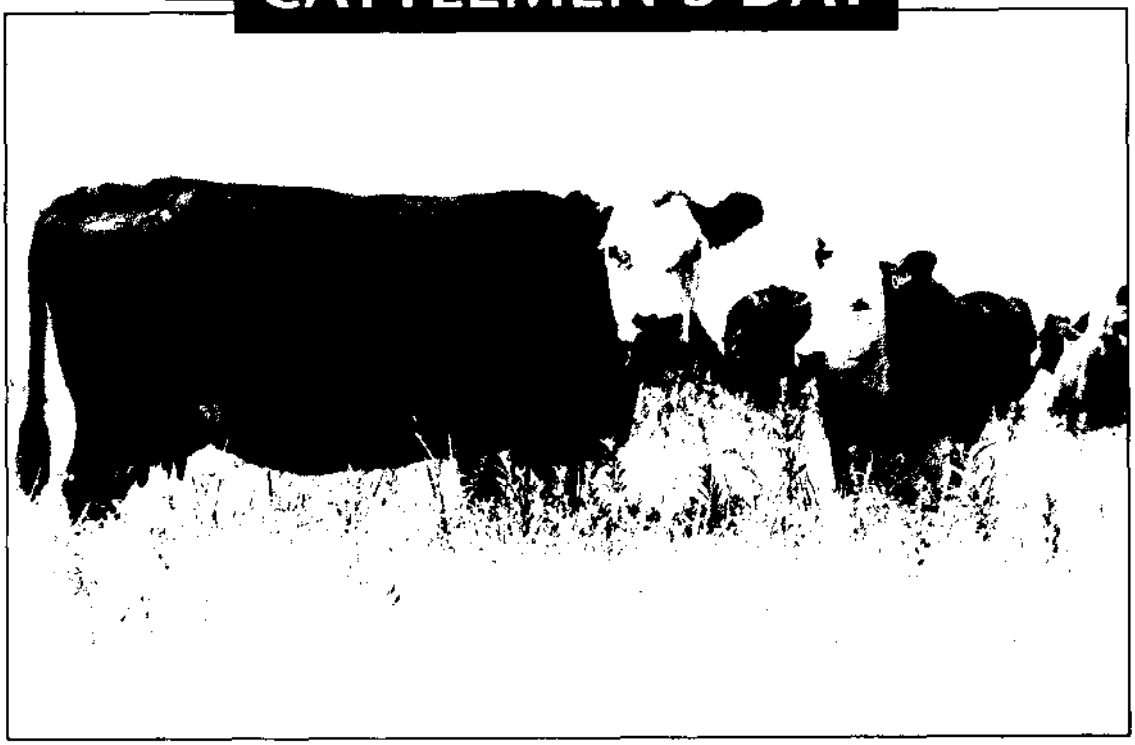
1994 CATTLEMEN'S DAY



Report of Progress 704
Agricultural Experiment Station
Kansas State University, Manhattan
Marc A. Johnson, Director

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LEVEL OF UREA IN HIGH GRAIN DIETS: FINISHING STEER PERFORMANCE

C. T. Milton and R. T. Brandt, Jr.

Summary

Eighty-eight medium-framed crossbred steers (731 lb) were used to identify the optimal level of urea in finishing diets for growth and carcass traits. Diets contained no urea or .5, 1.0, or 1.5% urea (dry matter basis) and no other supplemental protein. Feed efficiency and gain were improved substantially by the first increment of urea (.5%), with little or no improvement from subsequent urea additions. Pooled across level, urea improved feed efficiency by 5.6% and gain by 8.9%, whereas dry matter intake declined 3.3% compared to controls. Regression analysis indicated that the optimal level of urea for gain and feed efficiency was .91% of dietary dry matter. Dressing percentage and hot carcass weight responded quadratically, being higher for steers receiving .5 or 1.0% urea. Fat thickness, yield grade, and KPH fat increased linearly with level of urea. Percentage choice carcasses tended to increase, although no differences in marbling score were observed with increased urea. Because of increased carcass weight and finish, with no increase in loineye area, these data suggest that adding urea increased energy utilization (diet digestibility) rather than metabolizable protein supply to the small intestine.

(Key Words: Finishing Steers, Urea, Performance, Metabolizable Protein.)

Introduction

Current information concerning requirements of finishing cattle for rumen degradable protein and metabolizable protein is limited. In order to establish metabolizable or net protein systems, a requirement for ruminal degradable protein needs to be established. Urea is a common source of rumen degradable nitrogen in finishing diets and, therefore, our objective was to identify the optimal level of urea for performance and carcass traits of finishing yearling steers.

Experimental Procedures

Eighty-eight medium-framed crossbred steers (731 lb) were received from Flint Hills grass in July 1993. A single initial weight was taken following a 3-day equalized intake period of prairie hay and protein supplement. Steers were stratified into three weight blocks; implanted with Revalor®; and stepped up to the final ration without urea or containing .5, 1.0, or 1.5% urea (dry matter basis). The step-up period of 14 days began on the day initial weights were taken. Diets (Table 1) contained no supplemental protein other than urea. All diets were formulated to contain .7% Ca, .35% P, .7% K, 25 g/ton Rumensin®, and 10 g/ton Tylosin®. Steers were fed experimental diets for an average of 131 days. The two largest weight blocks were slaughtered following 119 days on feed, but the smallest weight block required an additional 35 days on feed to reach a desirable finished weight. Hot carcass weights and a 62% dressing percent were used to determine final weight for calculation of gain and feed efficiency. Steers were slaughtered at a commercial plant, and carcass data were obtained following a 24-hour chill.

Results and Discussion

Dry matter intake responded cubically ($P<.10$) to the addition of urea, being lower

for steers supplemented with .5 or 1.5% urea. The reduction in intake was probably associated with an increased starch fermentation rate. Daily gain (P=.10) and feed efficiency (P<.02) responded quadratically to the addition of urea. Both daily gain and feed efficiency were increased substantially by the first increment of urea (.5%), with little or no improvement from subsequent urea additions. Pooled across level, urea supplementation improved daily gain 5.6% and feed efficiency 8.9% and reduced dry matter intake 3.3% compared to the control diet. As dietary urea increased, dressing percentage responded quadratically (P<.01). A quadratic trend (P=.16) also was observed for hot carcass weights. Fat thickness (12th rib) increased (P<.04) and KPH fat tended (P=.14) to increase linearly with level of urea. Loin eye area and incidence of liver abscesses were not affected by dietary level of urea. Calculated yield grade increased linearly (P<.10) with level of urea as a result of increased 12th rib fat and KPH fat. Percentage of carcasses grading Choice tended (P=.17) to increase as dietary level of urea increased, although urea level had little effect on marbling scores. Predicted crude protein requirements of steers in this study (1.88 lb/day) were met by the control diet. Improvements in performance and increased carcass weight and finish, with no improvement in loineye area, suggest that urea enhanced energy utilization (diet digestibility) by the animal, rather than metabolizable protein supply to the small intestine. The Iowa State metabolizable protein system predicted the urea fermentation potential for the basal diet in this study to be 1.09%. Regression analysis (model $Y = \text{urea} + \text{urea}^2$) showed the optimal level of urea for gain (r^2=.31) and feed efficiency (r^2=.40) to be .91% of dietary dry matter.

Table 1. Diet Composition [a]

	Treatment (% Urea, dry matter basis)			
Ingredient	Control	.5	1.0	1.5
Rolled corn	76.9	77.0	77.2	77.2
Prairie hay	10.0	10.0	10.0	10.0
Supplement 1 [b]	10.6	7.1	3.5	--
Supplement 2 [c]	--	3.4	6.8	10.3
Molasses	2.5	2.5	2.5	2.5
% Crude protein (dry matter basis)	7.7	9.0	10.3	11.6

[a]Dry matter basis. Formulated to contain .7% Ca, .35% P, .7% K, 25 g/ton Rumensin, and 10 g/ton Tylosin. Elemental sulfur was supplied to maintain a N:S ratio of 10:1 across treatments.
[b]Supplement supplied no urea.
[c]Supplement supplied 1.5% urea (dry matter basis) in 1.5 treatment.

Table 2. Effect of Dietary Urea Level on Performance and Carcass Traits of Steers

Item	Treatment (% Urea dry matter basis)				SEM
	Control	.5	1.0	1.5	
No. pens	3	3	3	3	
No. steers	22	22	22	22	
Initial wt., lb	735	731	729	730	4.8
Final wt.[a], lb	1170	1193	1201	1184	12.6
Daily feed[b], lb	24.37	23.12	24.00	23.56	.38
Daily gain[c], lb	3.35	3.53	3.64	3.49	.09
Feed/gain[d]	7.29	6.54	6.62	6.76	.13
Hot carcass wt., lb	726	740	745	734	7.8
Dressing %[e]	62.04	63.13	63.09	62.11	.18
KPH, %	1.58	1.73	1.84	2.00	.18
Loin eye area, in^2	13.5	13.7	13.4	13.4	.35
Fat 12th rib[f], in	.31	.36	.46	.50	.05
Yield grade[g]	2.02	2.16	2.57	2.64	.25
Marbling score[h]	5.32	5.01	5.28	5.64	.32
Pct Choice	41	41	59	68	
Liver abscesses, %	5	5	0	5	

[a]Calculated as hot carcass weight/.62.
[b]Cubic (P<.10).
[c]Quadratic (P=.10).
[d]Quadratic (P<.02).
[e]Quadratic (P<.01).
[f]Linear (P<.04).
[g]Linear (P<.10).
[h]4= slight, 5= small, 6= modest.

LEVEL OF UREA IN HIGH GRAIN DIETS: NUTRIENT DIGESTIBILITY, MICROBIAL PROTEIN PRODUCTION, AND RUMEN METABOLISM [1]

C. T. Milton and R. T. Brandt, Jr

Summary

Four ruminally and duodenally fistulated steers (1228 lb) were used in a 4 × 4 Latin square design to evaluate the effects of dietary urea level on nutrient digestion, microbial protein production, and rumen metabolism of steers fed a rolled corn diet without urea or with .5, 1.0, or 1.5% urea (dry matter basis) and no other supplemental protein. Rumen digestibilities increased 33% for organic matter and 25% for starch with the first increment (.5%) of urea, but little or no improvement occurred with subsequent urea additions. Apparent rumen nitrogen digestibility decreased linearly, whereas total tract and true ruminal nitrogen digestibility increased linearly with increased urea. Duodenal nitrogen flow and microbial protein production were not affected by treatment. Rumen pH decreased and total volatile fatty acids increased as dietary level of urea increased. Molar proportions of propionate increased and butyrate decreased linearly with the addition of urea, suggesting increased efficiency of rumen fermentation. Rumen NH_3 increased 63% following 1.0% urea addition to the diet. Urea improved ruminal digestibility and increased efficiency of fermentation but did not increase metabolizable protein to the small intestine.

(Key Words: Urea, Digestibility, Rumen, Steers.)

Introduction

Current information regarding the requirements by finishing steers for rumen degradable nitrogen and metabolizable protein remains limited. In order to establish metabolizable or net protein systems, rumen degradable protein requirements are needed. Urea is a common source of rumen degradable nitrogen in finishing diets. Therefore, the objective of this study was to evaluate the effects of dietary level of urea on nutrient digestion, microbial protein production, and rumen metabolism.

Experimental Procedures

Four ruminally and duodenally fistulated crossbred steers (1228 lb) were used in a 4 × 4 Latin square design to evaluate the effects of dietary urea level on nutrient digestibility and ruminal metabolism. Diets (Table 1) contained no urea or .5, 1.0, or 1.5% urea (dry matter basis) and no other supplemental protein. Steers were fed ad libitum twice daily. Chromic oxide was used as an indigestible flow marker. Each period consisted of a 10-day diet adaptation and a 4-day sample collection period. During the collection period, duodenal digesta and fecal grab samples were collected four times daily to determine ruminal and total tract digestibilities of organic matter, starch, and nitrogen. Rumen fluid was collected at 3, 6, 9, and 12 hours after the a.m. feeding and analyzed for pH, volatile fatty acids, and ammonia. Rumen contents were harvested

[1]The authors express appreciation to Shannon Schneider for assistance in sample collection and laboratory analysis.

twice daily for 2 days to determine microbial protein production.

Results and Discussion

Dry matter intake as a percent of body weight responded cubically to the addition of urea (Table 2). Ruminal organic matter and starch digestibilities tended (P=.23) to respond quadratically to the addition of urea. Both ruminal organic matter and starch were improved by the first increment of urea (.5%), with little or no improvement by subsequent additions. Pooled across level, urea increased ruminal digestibility of organic matter by 26% and starch by 25%, compared to the control diet. Average total tract digestibilities of organic matter were 76%, 87% for starch and were similar (P>.25) among treatments. Apparent rumen nitrogen digestibility increased (P<.07) linearly as level of urea increased. Nitrogen flowing from the rumen with the control diet was 182% of nitrogen intake, which indicates that a vast amount of nitrogen recycling was occurring. Total tract (P<.02) and true ruminal nitrogen (P<.10) digestibilities increased linearly as dietary level of urea increased. Duodenal ammonia nitrogen flow tended (P=.16) to respond quadratically to urea level. Duodenal nitrogen flow, microbial protein production, and microbial efficiency (g of microbial N/100g of organic matter fermented) were not affected (P>.24) by treatment. Rumen pH decreased (P<.01) and total volatile fatty acid concentration increased (P<.01) linearly with increasing urea, suggesting that supplemental urea enhanced organic matter fermentation. Molar proportion of propionate tended (P=.11) to increase, whereas that of butyrate decreased (P<.01) linearly with increasing urea, suggesting that fermentation efficiency was increased. Molar percent acetate responded cubically (P<.01) to the addition of urea. The increased molar percentage of acetate with the .5% urea diet was responsible for most of the cubic effect; other treatments varied little. Acetate:propionate ratios were not affected by dietary urea level. Rumen NH_3 concentration responded cubically (P<.01) to urea additions. Little increase was observed with the first increment of urea (.5%); however, 1.0% urea increased rumen NH_3 63%, with little further increase at 1.5%. The addition of urea improved rumen digestibility of organic matter and starch, increased nitrogen digestibility, and enhanced efficiency of rumen fermentation but did not increase the amount of microbial protein available to the animal. These results suggest that urea addition improved energy utilization by the animal but did not improve metabolizable protein supply to the small intestine. Levels of urea near .5% of the diet appear to be sufficient for optimal rumen digestibility and fermentation efficiency.

Table 1. Diet Composition [a]

	Treatment (% Urea, dry matter basis)			
Ingredient	Control	.5	1.0	1.5
Rolled corn	76.9	77.0	77.2	77.2
Prairie hay	10.0	10.0	10.0	10.0
Supplement 1 [b]	10.6	7.1	3.5	--
Supplement 2 [c]	--	3.4	6.8	10.3
Molasses	2.5	2.5	2.5	2.5
% Crude protein (dry matter basis)	7.7	9.0	10.3	11.6

[a]Dry matter basis. Formulated to supply .7% Ca, .35% P, .7% K, 25 g/ton Rumensin, and 10 g/ton Tylosin. Elemental sulfur was supplied to maintain N:S ratio of 10:1 for all diets. [b]Supplement supplied no urea. [c]Supplement supplied 1.5% dietary urea (dry matter basis) in 1.5 treatment.

Table 2. Effect of Urea Level on Nutrient Digestibility, Microbial Protein Production and Rumen Metabolism

	Treatment (% Urea, dry matter basis)				
Item	Control	.5	1.0	1.5	SEM
Dry matter intake[a], % BW	2.52	2.59	2.15	2.43	.12
Nitrogen intake, g/d	171	205	189	234	9.27
Apparent rumen digestibility, % of intake					
Organic matter	25.3	43.2	36.9	34.3	7.04
Starch	47.1	64.6	59.2	63.7	7.48
Nitrogen[b]	-82.9	-28.1	-37.3	-17.9	11.4
True rumen digestibility, % of intake					
Organic matter	45.6	57.2	55.8	51.6	7.49
Nitrogen[b]	3.7	32.9	33.4	46.7	14.8
Total tract digestibility, % of intake					
Organic matter	74.9	73.9	82.5	75.2	3.74
Starch	84.8	85.2	93.5	87.2	3.80
Nitrogen[c]	55.9	58.4	70.8	67.2	4.40
Duodenal N flow, g/d	321	264	267	291	27.2
Microbial N flow, g/d	146	125	141	153	14.01
Duodenal NH_3-N, g/d	17.6	22.4	29.2	19.6	4.51
Microbial efficiency[d]	2.93	1.75	2.38	4.08	1.13
Rumen pH[e]	6.00	6.06	5.81	5.74	.08
Rumen NH_3[f], mM	2.16	3.07	8.40	9.13	.69
Total VFA[e], mM	113	109	127	133	4.22
Acetate, molar %	44.7	47.1	43.1	44.8	.88
Propionate, molar %	27.3	28.0	29.6	30.3	1.46
Acetate:Propionate ratio	1.78	1.92	1.61	1.68	.14
Butyrate[e], molar %	16.4	12.3	11.2	9.9	1.21

[a]Cubic ($P<.07$).

[b]Linear ($P<.10$).

[c]Linear ($P<.02$).

[d]Grams of microbial N/100g of organic matter truly fermented in the rumen.

[e]Linear ($P<.01$).

[f]Cubic ($P<.01$).

SOURCE AND LEVEL OF CRUDE PROTEIN FOR IMPLANTED FINISHING STEERS

C. T. Milton and R. T. Brandt, Jr.

Summary

One hundred medium-framed, crossbred steers (738 lb) were used to compare non-protein nitrogen to natural protein supplementation of finishing diets for implanted steers. Diets were formulated to contain 11.5 or 13.5% crude protein and were supplemented with either urea or soybean meal. A fifth treatment of cottonseed meal supplementation (13.5% dietary crude protein) was added to evaluate differences between natural sources of rumen degradable protein. Steers were implanted with Revalor® and fed for 132 days. During the first 70 days, daily gain and feed efficiency were improved 8.8 and 6.1%, respectively, for steers supplemented with soybean meal vs urea. No difference was observed with protein level. For the entire feeding period, soybean meal increased dry matter intake 3.8% compared to urea. Protein source and level interacted on daily gain. Increasing dietary protein from 11.5 to 13.5% decreased gain by urea-fed steers 8%, whereas increasing dietary protein from 11.5 to 13.5% increased gain 6.1% for steers supplemented with soybean meal. Soybean meal improved feed efficiency 7.6% compared to urea. Protein level had no effect on feed efficiency. Steers supplemented with soybean meal had larger loineye areas than those supplemented with urea. Carcass finish, percentage of carcasses grading Choice, and yield grade were not affected by treatment. Performance and carcass traits of steers fed cottonseed meal were similar to those of steers fed soybean meal. We conclude that urea cannot meet the metabolizable protein needs of implanted finishing steers. Cottonseed meal did not differ from soybean meal as a protein source in this study.

(Key Words: Finishing Steers, Urea, Soybean Meal, Performance.)

Introduction

Growth promotants, especially the combination of estradiol and trenbolone acetate, have the potential to alter nutrient requirements in feedlot steers. Current information concerning requirements of rapidly growing feedlot steers for rumen degradable and metabolizable protein is limited. Soybean meal and urea are two commonly used sources of protein in finishing diets. The usefulness of urea is limited to the amount that provides sufficient rumen ammonia to maximize microbial protein production and(or) rumen organic matter digestion. Other research presented in this publication suggests that, although urea supplementation increases rumen organic matter digestion, it does not enhance protein flow to the small intestine. Conversely, soybean meal contains a degradable protein fraction to supply ammonia, amino acids, peptides, or other growth factors to rumen microbes, as well as an escape fraction to increase true protein reaching the small intestine. Therefore, soybean meal should be better able to increase the supply of metabolizable protein to rapidly growing steers. Our objective was to evaluate two levels of soybean meal and urea on performance and carcass traits of implanted finishing steers.

Experimental Procedures

One hundred medium-framed crossbred steers (738 lb) were stratified by weight into one of four blocks. Within each block, steers were allocated to one of five pens in a 2×2+1 factorially arranged experiment. Diets (Table 1) contained supplemental protein from urea or soybean meal and were formulated to provide 11.5 or 13.5% (dry matter basis) crude protein. A cottonseed meal diet, formulated to provide 13.5% dietary crude protein, was used as an additional treatment to determine differences between the two natural sources of rumen degradable protein. All diets were formulated (dry matter basis) to contain .7% Ca, .35% P, .7% K, 25 g/ton Rumensin®, and 10 g/ton Tylosin®. Initial weights were the averages of two consecutive early morning weights. Steers were implanted with Revalor and stepped up to final rations in 14 days. Steers were fed the experimental diets for 132 days. Hot carcass weights adjusted by a 62% dressing percent were used as final weights for calculation of gain and feed efficiency. Steers were slaughtered at a commercial plant with carcass data being obtained following a 24-hour chill. The statistical analysis allowed comparisons of: 1) level of crude protein, 2) source of crude protein, 3) interaction between level and source of crude protein, and 4) soybean meal vs cottonseed meal at 13.5% dietary protein.

Results and Discussion

During the first 70 days, daily gain ($P<.05$) and feed efficiency ($P<.10$) were improved 8.8 and 6.1%, respectively, for steers supplemented with soybean meal vs urea (Table 2). Despite rapid gains (3.6 to 4.0 lb/day), increasing dietary protein above 11.5% did not improve daily gain or feed efficiency.

Steers supplemented with soybean meal consumed 3.8% more feed ($P=.23$) over the entire feeding period than those supplemented with urea. A level by source interaction ($P<.05$) was observed for daily gain. Daily gain by steers fed urea was decreased 8.0% by increasing supplementation to 13.5% dietary crude protein, whereas gain by steers fed soybean meal increased 6.1% when crude protein levels were increased from 11.5 to 13.5%. Steers supplemented with soybean meal were 7.6% more efficient ($P<.03$) than those supplemented with urea; feed efficiency was not affected by dietary level of crude protein.

The improvement in performance from soybean meal probably was due to improved feed intake, increased metabolizable protein supply, and(or) improvements in fermentation from the provision of rumen degradable amino acids and peptides. Dietary crude protein level and source interacted ($P<.05$) to affect hot carcass weight. As dietary crude protein level from urea increased from 11.5 to 13.5%, hot carcass weight decreased 2.5%, whereas increasing dietary crude protein level from 11.5 to 13.5% with soybean meal increased hot carcass weight 2.4%. Compared to urea, soybean meal supplementation increased ($P<.10$) loineye area, but no effect of dietary protein level was observed. These data suggest that urea-fed steers were deficient in metabolizable protein and that this was at least partially corrected by supplementing with soybean meal. Dressing percentage, fat thickness (12th rib), marbling score, yield grade, and percentage of carcasses grading choice were not affected by treatment.

Results from previous research suggest that urea supplementation serves to enhance organic matter fermentation in the rumen, with little or no increase in metabolizable protein supply to the animal. Improvements in performance and increased carcass weights and loineye areas, with little increase in carcass finish, suggest that supplementing high grain diets with soybean meal increases the total supply of metabolizable protein to the animal. This may be mediated via increased feed intake, increased microbial protein production, or escape of soybean meal protein to the small intestine. Steers fed cottonseed meal had performance and carcass traits similar to those of steers fed soybean meal. Whether benefits from soybean and cottonseed meals result from the degradable

or escape fractions, or a combination of the two, is unclear. However, nonprotein nitrogen evidently cannot meet the metabolizable protein requirement of rapidly growing steers.

Feed cost of gain and economic return to level and source of crude protein are presented in Table 3. Relative to urea, ration costs were increased when soybean meal or cottonseed meal was fed. However, because of improved daily gain and feed efficiency, cost of gain was similar and economic returns were increased when soybean meal or cottonseed meal was fed.

Table 1. Diet Composition (Dry Matter Basis)

Item	Treatment[a]				
	11.5/Urea	13.5/Urea	11.5/SBM	13.5/SBM	13.5/CSM
Rolled corn	85.4	84.6	80.6	76.2	73.1
Prairie hay	8.0	8.0	8.0	8.0	8.0
Soybean meal[b]	--	--	6.2	10.7	--
Cottonseed meal[b]	--	--	--	--	13.7
Urea	.93	1.58	--	--	--
Vitamins, minerals, and additives[c]	3.2	3.3	2.7	2.6	2.7
Molasses	2.5	2.5	2.5	2.5	2.5

[a]Dietary treatments (% crude protein/source). SBM = soybean meal; CSM = cottonseed meal.

[b]Soybean meal and cottonseed meal contained (as-fed basis) 48 and 41% crude protein, respectively.

[c]To provide dietary levels of 1500 IU/lb Vitamin A, 20 IU/lb Vitamin E, .7% Ca, .35% P, .7% K, 25 g/ton Rumensin®, and 10 g/ton Tylosin®.

Table 2. Effect of Level and Source of Crude Protein on Performance and Carcass Traits of Implanted Finishing Steers

	Treatment [a]					
Item	11.5/Urea	13.5/Urea	11.5/SBM	13.5/SBM	13.5/CSM	SEM
No. pens	4	4	4	4	4	
No. steers	20	20	20	20	20	
Initial wt, lb	736	740	738	739	739	1.8
Final wt[b], lb	1147	1118	1168	1197	1198	12.8
Day 0-70						
Daily feed, lb	21.76	21.28	22.08	22.13	23.39	.58
Daily gain[c], lb	3.64	3.61	3.89	4.07	3.95	.14
Feed/gain[d,e]	6.01	5.89	5.73	5.46	5.95	.21
Day 0-132						
Daily feed, lb	21.66	20.56	21.78	22.09	22.80	.65
Daily gain[f], lb	3.11[h]	2.86[i]	3.25[hj]	3.46[j]	3.47[j]	.09
Feed/gain[c,e]	6.98	7.19	6.72	6.37	6.59	.21
Carcass Traits						
Hot carcass wt[f], lb	711[h]	693[hi]	724[hj]	742[j]	743[j]	7.9
Dressing %	62.0	60.4	61.3	61.2	61.9	.54
Fat 12th rib, in	.46	.41	.44	.49	.48	.03
KPH, %	2.43	2.30	2.38	2.42	2.48	.08
Loineye area[d], sq in	13.9	13.9	14.3	14.9	15.2	.37
Marbling score[g]	5.21	5.04	5.17	5.31	5.17	.16
Yield grade	2.38	2.16	2.26	2.24	2.16	.13
Percent choice	70	70	85	85	80	

[a]Dietary treatments (% crude protein/source) SBM = soybean meal; CSM = cottonseed meal.
[b]Final wt = Hot carcass wt÷.62.
[c]Urea vs soybean meal (P<.05).
[d]Urea vs soybean meal (P<.10).
[e]Feed/gain was analyzed as gain/feed and reported as the reciprocal.
[f]Crude protein level by protein source interaction (P<.05).
[g]4 = slight, 5 = small, 6 = modest.
[hij]Means in a row lacking a common superscript differ (P<.10).

Table 3. Effect of Level and Source of Crude P r otein on Economic Return in Implanted Finishing Steers

	Treatment				
Item	11.5/Urea	13.5/Urea	11.5/SBM	13.5/SBM	13.5/CSM
Ration cost, $/ton [a]	103.20	104.00	109.52	114.66	115.74
Ration cost, $/head	148.21	141.12	157.43	167.17	174.17
Yardage and interest [b]	46.20	46.20	46.20	46.20	46.20
Feed cost of gain, $/lb	.360	.373	.368	.365	.381
Cost of gain. $/lb	.472	.495	.474	.466	.480
Economic return, live basis [c]					
Income, $/head	837.31	816.14	852.64	873.81	874.54
Cost, $/head [d]	822.05	816.99	831.27	841.01	848.01
Return, $/head	15.26	4.15	21.37	32.80	26.53

[a]Urea = $220/ton, soybean meal = $220/ton, cottonseed meal = $205/ton.
[b]Calculated $.35 /head/day.
[c]Cash price $73.00 per cwt.
[d]Initial cost $85.00 per cwt.

D- VS L-METHIONINE UTILIZATION BY GROWING STEERS

C. G. Campbell, E. C. Titgemeyer, and G. St. Jean [1]

Summary

Increasing the amino acid supply to the small intestine of growing cattle can increase performance, if specific amino acids are limiting. Although this can be accomplished by feeding rumen undegradable protein, a more economical approach may be supplementing only those amino acids that actually limit performance, but in a form that will bypass the rumen. Methionine (MET) is thought to be a limiting amino acid for growing cattle. DL-MET, a 50 : 50 mixture of natural methionine (L-MET) and the unnatural optical isomer (D-MET) is used widely in monogastric rations. Ruminally protected DL-methionine is also available for cattle; however, little information is available about its utilization by growing steers. We studied the efficiency of utilization of D- vs L-MET by growing steers by measuring nitrogen retention of steers postruminally supplemented with graded levels of D- or L-MET. Nitrogen retention increased linearly in response to infusion of both L-MET and D-MET, with similar responses for the two isomers. The efficiency of utilization of D-MET relative to L-MET was estimated to be 95.5%. In conclusion, D-MET was similar to L-MET in increasing nitrogen retention of growing steers.

(Key Words: Methionine, Growing Steers, Nitrogen Retention.)

Introduction

Current research has looked at rumen undegradable protein sources as ways to increase the amount of amino acids available to the small intestine of growing cattle. An increase in amino acid availability should result in greater protein deposition by growing cattle, if specific amino acids limit performance. Alternatively, supplying only those limiting amino acids could be a more economical means of increasing performance. The swine and poultry industries currently supplement methionine (MET) as DL-MET, a 50:50 mixture of the natural L-MET and the unnatural D-optical isomer. Monogastric animals can convert D-MET to L-MET fairly efficiently. However, despite the fact that ruminally protected DL-MET is now commercially available for cattle, there is little information regarding the utilization of the D-MET by ruminant animals. Our objective was to determine whether D-MET was as efficiently utilized as L-MET by growing cattle.

Experimental Procedures

Five ruminally cannulated Holstein steers averaging 396 lb were utilized in a 5 × 5 Latin square and kept in individual metabolism crates in an environmentally controlled room. Each period lasted 6 days; the first 2 days for adaptation to treatments and the last 4 days for total collection of feces and urine to measure nitrogen retention. Treatments were no MET (control) or continuous abomasal infusion of 2 g/day of

[1]Department of Clinical Sciences.

L-MET, 4 g/day of L-MET, 2 g/day of D-MET, or 4 g/day of D-MET. To be sure that only MET limited steer performance, a diet low in ruminal undegradable protein was fed. The diet contained 84.7% soyhulls, 6.7% wheat straw, 8.2% mineral mix (minerals, vitamins, Bovatec, and molasses), and .5% urea and was fed twice daily at 6.6 lb/head/day. Because of the restricted intake, 150 g acetate, 150 g propionate, and 37.5 g butyrate were infused daily and continuously into the rumen to ensure that energy would not limit performance. Dextrose also was infused into the abosmaum continuously at 300 g/day to increase energy availability. To ensure that amino acids other than methionine would not limit nitrogen retention, 15 g of L-valine, 20 g of L-leucine, 15 g of L-isoleucine, 23.6 g of L-lysine, 7.4 g of L-histidine, 15 g of L-arginine, 14.7 g of L-threonine, 25 g of L-phenylalanine, 4.9 g of L-tryptophan, 75 g of L-glutamate, and 25 g of glycine were infused into the abomasum daily.

Results and Discussion

Nitrogen retention increased as the amount of infused MET increased (Table 1). This response was similar between D- and L-MET, with D-MET being 95.5% as efficient as L-MET. As expected, the differences in nitrogen retention among treatments were due to changes in urinary nitrogen; no significant differences occurred in fecal nitrogen. A regression model, used to estimate nitrogen retention from MET supplementation, showed nitrogen retention (g/day) equal to 19.2 + (1.81*D-MET) + (1.90*L-MET).

A major requirement of nitrogen in the body is for muscle protein synthesis, so we would expect skeletal muscle deposition to parallel as nitrogen retention. Previous work has estimated nitrogen content of tissue gain at 3.26%. Using that value, each gram of extra MET per day of treatment should lead to .25 lb of tissue, if all the nitrogen retained went for tissue protein gain, up to the point where MET is no longer limiting. These high levels of potential protein deposition relative to the small amount (4 and 2 g) of MET demonstrate the potential that exists for rumen-protected amino acids.

In conclusion, D-MET appears to be as efficient as L-MET in supporting nitrogen retention in growing steers. Ruminants apparently convert D-MET to the L-isomer as efficiently as monogastrics. Therefore, growing cattle diets that utilize a ruminally protected form of DL-MET should respond as favorably as those postruminally supplemented with L-MET.

Table 1. Effect of Postruminal Supplementation of D- or L-Methionine (MET) on Nitrogen Retention of Growing Holstein Steers

		L-MET		D-MET		
Nitrogen (g/d)	Control	2 g	4 g	2 g	4 g	SEM
Intake + infused	86.8	86.8	87.3	86.1	87.1	.6
Fecal	24.1	24.5	25.1	24.7	25.5	.6
Urinary[ab]	43.4	38.9	35.5	38.8	35.0	1.4
Retained[ab]	19.2	23.3	26.6	22.5	26.6	1.6

[a]Linear effect of L-MET (P<.05).

[b]Linear effect of D-MET (P<.05).

EFFECT OF RUMEN-ESCAPE PROTEIN LEVEL ON FEEDLOT PERFORMANCE AND CARCASS TRAITS OF IMPLANTED VS NONIMPLANTED YEARLING STEERS

C. D. Reinhardt and R. T. Brandt, Jr.

Summary

One hundred eighty yearling steers (743 lb) were blocked by weight; implanted with Synovex® (S), Synovex plus Finaplix® (SF), or not implanted (C); and fed diets containing 11.75% (L), 13.0% (M), or 14.25% (H) crude protein with all supplemental protein above 11.75% being supplied by corn gluten meal and blood meal in a 50:50 ratio (crude protein basis). An additional protein level fed to S and SF implanted cattle was H for the first 70 days on feed and L thereafter (H-L). Animals were reimplanted on day 70. Steers treated with SF gained faster and more efficiently than non-implanted cattle. Differences in protein level had no effect on fat deposition in control steers, but cattle receiving SF and consuming M had more back fat and kidney, pelvic, heart (KPH) fat than those fed either H or L and also had more marbling than those fed H. Also, no apparent differences occurred between cattle fed M throughout the trial and those switched from H to L at 70 days.

(Key Words: Estradiol, Trenbolone Acetate, Implants, Escape Protein, Protein Level.)

Introduction

Cattle receiving growth promotants, particularly trenbolone acetate (TBA), have greatly enhanced rates of lean deposition, which may increase their demand for metabolizable protein above traditional levels of supplementation. The amount of protein reaching the small intestine can be increased by using high rumen-escape protein sources such as blood meal and corn gluten meal, while requirements for ruminally available nitrogen are met with urea.

Experimental Procedures

One-hundred eighty head of mixed crossbred yearling steers were received off North Texas summer grass in September, 1992. Cattle were dewormed, vaccinated, ear-tagged, and fed a 57% concentrate ration for 28 days on a receiving study. The cattle were weighed (October 13 and 14, 1992; avg 743 lb); implanted with either Synovex-S (S), Synovex-S plus Finaplix (SF), or not implanted (C); and stepped up onto a 12% roughage finishing ration (Table 1). Cattle also were assigned to a diet containing either 11.75%, 13%, or 14.25% crude protein. The two higher protein levels were achieved with a 50:50 blend (crude protein basis) of blood meal and corn gluten meal (crude protein basis). An additional protein level assignment fed to S and SF implanted cattle was H for the first 70 days on feed and L thereafter (H-L). Cattle were reimplanted with their respective implants on day 70 and weighed at 35-day intervals until finished. Final weights were the averages of weights on 2 consecutive days (March 30 and 31, 1993). Hot carcass weights were taken at slaughter, and 12th rib fat thickness, ribeye area, KPH estimation, and marbling measurements were taken after a 24-hour chill.

Results and Discussion

Rate of gain was slower than expected for this size and type of cattle, even though intake was near expected levels across all treatments, probably because of several periods of freezing rain. These low gains

may have limited the response to bypass protein supplementation.

Final weights in this study were hot carcass weights adjusted to an average dressing percent of 61.1. Cattle implanted with SF gained faster (P<.05; Table 2) and more efficiently than nonimplanted steers. Steers implanted with SF also had heavier carcasses and greater ribeye areas (P<.05).

Interactions (P<.10) between implant and protein level affected dressing percent, fat thickness, KPH fat, and marbling. Steers receiving SF and consuming M had slightly lower dressing percentages, which may have been a function of slightly higher intake. Within the control group, no differences occurred in fat deposition, but within the SF treatment, steers consuming M had more back and KPH fat than those consuming either L or H (P<.10) and slightly more marbling than steers consuming H (P=.14).

Implants have been shown to be most effective in cattle with superior genetics for growth and in cattle on high energy intakes. Feedlot trials have shown benefits of escape protein supplementation, with the greatest advantages in fast gaining cattle. Although the SF-treated steers outperformed controls, faster gains across all treatments would be expected during milder weather. For this reason, further research is warranted on crude protein level and escape protein supplementation for implanted feedlot cattle.

Table 1. Composition of Experimental Diet

Ingredient	Low	Medium	High
	---------- % of Dry Matter ----------		
Corn	80.47	78.64	76.80
Corn silage	12.0	12.0	12.0
Supplement [a]	7.53	7.54	7.53
Blood meal	—	.79	1.57
Corn gluten meal	—	1.04	2.08
Crude protein	11.75	12.99	14.24

[a]Provided .86% dietary urea. Supplements were formulated so that diets contained (dry basis) .7% Ca, .35% P, .7% K, .35% salt, and 100 ppm Zn.

Table 2. Effects of Implant and Protein Level [a] on Steer Performance

	Control			Synovex® + Finaplix®				Synovex®	
Item	Low	Med	High	Low	Med	High	High-Low	Med	High-Low
Daily gain, lb [bc]	2.50	2.16	2.17	2.54	2.54	2.37	2.71	2.38	2.38
Daily feed, lb	20.28	20.45	20.15	20.57	20.84	20.12	19.98	20.42	20.67
Gain:Feed [b]	.119	.103	.103	.120	.118	.115	.131	.115	.115
Dressing % [d]	63.0[e]	61.3[ef]	59.5[ef]	60.5[ef]	58.6[f]	60.4[ef]	62.7[ef]	61.9[ef]	61.8[ef]
Carcass, lb [bc]	721	687	687	724	726	709	741	709	708
Back fat, in [d]	.44[e]	.46[ef]	.47[ef]	.45[e]	.58[f]	.39[e]	.46[ef]	.40[e]	.47[ef]
KPH, % [d]	2.61[fgh]	2.63[gh]	2.64[gh]	2.37[e]	2.70[h]	2.38[e]	2.43[efg]	2.41[ef]	2.43[efg]
REA, sq. in [b]	12.0	11.8	11.9	12.7	13.0	12.4	12.6	12.6	12.1
Yield grade	3.03	3.03	3.03	2.80	3.09	2.66	2.90	2.64	2.99
Marbling [di]	4.10[g]	4.11[g]	4.14[g]	3.69[ef]	3.88[efg]	3.52[e]	3.65[ef]	3.68[ef]	3.97[fg]
Choice, %	35	50	40	25	30	20	25	30	35

[a]Low=11.75% crude protein, Med=13% crude protein, High=14.25% crude protein.

[b]Synovex + Finaplix vs. Control (P<.05). Adjusted to common dressing % of 61.1.

[c]Low vs. High (P<.10).

[d]Protein × Implant interaction (P<.10).

[e,f,g,h]Within a row differ (P<.10).

[i]3=Slight[0], 4=Small[0].

PAYOUT CHARACTERISTICS OF ANABOLIC AGENTS FROM SYNOVEX®, FINAPLIX®, AND REVALOR® IMPLANTS IN FINISHING YEARLING STEERS

P. S. Hickman, R. T. Brandt, Jr., D. M. Henrick s [1], J. S. Stevenson, and J. E. Minton

Summary

Forty, individually fed, yearling steers (750 lbs) were used to measure payout characteristics of different tre n bolone acetate-containing implants and to correlate those characteristics to growth response. Treatments were 1) control, 2) Synovex-S®, 3) Finaplix-S®, 4) Synovex® plus Finaplix, and 5) Revalor®. Steers were fed a 12% crude protein, corn-based, finishing diet for 112 days. Compared to Revalor, which had a fairly constant payout over time, the combination of Synovex plus Finaplix resulted in higher blood levels of estradiol and trenbolone acetate (TBA) up to 56 days, followed by a relatively rapid declin e to 112 days. Despite elevated levels of TBA at 112 days for all TBA-containing implants and elevated estradiol at 112 days from Revalor steers, implants d id not improve performance in the final 28 days before slaughter. Short (less than 120 days) feeding periods may favor implants that increase blood levels of anabolics for shorter (56-84 day) periods. Data for plasma urea nitrogen were interpreted to indicate that 12% cr u de protein was adequate for yearling steers gaining approximately 3.5 lbs per day.

(Key Words: Tre n bolone Acetate, Estradiol, Serum Hormones, Feedlot.)

Introduction

Anabolic implants are proven, safe, and effective management tools to enhance profitability for cattle feeders. In order to optimize performance and maximize return, implant program s should be custom designed for each pen of cattle, based on cattle type, projected days on feed, and market or contract specifications for finished cattle.

Research has shown that, in beef cattle, maximal response to trenbolone acetate (TBA) has generally been achieved when it was administered in combination with an estrogenic implant used once and administered as the terminal implant in the schedule. Recent K-State research indicated that calf-fed Holstein steer performance is enhanced with multiple TBA implants, although carcass quality grade may be reduced. This places added importance on knowing release rates from TBA-containing implants, in order to maximize performance and minimize negative effects on carcass quality. Estrogenic implants also may reduce carcass quality if administered too close to slaughter (less than 60-65 days remaining on feed). Two TBA-containing implants are commercially available. Finaplix-S contains 140 mg TBA in a lactose-carrie r, and Revalor S contains 120 mg TBA plus 24 mg estradiol in a cholesterol-based implant. Synovex-S contains 20 mg estradiol benzoate and 200 mg progesterone. We measured payout characteristics of these implants and corresponding performance of finishing yearling steers.

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Experimental Procedures

Forty, crossbred, yearling, beef steers (750 lbs) were penned individually and fed a rolled corn finishing diet (10% roughage, dry basis) that contained 12% crude protein. Steers had been previously implanted with Synovex-S and backgrounded on corn silage for 90 days. Previous implants were removed 14 days before this study began.

Eight steers were assigned to each of five implant treatments: 1) Control (no implant), 2) Synovex-S only (SYN), 3) Finaplix-S only (FIN), 4) Synovex plus Finaplix used together (SYN + FIN), and 5) Revalor (REV). Blood samples were obtained twice daily (30 minutes apart, before the morning feeding) on days 0, 14, 28, 42, 56, 84, and 112. Serum was analyzed for estradiol, trenbolone acetate, and growth hormone. Plasma was analyzed for urea nitrogen. The trial was conducted for 112 days (May 1 to August 21, 1992). Steers then were slaughtered, and carcass characteristics were measured.

Results and Discussion

As expected, serum trenbolone acetate (TBA) concentrations were essentially zero for control and SYN steers and lower ($P<.05$) than those for the other treatments at all sampling times (Figure 1). Serum concentrations of TBA were higher ($P<.10$) in steers implanted with Finaplix vs Revalor for the first 42-56 days of the study, then declined. At 84 days, TBA levels were similar for steers implanted with Finaplix or Revalor, but were higher ($P<.10$) at 112 days for Revalor steers. Thus, TBA in Revalor apparently pays out at a fairly constant rate (at least to 112 days), whereas payout from Finaplix is characterized by a more rapid release for the first 42-56 days, followed by a decline.

Changes in serum estradiol concentrations (Figure 2), although somewhat more variable, show similar trends. Estradiol in Revalor-implanted steers remained relatively constant throughout the 112 days. Conversely, estradiol was elevated for SYN+FIN steers for approximately 84 days, then dropped rapidly. Serum estradiol levels were higher for SYN+FIN vs SYN steers throughout the first 84 days of the study. Although the reason for this synergistic effect is not entirely clear, we know that significant amounts of TBA can be converted to estradiol in the body. Alternatively, TBA can displace estradiol from receptor sites, thus increasing circulating estradiol concentration.

In our study, implant type did not affect serum growth hormone or plasma urea concentrations. Generally, implantation with estradiol has been associated with increased blood concentrations of growth hormone, although most of that work has been done with younger animals. These data indicate that some factor other than increased growth hormone is responsible for growth promotion by anabolic implants. Time on feed had significant effects on growth hormone and plasma urea nitrogen (Figure 3). Growth hormone concentration decreased linearly ($P<.01$) with time on feed, as animals approached physiological maturity. Plasma urea nitrogen increased ($P<.01$) with time on feed. This might be interpreted to indicate that 12% crude protein progressively exceeded the protein requirement of the steers during the finishing period, because elevated plasma urea is associated with protein wastage. Further, the lack of an implant effect or implant × time interaction suggests that 12% crude protein (50% soybean meal N:50% urea N) met or exceeded the protein requirements for implanted steers in this study. Compared to nonimplanted control steers, feed efficiency was improved 16.8, 8.1, 28.7 and 16.8% for steers implanted with Synovex, Finaplix, Synovex plus Finaplix, and Revalor, respectively. No deleterious carcass traits were seen for any implant treatment.

Ears were collected at slaughter and evaluated for abscesses. Large implant-site abscesses were noted for 2 of 16 steers implanted with Synovex, 2 of 16 steers implanted with Finaplix, and 1 of 8 steers implanted with Revalor. Blood levels of estradiol and TBA for steers with abscessed

implant sites did not deviate significantly from treatment averages.

Regardless of mechanisms involved, elevated serum concentrations of hormones generally correlated well with period daily gains by the steers (Figure 4), particularly for SYN+FIN steers. No gain response from any implant was seen in the last 28 days, despite elevated serum levels of TBA (REV, SYN+FIN, FIN) and estradiol (REV). Lack of an implant response as cattle approach slaughter has been observed in other Kansas State research. This suggests that finishing weight is nearing mature weight, and little response should be expected from anabolic agents. The implication is that, for yearlings fed for 120 days, the time frame for an implant response may be only about 90-100 days. A more rapid, shorter-lived payout of anabolic agents may promote faster, more efficient growth in this instance.

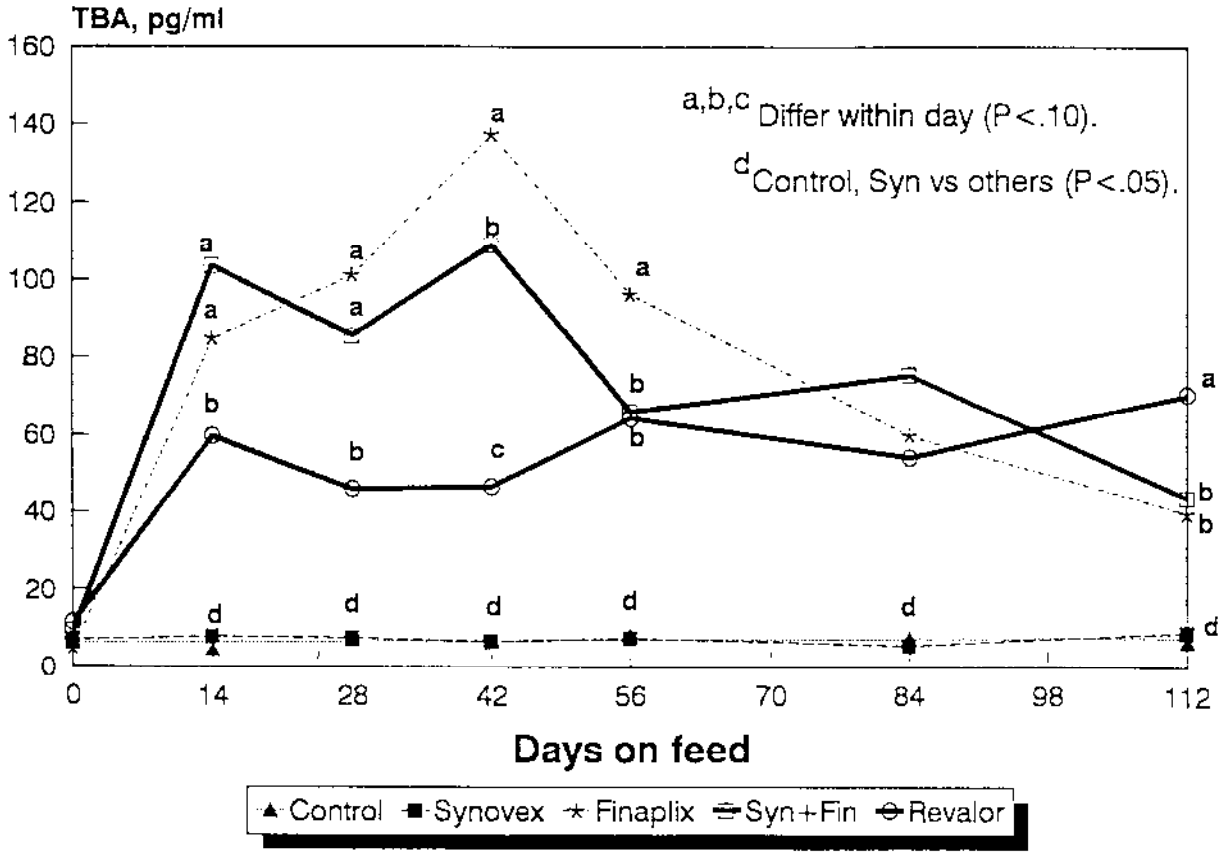

Figure 1. Serum Concentrations of Trenbolone Acetate

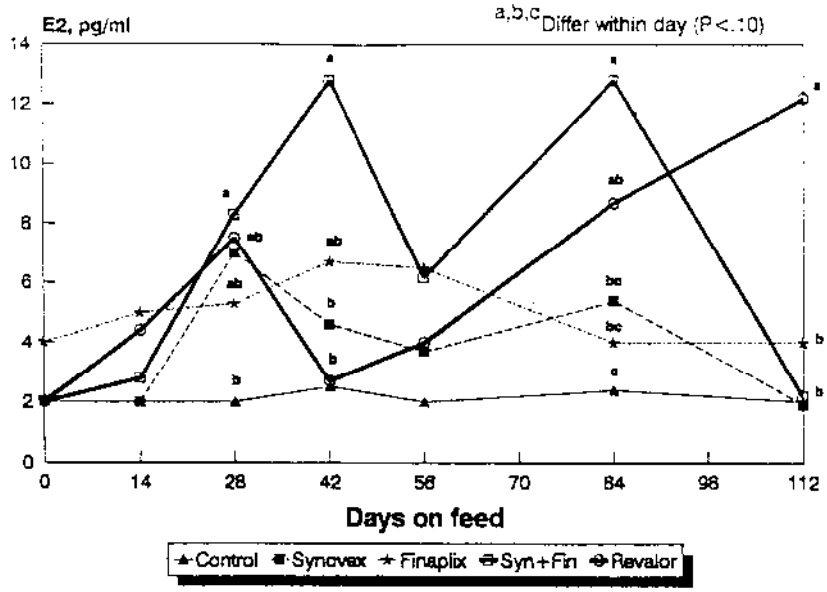

Figure 2. Serum Concentrations of Estradiol (E_2)

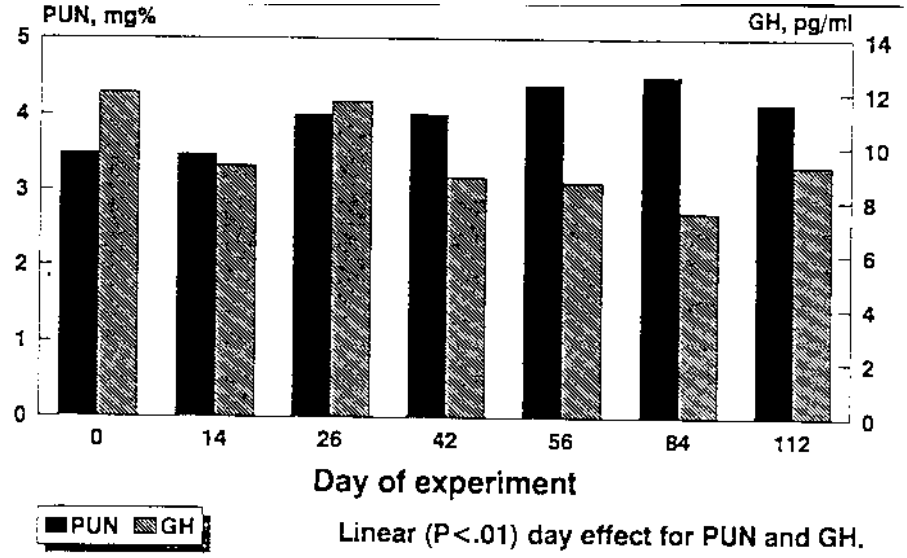

Figure 3. Plasma Urea Nitrogen (PUN) and Growth Hormone (GH) in Implanted Steers

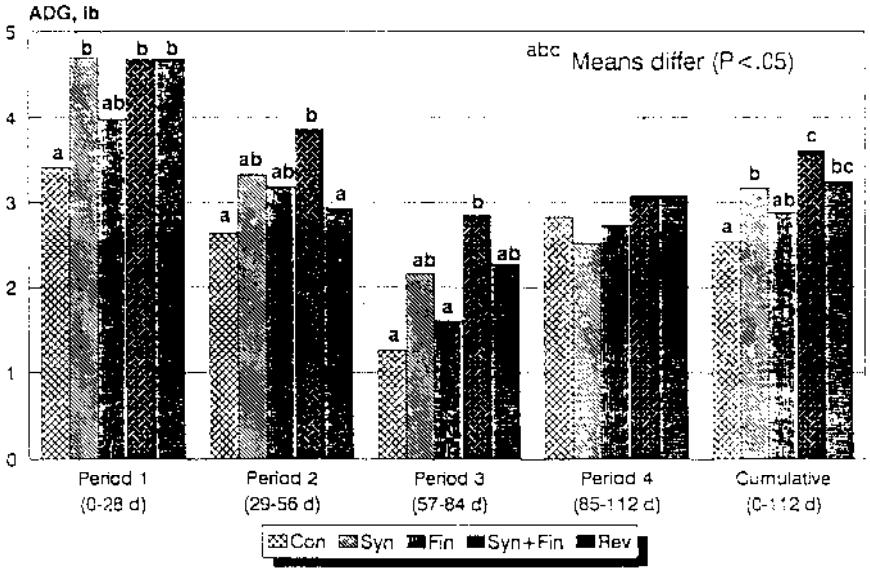

Figure 4. Average Daily Gain (ADG) by Implanted Steers

ROUGHAGE LEVELS AND COMPARISON OF MIXED RATIONS VS SELF-FEEDERS IN WHOLE SHELLED CORN FINISHING PROGRAMS

C. T. Milton, R. T. Brandt, Jr., and S. A. Shuey

Summary

Two trials were conducted to evaluate roughage levels in whole shelled-corn finishing diets and to compare use of self-feeders to a total mixed ration in a whole corn program. In trial 1, steers were fed whole corn diets alone or with 4 or 8% roughage or a rolled corn diet with 8% roughage. Increasing the roughage level increased dry matter intake, feed required per unit of gain, and carcass weight and finish, and reduced the incidence of liver abscesses. Despite better feed efficiency and lower costs of gain, reducing the dietary roughage level reduced profitability because of lighter slaughter weights. In trial 2, feeding 4% vs no roughage in a whole-corn finishing program increased dry matter intake and tended to increase rate of gain by finishing heifers. No performance benefit resulted from feeding a total mixed ration vs using self-feeders and providing chopped hay in a feed bunk.

Feeding very little or no roughage in whole corn diets can improve feed efficiency and reduce cost of gain. However, these advantages can be outweighed by potentially lower slaughter weights and increased metabolic problems (acidosis, bloat, liver abscesses).

(Key Words: Whole Shelled Corn, Roughage Level, Feedlot.)

Introduction

Whole shelled corn has been successfully used in cattle finishing programs for years. Whole corn diets are assumed to need lower amounts of roughage, because whole corn is thought to have some roughage value itself. However, little information exists for optimal roughage levels in whole corn rations. Further, although unproven, it is assumed that feeding a total mixed ration is preferable to using self-feeders in whole corn programs because roughage is supplied at the same time as the concentrate. Therefore, two studies were conducted to 1) identify the optimal roughage level for whole-corn finishing diets, and 2) to compare use of a whole corn ration (with or without roughage) in self-feeders to a total mixed ration.

Experimental Procedures

Trial 1. Ninety-two Angus crossbred steers (633 lbs) were allotted to one of three weight blocks and then assigned to one of four pens within each block. Treatments were whole shelled corn (WSC) diets without roughage or with 4 or 8% roughage (dry basis). A fourth treatment, dry rolled corn plus 8% roughage, served as a positive control.

In addition to the appropriate roughage level, all diets contained (dry basis) 3% molasses and 6.5% of a pelleted protein supplement. Diets were formulated to contain 12.25% crude protein, .70% Ca, .35% P, .7% K, and 100 ppm Zn. Diets contained monensin (27 g/ton) but no tylosin. Steers had been vaccinated, dewormed, and implanted with Revalor-S®. The trial was conducted from January 2 to June 15, 1993 (166 days). Slaughter and carcass data were obtained at the conclusion of the study.

Trial 2. Sixty-three heifer mates (715 lbs) to the steers in Trial 1 were used to evaluate the effects of offering roughage to cattle finished on whole corn and pelleted protein supplement in self-feeders and to compare these systems to a total mixed ration. Treatments were: 1) a total mixed ration with 4% alfalfa hay (dry basis), 2) a whole corn plus pelleted protein supplement offered ad libitum from self-feeders, and 3) treatment 2 plus 4% hay offered in a feed bunk.

Diets and supplements were similar to those in Trial 1, except molasses was reduced to .75% of the dry ration to facilitate handling in the self-feeders. Corn replaced molasses in these rations. Heifers were vaccinated, dewormed, and implanted with Finaplix-H and Ralgro. The study was conducted from April 20 to July 19, 1993 (90 days). Daily hay fed in treatment 3 was based on the previous day's hay consumption by heifers in treatment 1 and was offered in the morning. Three pen replicates were used per treatment.

Results and Discussion

Trial 1. Although adding roughage up to 8% of the diet dry matter linearly increased (P<.05) total intake by steers fed whole shelled corn (Table 1), corn intake remained constant. Steers fed dry rolled corn diets (8% roughage) consumed 10.5% more (P=.13) dry matter and corn than steers fed WSC with 8% roughage. The latter observation is consistent with other research and suggests that chewing efficiency (particle size reduction) may limit intake of whole vs processed corn.

Daily gain tended (P=.2) to increase with increased roughage level. Increased roughage levels resulted in a linear increase (P<.10) in feed required per unit of gain, as well as a linear reduction (P<.10) in net energy concentration of the diet. The latter, calculated from performance, was expected because adding roughage dilutes the net energy concentrations of high-grain diets.

The tendency for increased weight gain with increased roughage level translated into heavier, more highly finished carcasses (Table 2). Hot carcass weight and degree of marbling (P<.10) and backfat thickness (P<.05) increased as roughage level increased. The incidence of liver abscesses was greatest (P=.11) without roughage and tended to decline as roughage level was increased. The severity of liver abscesses was also greatest without roughage and tended to decline linearly (P<.2) with added roughage.

Adding roughage to whole shelled corn diets not only reduced feed efficiency, but increased both cost of gain and calculated selling breakeven price for the steers (Table 2). However, because of more weight sold (live or carcass) from the 8% roughage treatments, net returns were not different. Therefore, it is important to remember that reducing cost of gain does not always translate into increased profitability.

Trial 2. Similar to trial 1, heifers fed roughage, whether in a complete mixed ration or separately in the feed bunk, consumed more feed (P=.06) and gained 10.6% faster (P=.19) than heifers fed from self-feeders alone (Table 2). The differences would likely have been greater had 8% roughage been used.

Although reported efficiencies are similar, they do not include a heifer that died of bloat on the self-fed (no hay) treatment. Accounting for that heifer changes daily gain to 2.58 lb/day and feed/gain to 6.80. We observed no apparent advantage to feeding a total mixed ration vs using self-feeders and offering an equivalent amount of roughage in the feed bunk.

Table 1. Performance, Net Energy Values, Carcass Traits, and Economics (Trial 1)

	Treatment[a]			
Ingredient	WSC-0	WSC-4	WSC-8	DRC-8
In wt., lb	632	633	632	634
Payweight out, lb[b]	1149	1152	1171	1190
Daily gain, lb	3.12	3.13	3.24	3.35
Daily feed, lb DM[c]	18.6	19.6	20.5	21.6
Feed/gain[d]	6.06	6.33	6.37	6.54
Corn/gain	5.41	5.41	5.21	5.32
NEm, Mcal/cwt				
Diet[d]	98.3	94.7	93.5	91.8
Corn	102.7	100.1	100.7	98.7
NEg, Mcal/cwt				
Diet[d]	67.6	64.4	63.3	61.9
Corn	70.4	68.5	69.0	67.3
Hot carcass wt, lb[d]	704	703	731	753
Dressing pct.	61.3	60.9	62.6	63.3
Backfat, in[c]	.36	.39	.50	.51
KPH fat, %[e]	2.37	2.34	2.52	2.55
Marbling[d,f]	Mt[12]	Mt[28]	Mt[71]	Mt[60]
Choice, %	100	100	100	100
Liver data				
Abscessed, %[g]	35	13	9	7
Severity score[h]	.48	.17	.17	.44
Cost of gain, $/lb[i]	.449	.464	.460	.469
BE at 1150, $/cwt[j]	72.47	73.10	73.35	73.77
Profit (loss), $/head[k]				
Sold live	28.27	21.83	28.96	30.39
In the meat	4.28	(5.60)	20.60	33.96

[a]WSC=whole shelled corn; DRC=dry rolled corn; 0, 4, or 8 is percentage alfalfa hay in the diet (dry basis). [b]Final live weight pencil shrunk 4%. [c]Linear (P<.03). [d]Linear (P<.10). [e]Percentage kidney, pelvic, and heart fat. [f]Mt=modest. [g]Treatment effect (P=.11) using Chi-square. [h]0=no abscess, 3=severely abscessed. [i]Based on $2.40/bu corn. Ration costs marked up 20%, and $.35/head/day charged for yardage and interest. [j]Breakeven price for 633 lb feeders at $95/cwt. [k]Based on live weight price of $75/cwt and carcass price of $119/cwt.

Table 2. Performance of Heifers Fed Whole Shelled Corn in a Total Mixed Ration or Self-Feeders (Trial 2)

	Treatment[a]			
Item	TMR	Self	Self + Hay	SEM
Beginning wt, lb	711	722	712	
End wt, lb	1006	1003	1012	
Daily gain, lb[b]	3.29	3.12	3.33	.097
Daily feed, lb dry matter[c]	18.8	17.5	18.6	.38
Feed/gain	5.71	5.59	5.59	.121

[a]TMR=total mixed ration; Self=self-fed whole corn plus pelleted supplement self-fed; Self + hay=self-fed plus 4% hay provided in feed bunk. [b]Roughage vs none (P=.19). [c]Roughage vs none (P=.06).

ROUGHAGE LEVEL AND CORN PROCESSING IN FINISHING DIETS: SUBACUTE ACIDOSIS

S. A. Shuey, R. T. Brandt, Jr., S. M. Gramlich, and C. T. Milton

Summary

Roughage level and method of corn processing were evaluated for the propensity to cause subacute acidosis in a controlled acidosis challenge model. Four ruminally fistulated steers were adapted to a high grain diet, randomly allocated within a 4 × 4 Latin square, and fed a corn-based finishing ration at 2% of BW/day (dry basis) in two equal feedings. Chopped alfalfa hay was used as the roughage source and added at 8% of the diet dry matter or not added. Corn was fed either whole (WSC) or dry rolled (DRC). Roughage level and grain processing had no effect on postchallenge molar percentage of acetate or total volatile fatty acid production. An interaction (P<.05) was seen in both percent propionate and acetate:propionate ratio. Eliminating roughage in the WSC diet resulted in increased production of propionate and a lower acetate:propionate ratio. Ruminal pH at 3 hours postchallenge and intake during the recovery period were lower (P<.05) for 0 vs 8% roughage. Ruminal pH at 3 and 6 hours postchallenge was lower (P<.05) for DRC than for WSC. Intake during the recovery period did not differ between DRC and WSC. Hours below pH 5.6 were greater (P<.05) for DRC vs WSC and for 0 vs 8% roughage. Though statistically higher (P<.05), no biologically significant levels of lactate were found for either DRC or WSC. This study indicates that adding roughage or feeding WSC vs DRC reduces the propensity for subacute acidosis.

(Key Words: Cattle, Grain Processing, Roughage Level, Rumen pH, Acidosis.)

Introduction

Research has shown that decreasing roughage in finishing diets leads to improved feed efficiency and decreased cost of gain. This is most likely due to higher digestible energy values for grain than roughage. However, low or no roughage may result in increased incidences of liver abscesses and digestive upsets. Acute rumen acidosis would be the digestive upset most commonly expected. However, subacute acidosis may represent a larger problem, because reductions in feed efficiency and weight gain, caused by fluctuations in dry matter intake, exist even though cattle may not be clinically ill. Our study was conducted to determine the propensity for subacute acidosis with two different roughage levels. We also compared whole shelled vs dry rolled corn because whole shelled corn is thought to have some roughage value and, thus, may be used successfully in a diet with a lower level of roughage.

Experimental Procedures

Four ruminally fistulated black-baldy steers (550 kg) were adapted to a high grain diet, randomly allotted within a 4 × 4 Latin square with a 2 × 2 treatment structure, and fed a corn-based finishing diet at 2% of BW/day (dry basis). Chopped alfalfa hay was the roughage source and was added at 8% of the diet dry matter or not added. Corn was either whole shelled (WSC) or dry rolled (DRC). All diets were isonitrogenous (11.8% crude protein). Each 15-day period consisted of a 10-day treatment adaptation (diet dry matter at 1% of BW at 8 a.m. and 8 p.m.), a fasting period (no feed given at 8

p.m. on day 11), a feeding challenge on day 12 (1.5% of BW in a bunk at 8 a.m. plus 1% of BW via rumen fistula 1.5 hours later), and an intake recovery period when feeding returned to the prechallenge regimen. On the challenge day, any uneaten feed at 1.5 hours postfeeding was given via the rumen fistula. Feed refusals were weighed and discarded each day prior to the 8 a.m. feeding. At the beginning of each period, steers were inoculated with 1 liter of ruminal fluid from a common donor. Ruminal samples were obtained at feeding and 3, 6, 9, 12 hours postfeeding (day 10); 3, 6, 9, 12, 18, 24 hours postfeeding (day 12); and 12 and 24 hours after the a.m. feeding on days 13-15. Ruminal samples were analyzed for pH and concentrations of volatile fatty acids (VFA) and lactate (L).

Results and Discussion

Date are shown in Table 1. Neither roughage level nor grain processing had an effect on postchallenge molar percentage acetate (49%) or total VFA (106 *m*M). An interaction was seen for both propionate concentration and acetate:propionate level. Eliminating roughage in the WSC diet resulted in an increased percentage of propionate and a correspondingly lower acetate:propionate ratio. Roughage level had no effect on those measures in the DRC diet. Though statistically different ($P<.05$), no biologically significant levels of lactate were observed. Intake during the recovery period did not differ between DRC and WSC. Ruminal pH at 3 hours postchallenge and intake during the recovery period were both lower ($P<.05$) for 0 vs 8% roughage (5.29 vs 5.69 and 1.7 vs 1.9 %BW/day, respectively). Ruminal pH at 3 and 6 hours post feeding on the challenge day was lower ($P<.05$) for DRC than for WSC (Figure 1), and pH remained below 5.6 longer for DRC ($P<.05$; Table 1). Hours below pH 5.6 averaged 10.62 at 0% roughage vs 7.72 for 8% ($P<.06$). The addition of roughage to the diet most likely increased mastication time and, thus, increased the amount of saliva available in the rumen for buffering. Increased saliva production probably allowed the rumen environment to remain more stable during the challenge period and allowed a more rapid return to the prechallenge intake level. Lower rumen pH for DRC than WSC may have been due to a combination of the roughage value attributed to the WSC and the faster fermentation (acid production) from the DRC. Therefore, this study indicates that adding roughage or feeding WSC vs DRC reduces the propensity for subacute acidosis.

Table 1. Ruminal Fermentation Patterns during Subacute Acidosis Challenge

	Dry Rolled Corn		Whole Shelled Corn	
Item	0% Alf.	8% Alf.	0% Alf.	8% Alf.
Total VFA, *m*M	110.78	102.99	106.04	105.11
Acetate, %	46.37	48.87	45.85	49.93
Propionate [a]	40.84	40.35	43.01	39.75
Acetate:Propionate [a]	1.22	1.36	1.09	1.45
Lactate, *m*M [b]	.09	0.13	0.06	.05
Hours below pH 5.6 [cd]	11.28	10.35	9.95	5.08
Intake Recovery (%BW) [d]	1.69	1.94	1.74	1.90

[a]Roughage level × grain processing interaction ($P<.05$).
[b]Dry rolled vs whole shelled corn ($P<.01$).
[c]Dry rolled vs whole shelled corn ($P<.05$).
[d]0 vs 8% roughage ($P \leq .06$).

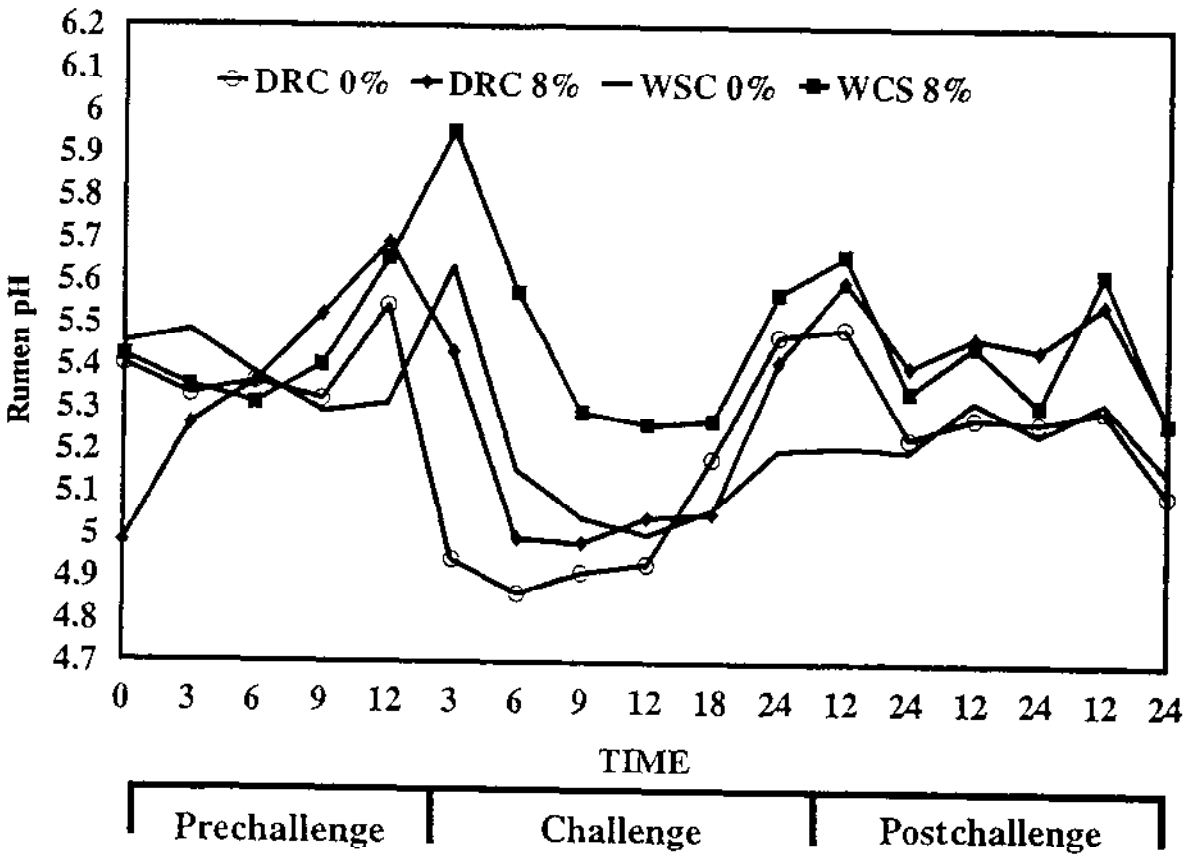

Figure 1. Effect of Corn Processing and Level of Roughage on Ruminal pH

EFFECTS OF ALFALFA FORM AND LEVEL ON SUBACUTE ACIDOSIS

B. J. Healy, R. T. Brandt, Jr., and S. M. Gramlich

Summary

Eight ruminally cannulated crossbred steers (1225 lb) were used to investigate the effects of 5 vs 10% alfalfa hay or pellets on rumen characteristics during subacute acidosis. Alfalfa hay was obtained from one source, and alternate bales were either chopped (3- to 4-inch length) or ground and pelleted (3/8-inch pellet). Intake during the recovery period after feed challenges tended (P=.12) to be greater for diets containing 10% alfalfa. Duration of rumen pH below 5.5 was less for diets with chopped vs pelleted (P<.10) or 10 vs 5% (P<.05) alfalfa. Total volatile fatty acid (VFA) concentrations during the challenge phase and for the overall experimental period were increased (P<.05) when steers were fed 5 vs 10% alfalfa diets but were similar during the baseline and recovery periods. The higher pH and lower VFA concentration resulting from feeding 10% alfalfa diets suggest that steers fed a moderate amount of roughage can withstand greater fluctuations in intake without developing acidosis.

(Key Words: Alfalfa, Subacute Acidosis, Finishing Cattle.)

Introduction

Roughage is a necessary component of high-grain diets for finishing cattle because it helps protect against effects of intake variation on rumen and digestive function. Physical form (particle length) has been assumed to play an integral role. Roughage is generally limited to low levels in finishing diets to maximize energy concentration, but when weather and(or) mechanical breakdown threaten to alter feed intake, ration roughage levels often are increased. Based on feedlot performance and carcass traits, previous research (1993 KSU Cattleman's Day) suggested that average quality alfalfa (15% crude protein) provided similar ruminal bulk and(or) tactile stimulation when either chopped or pelleted (3/8 inch pellet size). Additionally, that study found increased feed intake and a lowered incidence and severity of liver abscesses in steers fed 10 vs 5% alfalfa. Our objective in this study was to determine the effects of alfalfa form and level on subacute acidosis, using an approach that attempts to model the effect of intake fluctuations on rumen function.

Experimental Procedures

The chopped hay and pellets were from the same source used in a previous study (1993 KSU Cattleman's Day). Alternate bales of alfalfa hay from a common lot then were either chopped (3- to 4-inch length) or ground and pelleted (3/8-inch pellet). Eight ruminally cannulated crossbred steers (1225 lb) were used in two concurrent 4 × 4 Latin squares. Treatments were arranged as a 2 × 2 factorial experiment. Main effects were alfalfa form (chopped or pelleted) and level (5 or 10% of ration DM, Table 1). Steers were fed diet dry matter at 2% of BW in two equal feedings (8 a.m. and 8 p.m.) for a 10-day adaptation period. On day 11, steers received their 8 a.m. feed, but the p.m. feeding was omitted. Steers were challenged on the mornings of day 12 and day 13 by offering diet dry matter at 1.5% of BW in the feed bunk followed by diet dry matter at 1% of BW via the ruminal cannula 1.5 h postfeeding. Any offered feed that was not consumed

also was placed into the rumen through the cannula at that time. The challenge was followed by a 3-day (day 14-16) intake recovery period when feed was offered as in the adaptation phase. Ruminal samples were taken postfeeding at: 0, 3, 6, 9, and 12 h (day 10); 3, 6, 9, 12, 18, and 24 h (days 12 and 13); and 12 and 24 h after the a.m. feeding on days 14 to 16.

Results and Discussion

Intake during the recovery period tended (P=.12) to be greater for 10% than 5% alfalfa diets (Table 2), but alfalfa form did not affect intake. Rumen pH stayed below 5.5 longer when pelleted alfalfa (P<.10) and 5% alfalfa (P<.05) diets were fed. Similarly, mean pH for the entire experimental period was lower (P<.05) when pelleted and 5% alfalfa diets were fed. Average total volatile fatty acid (VFA) concentrations (Table 2) were similar between chopped and pelleted alfalfa but were increased (P<.05) when 5% alfalfa diets were fed. The changes in VFA from baseline to recovery are presented in Table 3. It is not surprising that VFA concentrations would be greater for a lower roughage diet, because at an equal intake, it provides more fermentable substrate. However, total VFA concentrations were similar during the baseline and recovery periods for both 5 and 10% alfalfa diets. An increase in total VFA was evident during the challenge phase, especially the second day of the challenge. We conclude that chopped alfalfa is more beneficial in moderating rumen pH during variable intake patterns than is pelleted alfalfa. Combined with earlier results, this study suggests that 10% inclusion of either form of alfalfa enhances and stabilizes feed intake compared to 5%.

Table 1. Diet Compositions [a]

	Chopped Alfalfa		Pelleted Alfalfa	
Ingredient	5%	10%	5%	10%
Dry rolled corn	84.96	81.10	85.62	81.28
Chopped alfalfa	5.00	10.00	----	----
Pelleted alfalfa	----	----	5.00	10.00
Supplement [b]	7.54	6.54	6.88	6.22
Molasses	2.50	2.50	2.50	2.50

[a]Dry matter basis.
[b]Supplements were formulated so that diets contained 12% crude protein, .7% Ca, .3% P, .7% K, 1550 IU Vit A, and 27 ppm monensin.

Table 2. Effect of Alfalfa Physical Form and Level on Intake and Ruminal Fermentation Characteristics

	Alfalfa Form		Alfalfa Level		
Item	Chopped	Pelleted	5%	10%	SEM
Intake, % of BW [a]	1.28	1.12	1.01	1.39	.16
Hours pH below 5.5 [bcd]	20.5	25.0	26.2	19.3	1.8
Mean pH [de]	5.28	5.14	5.14	5.28	.10
Total volatile fatty acids [d], mM	114.9	119.6	121.7	112.7	6.0

[a]During recovery (day 14 to 16). [b]During challenge days (day 12 and 13). [c]Alfalfa form effect (P<.10). [d]Alfalfa level effect (P<.05). [e]Alfalfa form effect (P<.05).

Table 3. Effect of Alfalfa Physical Form and Level on Total Volatile Fatty Acid Concentration over Time

	Alfalfa Form		Alfalfa Level	
Item, hr postfeeding	Chopped	Pelleted	5%	10%
Day 10, baseline	---------- millimoles/liter ----------			
0	93.0	96.4	96.6	92.8
3	98.3	103.4	103.7	98.0
6	99.9	90.6	97.5	93.0
9	91.4	92.7	93.7	90.5
12	92.2	94.0	96.6	89.6
Day 12, 1st challenge				
3	135.8	148.7	151.3[a]	133.2[b]
6	136.0	137.1	145.7[a]	127.4[b]
9	118.4	122.4	128.3[c]	112.5[d]
12	118.8	123.4	125.5	116.7
18	108.1	119.7	116.3	111.5
24	95.9	106.3	108.2[c]	94.0[d]
Day 13, 2nd challenge				
3	179.0	180.0	186.6[c]	172.3[d]
6	178.9	177.9	199.4[a]	157.4[b]
9	141.1	149.4	157.5[a]	133.1[b]
12	132.9	143.8	147.1[a]	130.0[b]
18	126.2	128.5	133.5	121.2
24	123.2	126.2	128.1	121.3
Recovery, hr after a.m. day 14				
12	95.9	106.6	102.2	100.3
24	97.0	104.4	101.8	99.6
36	95.9	104.2	99.3	100.8
48	98.1	97.6	95.9	99.8
60	92.0	98.6	89.9	100.7
72	94.3	99.0	95.3	98.0

[a,b]Means in a row with unlike superscripts differ (P<.05).
[c,d]Means in a row with unlike superscripts differ (P<.10).

THE EFFECT OF SODIUM BICARBONATE LEVEL ON RUMEN METABOLISM IN STEERS WITH INDUCED SUBACUTE ACIDOSIS

S. A. Shuey, R. T. Brandt, Jr., and S. M. Gramlich

Summary

Sodium bicarbonate at 1 or 2% of dry matter intake was evaluated as a means of alleviating subacute acidosis, using six fistulated Holstein steers in a controlled acidosis challenge model. Steers were feed challenged by withholding an evening feeding and then feeding 2.5% of BW for two consecutive mornings. Postchallenge rumen pH for control steers (no sodium bicarbonate) was lower ($P<.05$) than for steers fed either 1% or 2% sodium bicarbonate, which were similar to each other. Hours below pH 5.6 were less ($P<.01$) postchallenge for steers fed sodium bicarbonate and were similar between the 1 and 2% levels. Although sodium bicarbonate reduced ruminal pH hours below 5.6, it did not appear to alter concentrations of volatile fatty acids or lactate in acidotic steers. Sodium bicarbonate appears to be beneficial in managing subacute acidosis in situations where wide intake fluctuations are common or expected.

(Key Words: Cattle, Sodium Bicarbonate, Rumen pH, Acidosis.)

Introduction

Conditions that cause fluctuations in intake, such as changes in weather or mechanical breakdown, can produce subacute acidosis, reduce finishing cattle performance, and increase cost of gain, even though the cattle are not visibly ill. Sodium bicarbonate (Bicarb) is sometimes included in finishing rations, because of its acid neutralizing characteristics, to prevent acidosis. In a controlled situation, we interrupted normal feed intake patterns and followed this by rapid compensatory consumption to evaluate the potential of sodium bicarbonate to alleviate induced sub-acute acidosis.

Experimental Procedures

Six ruminally fistulated Holstein steers (1050 lbs) were adapted to a high grain diet; randomly allotted within a replicated 3 × 3 Latin square; and fed a corn-based finishing diet at 2% of BW/day, unsupplemented or supplemented with 1 or 2% of Bicarb (dry basis). The basal diet contained 80% rolled corn, 10% chopped alfalfa hay, 8% supplement, and 2% molasses. Allotted amounts of Bicarb were mixed with the basal ration at feeding time. The basal diet in this study contained 12% crude protein, .59% Ca, and .30% P. Each 16-day period consisted of a 10-day treatment adaptation (1% of BW fed at 8 a.m. and 8 p.m.); a fasting period (no feed at the 8 p.m. feeding on day 11); consecutive feeding challenges on days 12 and 13 (1.5% of BW in a bunk plus 1% of BW via rumen fistula 1.5 hours after bunk offering; 8 a.m. feeding); and an intake recovery period in which the feeding schedule returned to the prechallenge regimen. Any feed uneaten at 1.5 hours postfeeding on the challenge days was given via the rumen fistula. Feed refusals were weighed and discarded each day prior to the 8 a.m. feeding. At the beginning of each period, steers were inoculated with 1 liter of ruminal fluid from a common donor. Ruminal samples were obtained (postfeeding) at 0, 3, 6, 9, 12 hours (day 10); 3, 6, 9, 12, 18, 24 hours (days 12 and 13); and 12 and 24 hours after the a.m. feeding on days 14-16. Ruminal samples were analyzed for pH and

concentrations of volatile fatty acids (VFA) and lactate.

Results and Discussion

Molar percentages of acetate and propionate, acetate:propionate ratio, total VFA, and lactic acid concentration were unaffected (P<.05) by level of Bicarb in the diet (Table 1). Ruminal pH for control steers was less (P<.05) than for steers fed either the 1 or 2% levels, which were similar. Hours below pH 5.6 were lower (P<.01) during the challenge period for steers fed Bicarb and were similar between the 1 and 2% levels. No treatment differences in intake occurred during the recovery period. Results of this study indicate that the addition of Bicarb altered the ruminal environment, resulting in a more favorable ruminal pH without changing the amounts or ratios of major fermentation end-products. Total VFA concentrations and ruminal pH reductions in this study were lower than observed for beef breeds using a similar model and basal diet. Higher ruminal capacity per unit of BW for Holsteins (previously documented) may be partially responsible. Nonetheless, sodium bicarbonate should be beneficial in situations where wide intake fluctuations are expected or common.

Table 1. Effect of Sodium Bicarbonate Level on Rumen Metabolism i nSteers Induced with Subacute Acidosis

		Sodium Bicarbonate, % of dry matter	
Item	Control	1%	2%
pH	5.72[a]	6.06[b]	5.98[b]
Total volatile fatty acids, *m* M	87.07	79.60	86.72
Acetate, %	52.97	55.22	55.36
Propionate, %	28.95	26.25	27.98
Acetate:propionate ratio	2.04	2.23	2.16
Lactate, *m* M	0.09	0.08	0.07
Hours below pH 5.6	6.54[c]	1.47[d]	1.82[d]

[ab]Means without a common superscript differ (P<.05)
[cd]Means without a common superscript differ (P<.01)

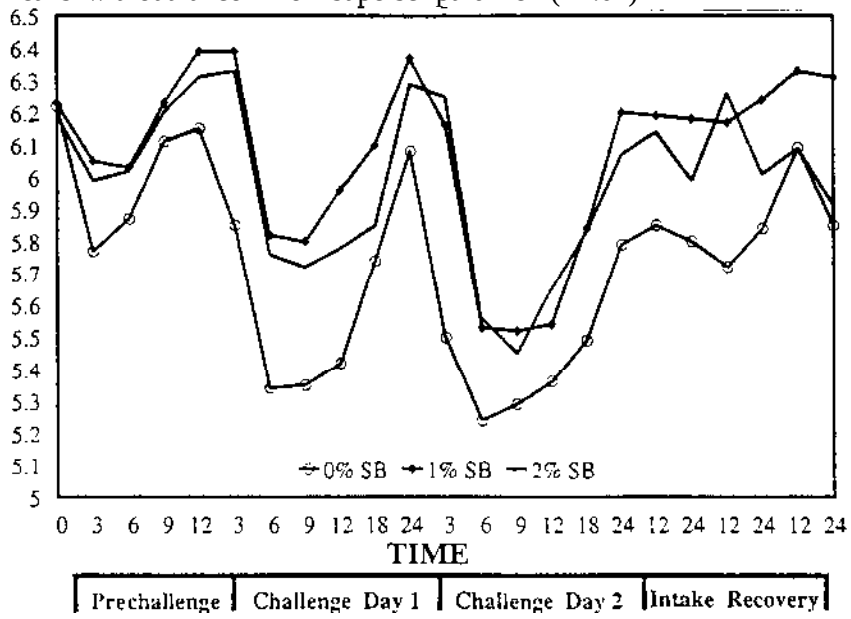

Figure 1. Effect of Sodium Bicarbonate Level on Ruminal pH

SUPPLEMENTAL CHROMIUM AND REVACCINATION EFFECTS ON PERFORMANCE AND HEALTH OF NEWLY WEANED CALVES

S. A. Lindell, R. T. Brandt, Jr., J. E. Minton, F. Blecha [1], G. L. Stokka [1], and C. T. Milton

Summary

Two trials were conducted to evaluate the effects of chromium (Cr) supplementation (4 mg/hd/day in a yeast form) or no supplementation, with or without revaccination with a modified live viral vaccine at 9 days postweaning on performance, health, and ability to withstand an IBR challenge infection. In Trial 1, Cr supplementation had no effect on performance of newly weaned calves in a 28-day receiving study, but reduced the incidence of respiratory disease by 37%. Revaccination depressed dry matter intake and had no effect on animal health. In trial 2, blood plasma levels of cortisol and ACTH (stress hormones) were measured at 6 and 26 days postweaning. Cortisol levels were unaffected by treatment or by time after weaning. Plasma ACTH concentrations were lower at 26 vs 6 days postweaning, and were reduced at 26 days by revaccination. Despite some slight differences in rectal temperature, treatment did not appear to affect the animals' ability to withstand a live IBR challenge. We concluded that supplemental Cr was beneficial in reducing the incidence of bovine respiratory disease, although mediation of stress hormones was not involved. Revaccination of newly weaned calves with a modified live viral vaccine showed no performance or health benefit.

(Key Words: Chromium, Weaned Calves, Respiratory Disease.)

Introduction

Minimizing losses from bovine respiratory disease continues to pose a major challenge to the beef cattle industry. Benefits from supplementing a variety of nutrients that stimulate the immune response in cattle and that may become deficient in an acute stress-disease complex have been documented. Most recently, Canadian research has shown that chromium (Cr) supplementation can reduce the incidence of morbidity and improve performance of stressed beef cattle. Whether Cr supplementation can have the same effects in newly weaned calves has not been tested. Vaccination programs for newly received calves also deserve research attention. Therefore, we studied the effects of supplemental Cr and revaccination on performance, health, and blood parameters of newly weaned calves.

Experimental Procedures

Trial 1. Two hundred and four British crossbred steer and heifer calves (492 lb) were separated from their dams at the KSU Range Unit and delivered to the Beef Research Unit. Calves were individually weighed and held on concrete without access to feed or water for 24 hours to impose additional stress. Calves then were weighed again; treated for parasites; and vaccinated against IBR, PI_3, BVD, BRSV (Bovishield-4®); and seven clostridial organisms (Ultrabac-7®). Calves were blocked by weight and allotted to one of 12 pens in a 2×2 factorially arranged experiment. An

[1]College of Veterinary Medicine. Provision of IBR virus by Harish Minocha, Dept. of Pathology and Microbiology, is gratefully acknowledged.

equal ratio of steers:heifers was maintained in each pen. Main effect factors were Cr supplementation (0 or 4 mg/head/day) and vaccination schedule (– or + revaccination with Bovishield-4® on day 9). Chromium was supplied in a dried yeast form that was 960 ppm Cr (Alltech, Inc., Nicholasville, KY). Diets were formulated to contain 14% crude protein and were composed of (dry basis): 44.45% corn, 36.0% chopped prairie hay, 3.75% molasses, and 15.8% supplement. Performance and health parameters were measured over a 28-day period.

Trial 2. This trial was conducted to measure plasma cortisol and ACTH levels during the weaning period. Twenty steer mates (393 lb) to the calves used in Trial 1 were individually housed and fed in an open-front barn. Processing procedures, treatments, and starting date were identical to those for Trial 1 and resulted in five steers per treatment combination. Steers were halter-trained, and blood samples were collected on days 6 and 26 (trial termination). On collection days, steers were fitted with indwelling jugular catheters, and blood samples were collected every 30 minutes for 4 hours (nine samples) beginning 5 hours after catheter placement. Samples were analyzed subsequently for cortisol and ACTH.

Following the 26-day trial, all steers were challenged with 300 million plaque-forming units (PFU) of IBR virus (200 million PFU intranasally, 100 million via the conjunctiva) to assess previous treatment effects on the ability of animals to withstand an infectious challenge. Rectal temperatures and clinical signs of illness were recorded over a 7-day period.

Results and Discussion

Trial 1. Feed and water deprivation for 24 hours resulted in a 5.6% weight loss (shrink) which took at least 9 days to recover (Table 1). No interactions occurred between Cr level and vaccination schedule; therefore, data are pooled by main effects. In contrast to other research, Cr supplementation had no effect on calf performance. However, 4 mg/head daily of Cr reduced (P=.04; Chi-square) the percentage of calves treated for respiratory disease by 37%. The fact that performance was not affected in the presence of large differences in morbidity may be related to a good response rate to antibiotic treatment and low number of retreatments (n=2 and 1 for 0 and 4 mg Cr treatments, respectively).

Revaccination depressed dry matter intake for the receiving period by more than .5 lb per day (P<.05). Revaccination had no effect on daily gain, feed efficiency, or reduction in incidence of respiratory disease.

Trial 2. Neither Cr supplementation nor revaccination had an effect on plasma cortisol levels (Table 2). Further, no differences occurred in cortisol concentrations between day 6 and day 26 of the study. We anticipated that cortisol concentration at day 6 would be elevated, because calves were still undergoing the stress of weaning at that time. Plasma ACTH concentrations were higher (P<.10) on day 6 than day 26, indicating a higher stress level at the earlier date. Revaccination reduced (P<.02) serum ACTH levels at day 26, with no change in plasma cortisol. The importance of this finding is unclear, because revaccination had no beneficial effect on performance or health of calves in Trial 1.

Rectal temperatures of calves during the IBR challenge period are shown in Figure 1. Two calves each in the (+) Cr, (–) Revac and (–) Cr, (+) Revac groups and one each in the other two groups showed no sign of infection (measured as temperature $\geq$ 103.5ºF). Peak morbidity occurred within 2 days after infection and lasted approximately 3 days. A Cr supplementation by revaccination interaction (P<.03) showed that Cr supplementation or revaccination alone reduced average rectal temperature by .5ºF during the challenge period, compared to control. However, the combination of revaccination and Cr supplementation had no effect on mean rectal temperature. Although slight differences were noted, treatment did

not appear to have a physiologically significant effect on the calves' ability to withstand an IBR viral challenge.

Results of these studies indicate that supplemental Cr can reduce morbidity of weaned calves. However, mediation of stress hormones was not involved, suggesting that supplementation corrected a Cr deficiency. Fermentation products or yeast preparations similar to that used in this study contain other nutrients and growth factors that reportedly stimulate ruminal diet digestion and(or) animal performance. Lack of a performance response in Trial 1 for the yeast treatment suggests that no response was directly attributable to the yeast. Revaccination of newly weaned calves showed no performance or health benefit.

Table 1. Effect of Chromium Supplementation (as Yeast) and Revaccination on Performance and Health of Newly Weaned Calves (Trial 1)

	Supplemental Cr, mg/hd/d			Revaccination [a]		
Item	0	4	Probability	–	+	Probability
No. pens	6	6		6	6	
No. head	102	102		102	102	
Weaning wt, lb	492	491		494	489	
Processing wt, lb [b]	463	465		466	461	
Shrink, % [b]	5.93	5.23		5.6	5.6	
Day 9 wt, lb	490	492		495	489	
Day 30 wt, lb	547	546		547	545	
Daily feed, lb dry matter	13.45	13.28	NS[f]	13.63	13.09	.05
Daily gain, lb [c]	1.96	1.97	NS	1.92	2.00	NS
Feed/gain	6.90	6.76	NS	7.09	6.54	NS
Treated, % [d]	34.3	21.6	.04	28.4	27.5	NS
Retreated, % [e]	5.7	4.5	NS	3.4	7.1	NS
Death loss, %	0	0		0	0	

[a]Revaccinated (+) or not (–) on day 9 with modified live IBR, PI_3, BVD, and BRSV.

[b]Following 24 hours of feed and water deprivation.

[c]From weaning weight.

[d]Treated for respiratory disease.

[e]Percentage of treated cattle treated twice or more.

[f]Not significant.

Table 2. Serum Cortisol and ACTH Concentrations in Calves at 6 and 26 Days Postweaning (Trial B)

Item	0 mg/hd/d Cr		4 mg/hd/d Cr		S E M
	– Revac	+ Revac	– Revac	+ Revac	
Cortisol, ng/ml					
Day 6	11.8	9.8	11.5	12.4	2.19
Day 26	13.3	13.3	13.2	12.3	
ACTH, pg/ml[a]					
Day 6	138.8	120.5	129.0	132.7	7.17
Day 26[b]	133.5	108.3	129.0	114.8	

[a]Day 6 vs day 26 (P<.10).
[b]Effect of revaccination (P<.02).

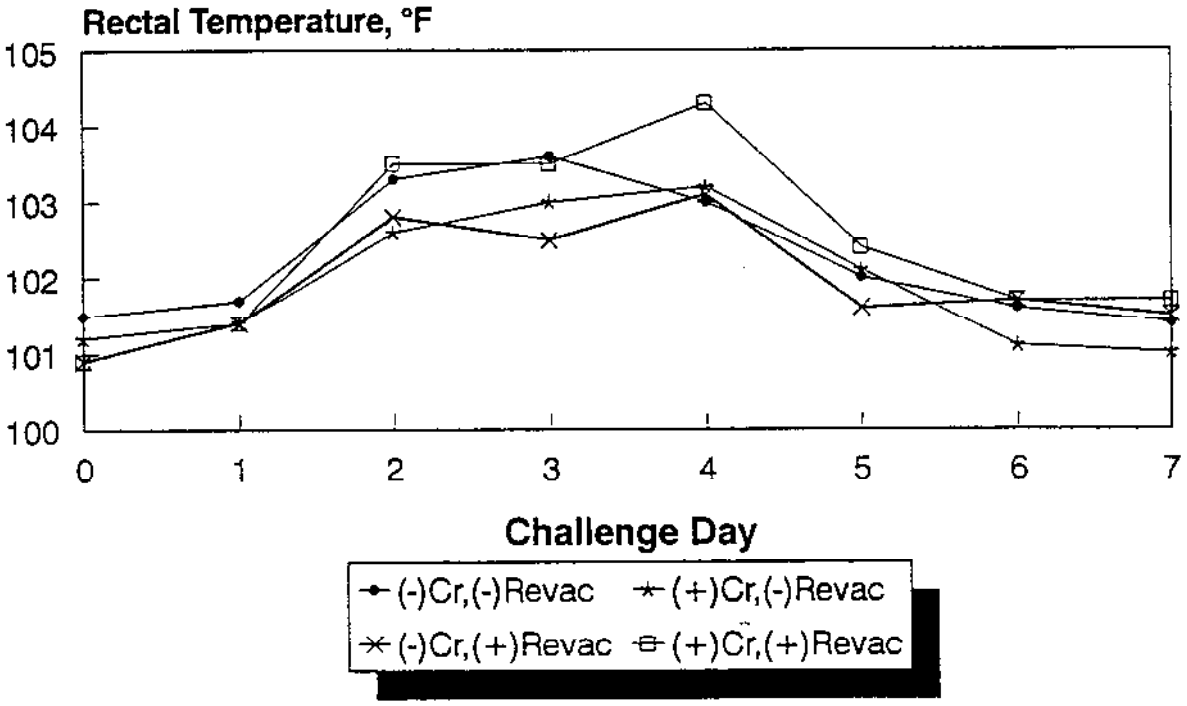

Figure 1. Rectal Temperatures of Steers Challenged With IBR Virus

EFFECTS OF SUPPLEMENTAL TRACE MINERALS AND PREVACCINATION ON STRESSED CALVES

S. A. Lindell, R. T. Brandt, Jr., G. L. Stokka [1], S. M. Gramlich, and C. T. Milton

Summary

Two trials were conducted to evaluate the effect of high dietary levels of trace minerals on performance and health of stressed calves. In trial 1, 221 Brahman crossbred steers (674 lb, 1/8 to 1/4 Brahman) were used to evaluate the effect of copper (Cu) and zinc (Zn) supplementation on performance and immune response. The steers were shipped from northern Texas to the KSU Beef Research Unit with an 18-hour transit time. Receiving diets were formulated to contain 1) NRC-recommended levels of Cu and Zn or 2) 4 times recommended levels. In trial 2, 112 Angus cross steers (518 lb) were used to evaluate effects of the same trace mineral supplementation and preweaning vaccination on performance and immune response. Half of the steers were vaccinated (modified live IBR, BVD, PI_3, BRSV) 14 days prior to weaning, and all were vaccinated at weaning (day 0). No differences occurred in dry matter intake, daily gain, serum Zn and Cu, or IBR antibody titer as a result of trace mineral level in either study. Prevaccination had no effect on performance or health of weaned calves. However, IBR antibody titers at weaning (day 0) were higher ($P<.001$) for prevaccinated vs non-prevaccinated calves. We concluded that either the level of stress imposed in the two trials was not great enough to cause acute trace mineral deficiencies, or that NRC-recommended levels are adequate for stressed as well as non-stressed animals. Prevaccination with a modified live vaccine resulted in an elevated antibody titer response but no improvement in health of newly weaned calves.

(Key Words: Bovine Respiratory Disease, IBR, Zinc, Copper, Morbidity.)

Introduction

Approximately 80% of all deaths of newly received calves in commercial feedlots is due to bovine respiratory disease (BRD). Stress and infection generally result in lower feed intake and increased mineral excretion, thus depleting mineral reserves that are essential to the immune system. Other research has shown that elevating levels of some nutrients (e.g., Zn and Cu) in feeds may increase performance and reduce morbidity. A functional immune system is critical before stressors are incurred. One strategy to enhance immune response is to vaccinate against pathogens involved in BRD before weaning, followed by a booster at weaning. These studies were initiated to determine if feeding high levels of Zn and Cu, as well as vaccinating against respiratory disease before weaning, would enhance performance and health of stressed calves.

Experimental Procedures

In trial 1, 221 head of Brahman cross steers (674 lb) were used to evaluate the effects of high levels of trace mineral supplementation on performance and health in a 30-day study. The steers were shipped from northern Texas with an 18 hour transit time and were randomly allotted to four pens

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(two pens/treatment). The control (1X) diet was formulated to meet NRC-suggested levels for Cu (10 ppm) and Zn (40 ppm). The treatment diet (4X) was formulated with four times those amounts. Diets consisted of corn, silage, molasses, and alfalfa hay (Table 1). Blood samples were taken upon arrival from Texas and upon completion of the trial and were analyzed for Zn and Cu.

In trial 2, 116 Angus crossbred steers (518 lb) from the KSU Cow-Calf Unit were used to evaluate the effects of high-level trace mineral supplementation and preweaning vaccination in a 35-day receiving study. Half of the steers were given Bovishield-4® 14 days prior to weaning. On October 1, 1992, steers were weaned (day 0) and shipped to the KSU Beef Research Unit. Upon arrival, steers were held on concrete without access to feed and water for 24 hours to induce further stress. The following day, steers were weighed, eartagged, treated for parasites (Ivomec®), vaccinated (Bovishield-4®, Ultrabac-7®), and assigned to one of 16 pens in a 2 × 2 factorially arranged, completely randomized design (four pens per treatment). Diets were the same as for trial 1. Blood samples were obtained on days 0 and 35 and were analyzed for Zn and Cu and IBR antibody titer.

Results and Discussion

In trial 1, steers consuming 4X diets were similar to those consuming the 1X in daily gain, feed efficiency, serum Cu and Zn, and morbidity (Table 2). Similar results were obtained in trial 2 (Table 3). In addition, in trial 2, IBR titers were similar between trace mineral levels. No differences were observed for steers that were vaccinated preweaning vs controls in dry matter intake, daily gains, feed efficiency, or serum Zn and Cu. IBR antibody titer was significantly elevated at day 0 ($P<.001$) in prevaccinated calves. However, no differences occurred in IBR antibody titers at day 35.

Feeding high levels of Zn and Cu did not increase serum levels, most likely because of homeostatic mechanisms of the body. Serum Zn and Cu levels at day 0 indicated that calves were not deficient (>1 ppm), so a response to supplementation would not be expected. Unfortunately, it is difficult to predict whether stressed feeder cattle are deficient in important trace nutrients on arrival. Therefore, fortifying receiving diets with trace nutrients (not necessarily at 4X the requirements) seems feasible as a precautionary measure. In trial 1, morbidity rate from BRD was very low at 3.2% (7 head). The response to treatment was very good with few repulls. We recorded no mortality and a 100% first-time response to treatment. In trial 2, the highest morbidity occurred during weeks 3 and 4, with the majority occurring during days 22 through 28. The overall morbidity rate from BRD was 29% (34 head), which is typical of that expected in newly weaned calves. Response to treatment was also very good, with no mortality and a 90% first-time response to treatment. Both trials indicated that the viral pathogens IBR, BVD, PI3, and BRSV were not primary factors in BRD and that bacterial agents were likely the primary pathogens.

Table 1. Composition of Total Mixed Rations [a] for Trials 1 and 2

Ingredient	As Fed Basis %	Dry Matter %
Corn	43.9	47.77
Silage	11.6	4.79
Supplement	7.0	7.75
Molasses	4.0	3.76
Alfalfa hay	33.5	35.93
Total	100	100

[a]Rations contained 12.7% crude protein, .55 % Ca, .3% P; 1X and 4X diets contained 13.7 and 54.65 ppm Cu and 47.01 and 194.45 ppm Zn, respectively. Supplemental Cu and Zn were supplied as copper sulfate and zinc oxide, respectively.

Table 2. Effects of Trace Mineral Supplementation on Performance, Health and Blood Constituents of Newly Received Calves in Trial 1

Item	Treatment [a] 1X	4X	SEM
Pen/trt.	2	2	
Head/trt.	110	111	
In wt.	669	679	10.33
End wt.	772	772	8.32
Daily gain, lb	3.34	3.00	.187
Daily feed, lb dry matter	22.15	21.48	.222
Gain/Feed	.151	.139	.0077
Day 0			
Serum Zn, ppm	1.12	1.05	.063
Serum Cu, ppm	1.26	1.28	.042
Day 30			
Serum Zn, ppm	.996	1.11	.048
Serum Cu, ppm	1.84	1.86	.080
Morbidity, head	5	2	

[a]1X = formulated using NRC recommendations for Cu and Zn. 4X = formulated with four times the 1X level.

Table 3. Effect of Trace Mineral Supplementation and Prevaccination (PV) on Performance, Blood Constituents and Health in Trial 2

Item	Treatment [a] 1X	4X	PV(-)	PV(+)	SE M
No. pens	8	8	8	8	
Head/trt.	58	54	58	54	
In wt.	519	516	515	519	4.7
End wt.	584	582	581	585	5.6
Daily gain, lb	1.88	1.89	1.89	1.87	.080
Daily feed, lb dry matter	11.6	11.6	11.6	11.8	.28
Gain/feed .161	.161	.163	.160	.0046	
Day 0					
Serum Zn ppm	1.40	1.36	1.36	1.39	.0428
Serum Cu, ppm	1.58	1.63	1.57	1.64	.0526
IBR titer[b]	1:1	1:1	1:1	1:2	.576
Day 35					
Serum Zn, ppm	1.40	1.39	1.48	1.33	.0445
Serum Cu, ppm	1.54	1.55	1.53	1.56	.0335
IBR titer	1:4	1:4	1:4	1:4	.984
Morbidity	17	17	18	16	

[a]1X = formulated using NRC recommendations for Cu and Zn. 4X = formulated with four times the 1X level. PV = preweaning vaccination with Bovishield - 4®.
[b]Prevaccination vs non-prevaccination (P<.001)

EFFECT OF MORNING VS EVENING FEEDING OF LIMIT-FED HOLSTEINS DURING SUMMER MONTHS

C. D. Reinhardt and R. T. Brandt, Jr.

Summary

Thirty-eight Holstein steers (avg 339 lb) were grouped into four weight blocks, with two pens per block. Within each block, cattle in one pen were fed at 8:00 a.m. and those in the other at 8:00 p.m. All cattle were limit-fed to achieve a programmed rate of gain of 2.2 lbs/d using NRC net energy equations. The trial lasted from July 13 through September 6, 1993. With the same quantity of feed, cattle fed in the evening gained 18% faster than cattle fed in the morning (P<.02) resulting in better feed efficiency for the evening-fed cattle (P<.06). Average high temperature for the 56-day period was 88°F, average low temperature was 69°F, average relative humidity was 73%, and average wind speed was 1.8 mph. Feed tended to be consumed within a 3-hour period, regardless of time of feeding. Because the effective ambient temperature frequently rose above the upper critical temperature for cattle (77°F), animals needed to expend energy to dissipate excess heat. These results indicate that cattle limit-fed during the summer may utilize metabolizable energy more efficiently if allowed to ferment the bulk of their feed during the cooler hours of the evening.

(Key Words: Limit-Feeding, Heat Stress, Night Feeding.)

Introduction

A large amount of heat is generated during fermentation of feedstuffs in the rumen. When ambient temperatures exceed the upper critical temperature of the thermoneutral zone, cattle must expend energy to dissipate excess heat to maintain their body temperature. If limit-fed cattle are programmed for a particular gain using NRC net energy values, and heat dissipation reduces efficiency of metabolizable energy use for gain, cattle will not achieve the desired rate of gain and will be less efficient. Therefore, we compared efficiencies of cattle limit-fed in the morning vs the evening.

Experimental Procedures

Thirty-eight Holstein steers were stepped up to a medium-energy ration containing 54% rolled corn, 25% sorghum silage, 11% soybean meal, 7% supplement, and 3% molasses (dry matter basis) and weighed on July 13, 1993 (avg 339 lb). Cattle were grouped into four weight blocks and equally stratified within blocks into two outdoor, unshaded, concrete-floored pens. One pen per weight block was assigned to morning feeding and one pen to evening feeding. Morning-fed cattle were fed at 8:00 a.m., and evening-fed cattle were fed at 8:00 p.m. In calculating daily feed requirements, we assumed that the maintenance requirement of Holstein steers was 13% greater than that of beef breeds (87 vs. 77 kcal/BW$^{.75}$). Energy required for gain was assumed to be the same as for large frame beef calves. Diet net energy values were taken from NRC tabular values. Intakes were adjusted every 14 days based on the assumed rate of gain. At the end of the experiment, all cattle were fed in the morning for two consecutive days and weighed on the third consecutive day (September 6, 1993, avg 438 lb). Weather data were provided by the Kansas State University Weather Data Library in Manhattan.

Results and Discussion

By design, daily dry matter intakes were equal across all pens when expressed as a percent of body weight (Table 1). However, neither treatment group realized the desired rate of gain of 2.2 lbs/day. Cattle fed in the evening gained faster (P<.02) and, subsequently, more efficiently than those fed in the morning (P<.06). Average high temperature for the 56-day period was 88°F, average low temperature was 69°F, average humidity was 73%, and average wind speed was 1.8 mph.

Table 1. Performance of Limit-Fed Cattle during the Summer when Fed in the Morning or Evening

Item	Morning	Evening	SEM
Number of pens	4	4	
Number of head	19	19	
DM intake, lbs/d	9.3	9.4	.286
DM intake, % of BW	2.3	2.3	.081
Daily gain[a], lb	1.66	1.96	.043
Feed:Gain[b,c]	7.46	6.37	.303

[a]Means differ (P<.02).
[b]Means differ (P<.06).
[c]Analyzed as Gain:Feed.

The thermoneutral zone (the range in effective ambient temperature for which no physiological adaptation must be made to maintain homeostasis) for beef cattle is from 59 to 77°F. Effective ambient temperature increases with rising relative humidity, because cattle are less able to cool themselves through sweating and respiratory evaporation. Sunny conditions elevate the effective ambient temperature 5 to 9°F by direct and indirect radiant heat.

Ruminal fermentation of high-grain diets peaks during the first 12 hours after consumption. Hence, cattle fed in the evening digest the bulk of their daily allotment of feed between sundown and sunrise, whereas cattle fed in the morning experience a fermentation peak during the hottest part of the day. If cattle are already experiencing heat stress, the heat of fermentation adds to the animals' total heat load and increases the energy expenditure needed for heat dissipation. Slightly increased respiration from heat stress can increase the maintenance energy expenditure by 7%, and heavy, labored panting can increase the maintenance energy cost by 11 to 25%. Our data suggest that, during the summer, cattle limit-fed in the evening convert feed to gain more efficiently than those fed in the morning.

IMPLANTING SUCKLING HEIFER CALVES: GROWTH AND SUBSEQUENT PERFORMANCE [1]

D. D. Simms

Summary

A total of 361, suckling, heifer calves was used over a 2-year period to assess the effects of implanting with either Ralgro® or Synovex-C® on growth and subsequent performance as replacement females. Both implants increased (P<.01) weaning weights over that of controls, with the weight increase being retained by yearlings. Pelvic area also was increased at 1 year of age by both implants, with Synovex-C producing larger (P<.01) pelvic areas than Ralgro. However, just prior to calving, body weight and pelvic area were similar among treatments. Uterine scores, cycling activity prior to breeding, percentage exhibiting estrus, and pregnancy percentage were similar for all treatments. Implanting tended to reduce first-service conception rates. Synovex-C-implanted heifers calved later (P<.05) than Ralgro-implanted heifers and, consequently, their calves tended to be lighter at weaning. Levels of calving difficulty were similar for all treatments. In summary, implanting suckling heifer calves at 2-4 months of age will increase growth rate, but this research indicates some potential for reduction in reproductive performance.

(Key Words: Beef Heifers, Implants, Ralgro®, Synovex-C®, Calving Difficulty.)

Introduction

Implanting suckling heifer calves significantly increases weaning weight. However, because some heifers will be retained as replacements, the effect of implanting on subsequent reproduction and/or production is cause for concern. Consequently, this research was conducted to compare the effects of Ralgro and Synovex-C on the growth rate of suckling heifer calves and their subsequent performance as replacement females.

Experimental Procedures

Over a 2-year period, a total of 361, suckling, heifer calves were allotted by order of birth and pasture to the following treatments: 1) controls - nonimplanted, 2) Ralgro - a single 36-mg implant, or 3) Synovex-C - a single implant containing 100 mg Progesterone + 10 mg Estradiol.

The heifers were individually weighed at implantation (3 month old, n=120/trt), at weaning (n=120/trt), at approximately 1 year-of-age (n=95/trt), and at approximately 1 month prior to the start of calving (n=68/trt). As heifers were culled from the herd, every effort was made to retain equal numbers in each treatment group. From weaning through calving, the heifers were managed as one group.

Pelvic area was measured as yearlings and at precalving, and uterine scores were taken at the same time as the yearling weight.

[1]Appreciation is expressed to Jon Ferguson, Kensington, for supplying cattle, to Dr. Vincent Traffas, Smith Center, for technical assistance; and to Pitman-Moore for financial support.

Blood samples, collected 10 days apart prior to initiating a synchronization program, were analyzed for progesterone to establish cycling activity. Thirty-two days prior to the start of breeding, 0.5 mg melengestrol acetate (MGA) per day was fed for 14 days. Seventeen days after removal of MGA from the ration, the heifers were injected with prostaglandin. Those visually detected in heat following synchronization were artificially inseminated with semen from low-birth-weight EPD Angus bulls. After approximately 5 days of breeding, low-birth-weight EPD Angus bulls were placed with the heifers for an additional 40 days.

Results and Discussion

Results are summarized in Table 1. Both implants increased (P<.01) weaning weight over that of controls, and this increase was still present at 1 year of age. However, shortly before the start of calving, body weights were all similar.

Both implants increased (P<.01) pelvic area over that of controls at 1 year of age, and Synovex-C-implanted heifers had larger pelvic areas than Ralgro-implanted heifers. However, shortly before calving, all three treatment groups had similar pelvic areas.

Prior to breeding, no difference occurred among treatments in uterine scores or in the percentage of heifers with blood progesterone levels high enough (> 1 µg/ml) to indicate cycling activity.

Implanting tended to reduce first-service conception rates, but pregnancy rates at the end of the 45-day breeding season were similar among treatments.

As might be expected from the pelvic areas, calving difficulty scores were all similar. However, that may be misleading, because calving difficulty was low in all treatments.

The average calving date was earlier (P<.05) for the Ralgro-implanted heifers than for the Synovex-C-implanted heifers, with the control heifers intermediate. The older calves produced by the Ralgro-implanted heifers were slightly heavier at weaning than those from the Synovex-C-implanted heifers, but the difference wasn't significant. The ADG of the calves from birth to weaning was the same for all treatments, which we interpreted as indicating similar levels of milk production.

Apparently, producers can implant suckling heifer calves at branding with either Ralgro or Synovex-C and obtain increased weaning weights; however, this research indicates a slight negative impact on reproduction. For example, implanting tended to reduce first-service conception rates, which could be significant in an AI program, especially when using expensive semen. Additionally, later calving dates for Synovex-C-implanted heifers compared to those implanted with Ralgro translate into lighter calf weaning weights. Also, this research shows that the claims that implanting suckling heifers will reduce subsequent calving difficulty are not justified.

Table 1. Effects of Implanting Suckling Heifers with Ralgro or Synovex-C on Growth and Subsequent Reproductive Performance

	Treatment		
Item	Controls	Ralgro	Synovex-C
Growth			
Weaning wt, lb	441[f]	452[g]	455[g]
Yearling wt, lb	689[f]	701[g]	712[g]
Precalving wt, lb	993	993	1002
Pelvic area			
Yearling, cm^2	142[f]	152[g]	156[h]
Precalving, cm^2	230	233	234
Reproduction			
Uterine scores[a]	4.5	4.5	4.5
Cycling, %[b]	72	67	63
Exhibited estrus, %[c]	95	77	92
1st service conception, %	78	66	55
Pregnant, %[d]	87	85	89
Average calving date	3/9[ij]	3/6[i]	3/12[j]
Calving difficulty			
Average calving scores[e]	1.3	1.2	1.4
First calf performance			
Birth wt, lb	73.4	72.1	74.2
Weaning wt, lb	394	401	391
ADG, lb	1.63	1.65	1.64

[a]1 = infantile tract, 5 = large tract with evidence of cycling activity.
[b]Based on circulating progesterone levels (>1 µg/ml) with the last blood sample taken 32 days prior to the start of breeding.
[c]% exhibiting estrus following synchronization.
[d]% pregnant following the 45 day breeding season.
[e]1 = no difficulty, 5 = Caesarean section.
[f,g,h]Values with different superscripts are significantly different (P<.01).
[i,j]Values with different superscripts are significantly different (P<.05).

EFFECT OF STAGE OF GROWTH AND SAMPLING PROCEDURE ON THE TRACE MINERAL CONTENT OF KANSAS NATIVE GRASS

J. D. Arthington, L. R. Corah, and S. D. Utter

Summary

To determine the trace mineral content of Kansas native grasses, samples were collected from four locations of tall or intermediate grasses and four locations of short grasses. Copper (Cu) and zinc (Zn) levels tended to be lower during dormancy than in the growing season; however, manganese (Mg) and iron (Fe) levels were essentially the same throughout the year. In terms of meeting the dietary requirements of grazing cattle, Cu was adequate in June but marginal in February, whereas Zn was marginal to deficient at both collection times.

In addition, the impact of grazing selectivity on the validity of trace mineral analysis of hand-clipped pasture samples was evaluated. Although samples collected via rumen cannulae from grazing steers contained higher ($P<.01$) levels of protein, calcium, and phosphorus than comparable hand-clipped samples, no differences occurred in the trace mineral contents.

(Key Words: Trace Mineral, Forage, Grazing Selectivity, Native Grass.)

Introduction

The evaluation of trace mineral content of forage is important when attempting to identify deficiencies. Because the crude protein, calcium, and phosphorus contents of Kansas native grasses vary greatly depending on the stage of growth, it seemed logical that the trace mineral content also might vary during the year. Another important consideration when attempting to utilize forage tests in ration balancing is the influence of animal selectivity. Given the opportunity, animals will selectively graze forages of greater palatability and higher nutritional value than the average forage in the pasture. Depending on the amount of forage available, selectivity can be a major factor in the quality of forage consumed. This research was conducted to determine seasonal variations in trace mineral content and to assess the accuracy of clipped samples in predicting animal consumption of trace minerals.

Experimental Procedures

Clipped, native grass samples from four tall or intermediate grass and four short grass range sites in central and western Kansas were collected in both early June and late February to represent two extremes in the plant life cycle. Clipped samples were taken from the same pasture location on each collection date. Trace mineral analysis was conducted using inductively coupled plasma (ICP) spectrometry (Peterson Laboratories; Hutchinson, KS).

To evaluate the impact of grazing selectivity on trace mineral intake, four ruminally cannulated steers were evacuated and allowed to graze controlled areas. At the same time, hand-clipped samples were obtained. The rumen of each steer was then evacuated, and the contents were rinsed with water until it ran clear. These collections were repeated four times.

Results and Discussion

No differences occurred in the trace mineral content of short vs tall or intermediate native grasses at similar stages of growth (Table 1). For both grass types, Cu and Zn concentrations tended to be lower during dormancy than during the growing season. Iron and Mg concentrations did not show that trend. The level of Cu in both forage types was adequate in June but marginal in February in terms of meeting a grazing animal's dietary requirements. The Zn levels were marginal to deficient in both forage types at both forage sampling times. The Fe content was adequate in both forage types in June and was very high in the short grass samples in February.

The steers consistently selected forage higher ($P<.01$) in crude protein, calcium, and phosphorus than comparable hand-clipped samples. Increases from selectivity were 30.0% for crude protein, 52.6% for calcium, and 36.8% for phosphorus. However, no differences occurred in the trace mineral contents of selected vs clipped grasses (Table 2).

This research indicates that Zn may be marginally deficient in Kansas native range forages. More research is planned to determine the importance of this potential deficiency. In addition, clipped pasture samples appear to be reliable indicators of the trace mineral content of the grass consumed by a grazing animal.

Table 1. Trace Mineral Content of Kansas Native Grasses [a]

Grass Type	Sampling Time	Iron	Copper	Zinc	Manganese
Tall/intermediate	June	314 ± 97	10.02 ± 1.16	19.78 ± 2.04	32.90 ± 4.18
	February	352 ± 58	5.43 ± .45	14.10 ± 2.04	22.15 ± 3.19
Short	June	347 ± 52	8.78 ± .84	16.30 ± 1.55	35.90 ± 2.04
	February	795 ± 128	4.40 ± .39	13.04 ± 1.25	41.90 ± 2.87

[a]Results are expressed as the mean mineral content ± SE; all results are expressed as mg/kg.

Table 2. A Comparison of the Trace Mineral Content of Hand-Clipped vs Grazed Forage Samples [a]

Collection Method	Iron	Copper	Zinc	Manganese
Steer selection	152.7 ± 16.8	10.65 ± .56	20.42 ± .54	11.32 ± .59
Hand-clipped	154.8 ± 23.7	11.49 ± .79	19.50 ± .76	12.84 ± .84

[a]Results are expressed as the mean mineral content ± SE; all results are expressed as mg/kg.

THE EFFECT OF COPPER SULFATE AND ZINC OXIDE IN A DRENCH ON THE GAIN AND HEALTH OF NEWLY ARRIVED CALVES

F. K. Brazle [1] and G. Stokka [2]

Summary

One hundred and fifty-four, newly arrived, bull calves averaging 295 lb were either drenched with a copper-zinc (Cu-Zn) solution or water at arrival. The Cu-Zn drench did not affect gains during a 56-day trial. Additionally, no differences occurred in morbidity or the number of antibiotic treatments required per animal.

(Key Words: Copper, Zinc, Trace Minerals.)

Introduction

Copper and zinc are important for certain enzymes in the immune system. Also, there have been reports that highly stressed calves may have higher requirements than healthy calves for copper and zinc. Therefore, our objective was to determine if a Ci-Zn drench at arrival would improve the health and gain of highly stressed calves.

Experimental Procedures

One hundred and fifty-four bull calves shipped from Georgia were allotted randomly to receive 40 ml of either a water (control) or a Cu-Zn drench treatment. The Cu-Zn treatment contained 250 mg Cu from copper sulfate, 650 mg Zn from zinc oxide, and 400 IU of Vitamin E. Additionally, they were dewormed with Inomec®, implanted with Ralgro®, and mass medicated with Micotil®. The calves were weighed on days 1, 14, 28, and 56. The calves were vaccinated at arrival with modified-live IBR+BVD+PI_3, 7-way blackleg, and Presponse®. On day 28, they were surgically castrated. The calves were fed an average of 6.25 lbs per day of a 16% crude protein milled ration plus prairie hay to appetite (average consumption of 3.7 lb/day).

Results and Discussion

Table 1. Effect of Copper Sulfate and Zinc Oxide on Health and Gain of Newly Arrived Calves

Item	Control	Cu-Zn
No. calves	77	77
Starting wt, lb	295	295
ADG, lb		
1 to 14 d	1.36	1.39
15 to 28 d	1.35	1.11
1 to 28 d	1.36	1.25
29 to 56 d	1.90	2.00
1 to 56	1.61	1.64
Health		
Morbidity, %, 1 to 28 d	29.8	32.4
Morbidity, %, 29 to 56 d	27.7	18.5
Treatments/animal, 1 to 28 d	9.0	7.1
Treatments/animal, 29 to 56 d	7.2	5.5

The Cu-Zn drench at arrival did not affect gains through 56 days (Table 1), although the Cu-Zn drench group tended to gain slower during the first 28 days. No difference occurred in morbidity or number of treatments required per animal.

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[2]Department of Clinical Sciences.

THE EFFECT OF FOURPLEX® ON GAIN AND HEALTH OF NEWLY ARRIVED CALVES [1]

F. K. Brazle [2] and G. L. Stokka [3]

Summary

Two trials were conducted to evaluate the effects of Fourplex®, a trace mineral supplement, on long-hauled stocker calves. In each trial, Fourplex was added to the ration of lightweight, long-hauled calves in four pens, while calves in another four pens served as controls. Additionally, every other calf that became sick, regardless of feed treatment, was drenched with a solution of Fourplex in Trial I and a Cu, Zn, Mn+Co solution in Trial II. Fourplex in the feed did not improve ADG, reduce morbidity, or reduce the number of treatments required per sick animal. In Trial II, Fourplex-fed calves that became sick required more treatments ($P<.12$) during the first 2 weeks; however, during the third and fourth weeks, they required fewer treatments ($P<.03$). In Trial I, sick calves drenched with Fourplex required more treatments. In Trial II, drenching with a Cu, Zn, Mn+Co solution resulted in an increase in treatments per sick calf during the fourth week. In these trials, Fourplex did not significantly increase performance or reduce sickness.

(Key Words: Fourplex®, Copper, Zinc, Trace Minerals.)

Introduction

Copper (Cu) and zinc (Zn) have been shown to be important for certain enzymes in the immune system. The objective of this study was to determine if Fourplex, a trace mineral premix containing Cu and Zn, would improve the health and gain of highly stressed calves when included in the diet or in a drench given when the calves first exhibited signs of sickness.

Experimental Procedures

Trial I. One hundred and fifty-nine bull calves shipped from Georgia were allotted randomly to treatments: 1) control or 2) Fourplex fed at 15 g/head/day, which provides three times the NRC minimum daily requirement for Cu, Zn, Mn, and Co. There were four pens per treatment. The calves were vaccinated at arrival with modified-live IBR+BVD+PI_3, 7-way blackleg, and Presponse®. They were individually weighed at processing and on day 28. Additionally, they were dewormed with levamisole, deloused with Lysoff®, implanted with Ralgro®, mass medicated with Micotil®, and castrated via banding. Every other calf pulled for sickness from each pen, regardless of treatment, was drenched with 100 ml of Fourplex C. This drench was made by adding 21 g of Fourplex C to 100 ml of water and straining through cheesecloth. The material was difficult to move through the drench guns and had to be diluted slightly in the straining process. A sick pen was provided for each treatment group; therefore, the calves remained on the original feed treatments while in the sick pen. Similar antibiotic treatment strategies were used on sick

[1]Appreciation is expressed to Zinpro Co-Pro, Edina, MN, for partial funding and to Richard Porter, Reading, KS, for supplying the cattle.

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calves regardless of feed or drench treatments.

Trial II. One hundred and sixty-eight calves were allotted randomly to the same feed treatments as in trial I with four pens per treatment. Processing treatments and handling procedures were also the same. However, in this trial, every other sick calf from each pen was drenched with 100 ml of a solution made with 5.4 g of Zinpro® 200, 3.75 g Cuplex® 100, 3.75 g Manpro® 160, 0.94 g Copro® PD, and 100 ml of water.

Rumen fluid was collected from two calves per pen on days 1, 14, and 28. In addition, rumen fluid was collected from the first two calves that became sick from each pen. Rumen fluid was collected again when they left the sick pen. The rumen fluid was frozen and later analyzed for Cu, Zn, Mn, and Co.

Results

In Trial I, no differences occurred in ADG, percent morbidity, number of treatments per animal, or feed intake between control and Fourplex-fed calves (Table 1). Drenching sick calves with Fourplex increased (P<.05) the treatments required (10.4 vs 5.3 for nondrenched calves).

Table 1. The Effect of Fourplex® in the Starter Diet for Long-Hauled Calves, Trial I

Item	Fourplex	Control
No.	80	79
Starting wt, lb	260	252
ADG, lb	1.41	1.50
Morbidity, %	40.5	29.9
Treatments/animal	6.9	6.5

In Trial II, Fourplex in the feed did not improve ADG, reduce mortality or morbidity, or influence feed intake (Table 2). The number of treatments required for sick animals was higher (P<.12) for those receiving Fourplex in the diet for the first 2 weeks. However, by the fourth week, the Fourplex-fed calves required fewer treatments than the controls. This might suggest that Fourplex in the feed adds stress to the calves before the additional mineral supplementation has a chance to improve the immune system. However, by week 4, the immune system may have had a chance to respond, resulting in fewer treatments per animal. The feeding of Fourplex resulted in increased (P<.05) rumen concentration of all minerals except Zn on days 14 and 28. Zinc was elevated in the rumen only at day 14. Feed intake was not affected by Fourplex.

Table 2. The Effect of Fourplex® in the Feed on Gain and Health of Calves, Trial II

Item	Fourplex	Control
No.	84	84
Starting wt, lb	246	255
ADG, lb	1.15	1.08
Mortality, %	5.8	3.5
Morbidity, %	72.0	63.4
Treatments/animal		
Week 1	4.6[a]	4.1[b]
Week 2	3.9[a]	3.1[b]
Week 3	5.3	4.9
Week 4	4.1[c]	6.2[d]

[a,b]Means in the same row with unlike superscripts are different (P<.12).

Drenching tended to increase the number of treatments required in both feed groups. In the fourth week, the difference became significant (P<.08); (6.0 vs 4.2 treatments per head). This suggests that drenching sick calves with high doses of trace minerals on the first day in the sick pen did not improve the response to antibiotic therapy. More research data are needed to understand better the dosage level and effect of the drench on the health of light-weight calves.

THE EFFECT OF PROTECTED LYSINE-METHIONINE ON GAIN AND HEALTH OF NEWLY ARRIVED CALVES [1]

F. K. Brazle [2] and G. L. Stokka [3]

Summary

Long-hauled calves averaging 293 lb were allotted to groups fed with or without protected lysine-methionine (Smartamine ML®). Protected lysine-methionine did not improve ADG in the first 28 days but did improve ADG from 29 to 56 days. It also reduced morbidity (16.1 vs 34.2%) from day 29 to 56. Based on this research, the response of long-hauled calves to protected lysine-methionine in the diet appears to occur after they have recovered from the stress of shipment.

(Key Words: Lysine, Methionine, Protected Amino Acids, Stocker Calves.)

Introduction

Escape or bypass protein has been shown to improve performance of lightweight calves, and it has been hypothesized that rumen bypass of certain amino acids might improve gain and health of calves. The objective of this study was to evaluate the effect of protected lysine-methionine (amino acids) on the gain and health of newly arrived, lightweight calves.

Experimental Procedures

One hundred and fifty-six bull and steer calves from Georgia were blocked by sexual status and randomly allotted to be fed with or without protected lysine-methionine at 10g/hd/day. There were four pens per treatment.

The calves were vaccinated at arrival with modified-live IBR+BVD+PI_3, 7-way blackleg, and Presponse®, and weighed individually on days 1, 14, 28, and 56. Additionally, they were dewormed and deloused with Ivomec®, implanted with Ralgro®, and mass medicated with Micotil®. On day 28, the bull calves were surgically castrated.

Body temperature of all calves was recorded on day 14. All calves with body temperature over 104°F were treated with Micotil, placed in sick pens by treatment group, and fed their original ration. The remaining calves were treated with long-acting penicillin and returned to their original pens.

Results and Discussion

The calves receiving the protected lysine-methionine gained faster ($P<.10$) than controls, with most of the increase occurring from days 29 to 56 (Table 1). Hay intake was increased ($P<.01$) by feeding protected lysine-methionine during the first 28 days. The calves fed protected lysine-methionine had less sickness ($P<.01$) from days 29 to 56. This reduction in sickness after 29 days could be very beneficial, if the calves were turned out to wheat pasture or grass.

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[1]Appreciation is expressed to Rhone-Poulenc, Atlanta, GA, for partial funding and to Richard Porter, Reading, KS, for supplying the cattle.

[2]Extension Livestock Specialist, Chanute, KS.

[3]Department of Clinical Sciences.

In this trial, the addition of lysine-methionine to the diet showed some potential to improve the health and gain of highly stressed calves; however, more research must be conducted to determine if this response is related to improved nutrition or to an immune response.

Table 1. Effect of Protected Lysine-Methionine on Gain and Health of Newly Arrived Calves during the First 56 Days

	Lysine Methionine	Control
No. calves	78	78
Starting wt., lb	293	293
ADG, lb		
1 to 14 d	1.31	1.45
15 to 28 d	1.36	1.10
1 to 28 d	1.34	1.27
29 to 56 d	2.04[a]	1.86[b]
1 to 56 d	1.69[a]	1.57[b]
Feed intake, lb		
Grain - 1 to 28 d	5.75	5.75
Hay - 1 to 28 d	4.50[e]	4.23[f]
Total - 1 to 28 d	10.25[e]	9.98[f]
Grain 29 to 56 d	6.80	6.80
Hay 29 to 56 d	3.05	3.02
Total 29 to 56 d	9.85	9.82
Grain 1 to 56 d	6.27	6.27
Hay 1 to 56 d	3.77	3.62
Health		
Morbidity, %, 1 to 28 d	27.6	32.2
Treatments/animal, 1 to 28 d	8.1	8.0
Body temp., d 14, °F	103.1	103.2
No. dead	1	0
Morbidity, %, 29 to 56 d	16.1[c]	34.2[d]
Treatment/animal, 29 to 56 d	6.1	6.6

[a,b]Means in the same row with unlike superscripts are different (P<.10).
[c,d]Means in the same row with unlike superscripts are different (P<.01).
[e,f]Means in the same row with unlike superscripts are different (P<.06).

THE EFFECT OF MASS TREATMENT WITH MICOTIL® [1] AT ARRIVAL ON THE HEALTH AND PERFORMANCE OF LONG-HAULED CALVES

F. K. Brazle [2]

Summary

Long-hauled calves (n=170 were either mass-medicated with Micotil® or served as controls. Micotil reduced mortality (1.2 vs 8.1%) and morbidity (59.7 vs 75.5%), but it did not improve ADG.

(Key Words: Stocker Calves, Micotil®, Receiving Program, Shipping Fever, Health.)

Introduction

Calves hauled long distances typically have high incidences of respiratory diseases and other health complications. Micotil (tilmicosin phosphate) is a long-acting antibiotic that has shown promise in reducing respiratory disease. Our objective was to determine if mass medication with Micotil at arrival would reduce sickness and improve gain of highly stressed, long-hauled calves.

Experimental Procedures

One hundred and seventy, mixed breed, bull calves from Alabama averaging 294 lb were allotted randomly to either receive Micotil (4.5 ml of IM at arrival) or serve as controls. All calves were vaccinated with modified-live IBR+BVD+PI_3 and Blackleg (7-way), dewormed with levamisole, deloused with Lysoff®, implanted with Ralgro®, and castrated via banding. They were fed 4.5 lbs per day of a 15.5% crude protein milled ration plus prairie hay to appetite (average, 2.9 lbs).

Results and Discussion

Table 1. The Effect of Mass Medication of Long-Hauled Calves with Micotil® at Arrival

	Treatment	
Item	Control	Micotil®
No. calves	85	85
Starting wt, lb	294	294
ADG, lb	1.12	1.18
Health		
Morbidity, %	75.6[a]	59.7[b]
Mortality, %	8.1[a]	1.2[b]
Treatments/animal		
Week 1	4.3	4.3
Week 2	3.9	3.1
Week 3	5.4	4.6
Week 4	4.5	5.1

[a,b]Means in the same row with unlike superscripts are significantly different (P<.05).

These calves were severely stressed as indicated by the level of morbidity and the number of antibiotic treatments required (Table 1). An injection of Micotil at arrival reduced both mortality (1.2 vs 8.1%; P<.05) and morbidity (59.7 vs 75.5% ; P<.04). However, it did not affect the number of antibiotic injections required to treat a sick calf and did not improve ADG. An injection of Micotil to highly stressed calves at arrival should be cost effective as a result of reductions in morbidity and mortality.

[1]Micotil is a registered trademark of Elanco Animal Health.

[2]Extension Livestock Specialist, Chanute, KS.

THE EFFECT OF FEEDING DIFFERENT LEVELS OF AUREOMYCIN® IN A MINERAL MIXTURE TO STOCKER CATTLE GRAZING NATIVE GRASS [1]

F. K. Brazle [2]

Summary

Two hundred and forty-three mixed breed steers were allotted to four treatments with two pastures per treatment. Treatments consisted of a free-choice mineral supplement alone or with Aureomycin® added to provide 150, 300, or 450 mg/hd/day. Gain was similar for all four treatments. The percentage of cattle with eye problems was reduced in pastures where 150 and 450 mg of Aureomycin were consumed daily; however, the incidence in the 300 mg/hd/day group was as high as in the control group.

(Key Words: Aureomycin®, Antibiotic, Mineral, Chlortetracycline, Native Grass, Stocker Cattle.)

Introduction

Aureomycin (chlortetracycline), at levels ranging from 75 to 500 mg/hd/day, has been shown to increase daily gain of stockers grazing native grass pastures. Additionally, it has reduced eye problems when fed at 350-500 mg/hd/day. The objective of this study was to determine the optimum level of Aureomycin needed to control eye problems and footrot, in addition to improving animal gains.

Experimental Procedures

Two hundred and forty-three mixed breed steers were allotted randomly to four treatments consisting of free-choice mineral mixes designed to provide 0, 150, 300, or 450 mg/hd/day of Aureomycin. Each treatment group was further divided into two pasture replications for a total of eight pastures. To attain the desired Aureomycin intake in the last three treatments, an Aureomycin premix (50 gram/lb) was added at 28, 56 or 84 lb per ton, respectively, of a commercial mineral mixture. The composition of the commercial mineral mixture is shown in Table 1.

Table 1. Composition of the Commercial Mineral Mixture

Ingredient	Percent
Calcium, not less than	7.0
Calcium, not more than	8.4
Phosphorus (P), not less than	7.0
Salt, not less than	39.0
Salt, not more than	41.0
Selenium, not less than	0.0026
Iodine, not less than	0.0002
Potassium, not less than	1.0
Magnesium, not less than	0.5
Vitamin A, not less than	50,000 IU/lb

[1]Appreciation is expressed to Dale Lanham, Woodson County Agricultural Agent and the Bressner Pasture Committee for their assistance.

[2]Extension Livestock Specialist, Chanute, KS.

The steers grazed for 92 days. Individual weights were taken at the start and end of the trial. Steers were commingled at weighing to remove time of weighing effects. Additionally, they were monitored each week for footrot and eye problems. Mineral intake was monitored weekly.

Results and Discussion

The typical gain response to Aureomycin was not observed in this trial (Table 2). Mineral intake was very close to the predicted level, which resulted in Aureomycin intakes very close to the target levels. There was a slight but nonsignificant trend toward a reduction in footrot with the increasing Aureomycin. The steers consuming 150 mg and 450 mg had a lower incidence of eye problems; however, the incidence was as high in the 300 mg group as in the controls. Given the low incidence of both footrot and eye problems in the control steers, this trial may not have been an adequate test of the efficacy of Aureomycin in preventing these problems.

Table 2. The Effect of Adding Aureomycin to a Mineral Mixture Supplied Free-Choice to Stocker Cattle

	Treatment - mg Aureomycin/hd/day			
Item	Control	150	300	450
No.	56	65	54	68
Starting wt, lb	565	561	562	553
ADG, lb	2.57	2.58	2.57	2.58
Mineral intake, g/day	88	93	97	99
Aureomycin intake, mg/day	—	143	298	458
Incidence of:				
Footrot, %	2.0	1.3	.4	1.0
Eye problems, %	6.9[b]	1.8[a]	7.7[b]	3.5[a]

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

EFFECT OF LASALOCID AND LENGTH OF MORNING GRAZING ON WEIGHT AND SHRINK OF STEERS GRAZING BROMEGRASS PASTURES

K. P. Coffey [1], F. K. Brazle [2], and J. L. Moyer [2]

Summary

A total of 72 mixed breed steers from two sources was used in an experiment to determine the effect of lasalocid and length of morning grazing prior to weighing on weight and shrink of steers grazing smooth bromegrass pastures. Steers were divided into eight groups and weighed at either 6, 7, 8, or 9 a.m. on 4 separate days. Half of the steers received a control mineral mixture and half received a mineral mixture containing lasalocid. Weights of purchased steers having an excitable disposition were not affected (P>.10) by length of morning grazing prior to weighing. However, weights of steers raised at the Southeast Kansas Branch Experiment Station (SEKES) increased with length of morning grazing. Steers allowed to graze for 3 hours before morning weighing had the lowest (P<.05) total % shrink and total % shrink/hour by 3 p.m. Lasaloid did not affect shrink. Using these figures, cattlemen could add additional weight to cattle by simply allowing them to graze longer before gathering them for sale.

(Key Words: Shrink, Steers, Grazing Time, Marketing.)

Introduction

Cattle generally graze for 3- to 4-h periods beginning at daybreak and prior to sunset, and for 1- to 2-h periods scattered throughout the day. In a fall-grazing study on smooth bromegrass at the Southeast Kansas Branch Experiment Station (SEKES), steers allowed to graze in the morning for 3 h before weighing were 16 lb heavier than those weighed as the morning grazing period began. This study was conducted to determine the effect of lasalocid and length of morning grazing prior to weighing on weight and shrink of steers grazing smooth bromegrass pastures in the summer.

Experimental Procedures

Forty purchased, mixed breed steers and 32 Simmental × Angus crossbred steers from the SEKES herd were allotted by source to one of eight, 10-acre, smooth bromegrass pastures. Within each cattle source, steers grazing two pastures were offered a control mineral mixture and steers grazing the two remaining pastures were offered a mineral mixture containing lasalocid (600 mg/lb). Steers were allotted to their respective pastures on June 3 and had grazed smooth bromegrass for at least 30 days prior to starting the study. Steers were allowed free access to water and their respective loose mineral mixture throughout the study.

All steers were removed from pasture on the afternoons of June 24 and July 13 and weighed before and after a 16-h shrink. Steers from the control and lasalocid groups were weighed full on June 28 and 30 and July 2 and 6 at either 6, 7, 8, or 9 a.m. On each day of weighing, each group of steers was weighed only once, and each group of steers was weighed at a different time on each

[1]Southeast Kansas Branch Experiment Station, Parsons, KS.
[2]Southeast Area Extension Office, Chanute, KS.

weigh day. Following their respective weighing on July 6, steers were placed in pens without feed or water and weighed at approximately 2-h intervals until 3 p.m. This was done to determine how lasalocid or length of morning grazing would affect rate of shrink.

Results and Discussion

A cattle source × grazing time interaction was detected (P<.10) for average full weights measured between June 28, 30 and July 2, 6 and weight change from the initial and final shrunk weights (Table 1). Neither weight nor weight change from shrunk weights of purchased cattle differed (P>.10) among lengths of morning grazing. Conversely, SEKES steer weights increased with length of morning grazing such that steers weighed at 9 a.m. weighed 14.3 lb more (P<.10) than those weighed at 6 a.m. Because steers started grazing at approximately 6 a.m., waiting until 9 a.m. gave them 3 hours to gain fill. Weight changes from shrunk weight were greater (P<.10) for steers from SEKES than for purchased steers at the 7 a.m. and 9 a.m. weighings and tended (P>.10) to be greater for SEKES steers at 6 a.m. and 8 a.m. weighings. These values represent fill and the ability of the cattle to regain fill following a shrink. The reason for the differential response between cattle sources probably can be attributed to cattle disposition. Purchased steers were difficult to manage, were extremely excitable when weighed, and did not appear to settle into their normal routine rapidly following handling. The SEKES steers were calm, moved quietly through the weighing facilities, and resumed a normal routine rapidly following handling. This is the most probable reason for the increased fill acquired during the intensive weighing period.

Rate of cattle shrink throughout the day also was affected by length of morning grazing (Table 2). Steers allowed to graze for 3 h before being removed from pasture shrank .86 %/h less during the first 2.2-2.6 h following removal from pasture than steers not allowed to graze. Steers allowed to graze for 3 h shrank at a faster rate (%/hour) during the ensuing 1.9 to 2.7 h period, but cumulative rate of shrink at any length of time following removal from pasture was lowest (P<.05) for steers allowed to graze for 3 h prior to removal from pasture. Total shrink at 3 p.m. was 2.9% less (P<.05) and rate of shrink was .19 %/h less (P<.05) for steers allowed to graze for 3 h compared with those removed from pasture at the time grazing began.

Table 1. Average Full Weight (lb) and Weight Change from a 16-hour Shrunk Weight of Two Cattle Sources following Different Lengths of Morning Grazing on Smooth Bromegrass Pastures

		Pasture Removal Time			
Item	Source	6 a.m.	7 a.m.	8 a.m.	9 a.m.
Average weight, lb	Purchased	669.8^{d}	665.6^{d}	674.8^{cd}	666.6^{d}
	SEKES	680.7^{bc}	683.9^{b}	686.6^{ab}	695.0^{a}
Weight change, lb	Purchased	25.5^{c}	21.3^{c}	30.5^{bc}	22.3^{c}
	SEKES	31.3^{bc}	34.5^{b}	37.2^{ab}	45.6^{a}

^{abcd}Means for average weight (both sources) or weight change (both sources) without a common superscript differ (P<.10).

Lasalocid supplementation did not affect (P>.10) rate of shrink.

Examples of the economic impact of this information are shown in Table 3. Example 1 is for 20 steers gathered at different times and sold at the local auction at 3 pm. Example 2 is for a group of 432 steers loaded under different scenarios and sent to a feedlot in western Kansas. A sale price of $80/cwt was assumed, although some price differential might occur because of cattle weight. Data gathered from this study indicate that cattlemen could add over $26/head to the value of steers sold at a local auction or over $11/head to the value of steers loaded off of pasture and sold to western Kansas feedlots.

Table 2. Rate of Shrink (%/hour) by Steers Gathered from Pasture following Different Lengths of Morning Grazing on Smooth Bromegrass Pastures

		Pasture Removal Time				Mineral	
Item	Period[a]	6 a.m.	7 a.m.	8 a.m.	9 a.m.	Lasal.	Cont.
Shrink, %/hour	1[b]	1.25[c]	1.19[c]	1.05[c]	.39[d]	.91	1.03
Shrink, %/hour	2[f]	.61[d]	.96[c]	.17[e]	.94[c]	.68	.66
Shrink, %/hour	1-2	.89[cd]	1.08[c]	.71[de]	.64[e]	.81	.85
Shrink, %/hour	3[g]	.16[d]	.02[d]	.59[c]	.15[d]	.19	.26
Shrink, %/hour	1-3	.67[c]	.72[c]	.67[c]	.49[d]	.62	.67
Total shrink, %[h]	to 3 pm	6.2[c]	5.9[cd]	5.0[d]	3.3[e]	4.9	5.3
Total shrink, %/hour	to 3 pm	.69[c]	.71[c]	.67[c]	.50[d]	.62	.67

[a]Periods are designations for times following removal from pasture. [b]Period 1 is the first 2.2-2.6 hours following removal from pasture, except for steers removed at 8 a.m. For those steers, period 1 was 3.4 hours. [cde]Means for pasture removal time within the same row without a common superscript letter differ (P<.05). [f]Period 2 is the next 1.9-2.7 hours following period 1. [g]Period 3 is the next 1.9 to 2.2 hours following period 2. [h]Total % shrink is based on the weight measured immediately upon removal from pasture and water and weight measured at approximately 1500 hours.

Table 3. Examples of the Effect of Different Lengths of Morning Grazing Allowance on Cattle Value

Example 1 - 20 steers gathered from pasture at different times and sold at local auction at 3 p.m.

	Pasture Removal Time			
	6 a.m.	7 a.m.	8 a.m.	9 a.m.
# head	20	20	20	20
Off pasture weight, lb	681	684	687	695
Shrink, %	6.2	5.9	5.0	3.3
Sale wt., lb	639	644	653	672
Average value, $/head[a]	$511.20	$515.20	$522.40	$537.60

Example 2 - 432 steers loaded off of pasture. Group 1 has all steers in one group and removed from pasture starting at 6 a.m. and loaded at a rate of one truck every 30 minutes. Group 2 has 432 steers divided onto three pastures and gathered at either 6, 7:30, or 9 a.m., with half loaded immediately and half loaded 30 minutes later.

	Group 1		Group 2	
	Depart	Arrive[b]	Depart	Arrive
Average weight, lb/head	671	634	685	651
Average value, $/head[a]	$536.80		$548.00	

[a]Total value is based on total sale weight multiplied by $80/cwt.
[b]Arrival weight at a western Kansas feedlot after an 8-hour transit time.

COMMERCIAL CATTLE PRODUCERS: BULL SELECTION CRITERIA [1]

D. D. Simms, J. M. Geske, and R. P. Bolze

Summary

A survey of 312 commercial cattle producers was conducted to determine the relative importance of selection criteria used in buying bulls. Calving ease was a major consideration of a high percentage of producers, and individual performance was being emphasized more than expected progeny differences (EPDs). Only 23% of the producers included EPDs in their first three selection criteria. Visual appraisal focused on structural soundness, length, and muscling.

(Key Words: Bulls, Selection, Breeding, Expected Progeny Differences.)

Introduction

Many traits are of importance to the commercial cattle industry, and the relative importance of specific traits tends to shift as the industry changes. Understanding the relative ranking of traits by commercial producers and the information they are using to evaluate bulls has potential value for purebred breeders and Extension specialists. Consequently, a survey was conducted in early 1993 to assess current emphasis on selection criteria. Additionally, producers were asked to give the strengths and weaknesses of the breeds that they were using to determine current perceptions of common beef breeds.

Experimental Procedures

A questionnaire was mailed to over 1,000 producers who purchased a bull in 1993. Buyer lists were provided by 13 Kansas cattle breeders and buyers at both the Beloit and Potwin bull sales. Breeds represented included Angus, Simmental, Charolais, Gelbvieh, Red Angus, Salers, Limousin, and Horned Hereford. Over 400 hundred questionnaires were returned, with 312 representing commercial producers. Because the criteria emphasized by commercial producers were of primary interest, the questionnaires returned by purebred buyers were not included in the analysis.

Results and Discussion

Producers were asked to rank (in order of importance) the factors considered in purchasing a bull. Table 1 shows the relative ranking of types of information available to commercial producers. Calving ease score was listed most commonly as the first criterion, and almost one-half of the producers had it in their first three criteria. This result was interesting, considering that only the Simmental and Gelbvieh breeds currently provide calving ease scores, and

[1]Appreciation is expressed to the following Kansas cattle breeders who assisted in this survey: Hubert Charolais, Monument; Green Garden Angus, Ellsworth; Gold Genetic Breeders, Phillipsburg; Dickinson Simmentals, Gorham; Thompson Cattle Company, Plainville; Schilling Limousin, Edson; Judd Ranch, Inc., Pomona; Gardiner Angus, Ashland; Stielow Angus, Paradise; BBB Charolais, Oakley; Runft Charolais, Scandia; RX Cattle Company, Hays; and Jamison Herefords, Quinter.

these breeds accounted only for approximately one-third of the bull purchases represented in the survey. The relatively low level of emphasis on expected progeny differences (EPDs) indicated that producers weren't using the most accurate selection criteria available. Relative ranking for all traits was similar across breeds, with the exception that buyers of Charolais and Horned Hereford bulls placed much less emphasis on EPDs than buyers of Angus, Simmental, and Gelbvieh bulls. Buyers of Charolais bulls emphasized birth weight and calving ease much more than buyers of any other breed, whereas buyers of Horned Herefords placed more emphasis on breeder reputation.

Table 2 summarizes the relative ranking of visual appraisal criteria. Structural soundness, length, and muscling were most often included in the first three criteria.

Performance information most often utilized is summarized in Table 3. Birth weight and birth weight EPD were the major performance items considered by producers. This emphasis indicates a shift from a similar survey conducted in 1981 (1982 Cattlemen's Day), in which growth traits received primary emphasis. The relative low ranking of maternal and milk EPDs was also interesting, given the economic importance of these traits. Actual performance of the bull, i.e., actual birth weight and weaning weight, were utilized more than their corresponding EPDs. Studies have shown that EPDs are more accurate predictors of progeny performance than the individual's actual performance. Therefore, producers should emphasize EPDs more than actual performance.

Producers also were asked to indicate their direction with respect to cow size. Of those that responded, 78% wished to maintain the size (weight) of their cows at current levels, whereas 7% wanted to increase size and 15% decrease size. Correspondingly, 41% wanted to increase the milking ability of their cow herd, whereas 58% were content with current levels, and the remaining 1% wanted to decrease milk production.

Another question addressed producers' attitudes about the use of crossbred or composite bulls. Forty-six percent indicated that they would use them, whereas 54% indicated that they would not. The most common reason given for not using a crossbred or composite bull was a concern about the lack of predictability and uniformity of the offspring.

Seventy-four percent expressed a need for across-breed EPDs, with breed comparisons given as the main reason. The 26% that didn't indicate a need believed that across-breed EPDs would not be accurate and would be confusing.

As a final part of the survey, producers were asked to indicate the perceived strengths and weaknesses of the breeds that they were currently using. The three most commonly mentioned strengths and weaknesses for each breed are shown in Table 4.

Table 1. Selection Criteria Utilized by Commercial Producers

Factor	First Criterion, %	Included in First 3 Criteria, %
Calving ease score	25	49
Frame score	12	20
Birth weight	11	39
Conformation/visual appraisal	11	24
Expected progeny differences	9	23
Disposition	7	31
Breeder reputation	5	13
Weaning weight	4	32
Yearling weight	4	19
Structural soundness	4	16
Price	3	12
Color	1	5
Dam's functional traits	1	5
Pedigree	1	4
Polled/horned	0	5

Table 2. Ranking of Visual Criteria Emphasized by Commercial Producers

Factor	First Criterion, %	Included in First 3 Criteria, %
Structural soundness	21	43
Disposition	17	29
Length	16	41
Frame score	12	33
Weight	12	26
Muscling	10	39
Straight top line	3	19
Smooth shoulder	3	15
Masculinity	2	7
Color	2	6
Large testicles	1	19

Table 3. Ranking of Performance Criteria Emphasized by Commercial Producers

Factor	First Criterion, %	Included in First 3 Criteria, %
Birth weight and ratio	35	51
Birth weight EPD	15	43
Weaning weight and ratio	11	38
Weaning weight EPD	10	32
Yearling weight EPD	10	26
Direct calving ease EPD	6	27
Yearling weight and ratio	5	33
Maternal weaning weight EPD	3	7
Weight per day of age	2	12
Average daily gain	1	9
Milk EPD	1	9
Maternal calving ease EPD	1	9

Table 4. Breed Strengths and Weaknesses Indicated by Commercial Producers [1]

Breed	Strength	% of Responses	Weakness	% of Responses
Angus	Maternal/milking ability	36	Slow growth rate	21
	Calving ease	32	Disposition	14
	Carcass quality	22	Too small framed	10
Red Angus	Maternal/milking ability	24	Slow growth rate	26
	Color	20	Small framed	10
	Calving ease	18	Lack of availability	6
Simmental	Growth rate	82	Too large framed	34
	Maternal/milking ability	24	Calving difficulty	25
	Frame size	8	Color/dilution gene	10
Charolais	Growth rate	70	Calving difficulty	37
	Buyers' demand	14	Lack of milk/maternal	20
	Frame size	10	Too large framed	17
Gelbvieh	Maternal/milking ability	63	Calving difficulty	20
	Growth rate	45	Too large framed	10
	Disposition	15	Lack of eye appeal	9
Hereford	Disposition	34	Eye problems	34
	Easy keepers	28	Poor milkers	21
	Growth rate	10	Lack of buyer demand	9
Limousin	Muscling	31	Poor milkers	28
	Lean carcass	28	Disposition	25
	Calving ease	16	Slow growth rate	19
Salers	Calving ease	84	Disposition	53
	Lean carcasses	16	Slow growth rate	16
	Maternal/milking ability	16	Lack of buyer demand	11

[1]Responses per breed were as follows: A N = 186, RA = 51, SM = 119, CH = 71, GV = 87, HH = 47, LM = 32 and SA = 19.

ECONOMIES OF SIZE FOR KANSAS BEEF COW PRODUCTION

M. R. Langemeier and T. C. Schroeder [1]

Summary

Economies of size measure the impact of increasing the size of operation on average cost of production. Economies of size exist if average total cost decreases as size increases. Enterprise data from producers enrolled in the Kansas Farm Management Associations in 1992 were used to empirically estimate economies of size for beef cow enterprises. Results indicate that economies of size exist for beef cow enterprises. Average total cost per head declined as the number of beef cows increased.

Substantial variability in costs of production between producers also were documented. Costs of production between producers of a given size varied considerably more than changes in cost of production attributed to size alone. Smaller than average beef cow enterprises can compete in the 1990's, if they are cost competitive. In addition to size, feed costs, fixed costs, production efficiency, and sale prices of calves were important factors affecting the profitability of beef cow enterprises.

(Key Words: Economies of Size, Cost of Production, Profitability, Cow/Calf.)

Introduction

Economies of size measure the relationship between the size of operation (number of cows) and the average cost of production or break-even price. If average total costs decline rapidly as firm size increases, the industry may become more consolidated as firms increase size to reduce average costs. Conversely, if average total costs are similar for firms of different sizes, incentive for consolidation may be less.

Economies of size measures can be used to determine whether it would be advantageous for farms to become larger. Economies of size can result from quantity discounts for inputs, from an increase in efficiency as size increases, or from adoption of capital-intensive technology. Additionally, as a producer increases the size of an enterprise, fixed costs such as unpaid operator labor, depreciation, and interest are spread over more units and fixed costs per unit decline. This research was conducted to examine economies of size for beef cow operations in Kansas using data from the Kansas Farm Management Associations. Additionally, differences in cost of production among producers were evaluated to determine which factors had the greatest impact on profitability.

Experimental Procedures

Enterprise data from 171 beef cow producers enrolled in the Kansas Farm Management Associations in 1992 were used in this study. Enterprise data included the size of the operation, gross income, costs of production, profitability, and productivity. The average farm in the sample had 101 beef cows, with a range of 12 to 465.

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Productivity was measured as hundred lb (cwt) produced per cow, which included calf and breeding livestock sales as well as inventory changes. Production costs and profits were expressed on both per cwt produced and per head bases.

Variable cost categories included hired labor, repairs, interest paid, feed, veterinary expenses, utilities, fuel, and miscellaneous cash expenses. Feed costs included raised and purchased feed and pasture expenses. All feed costs were measured using economic costs of production. Thus, owned pasture land was charged an opportunity cost equal to the rented value of the pasture. Raised feed was priced according to prevailing market prices. Fixed cost categories included unpaid operator labor, depreciation and interest on buildings and equipment, and real estate taxes.

The gross margin ratio, indicating the amount of variable costs incurred per dollar of revenue generated, was used as a measure of economic efficiency. The gross margin ratio was calculated by dividing variable cost per cwt by gross income per cwt. A lower ratio indicates that a firm is more efficient.

A cost function was estimated by regressing average total cost per cwt on size variables. If economies of size exist, the size variables in this regression would be significantly different from zero.

This study also used data from the Kansas Farm Management Associations to separate producers into top and bottom one-third profit groups. Return above total cost was used to separate the 171 producers into profit groups.

Results and Discussion

Figure 1 presents the average total cost curve (represented by the solid line) for 171 beef cow operations in the Kansas Farm Management Associations in 1992. Each triangle in Figure 1 represents the average total cost per cwt for a specific farm. Average total cost was significantly correlated with the size of the operation ($P<.05$). However, as evident from the variability in costs presented in Figure 1, size was not the only factor influencing cost. The average total cost curve did not reach a minimum over the range of the data.

Using the average total cost curve in Figure 1, farms with 25 and 50 beef cows had break-even prices that were 12% and 4% above that of a farm with 100 beef cows. Farms with 200 and 300 beef cows had average total costs 4% and 6% below those of a farm with 100 beef cows.

Variable costs were not significantly different across farm size. Thus, the cost advantages of large farms were related to unpaid operator labor costs and depreciation and interest on fixed assets.

As indicated by Figure 1, tremendous variability occurred in average total costs among operations. Differences in costs of production for farms of the same size were much wider than differences in costs of production between large and small farms.

Table 1 presents financial and production factors for the average farm, compared to those in the bottom and top one-third. Farms in the top one-third averaged about 30 cows more than farms in the bottom one-third profitability group. However, farms of all sizes occurred in both groups.

Gross income for producers in the top one-third profit group was about $6.80 per cwt higher than gross income for producers in the bottom one-third profit group. Sale price and sale weight were similar for the two profit groups. Cwt produced per cow, on the other hand, was relatively higher for producers in the top one-third profit group, which resulted from a larger calf crop. The gross margin ratio was significantly lower for producers in the top one-third group than for those in the bottom one-third profit group.

Costs of production were significantly lower for producers in the top one-third profit group. Their total costs of production

were about $147 per cow lower than those for producers in the bottom one-third. A large proportion (46%) of the difference in cost of production between profit groups was attributable to fixed costs. Another 37% of the difference was attributable to feed costs. Feed costs per head were about $55 lower for the producers in the top one-third group. The remaining 17% of the difference in costs was attributable to variable costs other than feed.

Using the above information, we identified five critical factors affecting the profitability of the beef cow enterprise:

(1) size of the herd,
(2) feed costs,
(3) fixed costs,
(4) pounds of beef produced per cow, and
(5) sale price of calves.

For any size of operation, it is imperative to control production costs. Even with higher than average performance, high-cost producers are at a competitive disadvantage.

Table 1. Selected Financial and Production Factors for Beef Cow Producers in Kansas

	Bottom One-Third (57 Farms)	Average (171 Farms)	Top One-Third (57 Farms)
Financial Factors ($/Cwt.)			
Gross income	73.85	77.52	80.66
Sale price of calves	86.18	86.29	85.58
Feed cost	50.18	43.66	36.10
Variable cost	72.49	62.97	52.27
Total cost	107.40	89.97	72.54
Gross margin ratio [1]	.99	.82	.65
Financial Factors ($/Cow)			
Gross income	409.50	447.45	497.02
Feed cost	277.85	249.48	223.66
Variable cost	400.42	359.37	321.28
Total cost	592.66	512.39	445.73
Return above variable cost	9.08	88.08	175.74
Return above total cost	-183.16	-64.94	51.29
Production Factors			
Number of cows	87	101	118
Sale weight of calves, lb	568	564	575
Cwt. produced per cow	5.63	5.85	6.25

[1]Variable costs ÷ revenue generated.
Source: Kansas Farm Management Associations.

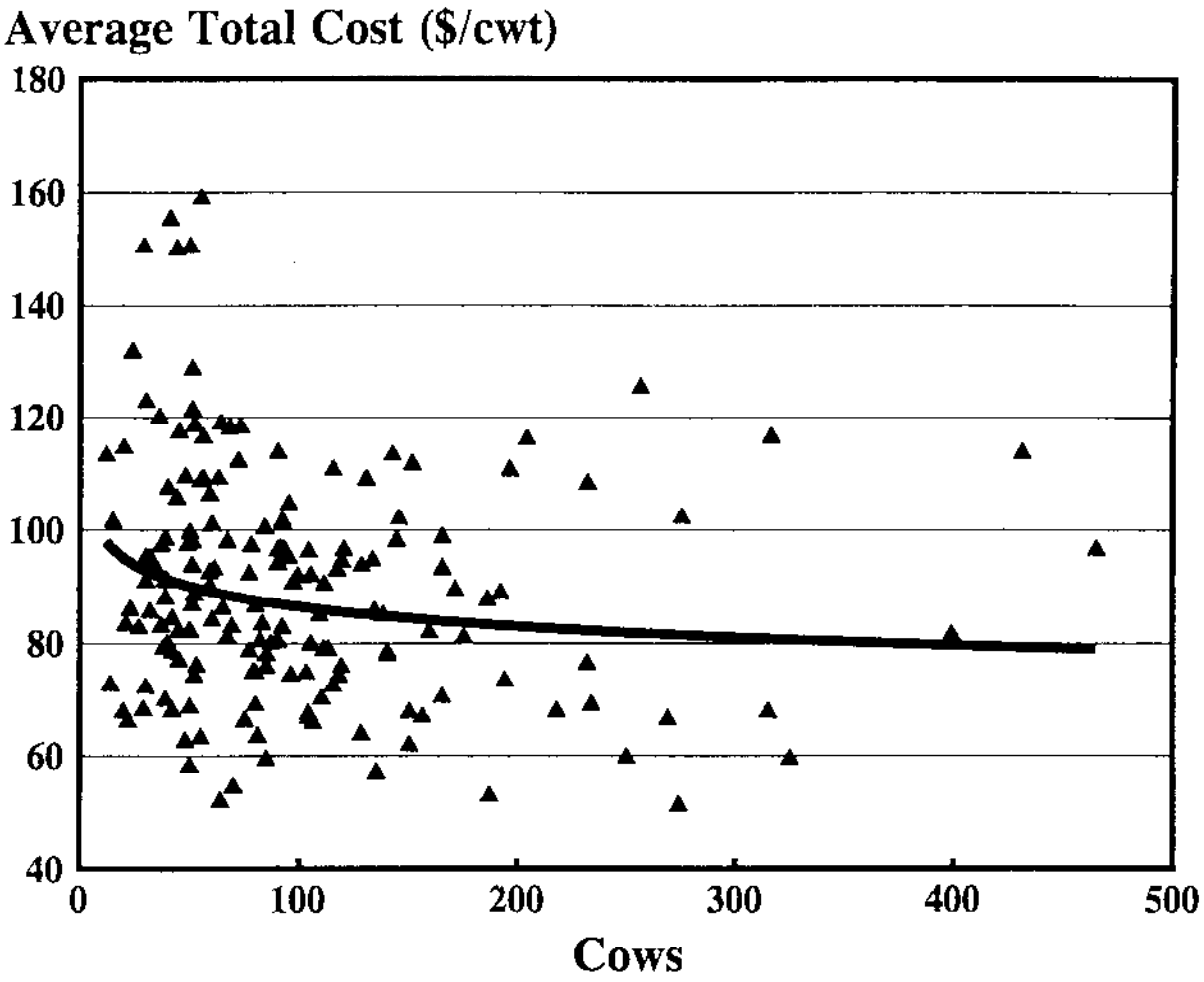

Figure 1. Average Total Cost per Cwt for Beef Cow Operations in Kansas, 1992

EFFICACY OF USING PARASITIC WASPS TO CONTROL STABLE FLIES IN KANSAS FEEDLOTS

***G. L. Greene*[1] *and J. E. Cilek*[1]**

Summary

Release of parasitic wasps has resulted in stable fly reductions averaging 28, 42 and 38% for 1991, 1992, and 1993, respectively, with considerable variation from feedlot to feedlot. Costs for parasites plus sampling averaged $.23, $.32 and $.26 per animal during 1991, 1992, and 1993, respectively. Because stable flies are estimated to cause losses of $5.00 to $30.00 per animal, these costs are very reasonable.

(Key Words: Cattle Feedlot, Stable Fly, Fly Parasites, Pest Management Costs.)

Introduction

Research on feedlot fly reduction with fly parasite releases has shown considerable promise since 1991. *Spalangia nigroaenea*, a fly parasite collected in southwest Kansas, has been used in this program. It attacks stable fly pupae and prevents fly emergence. The use of parasites to replace insecticides is needed because flies have become resistant to many of the available insecticides, and insecticides are becoming less available for livestock use. To determine the efficacy of substituting biological control methods for chemical applications, levels of fly reduction and related costs must be known.

Experimental Procedures

Costs for parasites and sampling fees are based on 4, 18, and 17 feedlots for 1991, 1992, and 1993, respectively. Four to six additional feedlots, where parasites were not released, were sampled each year as controls.

Adult fly numbers were monitored by placing Alsynite sticky traps at the margins of each feedlot. Each week, the number of stable flies trapped was recorded, and the sticky covers on the traps were replaced.

Costs reported reflect the average paid by cooperating feedlots. A sampling fee was established to cover sampling costs. This fee differed each year and from feedlot to feedlot, depending on size. During 1991, feedlots were charged for parasites only. In 1992, a sliding scale was established with smaller feedlots paying more per animal than larger feedlots. During 1993, $.10 per animal was charged with a maximum of $5,000/feedlot, which resulted in a cost of less than $.10 per animal for the large feedlots.

Results and Discussion

The costs per animal showed considerable variation (Table 1) ranging from $.03 to $1.55. This difference was related to

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cleanliness and/or excess fly breeding areas. During 1993, the maximum sampling costs increased because of an extreme amount of wet manure. Average sampling and total costs decreased from 1992 to 1993 as a result of delayed fly development during 1993. Parasite costs remained at $.08 per animal during 1992 and 1993. A total cost of $.26 per animal for 1993 was very reasonable considering the wet, cool season.

Numbers of stable flies caught were greater during 1993 than 1992 (Table 2), even though the populations were greater in 1992. This may have been the result of the sticky trap covers holding flies better during 1993. The relative costs for feedlots with low and medium fly populations switched from 1992 to 1993. The larger feedlots held both parasite and total costs per animal down for the medium level in 1992 and the low level in 1993. The single feedlot with a low fly level and costs of $.87 had a large fly breeding area where high numbers of parasites were released. Fly counts documented that large parasite releases held the fly numbers down, even in a heavily infested feedlot.

Cost of parasites was lower for the feedlots with a high fly level during 1993 than 1992 ($.27 vs $.42 per animal, respectively). Most of this cost reduction was due to the later buildup of stable flies during 1993.

In 1982, the average cost for parasites was $.05 per animal. The cost rose to $.10 per animal during the mid-1980s and to about $.30 during the late 1980s. Consequently, the current charge of $.26 per animal for the KSU fly management experimental program appears reasonable. However, the costs of $1.34 and $1.55 per animal for the most expensive feedlots are excessive. These costs suggest that sanitation improvement should precede fly parasite releases. Additionally, we should note that we have observed lower fly populations in feedlots where *S. nigroaenea* were released during previous years, suggesting carryover benefit.

The average reduction in stable fly populations measured by Alsynite traps is shown in Table 3. These reductions roughly parallel the rates of parasitism for 1991 and 1992. Parasitism data for 1993 are not yet available.

Table 1. Costs per Animal for Stable Fly Management in Cattle Feedlots with Parasite Releases, 1991-93

Year	No. of Feedlots	No. of Cattle/Lot (1000's)	Cost, $ per Head		
			Parasites	Sampling	Total
1991	4	54 (4.2-100)[a]	.08 (.05-.10)	.18 (.07-1.55)	.26
1992	18	48.9 (2.2-100)	.08 (.03-.30)	.24 (.06-1.10)	.32
1993	17	45.4 (2.2-100)	.08 (.05-.10)	.18 (.07-1.55)	.26

[a]Numbers in parentheses are the range from low to high.

Table 2. Comparison of Fly Level or Degree of Sanitation Relative to Costs for Parasites and Sampling during 1992 and 1993

Fly level[a]	Year	No. of Lots	No. of Cattle/Lot (1000's)	Cost, $ per Head	
				Parasites	Total
Low					
(45-53)[b]	92	5	9.8 (2.2-22.3)	.26	.37 (.27-.52)
(104-126)	93	6	34.7 (2.2-100)	.13	.18 (.12-.87)
Medium					
(107-138)	92	7	45.6 (9-100)	.18	.24 (.09-1.15)
(143-170)	93	5	23.0 (12-35)	.22	.29 (.20-.50)
High					
(184-253)	92	6	20.0 (7-37)	.42	.54 (.33-1.34)
(197-469)	93	6	14.9 (4.2-41)	.27	.37 (.25-1.55)

[a]Flies per Alsynite trap per day
[b]Numbers in parentheses are the range from low to high.

Table 3. Stable Fly Populations in Parasite Release and Control Feedlots

Feedlot Treatment	Stable Flies per Trap per Week		
	1991	1992	1993
Nonrelease	37	200	251
Release	27	116	156
% Reductions	28	42	38

IN VITRO DRY MATTER DIGESTIBILITY OF SELECTED FORAGE SORGHUM SILAGES AS INFLUENCED BY PLANT PARTS

R. N. Sonon, Jr., K. K. Bolsen, B. E. Brent, L. H. Harbers, and J. E. Boyer, Jr. [1]

Summary

Eleven forage sorghum cultivars and one grain sorghum hybrid were used to determine the effect of individual plant parts on in vitro dry matter digestibility (IVDMD) of sorghum silage. IVDMD was highest for the head and lowest for the leaf sheath. When head and leaf blade parts were added to whole-plant material, IVDMD increased. When leaf sheath and stalk parts were added, IVDMD decreased, with the greatest decrease for leaf sheath. These results are consistent with an earlier study in our laboratory.

(Key Words: Sorghum, Silage, Plant Part, Digestibility.)

Introduction

We have shown in previous reports (KAES Reports of Progress 568, page 12 and 623, page 65) the tremendous variation in silage nutritive value traits among forage sorghum hybrids and varieties. Huge cultivar differences also occur in the proportion of plant parts (i.e., head, leaf blade, leaf sheath, and stalk) and their digestibility. Our objective was to continue to document the effect of the individual plant parts on the nutritive value of forage sorghum silages.

Experimental Procedures

Eleven forage sorghum cultivars and one grain sorghum hybrid (Table 1) were grown under dryland conditions near the Kansas State University campus in 1989. The agronomic and silage quality results were presented in the KAES Report of Progress 623, page 65. In addition, 10 whole plants of each cultivar were taken at the late-dough stage of kernel maturity and separated into head, leaf blade, leaf sheath, and stalk. The separated parts were chopped by hand with a knife to a length of about .4-inch. Approximately 400 g of each chopped plant part was placed in a nylon bag and ensiled in the center of the forage mass whole-plant material from the same cultivar in pilot-scale silos made from polyethylene-lined, 55-gallon barrels. The silos were opened 90 days postfilling, the ensiled plant parts were recovered, and the surrounding silage was sampled. The plant part and whole-plant silage samples were dried for 72 h and ground in a Wiley mill.

IVDMD of the ensiled plant parts, whole-plant silages, and reconstituted silages for the 12 sorghum cultivars were determined by the artificial rumen method of Tilley and Terry. Reconstituted silages were prepared by combining the four ensiled plant parts according to their respective proportions in the original whole-plant DM (Table 1). The weighted sum of the IVDMD of the ensiled plant parts also was determined and compared to the IVDMD of the whole-plant silage.

For five of the silages, plant parts were exchanged with whole-plant material in .05 g increments until all .5 g of the artificial rumen substrate was made up of the plant part. The rumen fluid used was from a fistulated, dry,

[1]Department of Statistics.

dairy cow fed a ration containing 80% forage sorghum silage on an as-fed basis.

Results and Discussion

The mean pH, DM content, and IVDMD for the ensiled plant parts are presented in Table 2. All three measurements were significantly different among the four plant parts. The head, which was the driest, had the highest pH, whereas the stalk, which was the wettest, had the lowest pH. IVDMD was highest for the head, whereas the leaf sheath was the least digestible. This trend occurred in all 11 grain-producing cultivars (data not shown).

The mean IVDMD for the whole-plant material was 57%, that for the reconstituted silages was 60%, and that for the sum of the ensiled plant parts was 58%. Differences between all three means were significant. The IVDMDs for both the reconstituted silages and sum of the ensiled plant parts were higher than the IVDMD of the whole-plant silages for all 12 cultivars (data not shown).

As shown in Figure 1, as head material was increased, digestibility increased. As leaf sheath material was increased, IVDMD decreased substantially. Leaf blade and stalk material had less effect on digestibility. The slope data in Table 2 show the results of pooling plant parts across cultivars and treating the data by regression. Positive values indicate that IVDMD increased as the plant part was added, and negative values indicate that IVDMD decreased. Thus, much of the difference in digestibility between forage sorghum cultivars probably can be explained by the percentage of dry matter from leaf sheath.

Table 1. Plant Part Proportions for the 12 Sorghum Cultivars

	Plant Part[2]			
Cultivar[1]	Head	Leaf blade	Leaf sheath	Stalk
DeKalb 42Y	69.7	12.1	8.3	9.9
Oro Kandy Kane	60.8	11.0	6.8	21.4
Rox Orange	58.3	9.9	6.7	25.1
DeKalb FS5	45.0	15.9	8.7	30.4
Pioneer 947	48.4	17.8	10.0	23.8
Northrup King 300	45.5	21.7	12.8	20.0
DeKalb FS25E	22.6	22.6	11.2	43.6
Funk's 102F	39.4	20.3	13.0	27.3
Funk's G1990	0	34.0	15.7	50.3
GA T-E Silomaker	33.4	19.5	14.0	33.1
Garst 333	31.3	19.4	11.8	37.5
Seed Tec Hi-Energy II	33.1	18.1	9.8	39.0
Mean	40.6	18.5	10.8	30.1

[1]DeKalb 42Y is a grain sorghum hybrid and GA T-E is Golden Acres Taylor-Evans.
[2]Plant part proportions are expressed as a % of the whole-plant DM.

Table 2. Mean pH, DM Content, IVDMD, and Slope Parameter Estimates for the Ensiled Forage Sorghum Plant Parts

Plant Part	pH	DM Content	IVDMD	Slope[1]
		%	%	
Head	4.42[a]	53.9[a]	64.8[a]	16.2[a]
Leaf blade	4.32[a]	28.2[b]	57.1[b]	4.2[b]
Leaf sheath	3.92[b]	25.0[b]	46.4[d]	-23.4[d]
Stalk	3.75[c]	19.0[c]	53.7[c]	-3.5[c]
SE	.047	1.21	.62	1.80

[abcd]Means within a column with unlike superscripts differ at $P < .05$
[1]Change in IVDMD per g increase in the respective plant part in the artificial rumen substrate.

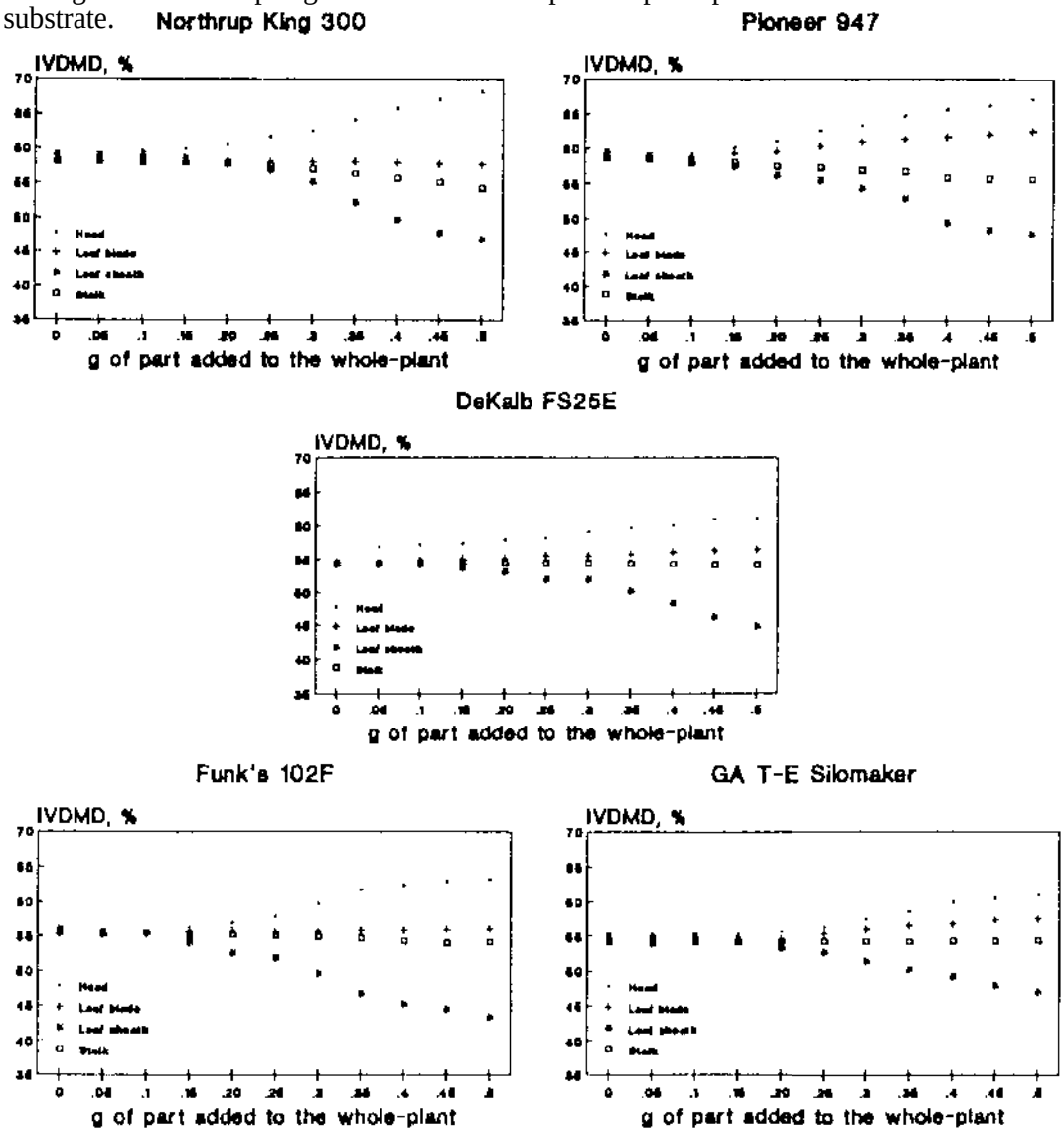

Figure 1. Influence of Plant Parts on IVDMD of the Five Forage Sorghum Hybrids

EFFECT OF GRAIN CONTENT ON THE NUTRITIVE VALUE OF WHOLE-PLANT CORN SILAGE

R. N. Sonon, Jr., B. S. Dalke, D. L. Holthaus, M. A. Young, L. Pfaff, and K. K. Bolsen

Summary

This experiment was conducted to determine the effect of grain content on the nutritive value of corn silage. Whole-plant silage dry matter (DM) increased, whereas neutral detergent fiber (NDF) and acid detergent fiber (ADF) contents decreased as the level of grain increased from 0 to 65% in the reconstituted, whole-plant, corn silages. Using sheep as a model, voluntary DM intake and DM and organic matter (OM) digestibility increased, but crude protein (CP) and ADF digestibilities decreased linearly as grain content increased from 0 to 52.5%. Our results indicate that the optimum level of grain in whole-plant corn silage to maximize the nutritive value of a high silage-based ration was about 52.5%.

(Key Words: Corn, Silage, Grain Content, Nutritive Value.)

Introduction

Typically, corn hybrids are selected for grain yield potential and not necessarily for their silage traits. There is a long-standing belief that the nutritive value of corn silage increases as the proportion of grain in the whole-plant silage increases. However, in two recent studies, we found that higher grain-containing corn silages were not always nutritionally superior to those with less grain (KAES Reports of Progress 592, page 110, and 678, page 19).

We compared all-stover silage with silage reconstituted to contain 27.5 to 60% grain.

Experimental Procedures

Cargill 6227 corn hybrid was planted on May 18, 1992 near the Kansas State University campus at Manhattan, on a Reading silt loam soil at a seeding rate of approximately 27,110 plants/acre. Anhydrous ammonia was applied preplant at 100 lb/acre, and 2.0 lb/acre of Ramrod-atrazine was applied at planting time. The hybrid was grown under irrigation and harvested at about 85% milk line stage of kernel maturity.

Three days before harvest, 30 whole plants were taken randomly from a cross section of the 118 × 690 ft experimental plot. The fresh whole plants were weighed and separated into grain, cob, and stover fractions. Fresh weights of the separated parts were recorded, and samples of the parts were dried to determine plant part proportions in the whole-plant DM.

The remaining plants were harvested on September 13, 1992. The ears were removed by hand, leaving the stover portion of the plant (including the husk). The ears and stover were chopped separately with a Fieldqueen, precision, forage harvester. The chopped ears and stover were combined to provide 27.5, 40.0, 52.5, and 65.0% grain in the reconstituted, whole-plant material (DM basis), and mixed in a mixer wagon. The silages, including an all-stover silage, were made in polyethylene-lined, 55-gallon barrels.

After about 90 days of storage, a voluntary intake and digestion trial was conducted to determine the nutritive value of the five silages. Because of the limited amount of silage we could make in barrels, sheep

were used as model animals. Thirty wether sheep were blocked by weight and individually housed in metabolism crates. The five silages were assigned randomly in each block. Rations contained 90% silage and 10% supplement (DM basis) and were balanced to 11.5% crude protein (DM basis) with ground corn grain, soybean meal, and urea. Rations supplied equal amounts of calcium, phosphorus, and vitamins A, D, and E. The trial consisted of 7-day adaptation, 7-day voluntary intake, 2-day transition, and 6-day total fecal collection phases. During transition and collection phases, all sheep were fed 90% of their mean voluntary DM intakes.

Table 1. pH, DM Content, and Chemical Composition of the All-Stover and Four Reconstituted, Whole-Plant, Corn Silages [a]

Grain	pH	DM	CP	NDF	ADF
%		%	————% of the silage DM————		
0	3.53	27.1	6.3	66.0	43.2
27.5	3.58	28.8	6.8	48.1	37.2
40.0	3.65	31.2	7.4	44.0	29.4
52.5	3.71	35.9	7.8	40.7	25.4
65.0	3.98	40.5	7.6	38.1	20.1

[a]DM = dry matter, CP = crude protein, NDF = neutral detergent fiber, ADF = acid detergent fiber.

Table 2. Chemical Composition of the Rations Fed to Sheep in the Voluntary Intake and Digestion Trial [a]

Grain	OM	CP	NDF	ADF
%	————————% of the ration DM————————			
0	90.9	12.0	60.8	39.5
27.5	91.3	11.5	45.0	34.2
40.0	92.9	11.0	41.0	27.1
52.5	93.9	11.0	37.8	22.5
65.0	94.8	11.2	35.6	18.6

[a]DM = dry matter, OM = organic matter, CP = crude protein, NDF = neutral detergent fiber, ADF = acid detergent fiber.

Grain content was used to predict voluntary DM intake; digestibilities of DM, CP, NDF, and ADF, and percent digestible organic matter.

Results and Discussion

The pH, DM content, and chemical composition of the five silages and chemical composition of the five rations are presented in Tables 1 and 2, respectively. All silages were well preserved, as evidenced by low pH values. Silage DM and OM contents in-

creased, whereas NDF and ADF contents decreased with increasing levels of grain in the reconstitute d silages. Crude protein content increased as grain in the silage increased.

Voluntary DM intake and digestibilities of DM, NDF, and ADF for the five silage rations fed to sheep are presented in Figures 1 through 4, respectively. Digestibility of CP and percent digestible organic matter are not shown. Regression analyses indicated that voluntary DM intake; digestibilities of DM, CP, and ADF; and percent digestible organic matter responded linearly to increasing grain content in the reconstituted, whole-plant silages. The greatest response to grain addition occurred from 0 to 27.5% grain. Voluntary DM intake increased by 12.6% between the increments from 27.5 to 40.0 and 40.0 to 52.5% grain in the silage. DM digestibility increased by 2.8 and 4.7 percentage units, when grain levels in the silage were increased from 27.5 to 40.0% and 40.0 to 52.5%, respectively. Crude protein and ADF digestibilities decreased with increasing grain content, whereas NDF digestibility showed a quadratic response. Grain content had only a modest effect on the digestibility of these nutrients.

The optimum level of grain in the reconstituted, whole-plant corn silages was 52.5%, at which DM intake was highest (62.5 g/kg BW $^{.75}$) and DM and OM digestibility approached their maxima (66.2 and 68.2%, respectively), with only slight numerical increases at 65.0% grain content. This is supported by the high predictive power of grain content for percent digestible OM (r^2=.846) and DM digestibility (r^2=.791).

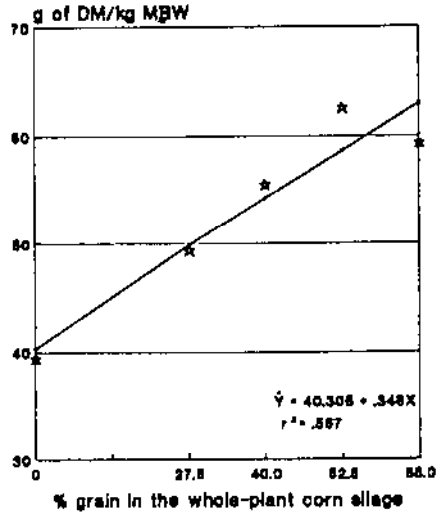

Figure 1. Effect of Grain Content on Voluntary DM Intake of Sheep. MBW is BW $^{.75}$

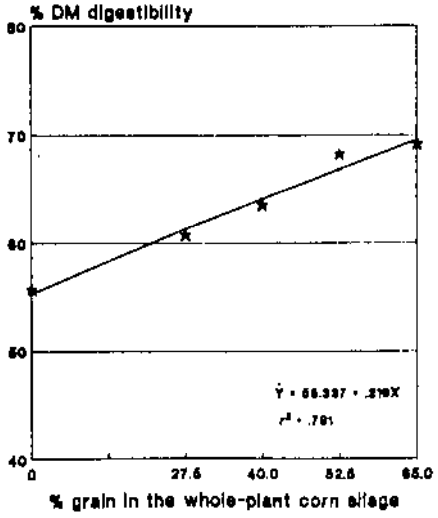

Figure 2. Effect of Grain Content on DM Digestibility in Sheep

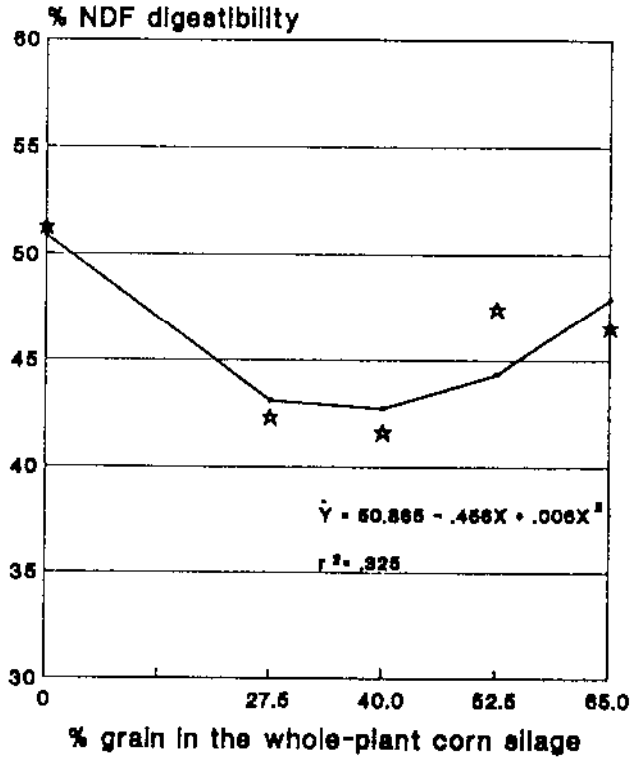

Figure 3. Effect of Grain Content on NDF Digestibility in Sheep

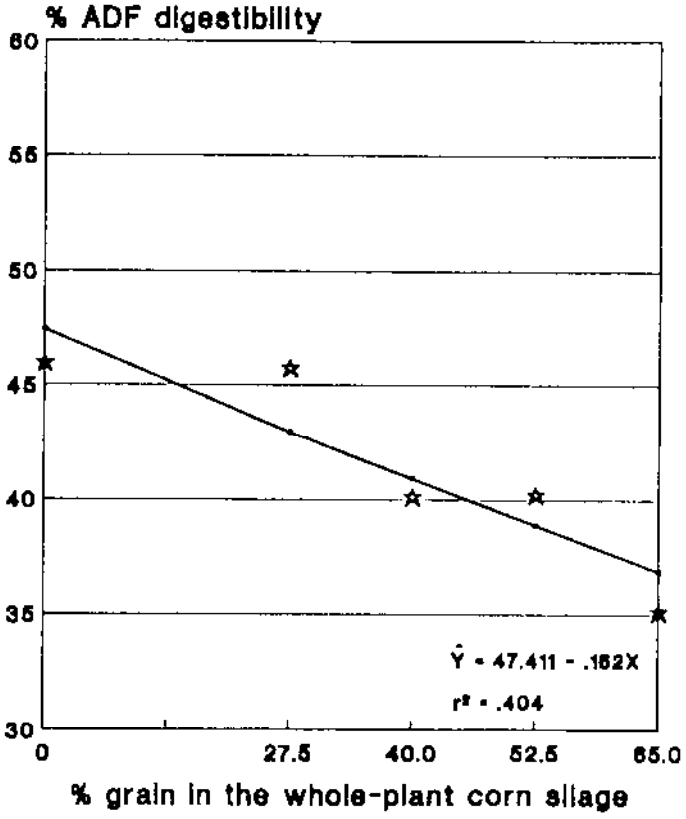

Figure 4. Effect of Grain Content on ADF Digestibility in Sheep

AGRONOMIC TRAITS AND GROWING CATTLE PERFORMANCE FOR WHOLE-PLANT CORN AND FORAGE AND GRAIN SORGHUM SILAGES [1]

B. S. Dalke, R. N. Sonon, Jr .[2], D. L. Holthaus, M. A. Young, L. Pfaff, and K. K. Bolsen

Summary

Agronomic and cattle performance traits were measured for the following silages produced in 1992: irrigated Pioneer 3377 corn, ensiled with or without Biotal® silage inoculant; DeKalb 42Y grain sorghum; and Cargill 200F, Pioneer 947, DeKalb FS-5 and FS-25E, and Northrup King (NK) 300 forage sorghums. All sorghums were grown under dryland conditions. The irrigated corn had the highest whole-plant dry matter (DM) and grain yields, and NK 300 and DeKalb FS-5 had the highest whole-plant DM yields among the sorghums. NK 300 also had the highest grain yield among the sorghums; DeKalb FS-5 and FS-25E had the lowest. Steers fed the irrigated corn silages had the fastest and most efficient gains, and the late-season forage sorghum, DeKalb FS-25E, produced the slowest and least efficient gains. Inoculating the corn silage increased DM recovery, fermentation efficiency, and steer gain per ton of crop ensiled.

(Key Words: Silage, Corn, Sorghum, Growing Cattle.)

Introduction

Silage production in Kansas is primarily from irrigated or dryland corns and dryland grain and forage sorghums. In several previous studies, we have documented the effects of growing condition, hybrid, stage of maturity, processing, grain addition, and climate (i.e., growing season) on the yield potential and nutritive value of numerous corn and sorghum silages. The objectives of this study were to compare both agronomic traits and cattle performance from silages produced in the 1992 growing season.

Experimental Procedures

The crops were grown near the Kansas State University campus during the 1992 season. The eight silages included irrigated Pioneer 3377 corn (with or without Biotal silage inoculant); dryland DeKalb 42Y grain sorghum; and Cargill 200F, Pioneer 947, DeKalb FS-5, Northrup King 300, and DeKalb FS-25E dryland forage sorghums. The two fields used were predominantly Reading silt loam soil. Prior to planting, anhydrous ammonia was applied at 100 lb per acre for the irrigated corn and dryland grain sorghum, and 80 lb per acre for the five forage sorghums. The corn was harvested at the 90% milk line stage of kernel maturity, and the six sorghums, at the very late-dough stage. All eight silages were made in 10 × 50 ft concrete stave silos. The silos containing the two corn silages were filled by the alternate load method.

The silos were opened on June 10 and 11, 1993 and emptied at uniform rates during the next 3 months. Silage samples were taken three times weekly. Each silage was fed to 16 yearling, crossbred steers (four pens of four steers per silage) in a 77-day growing

[1]Partial financial assistance was provided by Biotal, Inc., Eden Prairie, Minnesota.

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trial, which began on June 15, 1993. The complete mixed rations were fed twice daily to appetite and contained (DM basis) 89% silage and 11% supplement. Supplements were formulated to provide rations of 12.0% crude protein, .50% calcium, and .30% phosphorus (DM basis); 250 mg of rumensin and 30,000 IU of vitamin A per steer daily.

For 5 days before the start of the growing trial, all steers were limit-fed a forage sorghum silage ration to provide a DM intake of 2.0% of body weight. Steers then were weighed individually on 2 consecutive days. For 3 days before the final weighing, the steers were fed their respective silage rations at a restricted DM intake of 2.0% of body weight. Then individual weights were taken on 2 consecutive days.

Results and Discussion

Agronomic performance and chemical composition of the seven silage crops are shown in Table 1. The corn and DeKalb FS-5 and NK 300 had the highest whole-plant DM yields per acre; the late-season forage sorghum (DeKalb FS-25E) had the lowest DM yield. Grain yields of the five forage sorghums were above average and were highest for NK 300 and Pioneer 947. The CP values were lower and ADF values higher for the five forage sorghums than in previous years (KAES Report of Progress 678, page 16), which suggests that all were of lower than expected nutritional values. Gains and efficiencies were not related to the percent grain in the silages but were closely related to the silage ADF content.

Average daily gains and efficiencies of gain (Table 2) were excellent for steers fed the two corn silages and the DeKalb 42Y grain sorghum silage. As expected, the corn silages produced the fastest and most efficient gains. Steers fed the grain sorghum silage had the highest daily DM intake, whereas those receiving the late-season forage sorghum, DeKalb FS-25E, had the lowest DM intake and slowest and least efficient gain. Gains and efficiencies were poorer for steers fed the five forage

Table 1. Agronomic Performance and Chemical Composition of the Seven Crops and Silages in 1992

	1992			Whole-Plant			Silage[b]	
Crop, Growing Condition, and Hybrid	Planting date	Harvest date	Plant height, inches	DM, %	DM yield, tons/acre	Grain yield, bu/acre[a]	CP, %	ADF, %
Corn: irrigated								
Pioneer 3377	May 11	Aug. 28	108	29.8	9.4	200	7.4[c]	24.2[c]
Grain sorghum: dryland								
DeKalb 42Y	June 9	Sept. 22	54	36.2	6.9	108	8.8	27.9
Forage sorghum: dryland								
Cargill 200F	June 12	Sept. 23	117	37.3	6.0	105	7.0	33.0
Pioneer 947	June 12	Sept. 29	123	35.1	6.8	133	7.9	32.9
DeKalb FS-5	June 12	Sept. 28	115	32.0	7.6	96	7.7	36.5
Northrup King 300	June 12	Oct. 12	91	31.6	7.4	173	7.0	33.2
DeKalb FS-25E	June 12	Oct. 22	125	29.7	5.5	98	6.3	39.8

[a]Bushels/acre are adjusted to 14.5% moisture.
[b]CP = crude protein, ADF = acid detergent fiber. Both are reported on a DM basis.
[c]The Biotal-treated and untreated corn silages had similar CP and ADF contents and only the mean values are reported.

sorghum silages than for those fed the corn or grain sorghum silages.

Treating the corn silage with Biotal silage inoculant did not affect rate or efficiency of gain. However, the inoculant increased DM recovery by .9 percentage units compared to the control (91.7 vs. 90.8% of th e crop DM ensiled).

The inoculated silage also had a lower pH (3.72 vs. 4.02); more lactic acid; a higher lactic to acetic acid ratio (2.2 vs. 1.2); and less acetic acid, ethanol, and ammonia nitrogen compared to the control silage. When the DM recovery and feed efficiency results were combined, the inoculated corn silage produced 3.6 lb more steer gain per ton of crop ensiled than the control silage.

Table 2. Performance by Yearling Steers Fed the Eight Silage Rations in 1993

	Corn		Grain Sorghum	Forage Sorghum					
Item	Inoculated (Biotal)	Control (untreated)	DeKalb 42Y	Cargill 200F	Pioneer 947	DeKalb FS-5	NK 300	DeKalb FS-25E	LSD[a] (P<.05)
No. of steers	16	16	16	16	16	16	16	16	—
Initial wt, lb	570	572	570	568	572	575	564	567	—
Final wt, lb	808	811	769	711	731	719	731	711	71.0
ADG, lb	3.07	3.11	2.60	1.86	2.06	1.99	2.05	1.72	.3
Daily DM intake, lb	17.3	17.6	18.3	14.7	16.9	16.1	16.2	14.5	2.2
Feed/lb of gain, lb[b]	5.6	5.7	7.0	8.0	8.2	8.1	8.0	8.5	1.5

[a]LSD = least significant difference. Means that differ more than the LSD are statistically different (P<.05)
[b]DM basis.

EFFECTS OF SORGHUM HYBRID AND GRAIN SUPPLEMENTATION ON THE UTILIZATION OF SILAGE-BASED RATIONS FOR GROWING CATTLE [1]

B. S. Dalke, K. K. Bolsen, R. N. Sonon, Jr., M. A. Young, and D. L. Holthaus

Summary

Three whole-plant sorghum silages, each with or without 25% added rolled grain sorghum were fed to six medium-framed, ruminally cannulated steers in a 6 × 6 Latin square design. The grain sorghum silage rations (DeKalb 42Y) had the highest DM, OM, and ADF digestibilities; the late-season forage sorghum silage rations (DeKalb FS 25E), the lowest. Digestibility of NDF tended to be highest for the grain sorghum silage, but starch digestibilities were not affected by sorghum hybrid. Ruminal ammonia, acetate, propionate, butyrate, and total VFA concentrations were highest for the grain sorghum silage rations. Grain supplementation increased DM and OM digestibilities but had no effect on NDF, ADF, or starch digestibilities. Ruminal pH was decreased, whereas VFA concentrations were not affected by grain supplementation. The grain sorghum silage had the highest nutritive value, and the middle-season forage sorghum silage (DeKalb FS 5) was superior to the late-season forage sorghum. These results are consistent with several of our previous trials, which compared grain and forage sorghum silages for growing (backgrounding) cattle.

(Key Words: Silage, Forage Sorghum, Grain Sorghum, Hybrid.)

Introduction

The wide ranges of plant height, season length, DM content, and whole-plant DM and grain yields contribute to the large variations in nutritive values observed between forage sorghum hybrids and varieties (KAES Reports of Progress 539, pages 167, 172, and 177; 623, page 65; and 678, page 13).

We have reported previously that adding 25% grain (DM basis) to sorghum silage-based rations improved both rate and efficiency of gain, particularly the middle-season, moderate grain-content and late-season, low grain-content forage sorghum hybrids. The present study continued to document the effects of sorghum hybrid and grain supplementation on nutrient digestibilities and passage rates and ruminal metabolism of silage-based rations fed to growing cattle.

Experimental Procedures

Six medium-framed steers, fitted with ruminal cannula and averaging 680 lb, were utilized in a 6 × 6 Latin square design with a 3 × 2 arrangement of treatments. We fed three whole-plant silages (DeKalb 42Y grain sorghum and DeKalb FS 5 and FS 25E forage sorghums), each with or without 25% added rolled grain

[1]The steers used in this trial and partial financial assistance were provided by Mr. Richard Porter, Porter Farms, Reading, KS.

sorghum. DeKalb FS 5 is a middle-season, moderate grain-content hybrid; and DeKalb FS 25E is a late-season, low grain-content hybrid. On day 1 of each experimental period, the steers were allocated randomly to one of the six rations. The rations were formulated to be isonitrogenous and were fed ad libitum twice daily (8 am and 3 pm). Each 16-day experimental period consisted of 8 days for adaptation, 4 days for total fecal collection, and 4 days for rumen collection.

On day 12 of each experimental period, samples of ruminal digesta were collected before the first feeding (0 hour) and at 2, 4, 6, and 10 hours after the first feeding. The samples consisted of subsamples from the dorsal blind sac, mid-dorsal region, mid-ventral region, and the reticulum. On day 2 of the ruminal collection period, 1.0 kg of ytterbium-labeled silage and 250 ml of sodium cobalt EDTA were pulse-dosed ruminally before the first feeding (0 hour). Ruminal fluid and particulate samples were collected at 4, 8, 12, and 24 hours after dosing. Liquid and particulate dilution rates were determined by regressing the natural logarithm of the Yb and Co concentrations against time after dosing.

Data were analyzed using the SAS GLM procedure. Fermentation profile data were analyzed as a split-plot in time 6 × 6 Latin square design using a t-test for mean separations. Terms in the fixed effects model included the main effects of period, steer, time, sorghum hybrid, and grain supplementation and their interactions. Sorghum hybrid, grain supplementation, and sorghum hybrid by grain supplementation (whole-plot) effects were tested for significance by using the whole-plot residual sums of squares (sorghum hybrid by grain supplementation by period by steer). Time, time by sorghum hybrid, time by grain supplementation, and time by sorghum hybrid by grain supplementation (subplot) effects were tested for significance by the subplot residual sums of squares.

Digestibility, intake, and passage rate data were analyzed as a 6 × 6 Latin square using a t-test for mean separations. Terms in the fixed effects model included period, steer, sorghum hybrid, and grain supplementation and their interactions.

Results and Discussion

The nutrient composition and agronomic data for the three silages are presented in Table 1.

Table 1. Composition of the Sorghum Silages

Item	DeKalb 42Y	DeKalb FS 5	DeKalb FS 25E
DM, %	34.5	28.9	27.3
	——% on a DM basis——		
CP	8.8	7.7	6.3
NDF	47.8	55.5	54.5
ADF	27.9	36.5	39.8
Starch	45.3	39.7	30.5
Plant height, in	53	115	125
Grain, bu/acre	107	96	98
Percent grain	44.0	34.4	29.3
DM yield, ton/acre	6.6	7.6	8.8

Interactions between grain supplementation and the three sorghum silages were not statistically significant for any of the digestion criteria measured (Table 2). However, adding grain to the DeKalb 42Y and DeKalb FS-5 silage rations tended to reduce starch digestibility (14.1 and 3.9%, respectively). Starch digestibility of the DeKalb FS-25E silage rations was not affected by grain supplementation.

Intakes of DM and digestible DM were highest ($P<.001$) for steers fed the DeKalb 42Y silage rations (Table 2). Dry matter and OM digestibilities were highest ($P<.05$) for the DeKalb 42Y and DeKalb FS-5 silage rations. Acid detergent fiber digestibility was greatest ($P<.05$) for DeKalb 42Y silage

rations, but NDF and starch digestibilities and liquid and particulate passage rates were not affected (P>.05) by sorghum hybrid. Ammonia, acetate, propionate, butyrate, and total VFA concentrations were highest (P<.05), whereas acetate/propionate ratio and pH were lowest (P<.05) for steers fed DeKalb 42Y silage rations (Table 3). DeKalb FS-5 and DeKalb FS-25E silage rations produced statistically similar ruminal fermentation characteristics.

Grain supplementation increased (P<.001) intakes of DM and digestible DM by 25 and 34%, respectively, when compared to control rations (Table 2). Dry matter and OM digestibilities were increased (P<.05) by 5.1 and 5.2%, respectively, by grain addition. Starch digestibility tended to decrease (P=.06) with grain supplementation. Acid detergent fiber digestibility (P=.50), NDF digestibility (P=.21), liquid passage rate (P=.30), and particulate passage rate (P=.49) were not affected by grain supplementation of the sorghum silage-based rations.

Table 2. Effect of Hybrid and Grain Supplementation of Sorghum Silage-Based Rations on DM Intake, Intake of Digestible DM, and Nutrient Digestibilities and Passage Rates in Growing Steers [1]

	Sorghum Silage and Grain Addition									
	DeKalb 42Y		DeKalb FS 5		DeKalb FS 25E			Probability [2]		
Item	0	25%	0	25%	0	25%	SE	H	G	H×G
DM intake, lb/day	16.5	19.0	13.0	16.5	10.6	14.1	.62	.001	.001	NS
Intake of DDM, lb/day	10.1	12.1	7.7	10.1	5.5	8.6	.48	.001	.001	NS
Digestibility, %										
DM	62.1	63.8	59.5	61.3	52.5	59.8	1.70	.01	.05	NS
OM	63.4	64.5	61.0	62.6	55.5	62.3	1.80	.05	.05	NS
NDF	52.7	56.9	52.9	51.7	46.2	51.5	2.60	NS	NS	NS
ADF	53.2	53.6	44.4	39.9	41.7	39.8	3.50	.01	NS	NS
Starch	85.4	73.4	85.6	81.7	81.1	81.7	3.20	NS	NS	NS
Particulate passage rate, %/h	5.1	5.2	5.5	4.0	4.0	3.0	.94	NS	NS	NS
Liquid passage rate, %/h	7.8	8.4	9.3	9.9	9.5	7.1	.69	NS	NS	NS

[1]Values are least square means, and SE is the pooled standard error of the mean.
[2]H = hybrid, G = grain, H×G = hybrid x grain interaction, NS = not different.

Table 3. Effects of Hybrid and Grain Supplementation of Sorghum Silage-Based Rations on Ruminal Fermentation Characteristics in Growing Steers [1]

	Sorghum Silage and Grain Addition									
	DeKalb 42Y		DeKalb FS 5		DeKalb FS 25E			Probability [2]		
Item	0	25%	0	25%	0	25%	SE	H	G	H×G
pH	6.6	6.5	6.8	6.7	6.8	6.8	.02	.01	.01	NS
Ammonia, mM	5.7	5.5	4.5	4.2	4.7	3.8	.31	.01	NS	NS
VFA, mol/100 mol										
acetate	63.0	60.6	54.4	58.0	58.2	58.4	1.40	.01	NS	NS
propionate	18.6	19.8	15.9	16.8	16.2	16.0	.57	.01	NS	NS
butyrate	9.7	8.0	7.0	7.8	7.1	7.4	.29	.01	NS	.05
Total VFA, mM	97.5	94.6	81.8	88.1	86.8	86.8	2.30	.01	NS	NS
Acetate/ propionate	3.5	3.2	3.5	3.6	3.6	3.7	.07	.01	NS	NS

[1]Values are least square means, and SE is the pooled standard error of the mean.
[2]H = hybrid, G = grain, H×G = hybrid × grain interaction, NS = not different.

LOCATION EFFECTS ON FORAGE PRODUCTION AND QUALITY AMONG SELECTED PIONEER CORN HYBRIDS

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Summary

Six Pioneer corn hybrids were grown in Kansas and four of the six hybrids within three locations in Utah. The Utah hybrids were harvested between the one-quarter and one-half milk line stages of kernel maturity, whereas the Kansas hybrids wer e harvested at approximately 90% of kernel maturity. Location had a significant effect on the agronomic characteristics and chemical composition of the hybrids. Whole-plant dry matter (DM) and digestible DM yield, grain yield, and percent grain were higher in the Kansas-grown corn. The greater yield and proportion of grain were results of the excellent growth conditions in 1992 and their advanced stage of kernel maturity at harvest. Experimental hybrid X0811 yielded the highest whole-plant DM, grain, stover, and digestible DM among the Kansas corns. Hybrid X0811 also had the highest whole-plant and stover in vitro DM digestibility (IVDMD), the highest whole-plant and stover crude protein (CP), and the lowest whole-plant and stover neutral detergent fiber (NDF) and acid detergent fiber (ADF) contents among the Kansas corns. Hybrid X0811 had the highest stover and digestible DM yields, whole-plant C P and IVDMD, and stover IVDMD and the lowest stover NDF and ADF contents among the Utah hybrids. The high digestible DM yields of hybrid X0811 emphasize the contribution of the stover fraction, in addition to the proportion of grain, to the quality of the whole-plant forage.

(Key Words: Corn, Hybrid, Kansas, Utah.)

Introduction

The goal of an efficient corn silage production system oriented towards producing beef is to consistently maximize beef yield per acre. Therefore, corn silage producers strive for excellent silage management practices and search for corn hybrids with superior performance (i.e. high digestible energy yields per acre). To better accommodate corn silage producers, seed companies and universities are providing information not only on forage and grain yields, but also on plant part proportions (percent grain, stover, and cob) and digestibilities (whole-plant and stover).

However, limited information exists on the relative quality of superior forage corn hybrids grown with various fertility and irrigation practices and environmental conditions.

As a result of the corn hybrid evaluation trial in 1990 (KAES Report o f Progress 592), a cooperative res earch project was organized between Utah State and Kansas State Universities and Pioneer Hybrid Inc. to determine not only the forage yield and quality of several corn hybrids, but also the

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influence of production conditions on the forage yield and quality of the respective hybrids.

Experimental Procedures

Six mid-maturing, Pioneer, corn hybrids were grown in 1992. The corn hybrids selected by Pioneer for evaluation consisted of experimental (X0811, X1814, XC951) and currently marketed (3215, 3299, 3377) hybrids. The hybrids X0811, X1814, 3215, and 3377 were grown at three locations in Utah, and the hybrids X0811, X1814, XC951, 3215, 3299, and 3377 were grown in Kansas at a single location. All hybrids were grown under irrigated conditions. The corn hybrids were organized into randomized complete blocks with three replications at each location.

The locations in northern Utah were Hooper, Ellwood, and Bear River City. The hybrid plots in Utah were planted in 30 in. rows at plant populations of approximately 28,000 plants/acre.

The hybrids at Hooper were planted on April 25 in a Syracuse loamy fine sand soil that had been previously planted to alfalfa and heavily manured. Seventy-five lb per acre of N as ammonium nitrate was applied side-dress at furrow-making to meet soil requirements (N, P, and K). The hybrids were harvested on August 31.

The hybrids at Ellwood were planted on April 14 in a Fielding silt loam, warm soil that had been heavily manured. Eighty lb N and 60 lb P per acre were applied prior to planting to meet soil requirements (N, P, K). The hybrids were harvested on August 31.

The hybrids at Bear River City were planted on April 20 in a Fielding silt loam, warm soil that was fertilized with 175 and 75 lb per acre of N and P, respectively, to meet soil requirements (N, P, K). The hybrids were harvested on September 1.

The corn hybrid plots in Kansas were located at Manhattan. The plots were planted in 30 in. rows at populations of approximately 22,000 plants per acre. The hybrids were planted on May 20 in a Reading silt loam soil that was fertilized with 100 lb per acre of liquid N that fulfilled soil requirements (N, P, K). The hybrids were harvested during the second week of September.

All Utah hybrids were harvested when the kernels at the center of the ear were between the one-quarter and one-half milk line stages of maturity. In each plot, 10 plants were hand-harvested and weighed, and plant parts were separated to determine yield (whole plant, stover, ear, and cob) and plant part proportions (percent grain, stover, and cob). The whole plant and stover were chopped with a Kemp chipper-shredder and subsequently sampled for chemical analysis. The remaining ears from the plants designated as stover were frozen and later hand-shelled to determine grain and cob fractions.

In Kansas, the hybrids were harvested when the milk line in the kernels at the center of the ear had progressed through approximately 90% of kernel (just prior to black layer formation). Two inner rows, within a 25-foot-long plot of six rows, were harvested for whole-plant yield, and the remaining two inner rows were used to determine plant part yields and proportions. The whole-plant and stover were harvested and weighed with a modified one-row forage chopper. Samples of the whole-plant and stover material were taken after the harvesting process for chemical analysis. The two outside rows of each plot were designated as border rows and ignored.

The husk remaining from ear separation was included in the stover fraction at all locations. The samples of all plant parts then were dried in a forced-air drying oven. Chemical analysis was performed on all samples using standard techniques.

The donor animal for the IVDMD analysis was a 4-year-old 1200 lb, lactating, crossbred, beef cow fitted with a rumen

cannula. The ration was 90% corn silage and 10% supplement on a DM basis, was formulated to 10.5% protein, and met NRC requirements for vitamins and minerals. The animal was fed ad libitum twice daily and consumed from 27 to 35 lb DM of corn silage per day. The fluid for in vitro analyses was collected immediately prior to the a.m. feeding.

Results and Discussion

The agronomic characteristics are presented in Table 1. The chemical composition of the whole plant and stover are provided in Tables 2 and 3, respectively. Because the location by corn hybrid interaction was significant, the corn hybrids are presented within their respective locations. However, to more efficiently present the Kansas results for this publication, the results of the hybrids at each location in Utah have been combined as corn hybrid averages across Utah.

Whole-plant DM yield in Utah ranged from 9.0 to 10.58 tons per acre in corn hybrids 3215 and 3377, respectively, with an average of 10.01 tons. Whole-plant DM yield in Kansas ranged from 9.78 to 11.08 tons per acre in corn hybrids 3299 and X0811, respectively, with an average of 10.43 tons. The Utah-grown corn was able to maintain whole-plant DM yields equivalent to those of the Kansas corn even though the whole-plant DM content of the Utah corn was lower (27.46 vs 34.13%). This is a result of the higher plant populations of the Utah-grown corn.

The Kansas corn had higher whole-plant DM (27.46 vs 34.13) and CP (6.04 vs 8.01) contents than the Utah corn. The higher whole-plant DM content was a result of the advanced maturity of the Kansas corn. The higher DM content of the grain (not presented) elevated the whole-plant DM when compared to the stover DM alone. The differences in CP content were predominately functions of soil fertility and factors affecting soil nutrient exchange.

Grain yields in Utah ranged from 109.7 to 158.2 bu per acre in corn hybrids 3215 and 3377, respectively, with an average of 132.7 bu. Grain yields in Kansas were higher and ranged from 191.2 to 215.8 bu per acre in corn hybrids 3215 and X0811, respectively, with an average of 205.6 bu.

Stover DM yield was not significantly different across the corn hybrids in Utah and averaged 5.92 tons per acre. In Kansas, the stover DM yields were lower and ranged from 3.89 to 5.06 tons per acre in corn hybrids 3299 and X0811, respectively, with an average of 4.64 tons.

The Kansas-grown corn contained higher proportions of grain and lower proportions of stover and cob than did the Utah corn. The higher grain yield and proportion of grain was primarily due to the excellent growth conditions in 1992 and the more advanced stage of maturity, resulting in a greater proportion of the whole-plant DM residing in the grain.

Digestible DM yield was higher in Kansas than in Utah, 7.32 vs 6.93 tons per acre, which was primarily due to the higher whole-plant DM content and grain proportion in the Kansas-grown corn. The higher grain proportion in the Kansas corn reduced the ADF and NDF content of the whole-plant dry matter. Hybrid X0811 had the highest digestible DM yield across both Utah and Kansas. The high digestible DM yield of hybrid X0811 was a result of its high whole-plant IVDMD and low whole-plant NDF and ADF. The stover fraction of hybrid X0811 had the lowest NDF and ADF contents and the highest IVDMD in both Kansas and Utah. The high quality of whole-plant X0811 emphasizes the contribution of the stover fraction to the quality of the whole-plant dry matter. Therefore, experimental corn hybrid X0811 has the potential to be labeled as a superior forage hybrid because it consistently yields high proportions of grain and produces a high quality stover.

Table 1. Whole-Plant, Grain, Stover, and Digestible DM Yields, and Plant Part Proportions of the Corn Hybrids Grown in Utah and Kansas

Location and Hybrid	Whole-Plant DM Yield, tons/acre	Grain Yield, bu/acre [a]	Stover DM Yield, tons/acre	Digestible DM Yield, tons/acre	Plant Part (% DM basis)		
					Grain	Stover	Cob
Utah [b]	10.01	132.7	5.92	6.93	31.7	60.8	7.5
X0811	10.39	141.0	5.99	7.51	33.1	59.9	7.0
X1814	10.13	136.8	5.92	6.90	33.4	59.7	6.9
3215	9.00	109.7	5.58	6.05	28.4	63.9	7.7
3377	10.58	158.2	5.76	7.31	35.9	55.8	8.3
Kansas [b]	10.43	205.6	4.64	7.32	49.2	45.6	5.2
X0811	11.08	215.8	5.06	8.10	48.8	46.8	4.4
X1814	10.71	209.4	4.73	7.50	49.7	45.4	4.9
3215	10.21	191.2	4.89	7.04	46.0	49.1	4.9
3377	9.94	197.2	4.35	6.92	48.9	44.9	6.2
3299	9.78	210.7	3.89	7.03	54.0	40.9	5.1
XC951	10.83	209.4	4.89	7.32	47.8	46.8	5.4
LSD (P<.05) [c]	1.21	20.46	0.62	0.95	1.93	2.20	0.49

[a]Adjusted to 14.5% moisture.
[b]Utah and Kansas means, respectively.
[c]The LSD (least significant difference) is valid only among corn hybrids within Kansas.

Table 2. Chemical Composition and I n Vitro Digestibility of the Whole-Plant Forage of Corn Hybrids Grown in Kansas and Utah

Location and Hybrid	Dry Matter, %	CP	NDF	ADF	IVDMD
		---------- % of the forage DM ----------			
Utah[a]	27.46	6.04	48.63	28.75	69.30
X0811	26.73	6.50	47.74	27.41	72.39
X1814	27.70	5.96	48.02	29.30	68.33
3215	27.60	5.94	50.57	30.13	67.37
3377	29.85	6.11	45.91	26.14	69.19
Kansas[a]	34.13	8.01	41.64	24.84	70.16
X0811	34.63	8.60	39.81	23.09	73.13
X1814	35.97	8.32	39.84	23.47	69.96
3215	32.11	8.36	44.67	27.60	68.93
3377	31.25	7.70	41.69	25.27	69.58
3299	37.87	7.32	40.79	23.81	71.76
XC951	32.91	7.75	43.04	25.77	67.55
LSD (P<.05)[b]	6.26	0.46	3.98	2.62	2.34

[a]Utah and Kansas means, respectively.
[b]The LSD (least significant difference) is valid only among corn hybrids within Kansas.

Table 3. Chemical Composition and In Vitro Digestibility of the Stover Fraction of Corn Hybrids Grown in Utah and Kansas

Location and Hybrid	Dry Matter, %	CP	NDF	ADF	IVDMD
		---------- % of the forage DM ----------			
Utah[a]	22.30	5.38	61.87	39.75	63.71
X0811	21.23	5.53	60.90	38.25	67.10
X1814	22.48	5.30	62.40	41.86	61.45
3215	23.20	5.50	62.36	39.75	62.14
3377	23.29	5.68	60.75	38.54	64.17
Kansas[a]	24.01	6.38	62.04	41.14	60.11
X0811	23.61	6.60	57.52	38.38	65.47
X1814	23.50	6.17	63.36	42.29	57.63
3215	22.84	6.25	63.76	42.42	58.82
3377	21.15	7.18	62.44	40.79	61.05
3299	26.97	6.40	62.69	41.12	62.26
XC951	26.01	5.72	62.45	41.87	55.44
LSD (P<.05)[b]	2.18	0.88	2.54	2.62	4.15

[a]Utah and Kansas means, respectively.
[b]The LSD (least significant difference) is valid only among corn hybrids within location.

EFFECT OF GRAIN TYPE IN SUPPLEMENTS AND SUPPLEMENTATION FREQUENCY ON THE PERFORMANCE OF BEEF COWS GRAZING WINTER RANGE [1]

R. C. Cochran, J. L. Beat y [2], and E. S. Vanzant [3]

Summary

One hundred twenty, pregnant, Angus × Hereford cows (1111 lb) grazing dormant bluestem range were used to evaluate whether the effect of altered frequency of supplementation on cow performance depended on the grain type in the supplement. Two supplementation frequencies (daily and three times weekly) and two grain types in the supplements (sorghum grain or corn) were evaluated. Both supplements contained 21% CP and were fed to provide 32.6 lb DM/week. Interactions were not significant. Winter weight loss through calving was greater ($P \leq .02$) for the cows supplemented three times weekly, although the magnitude of the effect was not large. Use of different grain types in the supplements did not significantly affect most performance variables.

(Key Words: Beef Cattle, Frequency, Supplements.)

Introduction

Feeding supplements with relatively high crude protein (CP) concentrations has improved the performance of beef cows grazing winter range. However, feeding supplements daily can require considerable labor and equipment under range conditions. If one could reduce supplementation frequency without negatively affecting livestock performance, reduced labor and equipment demands might result.

Many studies conclude that high-protein supplements can be fed infrequently without significantly harming cow performance. However, few studies have evaluated the impact of altering supplementation frequency when supplements contain low to moderate concentrations of protein.

Some research suggests that alternate-day supplementation with low- to moderate-protein supplements (i.e., grain-based supplements with 10 to 25% CP) degrades performance compared with daily supplementation.

In contrast, a recent experiment at Kansas State University suggests that the effect of altering the frequency of supplementation is similar, regardless of the supplement's protein concentration (range from 10% to 40% CP). One explanation for that contradiction may be the grain type used in the supplements. Kansas State's experiment used supplements based on sorghum grain, which is a slowly fermented grain. Other research used supplements based on corn, which is rapidly fermented. Therefore, our objective was to monitor changes in gain and condition of cows grazing winter range and receiving supplements based on corn or sorghum grain either daily or three times weekly.

[1]Appreciation is expressed to Gary Ritter and Wayne Adolph and the student workers at the Cow-calf Unit for their invaluable assistance in conducting this trial.

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Experimental Procedures

One hundred and twenty pregnant, Angus × Hereford, beef cows (avg. initial BW = 1111 lb; avg. initial condition score = 5.4) were used in a 2 × 2 factorial design comparing supplementation frequency (daily = 7X, or three times weekly = 3X) and grain type in the supplement (corn or sorghum grain). Both supplements were formulated to contain 20% CP (dry basis). Actual CP was 21% for both supplements. Each supplement contained approximately 74% grain, 23% SBM, and 3% molasses.

All treatment groups were fed 32.6 lb dry matter per week. The 7X group received 14.65 lb DM/feeding; the 3X group, 10.86 lb. Body weight and condition were measured on days 0, 28, 56, and 84 and at calving (avg = day 111). Cows grazed four bluestem-range pastures (approximately 305 acres each) throughout the trial.

Each feeding-frequency treatment was assigned to two pastures, with cows receiving corn- and sorghum grain-based supplements equally represented within each pasture. The 7X cows were gathered daily, whereas the 3X cows were gathered only on Mondays, Wednesdays, and Fridays. Following gathering, cows were sorted and group-fed their supplement in a bunk. The feeding area was located in the center of the four pastures. To monitor effects on cow behavior, an area within .25 miles of the central feeding area within each pasture was marked with painted metal posts. Cattle presence or absence within this area before gathering for feeding was recorded daily. Supplements were fed from November 30, 1992 until calving.

Results and Discussion

The response to frequency of supplementation did not depend on the grain type in the supplements. Calving date was similar (P>.10) among treatments, averaging March 16, 1993 (day 111). Calf birth weights were also similar ($P \geq .17$) among treatments (avg. birth wt. = 83 lb).

Although cumulative and period changes in body weight (Table 1) were not significantly altered by grain type in the supplement, a trend (P = .07) was observed for those fed the corn-based supplement to lose slightly less condition through calving.

Although cows on the 3X treatment lost more (P = .02) weight by calving time than the 7X group, the difference (approximately 24 lb) was not great from a biological standpoint. That was corroborated by the lack of effect (P = .47) on cumulative body condition change during the same time period. Cows in the 3X group were more likely (P<.01; 18.1% vs 37.5% for the 7X and 3X groups, respectively) to be found close to the feeding area before the morning supplementation period.

Although cow performance and behavior was favored by daily supplementation, the magnitude of the changes were so small that three-times-weekly supplementation appears to be a viable way to reduce labor and equipment costs. The results of the current experiment were similar to those from previous research at Kansas State University, adding further support to our previous conclusion that response to altered supplementation frequency does not depend on the protein concentration in the supplement.

Although infrequent supplementation appears to be feasible with low- to moderate-protein supplements, an adequate balance must exist between supplemental protein and energy in order to ensure acceptable cow performance and efficient use of low-quality forage.

Table 1. Influence of Frequency of Supplementation and Grain Type in Supplement on Cumulative and Period Weight and Body Condition Changes in Beef Cows Grazing Dormant Bluestem Range

	Grain Type				Frequency [a]			
Item	Corn	Sorghum Grain	SEM	P value	7X	3X	SEM	P value
Initial wt, lb	1111.7	1111.2	11.4	.97	1112.6	1110.4	.97	.23
Cumulative wt. change, lb								
d 1-28	-39.2	-44.3	3.31	.39	-44.7	-38.8	5.88	.55
d 1-56	-35.5	-42.1	2.47	.20	-26.7	-50.9	5.91	.10
d 1-84	-43.6	-56.2	7.40	.36	-30.2	-69.6	2.31	<.01
d 1-111	-180.3	-189.8	4.74	.30	-174.6	-195.5	4.03	.02
Period wt change, lb								
d 1-28	-39.2	-44.3	3.31	.39	-44.7	-38.8	5.88	.55
d 28-56	3.7	2.2	2.36	.71	18.1	-12.1	4.01	.03
d 56-84	-8.4	-12.8	4.96	.58	-3.5	-17.6	6.17	.25
d 84-111	-138.6	-136.0	4.73	.73	-147.2	-123.0	3.70	.06
Initial body condition [b]	5.4	5.4	.01	.81	5.4	5.4	.003	.10
Cumulative body condition change								
d 1-28	-.10	-.21	.041	.20	-.11	-.21	.008	.01
d 1-56	-.36	-.50	.037	.12	-.40	-.46	.011	.08
d 1-84	-.75	-.91	.059	.18	-.85	-.81	.040	.49
d 1-111	-1.11	-1.26	.031	.07	-1.16	-1.21	.044	.47
Period body condition change								
d 1-28	-.10	-.21	.041	.20	-.11	-.21	.008	.01
d 28-56	-.26	-.29	.031	.58	-.29	-.25	.019	.22
d 56-84	-.39	-.43	.024	.41	-.46	-.36	.048	.26
d 84-111	-.36	-.37	.025	.94	-.31	-.42	.020	.06

[a]Frequency of supplementation: 7X=daily; 3X=three times weekly.
[b]Body condition scored on a 1-9 scale, 1 = emaciated and 9 = extremely obese.

DORMANT, TALLGRASS-PRAIRIE FORAGE: INFLUENCE OF RUMINAL DEGRADABLE PROTEIN ON INTAKE BY BEEF COWS AND FERMENTATION CHARACTERISTICS [1]

H. H. Köster, R. C. Cochran, E. C. Titgemeyer, E. S. Vanzant [2], and G. St. Jean [3]

Summary

Five ruminally and duodenally fistulated Angus × Hereford cows were fed dormant tallgrass-prairie forage ad libitum to monitor intake and fermentation responses associated with providing increasing amounts of supplemental ruminal degradable protein (RDP). The RDP was provided from sodium caseinate and infused intraruminally immediately before feeding forage. Levels of RDP were 0, 180, 360, 540, and 720 g/d. Maximal intake of dormant, tallgrass-prairie forage occurred with provision of 540 g RDP/d. Ruminal dry matter fill declined with increasing level of RDP infusion. Increasing supplmentation of RDP generally improved ruminal fermentation characteristics.

(Key Words: Beef Cows, Ruminal Degradable Protein, Intake, Forage.)

Introduction

Ruminants depend on the microorganisms that inhabit the rumen for effective use of fiber in forages. However, when low-quality forages are fed, protein and other important microbial nutrients may be deficient, limiting the ability of fiber- digesting microorganisms to grow and to ferment forage fiber. In order to overcome such deficiencies, supplemental ruminal degradable protein (RDP) frequently is required. Furthermore, intake of low-quality forage is increased in response to the provision of RDP. Because protein supplementation can be costly, it is important to know the amount of RDP required to optimize forage intake and digestion. Therefore, our objective was to determine the influence of different RDP levels on the intake and fermentation characteristics of a low-quality, tallgrass-prairie forage by beef cows.

Experimental Procedures

Five ruminally and duodenally fistulated Angus × Hereford cows (1296 lb) were penned individually and fed dormant tallgrass-prairie forage (1.9% crude protein [CP]; 70% neutral detergent fiber) ad libitum for the duration of the experiment. RDP was provided in the form of sodium caseinate (casein; 90% CP) which was solubilized in water (7 liters/d), divided into two equal portions, and infused intraruminally at 6:30 a.m. and 6:30 p.m. immediately before feeding forage. Levels of RDP were 0, 180, 360, 540, and 720 g/d. The amounts of RDP provided by these infusion levels would be approximated by 0, 1.1, 2.2, 3.3, or 4.4 lb soybean meal/d (dry matter [DM] basis), respectively, if the SBM contained approximately 50% CP on a dry basis (assumes approximately 75% of CP is ruminally degradable). During each experimental period, the cows were adapted to the diets for 14 days. Voluntary intake then was measured, and digesta samplings were made over the next 4 days. Subsequently, each cow's rumen was emptied manually to determine ruminal DM and liquid fill. Ruminal

[1]The authors express their appreciation to Gary Ritter, Wayne Adolph, Gary Breault, and Mike Sheffel for their expert assistance in conducting this experiment.

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evacuations were performed just prior to (0 h) and 4 h after feeding hay and infusing casein. Ruminal fluid samples were obtained at several times after feeding to determine pH, ammonia N (NH_3N), and volatile fatty acid (VFA) concentrations.

Results and Discussion

Forage DM intake increased in a quadratic (P<.01) fashion in response to increasing RDP infusion, with the peak observed at the 540 g infusion level (Table 1). This quantity equates to providing .42 g RDP/lb of BW. Increased forage intake in response to RDP concurs with the results of numerous other research trials. The direction and magnitude of the effect on forage intake further verifies the need to provide RDP to ensure optimal utilization of low-quality forage.

Table 1. Influence of Amount of Ruminal Degradable Protein (RDP) on Intake, Ruminal Fill, and Ruminal Fermentation in Beef Cows Consuming Dormant Tallgrass-Prairie Forage

	RDP Level (g/day)					Effect[a]			
Item	0	180	360	540	720	L	Q	C	SEM
FDMI[b], g/kg $BW^{.75}$	32.2	52.7	63.1	70.2	67.7	<.01	<.01	.97	3.08
Ruminal DM fill, g/kg $BW^{.75}$	15.3	14.7	15.9	12.3	12.4	.09	.95	.22	.40
Liquid fill, g/kg $BW^{.75}$	102	96	104	109	105	.03	.99	<.01	2.50
pH	6.92	6.62	6.63	6.58	6.52	<.01	<.01	.02	.02
NH_3 N, mM	0.24	1.36	3.47	5.17	6.87	<.01	.80	.69	.73
VFA, mM	43.3	65.9	71.4	74.5	76.4	<.01	<.01	.04	2.18
Acetate, moles/100 moles	78.0	75.4	74.8	73.6	72.4	<.01	.15	.14	.39
Propionate, moles/100 moles	15.2	16.1	16.3	16.5	15.7	.01	<.01	.50	.15
Butyrate, moles/100 moles	6.11	6.18	5.98	6.19	6.33	.18	.13	.52	.09
Isobutyrate, moles/100 moles	.43	.78	.94	1.11	1.70	<.01	.08	.02	.08
Isovalerate, moles/100 moles	.17	.84	1.14	1.40	2.21	<.01	.66	.05	.14
Valerate, moles/100 moles	0	.68	.91	1.17	1.60	<.01	.31	.12	.12
Acetate:propionate	5.14	4.70	4.61	4.48	4.66	<.01	<.01	.90	.08

[a]Probability of a greater F value. L=linear change with increasing RDP, Q=quadratic change with increasing RDP, C=cubic change with increasing RDP.

[b]FDMI=forage dry matter intake.

[c]DM=dry matter.

The influence of treatment on ruminal DM and liquid fill did not depend (P>.10) on the time of ruminal evacuation. At both evacuation times, liquid fill decreased somewhat with the 180 g infusion level, increased to a peak at the 540 g infusion level, and then slightly declined (cubic, P<.01). In contrast, ruminal DM fill tended (P=.09) to decrease linearly with increasing infusion level. The response for DM fill is opposite to that in previous trials at Kansas State University. The different response might be because RDP was infused alone, compared with actually feeding a supplement that contains RDP as well as other nutrients. In the present experiment, the increased forage DM intake with increasing RDP infusion appears related to changes in forage digestibility and (or) passage.

Variability was observed in the response over time for the different fermentation variables measured. Ruminal pH decreased rapidly with the initial RDP level, stabilized with the intermediate infusion levels, and then decreased slightly with the highest infusion level (cubic, P=.02). Total VFA concentration increased rapidly with the infusion of 180 g RDP/d and continued to increase slightly with increasing casein infusion (cubic, P=.04). Acetate proportion declined linearly (P<.01) with increasing infusion level, whereas propionate and acetate:propionate ratio responded in a quadratic (P<.01) manner. The peak in propionate and the low point in the acetate:propionate ratio corresponded with maximal forage DM intake. Molar proportions of isobutyrate and isovalerate increased with initial infusion level, continued to increase slightly with the intermediate infusion levels, and then exhibited a larger proportional increase at the highest level of infusion (cubic, P<.05). Valerate tended (P=.12) to follow the same trend. In general, increasing availability of RDP improved ruminal fermentation characteristics, reflecting improvement in nutrient supply to microorganisms.

EVALUATION OF THE POTENTIAL OF SUPPLEMENTS TO SUBSTITUTE FOR RANGE FORAGE [1]

S. D. Stafford, R. C. Cochran, E. S. Vanzant [2], and J. O. Fritz [3]

Summary

Thirteen, ruminally fistulated, Angus × Hereford, yearling steers were used to evaluate the effect of feeding different types and amounts of supplements on the likelihood of observing a substitution of supplement for range forage. Steers had ad libitum access to low-quality range forage and were fed a supplement comprised of sorghum grain (SG) and soybean meal (SBM) that contained 18% CP (SG/SBM 18%), a SG/SBM supplement that contained 36% CP (SG/SBM 36%), long-stem alfalfa hay (18% CP), or alfalfa-pellets (18% CP) in amounts that provided .05, .10, and .15 % BW of CP/day. In general, supplementation increased the intake and digestibility of low-quality range forage. No substitution effect was observed for the SG/SBM 36% supplement or the alfalfa pellets. However, the SG/SBM 18% supplement did substitute for forage at the high level of supplementation. A similar trend appeared to exist for the long-stem alfalfa hay.

(Key Words: Supplementation, Alfalfa, Range Forage, Pellets.)

Introduction

Providing supplements with moderate to high protein content has been shown to be beneficial for beef cows maintained on dormant, native range. Increased intake of range forage by supplemented cattle compared with nonsupplemented cattle is a major factor contributing to the positive effect of such supplements. However, the likelihood that a supplement substitutes for range forage increases as the amount of supplement fed increases. Furthermore, the amount required to elicit substitution effects may vary for supplements with different physical properties and (or) with different effects on digestive physiology. Therefore, our objective was to observe the influence of varied types and amounts of supplements on the likelihood that supplement will substitute for forage. In addition, associated effects on digestion and fill were monitored.

Experimental Procedures

Thirteen ruminally fistulated Angus × Hereford steers (avg initial wt = 574 lb) were used in an incomplete Latin square with 13 treatments and four periods. Steers were maintained in individual tie stalls and fed dormant, bluestem-range forage (CP ~2%) once daily at 130% of their previous 5-day average intake. Treatments were arranged as a 3 × 4 factorial plus a negative control treatment. Steers on the negative control treatment were unsupplemented. The first factor, amount of supplement, was designed so that steers received a daily amount of each supplement providing .05, .10, or .15 % body weight (BW) as crude protein (CP). The second factor, supplement type, was set such

[1]The authors express their appreciation to Gary Ritter, Wayne Adolph, Gary Breault, and Mike Scheffel for their invaluable assistance in conducting this experiment.

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that each of four supplements was fed within each supplementation level. The supplements were: 1) a sorghum grain (SG) and soybean meal (SBM) mixture that contained 18% CP (SG/SBM 18%); 2) a SG/SBM mixture that contained 36% CP (SG/SBM 36%); 3) long-stem alfalfa hay (LSAH); 4) alfalfa pellets (AP). The LSAH and AP were from the same source. The pellets were made by grinding through a 3/16" screen and pressing into a 1/4" pellet. The CP concentrations of the LSAH and AP were approximately the same as that of the SG/SBM 18%. Because the supplement amount was set relative to the amount of protein provided per unit of BW and because the SG/SBM 36% supplement contained twice the CP as the other supplements, the amount of supplement dry matter (DM) fed for the SG/SBM 36% supplement was half that for the other supplements. If expressed as the amount of DM fed per unit of BW, the SG/SBM 18%, LSAH, and AP supplements received approximately .28, .56, and .83 % BW daily, corresponding to 2.8, 5.6, and 8.3 lbs of supplement DM for a 1000 lb cow. Steers were adapted to each treatment for 16 days. Forage intake was measured during the 7-day period immediately following adaptation. Total fecal collections began 2 days after the beginning of intake measurements and ended 2 days after the last intake measurement. At the end of total fecal collection, total ruminal evacuations were performed (before feeding, 0 h, and 4 h after feeding) on each animal to determine ruminal fill.

Results and Discussion

Range forage intake increased linearly ($P<.01$) with increasing amounts of the SG/SBM 36% and AP (Table 1). In contrast, range forage intake for steers fed SG/SBM 18% increased up to the .10% supplementation level and then declined when steers were fed the .15% level ($P = .03$). This suggests that for every unit of additional supplement fed above the intermediate level, there was a decrease of .54 units of range forage. That is, for a 1000 lb cow, about .54 lb decrease in range forage intake would occur for each additional 1.0 lb of SG/SBM 18% DM fed above about 5.6 lbs. Although not statistically significant ($P = .37$), the trend for the LSAH group was similar. For LSAH, a decrease of .48 units of range forage occurred for each additional unit of LSAH fed above the intermediate level of supplementation. Similar substitution ratios have been observed for LSAH supplements in other research at Kansas State University. Because substitution was only partial in those treatments where it occurred, total dry matter intake (DMI) increased for all treatments in response to increasing supplementation.

Dry matter digestibility (DMD) increased linearly ($P<.01$) with increasing levels all supplements. Provision of nitrogen and other microbial nutrient requirements, as well as higher digestibility for the supplement than the hay, were probably responsible for that increase. No difference was seen in DMD for the groups receiving concentrate supplements compared with those receiving alfalfa supplements; however, DMD was greater ($P<.01$) for the LSAH group than for the AP group. The larger, coarser particles in the LSAH likely would allow for longer ruminal retention time than for the AP, thus providing the opportunity for increased ruminal disappearance of DM. Because all supplement groups displayed increased (although variable) total DMI and DMD with increasing supplementation, the digestible DMI also increased ($P<.01$). Thus, even in those cases where substitution occurred, overall nutrient input increased with increasing supplementation level.

Ruminal dry matter fill measured just before feeding (0 h) for the SG/SBM 18%, SG/SBM 36%, and LSAH groups decreased linearly ($P \leq .07$) with increasing amount of supplement. The AP group tended ($P = .11$) to display the same trend. However, at 4 hours after feeding, ruminal DM fill remained fairly constant for the nonsupplemented group but increased substantially from the 0 hour measurement for most groups receiving supplement. Increases in ruminal fill, DMD, and possible increases in passage rate at least partially explain the ability of the supplemented steers to increase the intake of

range forage compared with the nonsupplemented group.

Table 1. Effect of Supplemental Type and Amount on Forage Intake, Digestion, and Fill

Item[a]	18% SG/SBM	36% SG/SBM Alfalfa Pellets[b]			Alfalfa Hay				Statistically Significant						SEM	Contrasts[c]
	Ctrl.	.05	.10	.15	.05	.10	.15		.05	.10	.15		.05	.10	.15	
Hay DMI[d] %BW/d	1.15	1.46	1.59	1.71	1.34	1.48	1.33	1.39	1.47	1.54	1.17	1.22	1.09	0.07	1,2,4,5,8,10, 11,12	
Total DMI %BW/d	1.15	1.60	1.89	2.15	1.60	2.05	2.17	1.66	2.00	2.35	1.44	1.76	1.90	0.07	1,2,4,5,6,8,11	
DDMI[e] %BW/d	0.44	0.65	0.87	1.10	0.65	0.90	1.09	0.70	0.85	1.06	0.63	0.87	0.97	0.03	1,2,4,6,8,11	
DMD[f],%	38.1	41.1	46.0	53.0	40.9	42.9	49.9	41.9	42.8	45.3	43.4	49.9	51.4	1.46	1,2,4,6,8,10,11	
DM fill %BW																
0 h	2.5	2.6	2.2	2.2	2.4	1.9	2.0	2.3	2.2	2.1	2.1	1.8	1.9	0.18	1,2,4,6	
4 h	2.6	2.9	2.7	2.5	2.7	2.7	2.9	3.0	2.9	2.7	2.3	2.3	2.5	0.13	3,9,11	
Liquid fill %BW																
0 h	15.6	16.5	15.2	12.4	14.8	14.3	12.8	15.0	14.9	14.6	14.4	14.0	14.1	0.88	2,3,4	
4 h	16.2	17.6	16.4	14.0	16.1	15.2	15.2	17.1	17.6	16.2	16.4	16.4	16.7	0.78	2,3,12	

[a]SG/SBM = Supplement comprised of sorghum grain (SG) and soybean meal (SBM).

[b]Alfalfa pellets and hay were from the same source of alfalfa.

[c]Statistically significant ($P \leq .10$) contasts were: 1 = Supplemented vs nonsupplemented; 2 = Linear response for those receiving the SG/SBM 36% supplement; 3 = Quadratic response for those receiving the SG/SBM 36% supplement; 4 = Linear response for those receiving the SG/SBM 18% supplement; 5 = Quadratic response for those receiving the SG/SBM 18% supplement; 6 = Linear response for those receiving the LSAH supplement; 7 = Quadratic response for those receiving the LSAH supplement; 8 = Linear response for those receiving the AP supplement; 9 = Quadratic response for those receiving the AP supplement; 10 = SG/SBM 36% vs SG/SBM 18%; 11 = AP vs LSAH; 12 = Concentrate supplements vs alfalfa supplements.

[d]DMI = dry matter intake

[e]DDMI = digestible dry matter intake

[f]DMD = dry matter digestibility

CONTINUOUS-CULTURE FERMENTATION AS A TOOL FOR FORAGE EVALUATION

E. S. Vanzant [1], R. C. Cochran, K. C. Olson, S. Stafford, and G. St. Jean [2]

Summary

Ruminal degradation of organic matter and protein in alfalfa and prairie hay were evaluated in vivo, using cannulated cows, and in vitro, using a continuous-culture fermenter to simulate ruminal fermentation. Estimates of organic matter degradability, microbial N flow per unit feed N input, and efficiency of microbial growth were not different (P>.10) between the in vivo and in vitro systems. However, for both forages, estimates of nitrogen degradability were greater with the in vitro system. Despite the differences between in vivo and in vitro techniques for some variables, continuous-culture fermentation will allow us to compare the effects of dietary treatments on forage digestion and will aid in the formulation of supplements to meet specific nutrient requirements for cattle consuming forage-based diets.

(Key Words: Alfalfa, Prairie Hay, Ruminal Digestion, Protein.)

Introduction

The nutritive value of forages to ruminant animals depends on the extent to which forage components are digested and utilized within the rumen. Because measurement of ruminal digestion in the live animal presents various difficulties, other approaches have been developed to simulate ruminal digestion. One such approach is the use of continuous-culture fermentation. With this technique, ruminal microorganisms are maintained in glass fermentation vessels and are fed similar diets to those fed the live animal. Collection of the materials flowing out of the fermentation vessels allows for calculation of the extent of degradation. This technique deserves particular attention as a means for measuring forage protein degradation. New protein systems for cattle require knowledge about the quantity of dietary protein that is degraded in the rumen and, consequently, the quantity that passes to the small intestine without degradation by ruminal microorganisms. Most of the research in this area has dealt with concentrates, particularly grains and protein supplements. For cows and stocker cattle that receive most of their crude protein (CP) from forages, we have little information relating to the amount of rumen degradable and nondegradable protein in their diets. Thus, we are unable to assess accurately their needs for supplemental degradable and undegradable protein. This study was undertaken to evaluate the ability of continuous-culture fermentation to simulate ruminal fermentation of both high- and low-quality forages.

Experimental Procedures

Degradation of alfalfa (16.8% CP) and prairie hay (5.8% CP) in continuous-culture fermenters was compared with in vivo degradation measurements obtained using cannulated cows. The in vivo measurements were made using six Angus × Hereford cows that had been fitted surgically with cannulas

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in the rumen and duodenum. Samples were collected from the diet, the rumen, and the duodenum and were analyzed for organic matter; crude protein; and an internal marker, indigestible acid detergent fiber, which allowed us to calculate the amount of undegraded forage constituents flowing through the duodenum each day. We measured the quantity of these constituents derived from ruminal bacteria by determining the concentration of purine nitrogen in the duodenal contents and in bacteria that were isolated from the rumen. By assuming that all purine nitrogen at the duodenum comes from bacteria, we were able to determine the amount of organic matter and protein that came from bacteria. After estimating contributions to duodenal flow coming from animal cells and enzymes, the remainder of the flow through the duodenum was assumed to be undegraded forage constituents. For the in vitro technique, we fed each forage into a continuous-culture fermenter, a laboratory apparatus designed to simulate ruminal fermentation. The fermenter contained ruminal microorganisms harvested from a ruminally cannulated steer and maintained temperature, oxygen levels, and acidity within levels that allowed for continuous growth and digestion by the ruminal microorganisms. The amounts of organic matter and protein flowing into and out of the fermenter were measured, and microbial contribution was subtracted from the outflow as described above for the in vivo technique.

Results and Discussion

The amounts of organic matter and CP fed are shown in Table 1. Estimated ruminal digestibility of organic matter was greater ($P<.01$) for alfalfa than for prairie hay with both techniques. Although the difference between the forages was numerically greater when measured in vivo, differences between techniques were not significant. An interaction between forage type and measurement technique existed ($P=.05$) for estimated ruminal protein degradability, because protein degradability for alfalfa was similar between measurement techniques, whereas it was significantly greater for the in vitro technique with prairie hay. The flows of nitrogenous constituents out of the respective systems were calculated as fractions of the amount of feed N put into each system to account for the fact that much greater total amounts of N were required in vivo than in vitro. The values for nonammonia N in Table 1 represent a combination of N from both microbial cells and undegraded feed. The total nonammonia N flow out of each system as a fraction of the feed N put into the system was greater ($P<.01$) for prairie hay than for alfalfa and was greater ($P=.01$) in vivo than in vitro. The amount of bacterial N flowing out of each system as a fraction of the feed N put into the system was also greater ($P<.01$) for prairie hay than for alfalfa but was unaffected ($P>.10$) by the technique used. The large N outflows for prairie hay as compared with alfalfa, when expressed as a percentage of N input, are indicative of the small amount of ruminally degradable N provided by the prairie hay. Nonammonia N outflow can exceed feed N input, as demonstrated by in vivo outflow in excess of 100% of input for prairie hay. This is possible because ruminal bacteria utilize ammonia that is recycled back into the rumen to synthesize bacterial protein. Efficiency of bacterial growth is measured by the amount of bacterial N produced per kg of organic matter digested in the system. The efficiency of bacterial growth was unaffected by either forage type or measurement technique.

The similarity between the techniques with respect to estimates of bacterial N exiting the system as a proportion of feed N or per unit organic matter fermented suggests that continuous culture can provide a reasonable estimate of the ability of a forage to sustain bacterial protein production. This would allow us to predict the amount of bacterial N available to the animal consuming a forage diet. Thus, the need for additional ruminally undegradable N could be assessed. Further study is necessary to determine whether more accurate predictions of in vivo organic matter and N degradability are possible using our continuous culture fermenters.

In conclusion, specific values for degradability of protein measured with continuous-culture fermentation did not match values obtained from in vivo measurements. However, continuous-culture techniques provided a means to evaluate differences between the organic matter and protein degradability of forage diets and allowed for prediction of bacterial protein production supported by both high-quality and low-quality forages. Use of these techniques will allow for more accurate formulation of supplements to meet the nutrient requirements of ruminants consuming forage-based diets.

Table 1. Digestibility and Nitrogen Outflow for Alfalfa and Prairie Hay as Affected by Measurement Technique

	Alfalfa		Prairie Hay			P-value[b]		
Item	in vivo[a]	in vitro	in vivo	in vitro	SE	F×T	F	T
Feed input, g/d								
Organic matter	6337	13.5	6080	13.6	-	-	-	-
Crude protein	1149	2.4	366	.8	-	-	-	-
Digestibility[c], %								
Organic matter	61.6	60.5	45.9	53.9	3.73	.24	<.01	.36
Crude protein	83.0	90.7	54.1	75.5	3.26	.05	<.01	<.01
Nitrogen outflow, % of feed N input								
Non-ammonia N[d]	55.8	40.9	122.1	97.8	7.22	.53	<.01	.01
Bacterial N	38.8	31.5	76.2	73.4	7.42	.77	<.01	.51
Bacterial N flow, g/kg DOM[e]	17.8	16.2	16.5	14.1	2.56	.90	.54	.47

[a]Measurement techniques: in vivo = measurements made using cannulated cows; in vitro = measurements made using continuous culture fermenters.
[b]Probability of a greater F-value. F×T = forage type × measurement technique interaction; F = forage type effect; T = measurement technique effect.
[c]Digestibility values for in vivo technique represent true ruminal digestibility (corrected for bacterial contribution).
[d]Nonammonia N corrected for estimated endogenous N flow with in vivo technique and, therefore, represents sum of bacterial N and undegraded feed N for both techniques.
[e]DOM = organic matter digested in rumen or fermenter, corrected for microbial organic matter.

RELATIONSHIPS BETWEEN LIGNIN CONTENT AND FERMENTABILITY OF INTACT AND CHEMICALLY TREATED BIG BLUESTEM FIBER

E. C. Titgemeyer, R. C. Cochran, G. Towne, and K. C. Olson

Summary

An accurate assessment of forage quality is required to allow prediction of animal performance. One of the most commonly used methods of forage evaluation is to measure lignin content, with more heavily lignified materials being considered less digestible. Two measures of lignin, acid detergent lignin (ADL) and acetyl bromide lignin (ABL), were assessed with regard to their ability to predict forage digestibility. Big bluestem forage samples were collected from three ungrazed, annually burned pastures at 38, 58, and 97 days postburn. These times were selected to represent a broad range of forage quality. Cell wall material was treated chemically by: 1) partial delignification (chlorite), 2) isolation of α-cellulose, or 3) NaOH extraction.

Control and treated cell-wall material was analyzed for ABL and ADL and 24 and 72 hr in vitro dry matter disappearance (IVDMD). ABL increased with advancing maturity for intact fibers, whereas ADL was highest in the most mature forage but lowest for the intermediate maturity. Fermentability of the intact fiber decreased with maturity and was correlated highly to ABL content. ABL was a better indicator of forage degradability for intact bluestem fiber than was ADL, but neither ABL nor ADL was adequate for evaluating fermentability of treated residues.

(Key Words: Big Bluestem, Forage Quality, Lignin.)

Introduction

An accurate assessment of forage quality often is required to allow prediction of animal performance. One of the most commonly used methods of forage evaluation is to measure lignin content, with more heavily lignified materials being considered less digestible. Lignin is a large polyphenolic compound found in plants that not only is indigestible itself, but also reduces the digestibility of other forage fractions.

Unfortunately, lignin is not a uniform entity, and, therefore, the laboratory techniques that are used to assess its concentration are problematic. One of the most common techniques for measuring lignin is the acid detergent lignin (ADL) procedure that uses strong sulfuric acid to degrade all of the nonlignin structures in the plant; lignin then is calculated as the residue that remains. This technique typically underestimates the true lignin content because some of the lignin is solubilized by the strong acid. Another technique for measuring lignin content is the acetyl bromide lignin (ABL) procedure that solubilizes lignin and subsequently measures it spectrophotometrically. The biggest drawback to this procedure is the difficulty in finding an appropriate standard to compare to samples.

The objective of this experiment was to identify changes in the lignin composition of big bluestem forage as it matures and to relate changes in lignin concentration to depressions in digestibility. We also subjected the forage to various chemical treatments in order to identify structures in bluestem that could limit digestibility.

Experimental Procedures

Big bluestem was selected as representative of warm-season grasses found in the native range of Kansas. Samples of big bluestem were collected from three ungrazed, annually burned pastures on the Konza Prairie at 38, 58, and 97 days after the April 24, 1993 burning. These times were selected to represent a broad range of forage quality. Although the initial clipping was performed on June 1, the cold spring temperatures and slower than normal growth rate of the big bluestem caused this sample to be quite immature.

Entire plants were clipped 1 cm above the ground with clipping sites being marked to avoid collection of regrowth. Forage material was dried (50°C) and ground, and cell wall material was isolated by extracting with hot (70°C) water for 1 hour.

Cell wall material was treated chemically by: 1) partial delignification (chlorite), 2) isolation of α-cellulose (treatment of delignified material with 2N KOH for 24 hr), or 3) sodium hydroxide extraction to solubilize alkali-labile components and remove some of the core lignin (1N NaOH for 24 hr). Control and treated cell-wall material was analyzed for ABL, ADL, and 24 and 72 hr in vitro dry matter disappearance (IVDMD).

Results and Discussion

The lignin concentrations of bluestem as measured by the ADL and ABL procedures were quite different (Table 1); ABL yielded much higher estimates than did ADL. This is probably due to an underestimation of lignin by the ADL procedure, but could be partly due to the use of an inappropriate standard for the ABL procedure.

For the hot water extracted forage, ABL concentration increased with increasing maturity and was highly correlated to the depression in 72 h IVDMD that was observed as the bluestem aged. ADL content of the bluestem was more variable; although it was highest for the most mature sample, it was lower for the intermediate maturity than for the first harvest date. The relationship between ADL content and depressions of IVDMD was not as strong as that for ABL.

For the chlorite-delignified and NaOH-treated residues, ABL content increased with increasing maturity, mimicking the values for the untreated residues. However, ADL concentration in the chlorite-treated samples decreased with increasing maturity. Across maturities, IVDMD of chlorite-delignified and NaOH-treated samples were greater than that of the untreated material, indicating that the phenolic constituents that were solubilized played a significant role in the maturity-related decline in digestibility.

The cellulose residues should represent the largest single fraction within the plant cell wall. Typically, we believe that cellulose, when not encrusted by other cell wall materials like lignin, is highly digestible. With the ABL procedure, no lignin was found in the cellulose residues, whereas the ADL procedure indicated that some lignin remained.

As plants matured, the digestibility of the cellulose residue decreased, indicating that perhaps the size or crystallinity of the cellulose itself may limit digestion.

In conclusion, ABL was a better indicator of forage degradability for intact bluestem fiber than was ADL, but neither ABL nor ADL was adequate for evaluating fermentability of treated residues.

Table 1. Lignin Content and Digestibility of Big Bluestem and Chemically Treated Residues

Date/Treatment	ABL	ADL	24h IVDMD	72h IVDMD
June 1, 1993	---------- % of dry matter ----------			
Water	15.12	4.63	15.5	63.6
Chlorite	7.33	2.68	38.9	67.8
Cellulose	nd	2.73	34.6	84.5
NaOH	5.32	4.09	26.2	73.9
June 21, 1993				
Water	16.89	4.23	16.5	57.6
Chlorite	8.35	2.22	28.2	64.2
Cellulose	nd	2.30	21.1	77.6
NaOH	7.30	3.80	24.2	74.0
July 30, 1993				
Water	21.04	5.23	11.6	47.8
Chlorite	10.95	1.61	26.2	73.9
Cellulose	nd	1.36	26.8	72.5
NaOH	9.86	4.39	20.8	72.0
SEM	.19	.25	3.0	2.4

ABL = Acetyl bromide lignin, ADL = Acid detergent lignin, IVDMD = In vitro dry matter disappearance.
Water = Forage soaked in 70°C water for 1 hour. Chlorite = Delignification with sodium chlorite. Cellulose = Cellulose isolated from chlorite delignified residue by soaking in 2N potassium hydroxide for 24 hours. NaOH = Forag e soaked in 1 N sodium hydroxide for 24 hours.
nd = Not detectable.

PUBERTY AND BREEDING PERFORMANCE OF BEEF HEIFERS DEVELOPED AT DIFFERENT RATES OF GAIN

J. E. Minton, R. T. Brandt, Jr., C. M. Coughlin, and R. C. Cochran

Summary

Crossbred heifers (546 lb initial body weight) were developed in drylot and limit-fed a corn, corn silage diet to gain .5 (n = 14), 1.0 (n = 15), 1.5 (n = 14), or 2.0 lb/d (n = 15) from Dec. 7, 1992 until the onset of the breeding season, May 3, 1993. Actual daily gains averaged 1.0, 1.4, 1.8, and 2.1 lb/d, respectively. Age at puberty was not affected by feeding treatment. At the onset of the breeding season, nutritional treatment had a linear effect on body condition score, ribeye fat thickness (both P<.01), and reproductive tract score (P<.05), all increasing with increasing rate of gain. Nutritional treatment had a quadratic effect on pelvic area (P<.05), which averaged 190.6, 201.6, 206.5, and 205.3 cm^2 for heifers fed to gain .5, 1.0, 1.5, and 2.0 lb/d, respectively. At the conclusion of the development period, estrus was synchronized, and heifers were inseminated artificially at estrus for 45 days and, if open, mated naturally for another 17 d. Overall pregnancy rates were similar among heifers fed to gain .5, 1.0, and 1.5 lb/d (92.9, 93.3, and 92.9%, respectively), and all tended to be greater (P<.09) than the rate for heifers fed to gain 2.0 lb/d (66.7%). In summary, NRC recommendations underestimated gain of limit-fed heifers at lower predicted rates of gain. Thus, even though heifers fed to gain only .5 lb/d had lower body condition scores and reproductive tract scores at the onset of the breeding season, their actual body weight gains (1.0 lb/d) were sufficient for normal onset of puberty and subsequent conception. In addition, heifers fed to achieve relatively high rates of gain (2.0 lb/d) during development may have had impaired fertility.

(Key Words: Beef Heifers, Puberty, Heifer Development.)

Introduction

Numerous reports indicate that yearling beef heifers that are managed to conceive early in the breeding season have greater lifetime productivity than heifers that conceive later. To increase the likelihood that heifers will conceive early, they must have attained adequate age and body weight to be cycling before the start of the breeding season.

A popular rule of thumb is that heifers should be fed to attain 60 to 65% of their estimated mature body weight by the start of the breeding season. Although severe nutrient restriction during development delays puberty, information is limited regarding reproductive performance of heifers developed to body weights somewhat below 65% of mature weight. If reproductive performance remained normal, developing heifers to lower prebreeding target weights could lower feed costs and reduce the potential for overconditioning, especially in smaller-framed heifers.

Our primary objective was to evaluate age at puberty and breeding performance of heifers developed at different rates of gain. Treatments were designed to have heifers weighing 55 to 75% of their expected mature body weight by the onset of the breeding season.

Experimental Procedures

Angus × Hereford heifers were blocked by weight and assigned randomly within weight blocks to four treatments. Treatments were designed to produce body weight gains of .5 (n = 14), 1.0 (n = 15), 1.5 (n = 14), and 2.0 (n = 15) lb/d. Heifers were housed three or four per pen, with four pens per treatment. Diets were formulated according to NRC (1984) recommendations to achieve the desired rates of gain; the diet (as fed) was 70% corn silage, 30% corn, and 3% of a vitamin-mineral supplement that supplied Rumensin® at 150 mg/hd/d. Enough soybean meal was topdressed daily to supply protein requirements for the desired gains. The feeding period began on Dec. 7, 1992 and continued to May 3, 1993. Body weights, without shrink, were obtained every 14 d.

Beginning on Feb. 15, serum samples were obtained on Monday, Wednesday, and Friday and analyzed for progesterone. Two consecutive samples with progesterone concentrations above 1 ng/ml indicated ovulation and luteal function; age at puberty was defined as age at the sampling date immediately prior to the progesterone increase. Weight at puberty was the body weight closest to the age at puberty. The measured body weight was reduced by 4% to account for fill.

Body weight; body condition score (1 = extremely thin, 9 = extremely fat); ribeye fat thickness; pelvic area; and reproductive tract score (1 = infantile uterus, 5 = mature, cycling, corpus luteum present) were determined at the conclusion of the feeding period. Then estrus was synchronized by two injections of Lutalyse®, with the final injection on May 5. Heifers were inseminated artificially at estrus using the AM-PM rule for the first 45 days. Then clean-up bulls were used for 17 days. Pregnancy was verified by ultrasonic evaluation of the uterus 36 days after the end of the breeding period.

Fasting heat production was calculated retrospectively from the performance of the heifers, utilizing NRC (1984) net energy equations.

Results and Discussion

The performance and reproductive characteristics of heifers fed to gain .5, 1.0, 1.5, and 2.0 lb/d during development are illustrated in Table 1. Daily gains exceeded NRC-predicted daily gains. This overperfomance was generally greater at lower predicted rates of gain, which suggests that the performance predicted by the NRC becomes increasingly inaccurate as calculated gains are < 2 lb daily. This phenomenon may be explained, in part, by the reduced maintenance energy requirements of limited-fed cattle as reflected by reduced estimates of fasting heat production (Table 1).

The major objective of this study was to evaluate reproductive performance of heifers entering the breeding season below the currently recommended 60 to 65% of their expected mature body weight. Because our heifers gained faster than anticipated, even heifers on the most restricted diet entered the breeding season at approximately 63% of their expected 1100 lb mature body weight. Calculated percentages of mature body weight were 68%, 75%, and 78% for heifers fed to gain 1.0, 1.5, and 2.0 lb/d, respectively.

Age and weight at puberty were similar across treatments. However, body condition scores, ribeye fat thickness ($P<.01$), and reproductive tract scores ($P<.05$) all increased linearly in response to increased rates of gain. There was a quadratic response to treatment for pelvic area, which increased for heifers fed to gain between .5 to 1.5 lb per day but remained similar for heifers with predicted gains of 1.5 and 2.0 lb/d.

By the onset of breeding, only one heifer (.5 lb/d treatment) was not pubertal, as estimated by serum progesterone. Thus, even though heifers on this treatment had lower reproductive tract scores, all treatments, on average, had reproductive tract scores of 4 or greater, indicative of cyclicity. Based upon

our estimates of pubertal onset and reproductive tract scores, all heifers were developed sufficiently to enter the breeding season. However, heifers in the 1.0, 1.5, and 2.0 lb/d gain treatments, although reproductively competent, had increased body condition scores and ribeye fat thickness, indicating that they may have been fatter than desirable. This degree of overconditioning may have depressed the fertility of heifers fed to gain 2 lb/d, as evidenced by their tendency (P<.09) for reduced pregnancy rates.

Our data suggest that NRC net energy equations underestimate the performance of cattle at very low rates of gain. Although heifers fed to gain .5 lb/d had reduced body condition scores and reproductive tract scores, their body weight gains were sufficient to attain normal puberty and conception. In addition, overconditioning may impair fertility of heifers.

Table 1. Performance and Reproductive Characteristics of Heifers Developed at Different Rates of Gain

	Predicted Daily Gain, lb				
Item	.5	1.0	1.5	2.0	SE
No. of heifers	14	15	15	15	-
Initial wt., lb	547	544	550	545	19
Prebreeding wt., lb [a]	692	754	823	855	23
Daily gain, lb [a]	1.0	1.4	1.8	2.1	.08
Fasting heat production, kcal/kg $BW^{.75}$ [b]	62.7	66.8	66.1	84.1	4.8
Age at puberty, d [c]	386.6	374.1	373.6	385.6	9.8
Weight at puberty, lb	655	689	732	764	27
Body condition score [d]	5.7	6.1	6.6	6.8	.1
Fat thickness, in [a]	.25	.25	.39	.47	.03
Pelvic area, cm^2 [e]	190.6	201.6	206.5	205.2	2.7
Reproductive tract score [f]	4.0	4.2	4.5	4.5	.2
Pregnancy rate, % [g]	92.9	93.3	92.9	66.7	-

[a]Linear effect of treatment (P<.01).
[b]Linear effect of treatment (P<.05).
[c]Sampling period immediately preceding two consecutive measures of serum progesterone greater than 1 ng/ml.
[d]Linear effect of treatment (P<.01); 1 = extremely thin, 9 = extremely fat.
[e]Quadratic effect of treatment (P<.05).
[f]Linear effect of treatment (P<.05). Scale of 1 to 5; 1 = infantile, prepubertal, 4 = cycling, but no corpus luteum present, 5 = cycling, but corpus luteum present.
[g]Estimated ultrasonographically 36 d after the conclusion of the breeding period; lower for heifers fed to gain 2.0 lb/d (P<.09).

INFLUENCE OF DIETARY ENERGY LEVELS ON REPRODUCTIVE FUNCTION AND FERTILITY IN YEARLING BEEF HEIFERS [1,2]

S. D. Utter and L. R. Corah

Summary

Fifty-nine heifers were allotted to be fed at two different energy levels. One group gained 1.77 lb/hd/day, and the other 1.25 lb/hd/day. Estrus was synchronized with the MGA/prostaglandin system. After MGA removal, ovarian development was monitored daily by ultrasound (10 per group) until estrous was detected following the PGF injection. Heifers were inseminated artificially based on estrus behavior. Faster gaining heifers had higher final body condition scores and greater changes in body condition score. The high energy diet caused a slight (P=.11) decrease in AI pregnancy rate for purebred heifers.

(Key Words: Beef Heifers, Energy Levels, Ovarian Function, Fertility.)

Introduction

Proper development of replacement heifers can improve reproductive efficiency. Heifers that conceive early in the breeding season tend to rebreed the following year and have a more productive lifetime. Dietary management can influence the reproductive efficiency of heifers. Underfeeding has long been recognized as detrimental to reproductive efficiency, but the impact of overfeeding has not been studied extensively. Our purpose was to determine the influence of two levels of dietary energy on expression of estrus, ovarian function, concentrations of progesterone, and corresponding AI conception rates.

Experimental Procedures

Fifty-nine heifers (40 commercial, 19 purebred) were stratified by weight and body condition score (BCS) within breed into two different treatments. Heifers were targeted to gain 3.3 lb/hd/day (excess) or 1.2 lb/hd/day (optimum). Estrus was synchronized by feeding MGA for 14 days, with a prostaglandin injection 17 days after removing MGA. From the time MGA was withdrawn until breeding, the ovaries of the 19 purebred heifers were scanned daily by transrectal ultrasonography. Blood samples were collected daily in the scanned heifers to determine progesterone concentration. From the scans, the corpus luteum and number and size of follicles were counted and scored as medium (5 to 10 mm diameter) or large (>10 mm). The size of the ovulatory follicle also was recorded. Both commercial and purebred heifers were inseminated artificially based on observed estrus. Commercial heifers then were placed with a bull for the remainder of the breeding season, whereas the purebred heifers continued to be inseminated for an additional 45 days, then were

[1]Appreciation is expressed to Gary Johnson, Dwight, KS, for the commercial heifers used in this study.

[2]Sincere thanks to Paul Zuhkle, Kelly Griffin, and the crew at the purebred unit for their assistance in conducting this experiment. Thanks also to Todd Milton for statistical assistance and Colleen Coughlin for lab assistance.

placed with a bull for an additional 10-days. Pregnancy determination and calving data were used to calculate conception date.

Results and Discussion

Heifers targeted to gain 3.3 lb/hd/day actually gained only 1.77 lb/hd/day. Heifers on the optimum energy level were targeted to gain 1.2 lb/hd/day and actually averaged 1.25 lb/hd/day. These averages were diminished because the purebred heifers lost weight during the scanning period. Although the desired average daily gain was not achieved, excess energy increased (P<.01) final average daily gain, final body condition score, and change in body condition score for both commercial and purebred heifers (Table 1).

Dietary energy level had no effect on serum progesterone concentrations, follicular development, or CL size at the time of prostaglandin injection (Table 2).

Excess energy decreased AI pregnancy rates (P=.11) in purebred heifers but had no effect in commercial heifers. Combining results for the purebred and commercial heifers resulted in a decrease in first-service conception rates for heifers on the excess energy level (Table 3).

Serum progesterone concentrations in the purebred heifers are shown in Figure 1. Although no treatment effects occurred the progesterone profile illustrates the expected response following MGA feeding and an injection of prostaglandin.

Table 1. Average Daily Gain and Body Condition Scores for Purebred and Commercial Heifers Fed Excess or Optimal Dietary Energy Levels

Trait	Excess Energy	Optimum Energy
Purebred heifers (n=19)		
Overall average daily gain	1.41[a]	1.03
Final body condition score	5.8[a]	5.4
Change in body condition score	.50	-.14
Commercial heifers (n=39)		
Overall average daily gain	1.98[b]	1.41
Final body condition score	6.5[b]	5.7
Change in body condition score	1.00[b]	.24
Overall heifer averages		
Overall average daily gain	1.77	1.25
Final body condition score	6.3	5.4
Change in body condition score	.89	.12

[a]Different (P<.01) from optimum energy treatment.
[b]Different (P<.05) from optimum energy treatment.

Table 2. Influence of Dietary Energy on Concentration of Progesterone in Serum, CL Size, and Number and Size of Follicles

Item	Excess Energy	Optimum Energy	P-value
Prior to prostaglandin inj.			
Progesterone level (ng/ml)	3.3	3.6	.7
Diameter of CL (mm)	20.9	19.4	.4
No. of medium and large follicles	3.7	2.9	.25
Diameter of largest follicle (mm)	9.3	7.9	.24
At time of AI breeding			
No. of medium follicles	3.0	2.0	.19
Diameter of ovulatory follicle	10.9	10.3	.62

Table 3. Influence of Dietary Energy Levels on Response to Synchronization, AI Conception, and Overall Pregnancy Rates

Treatment	% Response to Synchronization	% Conceived through AI	% Overall Pregnancy
Excess Energy			
Purebred	7/10(70%)	3/7 (42.3%)	9/10(90%)
Commercial	18/19 (94.7%)	13/l8 (72.2%)	18/19 (94.7%)
Combined	25/29 (86.2%)	16/25 (64.0%)	27/29(93.1%)
Optimum Energy			
Purebred	7/9 (77.8%)	6/7 (85.7%)	9/9 (100%)
Commercial	19/20 (95.0%)	15/19 (79.0%)	20/20 (100%)
Combined	26/29 (89.7%)	21/26 (80.8%)	29/29 (100%)

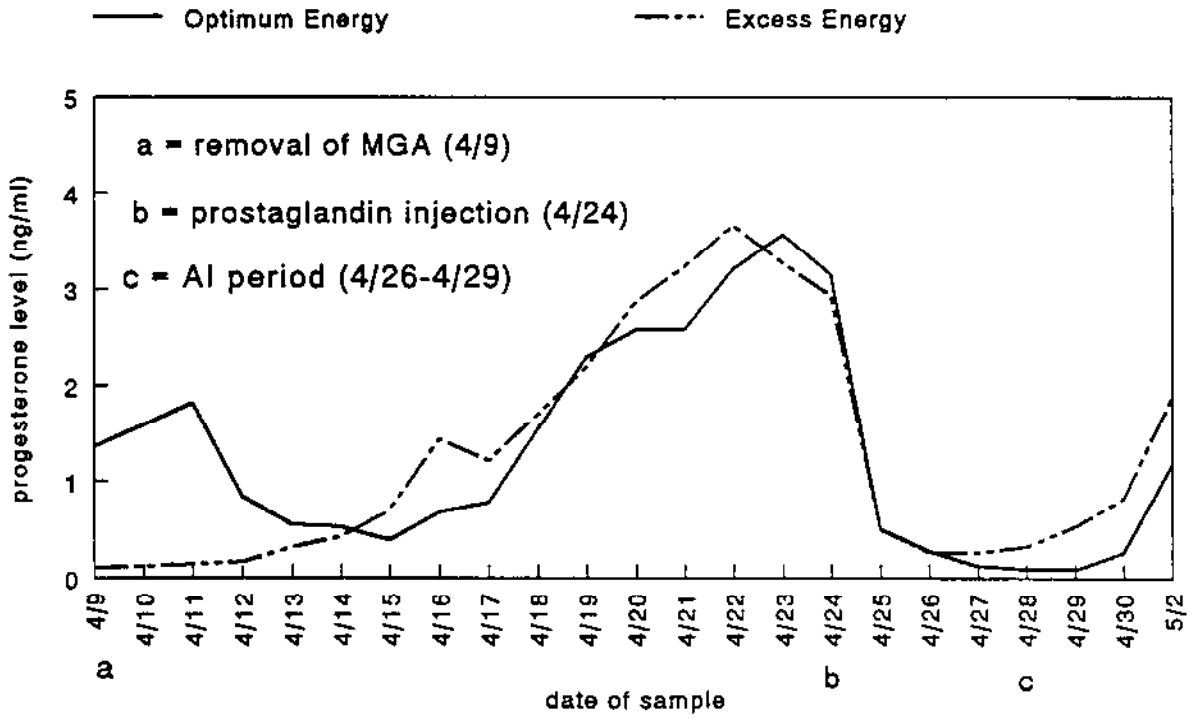

Figure 1. Average Progesterone Levels by Treatment for Purebred Heifers during Ultrasound Scan Period

FACTORS INFLUENCING FIRST-SERVICE CONCEPTION AND OVERALL PREGNANCY RATES IN COMMERCIAL BEEF HEIFERS [1]

S. D. Utter, P. L. Houghton[2], L. R. Corah, D. D. Simms, M. F. Spire[3], and M. D. Butine[4]

Summary

Commercial beef heifers (n=1863) from 16 different sources were used to evaluate the influence of management practices and biological traits on first-service conception and overall pregnancy rates. Frame score, initial weight, overall ADG, body condition score, reproductive tract score, source, AI technician, and AI sire significantly influenced first-service conception. Overall pregnancy rates were influenced by frame score, body weight, and ADG.

(Key Words: Beef Heifers, First-Service Conception, Pregnancy Rates.)

Introduction

Proper evaluation, selection, and management of replacement heifers are critical to the production and longevity of females in the cow herd. Heifers that conceive early in their first breeding season have a greater potential to rebreed as cows, ensuring continued production in the herd. Our objective was to evaluate the influence of management and biological parameters on first-service conception and overall pregnancy rates in heifers.

Experimental Procedures

To evaluate the effect of various management practices and biological traits on first-service conception and overall pregnancy rates, 1,863 heifers from six states and 16 sources were developed postweaning at a commercial heifer development facility in Southwest Nebraska. Initial body weight was measured when heifers entered the facility in early to mid-winter. A high roughage ration was limit-fed at a level so heifers would reach 65% of their projected mature body weight before the breeding season began. Production data collected 35 to 40 days prebreeding included frame score, reproductive tract score (1=highly developed, 6=infantile), and body condition score (1= thin, 9=obese).

The heifers were placed on a higher plane of nutrition 33 days before breeding. That plane was maintained through the first 21 days of the breeding season. Heifers were synchronized by feeding .5 mg/hd/day melengesterol acetate (MGA) for 14 days, followed by a subcutaneous injection of prostaglandin (Bovilene®) 14 days after MGA withdrawal. A breeding body weight was measured at the time of injection. Heifers were inseminated artificially approximately 12 hours after estrus was first detected. Nonresponders were reinjected 9 days after the first injection. If no estrus was observed after a third prostaglandin injection, heifers were inseminated at

[1]Sincere appreciation is expressed to Heartland Cattle Company for providing the data set used in this analysis.

[2]Heartland Cattle Co., McCook, NE.

[3]Department of Clinical Sciences.

[4]Department of Statistics.

72 hours post injection. First-service conception and overall pregnancy rates were determined by ultrasonography 35 to 45 days after the end of the 45-day breeding season. A final body weight was measured at that time. The difference between initial weight and final weight was used to calculate overall average daily gain (ADG).

A specialized statistical analysis (contingency tables) was used that allowed us to examine the influence of a single management factor or biological trait, while others were held constant. Because of the significant influence of heifer source, a separate analysis of heifers from a single source (n=507) was performed. A second statistical approach (mixed-model analysis) was used for the entire population (n=1863) to reduce the influence of source, technician, and sire.

Results and Discussion

As frame score increased, first-service conception (P=.16) and overall pregnancy rates (P<.10) tended to decrease (Figure 1). The contingency table analysis showed that heifers that gained 1 to 1.5 lbs/day had the highest first-service conception rates (Figure 2) and overall pregnancy rates (Figure 3). Daily gains above and below this range produced lower (P<.01) pregnancy rates. A quadratic response was observed as body condition score increased (P<.10), with a decline in first-service conception in either extremely thin or fat heifers (Figure 5). Reproductive tract score tended (P=.17) to influence first-service conception but not overall pregnancy rates (Figure 4). Heifers with infantile tracts, designated by a score of 6, had the lowest first-service conception rates when compared to those with scores of 1 through 5. The mixed model analysis found the fixed effects of body condition score (P<.0l; Figure 4) and reproductive tract score (P<.0l; Figure 5) to be significant. Interactions among ADG, frame score, breeding wt, prebreeding wt, body condition score, and reproductive tract score were significant, illustrating the impact of numerous factors on first-service conception.

Overall, heifers with frame score, body wt, body condition score, and ADG in the "moderate" range were more reproductively efficient. In addition, several factors interact to influence reproductive efficiency, demonstrating the importance of managing all contributing factors, rather than focusing on very few.

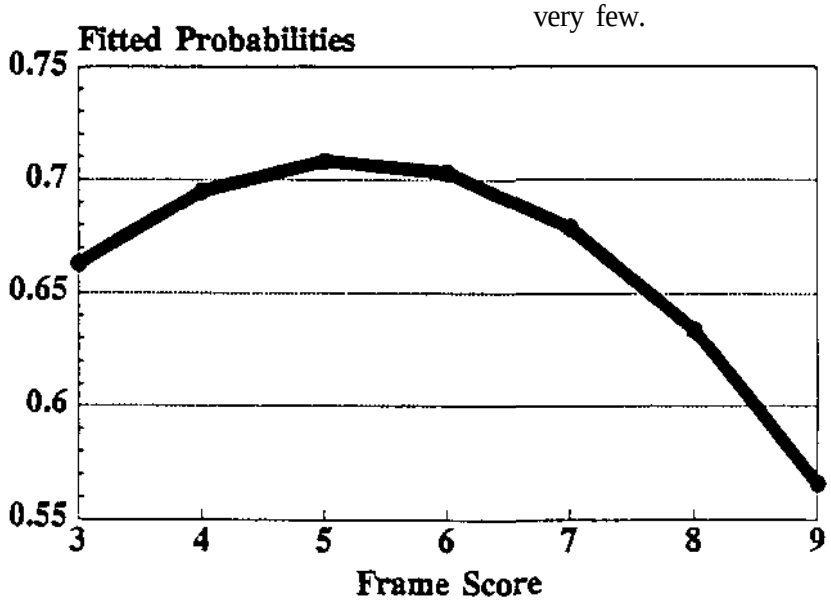

Figure 1. Influence of Frame Score on First-Service Conception

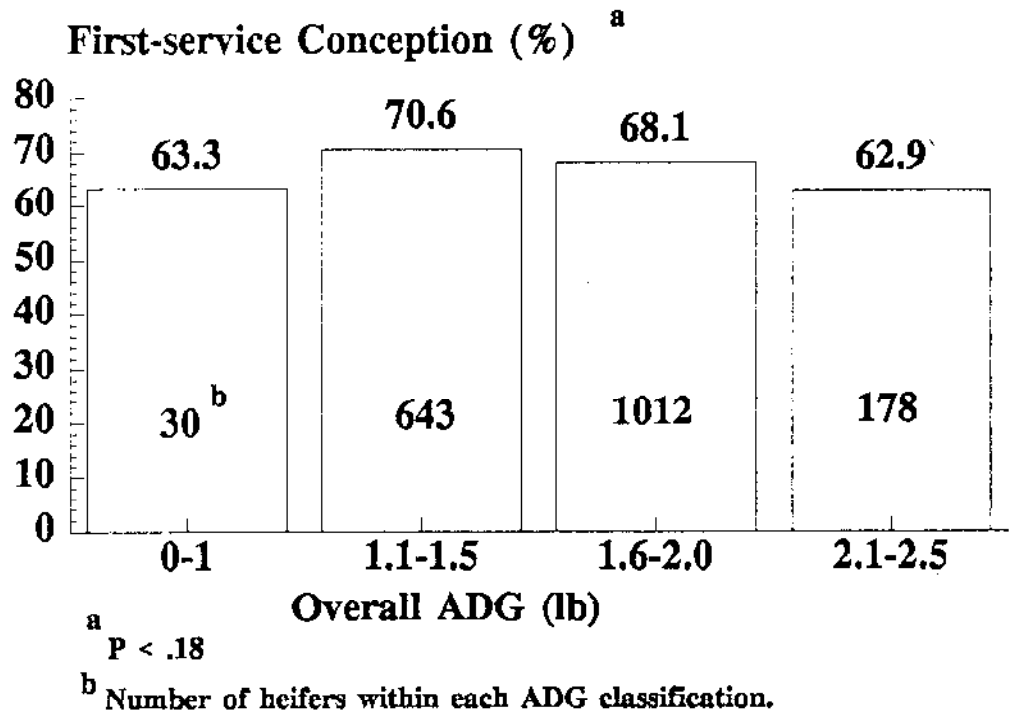

Figure 2. Influence of Overall Average Daily Gain on First-Service Conception

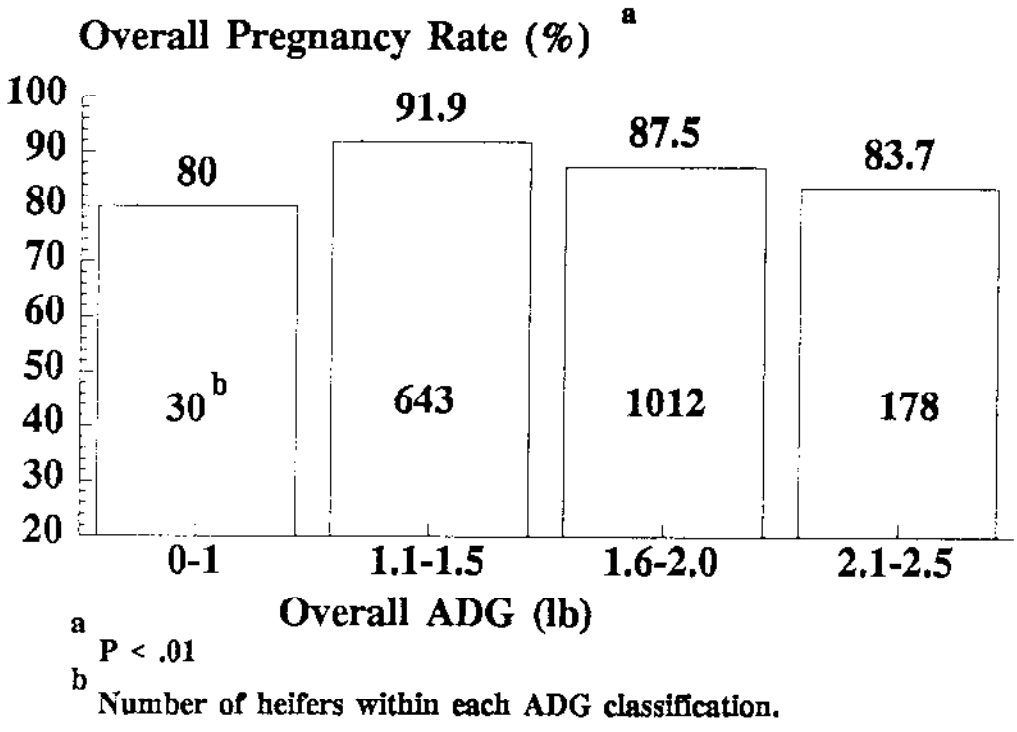

Figure 3. Influence of Overall Average Daily Gain on Overall Pregnancy Rate

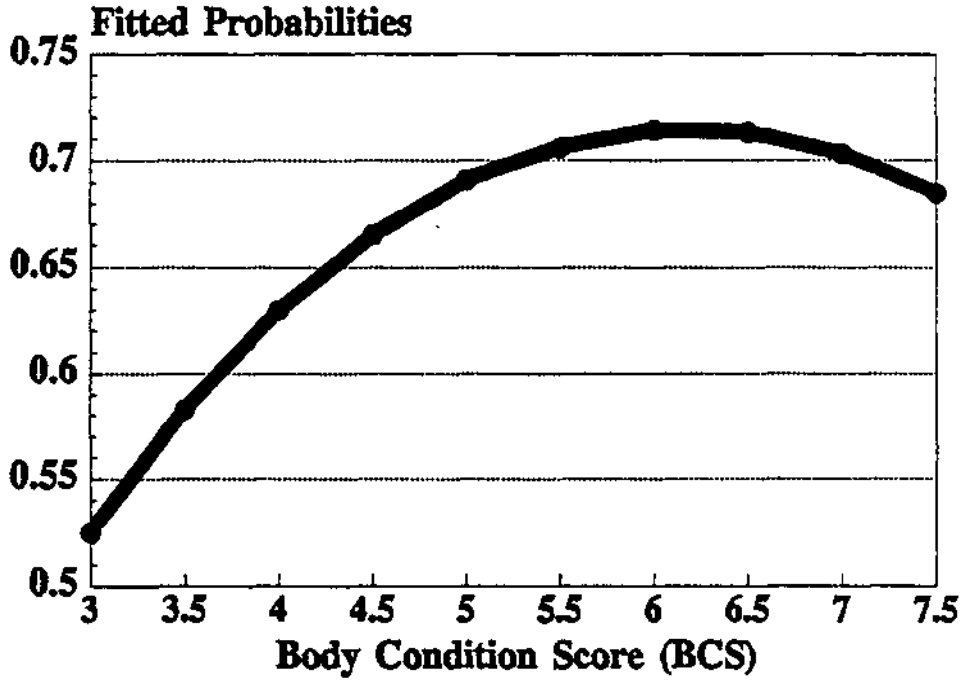

Figure 4. Influence of Body Condition Score on First-Service Conception

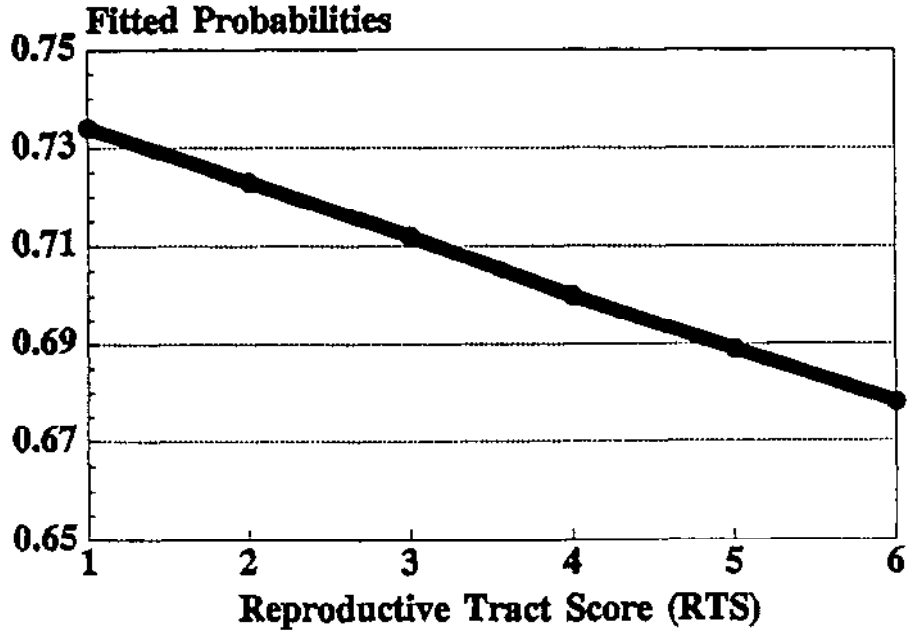

Figure 5. Influence of Reproductive Tract Score on First-Service Conception

RESTRICTING CALF PRESENCE WITHOUT SUCKLING SHORTENS POSTPARTUM INTERVAL TO FIRST OVULATION

D. P. Hoffman and J. S. Stevenson

Summary

The suckling interaction between a cow and her calf is one of the factors that maintains a cow in postpartum anestrus (the period between calving and the beginning of first estrous cycle). Anestrus continues if the cow perceives that her calf is attempting to nurse, even when the mammary glands have been denervated or removed. Cross-fostering of an alien calf to a cow fails to maintain postpartum anestrus, indicating that cow-calf recognition is also a factor. We restricted calves so they could nuzzle the cow's head and neck but could not suckle. Compared with weaning calves 1 wk postpartum, restriction lengthened the interval to first postpartum ovulation but less than with normal suckling. These results suggest that maintaining cow-calf recognition in the absence of the suckling stimulus is an essential part of the nursing mechanism that prolongs anovulation. Thus, blocking the cow's recognition of her calf might further decrease the postpartum interval to first ovulation.

(Key Words: Suckling, Anestrus, Estrous Cycles, Postpartum.)

Introduction

Reproduction is a critical factor limiting production efficiency in the beef cow. Failure of the cow to become pregnant during the breeding season limits the potential calf crop. To improve reproductive efficiency, the postpartum interval (time from parturition to first ovulation) needs to be reduced. The suckling stimulus is an important component in lengthening the postpartum period of anestrus.

Cows whose calves were weaned at birth had shorter intervals to first ovulation than cows that were suckled. Cows with non-suckling (muzzled or nose-plated) calves had longer intervals to first postpartum estrus than with cows whose calves were weaned. Suckled cows with denervated udders, maintained with their calves, had intervals to first postpartum estrus similar to those of intact cows maintained with their calves.

Mastectomized (udder removed) cows with their calves present had intervals to first postpartum ovulation similar to those of udder-intact cows with their calves, indicating that presence of the mammary glands was not essential for prolonging anestrus in beef cows. Mastectomized cows whose calves were restricted so they could not attempt to suckle cycled about 7 d later than mastectomized cows whose calves were removed at birth.

Cows with cross-fostered calves cycled as early as cows whose calves were weaned, suggesting that the cow must perceive her own calf to be suckling in order to prolong postpartum anestrus. The objective of our experiment was to determine how restricting the calf to head and neck contact with its dam would alter the onset of postpartum estrus in udder-intact beef cows.

Experimental Procedures

Twenty-four multiparous, crossbred, Angus, cow-calf pairs were assigned randomly to three groups: 1) calves had normal unrestricted contact with their dams (calf present; CP); 2) at 7 days (±3) of age calves were placed in a small individual pen within the dam's individual pen where the calf could make tactile contact to its dam's head and neck but could not suckle (calf restricted; CR); and 3) calves were weaned permanently from their dams 7 days (±3) after birth (calf weaned; CW). Calves in the CP and CR treatments were weaned permanently when 42 days (±3) old.

Cows were fed according to NRC recommendations based on weekly individual body weights of each cow. The CP cows were fed as superior milk producers and the CR and CW cows were fed as dry second-trimester, pregnant, beef cows. Calves in the CR treatment were bottle-fed milk replacer twice daily. The cows were removed twice daily from their pens for exercise, at which time they were observed for signs of estrus. Blood was collected daily to assess changes in serum progesterone.

Results and Discussion

Postpartum intervals to first ovulation are summarized in Table 1. The postpartum interval to first ovulation was shorter (P<.01) in the CW (21.5 ± 2.4 d) than the CP treatment (42.5 ± 2.2 d). This same response was observed in previous experiments using similar treatments but mastectomized cows. The CR cows had intervals to first ovulation (29.1 ± 2.2 d) between those for CP and CR cows, but different (P<.01) from both. These results suggest that maintaining cow-calf recognition in the absence of suckling by the calf is an essential part of the mechanism that prolongs anovulation. Thus, blocking the cow's recognition of her calf might further decrease the postpartum interval to first ovulation.

Table 1. Average Intervals to First Postpartum Ovulation in Beef Cows with Either Calf Presence, Restricted Calf Presence, or No Calf

Treatment[a]	No. of Cows	Interval, d
Calves weaned (CW)	7	21.5 ± 2.4[x]
Calves restricted (CR)	8	29.1 ± 2.2[y]
Calves present (CP)	8	42.5 ± 2.2[z]

[a]At d 7 (±3) postpartum, calves were weaned from their dams (CW), restricted to head and neck contact with their dams (CR), or allowed unlimited contact with their dams (CP). Calves in CR and CP treatments were weaned at d 42 (±3) postpartum.
[xyz]Average intervals with uncommon superscript letters are different (P<.01).

EFFECT OF MONENSIN ON WEIGHT GAIN, GROWTH TRAITS, AND SEMEN CHARACTERISTICS IN YEARLING BEEF BULLS [1]

C. W. Peters, S. B. Lauder t [2], L. R. Corah, D. A. Nichols, and C. L. Krehbiel

Summary

Feeding the ionophore monensin to yearling beef bulls improved (P<.05) weight gain by 4.2%. Final hip height was similar between treatments, but bulls fed monensin had almost 1 cm greater (P<.01) scrotal circumference and more than 10 cm^2 larger (P<.01) pelvic area. Semen characteristics generally were unaffected by treatment. However, bulls fed monensin had less (P<.01) semen motility than controls. Approximately 30 sperm morphology traits were evaluated; values were similar between treatments except for those traits listed. Collection date tended to influence (P<.15) volume, concentration, motility, and postfreeze characteristics.

(Key Words: Bulls, Performance, Monensin, Semen, Ionophore, Morphology.)

Introduction

The ionophore monensin has been used widely to improve gain and feed conversion by beef cattle. The vast majority of finishing cattle and many stocker cattle are fed an ionophore to improve performance. Previous research has suggested that the onset of puberty is hastened in developing heifers fed monensin. The objective of this trial was to evaluate the impact of monensin on weight gain, growth traits, and semen characteristics in yearling beef bulls.

Experimental Procedures

Forty-four, spring-born, yearling bulls were allotted by weight, breed, sire, and birthdate and assigned randomly to each of two dietary treatments: 1) a 13.5% crude protein control supplement consisting of corn, oats, and soybean meal (CON); or 2) the control supplement plus the ionophore monensin (Rumensin®) fed at 200 mg per head per day (RUM). Each treatment group contained 15 Angus, five Hereford, and two Polled Hereford bulls. Bulls averaged 838 lb at the beginning of the trial. They were weaned approximately on September 15 and fed the control supplement and hay ad libitum until 2 weeks prior to the start of the trial (December 14). Bulls fed monensin were allowed a 4-day warm-up period with monensin fed at 100 mg per head per day. All bulls were housed in dry lot; the remainder of the diet was native prairie hay fed ad libitum.

Data collection. Averages of two weights on consecutive days at the beginning and end of the trial were used as initial and final weights. Hip heights and scrotal circumferences were measured at the beginning and end of the trial. Measures of pelvic area and breeding soundness evaluations were made at the end of the trial. Semen was collected twice during the last 3 weeks of the trial using restrained cows and an artificial vagina. Bulls whose semen was

[1]Appreciation is expressed to Kansas Artificial Breeding Service Unit, Manhattan, KS, for semen collection and evaluation and Select Sires, Inc., Plain City, OH for assessment of sperm morphology.

[2]Senior Lilly Scientist, Lilly Research Labs, 804 Anderson, Garden City, KS.

not collected successfully on the first attempt were tested again 21 days later; bulls whose semen was not collected successfully with the artificial vagina were subjected to electroejaculation. Raw semen was processed on site, and ejaculate volume, sperm motility, and sperm concentration were determined. At the Kansas Artificial Breeding Service Unit, cryopreservation was attempted with all successful collections. Semen remained frozen for 24 hours before sperm morphology was further evaluated immediately postthaw and after incubation for 2 to 4 hours.

Results and Discussion

Overall weight gain and average daily gain were greater (P=.03) for bulls fed RUM compared to CON (Table 1). At the beginning of the trial, hip height and scrotal circumference were similar between treatments. Final hip height did not differ between treatments, but measurements of scrotal circumference and pelvic area were greater (P<.01) for bulls fed RUM.

Semen collection data are presented in Table 2. Semen was collected from more (P=.06) bulls fed CON on the first attempt than from bulls fed RUM. However, no differences existed in the number from each treatment whose semen was collected successfully by artificial vagina.

The morphological abnormalities that approached significance (P<.15) are listed in Table 3. Detailed are the number of bulls from each treatment that possessed each particular abnormality. Also presented is the percentage of abnormal sperm for traits that approached significance (P<.15). No consistent differences were present between treatments. Further analysis revealed that collection date (first or second attempt) had a greater (P<.10) influence on semen characteristics than dietary treatment. Feeding RUM promoted greater weight gain and enhanced growth traits in yearling bulls, with no general effect on semen traits.

Table 1. Effect of Monensin on Weight Gain and Growth Traits in Yearling Beef Bulls

Item	Control	Monensin	SE	Significance[a]
Final wt, lb	1208	1222	8	.23
Total wt gain, lb	371	386	5	.03
Avg daily gain, lb/d	3.64	3.78	.05	.03
Initial hip height, in	46.3	46.1	.1	.39
Hip height change, in	+ 4.1	+ 4.3	.1	.12
Initial SC[b], cm	29.2	29.2	.2	.95
Final SC, cm	34.8	35.7	.2	.01
Pelvic width, cm	11.0	11.4	.1	.01
Pelvic height, cm	14.4	14.8	.1	.01
Pelvic area, cm^2	158.9	169.1	1.1	.01

[a]Probability associated with treatment effect.
[b]SC=scrotal circumference.

Table 2. Effect of Monensin on Collection and Semen Characteristics in Yearling Beef Bulls

Item	Control	Monensin	SE	Significance[a]
BSE[b]	84.6	86.8	2.9	.59
Volume, ml/ejaculate	2.69	3.11	.26	.27
Concentration, %	64.0	69.9	2.9	.16
Motility, %	45.8	34.6	3.3	.02
Collected on first date	11/22	5/22		.06
Collected by AV[c]	19/22	18/22		.68

[a]Probability associated with treatment effect.

[b]BSE=breeding soundness examination score.

[c]AV=artificial vagina.

Table 3. Effect of Monensin on Sperm Morphology in Yearling Beef Bulls

Item	Control	Monensin	SE	Significance[a]
Number of bulls producing sperm with respective abnormality				
Tapered heads	15	18		.04
Asymmetrical heads	12	12		.82
Diadem (equatorial craters)	6	2		.13
Head and tail separated	19	16		.14
Protoplasmic droplets	11	15		.09
Percentage of sperm possessing abnormality				
Tapered heads	3.27	4.89	.70	.11
Asymmetrical heads	2.42	1.50	.43	.14
Diadem (equatorial craters)	4.67	1.00	1.5	.15
Head and tail separated	4.16	5.19	.88	.42
Protoplasmic droplets	6.36	10.73	4.05	.45

[a]Probability associated with treatment effect.

AMONG-BREED ESTIMATES OF HERITABILITY FOR BIRTH WEIGHT, WEANING WEIGHT, AND MATURE COW WEIGHT

K. M. Andries, R. R. Schalles, and D. E. Franke [1]

Summary

Data from a rotational crossbreeding study was used to calculate among-breed heritabilities of birth weight (BWT), weaning weight (WWT), and mature cow weight at 5 years of age. The among-breed estimates were higher than previous within-breed estimates because of the inclusion of genetic differences between breeds. Maternal effects for BWT and WWT also were calculated. These estimates allow for comparisons among breeds and for the eventual calculation of EPDs for hybrid cattle.

(Key Words: Heritability, Birth Weight, Weaning Weight, Cow Weight.)

Introduction

The wide-scale use of crossbreeding and increased number of available breeds requires comparison between breeds. With the analysis procedures currently being used by breed associations, direct comparisons between breeds are not possible without adjusting the EPDs. The purposes of this study were to produce estimates of heritabilities and correlations among breeds and to increase the data available for use in breed comparisons. These data also will allow for the calculation of EPDs for hybrid cattle. This study is part of the NC-196 national project to study the genetics of body composition of beef cattle.

Experimental Procedure

Data collected between 1970 and 1988 at Louisiana State University, Baton Rouge, were used for the analysis of birth weight (BWT), weaning weight (WWT), and mature cow weight (COWWT) taken at 5 years of age. The data set consisted of 3936 BWT, 3611 WWT, and 627 COWWT records. The data were from generations 1 through 4 of a rotational crossbreeding study involving Angus, Brahman, Charolais, and Hereford. Straightbred and crossbred data were included in the analysis. Cows were bred by natural service to calve between January 15 and April 10. Calves were dehorned, if needed, and weighed and ear notched within 24 h of birth. All bull calves were castrated in July. Calves were weaned in the first week of October at an average age of 220 days. Cows were weighed when the calves were weaned.

Cows were wintered on Bermudagrass hay and ryegrass pastures from November through March. Bermudagrass pastures were grazed during the spring and summer. Replacement heifers were kept from within the herd and managed similarly to the cows. All bulls were purebred and purchased from bull test stations or private sales.

The models used for this analysis included contemporary group (same year of

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birth and sex) and percent heterosis for all three traits. The BWT and WWT analyses also included age of dam and a regression for birth date or age at weaning, respectively. The cow weight analysis included the production status of the cow in her fifth year (weaned a calf, calf died preweaning, or open). Maternal influences also were calculated for BWT and WWT. The pedigree information was included in an animal model.

Results and Discussion

The averages (lb) were 72.6 for BWT, 497.2 for WWT, and 1082.1 for COWWT. Heritabilities and correlations are shown in Table 1. The heritability for BWT (.87) is higher than previously reported values, primarily because the value is an among-breed rather than a within-breed estimate. Heritabilities for WWT (.48) and COWWT (.81) were high, but more similar to within-breed estimates found in the literature. The high heritabilities for all three traits indicate that change can be made through selection among as well as within breeds in all traits.

The correlations between BWT and WWT were high (genetic = .79, phenotypic = .50), indicating that both traits should be considered in selection. These correlations indicate the need to keep BWT in a range that allows for reasonable calving ease, while producing acceptable WWT. The correlations between COWWT and the other two traits were zero, which indicates that selection for acceptable early weights will not necessarily have a direct influence on mature weight of cows. We believe that rate of maturity is one factor influencing this relationship.

Maternal heritability indicates the influence of the dam's genetics on the weight of her calf, apart from the genes she passed on. For BWT, maternal heritability primarily reflects the uterine environment, whereas for WWT, it reflects milking ability. The correlation between maternal and direct BWT was -.22, indicating a compensation by the dam to reduce the BWT of calves that have a high direct genetic value for BWT. This negative correlation was present even when the percent of Brahman in the dam was included in the analysis.

The analysis included the variation between breeds as well as within breeds. This allowed for calculation of among-breed heritabilities and correlations. We expected these estimates to be higher than the within-breed estimates because of the genetic differences between breeds. These values allow for comparisons among the breeds in the study. The high correlation between direct BWT and WWT shows the need to select for moderate BWT in order to achieve acceptable WWT. The high among-breed heritability of BWT indicates that it can be controlled by selection of breeds as well as individuals within a breed. The negative correlation between direct and maternal BWT shows the importance of not relying totally on actual weight to determine genetic potential of an animal. The results of this study can be used to produce EPDs for hybrid cattle in the future.

Table 1. Heritabilities and Correlations of Weight Traits [a]

	Direct			Maternal	
Trait	Birth wt	Weaning wt	Mature wt	Birth wt[b]	Weaning wt[b]
Direct					
Birth wt	.87	.50	0		
Weaning wt	.79	.48	0		
Mature wt	0	0	.81		
Maternal					
Birth wt	-.22	0	0	.26	
Weaning wt	0	0	0	0	.18

[a]Heritabilities are underlined, genetic correlations are below heritabilities, and phenotypic correlations above.

[b]Phenotypic correlations were not calculated for maternal effects.

Heritabilities and Genetic Correlations

Direct heritabilities estimate the fraction of variation among animals caused by genes received from the parents, and range from zero to 1. The dam also provides a maternal environment, such as uterine environment and milking ability which is influenced by the dam's own genetics, separate from the genes she passes on to the offspring. The heritability of this maternal environment is referred to as maternal heritability. Direct heritabilities include a calf's own genetics for growth up to birth, expressed as birth weight heritability or growth to weaning, expressed as weaning weight heritability, etc.

Correlations indicate the relationship between two traits and can range from -1 to +l. Genetic correlations indicate the relationship between two traits caused by the same genes. For example some genes that cause rapid growth from birth to weaning also cause rapid growth from weaning to yearling. Some genetic correlations are less obvious. A correlation between maternal weaning weight and direct yearling weight would indicate that some of the genes that influence milk production also influence the individual's own growth rate.

HERITABILITIES AND GENETIC CORRELATIONS FOR BIRTH WEIGHT, WEANING WEIGHT, AND YEARLING WEIGHT IN POLLED HEREFORD CATTLE

J. B. Glaze and R. R. Schalles

Summary

Performance data from a Polled Hereford herd selected for feed conversion were used in the calculation of heritabilities and genetic correlations for birth weight (BWT), weaning weight (WWT), and yearling weight (YWT). Direct heritabilities for BWT, WWT, and YWT were .31, .16, and .25, respectively. Corresponding maternal heritabilities for BWT, WWT and YWT were .04, .01, and .18, respectively. With the exception of the correlation between WWT and YWT (.98), the other genetic correlations were low to moderate, ranging from -.27 to .12.

(Key Words: Birth Weight, Weaning Weight, Yearling Weight, Heritabilities, Genetic Correlations.)

Introduction

Traditionally, beef cattle producers have marketed their product on the basis of weight. This has led to an increased emphasis on growth traits, such as birth weight, weaning weight, and yearling weight, in selection programs. For producers to make the most of their selection programs, they must have an understanding of the genetic relationships between traits. Therefore, the purpose of this study was to estimate the heritabilities and genetic correlations of birth weight, weaning weight, and yearling weight.

Experimental Procedures

Performance data were collected on 1410 animals from a Polled Hereford herd at Kansas State University, from 1967 through 1979. This herd was assembled using animals that were donated by breeders from several states and represented a cross section of the Polled Hereford breed. Calves from the original herd were used to establish a selection herd. The original herd then was used as a nonselected control. Bulls and heifers were selected from within each herd. Two bulls were selected based on feed conversion (high conversion) and used for 2 consecutive years in the selected herd. One bull was randomly selected in the control herd and used as a herd sire for approximately 6 years.

Cows representing the selected and control herds were maintained on native pasture throughout the year and were supplemented in the winter. Cows were bred to calve in March and April, with calves being weaned in the fall at an average age of 196 days. Bull calves were placed on a performance test, which allowed for selection for feed conversion and individually fed 140 days. Heifers were group fed and were not selected on the basis of feed conversion. Cows were culled according to the following: (1) open at the end of the breeding season, (2) severe structural problems, and (3) horned. Birth weight (BWT), weaning weight (WWT), and yearling weight (YWT) records were available for analysis. The number of observations, means, and standard deviations for each trait are presented in Table 1. Subsets of this data set have been analyzed previously using paternal half-sib analysis procedures. However, with the advent of new technologies, the relationships between animals were incorporated into the analysis.

A derivative-free, restricted maximum likelihood procedure, incorporating a full numerator relationship matrix, was used to analyze the data. The mixed linear animal model included age of dam (2, 3, 4, 5-10, and >10 yr) and contemporary group (sex and year of birth) as fixed effects. Birth date, age at weaning, and age at yearling were included to regress all records to the respective mean ages. Individual animal effect, maternal effect, and permanent environmental effect were included as random effects.

Results and Discussion

Heritabilities and genetic correlations for BWT, WWT, and YWT are presented in Table 2. The direct heritability for BWT (.31) is similar to those previously reported, whereas direct heritabilities for WWT (.16) and YWT (.25) are lower than previously reported estimates. The maternal heritabilities for BWT (.04) and WWT (.01) indicate that the genetic maternal influence on these traits is small, whereas the maternal heritability for YWT (.18) indicates a moderate genetic maternal influence. The strong positive genetic correlation between WWT and YWT (.98) indicates that many of the same genes affect both traits, and may be due to the part-whole relationship of the traits. The genetic correlation (-.27) between maternal birth weight and maternal weaning weight indicates that animals having a genetic uterine environment that increases birth weight tend to have the genetics for lower milk production, and vice versa. Genetic correlations between other traits were low, ranging from -.06 to .12. Another project is currently under way to examine the direct and correlated responses due to selection for feed conversion and to estimate heritabilities and genetic correlations of additional traits.

Table 1. Number of Observations, Means, and Standard Deviations for Each Trait Analyzed

Trait	n	Mean	SD
Birth wt, lb	1369	73.25	9.63
Weaning wt, lb	1284	383.82	68.24
Yearling wt, lb	1045	715.07	145.45

Table 2. Heritabilities and Genetic Correlations [a] for Each Trait Analyzed

	Direct			Maternal		
Trait	BWT	WWT	YWT	BWT	WWT	YWT
Direct						
Birth wt	<u>.31</u>					
Weaning wt	.12	<u>.16</u>				
Yearling wt	.00	.98	<u>.25</u>			
Maternal						
Birth wt	-.03	-.02	.00	<u>.04</u>		
Weaning wt	-.06	.09	.00	-.27	<u>.01</u>	
Yearling wt	.00	.00	.00	.00	.00	<u>.18</u>

[a]Heritabilities are underlined; genetic correlations are below the heritabilities.

DECONTAMINATION OF BEEF CARCASSES AND SUBPRIMAL CUTS

C. L. Kastner, P. B. Kenney [1], R. E. Campbell, R. K. Prasai, L. E. Mease [2], L. R. Vogt [3], D. H. Kropf, D.Y.C. Fung, and C. M. Garcia Zepeda

Summary

Lactic acid sprays effectively reduce the microbial load on both carcasses and subprimal cuts. Lactic acid decontamination of subprimals appears to carry through to retail cuts during display. Because of recontamination during fabrication, treating subprimals may be more effective than treating carcasses. This information will allow us to identify the most critical control points at which to employ decontamination practices designed to reduce the incidence of pathogenic bacteria and extend shelf life.

(Key Words: Microbiology, Decontamination, Carcass, Subprimal.)

Introduction

This report summarizes our Food Safety Consortium results and integrates previous research, current industry practices, and efficacy of decontamination practices at various critical control points (process step that leads to unacceptable microbial contamination if not properly controlled). We have completed a series of integrated studies in an attempt to identify the most critical and effective intervention points and technologies for controlling microbial contamination and assuring food safety.

To maximize safety and extend shelf life of meat and meat products, the meat industry and the Food Safety and Inspection Service (FSIS) strive to minimize carcass contamination during slaughter and subsequent processing. However, microbial contamination during slaughter cannot be avoided completely.

In addition to good manufacturing practices designed to minimize contamination and trimming of contaminated areas, spraying carcasses with hot water and sanitizers has been employed to reduce contamination. Although spraying/rinsing techniques have reduced microbial counts on carcasses, their effect does not necessarily carry over to resultant subprimal and retail cuts, trim used for further processing, and meat byproducts. The efficacy of trimming contaminated areas needs additional investigation. The industry and FSIS have worked together to supplement traditional carcass decontamination efforts with organic (lactic or acetic) acid rinsing because of its effectiveness for carcass decontamination.

Because industry and FSIS were evaluating pre-evisceration organic acid rinsing, our initial studies evaluated rinsing carcasses with sanitizers at other control points. We decided to rinse carcasses immediately after rail inspection and/or after spray chilling. Carcass rinsing was effective in decreasing

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microbial counts on the carcass, but it did not carry through to resultant subprimal and retail cuts, so we also rinsed subprimal cuts before vacuum storage.

Experimental Procedures and Results and Discussion

We evaluated microbiological quality of carcasses as affected by sprays of water (W), 200 ppm chlorine (C), and 3% lactic acid (L) applied immediately after rail inspection and again following 8 h spray-chill cycle in nine different combinations (W+W, C+W, L+W, W+C, C+C, L+C, W+L, C+L, and L+L). Samples for microbial counts were taken just before and just after spray treatments that followed rail inspection, spray chilling, and 3 days of aging. Six subprimals from each treated carcass were assigned randomly to the following treatments: 1) vacuum packaged (VP); 2) sprayed with C and VP (C+VP); 3) VP and microwaved (VP+MW); 4) inoculated with pathogens (*Listeria monocytogenes, Salmonella enteritidis, Escherichia coli* 0157:H7, and *Yersinia entercolitica*) and VP (P+VP); 5) P+C+VP; and 6) P+VP+MW). All products were stored at 34°F and sampled for aerobic plate counts (APCs) and/or pathogen at 4, 10, 15, 20, 30, 60, 90, and 120 days of vacuum storage.

All treatment combinations involving either chlorine or lactic acid reduced carcass contamination. The decrease in mean $\log_{10}$ APCs ranged from 0.4 to 1.8. A 1 log decrease is a 90% reduction, and a 2 log decrease equals a 99% reduction. The L+L treatment combination showed the greatest reduction. Also, most treatment combinations involving lactic acid tended to decontaminate better than those without acid (Figure 1). However, carcass decontamination did not carry over to subprimal cuts (Figure 2). Additionally, treating subprimal cuts did not effectively reduce APCs during extended storage (Figure 3). Maximum growth (6.0-7.0 $\log_{10}$ colony forming units, CFUs/cm^2) was reached at 60 days and did not change during the remainder of storage.

Following pathogen inoculation, *Salmonella* did not grow; *Listeria* increased gradually from 10 to 60 days, then declined from 60 to 120 days. *Yersinia* and *Escherichia* counts were not affected consistently by treatment.

Treating subprimal cuts with chlorine was not effective. Because lactic acid was effective on carcasses, we tested it on subprimal cuts and evaluated the carryover to retail cuts during display. That study involved spraying 1.5% lactic acid solution (v/v) on beef strip loins A) immediately before vacuum packaging, B) immediately after opening the vacuum bag at the end of storage, C) before vacuum packaging and again at the end of storage, and D) before vacuum packaging, with a water rinse at the end of storage. Loins were evaluated at once or stored for 14, 28, 56, 84, or 126 days. Two different storage temperatures (30 and 36°F) were used. Microbiological analyses (total aerobic plate count and presence or absence of *Salmonella* and *Listeria*) were conducted, and the overall appearance of strip loins was evaluated after the specified storage times.

We found:

1) Acid-treated loins had lower counts than nonacid-treated loins.
2) Spraying loins with lactic acid prior to vacuum packaging was more effective than spraying with acid at the end of storage.
3) Storage at 30°F was more effective than storage at 36°F.
4) Proper temperature control was at least as effective as acid treatment.

Retail cuts from the subprimals were also evaluated. Upon removal of the subprimals from storage, 1 inch-thick steaks were cut from each loin. They were packaged in oxygen-permeable polyvinylchloride film and evaluated immediately and after display at 36 ± 3°F under 100 foot candles of Warm White Deluxe fluorescent lighting for 3 or 5 days.

Lactic acid applied to strip loins both pre- and poststorage, and lactic acid applied prestorage with water sprays after 84 days of storage at 30°F yielded up to 2 log (99%) reductions in APCs of steaks not displayed or displayed for 3 days and >l.0 log (90%) reductions at 5 days of display. Lactic acid treatment pre- and post- 30°F-storage increased the length of the lag phase of microbial growth, thus increasing display life. Lactic acid was most effective at the colder (30 vs. 36°F) storage temperature. *L. monocytogenes* and *Salmonella* spp. were absent from all steaks.

On the basis of color, subprimal storage and/or display life were slightly shorter for lactic acid treated cuts than for controls. However, on the basis of bacterial counts, lactic acid sprays applied to strip loins resulted in longer storage life and/or steak display life. Preliminary data indicate similar results for companion vacuum-packaged retail cuts that were displayed for up to 14 d. However, the magnitude of the microbial reduction from acid treatment of the subprimal was less.

Lactic acid treatment of subprimal cuts appears to carry through to retail cuts during display and is more effective than treating carcasses, especially when retail cuts are packaged in oxygen-permeable film. Good temperature control enhanced the carryover effectiveness of lactic acid treatment at the subprimal level.

Details of the preceding studies are presented in the next two reports.

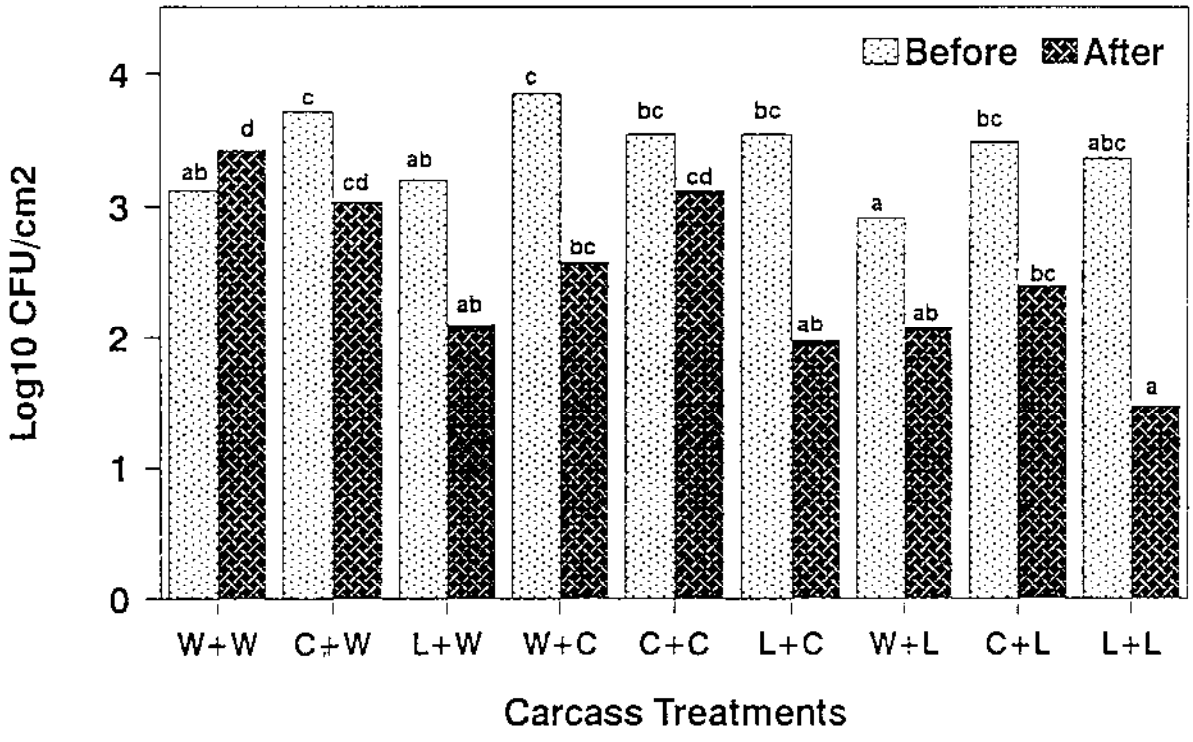

Figure 1. Effect of Water (W), Chlorine (C), and Lactic Acid (L), either Alone or in Combination, on Mean Carcass Aerobic Plate Counts. Means of before and after Treatment Groups with Same Letter Are Not Different (P>. 05).

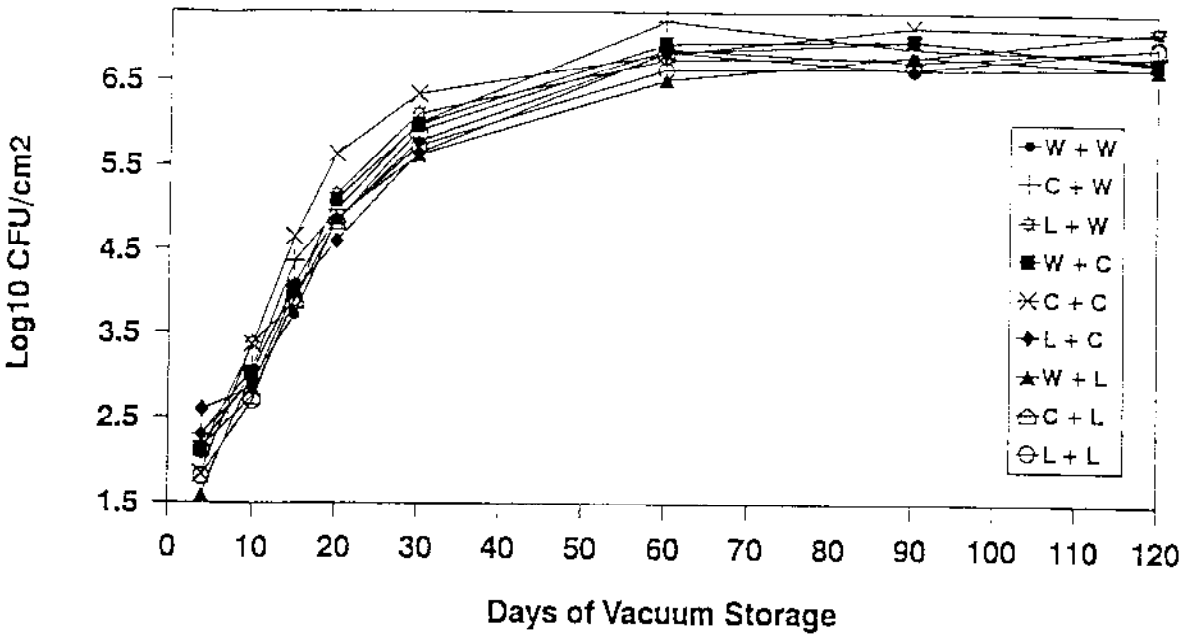

Figure 2. Aerobic Plate Counts of Subprimal Cuts as Affected by Length of Storage and Carcass Treatment (W=Water, C=Chlorine, and L=Lactic Acid).

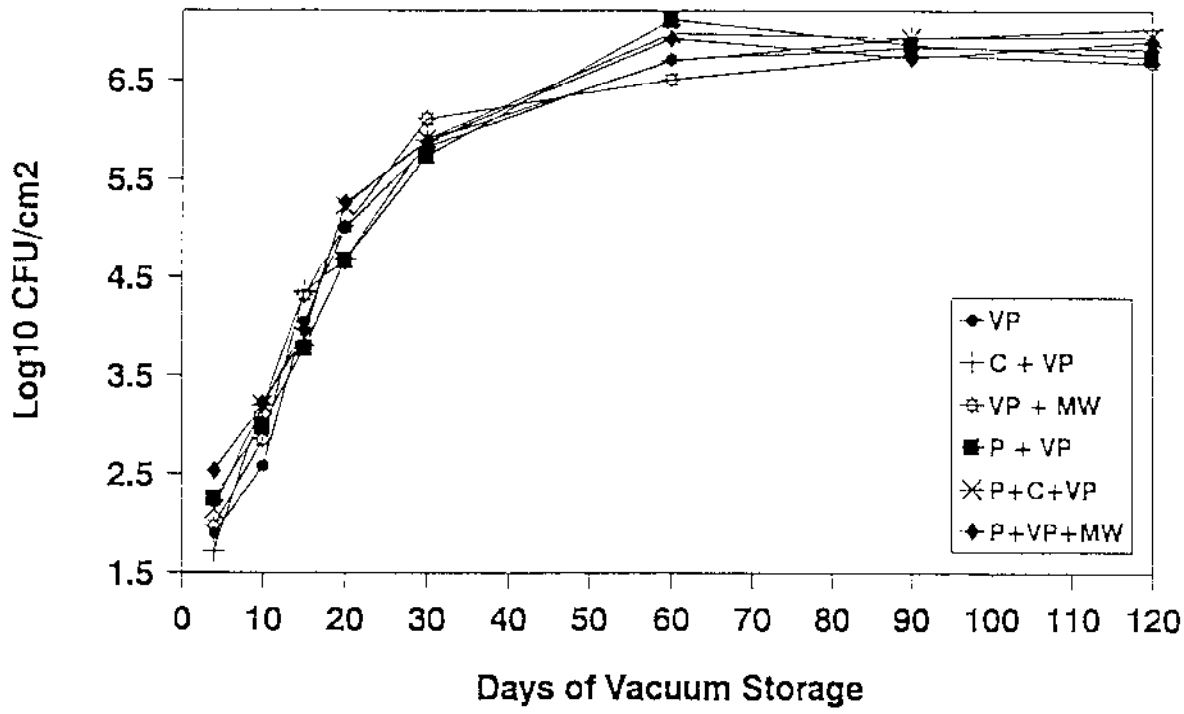

Figure 3. Aerobic Plate Counts of Subprimal Cuts as Affected by Length of Storage and Subprimal Treatment (VP=Vacuum Packaged, C=200 ppm Chlorine Spray, MW=Microwaved, and P=Pathogen Added).

EFFECT OF LACTIC ACID SPRAYS ON SHELF LIFE AND MICROBIOLOGICAL SAFETY OF BEEF SUBPRIMALS

R. K. Prasai, L. E. Meas e[1], L. R. Vogt[2], D. H. Kropf, D.Y.C. Fung, and C. L. Kastner

Summary

Beef loins were sprayed with 1.5% lactic acid either before or after vacuum storage, both before and after vacuum storage, and before vacuum packaging followed by a water spray after storage. We stored treated loins at either 30°F or 36°F for up to 126 days in vacuum packages. Nonsprayed or nonstored loins served as controls. Total aerobic plate counts (APCs) and tests for presence/absence of two importa nt foodborne pathogens, *Salmonella* spp. and *Listeria monocytogenes*, were conducted during storage. Acid spraying prior to vacuum packaging was more effective in reducing bacterial contamination than spraying after storage. However, counts were reduced ($P<.05$) for only 28 days of storage. Most loins stored at 30°F had lower APCs than those stored at 36°F. *Salmonella* was not detected in any samples. Twenty-eight percent of nonacid treated and 4 percent of acid-treated loins were positive for *Listeria* spp. with *L. monocytogenes* found from one nonacid-treated loin. No change in visual color was observed in acid-treated loins. Appropriate timing of acid s praying in combination with lower storage temperature can improve the keeping quality and microbial safety of meat.

(Key Words: Lactic Acid, Beef, Bacteria, Safety.)

Introduction

Initial numbers and types of microorganisms and storage temperature are major factors determining the s helf life and safety of meat. According to USDA, the annual cost of foodborne illness in the U.S ranges from $5.2 to $6.1 billion with $3.9 to $4.3 billion attributable to meat and poultry products. Organic (lactic and acetic) acid sprays effectively reduce microbial contamination of carcasses but have little or no effect in improving the microbiological quality of resultant fabricated cuts. Secondary contamination can occur during fabrication and mask effects of lactic acid decontamination. This study determine d if the microbiological quality of meat can be improved by spraying lactic acid directly on subprimal cuts rather than on carcasses.

Experimental Procedures

A total of 36 strip loins in each of three replicates were taken from a commercial processing line. Each loin re c eived two treatments, one for each half loin strip. Each replicate was treated as follows: I). Twelve loins were vacuum packaged and stored at 30°F (6 loins) or 36°F (6 loins) for 14, 28, 56, 84, or 126 days or not stored (0 days). On each specified day, a 1.5% lactic acid solution (approx. 725 ml per loin) was sprayed on one half of eac h loin as a second treatment. II). Another group of 12 loins was sprayed with acid solution prior to vacuum packagin g followed by storage and a

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second treatment with acid in the same manner as described in I. III). The last group of 12 loins was treated the same way as in II, except that the second treatment applied to the other half of each loin was water spray instead of acid. These three treatment groups yielded these different treatment combinations: vacuum packaged control (C), acid treatment only after vacuum storage (0-A), acid treatment before vacuum storage (A-0), acid treatment before and after vacuum storage (A-A), and acid treatment before storage and sprayed with water after storage (A-W).

On prespecified days of storage (0, 14, 28, 56, 84, and 126 days), one strip loin from each treatment group and storage temperature was selected randomly and one half of that loin was cored (surface) for microbiological analysis. The other half of the loin received a second treatment (either acid, or water spray) and was then sampled.

Microbiological samples obtained from two halves of each loin were analyzed separately for total aerobic plate count (APC) and for the presence or absence of *Salmonella* spp. and *Listeria monocytogenes*.

Results and Discussions

Mean (log_{10}/cm^2) APCs of subprimals as affected by treatments, storage temperatures, and length of storage are summarized in Table 1. Acid spray on loins prior to vacuum packaging (A-0) reduced bacterial contamination with counts being lower than those of controls (C) for all storage periods. The average reductions in mean log_{10} APCs ranged from .4 to 1.9 (1 log equals 90% reduction, 2 log equals 99% reduction), with the initial mean log_{10} APC in control loins ranging from 3.1 to 7.3.

Microbial reduction by acid spray generally was successful for loins stored for up to 28 days. After 28 days, few differences occurred between any of the treatments and controls. Loins treated with acid after storage (0-A) had microbial counts most similar to those of controls, indicating that acid application after storage was less useful than acid applied before storage. Generally, the mean reduction in APC of AW or A-A loins was slightly greater than that of A-0 loins.

Although not significant (P>.05), almost all loins stored at 30°F had numerically lower counts than those stored at 36°F, indicating the role of storage temperature as a major hurdle to control outgrowth of microorganisms. *Salmonella* was not detected in any samples. Twenty-eight percent of nonacid-treated and 4 percent of acid-treated loins were positive for *Listeria* spp., with *L. monocytogenes* found from one non-acid treated loin. We saw no change in visual color with acid treatment.

Appropriate time of application of acid at the subprimal level in combination with lower temperature of storage can improve the safety and shelf life of meat.

Table 1. Mean[a] Aerobic Plate Counts (lo g_{10}/cm^2) of Control and Acid-Treated Beef Subprimals Stored in Vacuum Packages at 30 and 3 6°F for up to 26 Days

Sampling Time (days)	Storage Temp. (°F)	Treatments[b]					
		C	0-A	A-0	A-W	A-0	A-A
0	30	3.12[c]	2.07	2.50[c]	2.02[c]	1.92	2.36[c]
	36	3.09[c]	2.80[c]	2.16[c]	1.89	2.42[c]	2.20[c]
14	30	3.46[c]	3.40[c]	2.50[c]	2.26	2.23	2.16
	36	4.30[c]	4.16[c]	3.26[c]	2.26	2.35	2.10
28	30	4.20[c]	4.26[c]	2.36	2.83[c]	2.26	1.96
	36	4.76[c]	5.41[c]	3.06	2.34	3.50	3.66[c]
56	30	5.10[c]	5.60[c]	4.80[c]	5.13[c]	4.35[c]	4.83[c]
	36	6.16[c]	5.29	5.63[c]	5.42[c]	5.92[c]	5.89[c]
84	30	6.16[c]	6.22[c]	4.94[c]	4.56	5.48[c]	4.95
	36	7.25[c]	6.66[c]	6.77[c]	5.90	6.39[c]	5.65
126	30	6.59[c]	5.98[c]	5.69[c]	5.50[c]	5.72[c]	5.48[c]
	36	7.20[c]	7.08[c]	6.56[c]	6.22[c]	7.16[c]	6.65[c]

[a]Individual means in each treatment are based on three samples from three loin halves in three replicate experiments. Each sample was taken from four different locations (two per side) of a loin half and then combined.

[b]C = no treatment (Control); 0-A = acid sprayed after vacuum storage; A-0 = acid sprayed before vacuum packaging; A-W = acid sprayed before vacuum packaging followed by water spray after storage; A-A = acid sprayed before and after vacuum storage.

[c]Means within a row with same superscript as C are not different (P>.05) from control.

POLYVINYLCHLORIDE-PACKAGED LOIN STRIP STEAKS FROM VACUUM-PACKAGED BEEF STRIP LOINS DECONTAMINATED WITH LACTIC ACID AND STORED FOR UP TO 126 DAYS

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Summary

Aerobic plate counts (APCs), presence/absence of *Listeria monocytogenes* and *Salmonella* spp., and visual color evaluations were used to determine the microbiological and display quality of steaks fabricated from beef strip loins sprayed with lactic acid (1.5% v/v) or water before, after, or both before and after vacuum storage (14, 28, 56, 84, or 126 days) at either 30° or 36°F compared to nonsprayed or nonstored controls. Lactic acid applied pre- and poststorage (126 days) at 30°F reduced APCs of steaks up to 2 log (99%). *L. monocytogenes* and *Salmonella* spp. were absent from all steaks. Lactic acid caused slightly more rapid color deterioration, resulting in slightly shorter display-life for steaks.

(Key Words: Decontamination, Lactic Acid, Beef Steaks, Display, Color, Bacteria.)

Introduction

Contamination of beef during slaughter and processing is inevitable. In addition to affecting food safety, high numbers of bacteria can degrade sensory qualities of retail beef. Organic acids, such as lactic and acetic acids, reduce microbial loads when sprayed on carcasses. However, microbial reductions from spraying acid on carcasses do not carry through to fabricated subprimal cuts. Therefore, treatment of subprimals may be more effective than treating carcasses.

The objectives of this study were to determine the effects of lactic acid or water sprays applied to vacuum-stored beef strip loins at different points during processing and effects of temperature of strip loin storage on microbiological and display quality of retail steaks.

Experimental Procedures

A total of 36 strip loins in each of three replicates were taken from a commercial processing line. Each loin had two treatments, one for each half loin strip. Each replicate was treated as follows: I). Twelve loins were vacuum packaged and stored at 30°F (6 loins) or 36°F (6 loins) for 14, 28, 56, 84, or 126 days or not stored (0 days). On each specified day, a 1.5% lactic acid solution (approx. 725 ml per loin) was sprayed on one half of each loin as a second treatment. II). Another group of 12 loins was sprayed with acid solution prior to vacuum packaging followed by storage and a second treatment with acid in the same manner as described in I. III). The last group of 12 loins was treated the same way as in II except that the second treatment applied to the other half of each loin was sprayed with water instead of acid. These three treatment groups yielded these different treatment combinations: vacuum packaged control (C), acid treatment only after vacuum

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storage (0-A), acid treatment before vacuum storage (A-0), acid treatment before and after vacuum storage (A-A), and acid treatment before storage and sprayed with water after storage (A-W).

An 8.5 liter hand-held sprayer was used to apply lactic acid (1.5% v/v, pH 2.4) and water sprays at a rate of 725 ml/min for 1 min (30 sec per side).

Strip loins were vacuum packaged in B-620 oxygen-barrier shrink bags (oxygen transmission rate 30-50 ml/m^2/24 h/atm at 73°F; water vapor transmission rate .5 to .6 g/100 in^2/24 hr in 100% relative humidity at 100°F) using a Cryovac 8300 series packaging machine at the processor location.

On the specified day of storage (0, 14, 28, 56, 84, or 126 days), a strip loin from each treatment pair was selected randomly from each storage-temperature treatment and processed in a refrigerated (48±2°F) fabrication room. The vacuum bag was opened with a sterile scalpel, and the strip loin was "faced" by removing a steak of sufficient thickness. Strip loins and steaks were handled aseptically.

The three steaks fabricated, 1 in. thick from each loin half, were assigned to one of three retail display periods (0, 3, and 5 days). Steaks were placed individually on an absorbent pad in a styrofoam tray and overwrapped with polyvinylchloride (PVC) film (high oxygen permeability) as used in retail meat counters. Steaks were displayed in open-top retail cases at 36°F under continuous 100-foot candle Warm White Deluxe fluorescent lighting.

On the specified day, steaks were sampled for microbiological analysis. Aerobic plate counts (APCs) were obtained by pour plate and/or spiral plate methods from two cores per steak. A modified USDA-FSIS procedure for isolation and identification of *Listeria monocytogenes* was followed. We also tested for the presence of *Salmonella*.

Color measurements and evaluations were conducted only on the loin eye muscle of steaks assigned to 5-day retail display. On days 0 (before exposure to light), 3, and 5 of display, a seven-member experienced panel visually scored "average" and "worst point" color to .5 point increments on a 5-point scale.

Results and Discussion

Data from day 3 of display are reported and best show the results. Microbial APCs were influenced by storage time, temperature, and their interaction. The lower temperature (30°F) resulted in lower counts, especially for steaks from cuts vacuum-stored for 28 days and longer, because of an extended lag growth phase through 28 days of storage. Storage for 56 days resulted in higher numbers of microbes than for 28 days (Figure 1).

Treatment also affected APCs, especially at 28 days for steaks from loins treated with lactic acid before vacuum packaging. Microbial reductions of 2 logs (99%) were shown for the most effective treatments. No microbial counts for steaks displayed for 3 days were unreasonably high. No *Listeria monocytogenes* or *Salmonella* were detected on steaks, even after 5 dats of display.

Average color score was affected primarily by storage time (Figure 2), because steaks from longer stored subprimal cuts were more discolored (higher score). A color score of 3.5 or higher is considered marginally unacceptable. At the higher storage temperature, the average color score for treatments exceeded this point after storage for 126 days. After vacuum storage for 14 and 28 days, steaks from loins treated with lactic acid were slightly darker in appearance. Instrumental color readings confirmed visual evaluations.

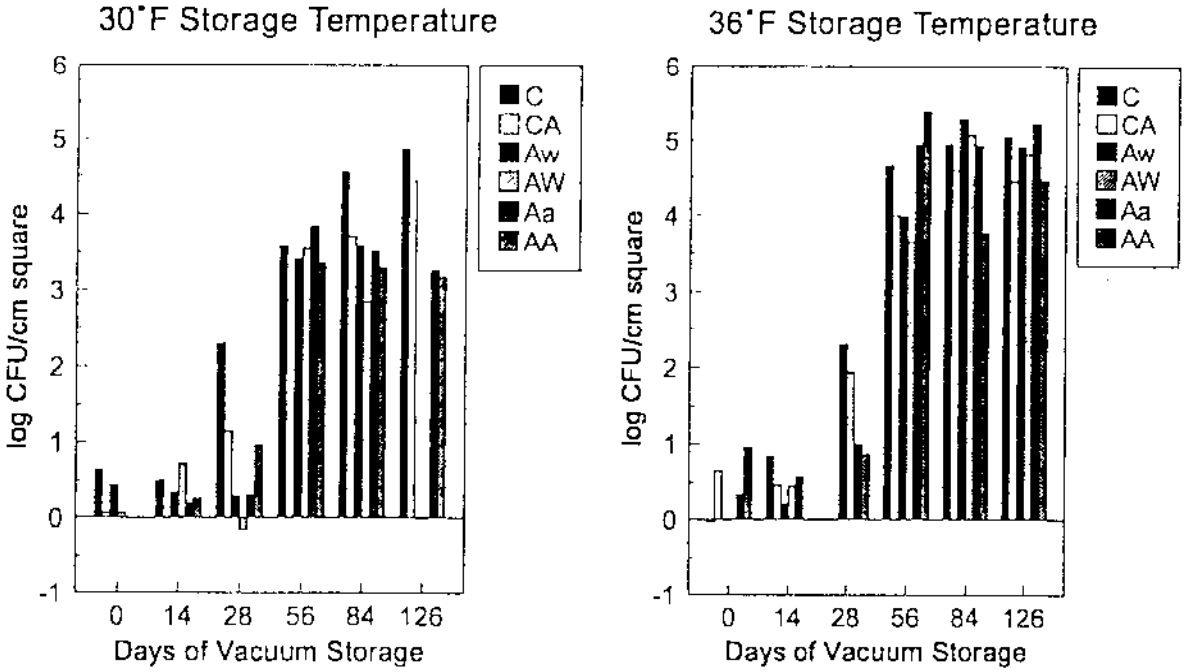

Figure 1. Aerobic Plate Counts of PVC-Packaged Steaks at 3 Days. of Retail Display.

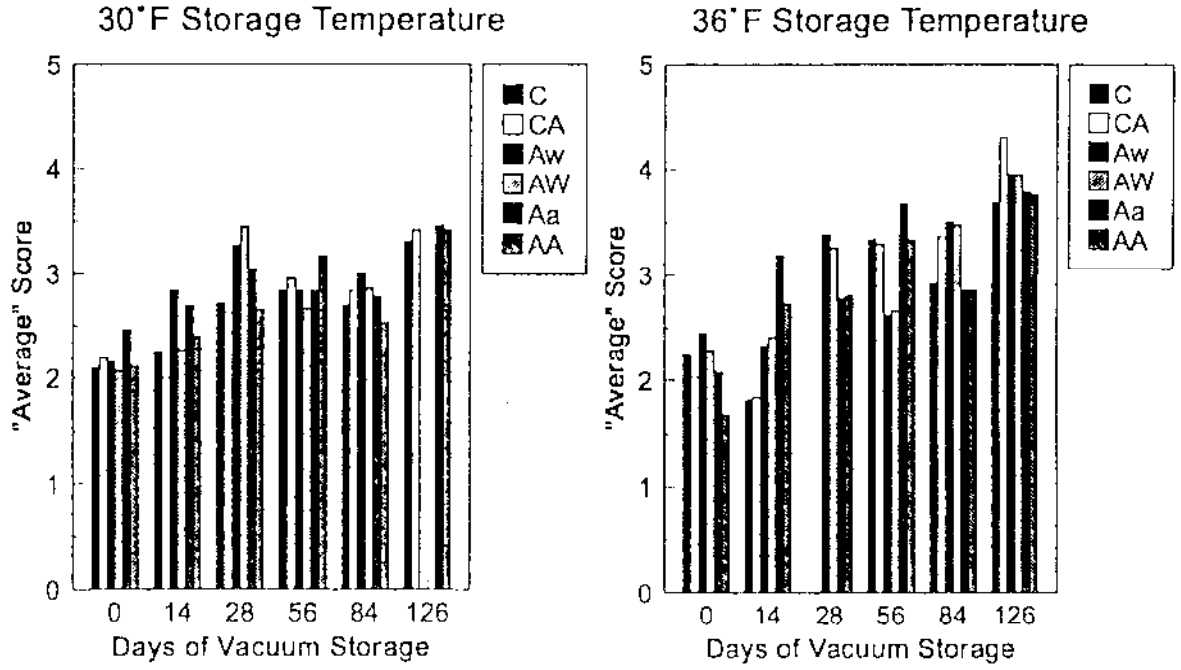

Figure 2. Average Visual Color Score [a] of PVC-Packaged Steaks at 3 Days of Retail Display. [a] 1=Bright Red, 2=Dull Red, 3=Slightl y Dark Red or Brown, 4=Dark Red or Brown, and 5=Very Dark Red or Brown.

USE OF OXYRASE® ENZYME TO ENHANCE RECOVERY OF *ESCHERICHIA COLI* O157:H7 FROM CULTURE MEDIA AND GROUND BEEF

R. K. Phebus, H. Thippareddi, K. Kone, D.Y.C. Fung, and C. L. Kastner

Summary

Escherichia coli O157:H7 is a bacterium that has caused great concern in the meat and food industry during the last few years because of several, well-publicized, disease outbreaks, including the incident at the Jack-in-the-Box fast food chain in Seattle, Washington. The organism can cause severe sickness and even death in certain population groups. To better assure meat safety, federal meat inspection is focusing on developing rapid methods to detect this disease agent and others. Oxyrase is a commercially available enzyme that can accelerate the growth of some bacteria. Current techniques for isolation and culturing of *E. coli* O157:H7 from foods require an enrichment period of 18 to 24 hours, thus limiting their usefulness for perishable foods that are marketed quickly. Our investigation found that Oxyrase shortened required enrichment periods in broth culture only. The enzyme was less effective in sterilized ground beef.

(Key Words: *Escherichia coli* O157:H7, Oxyrase, Ground Beef, Rapid Methodology, Meat Safety.)

Introduction

The January 1993 food poisoning outbreak in the northwestern United States resulting from eating undercooked ground beef contaminated with *Escherichia coli* O157:H7 has focused attention on the need for rapid methods for detecting meat-borne human pathogens. The Food Safety and Inspection Service of the Department of Agriculture is examining procedures to rapidly identify fresh meat and meat products harboring pathogenic (disease-causing) microorganisms. A scientifically based inspection system utilizing microbial testing to support current visual inspection is likely to result. Such a system will mandate improving existing microbiological procedures and developing better ones for detection of various food-borne pathogens. These tests need to be rapid, economical, sensitive, accurate, and simple.

Escherichia coli O157:H7 was identified as a human pathogen in 1982. Several food-related illness outbreaks have been attributed to this microorganism over the last decade. Many have been linked to consumption of under-cooked contaminated ground beef. Symptoms of infection include hemorrhagic colitis (bloody diarrhea) and hemolytic uremic syndrome (severe kidney failure); these manifestations often lead to lifelong disability or death. A limited number of surveys have indicated that about 4% of fresh, retail, ground beef is contaminated with *E. coli* O157:H7. However, because the organism is difficult to recover from foods, the incidence may be higher. Several screening methods for the isolation and/or enumeration of *E. coli* O157:H7 have been developed. Most are too complex and time-consuming to be useful in meat inspection. *E. coli* O157:H7 is usually present in foods in low numbers and is accompanied by competitive microbial populations, including other *E. coli* strains requiring differentiation. These factors mandate selective enrichment procedures that allow *E. coli* O157:H7 cells to repair injuries and grow to high enough numbers for detection, normally extending testing times by 18 to 24 hours. Techniques to reduce the time for enrichment, during which

very low numbers of *E. coli* O157:H7 are increased to detectable levels, are needed in regulatory detection of this pathogen.

Oxyrase enzyme derived from ruptured *E. coli* cells speeds up growth of several bacterial groups by removing oxygen from the growth medium. Several studies at Kansas State University have demonstrated that Oxyrase increases growth rates of certain bacteria, especially those found in the digestive tract of animals (i.e., *E. coli*, *Salmonella*, and *Campylobacter*). We undertook this study to evaluate incorporating Oxyrase into an enrichment medium designed to speed up the recovery of low levels of *E. coli* O157:H7 from culture media and sterile ground beef.

Experimental Procedures

We worked with four strains of *E. coli*, both O157 and non-O157 serotypes, isolated from meats or humans. Brain Heart Infusion (BHI) broth was used as an enrichment medium for all experiments. After specified enrichment periods, McConkey Sorbitol Agar (MSA) was used as a selective plating medium to isolate and count *E. coli* strains. In Experiment 1, flasks containing BHI broth with (*oxy* +) or without (*oxy* –) 0.1 unit/ml of Oxyrase were inoculated with approximately 1 *E. coli*/ml of broth. After inoculation, flasks were incubated in a 37°C water bath and sampled hourly from 0 to 10 h and after 12, 14 and 24 h by plating on MSA. Differences in *E. coli* growth rates in *oxy* + and *oxy* – BHI broth were determined. In Experiment 2, 10 sterile ground beef samples were prepared and placed into sterile plastic bags. BHI broth was added, and samples were mixed for 2 min in a lab blender. Oxyrase (0.1 unit/ml) was added to five of the samples (*oxy +)*. One *E. coli* O157:H7 strain (B) and one non-O157 strain (D) were investigated; strain B at initial levels of 1, 10 and 100 cells/g and strain D at 10 cells/g of meat. Samples were incubated in bags at 37°C, and *E. coli* counts performed hourly from 0 to 12 h and at 14, 16, 18, and 24 h.

Results and Discussion

Oxyrase increased the growth rate for all three pathogenic *E. coli* strains tested in BHI broth, when they were initially present at <1 cell/ml. However, we noticed some variation in the way different strains responded to Oxyrase supplementation. Where differences were noted, they resulted from a shortening of the lag phase (initial stage of growth) of the organisms. However, with nonpathogenic strain D, Oxyrase suppressed growth during the initial 4 h (Figure 1). Strain D numbers increased rapidly in *oxy* - broth during this period. This suppressive effect was overcome by the sampling at 5 h. This observation might be important in developing methods to specifically detect pathogenic strains of *E. coli*.

When pathogenic *E. coli* strain B was inoculated into sterilized meat, no enhancement in growth of the organism occurred. The level of Oxyrase may need to be greater than the 0.1 unit/ml we used, because of possible inhibitory effects of meat on the enzyme. Secondly, autoclaving ground beef to achieve sterility may reduce dissolved oxygen in the samples enough to nullify the benefits of Oxyrase. The use of cooked meat medium for cultivating anaerobic bacteria supports this hypothesis.

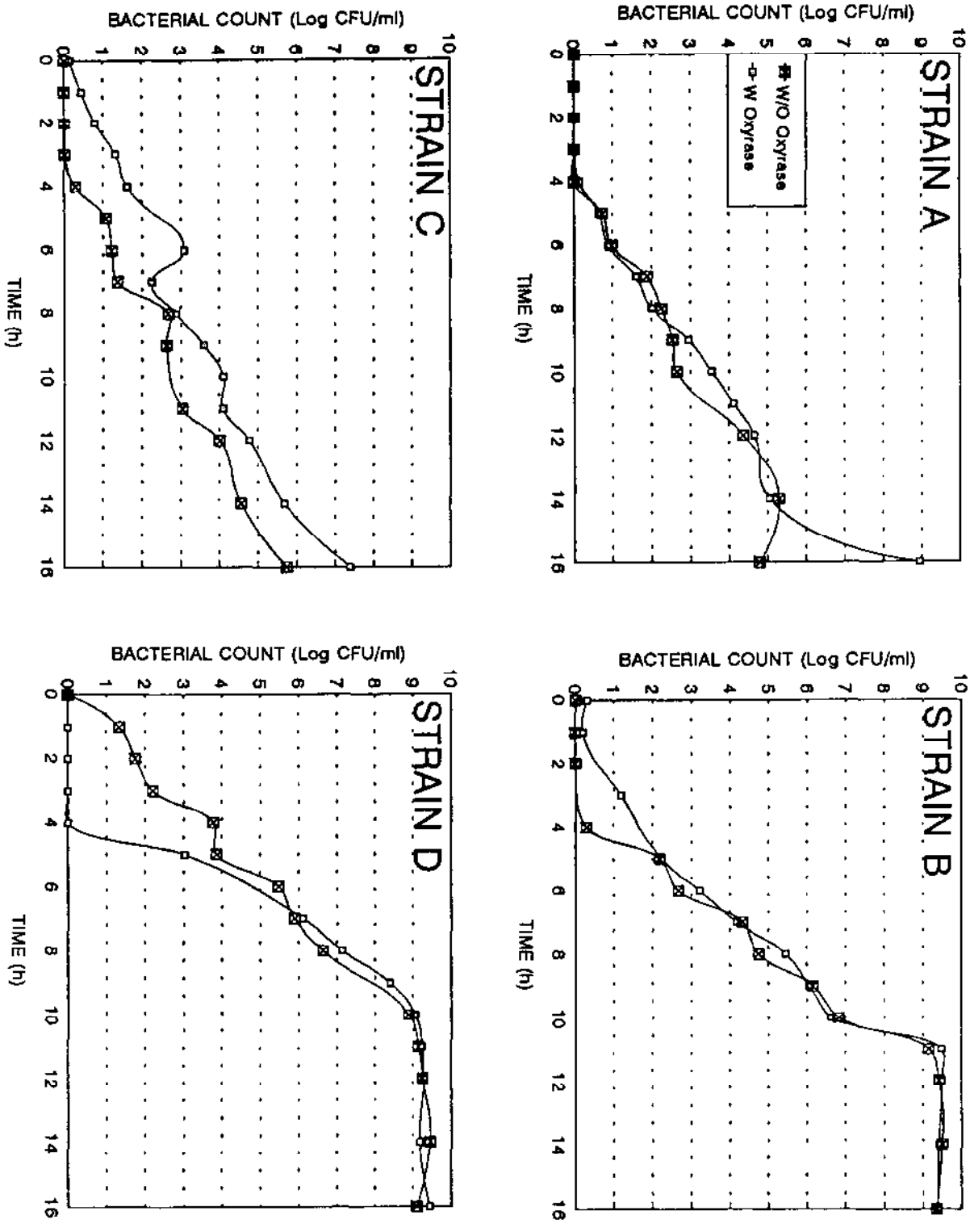

Figure 1. Effect of Oxyrase™ on the Growth of *E. coli* Strains Inoculated at 1 CFU/mL into BHI Broth at 37°C

BREED EFFECTS AND RETAINED HETEROSIS FOR GROWTH, CARCASS, AND MEAT TRAITS IN ADVANCED GENERATIONS OF COMPOSITE POPULATIONS OF BEEF CATTLE[1]

M. E. Dikeman K. E. Gregory[2], L. V. Cundiff[2], R. M. Koch[3], and M. Koohmaraie

Summary

Retained heterosis for growth, carcass, and meat traits was estimated in F_3 generation steer progeny in three composite populations finished on two levels of dietary energy density (2.82 MCal ME and 3.07 MCal ME, and 11.5 % CP) and serially slaughtered at four endpoints at intervals of 20 to 22 days. Breed effects were evaluated in the nine parental breeds of Red Poll (RP), Hereford (H), Angus (A), Limousin (L), Braunvieh (B), Pinzgauer (P), Gelbvieh (G) , Simmental (S), and Charolais (C) that contributed to the three 'composite' populations. MARC-I was l/4 B, l/4 C, l/4 L, l/8 H, and l/8 A; MARC-II was l/4 G, l/4 S, l/4 H, and l/4 A; and MARC-III was l/4 RP, l/4 P, l/4 H, and l/4 A.

Breed effects were important for growth traits; carcass traits; and retail product, fat trim and bone percentages, and weights. Even though mean slaughter weight was 126.6 lb heavier for Simmental, Gelbvieh and Charolais breeds, they did not differ from Limousins in retail product weight because of their lower dressing percentages, higher fat trim percentages, and higher bone percentages. The effects of dietary energy density were important for most traits, and little interaction occurred between breed group and dietary energy density. The MARC-III composite had lighter final and carcass weights, a lower percentage of retail product, a higher percentage of fat trim, and a higher percentage of ribeye fat than the MARC-I composite, with the MARC-II composite being generally intermediate. Retained heterosis generally was significant for each composite population and for the mean of the three composite populations for weight of retail product, fat trim, and bone. For percentage of retail product and fat trim, MARC-II and MARC-III composites had a lower percentage of retail product and a higher percentage of fat trim than the mean of the contributing breeds. Composite populations or breeds provide an opportunity to use breed differences to achieve and maintain optimum additive genetic composition for carcass composition traits and to use heterosis to increase lean tissue growth rate and(or) to increase rate of fat deposition.

Introduction

Fluctuation in breed composition between generations in rotational crossbreed-

[1]This article was derived from a research paper accepted for publication in the Journal of Animal Science. These data are from the Germ Plasm Utilization project that was conducted under the leadership of Dr. Keith E. Gregory at the Roman L. Hruska U.S. Meat Animal Research Center, Clay Center, NE. Michael E. Dikeman is a collaborator on the carcass retail product data collection.

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ing systems can result in considerable variation among both cows and calves in level of performance for major bioeconomic traits, unless breeds used in the rotation are similar in performance. Using breeds with similar performance characteristics restricts the use of breed differences to meet requirements for specific production and marketing situations. This report focuses on breed differences in growth, carcass, and meat traits and the potential of 'composite' breeds as alternatives to crossbreeds for using heterosis and genetic differences among breeds to achieve and maintain a more optimum additive genetic (breed) composition.

Experimental Procedures

Matings were made to establish three composite populations: MARC-I (l/4 Braunvieh, l/4 Charolais, l/4 Limousin, l/8 Hereford, and l/8 Angus); MARC-II (l/4 Gelbvieh, l/4 Simmental, l/4 Hereford, and l/4 Angus); and MARC-III (l/4 Red Poll, l/4 Pinzgauer, l/4 Hereford, and l/4 Angus). F_1 is defined as the first generation that reflects the final breed composition of a composite population; F_1, F_2, and F_3 generations were mated among themselves to produce, respectively, F_2, F_3, and F_4 generation progeny. Composite populations were formed from the same sires and dams represented in the nine contributing parental breeds (Table 1).

The 1,661 steers included in this study were unselected male progeny of 21 Red Poll, 22 Hereford, 23 Angus, 24 Limousin, 26 Braunvieh, 27 Pinzgauer, 27 Gelbvieh, 19 Simmental, 25 Charolais, 39 MARC-I, 30 MARC-II, and 24 MARC-III sires. Calves were born in 1988, 1989, 1990, and 1991. Mean birth date was April 13. Because of drought in 1988, calves were weaned at an average age of 127 days vs. about 150 days for other years. Weaned calves were started on a diet of 2.65 MCal ME/kg of dry matter and 15.4 % crude protein, which was changed gradually to a backgrounding diet that was 2.69 MCal ME/kg of dry matter and 12.88% crude protein. At an average age of 203 days over the 4 years, animals of each breed group were weighed and randomly assigned to treatment, stratified by weight. Prior to assigning animals to treatment, seven to nine males in each breed group were identified as candidate replacement sires to represent a broad pedigree base. They were near the mean weights of their respective breed groups. All except candidate replacement sires were castrated. Two finishing diets were fed to each year-breed-group-subclass. Both were 11.5% crude protein. One diet had 2.82 MCal ME/kg of dry matter, and the other, 3.07.

Animals were slaughtered serially at four end points with 20 to 22 days between slaughter dates, beginning at about 13 l/2 mo of age. Final weights were taken without shrink. Carcass USDA yield and quality grade data were obtained, and one side of each carcass was fabricated into boneless retail cuts to .30 inch fat cover. Retail cuts then were trimmed free of surface fat and reweighed. Rib steaks from each carcass were cooked and sheared with a Warner-Bratzler shear device and evaluated by a trained sensory panel.

Results and Discussion

The earlier maturing breed groups (i.e., Angus, Hereford, Red Poll and MARC-III) had more fat than the later maturing breed groups (i.e., Charolais, Simmental, Braunvieh, Gelbvieh, Limousin, and MARC-I). Contrary to expectations, breed groups responded similarly to the two dietary energy densities. Further, few breed differences occurred in the 63-day span between slaughter groups 1 and 4 (data not shown).

Large differences were observed among breed groups in growth and slaughter traits (Table 1). For initial weight, Herefords were lightest. Gelbviehs, Pinzgauers, Simmentals and Braunviehs were heaviest and did not differ from each other. Charolais were heavier than Angus, Red Polls, and Limousins, which were interme-

diate in initial weight. For final weight, Herefords, Angus, Red Polls, and Limousins did not differ statistically. Simmentals, Charolais, Gelbviehs, and Braunviehs were heaviest and similar, whereas Pinzgauers differed only from Simmentals among the heavier breed groups. For ADG, Red Polls gained slowest but were not different from Angus, Limousins, and Pinzgauers, whereas Simmentals and Charolais gained faster than all breed groups. For carcass weight, Herefords, Red Polls and Angus did not differ. Simmentals, Charolais, Gelbviehs, and Braunviehs were heaviest and did not differ from each other. Pinzgauers and Limousins were intermediate. Limousins dressed significantly higher than all breed groups; Angus and Charolais were intermediate. Differences in dressing percentage among other breed groups were relatively small, even though some of them were significant.

Adjusted fat thickness at the 12th rib ranged from .14 inches in Gelbviehs to .46 inches in Angus (Table 2). Breeds ranked similarly in ribeye area (REA) as for carcass weight, except that Limousins had larger REA than all breed groups except Braunviehs and Gelbviehs. Differences among breed groups in estimated kidney, pelvic, heart fat (KPH) percentages generally were small, except that Red Polls had a significantly higher KPH percentage than all other breed groups. For marbling score, Limousins were lower than all breeds except Gelbviehs. Angus were higher than all breeds except Red Polls, Herefords, and Pinzgauers. Braunviehs, Simmentals, and Charolais were intermediate in marbling score and not significantly different from each other.

The MARC-III composite had lighter initial, final, and carcass weights; lower ADG; higher fat thickness; and higher marbling score than MARC-I. The MARC-II composite had a higher fat thickness and marbling score than MARC-I.

Differences among breed groups in retail product, fat trim, and bone percentages when retail product was trimmed to .3 in. fat and then to 0 in. fat are presented in Table 3. The mean differences between .3 in. and 0 in. fat trim were 4.9% for retail product, 3.6% for fat trim, and 1.2% for bone. Differences in retail product percentage between the two trim levels tended to be less in breeds with less fat (i.e., Limousins, 4.2 %) than in breeds with more fat (Herefords, 5.9%), likely because breeds like Limousin had less than .3 in. fat cover on some cuts, so less fat was removed by trimming to 0 in. Limousins had the highest retail product percentage and lowest fat trim percentage (except for Gelbviehs) and were similar to Angus and Herefords in bone percentage. Herefords, Angus, and Red Polls were similar in retail product, fat trim, and bone percentages. The range in fat trim percentage was 12.1% among breeds at 0 in fat trim, whereas the range in bone percentage was only 2.4 %. The MARC-I composites had a higher percentage of retail product and a lower percentage of fat trim than MARC-II and MARC-III composites.

Differences among parental breeds in retail product and fat trim weights when retail product was trimmed to both .3 in. and 0 in. fat are presented in Table 4. Retail product weights reflect differences among parental breeds in lean tissue growth rate. The similarity of Limousin, Simmental, Charolais, and Gelbvieh in retail product weight at 0 in. fat trim is of interest. Even though the mean slaughter weight for the Simmental, Gelbvieh, and Charolais breeds was 126.6 lb greater than that for the Limousin breed, their lower dressing percent, lower retail product percent, and higher bone percent resulted in no difference among these four breeds in retail product weight. The Herefords had the lowest retail product weight of all breed groups, followed by Angus and Red Polls, which did not differ from each other.

Longissimus steaks from Angus and Pinzgauers had lower Warner-Bratzler shear force values (more tender) than those from all other breed groups except Red Polls (Table 5). Steaks from Gelbviehs and Limousins had higher shear force values than those from all breed groups except Simmental. The three composite breed groups were not different in shear force values. Limousins and Gelbviehs had a lower percentage of fat in the longissimus muscle than other breed groups, whereas Angus, Red Polls, and Herefords had a higher percentage of fat in the longissimus muscle than most other breed groups. MARC-I composites had a lower percentage of fat in the longissimus muscle than MARC-II and MARC-III composites.

Sensory panel scores for tenderness, juiciness and flavor are presented in Table 5. Longissimus steaks from Angus and Pinzgauers were more tender than those from all breed groups. Steaks from Gelbviehs were scored less tender than those from all breed groups except Limousins and Simmentals. Ranking of breed groups for greater sensory panel tenderness agreed very closely with the ranking of breed groups for lower shear force values. Differences among breed groups for sensory panel juiciness were smaller than those for tenderness. Steaks from Angus were scored juicier than those from most breed groups; steaks from Red Polls and Herefords were scored juicier than those from some breed groups. Differences among breed groups for sensory panel flavor were too small to be of practical importance. Longissimus muscle percentage of fat was poorly related to flavor.

Although not presented in tabular form, the high energy diet resulted in heavier final and carcass weights, higher ADG, higher dressing percentage, thicker fat, larger ribeye areas, higher KPH percentages, and higher marbling scores. It also resulted in a lower percentage of retail product, higher percentage of fat trim, and lower percentage of bone. However, weight of retail product was higher for cattle on the high energy diet. The high energy diet also resulted in more fat in the longissimus muscle and lower shear force values.

Estimates of retained heterosis for growth traits and for cooler-measured carcass traits are presented in Table 6. For traits related to growth and size, retained heterosis generally was significant for each composite population and for the mean of the three composites. Retained heterosis was not observed for dressing percentage or adjusted fat thickness. Significant retained heterosis was observed for marbling score for the MARC-II composite but not for MARC-I or MARC-III composites or for the mean of the three composites.

Estimates of retained heterosis for retail product, fat trim, and bone percentages at 0 in. fat trim are presented in Table 7. For composite MARC-I, retained heterosis was not significant for retail product or fat trim but was significant for bone. For composite MARC-II, retained heterosis was significant for retail product (less), fat trim (greater), and bone (less) percentages. For composite MARC-III, retained heterosis was significant for retail product (less) and fat trim (greater). For the mean of the three composites, retained heterosis was significant for retail product (less), fat trim (greater), and bone (less) percentages.

Estimates of retained heterosis for shear force of the longissimus muscle and percentage of fat are presented in Table 7. For composite MARC-II, retained heterosis was significant (greater) for fat percentage in the longissimus muscle. Significantly greater shear force was required for composite MARC-III than for the mean of the contributing purebreds. This anomaly is interpreted to result from chance, because there is no biological basis for this observation.

Table 1. Least Square Means for Growth and Slaughter Traits

Breed Group	N	Initial Weight (lb)	Final Weight (lb)	ADG (lb/d)	Carcass Weight (lb)	Dressing Percent (%)
Red Poll	114	551	1158	2.58	695	60.0
Hereford	146	478	1118	2.72	675	60.3
Angus	118	514	1136	2.64	697	61.3
Limousin	142	531	1144	2.61	728	63.4
Braunvieh	139	602	1250	2.78	748	59.7
Pinzgauer	118	609	1228	2.65	730	59.5
Gelbvieh	150	611	1250	2.73	750	59.9
Simmental	127	604	1281	2.90	767	59.8
Charolais	126	587	1263	2.90	767	60.7
D.05[a]		24	42	.11	27	.8
MARC-I F_3	178	584	1241	2.81	761	61.2
MARC-II F_3	148	604	1263	2.81	765	60.5
MARC-III_3	155	560	1197	2.70	725	60.6
D.05[b]		24	43	.13	28	.8

[a]D.05 is the approximate difference between means of parental breeds required for significance.
[b]D.05 is the approximate difference between means of all breed groups required for significance.

Table 2. Least Square Means for Cooler-Measured Carcass Traits

Breed Group	Adj. Fat (inches)	REA ($inches^2$)	Est. KPH (%)	Marbling Score[a]
Red Poll	.30	10.8	3.3	5.3
Hereford	.44	10.5	2.4	5.2
Angus	.46	10.6	2.6	5.4
Limousin	.17	13.4	2.5	4.4
Braunvieh	.18	13.2	2.8	4.8
Pinzgauer	.17	12.3	2.7	5.2
Gelbvieh	.14	13.0	2.7	4.5
Simmental	.16	12.6	2.5	4.8
Charolais	.15	12.5	2.8	4.7
D.05[b]	.05	.54	.3	.3
MARC-I F_3	.23	12.9	2.9	4.8
MARC-II F_3	.32	12.1	2.9	5.1
MARC-III F_3	.36	11.5	3.1	5.3
D.05[C]	.06	.56	.3	.3

[a]4.00-4.90 = slight; 5.00-5.90 = small.
[b]D.05 is the approximate difference between means of parental breeds required for significance.
[c]D.05 is the approximate difference between means of all breed groups required for significance.

Table 3. Least Square Means for Carcass Composition (Percentages)

	Retail Product[a]		Fat Trim		Bone	
Breed Group	.30 inch[b] %	0 inch[c] %	.30 inch[b] (%)	0 inch[c] (%)	.30 inch[b] (%)	0 inch[c] (%)
Red Poll	67.8	62.6	18.6	22.4	13.6	14.9
Hereford	66.0	60.1	20.8	25.5	13.2	14.4
Angus	67.1	61.5	20.0	24.4	12.9	14.1
Limousin	76.5	72.3	10.4	13.4	13.1	14.3
Braunvieh	71.9	67.3	12.9	16.1	15.1	16.5
Pinzgauer	71.5	66.8	13.7	17.0	14.8	16.1
Gelbvieh	74.2	70.0	11.3	14.2	14.5	15.8
Simmental	72.8	68.4	12.4	15.5	14.8	16.1
Charolais	73.2	68.7	11.9	15.0	14.9	16.2
D.05[d]	1.3	1.5	1.5	1.6	.4	.4
MARC I F_3	71.9	67.2	14.4	17.9	13.7	14.9
MARC II F_3	68.3	63.1	18.3	22.3	13.4	14.7
MARC III F_3	67.2	61.9	19.2	23.3	13.5	14.8
D.05[e]	1.4	1.5	1.5	1.7	.4	.4

[a]Retail product includes steaks and roasts plus lean trim adjusted to 20% fat based on chemical analysis of lean trim.
[b]Subcutaneous and accessible intermuscular fat trimmed to .3 inches.
[c]All subcutaneous and accessible intermuscular fat removed.
[d]D.05 is the approximate difference between means of parental breeds required for significance.
[e]D.05 is the approximate difference between means of all breed groups required for significance.

Table 4. Least Square Means for Carcass Composition (Weights)

	Retail Product		Fat Trim	
Breed Group	.30 inch[b] (lb)	0 inch[c]	.30 inch[b] (lb)	0 inch[c]
Red Poll	446.5	412.6	124.4	149.7
Hereford	424.0	385.9	136.5	166.3
Angus	443.6	427.8	134.9	164.5
Limousin	528.8	499.4	73.4	93.9
Braunvieh	511.9	478.5	94.2	117.3
Pinzgauer	496.1	463.5	96.1	119.1
Gelbvieh	529.4	498.8	82.9	103.9
Simmental	527.7	495.0	93.1	115.5
Charglais	532.1	499.0	88.0	110.9
D.05[d]	18.1	17.6	12.6	14.1
MARC I F_3	521.3	486.4	105.6	131.0
MARC IIF$_3$	497.4	459.1	134.9	164.1
MARC III F_3	464.4	427.1	135.6	164.1
D.05[e]	18.7	18.3	13.0	14.6

[a]Retail product includes steaks and roasts plus lean trim adjusted to 20% fat based on chemical analysis of lean trim.
[b]Subcutaneous and accessible intermuscular fat trimmed to .3 inch.
[c]All subcutaneous and accessible intermuscular fat removed.
[d]D.05 is the approximate difference between means of parental breeds required for significance.
[e]D.05 is the approximate difference between means of all breed groups required for significance.

Table 5. Least Square Means for Percentage of Fat, Shear Force Values and Sensory Panel Traits for the Longissimus (Ribeye) Muscle

			Sensory Panel		
Breed Group	% Fat	Shear Force, lb[a]	Tenderness[b]	Juiciness[b]	Flavor[b]
Red Poll	4.6	10.4	5.2	5.3	5.0
Hereford	4.5	11.2	5.1	5.3	4.8
Angus	4.8	9.9	5.6	5.4	4.9
Limousin	2.8	12.3	4.9	5.0	4.8
Braunvieh	3.7	11.2	5.1	5.1	4.9
Pinzgauer	4.2	9.9	5.4	5.2	5.0
Gelbvieh	3.2	12.8	4.6	5.0	4.8
Simmental	3.7	12.1	4.8	5.1	4.8
Charolais	3.4	11.5	5.0	5.1	4.9
D.05[c]	.5	.9	.3	.2	.1
MARC II	3.6	11.0	5.2	5.1	4.9
MARC II	4.3	11.2	5.0	5.2	4.9
MARC III	4.6	11.2	5.1	5.2	4.9
D.05[d]	.5	.9	.3	.2	.1

[a]Shear force required to cut through a .5 inch diameter core.
[b]Score of 8 = extremely tender, juicy and flavorful; 5 = slightly tender, juicy and flavorful; 1 = extremely tough, dry, and bland.
[c]D.05 is the approximate difference between means of parental breeds required for significance.
[d]D.05 is the approximate difference between means of all breed groups required for significance.

Table 6. Effects of Retained Heterosis on Growth and Slaughter Traits

Item	Initial Weight (lb)	Final Weight (lb)	ADG (lb/d)	Carcass Weight (lb)	Dressing Percent (%)	Adj Fat (inch)	REA ($inch^2$)	Marbling Score
Heterosis:								
MARC I[a] minus purebreds	30.2**	45.9**	.70*	29.5**	.08	-.008	.54**	-.03
MARC II[a] minus purebreds	51.2**	67.7**	.060†	42.3**	.13	.012	.43**	.15**
MARC III[a] minus purebreds	22.9**	37.0**	.055†	26.2**	.29	.012	.48**	.04
Mean heterosis:								
All composites minus purebreds	34.84**	50.27**	.062**	32.6**	.17	.004	.48**	.05

[a]F_3 generation progeny.
†P<.10.
*P.05.
**P<01.

Table 7. Effects of Retained Heterosis on Carcass Composition and Warner-Bratzler Shear Value

Item	Retail Product 0 Inch[c] %	Fat Trim 0 Inch[c] %	Bone 0 Inch[C] %	Retail Product 0 Inch[b] lb	Shear Force[b] lb	Longissimus Muscle Fat %
Heterosis:						
MARC I[d] minus purebreds	-.11	.49	-.38**	18.1**	-.33	-.08
MARC II[a] minus purebreds	-1.90**	2.35**	-.45**	12.6**	-.26	.28*
MARC III[a] minus purebreds	-.89*	1.00*	-.10	10.35*	.93**	.06
Mean heterosis:						
All composites minus purebreds	-.97**	1.28**	-.31**	13.7**	.01	.09

[a]Retail product includes steaks and roasts plus lean trim adjusted to 20% fat based on chemical analysis of lean trim.
[b]All subcutaneous and accessible intermuscular fat removed.
[c]Shear force required to shear through a .5 inch diameter core.
*P<.05.
**P< .01.

ESTIMATES OF GENETIC AND PHENOTYPIC PARAMETERS FOR CARCASS AND MEAT TRAITS OF BEEF CATTLE [1]

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Summary

Data from nine parental breeds and three composite populations described in the preceding article were used to calculate heritabilities and phenotypic and genotypic correlations among carcass and meat traits. Phenotypic correlations indicated that marbling was a poor predictor of longissimus muscle palatability attributes of the individual carcasses. Heritability estimates were intermediate to high for fatness measures but generally low for palatability attributes. The high negative genetic correlation (-.56) between percentage of retail product and marbling score and the relatively low genetic correlations between percentage of retail product and palatability attributes suggest simultaneous selection for percentage of retail product and palatability, rather than for marbling score. Correlations among breed group means were generally high between measures of fatness and palatability attributes and were high and negative between percentage of retail product and marbling score or other fatness measures. Thus, opportunity is limited to select among breeds for high levels of marbling and a high percentage of retail product at the same time. The most logical approach to resolving that genetic antagonism is to form composites from breeds that contribute an optimum balance between favorable carcass composition and desirable meat palatability.

(Key Words: Carcass, Meat Palatability, Heritabilities, Genetic Correlations.)

Introduction

Although interest in carcass and meat traits has increased dramatically in recent years, data on genetic relationships and heritabilities of carcass traits are limited. Our objective in this study was to estimate phenotypic and genetic (co)variation for carcass and meat traits of beef cattle.

Experimental Procedures

Breeds and matings used to establish the three composite populations, as well as specifics of feeding, management, slaughter, carcass data collection, carcass fabrication and longissimus palatability traits were described in the preceding article.

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[1]This article was derived from a research paper accepted for publication in the Journal of Animal Science. These data are from the Germ Plasm Utilization project that was conducted under the leadership of Dr. Keith E. Gregory at the USDA, ARS, Roman L. Hruska U.S. Meat Animal Research Center, Clay Center, NE. Michael E. Dikeman is a collaborator on the carcass retail product data collection.

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Results and Discussion

Differences among breed groups were statistically significant for all traits analyzed. Breed group means were presented in the preceding article.

Estimates of genetic correlations (rg's), phenotypic correlations (rp's), and heritabilities (h^2) for carcass and meat traits are presented in Table 1. The heritability estimate for 12th rib adjusted fat thickness was moderate (h^2=.30). Twelfth rib adjusted fat thickness accounted for considerable variation in percentage of retail product trimmed free of surface fat (rp=-.56, R^2=.31), but accounted for little variation in marbling score (rp=.24, R^2=.06). The heritability estimate for marbling was high (h^2=.52). Variation in marbling score accounted for little of the variation in longissimus shear force (R^2=.05) and sensory panel evaluations of tenderness (R^2=.03), juiciness (R^2=.04), or flavor (R^2=.01). These cattle were slaughtered at an average age of 437 days, following semi-accelerated feeding. Marbling had a very low predictive value for longissimus palatability of individual carcasses. The relationships of longissimus fat percentage with retail product and longissimus palatability were similar to those of marbling. The heritability estimates for longissimus shear force (h^2=.12) and sensory panel tenderness (h^2=.21), juiciness (h^2=.24), and flavor (h^2=.06) were relatively low, but that for percent retail product was high (h^2=.50).

Generally, estimates of genetic correlations were much higher than estimates of phenotypic correlations. Even though marbling was a poor predictor of longissimus palatability of individual carcasses, the high rg's of marbling and longissimus fat with shear force (rg's = -1.00 and -.93, respectively) and the high rg (.96) between marbling and longissimus fat suggest that marbling may be an indirect selection criterion to reduce shear force.

The relatively high negative rg of marbling with percentage of retail product (-.56) reveals the high genetic antagonism between these two traits. However, the rg's of retail product percentage with longissimus shear force and sensory panel evaluations of palatability were low.

Correlations among breed group means for carcass and meat traits are presented in Table 2. Marbling score and percentage of longissimus fat were highly correlated with shear force (-.80 and -.74) and with sensory panel scores for tenderness and juiciness (range from .65 to .92). The correlation of marbling score with sensory panel flavor was .61. The correlation between marbling score and longissimus fat was .99.

These values reflect high correlations among breed group means for both marbling score and percentage of longissimus fat at the 12th rib and palatability attributes. However, high correlations also were observed among breed group means for marbling score and longissimus fat percentage with other measures of fat, e.g., 12th rib adjusted fat (.81 and .82). The correlations of marbling score and longissimus fat percentage with percentage of retail product (free of fat) were -.94 and -.95. Retail product percentage was generally negatively associated with palatability attributes, suggesting limited opportunity to select among breeds to achieve high levels of marbling simultaneously with a high percent retail product in the carcass

The optimum way to resolve the generally high genetic antagonism between retail product percentage and meat palatability may be to form composites from breeds that contribute an optimum balance between favorable carcass composition and desirable meat palatability. Further, desirable carcass and meat traits should be balanced with production traits needed to achieve high production efficiency in a given production environment.

Table 1. Genetic and Phenotypic Parameters among Carcass and Meat Traits of Cattle[a,b,c]

Trait	Adj. Fat Th. (inch)	Marbling Score	Longissimus Muscle Fat (%)	Shear Force (lb)
Adj. fat th. (inch)	.30 ± .09	.24	.26	-.06
Marbling score	.32 ± .16	.52 ± .10	.63	-.23
Longissimus muscle fat (%)	.28 ± .17	.96 ± .06	.47 ± .09	-.23
Shear force (lb)	-.35 ± .34	-1.00 ± .45	-.93 ± .44	.12 ± .08
Tenderness	.30 ± .25	.34 ± .19	.34 ± .20	-.98 ± .74
Juiciness	.45 ± .23	.28 ± .18	.41 ± .18	-.96 ± .53
Flavor	.31 ± .45	.34 ± .38	.48 ± .43	-1.00 ± 1.00
Retail product (%) 0 in fat trim	-.76 ± .28	-.56 ± .19	-.55 ± .20	.22 ± .26

[a]Heritabilities (h^2) on diagonal (underlined).
[b]Genetic correlations (rg's) below diagonal.
[c]Phenotypic correlations (rp's) above diagonal.

Table 2. Genetic and Phenotypic Parameters among Carcass and Meat Traits of Cattle[a,b,c]

Trait	Sensory Panel			Retail Product (%) 0 in Fat Trim
	Tenderness	Juiciness	Flavor	
Adj. fat th. (inch)	.05	.10	.10	-.56
Marbling score	.19	.20	.12	-.42
Longissimus muscle fat (%)	.16	.20	.12	-.47
Shear force (lb)	-.57	-.19	-.23	.15
Tenderness	.21 ± .08	.60	.16	-.11
Juiciness	.91 ± .14	.24 ± .08	-.06	-.14
Flavor	.81 ± .60	1.00 ± .86	.06 ± .08	-.14
Retail product (%) 0 inch fat trim	-.14 ± .22	-.31 ± .21	.02 ± .38	.50 ± .10

[a]Heritabilities (h^2) on diagonal (underlined).
[b]Genetic correlations (rg's) below diagonal.
[c]Phenotypic correlations (rp's) above diagonal.

Table 3. Correlation Coefficients among Breed Group Means for Carcass and Meat Traits

Trait	Shear Force (lb)	Sensory Panel			Adj. Fat Th. (inch)	Marbling score	Longissimus Muscle Fat (%)
		Tenderness	Juiciness	Flavor			
Shear force (lb)							
Sensory Panel							
Tenderness	-.95**						
Juiciness	-.82**	.79**					
Flavor	-.86**	.75**	.55				
Adj. fat th. (inch)	-.49	.54	.82**	.17			
Marbling score	-.80**	.72**	.92**	.61*	.81**		
Longissimus muscle fat (%)	-.74**	.65*	.92**	.55	.82**	.99**	
Retail product .0 inch fat trim (%)	.62*	-.55	-.87**	-.37	-.91**	-.94**	-.95**

*P<.05. **P<.01.

The cattle Germ Plasm Utilization (GPU) research program began with the 1978 breeding season. The primary objective is to estimate the retention of combined individual and maternal heterosis in advanced generations of *'inter se'* mated 'composite' populations established with contributions from either four or five parental breeds. This research program is the largest, most comprehensive one of its kind.

Additional information on retained heterosis from composite populations for major bioeconomic traits can be obtained by writing to Dr. Keith E. Gregory, USDA, ARS, Roman L. Hruska U.S. Meat Animal Research Center, P.O. Box 166, Clay Center, Nebraska 68933.

INDEX OF KEY WORDS

Indexer's note: The pages identified here are th e first pages of each article which uses the listed key word.

BIOLOGICAL VARIABILITY AND STATISTICAL EVALUATION OF DATA

The variability among individual animals in an experiment leads to problems in interpreting the results. Animals on treatment X may have a higher average daily gain than those on treatment Y, but variability within the groups may indicate that the difference between X and Y is not the result of the treatment alone. You can never be totally sure that the difference you observe is due to the treatment, but statistical analysis lets researchers calculate the probability that such differences are from chance rather than from the treatment.

In some articles, you will see the notation "P <.05." That means the probability that the observed difference was due to chance is less than 5%. If two averages are said to be "significantly different," the probability is less than 5% that the difference is due to chance — the probability exceeds 95% that the difference is true and was caused by the treatment.

Some papers report correlations — measures of the relationship between traits. The relationship may be positive (both traits tend to get larger or smaller together) or negative (as one gets larger, the other gets smaller). A perfect correlation is either +1 or –1. If there is no relationship at all, the correlation is zero.

You may see an average given as 2.5 ± .1. The 2.5 is the average; .1 is the "standard error." That means there is a 68% probability that the "true" mean (based on an unlimited number of animals) will be between 2.4 and 2.6. "Standard deviation" is a measure of variability in a set of data. One standard deviation on each side of the mean is expected to contain 68% of the observations.

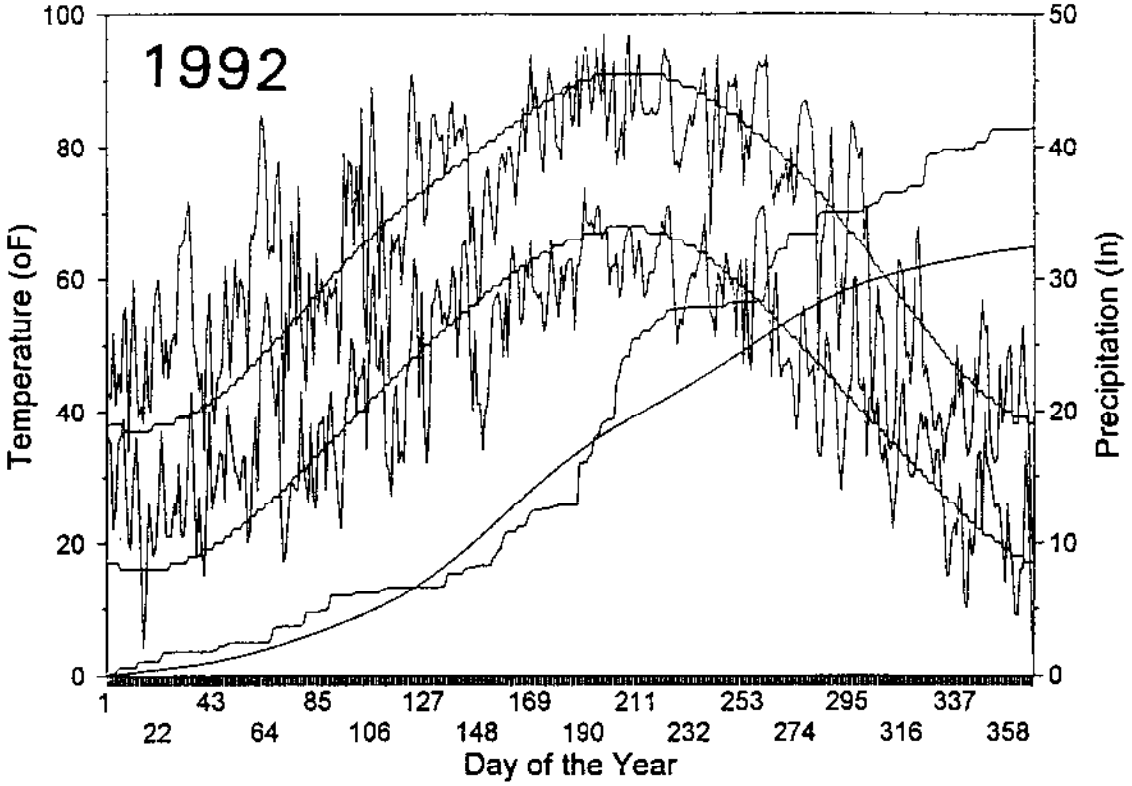
Many animals per treatment, replicating treatments several times, and using uniform animals all increase the probability of finding real differences when they actually exist. Statistical analysis allows more valid interpretation of the results, regardless of the number of animals in an experiment. In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

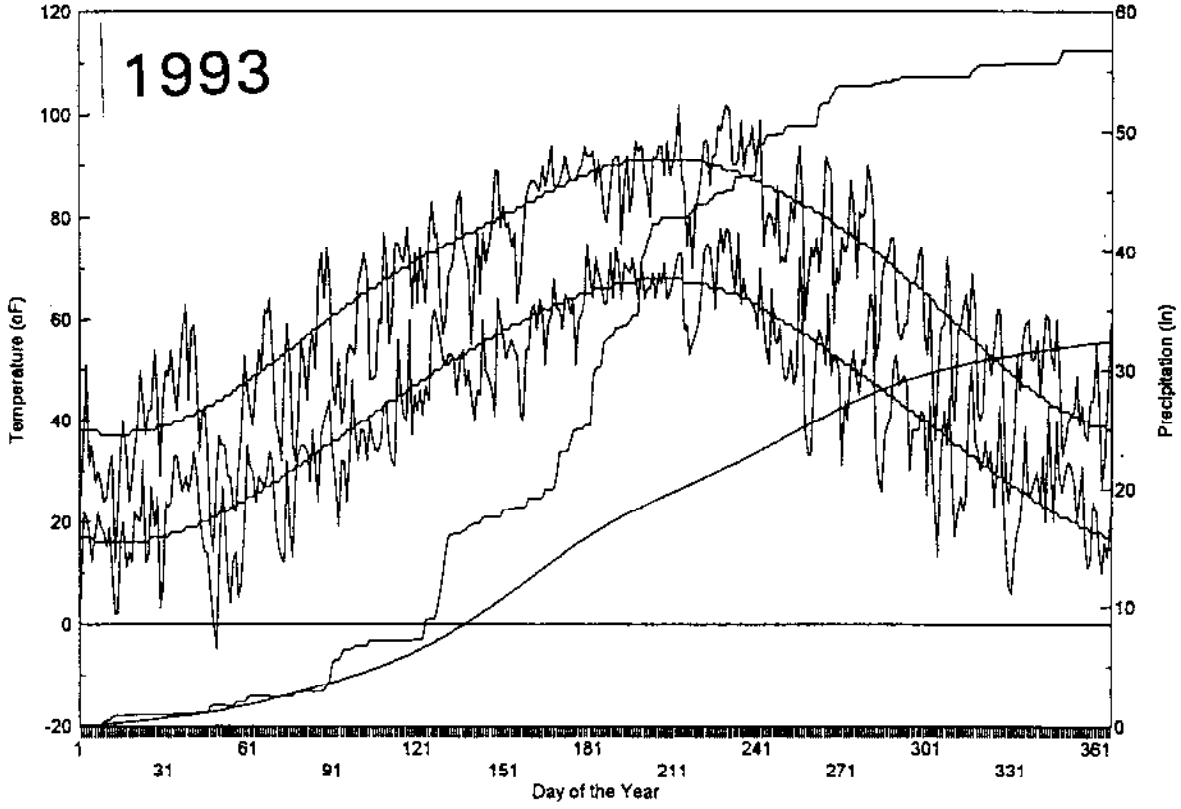
In most experiments, the statistical analysis is too complex to present in the space available. Contact the authors if you need further statistical information.

WEATHER DATA, 1992-1993

On the following page are graphs of the 1992 and 1993 Manhattan weather. They were produced by the Kansas Agricultural Experiment Station 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, 1992 and 1993

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SRP 704 March 1994

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