.

(Key Words: *Fustobacterium necrophorum*, Liver Abscesses, Feedlot.)

Introduction

Liver abscesses occur most often in cattle fed high grain diets. Abscessed livers commonly are found in 10-30% of feedlot cattle at slaughter. *Fusobacterium necrophorum*, a bacterium normally present in the rumen, is the primary causative agent of liver abscesses in cattle.

The incidence of liver abscesses is generally higher in cattle with lesions of the rumen lining than in cattle with normal rumens. The positive correlation between incidence of liver abscesses and ruminal lesions was the basis for the hypothesis that *F. necrophorum* in liver abscesses is of ruminal origin. Our approach to documenting that *F. necrophorum* of liver abscesses originates in the rumen was to show that the rumen wall and liver abscess isolates are genetically identical and, thus, are progeny of a single cell.

Experimental Procedures

Samples of ruminal contents, ruminal wall tissue (from the dorsal sac), and liver abscesses were collected from 11 cattle at slaughter, packed in ice, and transported to the laboratory. Swab samples of the pus from liver abscesses, homogenates of the epithelial layer of the ruminal wall, and diluted ruminal contents were used for isolation of *F. necrophorum*.

In order to genetically compare the isolates, the technique of restriction fragment length polymorphism (RFLP) analysis of ribosomal DNA or ribotyping was employed. Ribotyping involves the fingerprinting of

[1]A detailed description of this study has been published in the Journal of Applied and Environomental Microbiology (volume 63, pages 4671-4678, 1997).

[2]Department of Diagnostic Medicine/Pathology and Microbiology.

[3]Food Animal Health and Management Center.

chromosomal DNA restriction fragments that contain genes coding for 16S and 23S ribosomal RNA (rRNA). Because the genes coding for rRNA are highly conserved and most bacteria contain multiple copies of rRNA genes, a reasonable number of fragments are obtained after probing, and this allows discrimination among strains within the same species.

Briefly, the procedure for ribotyping was as follows: chromosomal DNA was extracted and digested with restriction endonucleases alone (*Eco*RI, *Eco*RV, *Sal*I, and *Hae*III) or in combination (*Eco*RI and *Eco*RV).). Restriction fragments were separated by gel electrophoresis and probed with a commercially available 16 and 23S rRNA from *E. coli*. Hybridization banding patterns of the isolates were compared among isolates from all three locations within the same animal. Isolates were considered genetically different if even a single band was different between two isolates with any of the restriction enzymes used to fragment the DNA.

Results and Discussion

Out of sets of liver abscesses, ruminal walls, and ruminal content samples from 11 cattle, *F. necrophorum* was isolated from all three locations from four animals, from liver abscesses and ruminal walls in five animals, and from liver abscesses and ruminal contents from two animals. This allowed comparison of nine isolates from liver abscesses and ruminal walls and six isolates from ruminal contents and liver abscesses. The number of major bands of DNA among the Isolates ranged form nine to 11. Isolates differing by one or more bands in their hybridization patterns were considered distinct strains (Figure 1). .

The ribotypic comparison of isolates from liver abscess and ruminal wall of the ame animal showed that in eight out of nine cases, *F. necrophorum* isolated from the ruminal wall was identical to liver abscess isolates (Table 1). None of the ruminal content isolates matched with either the ruminal wall isolate or liver abscess isolate from the same animal. These results provide direct evidence for the proposed pathogenesis of liver abscesses. Prior to this, the only evidence available in support of this hypothesis was the statistical correlation between the occurrence of liver abscesses and ruminal pathology.

The genetic similarity between the isolates from liver abscesses and the isolates from the ruminal walls lends credence to the hypothesis that *F. necrophorum* of liver abscesses originates from the rumen. The lack of genetic similarity between ruminal content and liver abscess isolates is not surprising, because ruminal contents presumably have a multitude of strains. Therefore, chance is involved in finding a match. Presumably, a single strain among this multitude of strains penetrates and colonizes the ruminal wall.

Table 1. Comparison of *Fusobacterium necrophorum* Isolates from Ruminal Contents, Ruminal Wall, and Liver Abscesses

Animal	Ruminal Contents	Ruminal Wall	Liver Abscesses
1	---	✖	✔
2	---	✔	✔
3	✖	✔	✔
4	---	✔	✔
5	✖	✔	✔
6	✖	✔	✔
7	---	✔	✔
8	✖	✔	✔
9	✖	---	✔
10	---	✔	✔
11	✖	---	✔

✔Match
✖ No Match

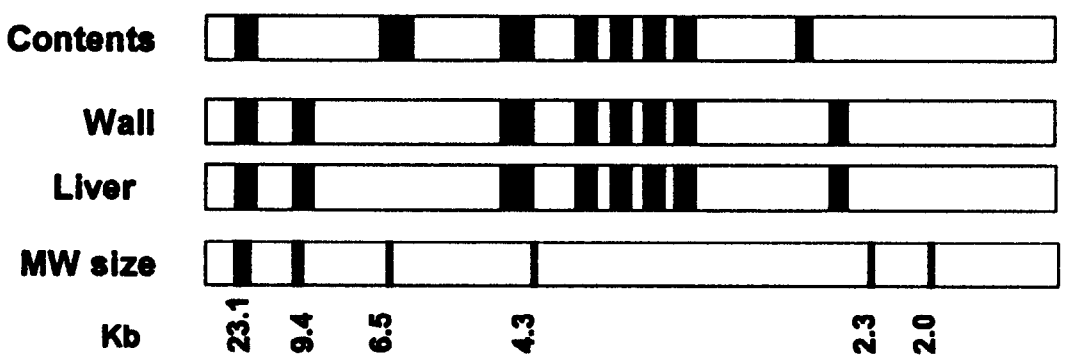

Figure 1. Hybridization Patterns of Restriction Fragments of DNA from *Fusobacterium necrophorum* Isolates from the Ruminal Contents, Ruminal Wall, and Liver Abscesses Isolated from Animal No. 6. Lane MW Has Molecular Weight Markers. *F. necrophorum* from the Liver Abscesses Was Identical to That from Rumen Wall but Different from That of Rumen Contents.

ANTIBIOTIC SUSCEPTIBILITY OF *FUSOBACTERIUM NECROPHORUM* ISOLATED FROM LIVER ABSCESSES [1]

T. G. Nagaraja, K. F. Lechtenberg [2], and M. M. Chengappa [3]

Summary

Antibiotic susceptibility patterns of thirty-seven isolates of *Fusobacterium necrophorum* (21 biotype A and 16 biotype B) from liver abscesses of feedlot cattle were determined. These isolates were generally susceptible to penicillins, tetracyclines (chlortetracycline and oxytetracycline), lincosamides (clindamycin and lincomycin), and macrolides (tylosin and erythromycin) but resistant to aminoglycosides (kanamycin, neomycin, gentamycin and streptomycin), ionophores (except narasin), and peptides (avoparcin, polymixin, and thiopeptin). Differences in antibiotic sensitivity patterns were observed between the two biotypes only for clindamycin and lincomycin. The minimum inhibitory concentrations (MIC) of FDA-approved antibiotics for liver abscess control did not parallel their efficacy in preventing clinical liver abscesses in feedlot cattle. Continuous tylosin feeding did not appear to induce antibiotic resistance in *F. necrophorum.*

(Key Words: *Fusobacterium necrophorum*, Liver Abscesses, Antibiotic Susceptibility.)

Introduction

Fusobacterium necrophorum, a gram-negative, anaerobic, rod-shaped bacterium, is the primary causative agent of liver abscesses in feedlot cattle. Two distinct biotypes or subspecies, biotype A (subsp. *necrophorum*) and biotype B (subsp. *funduliforme*), have been recognized. Biotype A is encountered most frequently in liver abscesses. Because of the importance of *F. necrophorum* as an animal pathogen, its antibiotic susceptibility, particularly to clinically relevant antibiotics, has been reported. However, studies on susceptibility to antibiotics used as feed additives have been limited. Also, the difference in susceptibility patterns between the two biotypes have not been reported. Our objectives were to determine the susceptibility of *F. necrophorum* of liver abscess origin to antibiotics, including FDA-approved and certain experimental feed additives, and to determine whether continuous antibiotic feeding during the finishing period would influence susceptibility of *F. necrophorum* to those antibiotics.

Experimental Procedures

Abscessed livers from feedlot cattle in Kansas and eastern Missouri were collected

[1]A detailed description of this study is published in the American Journal of Veterinary Research (volume 59, pages 44-48, 1998).

[2]Midwest Veterinary, Inc., Oakland, Nebraska.

[3]Department of Diagnostic Medicine/Pathology and Microbiology.

at a slaughter house. Lot numbers and cattle origins were recorded to enable obtaining information on antibiotic feeding. *Fusobacterium necrophorum* was isolated from the abscesses. Thirty-seven isolates (21 biotype A and 16 biotype B) were used in the study. The antibiotics tested included: ampicillin, avoparcin, bacitracin, carbenicillin, cephalothin, chloramphenicol, chlortetracycline, clindamycin, cloxacillin, erythromycin, gentamicin, ipronidazole, kanamycin, lasalocid, lincomycin, methicillin, monensin, nalidixic acid, narasin, neomycin, novobiocin, oxytetracycline, penicillin-G, polymyxin-B, salinomycin, streptomycin, tetronasin, thiopeptin, tylosin, vancomycin, and virginiamycin. Antibiotic type is shown in Table 1.

Susceptibility or resistance of *F. necrophorum* isolates to antibiotics was determined by inoculating overnight cultures (16 to 18 hours) into anaerobic media with 100 µg/ml or units/ml (for bacitracin, penicillin-G, polymyxin-B) of antibiotics or no antibiotic. Culture absorbance was measured three times to determine growth. For antibiotics that were inhibitory at 100 µg/ml or units/ml, the minimum inhibitory concentration (MIC) was determined by broth microdilution. The MIC was the lowest concentration of the antibiotic that inhibited growth. Differences in MIC between the two biotypes, between tylosin- and nontylosin-fed cattle, and between chlortetracycline- and nonchlortetracycline-fed cattle were compared by a statistical t test.

Results and Discussion

Fusobacterium necrophorum isolates from liver abscesses were resistant (100 µg or units/ml) to avoparcin, gentamycin, kanamycin, lasalocid, monensin, nalidixic acid, neomycin, salinomycin, streptomycin, tetronasin, thiopeptin, and vancomycin. The resistance of *F. necrophorum* to ionophore antibiotics explains the lack of influence of monensin or lasalocid on the incidence of liver abscesses.

The isolates were susceptible to ampicillin, bacitracin, carbenicillin, cephalothin, chloramphenicol, chlortetracycline, clindamycin, cloxacillin, erythromycin, ipro nidazole, lincomycin, methicillin, narasin, novobiocin, oxytetracycline, penicillin-G, polymyxin-B, tylosin, and virginiamycin. Mean MICs of antibiotics to which *F. necrophorum* was susceptible are shown in Table 1. The MICs of all antibiotic compounds except for clindamycin and lincomycin did not differ between the two biotypes of *F necrophorum*. For clindamycin and lincomycin, MICs were lower ($P < 0.05$) for biotype A than biotype B (Table 1).

Only 31 of the 37 isolates were from cattle with known antibiotic feeding status during the finishing period. Twenty-three isolates were from tylosin-fed (10 g/ton of feed) cattle and eight were from cattle that did not receive tylosin. Only four isolates were from chlortetracycline-fed (75 mg/head/day) cattle. The mean MICs for tylosin were similar whether or not the cattle had been fed tylosin (Table 2). Similarly, continuous feeding of chlortetracycline had no effect on the MIC of either chlortetracycline or oxytetracycline (Table 2). Apparently, continuous feeding of tylosin or chlortetracycline did not induce antibiotic resistance *F. necrophorum* isolates.

According to the U.S. Feed Additive Compendium, five antibiotics (bacitracin, chlortetracycline, oxytetracycline, tylosin, and virginiamycin) are approved for use in the prevention of liver abscesses in feedlot cattle. Based on MIC, chlortetracycline and oxytetracycline were most effective and bacitracin was the least effective. However tylosin is

most effective in preventing clinical liver abscesses. Except for bacitracin, MIC does not appear related to clinical efficacy. The mode of action of these antibiotics in preventing liver abscesses is possibly inhibition or reduction of the population of *F. necrophorum* in ruminal contents and (or) in the liver.

Table 1. Mean Minimum Inhibitory Concentrations (MICs) of Antibiotics for *Fusobacterium necrophorum* Isolates from Liver Abscesses[a]

		Fusobacterium necrophorum Biotypes		Total (n = 37)	
Antibiotics[b]	Antibiotic Type	Biotype A (n = 21)	Biotype B (n=16)	Mean	Range
Ampicillin	Lactam	1.6	1.4	1.5	.2-9.4
Bacitracin		50.2	42.7	46.8	9.4-100.0
Carbenicillin	Lactam	1.8	4.4	2.9	.3-18.8
Cephalothin	Lactam	.1	.2	.2	.1-.3
Chloramphenicol		14.1	20.1	16.7	1.6-42.5
Chlortetracycline	Tetracycline	.8	1.5	1.1	.1-6.3
Clindamycin	Lincosamide	.04	.8[c]	.4	.02-3.1
Cloxacillin	Lactam	.4	1.1	.7	.1-3.1
Erythromycin	Macrolide	3.5	3.0	3.2	.8-6.3
Ipronidazole		.3	2.7	1.9	.2-5.6
Lincomycin	Lincosamide	.04	.7[c]	.3	.01-3.1
Methicillin	Lactam	.4	.9	.6	.1-6.3
Narasin	Ionophore	2.5	3.3	2.9	.8-4.7
Novobiocin		8.0	4.3	6.4	.2-12.5
Oxytetracycline	Tetracycline	.4	1.5	.9	.03-4.1
Penicillin-G	Lactam	.1	1.3	.7	.1-2.1
Polymyxin-B		37.4	46.0	41.1	8.1-100.0
Tylosin	Macroliode	3.7	7.4	5.3	2.0-12.5
Virginiamycin	Streptogramn	2.8	3.9	3.3	2.3-6.3

[a]Mean of six replications, each utilizing twofold dilutions from 0.01 to 100.00.
[b]Concentrations in µg/ml except for bacitracin, penicillin-G, and polymyxin-B, which are in units/ml.
[c]Different from biotype A.

Table 2. Effect of Continuous Feeding of Tylosin or Chlortetracycline On Antibiotic Susceptibility of *Fusobacterium necrophroum* Isolates from Liver Abscesses

	Minimum Inhibitory Concentration, µg/ml			
Antibiotics	Tylosin-Fed[a] (n = 23)	No Tylosin (n = 8)	Chlortetracycline-Fed [b] (n = 4)	No Chlortetracycline (n = 27)
Tylosin	5.9	5.1		
Chlortetracycline			2.2	1.2
Oxytetracycline			.1	1.1

[a]Tylosin was fed at 10 g/ton of feed throughout the finishing period.
[b]Chlortetracycline was fed at 75 mg/head/day throughout the finishing period.

EFFECT OF TYLOSIN ON RUMINAL *FUSOBACTERIUM NECROPHORUM* POPULATION AND FERMENTATION PRODUCTS IN CATTLE FED A HIGH-GRAIN DIET

T. G. Nagaraja, N. Wallace, Y. Sun, K. E. Kemp [1], and J. C. Parrott [2]

Summary

Tylosin feeding prevented the increase in *Fusobacterium necrophorum* population normally associated with the feeding of a high-grain diet. Also, tylosin appeared to moderate the ruminal fermentation during initial adaptation to a high-grain diet.

(Key Words:Tylosin, *Fusobacterium necrophorum*, High-Grain Diet.)

Introduction

Fusobacterium necrophorum, a normal inhabitant of the rumen, is the primary causative agent of liver abscesses in cattle. It has been detected in or isolated from bovine ruminal contents and ruminal wall lesions by a variety of methods. The concentration in the rumen is in the range of 100,000 to a 1,000,000 cells per gram of ruminal contents.

Tylosin is used widely in the feedlot industry to prevent liver abscesses. The antibiotic is a macrolide and is primarily effective against gram-positive bacteria. Although, *F. necrophorum* is gram-negative, it is susceptible to tylosin. However, the effect of feeding tylosin on the population of *F. necrophorum* in the rumen has not been determined. Also, the antimicrobial activity of tylosin could moderate the rate of ruminal fermentation and, thus, contribute to a stable fermentation. Therefore, a study was conducted to determine the effect of dietary tylosin on the concentration of *F. necrophorum* and fermentation products in the rumen during adaptation to a high-grain diet.

Experimental Procedures

Six ruminally cannulated Holstein steers were used in a crossover design to determine the effect of tylosin on *F. necrophorum* counts in ruminal contents. Treatment groups were control and tylosin-fed (90 mg/head/day). Steers were adapted initially to an alfalfa hay diet and then stepped up rapidly (4-day step up) to an 85% grain diet. Steers were fed a 70% grain diet on days 1 to 3 and an 85% grain diet from days 4 to 32. The intention of rapid step-up was to promote lactic acid production and accumulation in the rumen. The grain portion of the diet was composed of cracked corn (87.8%); soybean meal (10.5%); salt (1.0%); dicalcium phosphate (0.3%); trace mineral mixture (0.2%); and vitamins A, D, and E (0.1%). Steers were fed daily at 2% of BW.

Ruminal contents were collected on 3 consecutive days before grain feeding (days -2, -1, and 0); after feeding the 70% grain diet (days 2, 3, and 4) and 85% grain diet (days 5, 6, and 7); and thereafter on 2 consecutive days weekly for 4 weeks. Ruminal samples were

[1]Department of Statistics.
[2]Lilly Research Laboratories, Council Bluffs, Iowa.

collected before feeding (time 0), transported to the laboratory, and processed for enumeration of *F. necrophorum* and analyses of pH and concentrations of lactate, volatile fatty acids (VFA), and ammonia. Also, on days 1 (70% grain diet) and 4 and 11 (85% grain diet), ruminal samples were collected at feeding and 3, 6, 9, 12, and 24 hours after feeding to monitor the effect of tylosin on postfeeding feeding ruminal fermentation products. *F. necrophorum* was counted by the most-probable-number (MPN) technique using a selective culture medium.

Results and Discussion

Before grain feeding, *F. necrophorum* counts in ruminal contents averaged 8.8 and 10.0 x 10^5/g DM in the control and tylosin-fed groups, respectively. In the control, *F. necrophorum* counts increased in response to grain feeding (Table 1), possibly because of availability of lactate, an energy substrate for *F. necrophorum.* The increase peaked at week 2, and counts decreased somewhat following adaptation to the 85% grain diet. Including tylosin in the diet inhibited the increase in *F. necrophorum* associated with increased grain feeding. The counts throughout the grain feeding period remained similar to or less than the baseline counts during alfalfa feeding. Apparently, feeding tylosin did not induce resistance in *F. necrophorum,* because counts did not increase during the feeding period.

We observed a trend (P=0.08) for ruminal pH to be higher in tylosin-fed than in control steers during the initial step-up to the 70 and 85% grain diets. Once the steers were adapted to the 85% grain diet, ruminal pH was similar between both groups. Ruminal lactate VFA and ammonia concentrations were not affected by including tylosin in the feed (Table 2). A 24-hour profile of ruminal fermentation products was obtained on days 1, 4, and 11 to determine whether tylosin moderates ruminal fermentation. On day 1, when steers were switched abruptly to the 70% grain diet, the postfeeding ruminal pH and concentrations of fermentation products were not affected by tylosin (data not shown). However, on days 4 and 11, ruminal pH tended to be higher in tylosin-fed than in control steers (Figure 1). The postfeeding concentrations of ruminal VFA, lactate, and ammonia were not affected by tylosin in the feed.

Table 1. Effect of Tylosin on Ruminal *Fusobacterium necrophorum*[abc]

		Most-Probable Number x 10^5/g DM	
Diet	Sampling Days	Control	Tylosin
70% grain	2 to 4	27.5	10.7
85% grain	5 to 7	35.5	5.5
	11	56.0	4.1[d]
	18	23.3	2.5[d]
	25	32.7	5.8
	32	26.9	3.0[d]
SEM		1.4	

[a]Treatment effect P < .01.
[b]Sampling days effect P = 0.06.
[c]Treatment x sampling days interaction P = .09.
[d]Different from days 1 to 3 at P < .05.

Table 2. Effect of Tylosin on Ruminal Fermentation Products

Grain		pH[a b c]		Lactate, mM		Total VFA, mM		Ammonia, mM	
Diet	Days	Control	Tylosin	Control	Tylosin	Control	Tylosin	Control	Tylosin
70%	2 to 4	6.18	6.43	0.03	0.02	87.3	85.5	0.7	0.7
85%	5 to 7	6.04	6.38	0.03	0.14	84.7	75.6	0.7	0.9
	11	6.08	6.53	0.16	0.10	71.4	73.0	0.7	0.8
	18	6.34	6.51	0.03	0.03	79.9	71.4	1.0	1.1
	25	6.60	6.53	0.03	0.03	77.8	78.6	0.7	0.8
	32	6.48	6.34	0.10	0.02	73.5	84.2	0.5	0.4
SEM		0.12		0.06		5.8		0.2	

[a]Treatment effect, P = 0.09.
[b]Sampling days effect, P < 0.05.
[c]Treatment * sampling days interaction, P < 0.05.

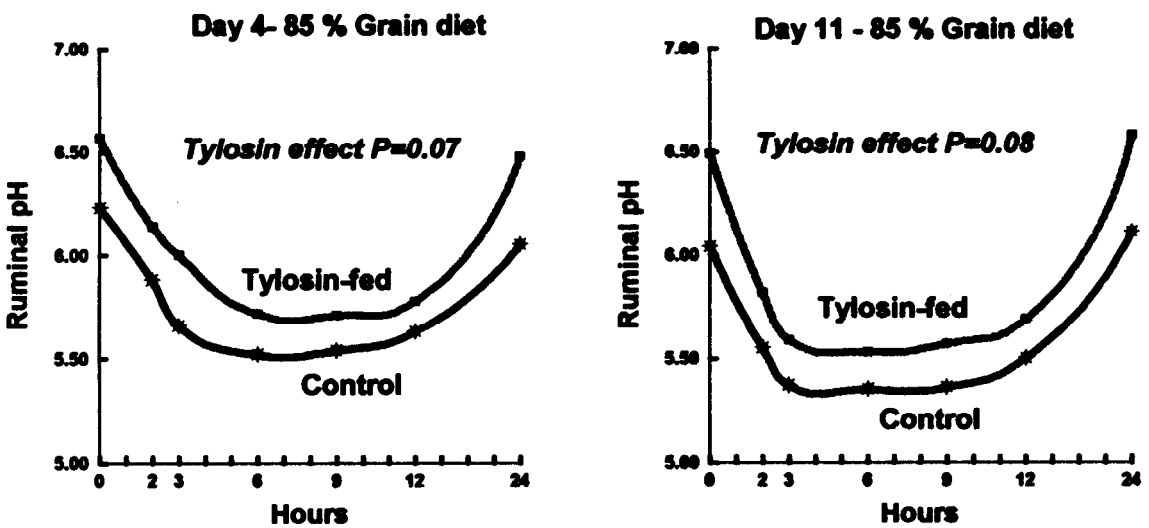

Figure 1. Ruminal pH Profile on Days 4 and 11 in Steers Fed High-Grain Diets with or without Tylosin.

WHEAT MIDDLINGS IN ROUGHAGE-BASED OR LIMIT-FED, HIGH-CONCENTRATE DIETS FOR GROWING CALVES [1,2]

D. A. Blasi, J. S. Drouillard, G. L. Kuhl, and R. H. Wessels

Summary

A 101-day growing study was conducted to evaluate the growth performance of beef heifers fed wheat middlings in traditional full-fed, sorghum silage-based rations and in limit-fed, high-concentrate rations. Diets were formulated without wheat middlings or with wheat middlings replacing 33, 67, or 100% of rolled corn plus soybean meal. Daily gains decreased linearly (P<.01) with increasing levels of wheat middlings in the roughage-based diets because of lower feed intake (P<.10), but feed efficiency was not affected (P>.30). For the limit-fed diets, heifer daily gains decreased linearly (P<.01) as the proportion of wheat middlings in the diet increased, resulting in a linear reduction (P<.01) in feed efficiency. Wheat middlings can be utilized effectively as the predominant energy/protein source for growing cattle, though their nutritional and economic value, relative to corn and soybean meal, may be different for roughage-based and limit-fed diets.

(Key Words: Wheat Middlings, Growing Calves, Limit Feeding, Sorghum Silage.)

Introduction

Previous research with wheat middlings (WM) has focused primarily on its use as a supplement for beef cows grazing poor quality roughages, where forage utilization is an important consideration. Limited studies indicate that growing cattle respond very favorably to WM as a replacement for grain and soybean meal in backgrounding rations. The objective of this study was to determine the feeding value of WM relative to corn and soybean meal in traditional high roughage diets and in limit-fed growing cattle diets. This information about the substitution value of WM in growing rations will enable beef producers to make more informed purchase decisions.

Experimental Procedures

Two hundred and eighty-eight predominantly British crossbred heifers averaging 442 lb were used in a randomized complete block design to evaluate the following eight treatments:

1. 40% sorghum silage plus dry-rolled corn (SSCRN100).

[1]Sincere appreciation is estended to the Kansas Wheat Commission, ADM Milling Co., Cargill Flour Milling Division, Cereal Food Processors, Stafford Country Flour Mills Company, and the Wall-Rogalsky Milling Company for partial funding of this research.

[2]Sincere appreciation is also extended to Western Star Mill Company, Division of ADM Milling Co., Salina, Kansas for providing the wheat middlings used in this study.

2. 40% sorghum silage plus 2:1 mixture of dry-rolled corn and wheat middlings (SSCRN67).
3. 40% sorghum silage plus 1:2 mixture of dry-rolled corn and wheat middlings (SSCRN33).
4. 40% sorghum silage plus wheat middlings (SSMID100).
5. Limit-fed diet containing dry-rolled corn as the primary energy source (LFCRN100).
6. Limit-fed diet containing 2:1 mixture of dry-rolled corn and wheat middlings (LFCRN67).
7. Limit-fed diet containing 1:2 mixture of dry-rolled corn and wheat middlings (LFCRN33).
8. Limit-fed diet containing wheat middlings as the primary energy/protein source (LFMID100).

Upon arrival at the KSU Beef Teaching and Research Center, heifers were vaccinated against common viral and clostridial diseases, treated for internal and external parasites with a topically applied parasiticide, implanted with Synovex®-H, and fed a common receiving diet for approximately 2 weeks. At the start of the study, all calves were weighed individually and blocked into three weight groups. On day 2, cattle in each weight block were reweighed individually, stratified by weight, and randomly allotted within strata to 48 pens containing six head each for a total of six replicate pens per dietary treatment. Cattle were pen weighed at about 30-day intervals during the study and were weighed individually on the final 2 days of the experiment.

Diets were formulated for approximately 2.0 lb daily gain. The roughage-based diets contained 40% sorghum silage, 14.8% crude protein and a Ca:P ratio of 2:1, and the limit-fed diets contained 15% chopped alfalfa hay, 16.7% crude protein, and a Ca:P ratio of 2:1. The roughage-based and limit-fed diets were formulated to provide no WM or 33, 67, or 100% replacement of corn/soybean meal with WM (Table 1). WM were obtained directly from a commercial flour mill. Cattle were fed their respective diets once daily at ad-libitum intake (roughage-based) or at 2.4% of body weight (limit-fed, DM basis), during the first 91 days of the growing trial. The amount of feed offered to the limit-fed cattle was adjusted every 14 days. During the final 10 days, all heifers were fed their respective diet at 2.4% (DM basis) of body weight daily to equalize ruminal fill differences between the roughage- and limit-fed diets. Feed consumption, weight gain, and feed efficiency were monitored throughout the growing period.

Results and Discussion

Heifer performance data were analyzed by regression using percentage of WM in the diet as a continuous variable, nested within diet type. Over the spectrum of WM evaluated in either the sorghum silage or limit-fed diets, a similar linear decline ($P<.01$) in daily gain occurred as the proportion of WM was increased (Figure 1). Heifer dry matter intake of the SSMID100 diet was approximately 10% percent less ($P<.10$) than intakes of the other sorghum silage diets (Table 2). On the silage diets, feed efficiency (feed DM/gain) changed little ($P>.30$) as WM increased. However, in the limit-fed diets, efficiency decreased ($P<.01$) as WM increased (Figure 2).

Based on the feed efficiency data from this study, WM had a feed value of 95% relative to corn and soybean meal when used in full-fed sorghum silage-based rations but a value of 83% when used in limit-fed diets.

Table 1. Composition of Experimental Diets

Diet	Dry-Rolled Corn	Wheat Middlings	Sorghum Silage	Alfalfa Hay	Molasses	Soybean Meal	Limestone	Diacalcium Phosphate	Urea	Premix
	))%DM basis)))									
SSCRN100	46.6	0	40.0			10.8	1.2	.33	.66	.38[1]
SSCRN76	33.0	16.5	40.0			7.6	1.7	.23	.66	.38[1]
SSCRN33	17.6	35.1	40.0			4.1	2.2	.12	.66	.38[1]
SSMID100	0	56.2	40.0			0	2.7	0	.66	.38[1]
LFCRN100	68.0	0		15.0	4.0	10.4	1.1	.38	.66	.44[2]
LFCRN67	47.2	23.6		15.0	4.0	7.2	1.8	.26	.46	.44[2]
LFCRN33	24.5	49.3		15.0	4.0	3.8	2.5	.14	.24	.44[2]
LFMID100	0	77.2		15.0	4.0	0	3.3	0	0	.44[2]

[1]Provided 30% salt; 1200 IU/lb Vitamin A; .04 ppm Cu; .50 ppm I; 48 ppm Mn; 23 ppm Se; 48 ppm Zn, and 25 g/ton Rumensin®.
[2]Provided .33% Salt; 1330 IU/lb Vitamin A; .04 ppm Co; 8.8 ppm Cu; .55 ppm I; 53 ppm Mn; .25 ppm Se; 53 ppm Zn; 30 g/ton Rumensin®, and 10 g/ton Tylan®.

Table 2. Dry Matter Intake of Experimental Diets

Diet	Dry Matter Intake, lb/day
SSCRN100	17.8[ab]
SSCRN67	18.0[b]
SSCRN33	18.0[b]
SSMID100	16.5[a]
LFCRN100	12.1[c]
LFCRN67	12.3[c]
LFCRN67	12.2[c]
LFMID100	12.2[c]
SEM	.6

[a,b,c]Means with common superscripts are not different (P>.10).

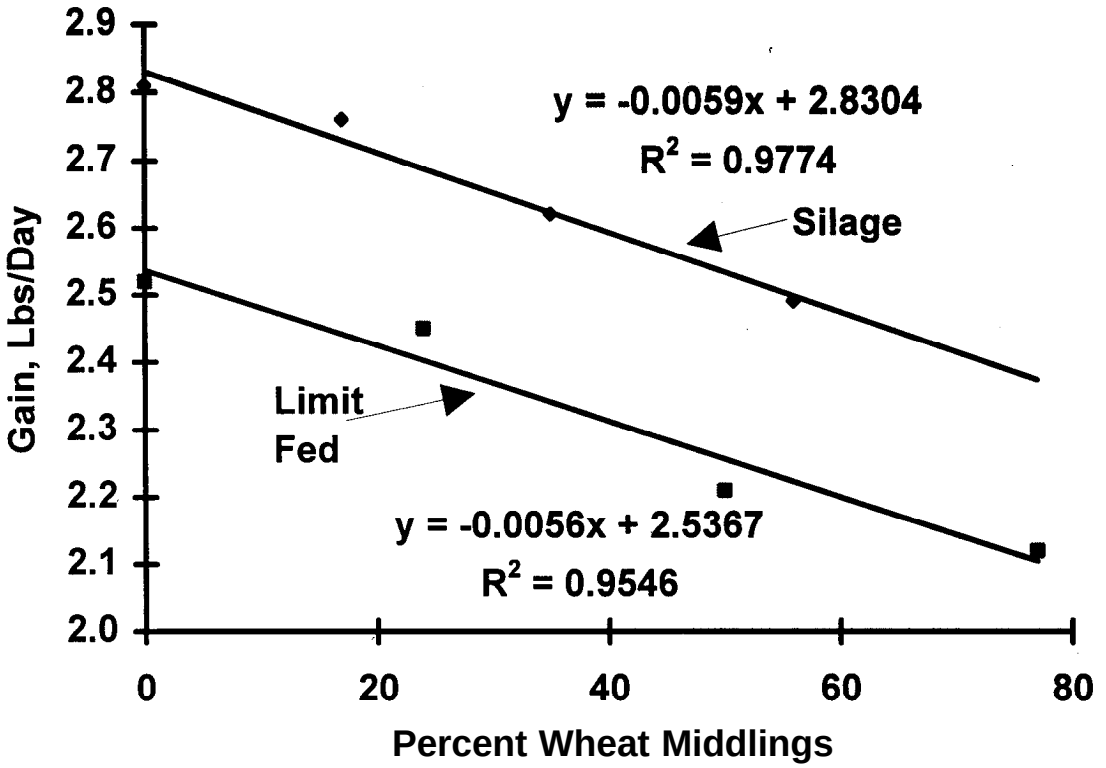

Figure 1. **Effect of Increasing Levels of Wheat Middlings on Daily Gain of Growing Heifers Fed either a Sorghum Silage or Limit-Fed Diet.**

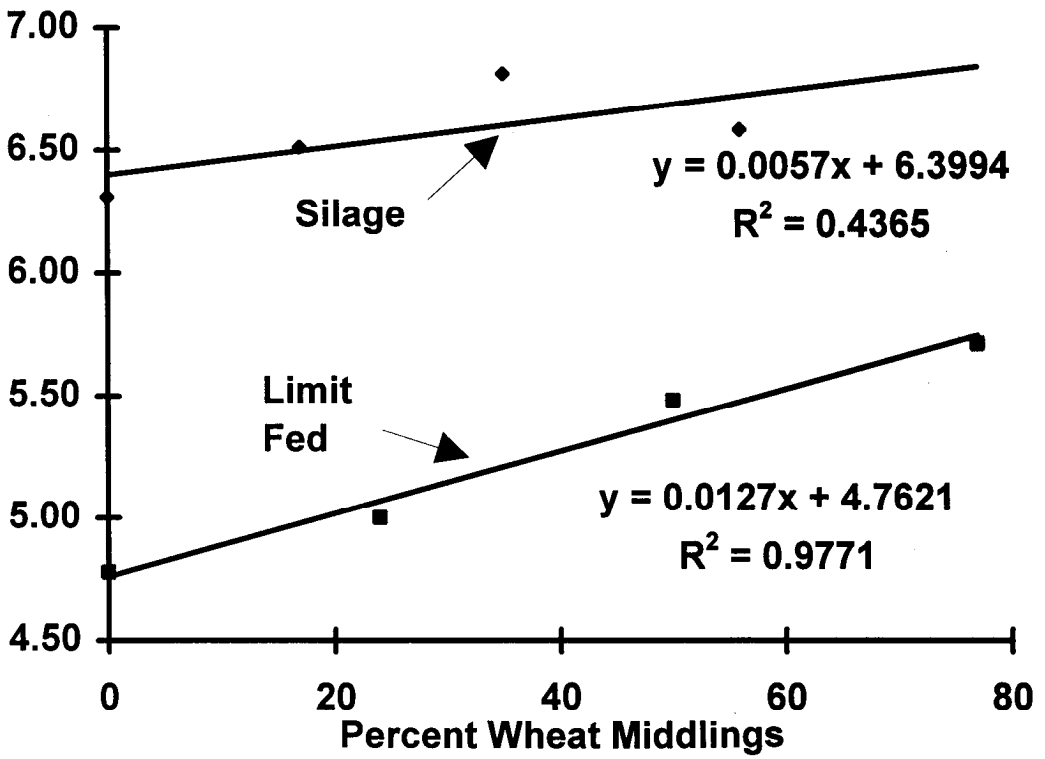

Figure 2. **Effect of Increasing Levels of Wheat Middlings on Feed Efficiency of Growing Heifers Fed either a Sorghum Silage or Limit-Fed Diet.**

SOYBEAN HULLS IN ROUGHAGE-FREE DIETS FOR LIMIT-FED GROWING CATTLE

C. A. Löest, E. C. Titgemeyer, J. S. Drouillard, D. A. Blasi, and D. J. Bindel

Summary

Three hundred heifers (573 lb initial body weight) were used in a growing study to compare growth performance of cattle fed roughage-free diets comprised mainly of soybean hulls with that of cattle receiving roughage- and corn-based diets and to determine if cattle fed soybean hull-based diets would respond to supplemental methionine hydroxy analogue (MHA; a source of methionine), ruminally protected betaine, or concentrated separator by-product (CSB; a source of betaine). Treatments included 1) a roughage-based diet fed at 2.75% of body weight (ROUGH), 2) a corn-based diet fed at 1.5% of body weight (CORN1.5), 3) a corn-based diet fed at 2.25% of body weight (CORN2.25), 4) a soybean hull-based diet fed at 1.5% of body weight (SH1.5), 5) a soybean hull-based diet fed at 2.25% of body weight (SH2.25), 6) SH1.5 top-dressed with 11.4 g/head daily MHA, 7) SH2.25 top-dressed with 11.4 g/head daily MHA, 8) SH2.25 top-dressed with 7 g/head daily rumen protected betaine, and 9) SH2.25 top-dressed with 250 g/head daily CSB. Supplemental MHA, betaine, and CSB did not change feed intakes, gains, or feed efficiencies for cattle fed soybean hulls. Heifers fed soyhulls at 2.25% of body weight gained 27% slower (P<.01) than heifers fed the corn-based diet at similar intakes and were 25% less efficient (P<.01). Similar results were observed for cattle fed soybean hulls and corn at 1.5% of body weight. Cattle fed soybean hulls at 2.25% of body weight had gains similar to those of cattle receiving the roughage-based diet at 2.75% of body weight, but feed efficiencies tended to be better (P=0.11) for the cattle receiving soybean hulls because less feed was consumed. The roughage-fed cattle gained 23% less (P<.01) than cattle fed corn at 2.25% of body weight and were 34% less efficient.

(Key Words: Soybean Hulls, Heifers, Performance, Feedlot.)

Introduction

Although soybean hulls have been evaluated as additions to a number of different diet types, they have not been studied extensively as the primary ingredient in high concentrate diets for cattle. Soybean hulls appear to be an excellent candidate as the predominant energy source in feedlot diets for limit-fed, growing cattle because 1) they are nearly as easy to transport and handle as grain; 2) they are highly digestible, reducing manure production when compared to forage-based diets; and 3) they have a fairly stable fermentation pattern when compared to grain. Because of the stable fermentation, it also should be possible to remove all roughage from soybean hull-based diets without compromising ruminal health.

Because soybean hulls have little rumen escape protein, and microbial protein synthesis may be low because of restricted feed intake, the metabolizable protein supply of such diets may be inadequate. Based on estimates of amino acid supply, methionine is implicated as the first-limiting amino acid for

growing cattle fed restricted amounts of soybean hull-based diets. Because one of the important roles that methionine plays is methyl group donation, in situations where diets are deficient in methyl groups, cattle may respond to alternative methyl donors, such as betaine.

Our objectives were 1) to compare growth performance of cattle fed roughage-free diets comprised predominantly of soybean hulls with that of cattle receiving roughage- and corn-based diets and 2) to determine if cattle fed soybean hull-based diets respond to supplementation with methionine hydroxy analogue (MHA; a source of methionine), ruminally protected betaine, or concentrated separator by-product (CSB; a source of betaine).

Experimental Procedures

Three hundred heifers (573 lb initial body weight) were used in an randomized complete block design. Cattle were allotted to pens (4 to 6 heifers/pen, 6 pens/treatment) based on previous treatment. Treatments included 1) a roughage-based diet fed at 2.75% of body weight (ROUGH), 2) a corn-based diet fed at 1.5% of body weight (CORN1.5), 3) a corn-based diet fed at 2.25% of body weight (CORN2.25), 4) a soybean hull-based diet fed at 1.5% of body weight (SH1.5), 5) a soybean hull-based diet fed at 2.25% of body weight (SH2.25), 6) SH1.5 top-dressed with 11.4 g/head daily MHA, 7) SH2.25 top-dressed with 11.4 g/head daily MHA, 8) SH2.25 top-dressed with 7 g/head daily rumen protected betaine, and 9) SH2.25 top-dressed with 250 g/head daily CSB. The CSB supplied 15.5 g of betaine per day. Heifers were stepped up to final diets over a 13-day adaptation period and fed the final diets for 71 days. The cattle then were stepped up over 14 days to the corn-based diet, which all cattle were fed at 2.25% of body weight (CORN2.25).

Results and Discussion

Supplemental MHA, betaine, and CSB did not change feed intakes, gains, or feed efficiencies for cattle fed soybean hulls (Table 2). Heifers fed soybean hulls at 2.25% of body weight gained 27% slower ($P<.01$) than heifers fed the corn-based diet at similar intakes. As a result of their slower growth, the cattle receiving soybean hulls were also 25% less efficient ($P<.01$). Similar results were observed for cattle fed soybean hulls and corn at 1.5% of body weight. Cattle fed soybean hulls at 2.25% of body weight had gains similar to those of cattle receiving the roughage-based diet at 2.75% of body weight. Feed efficiencies, however, tended to be higher ($P=0.11$) for the cattle receiving soybean hulls because of 27% lower feed consumption. The roughage-fed cattle gained 23% less ($P<.01$) than cattle fed corn-based diets at 2.25% of body weight and were 34% less efficient.

Most of the heifers fed soybean hulls at 2.25% of body weight did not consume all their feed, resulting in intakes that averaged approximately 2.15% of body weight. During the study, three cattle receiving soybean hulls at 1.5% of body weight died, apparently because of overeating.

Gains of cattle fed soybean hull-based, roughage-free diets were 27% less than those of cattle fed similar amounts of a corn-based diet, but gains and efficiencies of heifers fed the soybean hull-based diet at 2.25% of body weight were roughly comparable to those of heifers fed a roughage-based diet at 2.75% of body weight. Soybean hulls can be used as the primary ingredient in roughage-free diets for growing cattle.

Table 1. Compositions of Diets

Item	Diet		
	Soybean Hull-Based	Corn-Based	Roughage-Based
	----------% of DM----------		
Soybean hulls, pelleted	91.6	0	0
Corn grain	0	76.6	29.3
Alfalfa hay	0	15.0	45.0
Prairie hay	0	0	20.0
Molasses (cane)	3.1	4.0	5.0
Vitamin/mineral mix[a]	0	0	.7
Vitamin/mineral mix[b]	0	3.0	0
Vitamin/mineral mix[c]	2.5	0	0
Soybean meal (47.5%)	0	1.4	0
Blood meal	.5	0	0
Urea	.4	0	0
Lignin sulfonate	1.9	0	0
Crude protein, calculated	13.6	14.0	12.0

[a]Formulated for the complete diet to contain .90% Ca, .30% P, 1.29% K, 1200 IU/lb added vitamin A, and 20 g/ton Rumensin® (DM basis).
[b]Formulated for the complete diet to contain .73% Ca, .34% P, .76% K, 1230 IU/lb added vitamin A, 30 g/ton Rumensin, and 10 g/ton Tylan® (DM basis).
[c]Formulated for the complete diet to contain 1.02% Ca, .51% P, 1.41% K, 3378 IU/lb added vitamin A, 34 g/ton Rumensin, and 11 g/ton Tylan (DM basis).

Table 2. Performance of Cattle Fed Roughage-, Corn-, and Soybean Hull-Based Diets

Treatment[a]	Day 0 to 98 Performance		
	Intake, lb/d	Daily Gain, lb/d	Gain:Feed
ROUGH	16.79[b]	1.80[c]	.107[cd]
CORN1.5	9.29[d]	1.13[d]	.122[c]
CORN2.25	14.36[c]	2.34[b]	.163[b]
SH1.5	9.07[d]	.84[de]	.092[d]
SH1.5 + MHA	9.10[d]	.78[e]	.085[d]
SH2.25	13.97[c]	1.71[c]	.122[c]
SH2.25 + MHA	13.45[c]	1.58[c]	.118[c]
SH2.25 + BET	13.94[c]	1.71[c]	.122[c]
SH2.25 + CSB	13.53[c]	1.61[c]	.119[c]
SEM	.25	.081	.0066

[a]ROUGH = roughage-based diet fed at 2.75% of BW, CORN1.5 = corn-based diet fed at 1.5% of BW, CORN2.25 = corn-based diet fed at 2.25% of BW, SH1.5 = soybean hull-based diets fed at 1.5% of BW, SH2.25 = soybean hull-based diets fed at 2.25% of BW, MHA = 11.4 g/d supplemental methionine hydroxy analogue, BET = 7 g/d supplemental rumen-protected betaine, CSB = 250 g/d supplemental concentrated separator by-product.
[b,c,d,e]Means within the same column differ (P<.01).

FEEDING SYSTEMS AND IMPLANT STRATEGIES FOR CALF-FED HOLSTEIN STEERS

C. T. Milton[1], R. T. Brandt, Jr.[1], and E. C. Titgemeyer

Summary

Two hundred sixty-four Holstein steer calves (308 lb) were used in a 2×3 factorially designed experiment to compare the effect of two feeding systems and three implant strategies on performance and carcass characteristics. Steers were allowed ad libitum access to a conventional, high-grain diet for the entire feeding period or were program-fed a high-grain diet to gain 2.2 lb/d for 109 days and 2.6 lb/d for 92 days and then allowed ad libitum access to feed for the remainder of the feeding period. Steers were fed to a common weight endpoint (1260 lb). Implant strategies were: 1) Synovex®-S on days 1, 109, and 201 (S-S-S); 2) Synovex®-C on day 1, Synovex-S on day 109, and Revalor®-S on day 201 (C-S-R); and 3) Synovex-C on day 1 and Revalor-S on days 109 and 201 (C-R-R). Over the entire feeding period, steers finished on the ad libitum system consumed 7% (P<.01) more feed daily and gained 7.2% (P<.01) faster than those in the programmed feeding system. Steers in the programmed feeding system required an additional 24 days to achieve similar finished weights and had smaller (P<.05) ribeye areas and less (P<.01) backfat than steers feeding ad libitum throughout. Feed efficiency and total feed consumed were similar between feeding systems. Compared to S-S-S, feed efficiency was improved 4.3% by C-S-R and 6.7% (P<.05) by C-R-R. The C-R-R implant strategy reduced marbling (P<.01) and percentage of USDA Choice carcasses (P=.01) compared with S-S-S or C-S-R. A two-phase, programmed feeding system can result in improved feed efficiency and a compensatory gain response during the latter phase of the feeding period. However, the gain restriction over the first 200 days in this study probably was too severe to allow program-fed steers to finish at a similar weight with a similar number of days on feed those feeding ad libitum. Implanting calf-fed Holstein steers with a low dose of estrogen and then increasing implant potency step-wise optimized performance and carcass quality.

(Key Words: Holstein, Calf-Fed Steers, Feeding Systems, Implants, Carcasses.)

Introduction

Holstein steers placed on feed as young calves (300 to 400 lb) often are fed high-grain diets for 280 to 350 days. These steers often display reduced feed consumption during the final 80 to 100 days on feed. The cause of this "stalling out" phenomenon remains unknown but may be related to extended ruminal acidic conditions, metabolic signals associated with physiological maturity or body composition, and(or) boredom with the diet. Managing calf-fed Holsteins in a two-step programmed feeding system before placing them on full feed may improve feed efficiency, take advantage of compensatory growth, and minimize "stall out" from continuous ad libitum feeding.

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Implant programs that optimize performance and carcass characteristics for calf-fed Holsteins remain elusive. Implants too potent early in the feeding period may down-regulate receptors and reduce responses to subsequent implants.

Our objectives were to 1) compare a two-phase programmed feeding system followed by full feeding a high-grain diet to a conventional, full-fed system and 2) evaluate three implant programs using products varying in hormonal compounds and concentration.

Experimental Procedures

Two hundred sixty-four Holstein steer calves (308 lb) were stratified by weight into one of four weight replicates. Within each replicate, steers were allotted randomly to one of six pens (11 head/pen) in a 2x3 factorially arranged experiment. Factors were two feeding systems and three implant strategies. Steers in 12 pens were allowed to feed ad libitum on a conventional high-grain finishing diet for the entire feeding period. Steers in the other 12 pens were limit-fed a high-grain diet and programmed to gain 2.2 lb/day for 108 days, 2.6 lb/day for 92 days, and then allowed ad libitum access to a finishing diet for the remainder of the feeding period. Programmed rates of gain represented approximately 65% and 85% of maximal rate of gain for the respective periods. Four pens within each feeding system received one of three implant strategies: 1) Synovex-S on days 1,109, and 201 (S-S-S); 2) Synovex-C on day 1, Synovex-S on day 109, and Revalor-S on day 201 (C-S-R); and 3) Synovex-C on day 1 followed Revalor-S on days 109 and 201 (C-R-R).

During the first 200 days of the experiment, the finishing diet (Finisher 1) was based on dry-rolled corn and contained (dry basis) 10% corn silage (Table 1). Because feed intake was restricted in the programmed feeding system, corn silage was increased to 25% of the diet. When programmed steers were changed to ad libitum intake (day 201), all steers were fed a common diet based on

Table 1. Composition of Experimental Diets (Dry Matter Basis)

Ingredient	Programmed[a]	Finisher 1	Finisher 2
Dry-rolled corn	56.1	77.9	23.4
High-moisture corn	–	–	54.5
Corn silage	25.0	10.0	10.0
Molasses	3.0	3.0	3.0
Soybean meal	11.9	5.2	5.2
Urea	.5	.5	.5
Ammonium sulfate	.3	.3	.3
Minerals/vitamins[b]	2.2	2.1	2.1
Rumensin/Tylan premix[c]	1.0	1.0	1.0
% Crude protein			

[a]Diet for periods of programmed gain.
[b]Provided .8% Ca .4% P, 1.0% K, 2000 IU/lb vitamin A, and 20 IU/lb vitamin E in programmed diet. Provided .7% Ca, .35% P, .7% K, 1500 IU/lb vitamin A, and 15 IU/lb vitamin E in Finisher 1 and Finisher 2.
[c]To supply 275 mg Rumensin and 90 mg Tylan per steer daily.

high-moisture and dry-rolled corn (Finisher 2; Table 1). All diets provided 275 mg of Rumensin® and 90 mg of Tylan® per head daily. Initial and final weights were the averages of two consecutive, early morning, full weights taken before feeding. Steers were slaughtered by feeding system at a weight-constant endpoint (1260 lb). Steers in the ad libitum system were fed for 326 days, whereas those on the programmed feeding system were fed for 350 days.

Results and Discussion

Because no interactions between feeding system and implant strategy occurred for feedlot performance or carcass characteristics, only the main effects are presented. Nine steers either died or were removed from the experiment for reasons not related to treatment. They were distributed approximately equally across treatments.

During the first implant period (day 1 to 108), programmed feeding resulted in lower (P<.01) daily gain, but feed efficiency was improved 3.7% (P<.10) compared with ad libitum feeding (Table 2). Daily gain of programmed steers (2.4 lb/day) was slightly higher than the 2.2 lb/day predicted. Implanting steers with Synovex-C tended (P=.13) to improve feed efficiency compared with Synovex-S.

During the second implant period (Day 109 to 200), programmed feeding resulted in lower (P<.01) daily gain, but feed efficiency was improved 5.4% (P<.05) compared with ad libitum feeding. Steers implanted with Synovex-S that had initially received Synovex-C gained faster (P<.05) and more efficiently (P<.05) in this period than steers initially implanted with Synovex-S.

During the third implant period (day 201 to 326 or 350), all steers were allowed ad libitum access to a common finishing diet. Steers previously programmed to gain 2.2 and 2.6 lb/day had higher (P<.01) feed intake, gained 15% (P<.01) faster, and were 7% (P<.05) more efficient than those having continuous access to feed. Increased feed intake and daily gain and improved feed efficiency are characteristic of compensatory growth. Steers reimplanted with Revalor-S gained faster (P<.05) and more efficiently (P<.05) than those reimplanted with Synovex-S and those receiving their first Revalor-S.

Over the entire feeding period, steers finished using the conventional, ad libitum system consumed 7% (P<.01) more feed per day and gained 7.2% (P<.01) faster compared with steers in the programmed feeding system. Feed efficiency was similar between feeding systems, and equal amounts of feed were required to achieve similar finished weights. Although steers finished on the programmed gain system expressed compensatory growth during the final 150 days on feed, an additional 24 days were required to achieve a finished weight similar to that of steers in the continuous ad libitum system. The length and(or) severity of restriction likely increased the time required to achieve the desired finished weight. Steers implanted with C-S-R or C-R-R gained faster (P<.05) than steers implanted with S-S-S. Steers implanted with C-S-R or C-R-R were 4.3 and 6.7% (P<.05) more efficient, respectively, than steers implanted with S-S-S.

Hot carcass weights were heavier (P<.05) for steers implanted with C-S-R or C-R-R than S-S-S (Table 3). Carcass weights were similar between feeding systems. However, fat thickness (P<.01), ribeye area (P<.05), marbling (P<.10), and percentage of Choice carcasses (P<.01) were greater for steers in the ad libitum than the programmed feeding system. These data indicate that the level of restriction during the programmed feeding was severe enough to alter body composition. Dressing percentage, kidney, pelvic, and heart fat, yield grade, and the incidence of

abscessed livers were unaffected by feeding system or implant strategy. The C-R-R implant strategy reduced marbling (P<.01) and percentage of Choice carcasses (P=.01) compared with S-S-S or C-S-R. Compared to S-S-S, implanting with C-S-R had no effect on marbling or percentage of Choice carcasses.

A two-phase programmed feeding system followed by full feeding produced a compensatory growth response later in the finishing period compared with continuous ad libitum feeding. However, the duration and level of restriction that is needed to improve overall feed efficiency remains elusive. Implanting steers with a low dose of estrogen initially and then increasing implant potency step-wise optimized animal performance and carcass quality in calf-fed Holstein steers.

Table 2. Effects of Feeding System and Implant Strategy on Performance of Calf-Fed Holstein Steers

	Feeding System[a]			Implant Strategy[b]			
Item	Programmed	Ad Lib	SEM	S-S-S	C-S-R	C-R-R	SEM
No. pens	12	12		8	8	8	
No. steers	128	127		85	85	85	
Initial wt, lb	308	308	.98	310	306	308	1.2
Final wt, lb	1259	1264	9.4	1231	1272	1282	11.5
Day 1 to 108; programmed gain=2.2 lb/day; 1st implant period							
Daily feed[c], lb	10.1	13.4	.21	11.8	11.7	11.7	.25
Daily gain[c], lb	2.39	3.07	.03	2.69	2.76	2.73	.04
Feed/gain[de]	4.22	4.38	.06	4.39	4.22	4.28	.07
Day 109 to 200; programmed gain=2.6 lb/day; 2nd implant period							
Daily feed[c], lb	14.1	18.6	.31	16.4	16.4	16.3	.37
Daily gain[cg], lb	2.63	3.30	.05	2.84[h]	3.07[i]	2.97[hi]	.06
Feed/gain[fg]	5.37	5.66	.09	5.75[h]	5.32[i]	5.49[hi]	.11
Day 201 to 326 or 350; all steers ad libitum access to feed; 3rd implant period							
Daily feed[c], lb	21.4	19.4	.27	20.4	20.7	20.0	.33
Daily gain[cg], lb	3.01	2.56	.04	2.66[h]	2.77[h]	2.91[i]	.05
Feed/gain[fg]	7.12	7.62	.14	7.71[h]	7.54[h]	6.87[i]	.18
Overall (Day 0 to 326 or 350)							
Daily feed[c], lb	16.0	17.2	.22	16.6	16.7	16.4	.27
Daily gain[cg], lb	2.72	2.93	.03	2.72[h]	2.86[i]	2.88[i]	.03
Feed/gain[g]	5.90	5.87	.08	6.11[h]	5.85[hi]	5.70[i]	.09
Total feed, lb	5,598	5,609	71.3	-	-	-	-
Days fed	350	326	-	338	338	338	

[a]Programmed= Feed intake limited for steers to gain 2.2 and 2.6 lb/day during first and second implant periods, respectively, and ad libitum access during the third implant period.

[c]Feeding system effect (P<.01).

[b]S=Synovex-S; C=Synovex-C; R=Revalor-S.

[d]Feeding system effect (P<.10).

[e]Synovex-C versus Synovex-S (trend; P=.13).

[f]Feeding system effect (P<.05).

[g]Implant effect (P<.05).

[h,i]Means in a row not bearing a common letter differ (P<.05).

Table 3. Effects of Feeding System and Implant Strategy on Carcass Characteristics of Calf-Fed Holstein Steers

	Feeding System[a]			Implant Strategy[b]			
Carcass Trait	Programmed	Ad-Lib	SEM	S-S-S	C-S-R	C-R-R	SEM
Hot carcass wt[c], lb	726	729	7.0	709[k]	735[l]	738[l]	8.6
Dressing %	60.1	60.2	.63	60.1	60.3	60.0	.77
12th rib fat[d], in	.19	.22	.01	.20	.22	.20	.01
KPH[e] fat, %	2.15	2.20	.05	2.16	2.23	2.14	.06
Yield grade	2.64	2.43	.10	2.61	2.45	2.55	.13
Ribeye area[f], in^2	11.1	12.0	.28	11.1	11.9	11.6	.35
Marbling score[ghi]	5.10	5.28	.06	5.43[l]	5.29[l]	4.86[k]	.08
USDA Choice[j]%	58	74	-	75	69	53	-
Liver abscesses, %	13	14	-	13	14	14	-

[a]Programmed=Feed intake limited for steers to gain 2.2 and 2.6 lb/day during first and second implant periods, respectively, and ad libitum access during the third implant period.

[b]S=Synovex-S; C=Synovex-C; R=Revalor-S.

[c]Implant effect (P<.10).

[d]Feeding system effect (P<.01).

[e]KPH=kidney, pelvic, and heart.

[f]Feeding system effect (P<.05).

[g]Slight 0=4.0, Slight 50=4.5, Small 0=5.0, Small 50=5.5.

[h]Feeding system effect (P<.10).

[i]Implant effect (P<.01)

[j]Chi square statistic: Feeding system (P<.01); Implant strategy (P=.01).

[kl]Means in a row not bearing a common letter differ (P<.05).

EFFECTS OF RUMINALLY PROTECTED CHOLINE AND DIETARY FAT ON PERFORMANCE OF FINISHING HEIFERS

D. J. Bindel, J. S. Drouillard, E. C. Titgemeyer, R. H. Wessels, and C. A. Löest

Summary

A 120-day finishing study utilizing 318 heifers (753 lb initial body weight) examined the effects of ruminally protected choline in diets with no tallow or 2 or 4% of supplemental tallow. Heifers were fed a finishing diet based on a mix of steam-flaked and dry-rolled corn; encapsulated choline (20, 40, or 60 g/head/day, supplying 5, 10 or 15 g choline/head/day) was top-dressed to the diet or not added. Dry matter intake decreased linearly with inclusion of fat (P<.05) but was not affected significantly by addition of choline. Daily gains also decreased linearly (P<.05) with fat addition. Choline supplementation increased gain (linear, P<.1; quadratic, P<.05), with the greatest increase occurring for the first 20 g increment encapsulated choline/day. Likewise, feed efficiency improved (P<.1) with supplemental choline. Again, the greatest response occurred for the first 20 g/day. Kidney, pelvic, and heart fat and yield grade both increased linearly (P<.1) with fat supplementation. The percentage of carcasses grading USDA Choice decreased (linear, P<.05; quadratic, P<.1) when choline was added at 60 g/day. Hot carcass weight, marbling, dressing percent, and 12th rib fat thickness were not affected significantly by either fat or choline. Ruminally protected choline can improve average daily gain and feed efficiency of finishing cattle.

(Key Words: Choline, Fat, Finishing, Heifers, Performance, Carcass.)

Introduction

Fat commonly is included in feedlot diets to add texture and increase energy density. However, supplemental fat can reduce ruminal protozoal populations. Choline, a B-vitamin, is normally present in adequate amounts. However, because protozoa synthesize choline, dietary conditions that suppress protozoal populations can reduce choline supply to the animal. Choline exists mainly in phospholipids and is involved in lipid digestion and transport. It functions in cell membrane integrity and is a methyl donor, much like betaine and methionine. Because finishing cattle fed a high concentrate diet with added fat might benefit from added choline, our objective was to evaluate responses to graded levels of ruminally protected choline in diets containing 2 or 4% added tallow or not tallow.

Experimental Procedures

Three hundred eighteen yearling heifers (753 lb average initial body weight) were dispersed into 24 pens containing 11 to 15 head each. Cattle were blocked according to previous nutritional regimen (full-fed or limit-fed growing diets) and allotted to one of 12 treatments. Two pens, one within each block,

were assigned randomly to each treatment. Treatments were levels of tallow (0, 2, or 4%

of diet) and graded levels of encapsulated choline (0, 20, 40, or 60 g/ head/day, supply-

ing 0, 5, 10, or 15 g choline/head/day; Balchem Corp., Slate Hill, NY).

Heifers were implanted with Revalor®-H and treated for internal and external parasites upon initiation of the step-up period. The cattle were fed ad libitum on finishing diets based on a mix of steam-flaked (≈26 lb/bu) and dry-rolled corn (≈3,800µ particle size) and alfalfa (Table 1). Diets were formulated to contain approximately 12.5% crude protein, 0.69% calcium, 0.67% potassium, 0.30% phosphorous, 30 g/ton Rumensin®, and 10 g/ton Tylan®. Encapsulated choline was top-dressed onto the basal diet at feeding. Heifers were weighed every 30 days and fed their respective diets for 120 days. Cattle were slaughtered at a commercial packing plant, and carcass data were obtained after a 24-hour chill. Percentage of carcasses grading USDA Choice was reassessed after an additional 6- to 8-hour chill period.

Results and Discussion

Performance of cattle in this experiment was below average, likely attributable to damp, cold, and muddy conditions that prevailed throughout the final 30 days of the study. Daily gains (unshrunk) averaged approximately 3.35 lb/day during the first 90 days of the experiment but were only .8 lb/day during the final 30 days. The average daily gains shown in Tables 2 and 3 reflect a 4% pencil shrink.

Dry matter intakes decreased linearly (P<.05) as supplemental fat increased. Choline had no effect on intake but increased both average daily gain (linear, P<.1; quadratic, p<.05) and feed efficiency (P<.1), with the greatest improvements occurring with the first 20 g/day of protected choline. With fat supplementation, kidney, pelvic, and heart fat and yield grade both increased linearly (P<.1). The percentage of carcasses grading USDA Choice was decreased when 60 g/day of choline was supplemented (linear, P<.05; quadratic, P<.1).

Encapsulated choline can be supplemented in feedlot diets to improve growth performance without having a negative effect on carcass characteristics. The optimum level appears to be about 20 g/head/day (5 g choline). Increases in encapsulated choline above 40 grams/head/day yielded no additional benefits.

Table 1. Compositions of Experimental Diets Fed to Heifers (% of DM)[a]

	Supplemental Fat		
Ingredient	0	2%	4%
Flaked corn	40.31	38.40	37.24
Dry-rolled corn	43.75	41.67	40.42
Alfalfa hay	8.00	8.00	8.00
Molasses (cane)	3.00	3.00	3.00
Tallow		2.00	4.00
Urea	.79	.50	.50
Vitamin-mineral mix[b]	2.16	2.13	2.13
Soybean meal (47.5%)	1.99	4.30	4.30

[a]Each diet was top-dressed with 20, 40, or 60 g/head/day encapsulated choline or no choline was added.
[b]Formulated for diets to contain 0.69% Ca, 0.30% P, and 0.67% K, and to add 1.2 KIU/lb Vitamin A, .03 ppm Co, 6.8 ppm Cu, .43 ppm I, 1.0 ppm Fe, 41 ppm Mn, .20 ppm Se, 41 ppm Zn, 30 g/ton Rumensin, and 10 g/ton Tylan.

Table 2. Effect of Fat on Performance and Carcass Traits of Heifers

	Supplemental Fat			
Item	0	2%	4%	SEM
Performance data				
Initial weight, lb	751	747	760	
Final weight, lb	1091	1070	1077	
Feed intake, lb/day[b]	18.5	18.0	17.5	.24
Gain, lb/day[ab]	2.47	2.35	2.29	.06
Feed:Gain[ac]	7.46	7.63	7.63	
Carcass Characteristics				
Carcass weight, lb	651	646	645	5.6
KPH fat, %[b]	1.95	2.05	2.05	.03
Dressing %	62.2	62.8	62.4	.28
Backfat, inches	.37	.39	.40	.02
USDA Yield Grade[b]	1.93	2.06	2.13	.07
Marbling score	4.04	4.13	4.16	.07
USDA Choice, %	57.8	68.4	65.4	3.3

[a]Gain and efficiency were computed after applying a 4% pencil shrink to final weights.
[b]Linear effect of fat supplementation (P<.1).
[c]Analyzed statistically as Gain:Feed but reported as Feed:Gain.

Table 3. Effect of Choline on Performance and Carcass Traits of Heifers

	Encapsulated Choline, g/head/day				
Item	0	20	40	60	SEM
Performance data					
Initial weight, lb	755	753	743	742	
Final weight, lb	1061	1082	1088	1086	
Feed intake, lb/day	17.8	17.9	18.2	18.0	.28
Gain, lb/day[abc]	2.20	2.39	2.52	2.36	.06
Feed:Gain[acd]	8.06	7.52	7.25	7.63	
Carcass characteristics					
Carcass weight, lb	641	651	645	652	6.4
KPH, %	1.99	2.02	2.06	2.01	.04
Dressing %	62.9	62.6	61.8	62.6	.32
Backfat, inches	.39	.38	.40	.36	.02
USDA Yield Grade	2.02	2.05	2.15	1.94	.08
Marbling score	4.17	4.06	4.20	4.02	.08
USDA Choice, %[bc]	67.2	68.2	68.0	52.0	3.8

[a]Gain and efficiency were computed after applying a 4% pencil shrink to final weights.
[b]Linear effect of encapsulated choline (P<.1).
[c]Quadratic effect of encapsulated choline (P<.1).
[d]Analyzed statistically as Gain:Feed but reported as Feed:Gain.

EFFECTS OF ADDED FAT, DEGRADABLE INTAKE PROTEIN, AND RUMINALLY-PROTECTED CHOLINE IN DIETS OF FINISHING STEERS

J. S. Drouillard, A. S. Flake, and G. L. Kuhl

Summary

A total of 216 yearling steers was used in two finishing experiments to evaluate interactions between levels of dietary fat, protein and ruminally protected choline. In Trial 1, steers received diets that combined levels of 0% or 5% added fat (choice white grease), 10.8% or 12.5% crude protein, and 0 or 5 grams per head daily of ruminally protected choline. Steers were fed in pens of five head each for 89 days. Adding fat decreased intake (P<.01), average daily gain (P<.1), and carcass weight (P<.07) and increased carcass yield grade (P<.06) but did not alter feed efficiency (P>.9). Increasing the protein level from 10.8 to 12.5% had no significant effects on live animal performance, but the high protein level resulted in a greater (P<.05) percentage of carcasses grading USDA Choice. Choline supplementation tended to increase average daily gain (P=.13) as well as the percentage of carcasses grading USDA Choice (P=.23). Choline also increased dressing percentage (P<.07); this effect was most pronounced when fat was not included in the diet, indicating an interaction between fat and choline (P<.1). In Trial 2, steers were fed a common finishing diet, which was top-dressed with ruminally protected choline at 2 to 9 grams per head daily or no added choline. Choline supplementation yielded linear improvements in rate of gain (P<.01), dry matter intake (P<.05), and carcass weight (P<.01). All measures of carcass fatness increased as the amount of choline increased. Adding ruminally protected choline to diets of finishing steers significantly improved growth performance and carcass traits.

(Key Words: Finishing Cattle, Choline, Fat, Protein, Carcass.)

Introduction

Protein requirements of rumen microorganisms are influenced by the amount of available energy; as available carbohydrate increases, more ruminally degraded protein is needed to satisfy requirements of the ruminal microflora. Starch is extensively degraded to volatile fatty acids by rumen microflora. Conversely, minimal lipid digestion takes place in the rumen. Therefore, the potential exists for an interaction between source of energy (i.e., lipid vs starch) and ruminal protein requirements. Partial replacement of feed grains with animal fats may make it feasible to reduce the amount of protein that must be supplemented to feedlot cattle and thus, reduce supplementation costs.

Choline normally is provided in adequate quantities as a result of synthesis by ruminal protozoa. Therefore diets that create ruminal conditions that compromise protozoal growth may reduce choline supply postruminally. High-concentrate diets frequently produce ruminal pH to the range of 5.5 to 5.8, which is less than optimal for proliferation of protozoa. Including fat in the diet may further reduce protozoal populations. Consequently, diets that induce

low protozoal populations may benefit from choline supplementation. In addition, previous research has suggested that choline chloride is degraded extensively in the rumen. Supplementing choline as a ruminally protected form may provide the choline needed to satisfy requirements for optimal growth rate in finishing cattle.

The objectives of these studies were to evaluate effects of various levels of added fat, degradable intake protein, and ruminally protected choline and to determine how these factors interact with respect to their influence on performance and carcass traits of finishing beef steers. A secondary objective was to determine the optimum level of ruminally protected choline for finishing beef steers.

Experimental Procedures

Trial 1. A trial was conducted using 159 crossbred beef steers to evaluate finishing performance of cattle fed diets combining various levels of protein (10.8 or 12.5%), choice white grease (0 or 5%), or ruminally protected choline (0 or 5 g/head daily; Balchem Corporation). Cattle were fed a common diet for several weeks to minimize variation in gut fill. Following the transition period, cattle were treated for internal and external parasites and implanted with Synovex® Plus™. Steers were stratified by weight and assigned randomly, within strata, to each of the eight treatment groups. Treatments were arranged as a 2 × 3 factorial, in four replicates. Cattle were housed in partially covered, 14' x 28' pens with concrete surfaces and fed once per day. The concentrate in the diets was increased incrementally from 40 to 92% by feeding each of five step-up diets for a period of 2 to 6 days. Experimental diets were fed for 89 days.

Steers were slaughtered when they achieved an estimated outside fat thickness (12th rib) of 0.4 inches. Daily gain and efficiency were determined by calculating final live weight as hot carcass weight divided by a common dressing percentage.

Trial 2. A dose-titration experiment was conducted to determine the optimum inclusion level for ruminally protected choline. Cattle were adapted to high grain diets, processed, and allocated to treatments in a manner identical to that used for Trial 1. Treatments were composed of increasing levels of ruminally-protected choline. The high-fat, high protein diet from Trial 1 was top-dressed with 2, 3, 4, 6, 7, 8, or 9 grams per head daily of choline as a fat-encapsulated product. Cattle in four pens were fed the control diet (no added choline), and a single pen of cattle was allotted to each level of added choline.

Results and Discussion

Table 2 summarizes the effects of choice white grease and dietary protein on performance and carcass characteristics of steers (Trial 1). No significant interactions occurred between dietary protein and fat. Increasing dietary protein did not influence gain or feed efficiency, but the percentage of carcasses grading USDA Choice was dramatically improved ($P<.05$) for cattle fed the higher protein level. Adding choice white grease to the diet depressed feed intake ($P<.01$) and average daily gain ($P<.1$), but efficiency was not altered.

Interactions between choline and fat are shown in Table 3. Dietary levels of fat or choline did not influence final live weight but did affect dressing percentage. Adding 5 g/day of choline significantly increased dressing percentage (60.1 vs 60.9%). The effect of choline on dressing percentage was more pronounced when fat was not included in the diet ($P<.1$). Feeding choice

white grease depressed rate of gain (P<.1), but the addition of choline tended to alleviate this effect (P=.15). Dry matter intake was reduced with the addition of choline when fat was not included, but intake was not impacted greatly by choline when choice white grease was added. Adding choline to the diet tended to improve feed efficiency when fat was not added to the diet (P=.13). Yield grade also was impacted by the interaction between choline and fat (P<.1). Other measures of carcass fatness followed similar trends but were not significant.

Results of Trial 2 are summarized in Table 4. Each gram of added choline resulted in an increase in feed intake of 0.33 lb/head daily and a concomitant increase in gain of .09lb/head daily. Carcass weights were increased by nearly 5 lb/gram of added choline. All measures of body fatness tend to support the suggestion that increasing the level of ruminally protected choline in the diet may reduce days required to achieve a desired compositional endpoint.

Table 1. Compositions (Dry Basis) of Experimental Diets[a]

	10.8% Protein		12.5% Protein	
Item	0% Fat	5% Fat	0% Fat	5% Fat
Rolled corn, %	85.30	79.36	84.69	78.74
Ground alfalfa hay, %	8.0	8.0	8.0	8.0
Choice white grease , %	-	5.0	-	5.0
Car-Mil Glo®, %	3.0	3.0	3.0	3.0
Dehulled soybean meal, %	1.0	1.0	1.0	1.0
Corn gluten meal, %	-	.9	-	.9
Urea, %	.09	.09	.70	.70
Limestone, %	1.55	1.55	1.55	1.55
Potassium chloride, %	.40	.43	.40	.44
Salt, %	.30	.30	.30	.30
Magnesium oxide, %	.11	.12	.11	.12
Ammonium sulfate, %	.10	.10	.10	.10
Vitamin/mineral premixes, %	.15	.15	.15	.15
Ruminally-protected choline, g/head/day	0 or 5	0 or 5	0 or 5	0 or 5
Crude protein, %	10.8	10.8	12.5	12.5
NPN, %	.40	.40	2.17	2.17
Crude Fat, %	4.09	8.84	4.06	8.81
NEm, Mcal/lb	.84	.91	.84	.90
NEg, Mcal/lb	.55	.60	.54	.59
Calcium, %	.75	.75	.75	.75
Phosphorus, %	.32	.31	.30	.30
Potassium, %	.75	.75	.75	.75
Magnesium, %	.25	.25	.25	.25
Sulfur, %	.17	.17	.17	.17
Rumensin®, g/ton	30	30	30	30
Tylan®, g/ton	10	10	10	10

[a]Diets contained the following concentrations of added vitamins and trace minerals (dry basis): 1,200 IU/lb vitamin A; 10 IU/lb vitamin E; .05 ppm cobalt; 10 ppm copper; .6 ppm iodine; 60 ppm manganese; .25 ppm selenium; 60 ppm zinc.

Table 2. Effects of Added Fat and Protein Level on Performance and Carcass Traits (Trial 1)

	0% Added Fat		5% Added Fat		
Item	10.8% CP	12.5% CP	10.8% CP	12.5% CP	SEM
Number of head	40	39	40	40	
Initial weight, lb	895	899	894	899	5
Final live weight, lb	1190	1212	1185	1188	11
Gain, lb/day[ac]	3.48	3.46	3.22	3.27	.13
Dry matter intake, lb/day[b]	22.2[de]	22.7[d]	20.9[f]	21.1[ef]	.48
Feed:Gain	6.33	6.58	6.49	6.41	.25
Liver abscesses, %	4.7	2.7	11.8	8.3	4.5
Hot Carcass Weight, lb	728	729	713	719	7
Dressing percentage	61.2	60.1	60.2	60.5	.5
Kidney, pelvic and heart fat	2.2	2.3	2.2	2.2	.1
12th rib fat thickness, in	.40	.45	.46	.47	.03
Ribeye area, in^2	13.5	13.3	13.3	13.0	.3
USDA Yield Grade	1.7	1.9	2.1	2.0	.1
USDA Choice, %g	50	69	39	59	8

[a]Effect of added fat (P<.1).
[b]Effect of added fat (P<.01).
[c]0% fat greater than 5% fat (P<.1).
[def]Means in the same row with common superscripts are not different at P<.1.
[g]Effect of protein (P<.05).

Table 3. AEffects of Added Fat and Protected Choline on Performance and Carcass Traits (Trial 1)

	0% Added Fat		% Added Fat		
Item Choline>	0 g/day	5 g/day	0 g/day	5 g/day	SEM
Number of head	40	39	40	40	
Initial weight, lb	901	893	896	896	4
Final live weight, lb	1211	1191	1182	1191	10
Gain, lb/day[a]	3.36[gh]	3.58[g]	3.18[h]	3.32[gh]	.13
Dry matter intake, lb/day[de]	23.1[g]	21.9[h]	20.6[i]	21.4[hi]	.5
Feed:Gain[f]	.146[g]	.164[h]	.155[gh]	.155[gh]	.25
Liver abscesses, %	4.9	2.5	5.3	14.8	4.5
Hot carcass weight, lb	725	732	713	720	6
Dressing percentage[bc]	59.9[g]	61.5[h]	60.3[g]	60.4[g]	.5
12th rib fat thickness, in[e]	.46[h]	.39[g]	.43[gh]	.50[h]	.03
Kidney, pelvic and heart fat	2.2	2.3	2.2	2.2	.1
Ribeye area, in^2	13.3	13.6	12.8	12.4	.3
USDA Yield Grade[ac]	1.9[gh]	1.7[h]	1.9[gh]	2.1[g]	.1
USDA Choice, %	52	67	48	51	8

[a]Effect of added fat (P<.1).
[b]Effect of added choline (P<.1)
[c]Fat by choline interaction (P<.1).
[d]Effect of added fat (P<.01).
[e]Fat by choline interaction (P<.05).
[f]Effect of added choline (P=.1)
[ghi] Means in the same row with common superscripts are not different at P<.1.

Table 4. Effects of Ruminally Protected Choline on Finishing Performance and Carcass Characteristics of Steers (Trial 2)

Item	Intercept ± SE[a]	Slope ± SE[a]	Significance (P)
Number of head	60		
Initial weight, lb	882 ± 10	.3 ± 2.1	.89
Final live weight, lb	1173 ± 12	6.7 ± 2.6	.03
Gain, lb/day	3.30 ± .09	.09 ± .03	.01
Dry Matter Intake, lb/day	20.20 ± .63	.33 ± .13	.03
Gain:Feed	.163 ± .006	.002 ± .001	.25
Liver abscesses, %	.17 ± 3.4	.98 ± .70	.20
Hot Carcass Weight, lb	710.2 ± 6.4	4.8 ± 1.3	.01
Dressing percentage	60.52 ± .25	.07 ± .05	.22
12th rib fat thickness, in	.39 ± .03	.02 ± .01	.01
Kidney, pelvic and heart fat	2.12 ± .08	.05 ± .02	.02
Ribeye area, in^2	13.25 ± .34	-.002 ± .07	.98
USDA Yield Grade	1.76 ± .11	.06 ± .02	.02
USDA Choice, %	49.1 ± 8.4	1.0 ± 1.7	.57

[a]Intercept represents the expected value when steers are fed no supplemental choline. The slope represents the expected change for each 1 g increase in the amount of supplemental choline fed.

BETAINE AS A DIETARY SUPPLEMENT FOR FINISHING CATTLE

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Summary

One hundred seventy five steers (902 lb initial body weight) were used in a finishing study to determine the effect of betaine, provided either as feed-grade betaine (Betafin-S6, Finnsugar Bioproducts) or as concentrated separator by-product (CSB; desugared beet molasses), on animal performance and carcass characteristics. Steers were fed a finishing diet based on steam-flaked and dry-rolled corn. Treatments included 10.5 or 21 g/steer daily supplemental feed-grade betaine or 250 g (15.5 betaine) or 500 g (31 g betaine) of CSB per steer daily. Dry matter intakes increased (linear, $P<0.1$) for steers supplemented with feed-grade betaine. Average daily gains and feed efficiencies were not affected by treatments. Dressing percent and twelfth rib back fat increased ($P<0.1$) for steers that received feed-grade betaine. Rib-eye area decreased ($P<0.1$) when steers were supplemented with either feed-grade betaine or CSB. Yield grades were significantly higher (linear, $P<0.1$) for cattle receiving supplemental CSB or feed-grade betaine (quadratic, $P<.05$). Hot carcass weights, KPH, marbling scores, and percentage of carcasses grading USDA Choice were not affected by supplemental betaine. In this study, betaine supplementation did not markedly alter growth performance, but carcass fatness tended to increase for both supplements.

(Key Words: Betaine, Steers, Performance, Feedlot Carcasses.)

Introduction

Previous research has demonstrated that feedlot cattle fed finishing diets may respond positively to supplemental choline. However, choline is degraded extensively by ruminal bacteria, so it must be protected from ruminal fermentation. One function of choline is methyl donation via betaine. Ruminal degradation of betaine may be somewhat slower than that of choline; thus, betaine may yield results similar to those with rumen protected choline. In addition, betaine may possibly alter ruminal fermentation by serving as a source of either ruminally available nitrogen or methyl groups. Our objective was to investigate the effect of betaine, provided either as feed-grade betaine (Betafin-S6, Finnsugar Bioproducts) or as a concentrated separator by-product (CSB), on animal performance and carcass characteristics.

Experimental Procedures

One hundred seventy five steers (902 lb initial body weight) were used in a randomized complete block design. Steers were allotted to one of five blocks based on weight and stratified by breed and weight to one of five pens within each block. The three heaviest blocks had five steers per pen (open front barn), whereas the remaining two housed 10 steers per pen (uncovered). All steers were implanted with Revalor®-S and treated for external parasites using Boss™ pour-on insecticide 8 days before starting the experiment. Steers were allowed ad-libitum access to a finishing diet based on a mix of steam-flaked and dry-rolled corn (Table 1). Treatments were 1) control (no added

betaine), 2) 10.5 g/steer daily supplemental feed-grade betaine, 3) 21 g/steer daily supplemental feed-grade betaine, 4) 250 g/steer daily CSB (supplied 15.5 g betaine), and 5) 500 g/steer daily CSB (31 g betaine). The treatments were top-dressed to the basal diet at feeding. Steers were weighed at the initiation and end of the finishing period, as well as at 28-day intervals. The heaviest four blocks were fed for 82 days, whereas the lightest block was fed for 113 days. Carcass data were collected at a commercial packing plant. All carcass traits, except for hot carcass weights, were measured after a 24-hour chill.

Results and Discussion

Feed intakes increased linearly ($P<0.1$) for steers supplemented with feed-grade betaine. Supplemental CSB also tended to increase feed intake linearly ($P=0.12$). Average daily gains and feed efficiencies were not affected by treatments. Hot carcass weights were not different among treatments; however, dressing percent increased linearly ($P<0.1$) for steers receiving feed-grade betaine. Twelfth rib backfat increased (quadratic, $P<0.1$) for steers fed 10.5 g/d feed-grade betaine. Rib-eye area decreased for steers receiving supplemental CSB (linear, P<.01) or feed-grade betaine (quadratic, P,.1). Yield grades were significantly higher for cattle receiving either supplemental CSB (linear, P<.01) or feed-grade betaine (quadratic, P<.05). Marbling scores tended to be increased linearly ($P=0.16$) by both feed-grade betaine and CSB. However, differences were not large enough to significantly alter the percentage of carcasses grading USDA Choice.

CSB is a byproduct of the sugar industry that results when additional sugar is extracted from molasses. Addition of CSB to finishing diets in amounts greater than 1 lb per day did not markedly alter steer performance and tended to improve carcass quality grades. Because CSB currently is relatively inexpensive, it may be an economical ingredient for use in finishing diets. Similarly, feed-grade betaine had only minor effects on performance, but tended to improve carcass quality grades. These observations need further study to determine if responses are consistent.

Table. Diet Composition

Item	% of DM
Corn, steam-flaked	39.2
Corn, dry-rolled	43.6
Alfalfa hay	8.0
Soybean meal (47.5% protein)	2.0
Urea	1.1
Vitamin/mineral premix[a]	2.2
Molasses (cane)	2.0
Bleachable tallow	2.0
Crude protein, calculated	14.0

[a] Formulated for the complete diet to contain 0.68% Ca, 0.30% P, 0.63% K, 0.03 ppm added Co, 6.8 ppm added Cu, 0.43 ppm added I, 1.0 ppm added Fe, 41 ppm added Mn, 0.20 ppm added Se, 41 ppm added Zn, 1200 IU/lb added vitamin A, 30 g/ton Rumensin®, and 10 g/ton Tylan®.

Table 2. Effects of Feed-Grade Betaine (FGB) and Concentrated Separator By-product (CSB) on the Performance and Carcass Characteristics of Finishing Cattle

		FGB		CSB		
Item	Control	10.5 g/d	21 g/d	250 g/d	500 g/d	SEM
Performance data						
Beginning wt, lb	937	935	935	928	928	9.6
Ending wt, lb	1268	1271	1267	1248	1259	13.5
Feed intake, lb/day [ab]	21.0	22.1	21.7	21.2	21.7	.28
Gain, lb/day	3.75	3.85	3.83	3.65	3.79	.14
Gain:feed	.18	.17	.18	.17	.18	.006
Carcass characteristics						
Hot carcass wt, lb	765	767	773	760	762	6.2
KPH fat, %	2.14	2.17	2.08	2.04	2.07	.04
Dressing % [a]	62.9	62.8	63.5	63.4	63.0	.27
Backfat, in [b]	0.41	0.48	0.41	0.41	0.43	.03
Rib-eye area, sq in [bc]	14.12	13.36	13.80	13.53	13.38	.25
Yield grade [b]	2.34	2.78	2.45	2.48	2.59	.10
Marbling score	3.92	4.19	4.17	4.06	4.17	.12
% USDA Choice	51	70	68	56	62	9.4
Liver abscesses, % [d]	2	4	8	17	4	5.0

[a]Linear effect of feed-grade betaine supplement ($P < 0.1$).
[b]Quadratic effect of feed-grade betaine supplement ($P < 0.1$).
[c]Linear effect of CSB supplement ($P < 0.1$).
[d]Quadratic effect of CSB supplement ($P < 0.1$).

MOLASSES-FAT BLEND AS AN ENERGY SOURCE AND CONDITIONING AGENT IN FEEDLOT DIETS

J. S. Drouillard, A. S. Flake, and G. L. Kuhl

Summary

Seventy-two yearling crossbred steers were used in an individual feeding trial to evaluate the effects of adding a molasses-fat blend (Synergy® 19/14; Cargill Molasses Liquid Products) to diets at 6 or 12% (dry basis) on growth performance, carcass traits, and feed intake behavior. Dry-rolled corn was processed to a mean geometric particle size of either 2,000 or 3,800 microns. Adding the liquid supplement at 6% to the coarse-rolled finishing ration improved gain ($P<.1$) and feed efficiency ($P<.1$). Incorporation of Synergy 19/14 into feedlot rations may help reduce fluctuations in feed intake.

(Key Words: Molasses, Fat, Steers, Finishing, Carcasses.)

Introduction

Molasses and fat are used commonly as conditioning agents in feedlot diets because of their ability to agglomerate fine particles and reduce dustiness. Both are excellent sources of readily available energy and can reduce feed costs when grain prices become inflated. Improvements in emulsion/suspension technology have resulted in mixtures that offer a convenient means of using a single product to incorporate both fat and molasses into cattle diets.

Fine particles and/or dust in the diet influence consumption behavior of feedlot cattle. Fine particles segregate from larger particles or may be physically sorted out because of their floury texture and poor palatability. However, from a nutritional perspective, processing to a fine particle size can improve digestibility. The challenge is to maintain a reasonable balance among feed intake, diet digestibility, and digestive disturbances and still achieve optimum animal performance. Liquid ingredients can help to agglomerate fine particles when diets are highly processed, thereby improving consumption. Our objectives were to: 1) measure performance and carcass traits of feedlot cattle in response to increasing dietary concentrations of a molasses-fat blend and 2) evaluate the potential for using that blend to minimize diet segregation and sorting.

Experimental Procedures

A study was conducted at the Kansas State University Beef Teaching and Research Center using 72 individually fed, British- and Continental-cross yearling steers averaging 828 lb. They were fed a series of transition diets (40 to 92% concentrate) during a 21-day pretrial period, then treated for internal and external parasites and implanted with Revalor-S®. Animals were stratified by weight and assigned randomly, within strata, to each of six treatment groups. Treatments were arranged as a 2×3 factorial in 12 replicates. Factors were grain particle size (mean geometric particle size, 2,000 or 3,800 microns) and level of the molasses-fat blend (0, 6 or 12% of dry matter). The molasses-fat blend (Synergy) contained approximately 14% crude protein and 19% fat, as-fed. Diets (Table 1) were fed once daily for a

period of 80 days. Rejected (uneaten) feed was collected from each animal at the midpoint and end of the trial, and mean geometric particle size was measured to quantify differences in segregation and/or sorting of the experimental diets. Steers were slaughtered at a commercial abattoir when they were estimated to have an average fat thickness (12th rib) of 0.4 inches.

Table 1. Composition (Dry Basis) of Experimental Diets

	Concentration of Synergy			
Item	0%	6%	12%	
Dry-rolled corn	87.15	81.84		76.43
Ground alfalfa hay	8.0	8.0	8.0	
Synergy 19/14	0.0	6.0	12.0	
Dehulled soybean meal	1.5	1.5	1.5	
Urea	.65	.33	-	
Limestone	1.33	1.48	1.47	
Potassium chloride	.44	.20	-	
Salt	.3	.3	.3	
Magnesium oxide	.12	.14	.15	
Ammonium sulfate	.05	-	-	
Vitamin/mineral premixes[a]	.15	.15	.15	
Crude protein, %	12.66	12.66	12.66	
NPN, %	1.95	2.19	2.44	
Crude fat, %	3.92	5.75	7.57	
NEm, Mcal/100 lb	.82	.87	.92	
NEg, Mcal/100 lb	.55	.58	.62	
Calcium, %	.70	.70	.70	
Phosphorus, %	.35	.35	.36	
Potassium, %	.70	.70	.72	
Magnesium, %	.25	.25	.25	
Sulfur, %	.16	.26	.37	

[a]Diets contained the following concentrations of added vitamins, trace minerals and feed additives (dry basis): 1,200 IU/lb vitamin A; 10 IU/lb vitamin E; .05 ppm cobalt; 10 ppm copper; .6 ppm iodine; 60 ppm manganese; .25 ppm selenium; 60 ppm zinc; 30 g/ton Rumensin®; 10 g/ton Tylan®.

Results and Discussion

Performance is summarized in Table 2. Steers fed the coarse grain had improved gains (P<.05) and greater dry matter intakes (P<.1) and tended to be more efficient (P=.13) than those fed the fine-rolled grain. Cattle fed the coarse-rolled diets with 6% Synergy performed far better than those fed the other treatments. In other instances, adding Synergy to reduced gain (linear P<.05; quadratic P<.05) and tended to reduce feed efficiency (quadratic P<.1). In fine diets, fat thickness at the

12th rib decreased as the amount of Synergy was increased, but the opposite was true in the coarse-rolled diets (interaction, P<.1). Carcasses averaged only 30% Choice across the entire experiment; according to USDA graders, the plant average that week was 35% Choice. Because of high variability and few observations, no significant differences were noted among treatments for quality grade. Adding Synergy to the diet reduced the number of instances in which feed intake decreased more than 5, 10, or 20% from the previous day (Table 3). Particle size of the grain had a less notable impact on variances in feed intake. Processing to the finer particle size tended to result in a greater incidence of feed intake reduction (P<.2) at the 5 or 10% level. Mean geometric particle size of refused feed is shown in Table 4. As expected, coarse rolled diets resulted in fewer fine particles in the rejected feed. Adding Synergy to the diet resulted in a linear increase (P<.01) the size of particles in refused feed,suggesting that it may help to reduce diet sorting and/or segregation.

Table 2. Performance and Carcass Traits of Steers Fed Diets Containing Coarse- or Fine-Rolled Corn with 0, 6, or 12% Synergy

	2,000µ Particle Size			3,800µ Particle Size			
Item	0%	6%	12%	0%	6%	12%	SEM
Initial weight, lb	986	989	988	986	986	986	10
Final weight, lb[a]	1275[d]	1278[d]	1265[d]	1275[d]	1350[e]	1262[d]	21
Gain, lb/day[abc]	3.58[d]	3.55[d]	3.43[d]	3.67[d]	4.41[e]	3.49[d]	.20
Dry matter intake, lb/day	21.6[d]	22.3[de]	22.1[d]	22.0[d]	23.9[e]	22.6[de]	.7
Feed:Gain[abc]	6.10[d]	6.41[d]	6.37[d]	5.99[d]	5.43[e]	6.54[d]	.22
Hot carcass weight, lb[c]	781[d]	775[d]	788[d]	790[d]	827[d]	760[d]	14
Dressing percentage[c]	61.3[de]	60.6[e]	62.3[d]	62.0[d]	61.2[de]	60.2[e]	.5
Fat over 12th rib, in[c]	.45[e]	.40[de]	.35[d]	.33[d]	.39[de]	.39[de]	.04
KPH fat, %	2.7	2.7	2.5	2.2	2.4	2.6	.1
Ribeye area, in^2 [c]	12.8[de]	12.5[d]	12.9[de]	13.3[e]	13.6[e]	12.1[d]	.3
Marbling, degrees	SL[50]	SL[44]	SL[48]	SL[25]	SL[20]	SL[53]	17
USDA yield grade[c]	2.4	2.2	1.7	1.3	1.7	2.5	.2
Percent USDA Choice	50.0	16.7	25.0	33.3	16.7	33.3	

[a]Effect of liquid supplement level (P<.1).
[b]Effect of grain particle size (P<.1).
[c]Interaction between grain particle size and liquid supplement level (P<.1).
[de]Means in the same row with common superscripts are not different at P<.05.

Table 3. Occurrences (per Animal) of a 5, 10, or 20% Reduction in Feed Intake Relative to Intake the Previous Day (First Two Weeks of Feeding Period Only)

	Concentration of Synergy			
Change From Previous Day	0%	6%	12%	SEM
5% Reduction	1.42[a]	.92[b]	.58[b]	.18
10% Reduction	.92[a]	.50[b]	.25[b]	.15
20% Reduction	.46[a]	.17[b]	.17[b]	.11

[a,b]Means in the same row with common superscripts are not different at P<.05.

Table 4. Mean Geometric Particle Size of Refused Feed from Steers Fed Diets Containing Coarse- or Fine-Rolled Corn with 0, 6, or 12% Synergy

	2,000µ Particle Size			3,800µ Particle Size			
Item	0%	6%	12%	0%	6%	12%	SEM
Number of samples	9	11	10	9	11	12	
Particle size, microns	894[a]	881[a]	1180[b]	772[a]	1194[b]	1666[c]	21

[a,b,c]Means in the same row with common superscripts are not different at P<.10.

INFLUENCE OF MELENGESTEROL ACETATE (MGA®) AND IMPLUS-H® IMPLANTS ON RATE OF GAIN, FEED EFFICIENCY, AND CARCASS CHARACTERISTICS OF CULLED BEEF COWS FED A HIGH CONCENTRATE RATION[1]

M. F. Spire[2], J. A. Unruh, J. S. Drouillard, and J. C. Galland[2]

Summary

No statistical differences were detected in feedlot performance or carcass traits between control culled beef cows and those that were treated with melengesterol acetate (MGA®) and/or Implus-H® when fed in a feedyard for 56 days before slaughter. All groups performed well, indicating that this practice may be used to improve the market value of culled cows. Cow health during the feeding period is a major concern.

(Key Words: Culled Cows, Melengesterol Acetate, Implus-H Implant, Feedlot Health, Carcasses.)

Introduction

Melengesterol acetate (MGA)suppresses behavioral and hormonal changes associated with the estrous cycle of intact bovine females. Riding behavior associated with cycling heifers and cows is thought to be associated with decreased performance. The objective of this study was to evaluate the effects of MGA alone, Implus-H alone, and the combination of the two on feedlot performance and carcass characteristics of culled beef cows.

Experimental Procedures

The experimental group consisted of 128 mature beef cows purchased from six Kansas livestock markets. On arrival at the feedyard, age of cows was estimated and they were given a broad spectrum anthelmintic, treated topically for external parasites, pregnancy checked, given a health physical, weighed, and frame scored. The cows were ranked by weight and allocated randomly into one of four experimental groups of 32 head each; control, MGA only, Implus-H implant only, or MGA + Implus-H. Within each experimental group, cows were assigned by weight, heaviest to lightest, into one of four replicates.

All cows were fed a ration based on corn grain and sorghum silage. Ration net energy was increased incrementally in five steps through day 24. The sixth and final ration was fed from day 25 through the end of the feeding period on day 57. The final ration (dry basis) consisted of 68.6% corn, 19.1% sorghum silage, 6.1% supplement, 3.5% alfalfa hay, and 2.7% molasses. Dry matter intake was calculated daily for each pen. For those groups receiving MGA, the product was added to the ration at 4.0 mg/head/day beginning on day 2 of the trial. Rumensin

[1]The authors express their appreciation to Pharmacia/Upjohn and Excel Corporation for providing grant support for this research.

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was added at a rate of 30g/ton to the base ration formulation for all experimental groups.

Cows were monitored twice daily for estrus and health status. All animals in standing estrus were identified, and the date was recorded. All animals showing signs of illness were pulled for medical examination and treatment. Cows with severe medical conditions were removed from the trial.

On day 29 of the trial, the cows were weighed. At the end of the trial on day 56 and the morning of day 57, the cows were weighed, and the weights averaged to calculate final weight. On day 57, the cows were shipped to the Excel, Inc. processing plant at Sterling, CO for slaughter.

Health information was recorded for each cow at evisceration. Hot carcass weight (HCW); fat thickness; ribeye area (REA); kidney, pelvic, and heart fat percent (KPH%); skeletal maturity; lean maturity; marbling; and fat color were recorded for each carcass. Dressing percent, USDA quality grade (USDA QG) and yield grade (YG) were determined for each cow.

Mean gain, intake, and feed/gain ratio were tabulated for each treatment group for days 1-28, days 29-56, and days 1-56. Means for each treatment group were compared by analysis of variance. Frequency of disease was tabulated. Twenty-two cows (chronic, dead, or pregnant at slaughter) were removed from the study and not considered in the final statistical analysis.

Results and Discussion

No significant differences (P>.05) were detected between treatment and control group means for gains, feed intakes, or effi ciencies (Table 1) or carcass traits. Means across all treatments were 9.8 $in.^2$ for REA, 0.27 in. for fat thickness, 53.0% for dressing percent, 153.4 (Utility grade= 100-199) for USDA QG, and 2.6 for YG.

Estrus was detected in 37 cows. Average daily gains were 3.91 lb for those cows displaying estrus and 3.79 lb for those not displaying estrus. The difference was not statistically significant.

During the feeding period, 29 animals were pulled for evaluation and medical treatment (Table 2). No differences in number of animals treated were found among experimental groups. At slaughter, post- mortem examination revealed 35 cows with single or multiple pathological conditions of a minor to severe nature. The type and frequency of postmortem finding were comparable to USDA reports for cull cows, except for liver condemnations, which were 10% greater than USDA reports. Based upon texture and physical characteristics, the liver abscesses appeared to be healed and had been of considerable duration. No acute or wet lesions were found. Whether this higher than expected incidence was due to feedlot management practices or to preexisting hepatic insult is unknown. One or more bruises requiring extensive tissue trimming were found on 53% of the carcasses. Average daily gains for cows pulled and treated or having pathology at slaughter were lower than gains for other cows on trial (3.58 vs 3.99 lb, P<0.09).

Cull cows are market-ready from the first day in the feedlot. The option to slaughter before the projected slaughter date can be used when unanticipated price fluctuations occur or a cow exhibits poor performance, becomes lame, goes off-feed, or is injured. Thus, products such as vaccines, insecticides, and anthelmintic should be selected for the shortest withdraw times or their use should be avoided.

Table 1. Feedlot Performance of Culled Cows

	Diet/Implant Regime			
Item	No MGA/ No Implant	No MGA/ Implus-H	MGA/ No Implant	MGA/ Implus-H
No. head	27	26	29	24
Pens	4	4	4	4
	Days 1 to 28			
Gain, lb/day	3.65	3.97	3.88	3.56
Intake, lb/day	28.76	29.95	28.69	28.83
Feed/gain	7.95	7.86	7.51	8.13
	Days 29 to 56			
Gain, lb/day	3.43	3.95	3.94	4.11
Intake, lb/day	26.84	26.55	26.39	26.25
Feed/gain	8.3	6.97	6.96	7.33
	Overall days 1 to 56			
Gain, lb/day	3.54	3.96	3.94	3.83
Intake, lb/day	27.80	28.25	27.51	27.54
Feed/gain	7.9	7.38	7.13	7.36

Table 2. Feedlot Health Report - Diagnosis and Disposition

Clinical Diagnosis	No. Treated	No. Removed from Trial	No.Died/Euthanized
Foot rot/toe abscesses	13	5	0
Off-feed/noncompetitor	5	0	2
Lame	4	1	1
Cancer in eye	2	0	0
Reproductive disorder	3	0	0
Clostridial disease	1	0	1
Jaw abscess	1	0	0
Total	29	6	4

DEVELOPMENT OF AN *IN VITRO* PROCEDURE TO DETERMINE RUMINAL AVAILABILITY OF PROTEIN

C. K. Schoenholz, J. S. Drouillard, E. C. Titgemeyer, and C. K. Armendariz

Summary

A series of *in vitro* experiments was conducted to determine the ruminal availability of protein from grains. Procedures were based on assumptions that 1) ruminal availability of protein is first-limiting to microbial growth, 2) accumulation of microbial cells accurately predicts ruminal protein availability, 3) cytosine can be used to accurately estimate microbial cell mass, and 4) cytosine is present in microorganisms but not in feeds. Cytosine content of *in vitro* cultures was measured by high performance liquid chromatography. Early experiments determined that adding 0.75 g soluble starch provided enough energy that culture growth depended on available protein. In the final experiment, microbial cytosine was measured for several processed grains and for graded levels of sodium caseinate (as a standard for comparison). Cytosine increased as sodium caseinate levels increased. Heat-processed grains yielded less cytosine than grains processed without heat. Cytosine accumulation during *in vitro* fermentation provides a useful measure of ruminal protein availability.

(Key Words: Cytosine, Protein Degradability, Microbial Growth.)

Introduction

The proportion of dietary protein that is ruminally degradable vs. undegradable is a component of modern ration formulation systems. Protein degradability can be measured in numerous ways; the most common is the *in situ* procedure, in which feeds are placed into nylon bags and suspended in the rumen for digestion. Although somewhat expensive and labor-intensive, it assesses the protein availability for a variety of feedstuffs. However, questions have been raised about the *in situ* procedure for feedstuffs that are low in protein. Our objective was to develop a method for measuring ruminally degradable protein that would be appropriate for all feedstuffs, regardless of protein level.

Experimental Procedures

Samples of various feedstuffs (0.5 g) were measured into 50-ml centrifuge tubes. A 30-ml aliquot of a mixture of rumen fluid/McDougall's buffer was added to each tube. The tubes were flushed with carbon dioxide, sealed with one-way valve rubber stoppers, and allowed to incubate for 12 hours at 39°C. At the end of the incubation period, the microbial fermentation was stopped by adding 0.1 ml formalin and refrigerating the tubes. Solids were harvested by centrifuging for 15 minutes at 30,000 x *g*. The resulting pellet was dried in a 55°C forced-air oven for 48 hours. The dry residue was hydrolyzed in perchloric acid, and high performance liquid chromatography was used to measure cytosine. All feed samples were run in quadruplicate.

Experiment 1. Dry-rolled wheat, grain sorghum, and corn were prepared by cracking whole kernels and then grinding them through a 1-mm mesh screen. Steam-flaked

corn was simulated by autoclaving corn for 45 minutes under dry steam, then grinding through a 1-mm mesh screen. High-moisture corn was produced by reconstituting cracked corn, allowing 4 weeks for fermentation, and then grinding through a 1-mm mesh screen using dry ice. Dry samples were kept in sealed bags at room temperature. Wet samples were kept frozen in sealed bags. Pure soluble starch was used as a control (an energy source without protein). Incubations of 3, 6, 9, 12, and 24 hours were tested to determine appropriate fermentation times for microbial growth.

Experiment 2. Previously ground wheat and grain sorghum samples were combined with 0.25 or 0.5 g soluble starch to determine if the fermentation system was energy deficient. Grain samples also were supplemented with sodium caseinate (0.05 g) to determine the effect of degradable protein on microbial growth. Samples without additives served as controls.

Experiment 3. The ground wheat and grain sorghum used in experiments 1 and 2 were supplemented with identical caseinate levels. In this experiment, soluble starch was added at 0.5, 0.75, or 1.0 g to evaluate effects of energy addition on microbial growth.

Experiment 4. Samples of wheat and corn were autoclaved to simulate flaking. Samples of autoclaved wheat and corn were compared to the same grains dry rolled without heat. Samples of soybean meal and nonenzymatically browned soybean meal (a high escape protein source) also were tested. Sodium caseinate, a protein source that is completely rumen-degradable, was used to develop a standard curve. Starch was added to all incubations at 0.75 g per tube to ensure that energy was not limiting.

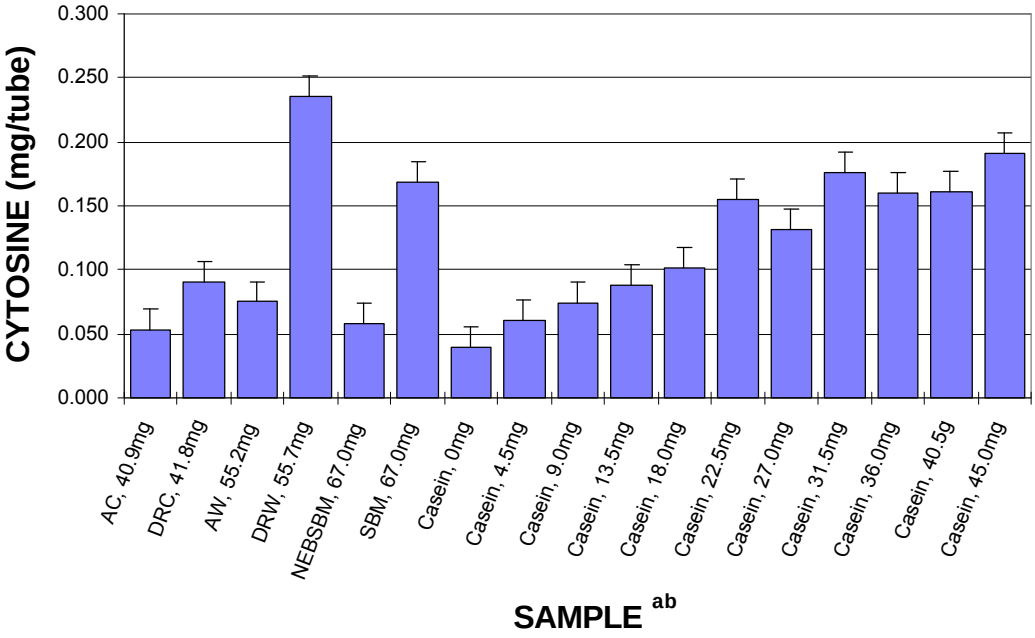
Results and Discussion

Experiment 1. Microbial growth was higher ($P<.05$) for samples containing soluble starch, indicating that energy, not protein, was first-limiting. Microbial growth reached a maximum at 12 hours of fermentation, so this incubation period was used.

Experiment 2. As the level of starch supplementation increased, cytosine content increased in a linear manner ($P<.01$), indicating that microbial growth was stimulated. Cytosine amounts also increased ($P<.01$) when sodium caseinate was added to fermentation samples. No interactive effects occurred when caseinate and starch were added in combination.

Experiment 3. Adding soluble starch at levels above 0.5 grams had no effect on microbial growth ($P>.7$), so energy was no longer limiting above the level. Cytosine increased ($P<.01$) when sodium caseinate was added to grain samples, indicating that microbial growth was responding to added degradable protein.

Experiment 4. Microbial growth increased ($P<.05$) with additions of sodium caseinate up to levels of about 0.03 g of protein (Fig. 1). Thus, the availability of protein appeared to be limiting microbial growth. Cytosine concentrations resulting from fermenting dry-rolled wheat and soybean meal were significantly higher ($P<.01$) than those from autoclaved wheat or the nonenzymatically browned soybean meal, indicating that heat processing in those feeds decreased the availability of protein to rumen microbes. Cytosine contents were numerically, but not significantly, higher for dry-rolled than autoclaved corn. This *in vitro* procedure currently is being applied to a wider range of feedstuffs for further validation.



[a]AC=autoclaved corn; DRC=dry-rolled corn; AW=autoclaved wheat; DRW=dry-rolled wheat; NEBSBM=nonenzymatically browned (high escape) soybean meal; SBM=soybean meal; casein=sodium caseinate.
[b]Numbers following abbreviations display mg of crude protein provided by samples.

Figure 1. Average Cytosine Contents after Fermentation of Processed Feeds and Additions of Graded Levels of Sodium Caseinate.

MICROBIAL EVALUATION OF STEAM PASTEURIZATION AND COMPARISON OF EXCISION VERSUS SPONGE SAMPLING RECOVERY

D. L. Retzlaff, R. K. Phebus, S. A. Rueger, J. L. Marsden, and C. L. Kastner

Summary

The use of steam pasteurization (SPS 400™; Frigoscandia, Bellevue, WA) as a viable commercial-scale intervention method to treat pre-rigor beef carcasses uniformly has been evaluated for temperatures from 180° to 201°F. Effectiveness at lower temperatures (minimum atmospheric temperature of 170°F) has not been evaluated. Previous studies of steam pasteurization used excision sampling. However, the USDA-FSIS has suggested use of nondestructive sampling of chilled beef carcasses for generic *Escherichia coli*, so we compared excision and sponge sampling in a commercial slaughter facility. Twenty-eight beef carcasses were monitored to determine the effectiveness of steam pasteurization and to compare the two sampling methods. Total aerobic mesophilic bacteria, *E. coli*, and coliform counts were all reduced ($P \leq 0.01$) by steam pasteurization. Sponge sampling of carcasses for *E. coli.* provided lower recovery ($P \leq 0.01$) than excision sampling. None of 28 carcasses tested positive by sponge sampling; however, six of the same carcasses were positive (0.39-23.6 CFU/cm^2) by excision sampling immediately adjacent to the sponged area. The SPS 400™ steam pasteurization unit, operating at a minimum atmospheric temperature of 170°F reduced ($P \leq 0.01$) all bacterial populations on pre-rigor beef carcasses. Excision data, compared to previous commercial evaluations of the SPS 400™ at a slightly higher operating atmospheric temperature, provided comparable total reductions, but a few more *E. coli* survived at 170°F.

(Key Words: Steam Pasteurization, Microbial Evaluation, Carcasses.)

Introduction

Microbiological safety of the food supply has been under intense scrutiny. Foodborne disease outbreaks and large food recalls are causing increased concerns by consumers and producers. New regulations have been implemented by the USDA-FSIS to minimize contamination and proliferation of pathogens in food.

Steam pasteurization, an intervention method that has been tested and verified in commercial slaughter facilities, has reduced both indigenous flora and pathogens on freshly slaughtered beef carcasses.

Our study evaluated the effectiveness of a steam pasteurization system (SPS 400™) operating at 170°F, based on microbial enumeration at several steps. Microbial recoveries from chilled beef carcasses using excision and sponge sampling methods also were compared.

Experimental Procedures

Twenty-eight randomly selected carcasses were sampled immediately before and after steam pasteurization and after 18-24 hours in

the cooler. All carcasses were surface sampled using a circular coring device to excise 21.2 cm^2 of tissue at three locations (rump, flank, and brisket) to create a composite sample of 63.6 cm^2. All chilled carcasses (18-24 hour) were surface sampled using both the coring device (excision) and the USDA-FSIS sponge sampling method at adjacent locations on the same carcass. All samples were shipped overnight to the Kansas State University Food Microbiology Laboratory (Manhattan, KS) in insulated coolers with cold-packs. During shipment, temperatures were monitored by data loggers and remained below 45°F.

All samples were enumuated within 1 day of collection for total aerobic mesophilic bacteria, *Escherichia coli*, and coliforms, using appropriate Petrifilm™ plates. The excision samples were diluted with 0.1% peptone diluent. Sponges were rehydrated according to USDA-FSIS methods using Butterfield's phosphate buffered dilution water (FDA Bacteriological Analytical Method). All plates were incubated 48 hours at 95°F. Data were converted to $\log_{10}$ colony forming units (CFU) per cm^2 and mean values determined at each sampling step. A value one-half the detection limit was reported for samples with no colonies on the lowest dilution, in order to be able to perform statistical analysis. Statistical significance ($P \leq 0.01$) was determined using Proc GLM in the Statistical Analysis System (SAS) for each bacterial type.

Results and Discussion

Total aerobic mesophilic bacteria, *E. coli*, and coliform counts were lower ($P \leq 0.01$) after than before steam pasteurization and remained lower after a 18-24 hour chill. Bacterial counts after 18-24 hours in the cooler and immediately after steam pasteurization were similar ($P > 0.01$).

Counts were lower ($P \leq 0.01$) with sponge samples than excision samples for all bacteria. Detection limits were 0.39 CFU/ cm^2 for the excision method and 0.04 CFU/cm^2 for the sponge method. This means that the sponge method should detect bacterial colony forming units, including *E. coli* colonies, more often than the excision method. However, in this study no *E. coli* colonies were detected with sponge sampling, whereas *E. coli* colonies were detected on some of the same carcasses using the excision sampling method.

Escherichia coli counts were compared to the performance criterion of 9 CFU published in the Federal Register, July 25, 1996. Only three unacceptable results were identified and were from carcasses sampled before steam pasteurization. Using the excision method, one chilled carcass had a marginal level of *E. coli*. All chilled carcasses had acceptable test results for *E. coli* with sponge sampling. In conclusion, steam pasteurization decreased ($P \leq 0.01$) all bacterial counts. All excision samples from chilled carcasses indicate that the slaughter process was in compliance with FSIS *E. coli* criteria. However, reduction in SPS 400™ operating temperatures should be avoided if possible, as a margin of safety.

The sponge sampling method revealed lower ($P \leq 0.01$) counts for all bacterial types, compared to excision sampling.

EVALUATION OF CHANGES IN MICROBIAL POPULATIONS ON BEEF CARCASSES RESULTING FROM STEAM PASTEURIZATION

T. L. Brown, R. K. Phebus, P. E. Peters, A. L. Nutsch, C. L. Kastner, and D. H. Kropf

Summary

The steam pasteurization process (SPS 400) developed by Frigoscandia Food Process Systems (Bellevue, WA) was effective in reducing bacterial populations in both laboratory and commercial settings. The objective of steam pasteurization and other meat decontamination measures is to extend product shelf life and improve safety by inhibiting or inactivating pathogens, while at the same time maintaining acceptable meat quality characteristics. The effects of steam pasteurization on beef carcass bacterial populations were evaluated at two large commercial beef processing facilities. A shelf-life study also was conducted to determine the microbial profiles of vacuum packaged beef loins from pasteurized and non-pasteurized carcasses. Steam pasteurization greatly reduced total beef carcass bacterial populations and was most effective in reducing gram negative organisms, including potential enteric pathogens of fecal origin. Thus, the relative percentage of gram positive microflora on beef carcass surfaces, especially *Bacillus* spp. and *Staphylococcus* spp., increased.

(Key Words: Steam Pasteurization, Microbial, Populations, Carcasses.)

Introduction

Emerging pathogens and new spoilage organisms continue to generate potential hazards and spoilage problems. Modern sanitation practices, packaging, decontamination technologies, and storage practices could result in emergence of "new" microorganisms and lead to new issues in meat safety. Changes in microflora caused by a decontamination or processing treatment must be evaluated to ensure that new problems are not being created. Conversely, certain decontamination treatments may select for microflora that improve shelf life and even sensory quality. Each decontamination strategy should be evaluated individually to ascertain its effects on the resulting microbiological safety and quality of meat products.

This experiment examined the effects of steam pasteurization on beef carcass microflora. Our goal was to identify the types of native microflora of beef carcasses before and after steam pasteurization and to observe any changes resulting from this treatment, compared to nontreated carcasses. The changes in microflora in vacuum-packaged beef subprimals over time caused by steam pasteurization of carcasses also were analyzed.

Experimental Procedures

Isolates selected for identification in this study were collected during two earlier large in-plant steam pasteurization trials. The isolates from Plant I were chosen randomly from the APC Petrifilm™ before steam pasteurization, after steam pasteurization, and

after 24 hr of chilling; 288 from each period, representing 140 carcasses.

Plant II isolates were picked randomly from the APC Petrifilm™ representing five anatomical locations on 200 carcasses; inside round, loin, mid-line, brisket and neck, 150 before steam pasteurization and 150 after steam pasteurization. Isolates were identified by standard microbial isolation techniques, using commercially available identification test kits.

Boneless strip loins were vacuum packaged to determine microbial changes over time and the effect of steam pasteurization on shelf life. Samples were collected and enumerated microbiologically every 20 days over a 100-day storage period at 34°F.

Results and Discussion

Comparisons in this study are based on relative percentages of isolated colonies remaining on detection media and do not account for the large bacterial reduction in populations by commercial steam pasteurization. In Plant I, steam pasteurization (8 seconds exposure time at 195-201°F) reduced aerobic plate counts (APCs) approximately 1.35 $\log_{10}$ CFU(colony forming units)/cm^2, and that reduction was maintained after a 24-hour chill. A 1 $\log_{10}$ reduction means 90% reduction; 2 $\log_{10}$ is 99% reduction. The population remaining after steam pasteurization was dominated by gram positive, spore-forming rods. *Bacillus* comprised 41.7% of the aerobes before pasteurization, 48.4% immediately after pasteurization, and 37.0% after chilling. The surface microflora was more diverse before pasteurization and after chilling than immediately after treatment.

In Plant II, steam pasteurization (6.5 second steam exposure at 180°F) reduced ($P \leq 0.01$) bacterial populations from 1.84 $\log_{10}$ CFU/cm^2 before pasteurization to 0.84 $\log_{10}$ CFU/cm^2 afterward. A total of 148 APC isolates were identified before pasteurization and 108 afterward. Steam pasteurization virtually eliminated gram negative bacteria, leaving a residual population comprised almost exclusively of gram positive spore-forming rods and cocci. After treatment, *Bacillus* again were predominant. This is a spore-forming microorganism and, therefore, is highly tolerant to heat and other extreme environmental conditions. *B. cereus* does not proliferate well at cold temperatures, so the percentage increase of *Bacillus* does not in increase food safety risk. *Staphylococcus aureus* was not identified in this study.

Aerobic plate counts of pasteurized and nonpasteurized samples were essentially the same prior to fabrication and remained so throughout storage. However, shelf life results were highly influenced by the simultaneous processing of pasteurized and nonpasteurized carcass primals and subprimals, which provided a constant source of cross contamination. *Bacillus* and *Staphylococcus* constituted 60% of the microflora present throughout the shelf-life period.

The reduction in bacterial populations indicates that steam pasteurization is very effective and adaptable to commercial processing facilities. The microflora changes do not appear to be hazardous and occur normally under typical processing conditions.

PREVALENCE OF *ESCHERICHIA COLI* O157:H7 IN COW-CALF HERDS IN KANSAS [1]

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Summary

Fecal samples from cows and calves and samples of water sources were collected monthly for 8 months from 10 Kansas cow-calf farms to determine the prevalence of *E. coli* O157:H7. The bacterium was found in 8% of fecal samples from cows that were within 24 hours of calving, 1.4% of fecal samples from cows which were not within 24 hours of calving, 1.4% of calf fecal samples, and 1.5% of water samples. *E. coli* O157:H7 was identified from at least one sample on all farms.

(Key Words: Cow-Calf Herds, *E. coli* 0157:H7, Bacterial Infection.)

Introduction

Over the past decade, *Escherichia coli* O157:H7 has emerged as a significant public health concern. Humans infected with this bacterium experience a range of illnesses, including severe bloody diarrhea, hemolytic uremic syndrome, and occasionally death. Many cases of the disease in humans are linked to consumption of contaminated beef products. The food processing industry has introduced HACCP (Hazard Analysis Critical Control Points) programs aimed at reducing the risk of contamination of beef products with pathogens, including *E. coli* O157:H7. Considerable interest exists in extending HACCP programs to the farm to further minimize the risk that *E. coli* O157:H7 will enter the human food chain.

To extend HACCP programs to the farm, it is necessary to identify the prevalence of *E. coli* O157:H7 infection in livestock and to understand how the bacterium is spread between animals. Although this bacterium is shed in animals' feces, it does not cause illness in cattle. Because infection is relatively uncommon, it is necessary to sample large numbers of apparently healthy animals to identify which cattle are shedding *E. coli* O157:H7. The cow-calf industry is generally pasture-based, making it difficult to collect samples from large numbers of animals. Therefore, little is known about the frequency of *E. coli* O157:H7 in these animals. The objective of this study was to determine the prevalence of *E. coli* O157:H7 in cow-calf herds in Kansas.

Experimental Procedures

Ten commercial cow-calf herds in Kansas participated in the study; five were large (>300 cows) and five were small (<100 cows). All herds had a spring calving program. Each farm was visited approximately once per month from Dec., 1996 to July, 1997. At each visit, we collected fecal samples from 10% of the cows and a water sample from all water sources available to the

[1]This research was funded in part by USDA Special Research Grant #96-34359-2593 and the KSU-Food Animal Health and Management Center.

[2]Food Animal Health and Management Center, Veterinary Clinical Sciences.

cattle. After the start of the calving season, we also collected fecal samples from 10% of the calves. We collected fecal samples from 50 cows that were within 24 hours of calving, 1277 cows that were not within 24 hours of calving, and 418 calves. We also collected 135 water samples.

The fecal and water samples were tested for *E. coli* O157:H7 using standard culture techniques, which included immunomagnetic separation and latex agglutination.

Results and Discussion

E. coli O157:H7 was isolated from 8.0% of the cows that were near calving, 1.4% of the cows that were not near calving, 1.4% of the calves, and 1.5% of the water samples. The presence of *E. coli* O157:H7 in water samples is of concern, because this might spread the bacterium to uninfected cattle.

Prevalence did not differ (P>.05) between the types of samples, and tended to be higher in cows near calving.

Figure 1 shows the prevalence of *E. coli* O157:H7 by farm. Although smaller farms tended to have a higher prevalence, the difference was not significant (P>.05). The prevalence was quite low on all farms (<4%), but every farm in this study had at least one sample that contained *E. coli* O157:H7. This suggests that, although the rate is low, infection is present to some degree on many farms. This has implications for control programs but also suggests that producers should use hygienic practices such as hand-washing after handling cattle and prior to eating.

Figure 2 shows the prevalence of infection by month. The prevalence of *E. coli* O157:H7 was higher (P<.05) in March compared to May and June. The graph indicates that infection was also more common in December. However, relatively few cattle were sampled in December, so this rate was not different (P>.05). The increased prevalence in March may be related to calving patterns and not a true seasonal effect. The majority of samples from cows near calving were collected in March, and cows near calving tended to have a higher prevalence of *E. coli* O157:H7.

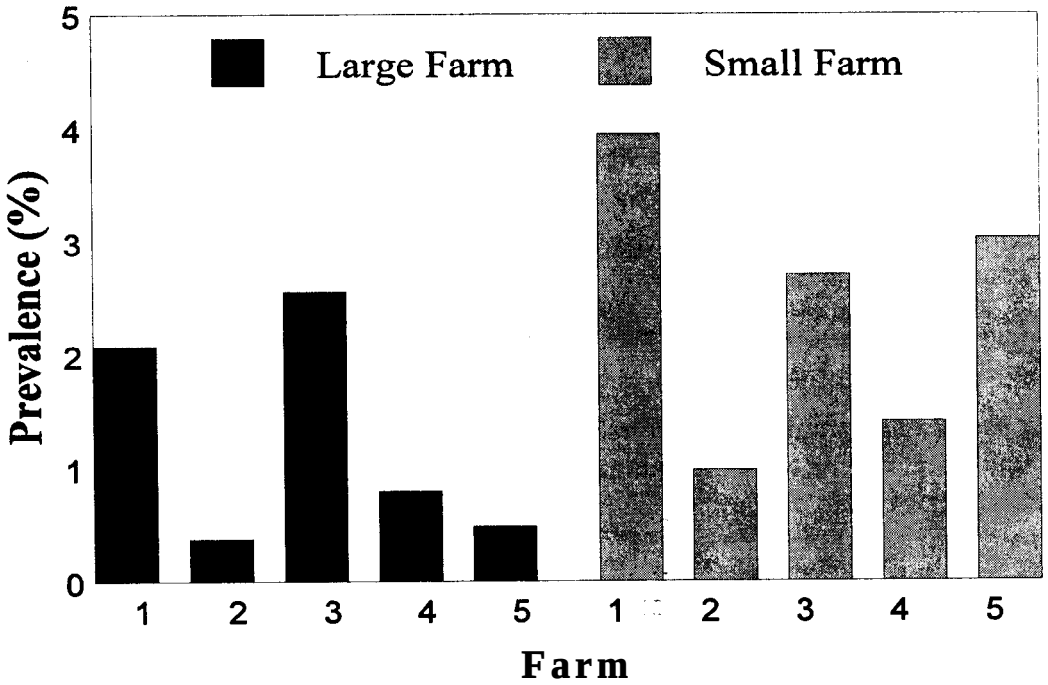

Figure 1. Prevalence of *E. coli* O157:H7 in Fecal and Water Samples by Farm.

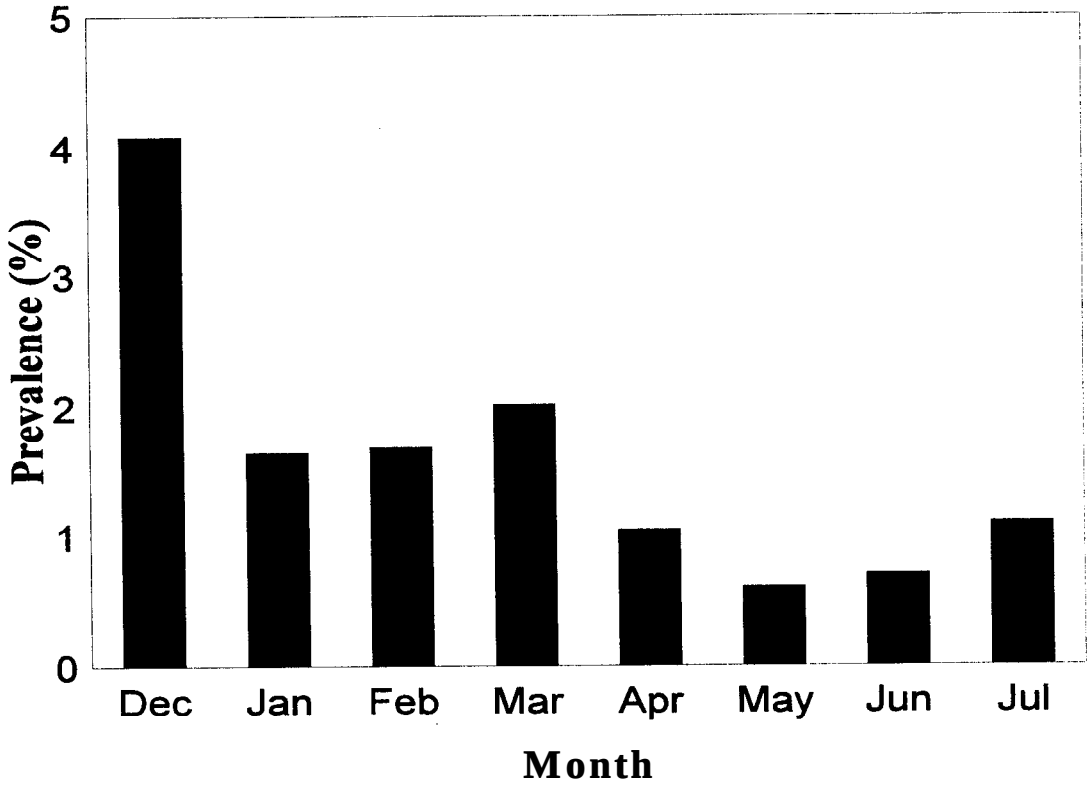

Figure 2. Prevalence of *E. coli* O157:H7 in Fecal and Water Samples by Month.

PREVALENCE, ANTIBIOTIC SUSCEPTIBILITY, AND GENETIC DIVERSITY OF *SALMONELLA*, *CAMPYLOBACTER*, AND *ESCHERICHIA COLI* O157:H7 COLLECTED AT FOUR KANSAS BEEF CATTLE FEEDYARDS OVER 13 MONTHS [1]

D. R. Hyatt [2], J. C. Galland [2], S. Crupper [3], L. Hawkins, N. V. Anderson [2], G. L. Stokka

Summary

Salmonella, *Campylobacter*, and *Eschericia coli* O157:H7 are important foodborne pathogens, but longitudinal studies of their prevalence in beef cattle feedyards have not been done. Our long-term study involved 24,556 samples taken from beef cattle feedyards found overall prevalences of 4.87% for *Salmonella*, 20.1% for *Campylobacter* in hospital pen fecal samples, and 0.20% for *E. coli* O157:H7. Yard and pen differences ($P<0.05$) were detected. All 53 *E. coli* O157:H7 isolates were resistant to Talmicosin and Erythromycin, two antimicrobials used in food animal medicine. Their genetic diversity was high and did not indicate the presence of resident strains at the yards studied. *Salmonella*, *Campylobacter*, and *E. coli* O157:H7 were probably brought into the yards by shipments of new cattle. Many of these organisms were susceptible to antibiotics commonly used to treat beef cattle.

(Key Words: Bacterial Infection, *Salmonella*, *Campylobacter*, *E. coli* O157:H7, Feedyards, Antibiotic Susceptibility.)

Introduction

Agricultural use of antibiotics has been suggested as the reason for the development of antibiotic resistance in strains of human pathogens. However, strong evidence to support this hypothesis has not been presented. Knowing antibiotic susceptibility of gentically identical *Escherichia coli* O157:H7 isolates will help to determine 1) their feedyard sources, 2) which antibiotics could be effective for cattle therapy, 3) sources that have greatest resistance, 4) whether some genetically identical isolates are developing resistance over time, and 5) seasonal resistance patterns for each antibiotic tested. Knowing the genetic diversity of organisms such as *E. coli* O157:H7 aids investigators in determining if contamination is due primarily to resident or transient isolates and could help trace the source of disease outbreaks. Monitoring the prevalence, antibiotic susceptibility, and genetic diversity of foodborne pathogens at cattle feedyards is important for producers designing production animal (preharvest) Hazard Analysis Critical Control Points (HACCP) programs for pathogen reduction.

Experimental Procedures

Four large (>25,000 head) beef cattle feedyards in southwest Kansas were sampled every 3 weeks for 13 months for a total of 20 collections per yard. Pens typically had new lots of cattle every 155 days. Six composite fresh fecal pat samples (five pat samples/ composite) from the floor of approximately 30 home pens and all special pens were collected as well as a composite water sample from the pen's water

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trough and a composite feed sample from the pen's feed bunk. Lagoon water and ration ingredients also were collected from each yard at each visit. Standard microbiological techniques were used to isolate *Salmonella*, *Campylobacter* and *E. coli* O157:H7. The susceptibility of the *E. coli* O157:H7 isolates to 16 antibiotics used in human medicine and eight antibiotics approved for use in food animals was determined by use of the Sensititre Accumed semi-automated system. Random amplification of polymorphic DNA (RAPD) was used to genetically characterize the *E. coli* O157:H7 isolates.

Results and Discussion

Analysis of over 24,500 samples showed that prevalence of the three bacteria varied among yards; type of pen (home, hospital, other); and sample type (fecal, water, total ration, individual ration ingredients, and lagoon). *Salmonella* spp. were isolated from 4.87% of samples, and *E. coli* O157:H7 was isolated from 0.20%. *Campylobacter* was isolated from 20.1% of hospital pen fecal samples (n=2672). Total prevalences for all yards varied from 1.88% to 10.66% for *Salmonella*; from 0.06% to 0.36% for *E. coli*; and from 14.43% to 30.49% for *Campylobacter* (in hospital pens only). Over all four yards, *Salmonella* spp. were isolated from 6.3% of bunk ration samples (n=2921), 0.80% of drinking trough samples (n=3248), 5.44% of fecal samples (n=17494), 2.24% of ration ingredient samples (n=581), and 6.09% of lagoon samples (n=312). *E. coli* O157:H7 was isolated from 0.10% of rations, 0.03% of drinking water, and 0.26% of fecal samples but was not detected in any lagoon or ration ingredient samples. Total prevalence of *Salmonella* varied in different yards from 2.08% to 12.2% in fecal pat samples, 0.58% to 0.97% in water samples, 1.47% to 13.3% in ration samples, 0.67% to 3.82% in ingredient samples, and 2.7% to 8.77% in lagoon samples. Hospital and other special pens had higher total prevalence of *Campylobacter* than home pens ($P<0.05$). No differences were detected in *E. coli* O157:H7 prevalence among pen types. All isolates of *E. coli* O157:H7 were resistant (Table 1) to Tilmicosin and Erythromycin. Most of the *E. coli* O157:H7 isolates were susceptible to Ceftiofur and Ampicillin. All but three isolates were susceptible to Trimethoprim sulfate, which was used widely in cattle feedyards 10 years ago but is used infrequently now.

Genetic diversity among 53 *E. coli* O157:H7 isolates was high (16 RAPD prints) and indicates that the strains found were brought in with loads of cattle and did not remain resident at these large well-managed feedyards. Pens rarely tested positive for *E. coli* O157:H7 twice. It was rarely isolated from feed and never isolated from water. Thus it was not persistent in these yards. *E. coli* O157:H7 was isolated from the same pen at different collections only three times. In two of those cases (separate yards), a genetic pattern found during collection 1 was found again in collection 15, which was made 42 weeks later.

Table 1. Antimicrobial Susceptibility (Susceptible (S), Intermediate (I), or Resistant (R)) of 53 *E. coli* O157:h7 Isolates

Antibiotic	S	I	R
Trimethoprim Sulfa	50	0	3
Ceftiofur	44	0	9
Ampicillin	44	0	9
Cephalothin	31	13	9
Tetracycline	28	2	23
Amoxicillin	11	0	42
Penicillin	0	3	50
Erythromycin	0	0	53
Tilmicosin	0	0	53

CONTROL OF *ESCHERICHIA COLI* O157:H7 IN LARGE-DIAMETER, LEBANON-STYLE BOLOGNA

K. J. Karr, C. L. Kastner, J. L. Marsden, and R. K. Phebus

Summary

Lebanon bologna raw batter was mixed with a five-strain mixture of *Escherichia coli* O157:H7 to achieve average inoculum levels of 7.79, 7.77, and 7.92 log CFU/g as determined on MSA, 202, and PRSA media, respectively. Treatment 1 consisted of a fermentation cycle of 8 hrs at an internal temperature (I.T.) of 80°F then 24 hrs at 100°F I.T., followed by 24 hrs at 110°F I.T. Treatments 2, 3, and 4 included additional heating at 115°F I.T. for 1, 2, and 5 hrs, respectively. All heat treatments resulted in product that was negative (<1.9 log CFU/g detection limit) on all culture media and negative after enrichment on mEC selective medium. This study validates that a five-log reduction of *E. coli* O157:H7 can be achieved using the described protocol, thus meeting USDA/FSIS requirements.

(Key Words: *E. coli* O157:H7, Food Safety, Fermented Beef, Sausage.)

Introduction

In December of 1994, an outbreak of *Escherichia coli* O157:H7 was linked to the consumption of dry cured salami. This outbreak caused USDA/FSIS to require that fermented sausage processes achieve a five-log reduction of *E. coli* O157:H7 in a test situation when starting with at least 7.3 CFU.

Lebanon bologna is a fermented beef sausage that utilizes a low-temperature, long-time fermentation process, but is susceptible to *E. coli* O157:H7 contamination. An available medium is sensitive to recovering heat-injured cells. Therefore, the objectives of this study were: 1) to determine the effects of typical thermal processing temperatures and times for Lebanon bologna on reducing *E. coli* O157:H7 and 2) to evaluate the effectiveness of MacConkey Sorbitol Agar (MSA), 202 agar, and Phenol Red Agar with 1% sorbitol (PRSA) for detecting *E. coli* O157:H7.

Experimental Procedures

Five different isolates of *E. coli* O157:H7 were used. Two were human isolates, and the others were of meat origin, one being implicated in the 1995 salami outbreak. Isolates were incubated on tryptic soy agar slants at 98°F for 20 ± 2 hrs and maintained at 40°F until needed. After further inoculation, cells were harvested by centrifugation, resuspended, centrifuged again, and then held at 40°F until needed (less than 2 hrs).

Commercially prepared beef meat batter (90% lean) containing salt; sucrose; dextrose; spices; potassium nitrate; sodium nitrite; and starter culture (*Pediococcus*, *Lactobacillus*, and *Micrococcus* spp.) was received overnight from the manufacturer. Upon receipt, the raw batter was at 45 ± 4°F.

For the inoculated treatments, 55 lb of meat batter was spread evenly (1 to 1.5 in. thick) onto a flat surface to allow for even distribution. The inoculum was intermittently pipetted drop-wise over the meat surface and thoroughly mixed.

The meat batters (control and inoculated) were transferred to a hand stuffer and stuffed into prestuck, presoaked, 4½ in.-diameter casings. Each chub weighed approximately 6.6 lb and was about 10 in. long.

Chubs were hung vertically on racks. Inoculated and control chubs were placed randomly in a commercial smoke house (Alkar, Lodi, WI). Fermentation included 8 hrs at an internal temperature (I.T.) of 80°F, then 24 hrs at 100°F I.T., followed by 24 hrs at 110°F I.T. Natural smoke was applied during the last 2 hrs of the 110°F cycle. Heat treatments 2, 3, and 4 included additional heating at 115°F I.T. for 1, 2, and 5 hrs, respectively. For each internal temperature, an appropirate time was allowed for that temperature to be reached. The relative humidity (RH) for the 80°F stage was 90%. For the 110, 110, and 115°F stages, the relative humidity was 60 to 65%. In the commercial Lebanon bologna process, the RH is maintained at 90% throughout the process, and the specified moisture to protein ratio is 3.1:1. Because of the lower relative humidity, our product is referred to as "Lebanon-style bologna."

MacConkey Sorbitol Agar, 202 agar, and PRSA were used for enumerating *E. coli* O157:H7. All plates were spiral plated and incubated at 107°F for 24 hrs. Modified *E. coli* broth was used for enrichment of *E. coli* O157:H7. Identification was confirmed with API 20# and RIM *E. coli* O157:H7 latex agglutination test.

A special medium (APT) was used for lactic acid bacteria (LAB) enumeration. All LAB plates were incubated at 95°F for 24 hrs in a CO_2 chamber with 20% CO_2.

Both raw and heat-treated samples were analyzed for moisture, fat, salt, protein, ash, water activity, pH, and titratable acidity.

Results and Discussion

For all heat treatments, the log (CFU/g) reduction values were 5.89, 5.87, and 6.07 on MSA, 202, PRSA media, respectively. A 6 log reduction means a kill of 99.9999% of original *E. coli* O157:H7 organisms. All heat treatment samples were also negative after enrichment on mEC selective medium. The LAB counts were between 7.2 and 7.4 log CFU/g for the raw batter and 6.8 to 6.9 log CFU/g for all of the heat treatments. A 7 log population is 10 million organisms.

Minimal variation was found for all product characteristics both within and between treatments. Overall pH was 4.4 after fermentation. Moisture was 60.8%; protein, 22.5%; fat, 10.6%; and salt, 4.8%. The moisture to protein ratio was 2.7, with water activity at 0.94. All heat treatments on all media resulted in a product that was negative (<1.9 log CFU/g detection limit) for *E. coli* O157:H7 and negative after enrichment on mEC selective medium. This study validates that a five-log reduction of *E. coli* O157:H7 can be achieved using the described heating protocol, thus meeting USDA/FSIS requirements.

Cattlemen's Day 1998

MICROBIAL SHELF LIFE OF CHUB-PACKAGED GROUND BEEF FROM FOUR LARGE U.S. PROCESSING PLANTS

P. E. Peters, S .D. Gamage [1], R. K. Phebus, and J. B. Luchansky [1]

Summary

Ten pound chubs of coarsely ground beef of two different lean:fat specifications (73:27 and 81:19) were stored at three temperatures (34, 38 or 45°F) to monitor the effects of storage temperature on microbial condition of the product. Ground beef from four U.S. plants was tested (2 trials each), and microbial analyses were conducted on storage days 0, 6, 10, 14, and 18 using seven different media to estimate counts of total aerobic and anaerobic, lactic acid bacteria (LAB), and Gram-negative bacteria. Bacterial counts for a given culture medium were similar among plants and meat types. At day 10, total microbial counts from chubs stored at 38 or 45°F were approximately 8 $\log_{10}$ CFU/g, whereas total counts from chubs stored at 34°F were approximately 4.5 $\log_{10}$ CFU/g (4 log=10,000, CFU is colony forming units). Regardless of storage temperature and meat type, LAB predominated. Growth of gram-negative enteric bacteria was delayed in chubs stored at 34°F throughout the 18 day study, whereas counts increased in chubs stored at 38 or 45°F.

(Key Words: Ground Beef, Shelf Life, Meat Spoilage, Microbiology.)

Introduction

In 1994, the average American consumed 64 pounds of ground beef. Therefore, the quality of ground beef becomes an important issue. The nutrients in meat that are essential for humans also are essential for microorganisms, resulting in an extremely perishable product.

Increased bacterial growth reduces shelf life by initiating spoilage characteristics such as off odor, off color, and gas formation in vacuum bags. Contamination during processing limits shelf life of the already fragile ground beef product.

Groups of microorganisms interact to inhibit each other, depending especially on storage temperature. A small number of initial carcass microflora are psychrotropic (grow best in the cold). They increase as the initial predominant mesophilic organisms (grow best at body temperature) decrease under cold conditions.

Organisms associated with meat spoilage include *Pseudomonas, Acinetobacter, Moraxella, Serratia, Altermonas, Brochrothrix, Lactobacillus,* and *Hafnia*. Packaging can enhance populations of lactic acid bacteria(LAB). *Pseudomonas* spp. are most prevalent in aerobically packaged fresh beef, whereas *Hafnia alvei* has been implicated in

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the spoilage (gassy packages, hydrogen sulfide odor) of vacuum-packaged strip loin steaks. Because the initial microflora on meat is primarily mesophilic, shelf life is prolonged by the combined use of refrigeration and vacuum packaging. A greater increase in microbial counts in chub-packed ground beef during storage was reported at 45°F than at 36°F. Total aerobic plate counts have been reported to increase during storage, as well as the proportion of gram negative to gram positive organisms. Severe or even slight temperature abuse contributes to premature product deterioration, resulting in financial loss and negative response from consumers.

This study was conducted to determine the changes in microflora of three formulations of chub packaged ground beef over an 18 day storage at three temperatures using total aerobic and anaerobic plate counts in conjunction with selective and differential agars. Four individual meat packing facilities in four separate locations throughout the United States were sources of beef.

Experimental Procedures

Ten pound ground beef chubs were sampled from four U.S. meat processing facilities. Samples were collected twice from each facility between August, 1996 and January, 1997. Three product types with different fat and lean concentrations were examined from each facility [73/27 (73%) ground beef, 81/19 (81%) ground beef, and 81/19 (GC) ground chuck]. All ground beef samples were coarsely ground. During product collection from each facility, chubs from each product type were collected randomly and boxed. All chubs used for one trial at one plant were produced on the same day during the same shift. The chubs used for day 0 sampling were transported on ice to either Kansas State University (KSU) Manhattan, KS or the Food Research Institute (FRI) Madison, WI for microbiological analysis. The chubs to be sampled on days 6, 10, 14, and 18 were transported to corresponding laboratories by commercial refrigerated truck.

Kansas State University stored ground beef from two plants at 38 and 45°F, and the FRI stored product from two other plants at 34 and 45°F. Immediately upon arrival at the laboratories, chubs were separated randomly into two equal groups and stored at the two different temperatures.

Microbial analyses were performed on two chubs from each temperature on days 0, 6, 10, 14, and 18. A 50 g sample of ground beef was removed aseptically from the chub and placed into a stomacher bag along with 150 ml of 0.1% peptone (Difco), resulting in an initial 1:4 dilution. Serial 1:10 dilutions (0.1% peptone) were spiral-(KSU), spread-(FRI), or pour- (KSU, FRI) plated onto seven different commercially available agars and incubated at 68°F for 5 days.

Tryptic Soy Agar (Difco, Detroit, MI) with 5% defibrinated sheep blood added was used to determine both the total aerobic and anaerobic plate counts. Anaerobic incubation conditions were achieved using an anaerobe jar in conjunction with a BBL GasPak Plus anaerobic atmosphere generators (4 to 10% carbon dioxide). APT Agar (APT) was used by KSU, whereas the FRI used MRS Agar (MRS) to enumerate LAB. *Pseudomonas* Isolation Agar (PIA) was used to determine the presence of *Pseudomonas* spp., especially *P. aeruginosa*. Violet Red Bile Agar (VRBA) was used in the pour plate method to determine coliform and gram negative counts. Desoxycholate Lactose Agar (DL)

was used to enumerate gram negative enteric bacilli. All plates were incubated at 68°F.

Results and Discussion

Because the bacterial plate counts were similar for all three meat types, data are presented only for 73% lean ground beef. Initial total aerobic plate counts were approximately 4 to 5 $\log_{10}$ CFU/g for samples from all four plants. Within 10 days, total aerobic and anaerobic counts from chubs stored at 45°F had reached 8 $\log_{10}$ (100 million) CFU/g and were similar for all four plants. Product stored at 38°F (two plants, FRI) had counts similar to those of product stored at 45°F; 7.5 $\log_{10}$ at day 10 and increasing to 8 $\log_{10}$ CFU/g at day 14. In contrast, plate counts from products stored at 34°F (two other plants, KSU) increased approximately 1 $\log_{10}$ CFU/g by day 10 and reached 7 $\log_{10}$ CFU/g by day 18.

After 18 days at 34°F, LAB reached about 7 $\log_{10}$ CFU/g; at 38 or 45°F counts reached 7 to 8 $\log_{10}$ CFU/g. Because counts of 8 $\log_{10}$ CFU/g also were recovered on Blood Agar (total aerobic and anaerobic-microbial load), LAB were presumed to predominate.

Initial gram negative enteric bacteria were present at about 2 to 3.5 $\log_{10}$ CFU/g in samples from all plants and increased to approximately 5.0 and 5.5 $\log_{10}$ CFU/g during the 18 days of storage.

Because the initial bacterial load of ground beef in general is relatively high, low refrigeration temperature (ca. 34°F or less) is important for delaying microbial growth and inhibiting the proliferation of spoilage organisms. Temperature control is critical, because only a 4°F increase in storage temperature resulted in more rapid microbial growth and faster product spoilage.

Cattlemen's Day 1998

DRY AGING: AN OLD PROCESS REVISITED

R. E. Campbell and M. C. Hunt

Summary

Dry aging of beef cuts, once considered the "gold standard" for premium palatability, is practiced by only a few processors. We were asked by a major southern meat purveyor to study variables of dry-aging processing. Detailed sensory analyses of flavor, juiciness, and tenderness clearly indicated that beef loins dry aged for 14 and 21 days were superior for all three traits to a product vacuum aged for 14 days and to a product dry aged for 7 days. In addition, dry- aged steaks could be vacuum packaged and stored for up to 16 days without losses in palatability. Dry aging definitely intensified desirable flavor traits and reduced flavor notes typical of vacuum aging. Counts showed that dry aging controlled bacteria. Dry aging, properly done, produces beef steaks with desired eating characteristics for the high-end, value-added markets.

(Key Words: Dry Aging, Meat Sensory Attributes, Meat Physical Attributes, Microbiology.)

Introduction

Dry aging (aging in air without packaging) was used to improve the flavor and tenderness of beef before the introduction of vacuum-packaging technology. More recently, beef has been shipped as subprimal cuts in vacuum packaging, which reduces shipping costs, extends shelf life, and decreases evaporative losses. Aging in vacuum can improve tenderness; however, the flavor development is different from that in dry aging.

Dry-aging weight losses can exceed 10 %, so it generally has been abandoned except for a few restaurants and specialty shops. This study developed because Buckhead Beef Inc, (Atlanta, GA) became interested in marketing dry-aged beef on a large scale. Our objectives were to develop a flavor profile for dry-aged beef and determine optimum processing times.

Experimental Procedures

Three time parameters were studied: pre-aging time (7 or 14 days) in vacuum before dry aging; dry-aging time (7, 14 or 21 days); and time in vacuum after aging (2, 9, or 16 days). All beef used for this experiment was Certified Angus Beef (CAB^{TM}).

Strip loins (NAMP 180) were stored in vacuum for 7 or 14 days, then dry aged for 7 or 14 days, trimmed, vacuum packaged, and shipped to the KSU Meats Laboratory, where they were and processed into steaks at 2, 9, and 16 days after the completion of dry aging. CAB short loins (NAMP 174) were stored in vacuum packages for 7 or 14 days, then the tenderloin was removed and the shell loin was dry aged for 21 days. After dry aging, shell loins were processed into strip loins, vacuum packaged, and shipped to the KSU Meat Laboratory , where they were processed into steaks at 2, 9 and 16 days

after dry aging. Control steaks for all sensory sessions were from CAB strip loins (NAMP 180) stored for 14 days in vacuum packaging.

Steaks were cooked on an electric grill at 662°F (350°C) for 4 minutes on one side, then turned and cooked for 4 more minutes. Steaks then were turned every 2 minutes until 145° F (63°C, medium rare) was reached. Total cooking times ranged from 11 to 15 minutes.

The center portion of the loin eye muscle cut into ½ in. × ½ in. × 1 in. pieces and served to a sensory panel. Each panelist got four randomly selected pieces of every steak tested.

The highly trained sensory descriptive panel (six members) from the KSU Sensory Analysis Center evaluated flavor intensities, of overall dry-aged beef, beef, brown/roasted, bloody/serumy, metallic, and astringent sensation and also tenderness, and juiciness. Panelists rated each on a 15-point scale with 1 being the lowest and 15 the highest.

Samples for aerobic plate counts, lactic acid organism counts, and *Psueduomonas* counts were taken from each loin at 2, 9, and 16 days after dry aging. Samples were taken using a core device that removed 2.9 cm^2 of surface in 2 samples. Samples were stomached in 100 ml of diluent and subsamples were plated according to standard procedures for each type of microbe.

Physical measurements taken for each steak were weight, length, width, and thickness; a loin eye tracing before and after cooking; and Warner-Bratzler shear (6 to 8 cores of 1-in.-diameter).

Results and Discussion

Strips dry aged for 14 days had the most intense aged flavor followed by the 21-day dry-aged product (Table 1). Seven-day dry-aged and control steaks were similar to each other and lower in aged flavor than steaks from the longer aging treatments. Beef flavor was most intense for 21- and 14-day products and lower for 7-day dry-aged steaks. The 14-day dry-aged treatment had the most intense brown/roasted flavor. Serumy and metallic flavor notes were higher in control and 7-day dry-aged samples. Astringent flavor notes were not affected by aging treatment.

Juiciness and tenderness are sensory attributes that are arguably more important for overall acceptance of beef than flavor. Steaks dry aged for 14 and 21 days were slightly more tender ($P<0.05$) than 7-day dry-aged steaks or controls (Table 2). The vacuum aged (14 days) controls were the least tender. Juiciness was the highest for 21-day dry-aged steaks followed by 14-day. Juiciness was lower and similar for the 7-day dry-aged steaks and the controls. The 21-day dry-aged steaks showed the lowest shear force.

Counts (Table 3) showed that bacteria were controlled with the processing conditions. Thus, a safe, value-added product can be produced.

In conclusion, dry aging provides advantages in flavor, tenderness, and juiciness over vacuum aging product. These advantages are offset by the yield losses; however, for high-quality markets, dry aging adds value and provides distinctive palatability profiles not obtainable with vacuum aging.

Table 1. Means of Flavor Parameters vs. Length of Dry Aging[1]

Dry Aging, Days	Aged Flavor	Beef Flavor	Brown Roasted	Bloody/ Serumy	Metallic	Astringent
0 (control)	9.69[c]	11.41[ab]	10.36[b]	4.79[b]	4.87[ab]	3.02
7	9.72[c]	11.34[b]	10.34[b]	4.93[a]	4.94[a]	2.98
14	10.60[a]	11.51[a]	10.64[a]	4.72[b]	4.75[b]	2.98
21	10.08[b]	11.52[a]	10.47[b]	4.80[ab]	4.77[b]	2.99
LSD	0.25	0.13	0.14	0.13	0.13	0.09

[1]Means within a column that have different superscripts are different (P<0.05).

Table 2. Means for Tenderness, Juiciness, and Shear Force as Affected by Length of Dry Aging[1]

Dry Aging, Days	Tenderness	Juiciness	Peak Shear Force (kg)
0 (control)	10.04[c]	8.28[c]	2.28[b]
7	10.23[b]	8.22[c]	2.31[b]
14	10.64[a]	8.43[b]	2.28[b]
21	10.65[a]	9.04[a]	1.86[a]
LSD	0.18	0.14	0.14

[1]Means within a column that have different superscripts are different (P<0.05).

Table 3. Mean Microbial Counts vs. Length of Dry Aging[1]

Dry Aging, Days	Aerobic Plate Count (log 10)	Lactics Plate Count (log 10)	*Pseudomonas* Plate Count (log 10)
0 (control)	1.39[a]	1.36[b]	2.80[b]
7	3.32[b]	1.42[b]	3.51[ab]
14	3.92[b]	1.45[b]	5.28[a]
21	3.27[b]	1.98[a]	3.29[ab]
LSD	0.73	0.49	2.21

[1]Means within a column that have different superscripts are different (P<0.05).

PRICE DISCOVERY ISSUES FOR FED CATTLE

T. C. Schroeder [1], J. Mintert [1], C. E. Ward [2], and D. S. Peel [2]

Summary

Interviews were conducted with cattle feeders, beef packers, and others involved in the beef industry to discern their concerns about fed-cattle price discovery. Three issues predominated. First was the need to better identify beef quality, ideally by objective means. Quality often, but not always, referred to tenderness and the "eating experience" of consumers. Second was the need for greater pricing accuracy, signaling a desire for less average pricing and more value-based pricing. The need for improved market information was the third issue identified.

(Key Words: Fed Cattle Price, Price Discovery.)

Introduction

Price discovery is the process of buyers and sellers arriving at transaction prices. Several factors, including issues related to value-based marketing, market information, and pricing methods, have caused price discovery concerns for cattle producers and others. This research was initiated to examine price discovery issues in the beef industry.

Experimental Procedures

Most of our information for this study came from a series of personal and telephone interviews with persons associated with selected cattle feeding, beef packing, and related industry firms and organizations. These interviews were conducted during October 1996 through February 1997. They included discussions with five of the largest beef packing firms and eight of the 25 largest cattle feeding operations (located primarily in the midwest and plains regions), as well as numerous others in the industry.

Results and Discussion

Many differences were identified *among* packers and *among* feeders during our interviews as well as *between* packers and feeders. Some packers and feeders thought price discovery was not really a problem or issue. Others thought it was a major problem. Six price discovery issues surfaced frequently.

(1) More accurate, less subjective measurements of beef quality are needed. Participants generally agreed that third party quality grading was essential. However, larger packers felt that they could quickly adjust to elimination of federal quality grading. There was consensus that mechanized, objective, quality grading would be preferable to the current, subjective, quality-grading system.

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Several cattle feeders and packers indicated that a large market exists for lower-quality, cheaper, beef products. The issue is that these lower quality beef products need to be accurately identified and targeted to the appropriate markets. Concurrently, animals producing these lower quality cuts should receive lower prices.

Many also voiced considerable concern regarding predictability of red meat yields. Yields of boxed beef from the same quality and yield grade of carcasses vary considerably, and current technology does not accurately estimate that yield. Technological developments, such as video imaging, seem to hold considerable promise in this regard in the near future. Adoption of improved technology in this area would make it possible to reward high yielding carcasses and penalize low yielding carcasses.

(2) *Price premiums and discounts for fed cattle do not adequately reflect cattle value*. Cattle feeders with small operations located in areas with access to high quality, more uniform cattle had strong sentiments regarding this issue. They felt that for prices to reflect value differences, cattle must be marketed on a grade and yield, dressed-weight basis. However, large custom cattle feeders tend to be less concerned about selling cattle on averages. Large operations that feed large numbers of their own cattle varied in their opinion on this issue, depending upon their management strategy. Cattle feeders striving to be low-cost operators were more willing to sell cattle on averages than those attempting to target their cattle to specific markets.

Most beef packers interviewed felt that buying cattle on averages was detrimental to the industry. All packers indicated a willingness to buy cattle based on quality. Buying cattle based on dressed weight seemed to be more prevalent than buying on grade and yield. Packers felt fewer cattle would be traded on a live basis (i.e., on averages) over time, but it would be slow to happen because of some cattle feeders' resistance to change.

(3) Inadequate market information inhibits efficient price discovery. Almost every cattle feeder interviewed, many of the beef packers, and even retailers indicated a need for increased and more reliable market information. An issue not addressed was the willingness to pay for more or better information. Different individuals and firms stressed different needs.

Cattle feeders felt that more information was needed on short-run, week-to-week, supply and demand conditions. In particular, they wanted more information regarding the volume of formula and contract cattle being delivered to packers. Many industry participants across different sectors indicated a need for better price reporting for wholesale boxed beef products. They felt current price reports did not represent boxed beef trades, primarily because of the low volume of trades reported, especially for close-trimmed products. Recommendations included using less-than-truckload prices to increase the volume of trade reported and greater efforts to capture more of the total boxed beef trade in price reports.

Inadequate retail price reporting was identified as a problem area by several individuals. Concerns included the need for volume-weighted retail prices to reflect actual trade rather than just published prices, and a desire that retail specials be better reflected in price reports. Improved knowledge of retail prices would provide a better indication of beef demand.

(4) Risks of live cattle futures basis is excessive. Some cattle feeders felt that the

risk of the live cattle futures market basis (basis is cash price minus futures market price) has become excessive, since contract specification changes were implemented with the June 1995 contract. They indicated problems with the delivery process for the live cattle contract, especially for cattle that do not meet contract specifications. These participants advocated cash settlement of live cattle futures.

Concerns regarding live cattle futures tended to be regional. Cattle feeders in the northern states generally were less concerned about basis risk than cattle feeders located in Texas and Kansas. This may be partly due to differences in quality distributions of cattle fed in northern versus southern states. Several individuals indicated that cattle fed in the north may fit quality specifications of futures contract more closely.

(5) *Formula pricing arrangements adversely affect cash fed cattle markets.* Cattle feeders who do not participate in formula marketing agreements had strong sentiments against such agreements. This was true regardless of size of the feedlot operation. They voiced considerable concern that existence of formula pricing arrangements made it difficult for them to discern fed-cattle supply and demand on a week-to-week basis. As a result, this contributed to panic selling of fed cattle by feeders who have limited access to this information. Some of these feeders expressed a need for weekly information regarding how many cattle each packing plant had scheduled for delivery under formula. Some feeders indicated that when formula deliveries were at high levels, certain packers did not bid for cattle in the cash market, and they felt that this depressed live prices.

Cattle feeders involved in formula marketing agreements generally had much different perspectives. Feeders marketing via formulas indicated that formula pricing taught them the advantages of sorting cattle, including sorting several times prior to marketing. They indicated that formula prices better reflect true value and eliminate pricing on averages. In addition, they felt that pricing fed cattle on formulas helped them improve their purchasing strategies for feeder cattle. Some participants in formulas voiced concerns that if only better quality cattle are sold on formula, and the formula price is based on live cattle cash trade, then poor quality cattle will establish the base price for high quality cattle.

(6) Group marketing of fed cattle may offer solutions to some price discovery problems. Smaller cattle feeders, especially those not located in strategic locations relative to several competing packing plants, felt that group marketing efforts could reduce some of the problems associated with fed-cattle price discovery. Some perceived that one potential benefit of joint marketing was to countervail the market power of large packers. Generally, large feeding operations had less enthusiasm for group marketing. Many felt that group marketing efforts would fail, because nothing would bind participants to the group and benefits might not be as large as some organizers perceive.

Packers tended to be less excited about group marketing efforts. They noted that group marketing would not solve problems associated with pricing on averages. They voiced concern that cattle producers need to be cautious about getting tied into group marketing efforts that promise big returns by branding beef products and owning them all the way to retail. They cautioned that considerable capital, infrastructure, and marketing expertise will be needed to develop and sustain this kind of effort.

Cattlemen's Day 1998

GRID PRICING OF FED CATTLE

T. C. Schroeder [1]

Summary

Pricing fed cattle on a value-based quality and yield grade grid provides the best opportunity for cattle producers to recieve premiums associated with high quality cattle. However, grid discounts for cattle not desired by the particular packer are often quite substantial. Thus, cattle producers targeting cattle for specific grids need to have considerable knowledge regarding the quality attributes of their cattle. This study compared pricing of 202 pens of fed cattle on a live basis, a carcass (dressed) basis, and using four different packer grids. Results indicate that no single pricing method is optimal for all cattle. Producers need to know the quality of cattle they have, be willing and able to sort those cattle, and compare the various selling options and grids before deciding upon the pricing method that generates the highest revenue.

(Key Words: Grid Pricing, Value-Based Pricing, Fed Cattle Prices.)

Introduction

Value-based marketing refers to pricing cattle on an individual animal basis with prices differing according to the underlying value of beef and by-products produced from each animal. Achieving value-based marketing of fed cattle has been difficult. Incentives to sell cattle on averages and problems associated with identifying beef quality have inhibited development of value-based pricing. Recently, several value-based, fed cattle, pricing systems have become more prominent, including formula pricing, price grids, and alliances. Is there one "best" pricing method? How are live weight, dressed weight, and grid or formula prices related? The purpose of this report is to assist producers in evaluating which form of fed cattle pricing may be most profitable for them.

Should you market your cattle on a carcass merit basis? If so, does it matter which pricing system or packer you sell to? The answer to both questions is, "it depends." It depends on several things, but the most critical factors that influence the profitability of these decisions include: 1) the quality grade, yield grade, and dressing percent of the cattle you produce; 2) the price spread between Choice and Select; 3) the particular packer or alliance premium/discount price grid for which you target your cattle; 4) production and feeding cost differences associated with targeting your cattle to a particular price grid or packer; and 5) most importantly, your knowledge about the price/quality distribution of your cattle.

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Experimental Procedures

To compare price grids across packers, grids were obtained from four different Midwestern packers during the week of July 8, 1997. To evaluate how these grids compared with live and dressed basis pricing, 202 pens of fed steers were priced under each of the four packers grids, as well as live and dressed prices. The live and dressed cattle prices were quotes for Wednesday November 6, 1997 from the five-region daily weighted average reported by the USDA. The prices were as follows: $68.65/cwt for 80-100% Choice live steers; $68.07/cwt for 65-80% Choice live steers; $67.00/cwt for 35-65% Choice live steers; $109.28 for 80-100% Choice dressed steers; $108.12/cwt for 35-80% Choice dressed steers.

Steers in the 202 pens were predominantly English and English-Exotic cross breeds. The cattle had varied quality, with pens ranging from largely Choice and higher to largely Select and lower. Hot yield dressing percentage averaged from as high as 65.6% to as low as 61.2% with an overall average of 63.8%. Under assumptions that the four packers used a $109.28/cwt Choice yield grade 3 base price and the Choice to Select price spread was $6.25/cwt, the average revenue per head was calculated for live basis, dressed basis, and each of the four grids.

Results and Discussion

Most packer grids are based price on a Choice, yield grade 3, 550-950 lb, steer carcass. An example of a typical price grid offered by beef packers is presented in Table 1. The price received for each carcass is the base price plus the particular premiums and discounts. For example, assume a Choice yield grade 3, 550-950 lb carcass would receive the base price of $105/cwt. A Select yield grade 4 carcass would receive a price of $78.75/cwt ($105.00/cwt – $26.25/cwt).

The USDA reports a weekly survey summarizing seven beef packer, grid, premium and discount schedules in the publication NW LS195 *National Carcass Premiums and Discounts for Slaughter Steers and Heifers.* This report is available and updated weekly on the internet at *http://www.ams.usda.gov/mncs/mn_reports/NW_LS195.txt*.

The average revenues per head under the alternative selling methods are reported in Table 2. Given the prices and spreads used in this simulation, live pricing had the lowest overall mean revenue per head, and dressed pricing had the highest average price.

The implied dressing percentage between the live price ($68.65/cwt) and the dressed price ($109.28/cwt) is 62.8% ((68.65/109.28)×100). This suggests that cattle with a dressing percentage greater than 62.8% will net a higher revenue per head when sold on a dressed basis than live basis. Depending upon the distribution of the remaining quality traits, and the particular packer grid, selling on a grid can result in higher or lower revenue than either live or dressed pricing. Although the average revenues across all 202 pens were a little lower with the grids than with dressed selling, some pens received higher prices when sold using a grid.

Overall, 2.5% of the pens would have had the highest price by being sold on a live basis, whereas 58.9% would have secured the highest price when sold on a dressed basis (Table 2). The remaining 38.6% would have received the highest price if sold using a grid. This is an important result because it indicates that there is no single best pricing

method. Which method results in the highest price depends upon the type of cattle. In addition, only two of the individual packer grids (among four) had any pens in which that bid resulted in the highest price. Of course, this result would change as premiums and discounts for specific traits change or base prices differ. For pens in which live price resulted in the highest revenue, this was the best pricing method on average by $8/head or more compared to the others. However, for pens in which dressed pricing resulted in the highest price, on average, it was best by $15/head or more. For pens in which grid pricing was best, this method was considerably better than live pricing but similar to dressed pricing.

Pens that received the highest price on a live basis were those with the lowest average dressing percentage. Quality traits were less important in distinguishing between live and dressed or grid net revenues. In fact, pens receiving the highest price on a live basis were on average 69% Choice or higher quality grade compared to 57% for cattle in which dressed pricing resulted in the highest price. Cattle that received the highest price under packer grids tended to have a lot of yield grade 3 or better and Choice and CAB (Certified Angus Beef) type cattle.

Table 1. Example Premium and Discount Schedule for Grid Pricing[a]

	Yield Grade				
Quality Grade	1	2	3	4	5
			(Carcass $/cwt)		
Prime	8.00	7.00	6.00	-14.00	-19.00
CAB	3.00	2.00	1.00		
Choice	2.00	1.00	**Base**	-20.00	-25.00
Select	-4.25	-5.25	-6.25	-26.25	-31.25
Standard	-24.50	-25.50	-26.50	-46.50	-51.50
Dark cutters, stags, etc.		-20.00			
Greater than 950 lb.		-25.00			
Less than 550 lb.		-25.00			

[a] Premiums and discounts are all adjustments to the Choice, Yield Grade 3 base price.

Table 2. Comparison of Average Revenues per Head for Various Pricing Methods

		Pricing Method Offering Highest Revenue			
Selling Method	Overall	Live	Dressed	Packer 1 Grid	Packer 2 Grid
		Average Revenue ($/head)			
Live	841.73	834.31	854.90	816.96	840.62
Dressed	862.22	826.34	880.50	830.55	858.46
Packer 1 Grid	856.10	825.84	865.69	839.35	857.97
Packer 2 Grid	856.14	824.71	867.87	834.36	861.40
Packer 3 Grid	846.17	817.21	856.21	829.84	843.02
Packer 4 Grid	850.46	820.07	863.32	827.83	850.55
Pens (number)	202	5	119	61	17
Pens (% of 202)	100	2.5	58.9	30.2	8.4

PROJECTING FED CATTLE PRICE DISCOVERY OVER THE NEXT DECADE

T. C. Schroeder [1], J. Mintert [1], C. E. Ward [2], and D. S. Peel [2]

Summary

Interviews were conducted with cattle feeders, beef packers, and others involved in the beef industry to project how fed cattle prices will be discovered in the next decade. Respondents generally indicated that economics will determine beef's market share in 2010, how important public grades and grading will be, and whether consumer brands for fresh beef will become common. Economics also will determine how much influence alliances will have, whether most cattle will be marketed by some value-based pricing system, and what changes will occur in market information and futures markets.

(Key Words: Fed Cattle Price, Price Discovery Projections.)

Introduction

Price discovery is the process of buyers and sellers arriving at transaction prices. Several factors have caused price discovery to become a major concern to cattle producers and others in the past few years. This research was initiated to project how fed cattle price discovery will evolve over the next decade.

Experimental Procedures

Most information for this study came from a series of personal and telephone interviews with persons associated with selected cattle feeding, beef packing, and related industry firms and organizations. These interviews were conducted during October 1996 through February 1997. They included discussions with five of the largest beef packing firms and eight of the largest 25 cattle feeding operations.

Results and Discussion

Improved price discovery and vertical coordination in the beef industry are essential for beef to maintain market share into the future. Market prices need to better signal buyer preferences from the consumer level all the way to cow-calf producers. One theme that pervades all change in the beef sector is that the industry desperately needs to produce products perceived to possess greater value to consumers. Value means the product must be priced competitively, must be convenient, and must provide a consistently desirable eating experience for consumers. These attributes, though simple conceptually, have proven immensely difficult for the beef industry to manage. A myriad of beef products and product qualities are produced, and the target markets represent such a diverse set of consumer demands that there is no simple solution to the industry's struggle for

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market share. This diversity of beef products and array of target markets suggest that the industry and beef products are likely to become progressively more segmented. In order for beef product segmentation at the consumer level to succeed, segmentation will increase at all levels of the cattle and beef production chain as each level strives to become more customer-focused.

The following significant forces will influence price discovery and vertical market coordination in the beef industry over the next decade.

1. Technology to *improve* our ability to identify and sort beef products according to varying quality and value attributes will be developed and adopted commercially by processors. Several such technologies are already being developed, including beef tenderness tests, video imaging, and product identification tracking. Technology will create quantitative and/or mechanical quality determination procedures, reducing subjective assessment of meat quality. This is a necessary step toward better identifying and paying for quality attributes of fed cattle.

2. Federal beef quality grades are likely to be less important in 10 years. Many different means will be adopted to measure and describe beef quality differences, depending upon the targeted consumer. Because standardized quality grades are not likely to adequately measure all the different needs of consumers, standardized grades will have less general value. However, in transition, federal quality grades are *valuable* to the industry and should be *maintained*. Though the current grading system does not adequately describe beef tenderness and the eating experience consumers can expect, it does provide consumers with some information regarding beef quality.

3. Our ability to predict meat quality from visual inspection of live cattle will not improve much over the next decade. Thus, live cattle price differentials will not adequately reflect cattle and beef value differences. This will lead to more fed cattle being sold on a dressed weight, carcass quality, and yield grade basis.

4. Formula and grid-based pricing will become more common in procurement of fed cattle by packers. Pricing methods that more accurately reflect value differences will replace systems not based on product value. Grids may continue to have a variety of base prices and a range of premiums and discounts. Collecting and reporting of grid prices by the USDA will continue to be important.

5. More cattle will be produced under alliances that directly link cow-calf producers all the way to retail and food service outlets. Alliances provide opportunities for clearer price signals and encourage producers to produce beef products targeted to specific consumers. However, only a relatively small portion of the industry will find alliances profitable. They involve considerable risk, coordination, infrastructure, and control, and generally offer only modest opportunities for additional profit. Alliances will not replace the predominant pricing methods for fed cattle, but information exchanged in alliances will supplement price signals in the market place. Alliances also may contribute to better understanding between feeders and packers and a reduction in the disruptive adversarial relationship that plagues the beef industry.

6. Beef price discovery will shift toward the wholesale level and away from the live market. More fed cattle will be sold on a dressed weight, carcass quality, and yield grade basis with greater use of price grids and increased alliances. This suggests a greater need for

improved price reporting by USDA for boxed beef and by-products.

7. Producer group marketing and closed cooperative efforts will increase, but they will not represent a significant portion of the fed cattle market. The most probable beneficiaries of producer group marketing activities will be small and mid-sized operations. Group efforts may offer significant opportunities for information sharing and capturing of volume premiums associated with grouping cattle for large processors.

8. An increased share of beef will be marketed by brand name. Some alliances may introduce branded products, as may some producer groups. Certified programs will continue to market branded products. Many restaurants will differentiate themselves by the beef they sell, with their name serving as the brand. Some packers may brand beef products, and more retailer product branding could occur. Large beef processors will not brand much beef until profitability of doing so is clear. Successful beef product branding requires control over the type of cattle procured, careful beef quality measurement and sorting, extensive coordination between product merchandisers and commodity procurement, and national brand promotion programs. More intensive management and control are costly, and a packer whose comparative advantage is large volume, low-cost processing sees little benefit to the increase in costs and risks associated with large-scale branding.

9. Asymmetry of market information is a characteristic of the beef industry and was considered a problem by cattle feeders. The USDA has been very responsive to industry demands by developing new information and reports. Even more information is needed especially regarding boxed beef prices, especially closely trimmed boxed beef; export prices; hide and offal values; andshort-run captive supplies. If industry participants do not cooperate and provide the requested information, mandatory reporting may be the inevitable policy solution. The need for more market information regarding captive supplies is *not* an indictment against this marketing method or against packer concentration. It simply represents a need to balance information when these marketing alternatives are prevalent.

10. The live cattle futures contract will see increased pressure to move to a dressed weight specification. Overwhelming evidence suggests that live cattle cash trade will decline and dressed weight pricing will increase in the future. Carcass weight pricing likely will become the predominant fed cattle pricing method in 10 years, though a significant percentage of fed cattle will still be priced on a live weight basis. In addition, the dressed beef contract likely will be cash-settled because of the inherent difficulties in delivering dressed beef. Developing a cash-settled dressed beef contract will require improved reporting on boxed beef and carcass prices by the USDA.

11. Negotiating terms of trade will increase. Larger operations, group efforts by producers, producer cooperative ventures, alliances, and product branding all require more negotiation of terms of trade than have previous marketing methods. Beef product specifications, base prices, formulas for premiums and discounts, volume needs, and control and verification of production practices, all targeted on specific consumer demands, will increase the need for, and benefits of, negotiations among market participants. Increased negotiations require better market information, technology to more accurately measure product specifications, increased knowledge of how to control product quality, and more coordination among stages of the marketing and production system.

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DIFFERENCES IN EFFICIENCY AMONG KANSAS BEEF COW PRODUCERS

S. Eidson [1], M. Langemeier [1], and R. Jones [1]

Summary

Beef cow producers must manage costs of production and improve production efficiency to compete with hog and poultry and other beef cattle producers. A sample of 46 beef cow enterprises from the Kansas Farm Management database was used to measure technical, economic, and overall efficiencies. On average the farms were 92% technically efficient, 80% economically efficient, and 73% overall efficient. Our results suggest that 5% increases in economic and scale efficiencies would increase profit per cow by $20 and $24, respectively.

(Key Words: Cows, Efficiency, Profitability.)

Introduction

The hog and poultry industries have increased their production efficiencies through economies of size and the adoption of new technologies. These changes have increased the competitive pressure on the beef cattle industry.

For beef cattle producers to remain competitive with hog and poultry producers, they must continue to improve production efficiency and manage costs of production. High-cost producers need to evaluate their management practices and search for more efficient ways to produce a pound of beef. Inefficient producers will lose money and be forced to exit the industry because they are not cost competitive. The objective of this study was to evaluate the efficiencies of a sample of Kansas cow-calf producers and to determine the impact inefficiencies have on profitability.

Experimental Procedures

The data used in this study were from the Kansas Farm Management Association database. The 46 operations we studied had continuous data from 1992 to 1996. Four regions of Kansas were represented; southeast (27 farms), northcentral (11 farms), northeast (5 farms), and northwest (3 farms).

The efficiency analysis required data on costs of production, inputs, and outputs. Output was measured as total pounds of beef produced, which included weaned calves and culled breeding stock. Input costs included labor, feed, capital, fuel and utilities, veterinary expenditures, and miscellaneous. Labor costs included both hired and unpaid operator labor. Feed costs included pasture costs as well as raised and purchased feeds. Capital costs included interest, repairs, depreciation, machinery hired, and opportunity costs associated with owned assets. All input costs were converted to real 1996 dollars, and all the figures were averaged for each operation over the 5-year period.

Table 1 presents the statistical summary for gross revenue, profits, costs, and other relevant characteristics of the operations. On

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average, the producers lost $95.77 per cow during the 5 years. Net return per cow ranged from -$388 to $48. About 39% of the operations had an average return per cow that was less than -$100. Another 54% had an average return per cow that was between -$100 and $0. The remaining operations (7%) had an average return per cow that was above breakeven. Feed was the most costly input of all 46 farms, accounting for about 48% of the total cost. Capital comprised about 26% and labor costs about 46% of the total costs. The average herd size was about 114 cows, and nearly 561 pounds of beef were produced per cow from weaned calves and culled breeding stock.

A series of mathematical programs was used to determine the technical, economic, and overall efficiencies. Technical efficiency measures whether or not the producer uses the most up-to-date technologies. A technically inefficient farm does not produce as much as other farms with the same inputs. Economic efficiency measures how well the producer minimizes costs for a given level of output. Economic inefficiency can be attributed to technical inefficiency or allocative inefficiency (failure to utilize the optimal input mix). Scale efficiency measures whether a firm is producing at the optimal size. Overall efficiency (the product of technical, allocative, and scale efficiencies) determines the minimum cost of producing a given output level under constant returns to scale technology. Overall inefficiency can be attributed to economic inefficiency or not producing at the most efficient size.

Regression analysis was used to determine the relationship between economic and scale efficiencies and profit per cow. Specifically, the impact on profit per cow of 5% increases in economic and scale efficiencies was evaluated.

Results and Discussion

Table 2 reports the statistical summary for the efficiency measures. Technical efficiency ranged from 0.58 to 1.00. Approximately 42% of the operations in the sample were technically efficient (technical efficiency measure = 1.00). On average, technical efficiency was 0.92, indicating that output could be increased by 8%, if all the farms in the study possessed a technical efficiency measure of 1.00.

The average economic efficiency measure for the sample was 0.80. If all of the farms in the study were economically efficient, the same level of output could have been produced with 20% less cost . About 15% of the farms were economically efficient.

Average scale efficiency (not shown in Table 2) was 0.93. If all farms had been producing at the scale-efficient size (120 cows), cost could have been reduced by 7%. Scale-efficient size is the farm size that produces with the lowest average cost; this farm also possesses a scale efficiency measure of 1.0. Over 70% of the farms had scale efficiency indices over 0.90, indicating that scale inefficiency was a minor problem.

Overall efficiency ranged from 0.50 to 1.00 and averaged 0.73. The same level of output could have been produced using 27% less cost, if all farms had been economically and scale efficient. Only one farm in the sample was overall efficient.

Regression analysis indicated significant relationships between profit per cow and economic and scale efficiencies. Based on that analysis, a 5% increase in economic efficiency would result in a $20 increase in profit per cow. A 5% increase in scale efficiency would increase profit per cow by $24. Given the average levels of economic

and scale efficiencies in this study, significant room for improvement exists.

Because average economic efficiency was lower than average scale efficiency, inefficient farms should focus on input cost control before changing operation size.

Table 1. Summary Statistics for a Sample of Kansas Beef Cow Farms (1992-1996)

Variables	Unit	Mean	Standard Deviation
Gross revenue per cow	$	404.04	49.53
Labor expense per cow	$	80.28	28.44
Feed expense per cow	$	241.93	28.31
Capital expense per cow	$	128.80	27.24
Fuel expense per cow	$	19.60	10.28
Veterinary expense per cow	$	15.01	9.18
Miscellaneous expense per cow	$	14.23	8.46
Profit per cow	$	–95.77	79.89
Age of operator	yrs.	53.76	10.55
Beef produced per cow	lb.	560.76	52.85
Herd size	no.	114.44	78.89
Gross farm income	$	133,872	130,672
Percent of income from beef	%	45.65	27.16

Source: Kansas Farm Management Association.

Table 2. Efficiency Measures for a Sample of Kansas Beef Cow Farms (1992-1996)

Variable	Technical Efficiency	Economic Efficiency	Overall Efficiency
Summary statistics (index)			
Mean	.92	.80	.73
Standard deviation	.11	.13	.12
Minimum	.58	.54	.50
Maximum	1.00	1.00	1.00
Efficiency	)))))))	Percentage of farms	)))))))
0 to .50	0.0	0.0	2.2
.51 to .60	2.2	8.7	10.8
.61 to .70	6.5	17.4	26.1
.71 to .80	8.7	26.1	26.1
.81 to .90	15.2	23.9	26.1
.91 to .99	26.1	8.7	6.5
1.00	41.3	15.2	2.2

Source: Kansas Farm Management Association.

EARLY DETECTION OF PROBLEM IMPLANTS USING INFRARED THERMOGRAPHY[1]

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

Summary

Thermal imaging of feedlot cattle ears is a noninvasive diagnostic tool that aids in identifying properly placed or abscessed growth-promoting implants. Thirty-two calves were used to determine if abscessed and normal, functional implants could be identified and differentiated using infrared thermography. Infrared images were taken at implantation on days 2, 4, 7, 14, and 21 after implantation. Abscessed implants were easily identified. Use of thermal imaging can verify implant administration and, thus, has the potential to immediately impact feedlot quality assurance programs.

Introduction

Problem implants in fed cattle result in economic losses ranging from $2.70 to $4.94 per head implanted. Much of the observed loss is attributed to abscessed implants, missing implants and improper implantation technique that causes variation in the surface area of the implant. Factors affecting implant surface area will alter product release. The full extent of the problem rate can be assessed only by observing 100% of implant sites 7 to 21 days after implanting. The repeated handling of feedlot cattle necessary for 100% inspection is a major drawback for correcting problem implants. Infrared thermography can remotely and non-invasively detect problem implants. This experiment was designed to determine if variation over time exists in the thermographic appearance of ears implanted with normally functioning growth-promotant implants and improperly functioning abscessed implants.

Experimental Procedures

A total of 32 calves was assigned randomly to one of two treatment groups. Group A (normal implant) received a Synovex-Plus implant following disinfection of the ear. Group B (abscessed implant) received a Synovex-Plus implant in which the ear and the implant needle were contaminated with fecal material. Half of each treatment group received the implant in the left ear. The remaining calves were implanted in the right ear. The nonimplanted ear on each calf served as the control for thermographic comparisons. Thermographic images of the front and back of the ears of each calf were obtained on trial days 0, 2, 4, 7, 14, and 21 using an Amber Engineering Radiance PM, high resolution, shortwave length (3-5 μm), radiometric, infrared, thermal-imaging unit. All thermographic images were taken from a

[1]The authors express their appreciation to Ft. Dodge Animal Health for providing grant support of this research.

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distance of about 3 ft, with the animal in standing restraint in a hydraulic squeeze chute. Temperature measurements were determined from an area on the front of the ear or on the back of the ear at the base, middle, and tip.

A randomized, complete block design was used to investigate the thermographic patterns of cattle with normal, functional growth-promotant ear implants vs. cattle with abscessed implants. Repeated measures analysis of variance was used to determine the relationships among distribution of temperature for the entire ear and the zone surrounding the implant (the response variables) and treatment; pen; treatment×pen interaction; time, treatment×time interaction; and side (ear) of placement (the explanatory variables) for the front, back, and front/back of each implanted ear. Mean temperatures between normal implants vs. abscessed implants were contrasted.

Results and Discussion

Images of the front or back of the ear were comparable on postimplantation days 2, 4, 7, and 14 when used to differentiate abscessed ears from the nonimplanted ear. The side (left or right) of implantation did not affect detection of abscessed vs. functional implants. Thermal imaging the front of the ear detected the difference between an abscessed implant and a functional implant on postimplantation days 2, 4, 7, and 14 ($P<.001$). Abscessed implanted ears imaged from the front were found to be 32.9°F ± 5.02 warmer than functional implanted ears on day 4.

Image of the back of the ear detected temperature differences between abscessed and functional implanted ears on postimplantation days 4 and 7 ($P<.001$). Thermography also detected temperature differences between functional implanted ears and nonimplanted control ears on day 2 postimplantation using images of either the front or back and on day 4 when the ear was viewed from the rear. Figure 1 demonstrates the least square mean temperatures of abscessed implanted ears, functional implanted ears, and nonimplanted control ears on day 4 postimplantation at various locations on the ear.

Thermal imaging is a remote, noninvasive tool capable of detecting temperature differences between functional implanted, abscessed implanted, and nonimplanted ears. Thermal imaging within the first 2 weeks after arrival in the feedyard or at reimplanting after 60-70 days is a useful tool that can aid in identifying properly placed or abscessed growth-promoting implants placed in the ears of feedlot cattle. Its use to assess the efficiency of implanting by processing crews has the potential to immediately impact quality assurance programs. Far greater potential lies in the ability of thermal imaging to differentiate between functional implants and nonfunctional (abscessed or missing) implants in the pen (Figure 2). Once identified, cattle with nonfunctional implants can be reimplanted and returned immediately to their home pen with a functional implant.

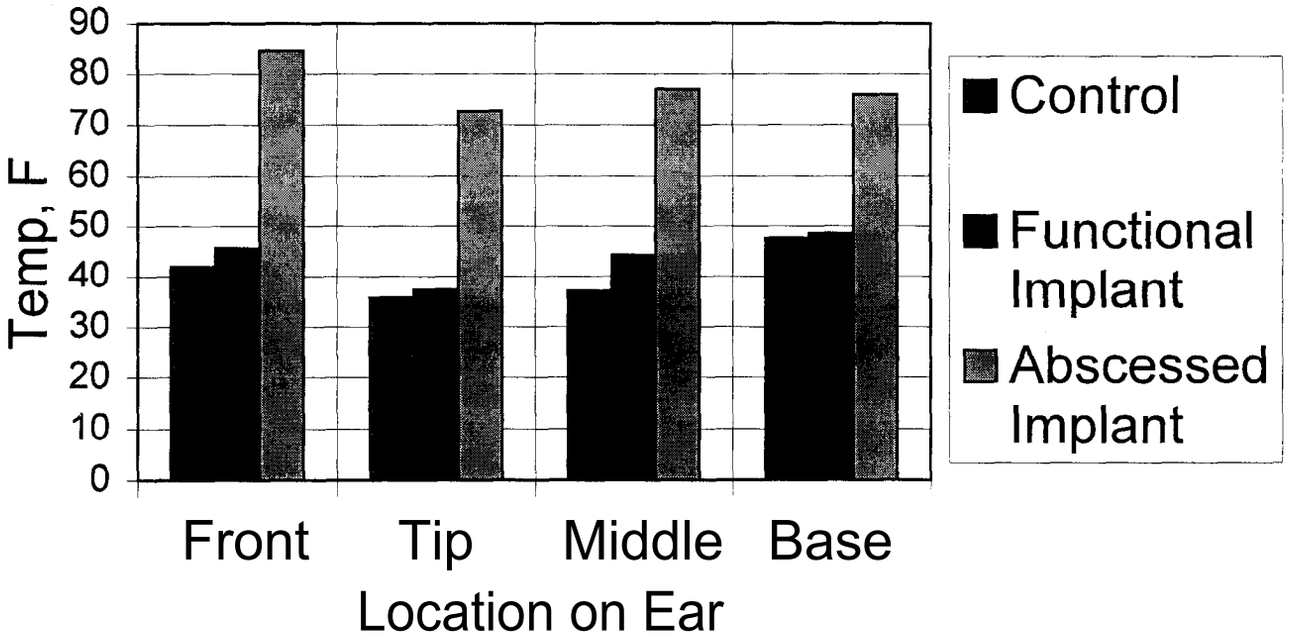

Figure 1. Least Square Mean Temperatures by Location on Ear, Day 4 Only, for Abscessed Implanted Ears, Functional Implanted Ears, and Nonimplanted Control Ears.

Figure 2. Thermal Image of Feedlot Heifers Taken in Pen. Heifer in Foreground Has a Functional Implant in Right Ear (4.0°F Warmer than Right Ear). Heifer in Background Has an Abscessed Implant in Left Ear (17.7°F Warmer than Left Ear). (Black=cold, White=hot).

COMPARISON OF IMPLANTS IN GRAZING HEIFERS AND CARRYOVER EFFECTS ON FINISHING GAINS AND CARCASS TRAITS

F. K. Brazle [1]

Summary

Crossbred yearling heifers were allotted randomly to three grazing implant treatments: 1) control (CONT), 2) Component® E-H (CEH), and 3)Ralgro® (RAL). After grazing native grass for 74 days, the heifers were transported to a western Kansas feedlot. All heifers were implanted with Synovex-H® upon arrival at the feedlot and were reimplanted 70 days later with Finaplix-H®. The CEH heifers gained faster while on grass (P<.10) and in the feedlot than the RAL heifers. The CEH heifers had heavier carcasses than RAL heifers. Control heifers had the largest ribeyes. Other carcass traits, including USDA quality grade, were not influenced by pasture treatment. In this study, administration of CEH to heifers grazing native grass optimized overall performance when combined with the feedlot implants (Synovex-H and Finaplix-H).

(Key Words: Implants, Heifers, Feedlot).

Introduction

Current implanting strategies involve the use of certain implants in specific phases of the cattle production cycle. Determining the relationship of implants used during the grazing phase to the trenbolon acetate-based implants employed in finishing programs might allow for the use of different implant combinations in growing/finishing systems. The objectives of this study were to compare the effectiveness of Component E-H (CEH) and Ralgro (RAL) when administered in a grazing program and to calculate their effects on subsequent feedlot and carcass performance.

Experimental Procedures

Two hundred fifty-eight crossbred yearling heifers were allotted randomly to three implant treatments: 1) control (CON), 2) Component E-H (CEH), and 3) 36 mg Ralgro (RAL). The heifers were implanted according to manufacturers' recommendations and weighed individually before being grazed on Flint Hills native grass pastures. Equal numbers of heifers in each implant group were allotted randomly to two pastures. All heifers were grazed for 74 days, then weighed individually early in the morning and shipped 300 miles to a commercial feedlot near Garden City, where they all were fed in one pen for 120 days. At the feedlot, all heifers were implanted initially with Synovex-H and reimplanted 70 days later with Finaplix-H. The heifers were slaughtered at a commercial packing plant, and carcass data were collected.

[1]Extension Specialist, Livestock Production, Southeast Kansas.

Results and Discussion

The CEH heifers gained 19.6% faster than control and 8.8% faster (P<.10) than RAL heifers during the grazing period. The RAL heifers gained less (P<.10) than the other groups during the feedlot phase. However, no differences occurred in feedlot gain between the CONT and CEH heifers (Table 1). The CEH heifers had heavier (P<.10) carcasses than RAL heifers, whereas those of controls were intermediate. In this study, grazing heifers implanted with Component E-H, when followed in the feedlot with Synovex-H and Finaplix-H, performed better overall than those implanted with Ralgro. The control heifers had the largest ribeyes, when expressed on either an actual or carcass weight-adjusted basis. This was not expected and either may be an artifact of cattle allotment or due to feedlot implants reacting differently in unimplanted cattle. At the time of implanting before grazing, the heifers were palpated for old implants, and only eight were found. Other carcass traits, including backfat thickness, KPH fat percentage, and USDA quality grade, were not affected by pasture implant treatments.

Table 1. Effects of Implanting Heifers on Grazing Gains and Subsequent Feedlot and Carcass Performance

	Pasture Treatment			
Item	Control	Component E-H	Ralgro	SE
No. heifers	87	86	85	
Starting wt, lb	517	515	520	
Daily gain, lb				
Grazing, 74 d	1.48[c]	1.77[a]	1.61[b]	.06
Finishing, 120 d	3.39[a]	3.32[a]	3.16[b]	.07
Results				
Hot carcass wt, lb	658.0[ab]	664.0[a]	647.0[b]	3.3
Backfat, in.	.45	.50	.51	.02
Ribeye area, sq. in.	12.70[a]	12.40[ab]	12.30[b]	.16
Ribeye area/cwt carcass wt	1.94[a]	1.87[b]	1.90[ab]	2.94
KPH fat, %	2.25	2.31	2.34	.05
USDA % Choice	49.4	50.3	51.0	5.5

[abc]Means in the same row with unlike superscripts are different (P<.10).

EFFECTS OF FEEDING RUMENSIN® IN A MINERAL MIXTURE ON STEERS GRAZING NATIVE GRASS PASTURES

F. K. Brazle [1] and S. B. Laudert [2]

Summary

Four hundred sixty-nine English and Continental cross yearling steers grazed on native grass pastures over a 2-year period. Rumensin® was added (1,620 g/ton) to the mineral mixture in half of the pastures. Some of the pastures were used from April 23 to July 15 and the remainder from April 23 to August 15. The pooled data for the grazing periods indicated that Rumensin-supplemented steers gained 7.7% faster (P<.05) and consumed 32% less mineral (P<.05) compared to the control steers.

(Key Words: Rumensin, Native Grass, Mineral.)

Introduction

Feed additives used to improve gains of stocker cattle grazing native grass are normally added to the mineral mixtures, resulting in changes in mineral consumption. The objective of this study was to determine the effect of Rumensin® on weight gain and mineral intake of steers grazing native grass pastures from April 23 to either July 15 or August 15.

Experimental Procedures

Four hundred sixty-nine English and Continental Cross yearling steers grazed on native grass pastures. In 1996, four pastures were used (2 acres/head for 83 days) from April 23 to July 15, and four pastures were used (3 acres/head for 114 days) from April 23 to August 15. In 1997, four pastures were used (2 acres/head for 83 days) from April 23 to July 15, and two pastures were used (3 acres/head for 114 days) from April 23 to August 15. Within each pasture replication, steers were allotted randomly to two treatments: a mineral mixture without Rumensin (control) or a mineral mixture with Rumensin-80 added at 1620 g/ton, replacing a processed grain by-product (Table 1). Mineral consumption was monitored weekly.

Results and Discussion

The performance data for the steers grazing to July 15 are shown in Table 2. Steers with access to the Rumensin mineral mixture tended to gain more, but the difference was not significant. Additionally, the Rumensin-supplemented steers consumed less mineral (P<.03) than controls. The Rumensin-supplemented steers that grazed to August 15 (Table 3) had significantly higher gains (P<.08) than the control steers.

The pooled data (across years and grazing periods) show a gain response of .19 lb/head/day (P<.05) for steers receiving Rumensin in a mineral mixture and grazing native grass pasture (Table 4). The average Rumensin intake was 170 mg/head/day. The

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presence of Rumensin in mineral mixtures reduced mineral intake to 3.4 oz per day vs. 5.0 oz per day for control. These data show that mineral mixtures containing Rumensin improve gains. The reduction in mineral intake may offset some of the cost of the mineral.

Control cattle grazing to July 15 consumed an average of 5.3 oz of mineral daily vs. an average of 4.6 oz daily for those grazing to August 15. Corresponding intakes for cattle receiving Rumensin were 3.4 and 3.3 oz. Cattle normally have high salt and/or mineral consumption early in the season, but consumption declines as the grass matures, which would explain the difference in mineral consumption for control steers. Intake of mineral mixtures containing Rumensin appearred to be more consistent from week to week.

Table 1. Formulation of Rumensin Mineral Mixture

Ingredient	Lbs/ton
Monocalcium phosphate	589.8
Salt	485.0
Dried cane molasses	400.0
Limestone	275.0
Cane molasses	60.0
Processed grain by-products	100.0
Vitamin/trace mineral premix	50.0
Rumensin 80	20.2
Antidusting oil	20.0

Table 2. Effects of a Mineral Mixture with Rumensin on ADG and Mineral Consumption of Steers Grazing Native Grass (2 ac/head/July 15, 1996-97)

Item	Rumensin	Control	SE
Pastures, no.	4	4	
Steers, no.	154	154	
Initial wt, lbs	552	543	
ADG, lb	2.81	2.59	.107
Mineral intake, oz/day	3.4[a]	5.3[b]	.464
Rumensin intake, mg/head/day	170	- -	

[ab]Means in the same row with unlike superscripts are different (P<.03).

Table 3. Effects of Mineral Mixture with Rumensin on ADG and Mineral Consumption to Steers Grazing Native Grass (3 acres/head/August 15, 1996-97)

Item	Rumensin	Control	SE
Pasture, no.	3	3	
Steers, no.	73	88	
Initial wt, lb	552	549	
ADG, lb	2.51[a]	2.35[b]	.051
Mineral intake, oz/day	3.3[a]	4.6[b]	.624
Rumensin intake, mg/head/day	170	- -	

[ab]Means in the same row with unlike superscripts are different (P<08).

Table 4. Overall Effects of a Mineral Mixture with Rumensin on Steers Grazing Native Grass to Either July 15 or August 15 (1996-97)

Items	Rumensin	Control	SE
Pastures, no.	7	7	
Steers, no.	227	242	
Starting wt, lb	552	545	8.376
ADG, lb	2.66[a]	2.47[b]	.064
Mineral intake, oz/day	3.4[a]	5.0[b]	.346
Rumensin intake, mg/day	170	- -	

[ab]Means in the same row with unlike superscripts are different (P<.05).

EFFECTS OF REVALOR-G®, RALGRO®, AND SYNOVEX-H® ON THE PERFORMANCE OF STOCKER HEIFERS GRAZING IRRIGATED RYE PASTURE [1]

D. A. Blasi and G. L. Kuhl

Summary

A 151-day field study was conducted to compare three anabolic implants for promoting weight gain in stocker heifers grazing center pivot-irrigated pastures of winter rye. Three hundred previously nonimplanted heifers averaging 421 lb were allotted to one of four treatments: 1) no implant-control (NC), 2) Ralgro® (RAL), 3) Revalor-G® (REV-G) and 4) Synovex-H® (SYN-H). Heifers were weighed at monthly intervals to evaluate the growth response curve of each implant type over time relative to controls. Only during the first 32-day period after implantation did heifers implanted with REV-G gain significantly faster (P<.05) than NC. All implant groups responded similarly (P>.05) during the next three monthly weigh periods. During the last period (day 124-151), SYN-H heifers gained faster (P<.05) than all other treatments. Over the entire 151-day study, daily gains (lb/day) averaged as follows: NC, 1.50; RAL, 1.58; REV-G, 1.64; and SYN-H, 1.79. All implant types except RAL significantly improved gain (P<.05) compared to NC. Although no significant difference (P>.24) occurred between RAL and REV-G, SYN-H-implanted heifers gained faster (P<.05) than the other implant groups over the 151-day grazing season.

(Key Words: Growth Implant, Revalor-G, Ralgro, Synovex-H, Heifers, Rye Pasture.)

Introduction

The use of estrogenic implants to enhance the performance of grazing stockers has been adopted widely by cattle producers. Revalor-G is a newly approved anabolic agent for grazing cattle containing trenbolone acetate (a potent testosterone analog) and estrogen. However, no published research is available comparing REV-G to traditional estrogenic implants for heifers grazing winter rye pasture. Our objective was to evaluate the relative effectiveness of Revalor-G (40 mg trenbolone acetate and 8 mg estradiol), Ralgro (36 mg zeranol), and Synovex-H (20 mg estradiol benzoate and 200 mg testosterone propionate), in improving weight gain of yearling heifers grazing irrigated, winter rye pasture.

Experimental Procedures

Three hundred and seventy-five predominantly British crossbred heifers were purchased in Mississippi and assembled near Pratt, KS for 4 weeks prior to trial initiation. Upon arrival, they were vaccinated against common viral and bacterial diseases. At trial initiation, all heifers were weighed individu-

[1]Sincere appreciation is expressed to Great Plains Cattle, Pratt, Kansas for providing cattle, facilities, and assistance, and to Hoeshst-Rouseel Vet for financial support.

ally (unshrunk) on 2 consecutive days, identified with a tag in each ear, dewormed, and checked for evidence of prior implants. Then, 300 uniform heifers were selected and allotted randomly to four treatments, within weight blocks, and implanted according to manufacturers' recommendations. The treatments were: 1) no implant-control (NC), 2) Ralgro (RAL), 3) Revalor-G (REV-G), and 4) Synovex-H (SYN-H). For each of the remaining weigh days (days 32, 60, 92, 123, and 151), heifers were gathered, placed in drylot, and fed hay and alfalfa/wheat middling (AWM) pellets for 1 day before individual weights were obtained.

All heifers grazed predominantly winter rye pasture during the 151-day trial. Heifers were assigned randomly to one of two rye pastures with center pivot irrigation. Equal pounds of live cattle were stocked per circle. However, inclement winter weather and insufficient rye forage necessitated feeding supplemental alfalfa and AWM pellets in addition to either rye or alfalfa hay during a 45-day period in December and January. Four heifers were removed because of health problems unrelated to implant treatment. Individual animal was the experimental unit for statistical analysis of weight gain data.

Results and Discussion

Table 1 presents heifer daily gains by implant treatment and monthly weigh period. Performance of RAL heifers was not significantly different ($P>.05$) than that of NC or REV-G heifers at any weigh period. All implant types produced similar ($P>.05$) growth responses during the second (days 33-60), third (day 61-92), and fourth (days 93-123) weigh periods. SYN-H heifers gained significantly faster ($P<.05$) than heifers in all other implant treatments between days 124 and 151 and over the entire 151-day trial.

Figure 1 presents the cumulative growth response of heifers to each implant type relative to nonimplanted controls over the course of the 151-day study. Both the REV-G and SYN-H-implanted heifers gained rapidly early in the study relative to the NC treatment. However, the anabolic response from each implant was different over the course of the study. For SYN-H, a sustained growth response was observed above the NC treatment that did not vary much throughout the 151-day experiment. This suggests that the payout response of SYN-H implants may last at least 151 days. In contrast, the REV-G implant demonstrated a classic "half-life" response relative to the NC treatment over the 151-day study. Finally, the response of heifers implanted with RAL was initially very slow and never reached the growth trajectory demonstrated by the other two implants.

Table 1. Effect of Implant Types on Heifer Gains during Successive Weigh Periods on Rye Pasture

		Heifer Daily Gain (lb) by Monthly Weigh the Period[b]					
Implant Treatment	No. Heifers	First (days 1-32)	Second (days 33-60)	Third (days 61-92)	Fourth (days 93-123)	Fifth (days 124-151)	Overall (days 1-151)
NC	75	.98[c]	1.90[c]	1.44[c]	1.37[c]	1.94[c]	1.50[c]
RAL	75	1.02[cd]	2.01[cd]	1.58[cd]	1.45[cd]	1.95[c]	1.58[cd]
REV-G	73	1.23[de]	2.09[cd]	1.57[cd]	1.43[cd]	1.98[c]	1.64[d]
SYN-H	73	1.37[c]	2.11[d]	1.70[d]	1.58[d]	2.26[d]	1.79[e]

[a]NC= Negative Control; RAL = Ralgro®, REV-G = Revalor-G®, SYN-H = Synovex-H®. All implants administered on day 1.
[b]First = First 32-day weigh period from 11/18/96 to 12/20/96; Second = 28-day period from 12/20/96 to 01/17/97;Third=32-day periodfrom 01/17/97 to 02/18/97; Fourth=3l-day period from 02/18/97 to 03/21/97; Fifth = 28-day period from 03/21/97 to 04/18/97.
[c,d,e]Values in columns not sharing a common superscript are different (P<.05).

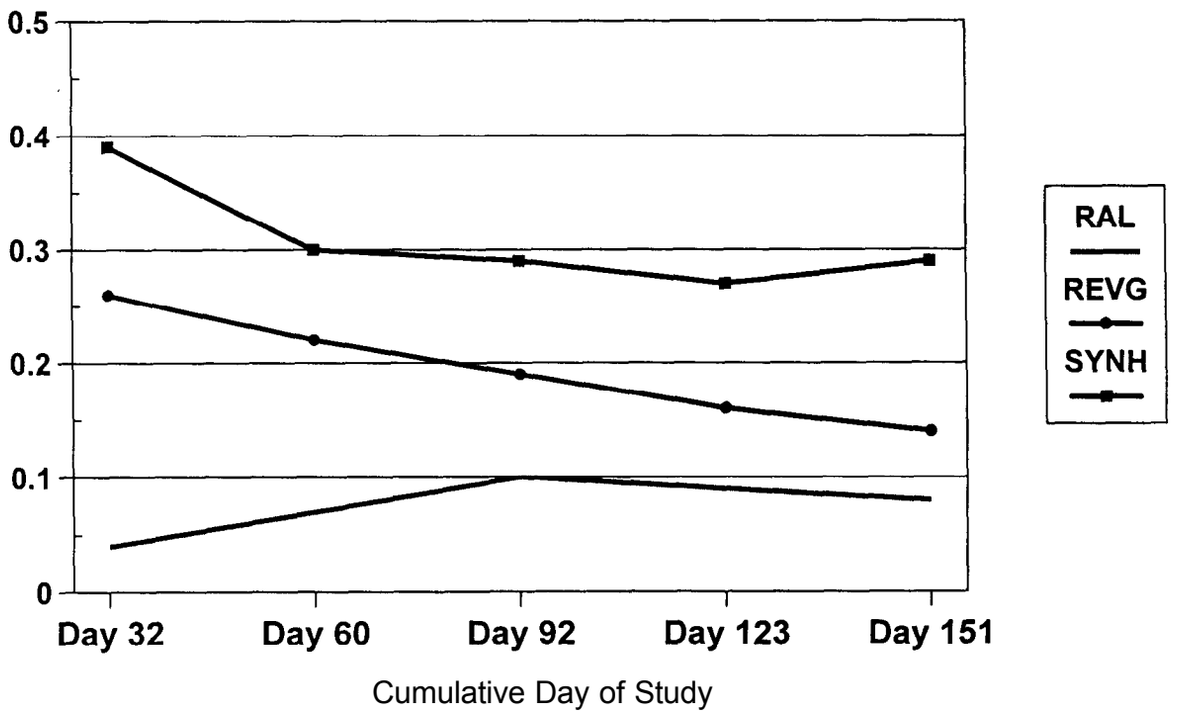

Figure 1. Cumulative Growth Responses of Heifers to Anabolic Implants Relative to Nonimplanted Controls during the Grazing Season.

CHARACTERISTICS OF PELLETED WHEAT MIDDLINGS THAT AFFECT SUMMER STORAGE

C. R. Reed[1], D. M. Trigo-Stockli[1], D. A. Blasi, and F. J. Fairchild[1]

Summary

Pelleted wheat middlings samples were collected from four Kansas flour mills in March, April, and May, 1997 to characterize their moisture content and bulk density as they would be purchased directly from the mills by a livestock producer. The average moisture content of pelleted wheat middlings was 14% as they left the mills but declined during the spring to 13.6%. Pellets purchased from Kansas mills during the summer months are likely to contain 13.0 to 13.5% moisture. The average bulk density was approximately 40 lb/ft^3, which is equivalent to about 50 lb/bu. Based on the equilibrium moisture contents determined from the collected samples, if air at typical Kansas summertime temperatures is above 65% relative humidity, pellets will absorb moisture during storage.

(Key Words: Wheat Middlings, Storage.)

Introduction

Wheat middlings (WM) are by-products of flour milling and have nutritional value in cattle rations. Ground WM are difficult to handle and quickly lose their flowability in bulk bins. However, pelleted WM are gaining acceptance with cattle feeders because of greater density and improved handling and flowability characteristics. During summer months, the price of pelleted WM declines, thereby creating an excellent feed ingredient value. However, when pelleted WM are stored on-farm through the summer months, many Kansas producers have observed heating, which has resulted in caking, discoloration, and loss of flowability (Blasi et al., 1997 Cattlemens Day Report of Progress, p 37).

This study was initiated in March, 1997 to investigate the characteristics of pelleted WM that relate to their storability, especially during summer months. Our objective was to describe moisture and bulk density characteristics of the pelleted WM as they would be purchased from Kansas mills. Our long-term goal is to develop practical recommendations for on-farm storage of WM during summer months.

Experimental Procedures

Pelleted WM were collected from four Kansas mills on four occasions in March, April, and May, 1997. Sealable containers were supplied to the millers with instructions that samples should be taken randomly from the pellet stream on three occasions during a selected day. The samples, weighing 30 to 80 lb each, were sealed, identified, and collected on the following day. Thus, the pellets collected were no more than one day old, and were to be representative of pellets purchased directly by livestock producers. They were transported to a university labo-

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ratory, where portions for moisture content and equilibrium moisture content were removed immediately, sealed, and stored at 40°F for later analysis. Moisture content (MC) was determined by a two-step air-oven method, and bulk density (BD) was determined with a 1-cubic-meter container.

To determine the relationship between the air temperature and moisture content and the tendency of the WM to gain or lose moisture (equilibrium moisture content), small quantities of pellets were weighed precisely and placed in sealed chambers over saturated salt solutions that produce known relative humidities. The sealed chambers then were placed in controlled temperature rooms at 75°F or 85°F, where the weight of the pellets was checked periodically until no change was observed over several days. The pellet moisture content at this equilibrium condition then was determined.

Results and Discussion

Forty-one samples of 1/4 in. and 3/4 in. pelleted WM were collected from Kansas mills. The average BD of the two types of pellets was not noticeably different and ranged from 37.7 to 42.2 lb/ft^3, with an average of 39.9 ± 0.9 lb/ft^3 (Table 1). Most pelleted WM, regardless of the sampling time, weighed 38 to 41 lb/ft^3, which is equivalent to approximately 50 lb/bu. In contrast, the ground middlings from which the pellets were manufactured weighed only about 20 lb/ft^3.

The overall average MC of the pellets was 14.0±0.5 %, and individual samples ranged from 12.8 % to 14.9 %. The MCs of the 3/4 in. pellets showed the greatest variability between sampling times. However, they contained about the same average MC as the smaller pellets. All pellets, regardless of size, were about 1% wetter than the ground middlings from which they were manufactured. As the ambient air warmed during the spring, the pellets arrived drier, with the average MC in May being 0.4 percent lower than the overall average. This trend continued into the summer. In August, we received pelleted WM for a separate study that contained only 13.3 % MC. Thus, WM pellets purchased from Kansas mills in June, July, or August likely will contain 13.0 to 13.5 % MC.

WM pellets swell and soften significantly when they gain moisture, losing their ability to flow. Storage practices must ensure that moisture is not transferred from the air to the pellets. Pelleted WM at 13.5% MC are in equilibrium with air containing 68% relative humidity (RH) at 75°F and with air contain- ing 69% RH at 85°F. (Figure 1). This indicates that in air at the temperature range encountered during summer storage (60°F - 95°F), pellets will absorb moisture if RH is greater than 65%. Studies currently underway will allow the development of specific recommendations for aeration management to minimize mold growth and maintain maximum pellet flowability.

Table 1. Moisture Content (MC) and Bulk Density (BD) of Pelleted Middlings Collected from Four Kansas Flour Mills in 1997

Mill Number	Physical Parameter	Sampling Date			
		March 25	April 2	April 29	May 7
1	Avg. MC.	13.9	14.4	14.1	13.9
	Avg. BD.	40.1	40.0	38.6	40.2
2	Avg. MC	14.6	14.1		12.8
	Avg. BD	40.6	41.0		
3	Avg. MC	14.4	14.8		14.2
	Avg. BD	41.2	40.6		40.6
4	Avg. MC	13.9	14.2	13.5	13.6
	Avg. BD	38.5	39.1	39.0	39.0
Overall Average	MC	14.2 ± 0.31	14.4 ± 0.27	13.8 ± 0.30	13.6 ± 0.52
	BD	40.1 ± 1.0	40.2 ± 0.7	38.8 ± 0.2	39.9 ± 0.7

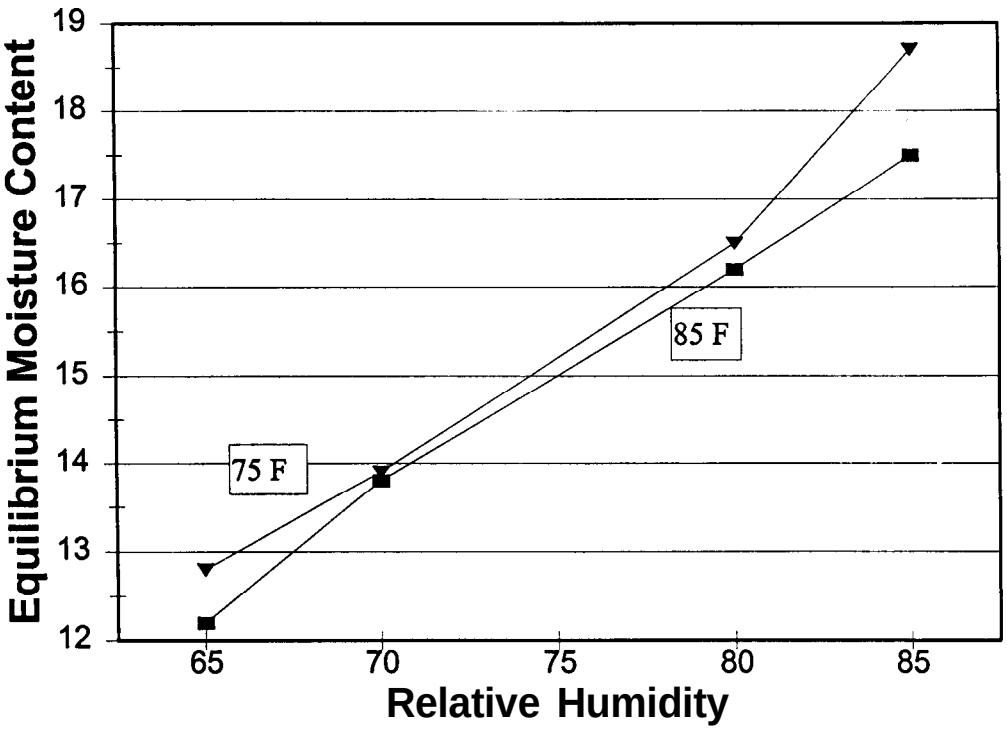

Figure 1. Observed Equilibrium Moisture Content of Pelleted Wheat Middlings at 75°F and 85°F.

BEEF CATTLE LAGOON SEEPAGE

J. P. Murphy[1] *and J. P. Harner*[1]

Summary

Most compacted soils can be used for lagoon liners to achieve seepage guidelines established by the Kansas Department of Health and Environment.

(Key Words: Lagoon Seepage, Permeability, Soil Lagoon Liner.)

Introduction

The protection of surface and groundwater and the utilization or disposal of animal waste are the primary functions of waste storage ponds and treatment lagoons. However, seepage from these structures creates risks of pollution to surface water and underground aquifers. The permeability of the soil in the boundaries of a constructed waste treatment lagoon or waste storage pond strongly affects the potential for downward or lateral seepage of the stored wastes.

Research has shown that many natural soils on the boundaries of waste treatment lagoons and waste storage ponds will seal at least partially as a result of physical, chemical, and biological processes. Suspended solids settle out of suspension and physically clog the pores of the soil mass. Anaerobic bacteria produce by-products that accumulate at the soil-water interface and reinforce the seal. Soil structure also can be altered as bacteria metabolize organic material. Chemicals in animal waste, such as salts, can disperse soil, which also may reduce seepage. Research has shown that soil permeability can be decreased by several orders of magnitude in a few weeks following contact with animal waste in a storage pond or treatment lagoon.

The physical clogging of the soil is considered to be a function of the type of waste; the percent total solids in the waste; and the permeability, size, and geometry of soil pores. Until recently, research has focused on total solids of the waste as the most important factor in the physical sealing process. However, research published in the late 1980's has shown convincingly that a soil's equivalent pore size computed as a function of particle size distribution and porosity is probably more important. Although research has shown that permeability in all soils will decrease from 1 to 3 orders of magnitude because of manure sealing, this sealing alone probably will not provide enough protection against excessive seepage and groundwater contamination for soils with a very high initial permeability. Other research has demonstrated that for soils with clay contents exceeding 5 percent for ruminant or 15 percent for monogastric animal manure, a final permeability of 10^{-6} to 10^{-7} cm/sec usually results from manure sealing. Clay content is defined as the percent by dry weight of a soil that is smaller than 2 microns (0.002 mm) and is roughly equivalent to the percentage of soil that will pass through a No. 200 seive.

Site Investigation

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An on-site investigation of a potential waste storage site should include: evaluating soils, bedrock, groundwater, climatic conditions, and local water uses, to provide insight into the potential impact of the site on groundwater resources. Data should include the presence of any water wells or any other water supply sources, depth to the seasonal high water table, general ground water gradient, general geology of the site, and depth to bedrock, if applicable.

Determining the intensity of any detailed site investigation is the joint responsibility of the designer and the person who has authority to approve the engineering job. The intensity of investigation required depends on past experience in a given area, the types of soils and variability of the soil deposits, the size of the structure, the environmental sensitivity, and an assessment of the associated risks involved. State and local laws should be followed in all cases.

The subsurface investigation can employ auger holes, dozer pits, or backhoe pits. The investigation should extend to at least 2 feet below the planned bottom of the excavation. A site investigation can include field permeability testing and taking samples for laboratory testing, or it can be limited to field classification of the soils. Information from the site investigation should be documented and included in the design documentation. When logging soils from auger holes, always consider that mixing will occur and can obscure the presence of cleaner sand or gravel lenses. Pits and trenches expose more of the foundation, which is helpful in detecting small, but important, lenses of permeable soil. Always use safety rules around trenches.

Soil Properties

Soil mechanics laboratories of the Natural Resources Conservation Service (NRCS) have a database of permeability tests performed on over 1,100 compacted soil samples. Experienced NRCS engineers have analyzed these data and correlated permeability rates with soil index properties and degree of compaction. Based on this analysis, Table 1 (from NRCS Technical Note 716) has been developed to provide general guidance on the probable permeability characteristics of soils. The grouping is based on the percent fines (percent by dry weight finer than the #200 sieve, roughly equivalent to percent clay) and a plasticity index. This index represents the range of moisture contents at which a soil remains cohesive.

Table 2 summarizes a total of 1,161 NRCS tests. Where tests are shown at 85 to 90% of maximum density, the vast majority of the tests were at 90%. Where 95% is shown, data include tests at both 95 and 100% degrees of compaction, with the majority of the tests performed at 95% of maximum density.

Table 2 gives a summary of the permeability test data. The first column indicates the general soil group described in Table 1. The second column indicates the degree of compaction of the soil. The higher the percent dry density, the greater the compaction. The four soil types each have been tested at two different compaction rates. The data indicate that additional compaction of the same soil reduces the permeability of the soils by a factor of 2 to 13. The average permeability values are listed in the fourth column. These values, when multiplied by the depth of a lagoon and divided by the thickness of the liner, predict the seepage rate. The last column of Table 2, shows the predicted seepage rate for a lagoon with an average depth of 4 feet and a liner thickness of 1 foot. Kansas Department of Health and Environment (KDHE) regulations require

that initial seepage be less than .25 inches per day. These data show that almost all soils in groups II, III, and IV can be adequately sealed. The permeability values shown are median values, so some soils in all the groups may have excessive seepage. Testing of existing soils is recommended to assess local conditions.

Soil liners are relatively impervious barriers used to reduce seepage losses to an acceptable level. One method of providing a liner for a waste storage structure is to improve the soils at the excavated grade by disking, watering, and compacting them to a suitable thickness. Soils with suitable properties make excellent material for liners, but the liners must be designed and installed correctly. Soil has an added benefit of providing an attenuation medium for the pollutants.

Those on-site soils in Groups I considered to be unsuitable usually can be treated with bentonite to produce a satisfactory soil liner. Additives such as bentonite or soil dispersants should be added and mixed well into a soil prior to compaction. A soil liner may also can be constructed by compacting imported clay from a nearby borrow source onto the bottom and sides of the storage pond. This is often the most economical method of constructing a clay liner, if suitable soils are available nearby. Concrete or synthetic materials such as GCL's (geosynthetic clay liners) and geomembranes also can serve as liners. In all cases, liners should provide a reduction in seepage from the storage/treatment pond and diminish the potential for contamination of groundwater.

Table 1. Grouping of Foundation Soils According to Their Percent of Small Particles and Plasticity Index - From NRCS/SNTC Technical Note 716

Group	Description
I	Soils that have less than 20% passing a No. 200 sieve and have a plasticity index less than 5. Generally, these soils have the highest permeability and, in their natural state, could allow excessive seepage losses.
II	Soils that have 20 to 100% passing a No. 200 sieve and have a plasticity index less than or equal to 15. Also included in this group are soils with less than 20% passing the No. 200 sieve with fines having a plasticity index of 5 or greater.
III	Soils that have 20 to 100% passing a No. 200 sieve and have a plasticity Index of 16 to 30. These soils generally have a very low permeability, good structural features, and only low to moderate shrink-swell behavior.
IV	Soils that have 20 to 100% passing a No. 200 sieve and have a plasticity index of more than 30. Normally, these soils have a very low permeability. However, because of their sometimes blocky and fissured structure, they often can experience high seepage losses through cracks that can develop when the material is allowed to dry. They possess good attenuation properties, if the seepage does not move through the cracks.

Table 2. Summary of Permeability Test Data, NRCS Soil Mechanics Laboratories

Soil Group	Percent of ASTM D698 Dry Density	Number of Observations	Permeability Median K cm/sec	Seepage (12-inch-thick liner 4 ft. avg. liquid depth)
				inch/day
I	85-90	27	7.2×10^{-4}	120
I	95	16	3.5×10^{-4}	60
II	85-90	376	4.8×10^{-6}	.85
II	95	244	1.5×10^{-6}	.24
III	85-90	226	8.8×10^{-7}	.15
III	95	177	2.1×10^{-7}	.036
IV	85-90	41	4.9×10^{-7}	.084
IV	95	54	3.5×10^{-8}	.006

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Boehringer Ingelheim Animal Health, St. Joseph, Missouri
Lee Borck, Larned, Kansas
Brill Corporation, Norcross, Georgia
Buckhead Beef, Atlanta, Georgia
Bunge Corporation, Emporia, Kansas
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Central City Scale, Central City, Nebraska
Cereal Food Processors, Mission Woods, Kansas
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Consolidated Nutrition, Omaha, Nebraska
Elanco Animal Health, Indianapolis, Indiana
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Merial Animal Health, Rahway, New Jersey
M&M Livestock Products Co., Eagle Grove, Iowa
National Byproducts, Des Moines, Iowa
Novus International Inc., St. Charles, Missouri
Peterson Farms, Wamego, Kansas
Pfizer Animal Health, Exton, Pennsylvania
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Richard Porter, Porter Farms, Reading, Kansas
Roche Animal Health, Nutley, New Jersey
Schering-Plough Animal Health, Kenilworth, New Jersey
Select Sires, Plain City, Ohio
Stafford County Flour Mills, Hudson, Kansas
Taylor Implement, Hoxie, Kansas
Terra Nitrogen Corporation, Sioux City, Iowa
USDA Food Safety Consortium, Washington, DC
USDA, Cooperative State Research Education and Extension Service, Washington, DC
Vet Life, Inc., Overland Park, Kansas
Wall-Rogalsky Flour Milling Company, McPherson, Kansas
Western Star Mill Company, Salina, Kansas

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 +l 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; .l 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.

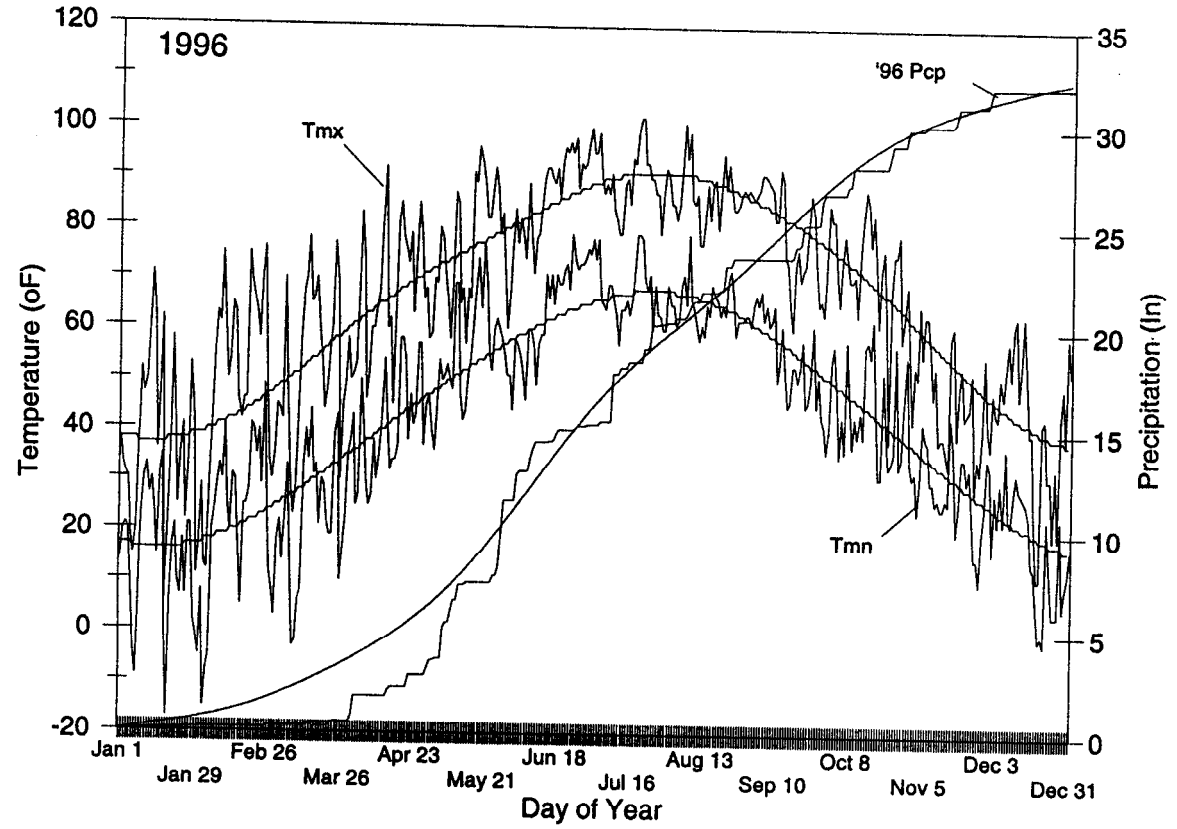
Many animals per treatment, replicating treatments several times, and using uniform animals all increase the probability of finding real differences when they actually exist. Statistical analysis allows more valid interpretation of the results, regardless of the number of animals in an experiment. In the research reported herein, statistical analyses are included to increase the confidence you can place in the results.

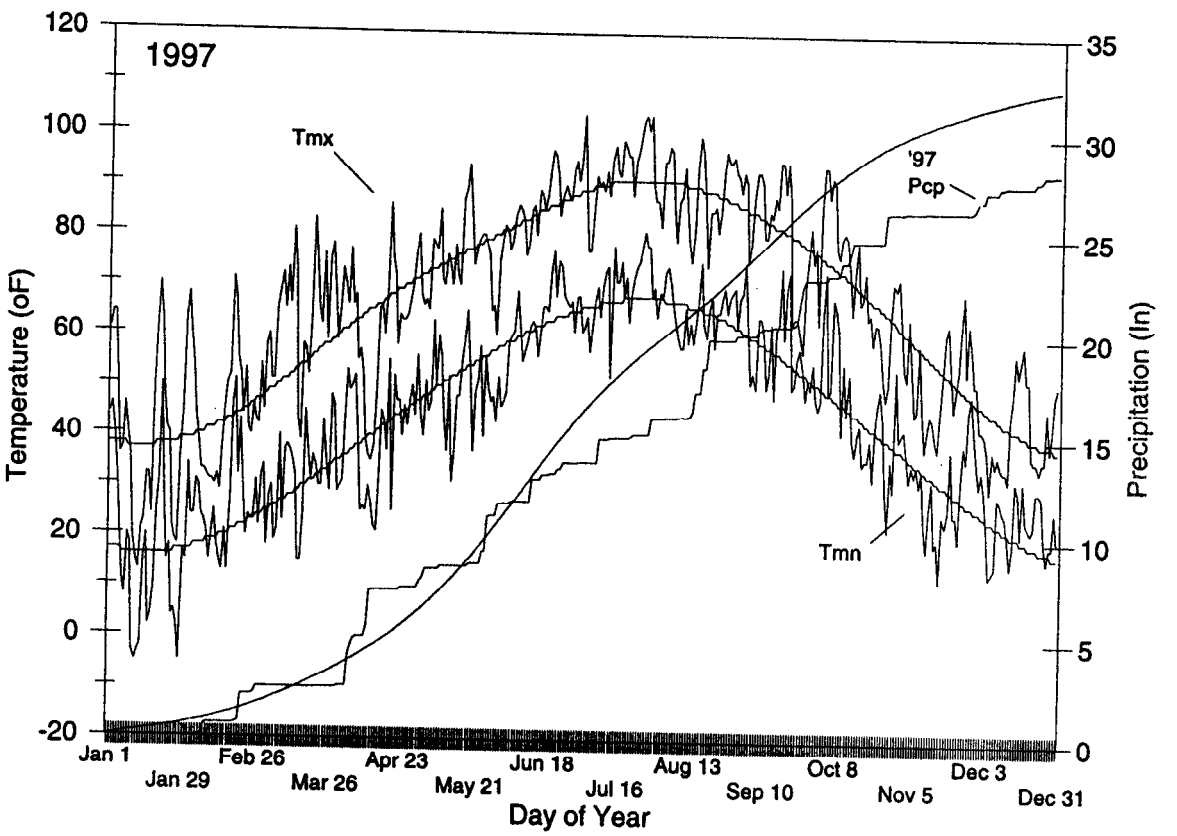
In most experiments, the statistical analysis is too complex to present in the space available. Contact the authors if you need further statistical information.

WEATHER DATA, 1996-1997

On the following page are graphs of the 1996 and 1997 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, 1996 and 1997

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