CATTLEMEN'S DAY 1990

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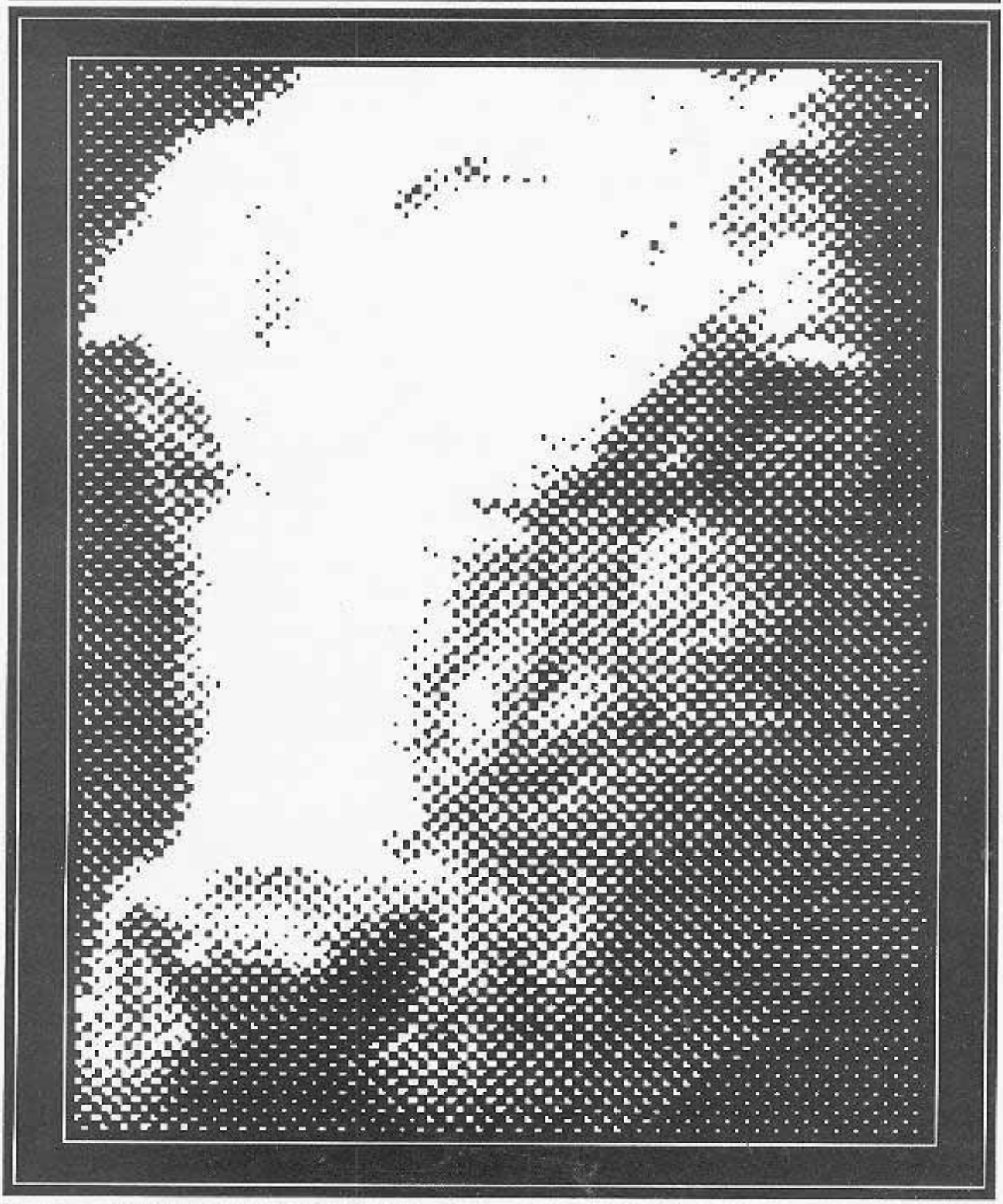

AGRICULTURAL EXPERIMENT STATION KANSAS STATE UNIVERSITY, MANHATTAN
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FAT SOURCE EFFECTS ON FINISHING STEER DIGESTION AND METABOLISM

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R. T. Brandt, Jr., and J. E. Schneider[1]

Summary

A replicated 3 × 3 Latin square design was used to explore the effects of fat source (none vs 3.5% soybean oil soapstock or animal tallow) when fed with high (1.0%) calcium on digestion and metabolism of a finishing diet by steers. Adding fat did not affect site or extent of starch or dry matter digestion. A net synthesis of long chain fatty acids occurred in the rumen. Feeding fat tended (P=.11) to depress bacterial N flowing at the duodenum but did not affect nonbacterial N or total N.

(Key Words: Digestibility, Fat, Calcium, Finishing.)

Introduction

Feeding fat to ruminants can cause palatability problems as well as depressed fiber digestibility, probably because of a toxic effect of long chain fatty acids on ruminal bacteria. Past research has indicated that a high dietary calcium (Ca) level helps alleviate negative effects on fiber digestion in high forage diets (>40% forage), presumably by increasing insoluble soap formation in the rumen. The type of fat used may affect these interactions. The low ruminal pH found in feedlot animals as compared with forage-fed animals would be more likely to ionize long chain fatty acids and Ca, thereby enhancing insoluble Ca soap formation. The objective of the present study was to evaluate the effect of feeding two types of fat with 1.0% dietary Ca in a cattle finishing diet.

Experimental Procedures

Six Holstein steers, averaging 768 lb, were prepared with permanent cannulae in the rumen, duodenum (15 cm posterior to the pylorus), and ileum (30 cm anterior to the ileal-cecal junction) and used in a replicated 3 × 3 Latin square experimental design. Dietary treatments consisted of a control (0% fat), 3.5% dietary soybean oil soapstock, or 3.5% tallow, all fed with 1.0% dietary Ca. The diets were based on dry, coarsely rolled wheat with 10% alfalfa. Chromic oxide was included in the supplement (crumbled pellet form) as the flow marker.

Steers were housed in an enclosed barn in individual tie-stalls and fed 2% (dry matter basis) of their body weight in 12 equal portions daily (2-hr intervals) using automated feeders. Animals gained an average of 3.12 lb/d over the 94-d trial. Each period of the Latin square

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consisted of 20 d. Dietary fat was analyzed as total long chain fatty acids (LCFA) using gas chromatography and represents fatty acids from C14:0 to C20:4 present in the diet or digesta sample. Insoluble fatty acid salts (IFAS) were isolated using three extractions of a 1:1 acetone and ether mixture.

Results and Discussion

Dry matter intakes were similar between treatments (Table 1.1). Starch and nitrogen (N) intakes were lower, and fatty acid intake, ruminal LCFA, and ruminal IFAS (% of ruminal LCFA) were higher ($P<.10$) in the diets containing fat. Intake of starch, fatty acids, dry matter (DM), or ruminal IFAS (% of ruminal LCFA) were similar between fat sources; however, animals fed tallow tended to have lower amounts of ruminal LCFA ($P=.11$) and ruminal IFAS ($P=.09$). Fat presence or type did not affect DM or starch digestibilities or ruminal IFAS content expressed as percent of ruminal fatty acids.

As shown by the negative numbers, a net ruminal synthesis of fatty acids occurred for all treatments. Fatty acid digestibility was lower ($P<.05$, measured as percent of fatty acid intake) in the rumen, small intestine, and total tract in animals fed fat compared to those not fed fat. Ruminal and small intestinal digestibilities of fatty acids were also lower ($P\leq .10$) in the tallow-fed animals compared to the animals fed soybean oil soapstock. The animals fed soybean oil soapstock had the lowest digestibilities of insoluble fatty acid salts, followed by the tallow diet, but digestibility nearly doubled comparatively in the diet not containing fat.

Feeding fat tended ($P=.11$) to depress bacterial N flowing to the duodenum but did not affect nonbacterial N or total N measured at the duodenum. Values were similar between the two fat sources.

Fat additions to high-Ca finishing diets did not affect DM or starch digestion in any segment of the gastrointestinal tract. Data indicate that large quantities of fatty acids are synthesized ruminally, and fat source causes small differences in fat digestibility and utilization by the animal.

Table 1.1. Fat Source Effects on DM, N, Starch, Fatty Acid, and Insoluble Fatty Acid Salt Digestion[1]

Item	No fat	Soybean oil soapstock (SS)	Tallow	SE	Prob. = No fat vs fat	Prob. = SS vs tallow
DMI, kg/d	7.98	7.88	7.89	.81	.3659	.9452
Starch intake, g/d	4342	4118	4090	38	.0023	.6302
N intake, g/d	177.6	174.8	172.1	1.7	.0968	.3220
Fatty acid intake, g/d	98.68	191.79	192.89	4.34	.0001	.2002
Ruminal LCFA, mg/g DM	44.3	87.2	74.5	4.7	.0008	.1083
Ruminal IFAS, mg/g DM	35.0	62.0	54.2	2.7	.0004	.0853
Ruminal IFAS, % of ruminal LCFA	79.2	71.8	73.3	3.0	.1237	.7359
DM digestibility, %						
ruminal	58.24	57.72	61.31	2.94	.7362	.4217
small intestinal	23.49	25.15	22.49	1.31	.8480	.2268
total tract	82.59	82.23	82.77	1.39	.9623	.7918
Starch digestibility, %						
ruminal	86.76	84.77	86.50	2.91	.7619	.6883
small intestinal						
% of intake	7.97	11.82	8.97	1.75	.3252	.3182
% of duodenal flow	78.40	72.20	66.62	3.85	.1331	.3659
total tract	95.90	96.11	96.04	.69	.8475	.9499
Fatty acid digestibility, %						
ruminal	−66.04	−55.28	−37.95	5.81	.0342	.0795
small intestinal						
% of intake	141.13	122.07	113.10	2.99	.0031	.1034
% of duodenal flow	86.00	78.62	77.14	2.54	.0614	.7041
total tract	72.46	59.79	65.48	2.80	.0285	.2003
Insoluble fatty acid salt (IFAS) digestibility, %						
total tract	82.45	24.77	46.52	4.26	.0002	.0178
Duodenum, g/d						
Bacterial N	90.2	75.7	71.5	7.2	.1102	.6942
Nonbacterial N	43.3	45.1	42.5	4.3	.9330	.6825
Total N	133.5	120.8	114.0	9.0	.1912	.6093

[1]Least squares means, n=6. Digestibilities reported as a percent of intake.

DOSE RESPONSE TO SUPPLEMENTAL FAT BY FINISHING STEERS

S. M. Gramlich, R. T. Brandt, Jr., and R. V. Pope

Summary

A trial with 100 head of crossbred steers (avg wt 879 lb) was conducted to determine the effects of tallow (none, 2, 4, 6, 8% of ration dry matter) on the performance and carcass characteristics of finishing cattle fed a corn-based diet. Protein levels were maintained at a constant ratio to the calculated metabolizable energy concentration of the diets. Initially, feed intake decreased as tallow increased; however, similar intakes were obtained after 11 days. Dry matter intakes throughout the finishing period were reduced 5.2, 6.9 and 7.7%, respectively, for the 4, 6 and 8% tallow diets. Average daily gain was similar for the control, 2, and 4% levels and declined 4.9 and 13.3% for the 6 and 8% tallow diets, respectively. Feed efficiency had a quadratic relationship with added fat and was best at 4% fat. There were no significant differences in carcass traits among treatments. Therefore, for steers finished on corn-based diets, 4% tallow appeared to be optimum, considering performance, efficiency, and carcass quality.

(Key Words: Tallow, Finishing, Performance, Carcass Traits.)

Introduction

Fat additions to finishing diets provide the opportunity to increase the energy content, while increasing the cohesiveness of small particles and reducing the dustiness of the diet. Research evaluating various types of fat additions has been conducted at Kansas State University and other research centers. However, the optimum level of supplemental fat has not been clearly determined. Further, the use of supplemental fat in corn-based diets may be less beneficial because of corn's higher oil content; 4.2% vs 2.4% for sorghum and 1.8% for wheat (NRC, 1984). The purpose of this study was to determine the optimum level of tallow addition to corn-based diets for finishing cattle, based on animal performance and carcass characteristics.

Experimental Procedures

One hundred English crossbred steers (avg wt 879 lb) were blocked on the basis of weight to four replicates and randomly assigned to one of five treatments: control, 2, 4, 6, or 8% tallow (dry basis). Animals were weighed on two consecutive days, implanted with Compudose 200; vaccinated against IBR, BVD, and PI_3; and dewormed with Ivomec®.

Steers were stepped up to a high concentrate finishing diet (without added fat) in a large common pen before being weighed and assigned to their respective treatments. The final diet dry matter composition was 10% supplement, 10% roughage (5% sorghum silage, 5%

ground prairie hay), 2% molasses, the treatment level of tallow, and the balance dry rolled corn. Diets were formulated to maintain a constant ratio of metabolizable energy to crude protein, based on NRC values. The no added fat diet was formulated for 12% crude protein. Urea was held constant across diets, and soybean meal provided the balance of supplemental protein. Tylosin was added to supply 10 g per ton of complete diet.

Diets were mixed daily in a stationary horizontal mixer. The supplement and grain components were mixed, and then the tallow and molasses were applied. After several minutes of mixing, the roughage components were blended in. Rations were then weighed out for each pen and transported to the bunk. During the first 14 d, daily feed not consumed was collected to determine pen intakes as cattle adapted to the treatment diets.

Animals were slaughtered after 59 (heavy replicate) or 75 d. Following a 24-hr chill, ribeye area; fat thickness; kidney, heart, and pelvic fat; and yield and quality grades were determined.

Results and Discussion

Figure 2.1 represents the dry matter intake when cattle were first fed tallow. Steers were started on their respective treatment level of tallow without benefit of an adjustment period. Tallow additions initially depressed feed intake in all diets, with the intensity of the depression related to tallow level. Intakes of tallow-containing diets approximated that of the control diet after 11 d, underscoring the need to adjust finishing cattle gradually to supplemental fat. Further, because of its negative effect on fiber digestion, supplemental fat in receiving and early step-up rations may be counter-productive.

Average dry matter intake computed for the entire feeding period decreased linearly (P<.01) with increased tallow (Table 2.1) and was reduced 5.2, 6.9, and 7.7% for the 4, 6, and 8% tallow diets, respectively. The reason for depressed intake is not fully understood. The initial reduction in intake could result from palatability preferences or from the need of the ruminal environment to adapt. Research is currently under way to determine how the ruminal environment responds to tallow additions.

Average daily gain responded quadratically (P<.01), because steers gained at similar rates when fed control, 2 or 4% added tallow, then declined 4.9 and 13.3% with the 6% and 8% diets, respectively. Feed efficiency responded quadratically (P<.03), with peak efficiency occurring at 4%

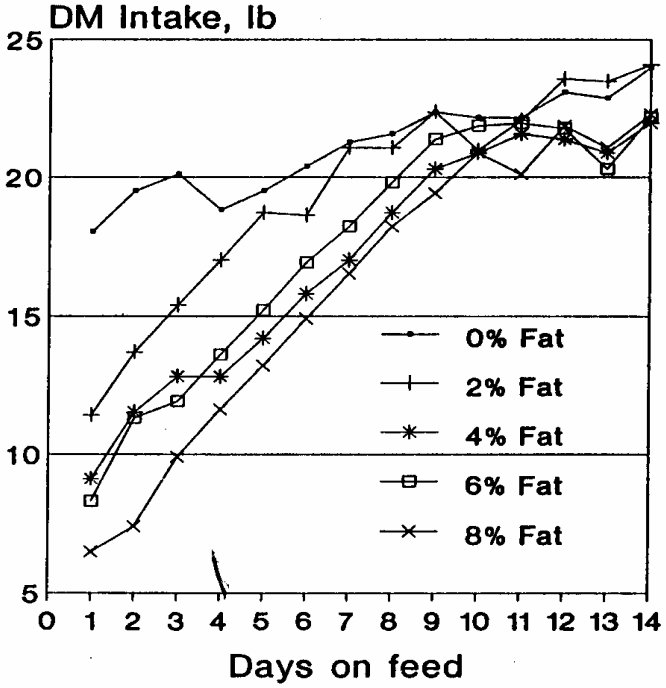

Figure 2.1. Initial Feed Intake Response to Percent Tallow in the Diet

Table 2.1. Performance and Carcass Characteristics for Finishing Steers on Tallow Diets

Item	Control	Tallow level, percent of dry matter 2	4	6	8	SE
Daily feed, lb DM[a]	23.3	23.7	22.1	21.7	21.5	.58
Daily gain, lb[b]	3.84	3.88	3.88	3.65	3.33	.087
Gain/feed[c]	.165	.164	.175	.168	.155	.0046
Gain/Mcal ME[d]	.103	.101	.107	.101	.095	.0047
Ribeye area, in.^{2}	13.15	13.41	12.90	13.00	12.73	.249
Backfat, in.	.55	.51	.51	.54	.53	.033
KPH, %	2.68	2.80	2.68	2.69	2.74	.103
Yield grade[e]	2.86	2.68	2.84	2.84	2.87	.139
Percent Choice	80	75	70	68	60	

[a]Dry matter intake. Linear (P<.01)
[b]Average daily gain. Linear (P<.001), Quadratic (P<.01)
[c]Gain/feed. Quadratic (P<.03)
[d]Gain per Mcal metabolizable energy. Quadratic (P<.05)
[e]Calculated USDA yield grade.

supplementation. The efficiency of gain when evaluated per unit of energy consumed showed a quadratic response (P<.05). The 4% tallow diet was 3.9, 5.9, 5.9, and 12.6% more efficient, respectively, than the control, 2, 6, or 8% diets. Metabolic responses to tallow in the diet are currently being evaluated to help explain why this response was observed.

Treatment caused no differences in ribeye area, backfat thickness, kidney pelvic fat, or quality or yield grade. It should be noted that increased carcass fatness has been observed in previous research trials in which fats or oils were fed for longer periods of time.

The performance of heavy feeder steers fed a corn-based diet can be enhanced by adding up to 4% tallow to the diet. Whether the improvement in efficiency noted in this study is economically significant will depend on the input prices of corn and tallow.

UTILIZATION OF STEAM-FLAKED MILO OR CORN AND SUPPLEMENTAL FAT BY FINISHING STEERS[1]

R. T. Brandt, Jr., G. L. Kuhl, C. L. Kastner, and A. S. Freeman[2]

Summary

One hundred forty crossbred yearling steers (815 lb) were utilized to evaluate grain type (steam flaked corn vs steam flaked milo) and supplemental fat (0 or 4% yellow grease) on finishing performance. There were no differences in carcass-adjusted average daily gain, feed intake, or feed conversion between steers fed milo vs corn. Calculated NEm and NEg contents of flaked milo were approximately 99% those of flaked corn and 15 to 20% greater than those of dry rolled milo (NRC, 1984). Supplemental yellow grease increased (P=.12) average daily gain 4.4% and improved (P<.05) feed efficiency 6%. There were no grain type x fat interactions for any performance parameter measured. Steers fed milo had smaller (P<.05) ribeye areas and tended to have more backfat and internal (KPH) fat than corn-fed steers. As a result, milo-fed steers had a higher (P<.001) yield grade. Steers fed corn had a higher (P<.001) degree of yellow pigmentation in external fat than those fed milo. Supplemental yellow grease resulted in an additive increase (P<.025) in yellow pigmentation. There were no differences in peak shear force or sensory traits of beef longissimus muscle as a result of either grain type or fat level. Our data indicate that steam flaking can increase the net energy value of milo to nearly that of flaked corn, with no detrimental effects on the quality of beef produced.

(Key words: Steam-flaking, Milo, Corn, Fat, Finishing, Carcass Traits.)

Experimental Procedures

One hundred forty yearling crossbred steers (815 lb) were utilized in a 2×2 factorial experiment to evaluate the effects of grain type (steam flaked milo vs steam flaked corn) and level of supplemental fat (0 or 4% yellow grease) on finishing performance, carcass characteristics, chemical composition, and organoleptic properties of beef. Steers were allotted to five weight replicates (seven head per pen), and treatments were assigned to pens at random.

Diets were formulated to contain 13% crude protein and 10% alfalfa hay. Yellow grease, when used, replaced 4% of molasses. Milo and corn were flaked to densities of 26 and 20 lb/bu, respectively, measured directly off the rolls (20% moisture). Steers were weighed on trial immediately before being placed on the final diet. Initial weights were the average of two consecutive weights obtained on October 3 and 4, 1988. Final weights were based on hot carcass weights adjusted to a 63% dressing percent. Carcass data were obtained following a 24-

[1]Appreciation is expressed to the National Grain Sorghum Producers Association, Abernathy, Texas, for partial funding of this study.
[2]Southwest Kansas Research-Extension Center, Garden City.

hr chill. Rib sections were obtained from half the carcasses from each treatment for subsequent determination of chemical composition, shear force, and sensory analysis by a trained taste panel. The trial was conducted for 100 d.

Results and Discussion

There were no differences in dry matter intake, average daily gain, or feed conversion between steers fed steam-flaked milo (SFM) or steam flaked corn (SFC, Table 3.1). Main effect means for daily gain (lb/d), dry matter intake (lb/d), and efficiency of feed conversion (feed/gain) were 4.03 vs 4.03, 21.3 vs 21.2, and 5.32 vs 5.28 for SFM vs SFC, respectively. Prices are shown in footnote, Table 3.1. Addition of 4% yellow grease improved daily gain 4.4% (P=.12) and feed efficiency 6% (P<.05) compared to non-supplemental diets. Costs of gain for SFM (−fat), SFM (+fat), SFC (−fat), and SFC (+fat) were 44, 43, 49, and 48¢/lb, respectively. Thus, with the current price structure, milo is much more economical than corn for feedlots equipped with steam flakers. Although supplemental fat increased ration costs, costs of gain were reduced by 1¢/lb. In this study, cattle were all slaughtered at the same time. Because fat produced faster gain, cattle fed fat could have been killed sooner, reducing interest and yardage and increasing their cost of gain advantage. Ration net energy concentrations were calculated from animal performance. Flaked milo and corn were 107.9, 75.9 and 108.8, 76.7 Mcal/cwt NEm and NEg, respectively. Thus, flaked milo contained about 99% the NEm and NEg of flaked corn. Further, flaking increased the NEm and NEg of milo 15 and 19%, respectively, compared to NRC (1984) values for dry rolled milo.

Steers fed SFM had a smaller (P<.05) ribeye area and numerically higher dressing percentage, backfat thickness, and percentage of KPH fat than steers fed SFC (Table 3.2). As a result, SFM steers had a higher (P<.001) yield grade than SFC steers. The fact that SFM steers had smaller ribeye areas and higher numerical yield grades is puzzling, and no

Table 3.1. Effect of Grain Type and Supplemental Fat on Steer Finishing Performance

Item	Flaked milo		Flaked corn		SE
	0% fat	4% fat	0% fat	4% fat	
No. pens	5	5	5	5	
No. steers	35	35	35	35	
Initial wt, lb	815	815	815	816	.5
Daily gain, lb[a]	3.94	4.12	3.94	4.11	.104
Daily feed, lb DM	21.3	21.3	21.5	20.9	.32
Feed/gain[bc]	5.46	5.19	5.46	5.10	.160
Cost of gain, $/lb[d]	.44	.43	.49	.48	
Ration net energy, Mcal/cwt					
NEm	99.5	102.7	98.6	104.1	
NEg	68.7	71.5	67.9	72.7	

[a]Final weights were warm carcass weights adjusted to a 63% dress.
[b]Analyzed statistically as gain/feed.
[c]Fat effect (P<.05).
[d]Based on $2.85/bu corn, $4.30/cwt milo, 11% interest, $.06 daily yardage.

Table 3.2. Effect of Grain Type and Supplemental Fat on Carcass Traits

Item	Flaked milo		Flaked corn		SE
	0% fat	4% fat	0% fat	4% fat	
Warm wt, lb	762	772	762	773	9.2
Dressing percent	63.8	63.6	62.7	63.2	.61
Ribeye area, in.^{2} [ab]	12.4	12.8	13.0	13.3	.22
Backfat, in.[a]	.46	.53	.46	.47	.023
Kidney, pelvic, and heart fat, %	2.40	2.61	2.33	2.41	.112
Yield grade[d]	3.07	3.21	2.87	2.84	.103
Marbling	Sm^{40}	Sm^{40}	Sm^{30}	Sm^{30}	.130
Percent Choice	83	74	83	80	
Fat color[1] [cd]	1.8	2.0	2.5	2.8	.10
Lean color[2] [a]	4.9	4.4	4.7	4.4	.20

[1]Scale of 1-5; 1=bleached white, 5=yellow.
[2]Scale 1-10; 1=light cherry red, 10=dark red.
[ac]Fat effect ([a]P<.08;[c]P<.025).
[bd]Grain effect ([b]P<.05; [d]P<.001).

reasonable explanation for this difference is available. SFC steers had a higher (P<.001) degree of yellow color in their subcutaneous fat than SFM steers. Steers fed yellow grease also had a higher (P<.025) fat color score, but lighter (P<.05) lean color than non-supplemented steers. Whether these findings have any potential effect on consumer acceptability is unclear at this point.

Neither grain type nor supplemental fat had an effect on tenderness (shear force) or sensory traits of beef (Table 3.3). These data discount the misconception that beef from milo-fed cattle is inferior to that from corn-fed cattle.

Table 3.3. Effect of Grain Type and Supplemental Fat on Consumer Attributes of Beef

Item	Flaked milo		Flaked corn	
	0% fat	4% fat	0% fat	4% fat
Flavor intensity[1]	6.2	6.1	6.1	6.2
Off flavor[1]	7.8	7.8	7.7	7.8
Juiciness[1]	5.9	5.9	6.0	6.0
Myofibrillar tenderness[1]	6.2	6.1	6.2	6.2
Connective tissue[1]	7.4	7.3	7.3	7.3
Overall tenderness[1]	6.5	6.3	6.4	6.4
Warner-Bratzler peak shear force, kg	4.0	4.0	3.9	4.0

[1]Trained taste panel evaluation of rib steaks on a scale of 1 to 8, with 8 most desirable.

INFLUENCE OF FAT AND IONOPHORES ON PERFORMANCE OF FINISHING STEERS[1]

E. M. Clary, R. T. Brandt, Jr., and R. V. Pope

Summary

One hundred ninety-two crossbred steers were used in a 2 × 4 factorially arranged experiment to study the effects of including fat and ionophores in finishing rations. Main effects were level of supplemental fat (0 or 4% tallow) and ionophore type [none, Bovatec® (B), Rumensin® + Tylan® (RT), or daily rotation of B and RT (BRT)]. Daily feed intake ($P<.10$) and daily gain ($P<.005$) were reduced for steers fed RT, but only when fat was included in the diet. In diets containing no supplemental fat, RT increased daily gain 10%. RT improved feed efficiency 8% ($P<.05$) in nonfat diets, but there was no difference between ionophores in diets containing fat. Adding fat improved feed efficiency of steers fed no ionophore or B. This study suggests that response of finishing steers to ionophores can be modified by the inclusion of fat in the diet.

(Key Words: Ionophores, Fat, Finishing, Performance.)

Introduction

Previous KSU research indicates that adding fat to finishing diets can improve daily gain and feed efficiency. Two ionophores, Bovatec and Rumensin, are currently cleared for improvement of feed efficiency in feedlot cattle. There has been interest in evaluating rotational feeding of these ionophores, because some research suggests that rumen microorganisms adapt to an ionophore during the feeding period, thus diminishing its effect. Recent KSU research suggests that feeding supplemental fat may alter the response of finishing steers to an ionophore. We studied the potential interactions between fat and these two ionophores fed separately or in daily rotation.

Experimental Procedures

One hundred ninety-two crossbred steers originating from Louisiana were blocked by previous nutritional treatment to one of 48 pens in a 2 × 4 factorially arranged, randomized, complete block design. Main effects were ionophore type (none, Bovatec (B), Rumensin + Tylan (RT), or B and RT fed in a daily rotation (BRT)) and level of supplemental fat (0 or 4% tallow). Bovatec, R, and T were fed at levels of 30, 25, and 10 g/ton of complete feed (90% dry basis), respectively. Compositions of final diets are listed in Table 4.1. Initially, steers were weighed; treated for endo- and ectoparasites; vaccinated against IBR, PI_3, BVD, and

[1]Appreciation is expressed to National Byproducts, Inc., Wichita, for supplying the tallow used in this research.

seven clostridial strains; implanted with Compudose®; and allotted to pens as described above. The feeding period lasted from July 17 to November 9, 1989 (116 d). Final weights were pencil shrunk 4% to reflect pay weight performance. Carcass data were obtained following a 24-hr chill.

Table 4.1. Composition of Diets[1,2]

Diet	Rolled corn	Prairie hay	Sorghum silage	Beet molasses	Animal tallow	Supplement
No fat	78.0	5.0	5.0	4.0	0.0	8.0
Fat	78.0	5.0	5.0	0.0	4.0	8.0

[1]Dry matter basis.
[2]Formulated to contain 12% CP, 0.7% Ca, 0.3% P, 0.35% NaCl, 0.7% K, and 70 ppm Zn.

Results and Discussion

During the course of the trial, five steers were removed because of factors not related to the trial; 187 head remained.

There was a fat × ionophore interaction (P<.10) for daily feed intake (Table 4.2). Fat supplementation reduced feed intake 10% in steers fed RT, but had no effect in steers fed B or no ionophore. Fat supplementation resulted in a numerical reduction in feed intake in steers fed BRT. A fat × ionophore interaction (P<.005) was also noted for average daily gain (ADG). Fat supplementation reduced ADG 13% in steers fed RT, but increased ADG 10% in steers fed B. In fat-containing diets, ADG of steers fed RT was decreased compared with those fed no ionophore or BRT. In diets containing no supplemental fat, steers fed B gained 7% less than steers fed no ionophore. Rumensin + Tylan increased ADG 10% compared with no ionophore in steers receiving no supplemental fat.

Fat and ionophore type also interacted (P<.05) on feed conversion (F/G). Supplemental fat improved F/G 6.0, 9.5, and 3.9% for steers fed no ionophore, B, and BRT, respectively. However, supplemental fat reduced F/G of steers fed RT by 4.2%. With fat supplemented diets, ionophores did not improve F/G, consistent with previous KSU research. In cattle receiving no supplemental fat, feed efficiency was improved 8% by the addition of RT.

Fat × ionophore interactions (Table 4.3) were observed for hot carcass weight (P<.10), ribeye area (P<.05), backfat thickness (P<.05), yield grade (P<.10), and dressing percentage (P<.10). Fat supplementation reduced hot carcass weight in steers fed RT, but in non-fat diets, steers fed RT had higher carcass weights compared with those fed B or no ionophore, thus mirroring the differences in ADG. In cattle receiving no supplemental fat, dressing percentage was higher with B and BRT compared with cattle fed no ionophore. With the exception of steers receiving B, fat supplementation tended to increase dressing percentage, which may have been partially the result of increased kidney, pelvic, and heart (KPH) fat observed with fat supplementation. Contrary to our expectations, fat supplementation reduced (P<.01) marbling scores.

Table 4.2. Effect of Fat and Ionophore Treatment on Steer Performance

Item	Ionophore	None		Bovatec		Rumensin/ Tylan		Daily rotation		SE
	Fat	−	+	−	+	−	+	−	+	
Initial wt, lb		770	775	773	771	771	773	772	770	2.2
Final wt, lb[a,b]		1,122	1,153	1,102	1,133	1,158	1,109	1,140	1,135	12.8
No. of pens		6	6	6	6	6	6	6	6	
No. of steers		22	23	24	24	24	23	24	23	
Daily feed, lb DM[c]		21.74	21.93	21.25	21.21	22.12	19.97	21.96	20.94	.497
Daily gain, lb[b]		3.04	3.26	2.84	3.12	3.34	2.90	3.18	3.15	.102
Feed/gain[d]		7.19	6.76	7.51	6.80	6.62	6.90	6.94	6.67	.149

[a]Final wt pencil shrunk 4%.
[b]Fat × ionophore interaction (P<.01).
[c]Fat × ionophore interaction (P<.10).
[d]Fat × ionophore interaction (P<.05).

Table 4.3. Effect of Fat and Ionophore Treatment on Carcass Traits

Item	Ionophore	None		Bovatec		Rumensin/ Tylan		Daily rotation		SE
	Fat	−	+	−	+	−	+	−	+	
Hot weight, lb		715	738	709	728	740	712	730	737	9.8
Dressing, %		63.7	64.3	64.4	64.2	63.9	64.5	64.4	64.9	.265
KPH fat, %[a]		2.62	2.77	2.34	2.62	2.46	2.62	2.67	2.79	.136
Marbling score[b]		5.75	5.22	5.30	5.31	5.50	5.03	5.58	5.02	.183
Backfat, in.[c]		.48	.54	.51	.54	.54	.48	.55	.49	.024
Ribeye area, in.^{2} [c]		12.8	13.2	13.0	12.8	13.4	12.6	12.8	13.2	.232
Yield grade		2.84	2.98	2.82	30.3	2.85	2.91	3.12	2.85	.093
Liver abscesses, %		23.8	4.5	22.7	34.8	12.5	17.4	4.2	21.7	

[a]Fat effect (P<.10).
[b]Fat effect (P<.01).
[c]Fat × ionophore interaction (P<.05).

The results of this study indicate that the response of finishing steers to ionophores can be altered by fat supplementation. Further research is needed to enable the response of these feeding combinations to be predicted in a dependable manner.

EFFECT OF FATS AND IONOPHORES ON IN VITRO FERMENTATION OF A HIGH CONCENTRATE DIET

E. M. Clary, R. T. Brandt, Jr., and T. G. Nagaraja

Summary

Batch culture fermentations were used to determine the effects of fat type [none, animal tallow (AT), soybean oil soapstock (SOY), or yellow grease (YG)] and ionophore type [none, lasalocid (L), monensin + tylosin in a ratio of 2.5:1 (MT), or a 50:50 combination of L and MT (LMT)] on in vitro concentrations of lactate (LA) and volatile fatty acids (VFA). Fat-containing substrates had 4% fat on a dry basis. No significant interactions between fat and ionophore treatments were observed. Ionophore treatment resulted in a reduced pH, with the greatest reduction in the L treatment. Total VFA and LA increased with ionophore treatment and were highest with L treatment. All ionophore treatments decreased molar proportions of acetate and butyrate and increased propionate. Lasalocid produced a lower molar proportion of acetate and a higher molar proportion of propionate than did MT. Adding fat resulted in a reduction in total VFA and an increase in pH. The reduction in total VFA was less for SOY than AT or YG treatments. No significant differences in LA or VFA molar proportions were observed among fat treatments. Our results indicate that the rate of starch digestion may be slowed by fat, which may translate into a decreased incidence of ruminal acidosis.

(Key Words: Fats, Ionophores, Fermentation, Volatile Fatty Acids, Lactic Acid.)

Introduction

Supplemental fat and ionophores are commonly fed to finishing cattle. Fat at 2 to 5% of the diet dry matter controls dust, improves ration consistency, and aids feed processing. It also increases diet energy density and total energy intake. Ionophores improve nitrogen metabolism and the efficiency of energy metabolism in the rumen and also help control feedlot disorders such as lactic acidosis and bloat, probably because of shifts in the ruminal microbial flora. Previous research at Kansas State University suggests that the effects of feeding supplemental fat may be altered by the presence of an ionophore. This paper presents the results of an in vitro experiment designed to explore potential mechanisms for such interactions.

Experimental Procedures

Batch culture fermentations with substrates (Table 5.1) based on flaked grain were used in a 4 × 4 factorially arranged experiment (five replications). Main effects were supplemental fat type [none, animal tallow (AT), soybean oil soapstock (SOY), or yellow grease (YG)] and ionophore type [none, lasalocid (L), monensin + tylosin in a 2.5:1 ratio (MT), or a 50:50 combination of L and MT (LMT)]. Ionophores were dissolved in ethanol and added at 10 μg of total ionophore per ml of inoculum. To each tube was added 1 g of ground (Wiley mill, 2 mm sieve) substrate, 15 ml of McDougall's buffer, 15 ml of strained rumen fluid

Table 5.1. Composition of Diets[1]

Fat treatment	Dry rolled wheat	Dry rolled milo	Corn silage	Supplement	Beet molasses	Fat
No fat	40.4	40.4	10.0	5.2	4.0	0.0
Fat	40.3	40.3	10.0	5.4	0.0	4.0

[1]Dry matter basis.

obtained 12 to 14 hr post-feeding from a steer fed 80% alfalfa hay and 20% grain, and 100 μl of ionophore preparation (control tubes received 100 μl ethanol). Each tube was flushed with CO_2, stoppered with a rubber stopper and a Bunsen valve, and incubated at 39 C for 12 hr. Fermentations were conducted in duplicate for each treatment combination. Final pH's were recorded, and aliquots from each tube were taken for subsequent VFA and LA analysis.

Results and Discussion

Effects of fat treatment are listed in Table 5.2. Fat treatment significantly increased pH, which may simply reflect the changes in total VFA concentration. Animal tallow and YG reduced (P<.0001) total VFA compared to the no fat control. Fat did not significantly affect VFA molar proportions or LA.

Proposed mechanisms for fat's action on rumen fermentation include physical coating of feed particles, direct toxic effects of the fats on rumen microbes, and decreased cation availability through soap formation. Fiber digestion is generally reduced by supplemental fat, resulting in a decreased acetate:propionate ratio, and this effect is usually greater with polyunsaturated than saturated fats. Thus, one might expect SOY to decrease the acetate:propionate ratio and reduce total VFA more than AT or YG. Such changes were not observed in this experiment, perhaps because the substrate contained so little fiber that change in fiber digestion would have minimal effect.

Table 5.2. Effects of Fat Treatment on VFA Profile, pH, and Lactate Concentration

Treatment	pH[a]	Lactate, mM	Total VFA[a], mM	%Acetate	%Propionate	%Butyrate
No fat	5.64[b]	.198	179.5[b]	59.0	31.2	9.8
Animal tallow	5.77[c]	.171	170.4[c]	59.2	30.7	10.1
Soy oil soapstock	5.72[c]	.185	175.4[b]	59.2	30.8	10.0
Yellow grease	5.77[c]	.169	168.6[c]	59.0	30.7	10.3
SE	.023	.019	1.48	.20	.40	.26

[a]Fat effect (P<.001).
[bc]Means in a column with unlike superscripts differ (P<.05).

Table 5.3 lists the effects of ionophore treatment on in vitro batch culture fermentations. Lasalocid resulted in a lower (P<.05) pH than other ionophore treatments. The no-ionophore control treatment resulted in a higher pH than MT (P<.10) and LMT (P<.05). Changes in pH resulting from ionophore treatment were likely due to higher total VFA, which was significantly higher in all ionophore treatments vs the no-ionophore control. This is consistent with other in vitro work with ionophores at KSU and suggests that ionophores may alter fermentation endproducts via anti-protozoal activity. Lasalocid treatment resulted in a higher (P<.05) total VFA than LMT, but did not differ significantly from MT. Lasalocid treatment resulted in higher (P<.0001) LA than other ionophore treatments. No LA was detected in the control. Alterations in VFA profile associated with ionophore treatment included a reduction in the molar proportions of acetate and butyrate and an increase in the molar proportion of propionate. Lasalocid resulted in a lower molar proportion of acetate and higher molar proportion of propionate than the MT treatment (P<.05). Molar proportions of acetate and propionate for LMT were intermediate to those for L and MT treatments, but did not differ significantly from either. The effects of ionophores on ruminal fermentation are thought to be the result of changes in rumen microbial populations. Bacteria sensitive to ionophores include those that produce LA, butyric acid, formic acid, and hydrogen, whereas bacteria producing succinate and propionate are relatively resistent to the effects of ionophores. Reductions in rumen formic acid and hydrogen concentrations result in reduced methane production, thereby increasing efficiency of energy metabolism in the rumen. No significant interactions between fat and ionophore treatments were observed.

Table 5.3. Effects of Ionophore Treatment on VFA Profile, pH, and Lactate Concentration

Treatment	pH[a]	Lactate[a], mM	Total VFA[a], mM	%Acetate[a]	%Propionate[a]	%Butyrate[a]
No ionophore	5.80[b]	.00[b]	168.8[b]	61.6[b]	25.6[b]	12.8[b]
Lasalocid	5.63[c]	.37[c]	177.3[c]	57.9[c]	33.2[c]	8.9[c]
Monensin/Tylosin	5.74[bd]	.11[d]	174.7[cd]	58.6[d]	32.0[d]	9.4[c]
Las/Mon/Tylosin	5.72[d]	.24[e]	173.1[d]	58.3[cd]	32.6[cd]	9.1[c]
SE	.023	.019	1.48	.20	.40	.26

[a]Ionophore effect (P<.001).
[bcde]Means in a column with unlike superscripts differ (P<.05).

The reduction in total VFA and increase in pH resulting from the more saturated fats suggests a potential alteration in the rate of starch digestion, which, in turn, may reduce the incidence of acidosis. Further research should be conducted to verify this observation.

MODERATION OF RUMINAL FERMENTATION BY PROTOZOA IN CATTLE FED HIGH-GRAIN DIETS

T. G. Nagaraja, G. Towne,
and A. B. Beharka

Summary

Ruminal protozoa in cattle fed high-grain diets appear to contribute to the maintenance of a stable ruminal fermentation. This was evidenced by higher ruminal pH's and lower volatile fatty acid concentrations in faunated (with protozoa) than defaunated (without protozoa) cattle. The moderation of fermentation was likely due to reduced bacterial numbers associated with the presence of protozoa.

(Key Words: Acidosis, Fermentation, Protozoa, Rumen.)

Introduction

Ciliated protozoa constitute an important fraction of the total microbial population in the rumen of cattle fed high-grain diets. Although the overall value of protozoa to the ruminant host is a subject of considerable debate, many researchers believe that in animals fed high-grain diets, protozoa play a beneficial role, primarily because of their ability to regulate ruminal lactic acid metabolism. The presence of ruminal protozoa in animals on high-grain diets is associated with decreased accumulation and increased fermentation of lactic acid, suggesting that protozoa contribute to the maintenance of a stable ruminal fermentation. However, evidence to support this theory is lacking. Our study determined the influence of protozoa on ruminal pH, fermentation products, and bacterial numbers in steers fed a high-grain diet.

Experimental Procedures

Six ruminally cannulated steers were assigned randomly to two treatment groups — defaunated (devoid of ruminal protozoa) and faunated (with ruminal protozoa). Cattle were adapted to a high-grain diet (85% corn and 15% alfalfa hay) and fed at 12-hr intervals. All six steers were defaunated by ruminal emptying, omasal flushing, and treatment with an antiprotozoal compound, sodium sulfosuccinate. Then three steers received ruminal fluid inoculum from a faunated donor animal to re-establish protozoa. After 2 wk of adaptation, ruminal contents were sampled just before feeding and at 1, 2, 4, 6, 8, and 12 hr postfeeding and samples were analyzed for pH; fermentation products (lactate, ammonia, and volatile fatty acids); and numbers of total, lactic acid-producing, and lactic acid-fermenting bacteria.

Results and Discussion

Ruminal pH was lower ($P<.01$) in defaunated than faunated steers (5.97 vs 6.45). In both groups, ruminal pH declined following feeding and returned to the prefeeding level at 12 hr. Although there was no treatment × time interaction, the extent of postfeeding decline in ruminal pH tended to be greater in defaunated than faunated steers (Figure 6.1). Ruminal lactic acid concentrations were extremely low in both groups and were not affected by the absence or presence of protozoa (.12 vs .05 mM). Similarly, ruminal ammonia concentrations were not influenced by the protozoa (10.2 vs 9.1 mM). Ruminal volatile fatty acid (VFA) concentrations were significantly higher in the defaunated than faunated steers, and there was a significant treatment × time interaction (Figure 6.2). Therefore, assuming buffering was constant, the difference in total VFA and not lactic acid concentration was responsible for the difference in ruminal pH. Ruminal propionate concentrations were significantly higher in the defaunated than the faunated steers (27.2 vs 12.2 mM). However, ruminal butyrate concentrations were unaffected by the protozoa (8.3 vs 7.4 mM). Total bacterial numbers were about fourfold higher in the defaunated than the faunated steers (Table 6.1), probably because protozoa act as predators of bacteria. Although numbers of lactic acid-producing bacteria (*Streptococcus bovis*, lactobacilli, and starch-fermenters) and lactic acid-fermenting bacteria were not statistically different between the two groups, there was a trend for higher numbers in the defaunated than the faunated group (Table 6.1).

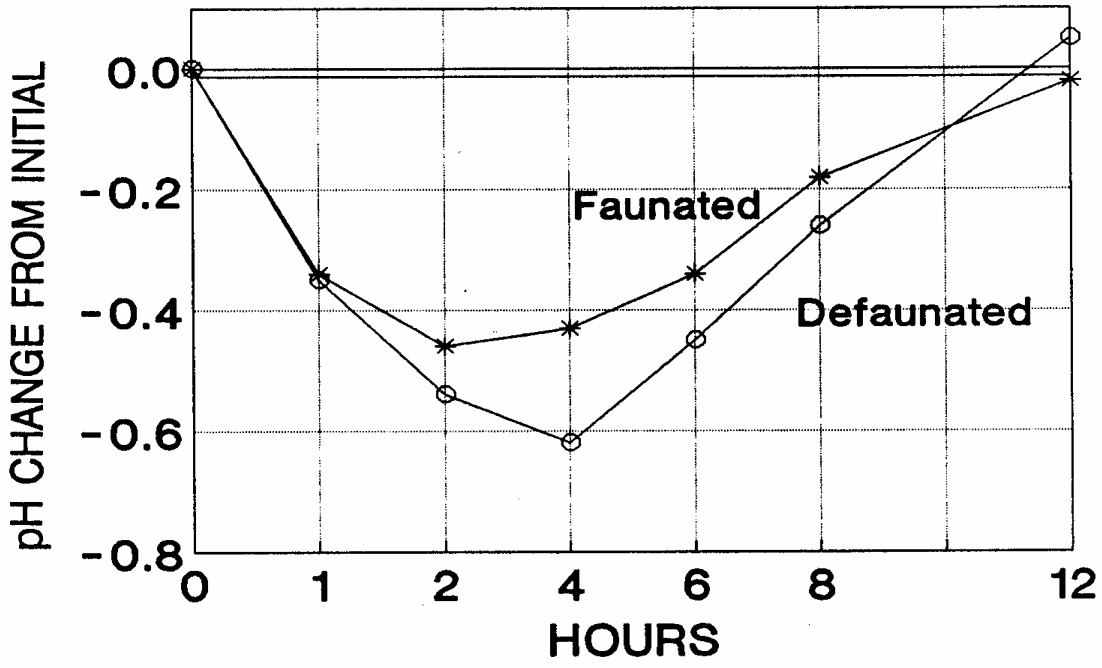

Figure 6.1. Postfeeding Ruminal pH Changes in Defaunated and Faunated Steers Fed a High-Grain Diet

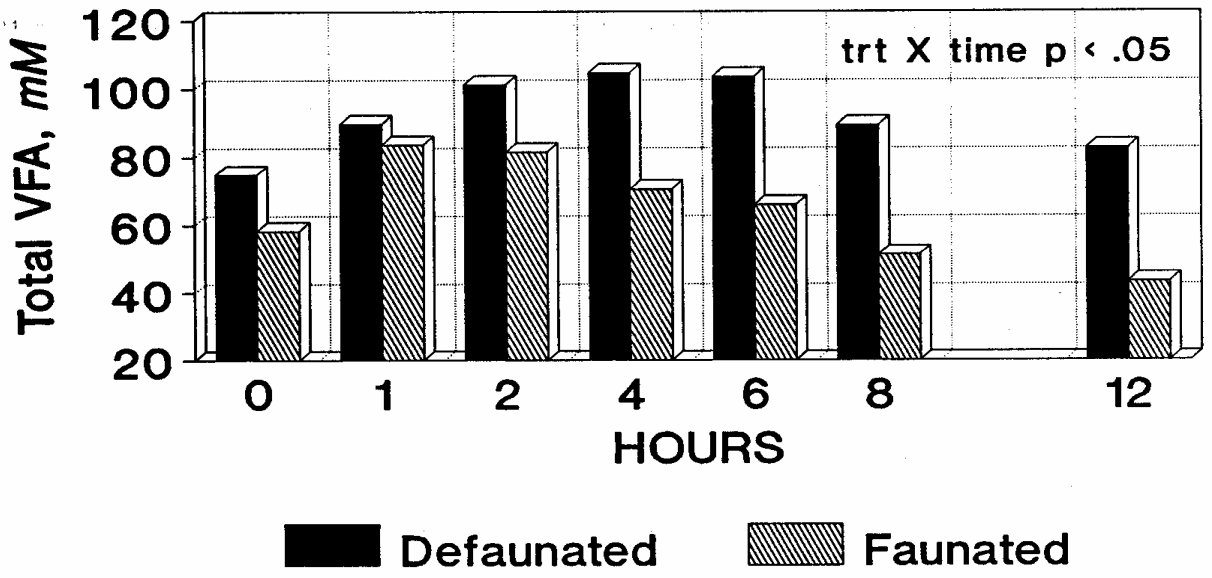

Figure 6.2. **Ruminal Volatile Fatty Acid Concentrations in Defaunated and Faunated Steers Fed a High-grain Diet**

Table 6.1. **Total, Lactic Acid-producing, and Fermenting Bacterial Numbers in Defaunated and Faunated Steers Fed a High-grain Diet**

Bacteria, per g DM	Defaunated	Faunated	P value[a]
Total bacteria, $\times 10^{10}$	13.0	2.9	.10
Streptococcus bovis, $\times 10^{7}$	36.9	23.7	.58
Lactobacillus, $\times 10^{8}$	27.7	8.4	.28
Starch-fermenting, $\times 10^{10}$	10.3	2.3	.11
Lactate-fermenting, $\times 10^{9}$	33.5	14.0	.25

[a]Probability that treatments are statistically similar.

It appears that ruminal protozoa help maintain higher ruminal pH by moderating ruminal fermentation, probably because of decreased bacterial numbers. The effect of protozoa on ruminal pH could have significant impact on overall ruminal metabolism because low pH inhibits bacterial activity.

INFLUENCE OF RUMINAL BUTYRATE SUPPLY ON NET NUTRIENT PRODUCTION AND ABSORPTION IN STEERS

C. R. Krehbiel, D. L. Harmon, and J. E. Schneider[1]

Summary

Six Holstein steers were used to evaluate the effects of increasing ruminal butyrate on net nutrient production and absorption by the gastrointestinal tract and liver. Ruminal and arterial concentrations and net hepatic flux of butyrate increased with increasing butyrate infusion. Concentrations of glucose and α-amino-N in arterial blood decreased as butyrate infusion increased. Of the ruminal butyrate infused, 24.5% appeared in portal blood as butyrate. Acetoacetate, D-β-hydroxybutyrate, and α-amino-N were the nutrients most altered by increasing ruminal butyrate.

(Key Words: Butyrate, Volatile Fatty Acids, Bloodflow, Nutrients, Rumen.)

Introduction

Acetate, propionate, and butyrate are major end products of microbial digestion of dietary carbohydrates in ruminants. These volatile fatty acids (VFA) appearing in portal blood draining the rumen make substantial contributions to the animal's energy supply. Of the three major VFA, butyrate is normally found in the lowest concentration (5 to 15% of the total VFA) in the rumen and is extensively metabolized (70 to 80%) during its absorption into portal circulation by the rumen epithelium. We conducted this experiment to determine if increasing amounts of butyrate in the rumen would alter extraruminal nutrient supplies.

Experimental Procedures

Six Holstein steers (720 to 869 lb) were fitted with permanent catheters in the portal vein entering the liver, in a hepatic vein exiting the liver, in two mesenteric veins, and a mesenteric artery and with a ruminal cannula. The steers were fed a diet consisting of 40% brome hay, 30% corn, and 30% milo in 12 portions daily at 1.25 times their maintenance energy requirements. Approximately 15 to 20 hr prior to sampling, butyrate was infused continuously via the ruminal cannula at 50, 100, 150, 200, and 250 mmol/hr. One steer served as the control. Five sets of hepatic, portal and arterial blood samples were taken at 1 hr intervals on the day of sampling. Portal and hepatic blood flow was determined by a primed continuous infusion of para-aminohippuric acid (PAH) into a small mesenteric vein. Portal and hepatic nutrient flux was calculated as venous-arterial concentration difference multiplied by blood flow. Portal and

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hepatic flux measures the quantities of nutrients that are transferred across the gastrointestinal tract (GIT) and liver, respectively, and are thus available for body maintenance and growth.

Results and Discussion

Ruminal fluid pH tended to decrease ($P<.06$) as the butyrate infusion increased (Table 7.1). Molar concentrations of butyrate increased ($P<.01$) while valerate decreased ($P<.05$) with increasing butyrate. Arterial concentrations of acetate, glucose, and α-amino-N decreased linearly ($P<.05$) as butyrate infusion increased. Acetoacetate, D-β-hydroxybutyrate, and butyrate arterial concentrations increased with increased butyrate infusion.

The effect of ruminal butyrate infusions on net portal and hepatic nutrient flux is reported in Table 7.2. A positive number means that the release or production of a specified nutrient by the GIT (portal flux) or by the liver (hepatic flux) has taken place. On the other hand, a negative number implies that an uptake or utilization has occurred. Increased butyrate produced an increased net portal flux of acetoacetate and butyrate ($P<.01$) and an increased

Table 7.1. Effect of Ruminal Butyrate Infusions on Ruminal Fluid pH, Ruminal VFA Concentration and Arterial Nutrient Concentration in Steers

Item	Control	Butyrate infusion rate, mmol/h 50	100	150	200	250	SE
Ruminal pH	6.65	6.51	6.57	6.58	6.53	6.43	.06
Ruminal VFA, mM							
Acetate	57.78	57.04	59.80	50.72	48.92	54.72	3.23
Propionate	14.94	14.20	15.39	13.49	13.43	14.59	.71
Isobutyrate	.65	.67	.74	.64	.66	.66	.05
Butyrate[a]	7.36	10.21	15.25	16.17	21.83	28.31	1.13
Isovalerate	1.34	1.31	1.28	1.03	1.37	1.31	.12
Valerate[b]	.68	.69	.69	.59	.58	.57	.04
Arterial conc., mM							
Glucose[b]	3.78	3.87	3.63	3.76	3.73	3.50	.09
Insulin(mU/h)	32.28	30.52	30.33	33.14	39.02	39.16	3.77
α-amino-N[b]	2.08	1.94	1.93	1.98	1.90	1.85	.06
Ammonia-N[c]	.076	.109	.094	.095	.101	.082	.008
Urea-N	2.93	3.13	3.10	2.82	2.89	3.01	.20
L-lactate	.62	.62	.56	.60	.52	.61	.05
D-β-hydroxybutyrate[a]	.29	.39	.46	.53	.67	.70	.04
Acetoacetate[b]	.023	.032	.014	.050	.050	.039	.008
Free fatty acids	.069	.066	.063	.053	.050	.055	.008
Acetate[b]	.95	1.01	.92	.88	.88	.86	.04
Propionate	.026	.031	.029	.038	.032	.034	.003
Butyrate[a]	.011	.021	.019	.034	.036	.048	.004

[a]Linear effect, $P<.01$ [b]Linear effect, $P<.05$ [c]Quadratic effect, $P<.05$

Table 7.2. Effect of Ruminal Butyrate Infusions on Net Portal and Hepatic Flux of Nutrients and Insulin in Steers

Item	Control	Butyrate infusion rate, mmol/h 50	100	150	200	250	SE
Bloodflow, l/hr							
Portal	543	501	600	568	566	597	35.0
Hepatic	644	599	722	674	663	720	44.0
Portal flux, mmol/hr							
Glucose	25.7	3.1	-25.8	1.5	7.0	9.3	17.62
Insulin (mU/hr)	2820	2986	2284	2641	4435	902	1747.9
α-amino-N	103.6	82.1	93.6	88.8	80.0	72.3	12.85
Ammonia-N	71.0	73.7	100.6	61.7	75.1	82.5	13.43
Urea-N	-61.7	-39.9	-27.2	-40.6	-49.5	-89.7	23.69
L-Lactate	147.2	12.4	101.0	91.2	119.6	139.1	51.16
D-β-hydroxybutyrate	59.5	42.0	61.1	63.7	63.5	62.4	12.10
Acetoacetate[a]	15.0	15.9	30.7	25.8	24.6	33.5	3.16
Free fatty acids	7.2	9.0	11.2	11.5	8.3	10.9	1.57
Acetate	387.4	290.8	412.0	345.9	292.1	298.7	41.91
Propionate	134.2	111.7	148.6	129.3	122.9	116.4	10.41
Butyrate[a]	29.5	36.5	55.3	68.6	76.5	88.7	5.57
Hepatic flux, mmol/hr							
Glucose	118.1	120.2	184.7	104.1	120.5	105.8	22.81
Insulin (mU/hr)	-3250	-1838	417	1615	-707	-2879	2119.1
α-amino-N[b]	-63.9	-43.1	-58.8	-35.0	-25.9	-28.1	14.05
Ammonia-N	-77.1	-83.5	-117.6	-71.7	-83.3	-88.9	13.09
Urea-N	126.1	97.1	144.0	94.4	94.3	151.3	19.36
L-Lactate	-102.0	-44.6	-84.2	-144.4	-92.8	-139.5	40.06
D-β-hydroxybutyrate[a]	55.9	65.3	105.9	114.0	139.4	156.9	11.96
Acetoacetate[b]	-11.9	-12.0	-22.1	-21.5	-17.0	-24.4	3.43
Free fatty acids	-9.4	-9.5	-7.4	-8.2	-9.4	-9.8	2.51
Acetate	87.8	59.3	103.6	86.9	91.5	102.8	36.23
Propionate	-121.0	-98.7	-131.0	-109.4	-104.1	-97.4	9.50
Butyrate[a]	-23.4	-30.1	-40.8	-46.9	-54.7	-55.1	4.04

[a]Linear effect, P<.01. [b]Linear effect, P<.05.

net hepatic flux of D-β-hydroxybutyrate. Net portal and hepatic fluxes of glucose, ammonia-N, urea-N, lactate, free fatty acids, acetate, and propionate were not affected by ruminal butyrate. Insulin net hepatic flux tended to respond quadratically (P=.08) to increasing butyrate. Acetoacetate and butyrate uptake by the liver increased as butyrate infusion increased. Alpha-amino-N net hepatic flux (uptake) decreased (P<.05) with increasing ruminal butyrate supply. Simple linear regression showed that 24.5% of butyrate appeared in portal blood (r^2=.98) as butyrate, indicating that 75.5% of infused butyrate was metabolized by GIT tissues.

VALUE OF RALGRO® IMPLANTS IN FEEDLOT STEERS PREVIOUSLY MAINTAINED ON A HIGH ENDOPHYTE-INFECTED FESCUE HAY[1]

L. R. Corah, F. K. Brazle[2], F. Blecha[3], P. G. Reddy[3], R. E. Wary, Jr.[4], and J. Klindt[5]

Summary

Steers previously fed high-endophyte fescue hay showed a greater response to Ralgro® implants than those fed a low-endophyte hay. The mode of action for this response was not explained by cellular immune system responses or variability in prolactin levels.

(Key Words: Stockers, Finishing, Endophyte, Fescue, Ralgro.)

Introduction

Tall fescue is an important cool-season forage utilized by Kansas beef producers, with over 700,000 acres in the state. Unfortunately, most fescue pastures contain sufficient endophyte fungus to depress animal performance. Typically, stocker cattle grazed on fescue pastures have been discounted by feedlots in the high plains.

One solution to the problem is renovation of infected pastures by reseeding with endophyte-free varieties. Another solution is to find ways to manage cattle that will allow better use of high-endophyte pastures.

Recent Kansas research has indicated that the response to Ralgro (zeranol) implants is influenced by the endophyte content in fescue, with a greater improvement in average daily gain observed in steers grazing high-endophyte pastures.

The objectives of this study were 1) to determine the effect of Ralgro in feedlot steers that were previously maintained on endophyte-infected hay and 2) to elucidate possible modes of action for the zeranol response.

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[1]Appreciation is expressed to Pitman-Moore, Terre Haute, Indiana, for partial funding of this trial.

[2]Extension Livestock Specialist, Southeast Kansas.
[3]College of Veterinary Medicine.
[4]Cherokee County Extension Agricultural Agent.
[5]Scientist, MARC, Clay Center, NE.

Experimental Procedures

Ninety-six crossbred steers were allotted initially (forage phase) to two treatments: 1) fed to appetite a low (L) endophyte (approximately 20% infestation) hay or 2) fed to appetite a high (H) endophyte (approximately 80% infestation) hay and fescue seed mixture (Table 8.1).

After 73 d on the L or H hay diets, the steers were re-allotted within hay treatments to a 65-d feedlot trial (Table 8.2). At the start of the feedlot trial, half of the steers on each hay treatment were implanted with 36 mg of zeranol.

To determine if the Ralgro implants influenced the animals' immune systems, blood samples were taken from 24 steers (six head per implant and hay treatment) at the start of the feedlot phase and 28 d later. From these samples, lymphocyte proliferation responses to phytohemagglutin (PHA), concanavalin A (Con A), and pokeweed mitogen (PWM) were determined. Lymphokines, such as interlukin 2 (IL-2), which are physiologically active proteins or glycoproteins, are secreted by antigen-sensitized T-cells and can be used to evaluate immune function. Yet another indicator of immune system response is the percentage specific lysis of virus-infected cells (% SL). Potential influ-

Table 8.1. Nutrient Analysis of Hay and Seed Fed during the Forage Phase

Item	Low endophyte hay	High endophyte hay	High endophyte seed
Dry matter, %	8.5	8.5	9.2
Crude protein, %	8.0	9.1	12.8
Crude fiber, %	32.7	34.0	23.8
Acid detergent fiber, %	36.9	40.9	30.3
Calcium, %	1.06	.88	.62
Phosphorus, %	.24	.19	.33

Table 8.2. Ingredient Composition of Feedlot Diets

Ingredient	Starter ration[a], % of DM	Final ration, % of DM
Grain sorghum	28.6	78.4
Forage sorghum silage	62.3	16.2
Soybean meal	3.9	—
Protein supplement[b]	5.2	5.4

[a]Steers were offered 10 lb prairie hay/head/day the first day and then over 3 d adapted to silage-based diet. Starter ration was gradually adjusted over 32 d to reach the level of concentrate in the final ration.

[b]Composition: 65.4% soybean meal, 19.3% limestone, 5.25% salt, 5% urea, 3.53% potassium chloride, 1.0% soybean oil, .35% Z-10® trace mineral and .175% Vitamin A-30®.

ences on the endocrine system were determined using prolactin hormone levels obtained from blood samples taken at the start of the forage phase and at 3-d intervals at the beginning of the feedlot phase. Body temperatures, indicators of endophyte stress, were monitored during the trial.

Results and Discussion

During the forage (hay) feeding phase, steers on the high endophyte hay lost more weight (−.54 vs −.19 lb/d) and had an increased body temperature at the end of the 73-d hay feeding period. Blood prolactin was 734 ng/ml at the start of the trial and was suppressed to an average of 23.9 ng/ml in steers across both hay treatments.

During the 65-d feedlot period, steers previously fed the high endophyte hay showed a greater response to Ralgro (.49 vs .20 lb/d) than steers previously fed the low endophyte hay (Table 8.3). However, this implant response was not explained by differences in the animals' cellular immune functions (Table 8.4) or by differences in serum prolactin levels.

Table 8.3. Effect of Fescue Hay Endophyte Level on Animal Performance and Subsequent Response to Ralgro Implants during the Feedlot Period

Item	Level of endophyte in the hay	
	Low	High
Forage phase—73 d		
Starting wt, lb	674.3	673.4
Daily weight change, lb	−.19[b]	−.54[a]
Body temp at end of trial, °F	100.3[b]	101.4[a]
Blood prolactin, ng/ml[1]	32.6[a]	15.2[b]

	Control	Implanted	Control	Implanted
Feedlot phase—65 d				
Daily gain, lb	2.17[a]	2.37[ab]	2.48[b]	2.97[c]
Body temp at 28 d, °F	102.2	102.2	102.4	102.4
Blood prolactin, ng/ml[2]	16.6[a]	25.0[ab]	35.9[b]	25.0[ab]

[1]Average of two sampling times.
[2]Average of six sampling times.
[abc]Values in a row without a common superscript differ ($P<.05$).

Table 8.4. Effect of Hay Endophyte Level and Ralgro Implants on the Animals' Cellular Immune Systems

Item	Low endophyte hay		High endophyte hay	
	Control	Ralgro	Control	Ralgro
Mitogen[1]				
Con A	64	176	57	129
PHA[2]	276	204	194	202
PWM[2]	226[a]	150[b]	196[ab]	212[ab]
% SL	6.7	7.9	3.6	5.3
IL-2, U/ml	6.5	14.4	7.9	5.3

[1]See text for discussion of mitogens.
[2]Net CPM× 10^3.

VALUE OF RICE MILL FEED AS A FEEDSTUFF FOR BACKGROUNDING HEIFERS

F. K. Brazle[1] and K. P. Coffey[2]

Summary

Stocker heifers were fed diets of either 67% rice mill feed + 33 % dehydrated alfalfa pellets (RA) or a 67% grain sorghum + 33% dehydrated alfalfa pellets (GA). The RA heifers consumed more feed daily but gained slower ($P<.05$), resulting in poorer feed efficiency. RA heifers also had a lower percentage shrink ($P<.05$) during the first 2 1/2 hr of simulated trucking. Rice mill feed is a poor feedstuff for growing calves when included in rations at high levels.

(Key Words: By-products, Rice Mill Feed, Backgrounding.)

Introduction

Many by-products have been fed to growing cattle, often with variable results. Rice mill feed is a by-product that contains about 40% rice bran and 60% rice hulls. Our objective was to evaluate the nutritional value of rice mill feed in a backgrounding ration.

Experimental Procedures

Twenty-four heifers averaging 607 lb were randomly allotted to diets of either 67% rice mill feed + 33% dehydrated alfalfa pellets (RA) or 67% ground grain sorghum + 33% dehydrated alfalfa pellets (GA). Four heifers were assigned per pen (200 ft^2/head) with three pens per treatment. They were fed to appetite for 60 d on the diets shown in Table 9.1, along with a 50% salt and 50% ground limestone mineral mix fed free-choice.

Table 9.1. Composition of Heifer Growing Rations

Ingredients	Rice mill feed + alfalfa	Grain sorghum + alfalfa
	lb per ton	
Rice mill feed	1,330	—
Grain sorghum	—	1,330
Dehydrated alfalfa pellets	660	660
Salt	10	10

The starting and ending weights were obtained after the heifers had been held off feed for 12 hr. At the end of the trial, the heif-

[1]Extension Livestock Specialist, Southeast Kansas.
[2]Beef Research Scientist, Southeast Kansas Experiment Station.

ers were weighed at 7:30 A.M., placed in a tight pen without feed or water, and individually weighed every 2 1/2 hr for 10 hr to simulate trucking shrink.

Dry matter digestibility, as well as rate and extent of digestion, were determined by in vitro techniques. The samples were analyzed for crude protein, neutral detergent fiber, acid detergent fiber, and acid detergent lignin. Data were subjected to analysis of variance, and results are reported as least squares means.

Results and Discussion

The RA heifers gained slower ($P<.05$), consumed 27% more feed, and had much poorer ($P<.05$) feed conversions than the GA heifers (Table 9.2). The rice mill feed contained more fiber and lignin and a lower 48-hr dry matter digestibility than either grain sorghum or alfalfa pellets (Table 9.3). The digestible fraction of rice mill feed was degraded fairly rapidly (less than 6 hr, Figure 9.1), which partially explains the excellent feed intake of heifers fed the RA diet. However, the total digestibility of rice mill feed was too low for economical stocker gains, when fed at the level used in this trial.

Table 9.2. Effect of Diet on Heifer Performance and Simulated Trucking Shrink

Item	Rice mill feed + alfalfa	Grain sorghum + alfalfa
No. heifers	12	12
Starting wt, lb	602	612
Daily gain, lb	.90[a]	1.63[b]
Daily intake, lb	16.53[a]	13.03[b]
Feed/gain	18.7[a]	7.97[b]
Shrink, %		
First 2.5 hr	3.41[a]	3.98[b]
Second 2.5 hr	1.35	1.75
Third 2.5 hr	1.50	1.21
Fourth 2.5 hr	1.82	1.50
Total 10 hr	8.09	8.46

[ab]Means in a row with unlike superscripts differ ($P<.05$).

During the first 2 wk of the trial, the GA heifers showed signs of lactic acidosis, and one heifer was treated for this condition. The rapid rate of digestion of the grain sorghum (Table 9.3 and Figure 9.1) would explain the acidosis and could also explain the lower intake of the GA diet.

Both groups were fed 2 lb per head daily of long-stem prairie hay on days 48, 52, and 56 of the trial because of bloat. This would suggest that the roughage factor in both diets was not sufficient to sustain good rumen function. Even though the acid detergent fiber level of rice mill feed was similar to that of many roughages in cattle rations, the small particle size of this feed may limit its value as a roughage.

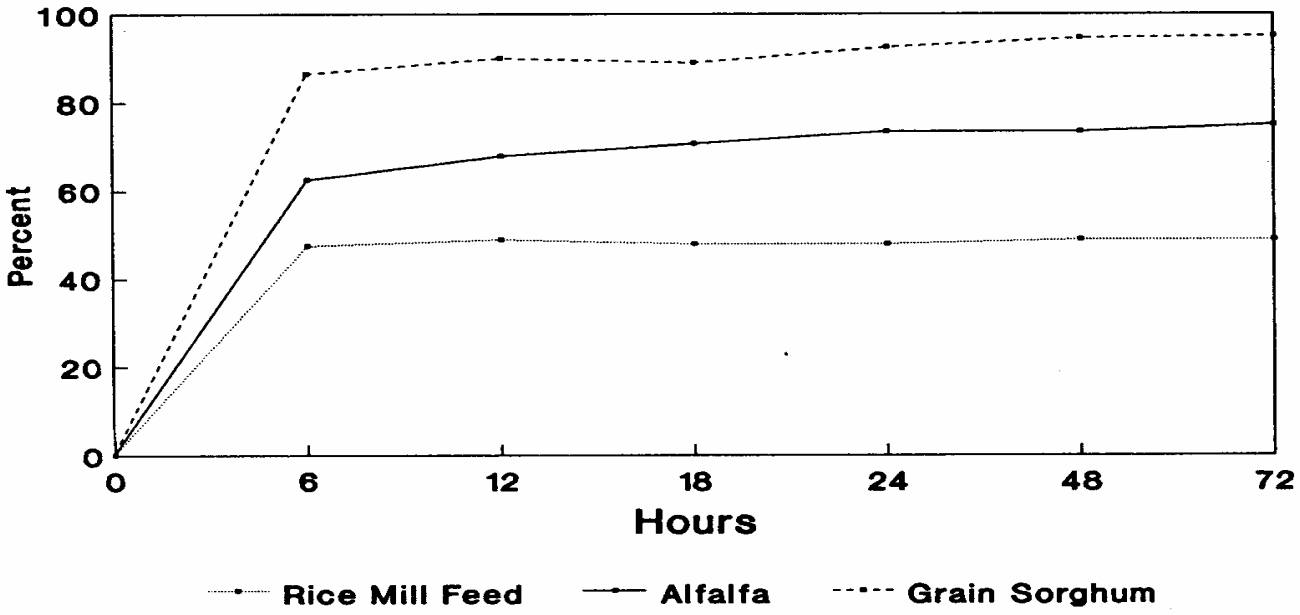

Figure 9.1. In Vitro Rate of Digestion of Feedstuffs

Table 9.3. Chemical Composition and In Vitro Digestibility of Feedstuffs

Item	Dehy alfalfa	Grain sorghum	Rice mill feed
Neutral detergent fiber, %	42.57	15.72	55.24
Acid detergent fiber, %	31.20	5.52	38.78
Acid detergent lignin, %	6.52	.87	8.77
48-hr DM digestibility, %	74.80	94.50	49.40
Digestion rate, %/hr	6.03	5.79	.91

ASPIRATED OAT LIFTINGS FOR GROWING CALVES

R. T. Brandt, Jr., G. L. Kuhl, F. K. Brazle[1], L. R. Corah, and R. V. Pope

Summary

Feed value of aspirated oat liftings (AOL), a by-product of the oat milling industry, was evaluated by using it to replace 33, 67, or 100% of 36 lb/bu oats in a growing diet fed to heifers. Ammonia treatment of AOL was also tested. Dry matter intake and feed/gain increased linearly (P<.10) with increased AOL. Daily gains were similar for 33, 67, and 100% AOL inclusions, which were lower (P<.01) than the control (0% AOL). Despite lower performance, cheaper costs of production may be achieved with AOL depending on its price relative to other feedstuffs. Ammonia treatment of AOL had no beneficial effect on heifer performance in this study.

(Key Words: Oats, By-products, Ammoniation, Growing.)

Introduction

Cow-calf producers and backgrounders must continually evaluate locally available feed by-products to reduce production costs and maintain profitability. Aspirated oat liftings (AOL), a by-product of the oat milling industry sometimes referred to as "bulk jeminas," offers potential as a dietary energy source for cattlemen in proximity to oat milling plants. Relative to normal oats, AOL contains more fiber and ash and less energy, which reflect the high content of lightweight grain, chaff, and other debris. Although AOL generally can be obtained at a considerable cost savings, the feeding value of this material has not been evaluated. Further, because of the relatively high fiber content, it was of interest to see if oat liftings would respond to ammonia (NH_3) treatment. Therefore, we conducted a study to evaluate the feeding value of non-treated or NH_3-treated AOL in growing diets for cattle.

Experimental Procedures

Aspirated oat liftings were trucked to Manhattan from an oat milling facility in St. Joseph, Missouri, split into two lots, and stored in Ag-Bags®. One bag was treated with anhydrous NH_3 (3% of weight) and was allowed to react for one month before feeding.

Eighty heifer calves with an average starting weight of 680 lb were blocked by weight to 10 pens (8 heifers per pen, two pens per treatment). Untreated AOL replaced 33, 67, or 100% of 36 lb/bu oats in the test diets (Table 10.1); control diet was 100% oats. To test the

[1]Southeast Area Extension Office, Chanute.

Table 10.1. Composition of Diets[a]

Ingredient	Ratio of oats to oat liftings				
	100: 0	67: 33	33: 67	0: 100	0: 100 (NH_3)
Sorghum silage	30	30	30	30	30
Oats (36 lb)	57	38	19		
Aspirated oat liftings		19	38	57	
NH_3-treated liftings					57
Supplement	13	13	13	13	13
Ration cost, $/ton[b]	58.36	52.06	45.98	40.12	40.90

[a]Dry basis. Diets formulated to contain 12% CP, .5% Ca, .3% P and .8% K.
[b]Using prices of $5.50, $2.50 and $3.25 per cwt for oats, aspirated oat liftings and NH_3-treated aspirated oat liftings, respectively.

ammoniated product, a fifth diet was formulated in which all the grain was ammonia-treated AOL. Daily gain, dry matter intake, and feed efficiency were measured over a 60-d period.

Results and Discussion

Aspirated oat liftings contained less protein and more fiber and ash than the control oats used in this study (Table 10.2). Ammonia treatment of AOL increased crude protein and reduced NDF contents by 8.1 and 8.2 percentage units, respectively, suggesting that effective ammonia treatment had been accomplished. Bulk density of AOL used in this study averaged about 24 lb/bu, or 65% of the density of the 36 lb control oats.

Table 10.2. Chemical[a] and Physical Parameters for Oats and Aspirated Oat Liftings

Item	Oats	Aspirated oat liftings	
		Nontreated	3% NH_3
Crude protein, %	12.9	11.1	19.2
NDF, %	43.0	53.1	44.9
ADF, %	27.1	30.8	29.3
TDN, %[b]	69.0	66.6	67.5
Ash, %	4.0	5.1	5.2
Bulk density, lb/bu	36.8	23.5	24.0

[a]Dry matter basis.
[b]Estimated from ADF content.

Table 10.3. Performance of Heifers Fed Oats or Aspirated Oat Liftings

Item	Ratio of oats to oat liftings				
	100: 0	67: 33	33: 67	0: 100	0: 100 (NH_3)
Initial wt, lb	680	680	680	680	681
Daily feed, lb DM[a]	18.1	18.9	19.7	20.7	20.4
Daily gain, lb[b]	2.87	2.57	2.63	2.55	2.41
Feed/gain[a]	6.31	7.41	7.49	8.13	8.46
Feed costs, $					
per head	48.75	45.44	41.81	38.33	38.88
per lb gain	.283	.295	.265	.251	.265

[a]Linear effect of aspirated oat liftings level ($P \leq .10$).
[b]Control vs AOL (trt 1 vs trt 2,3,4; $P < .01$).

Dry matter intake increased linearly ($P \leq .10$) with increased AOL in the diet (Table 10.3). Feeding AOL may exert a laxative effect, similar to other fibrous by-product feeds (rice bran, cottonseed hulls, soybean hulls). Alternatively, AOL may have diluted dietary energy concentration, resulting in increased intake. Daily gains were 8 to 11% greater ($P < .01$) for heifers fed oats vs untreated AOL. Level of AOL (from 33 to 100% replacement) did not affect daily gain. Gains were lowest with the NH_3-treated AOL diet. Efficiency of feed conversion decreased linearly ($P < .06$) with increased AOL, but total feed costs per head and per unit of gain decreased for the 67 and 100% AOL diets, because of the large price difference between oats and oat liftings. Using feed conversion as an index, AOL was 28 to 30% lower in feed value than oat grain. This substantial difference in feed value is at odds with the small 2.4 percentage unit difference in calculated TDN of oats vs AOL, based on ADF content (Table 10.1), and illustrates the shortcoming of using fiber content alone to estimate the energy value of certain by-product feeds.

Within the constraints of this experiment, it appears that oat liftings can be used successfully at up to 60% of the ration dry matter in growing diets. Although not tested in this experiment, higher levels of inclusion may result in inordinately high feed consumption, poorer efficiency, and higher costs of production. Further, the low bulk density of this and other milling by-products increases freight cost per unit, negating price advantages if shipping distance is great. Ammoniation of AOL produced no performance benefit and was not cost effective in this study.

PERFORMANCE OF STEERS LIMIT-FED IN DRYLOT OR ON MATURE NATIVE PASTURE[1]

F. K. Brazle[2] and G. L. Kuhl

Summary

Growing steers were limit-fed the same amount of a grain- and silage-based ration either in drylot or on dormant native range. The steers wintered on pasture gained 14.2% slower (1.82 vs 2.08 lb/d; P<.01) and were 15.3% less efficient than those in drylot, apparently because of increased energy expenditure from voluntary exercise.

(Key Words: Mature Grass, Drylot, Growing, Limit Feeding.)

Introduction

Winter pasture is often viewed as a "free" loafing area, offering convenience and freedom from mud, compared to drylot feeding. However, allowing cattle to roam large pastures can result in greater energy needs for maintenance because of unlimited exercise. The objective of this trial was to compare the performance of growing steers fed a medium energy ration on dormant pasture or in drylot.

Experimental Procedures

Two hundred twelve mixed-breed steers were allotted randomly to either a drylot or pasture group. Both groups were limit-fed a grain- and silage-based ration (Table 11.1) twice a day, 2 hr apart, in concrete bunks and were limited to about 80% of their estimated "full-feed" intake. Both groups were fed the same amount of mixed ration per head daily during the 112-d trial. Unheated drinking water was provided to both groups. The drylotted cattle were fed in well-drained pens with 675 sq. ft of space per head, so mud was not a problem. The pasture-fed steers were allowed access to a 320-acre pasture of dormant native tall grass. The pasture was stocked at the rate of 3 acres per steer.

Results and Discussion

The drylot-fed steers out-gained those fed on dormant native grass pasture by .26 lb per head daily (P<.01), even though both groups were fed the same level of mixed ration during the 112-d trial. Although the amount of grass consumed was not measured, our results suggest

[1]Sincere appreciation is expressed to Tom Moxley, Council Grove, for providing cattle, facilities, and assistance in data collection.

[2]Extension Livestock Specialist, Southeast Kansas.

that standing, mature, native grass has little value in a backgrounding program. The reason steers on pasture gained slower and required over 15% more feed per pound of gain than those in drylot was likely the differences in maintenance requirements. The drylot steers had limited exercise, whereas the pasture steers roamed freely over the half-section pasture.

Early research by Ed Smith at KSU showed similar results when calves were fed to gain about .50 lb per head daily either in drylot or on dormant winter pasture. However, wintering cattle in drylot can be a problem if lots become muddy; then the reduction in gain because of mud could be greater than that caused by unlimited exercise. The importance of clean, well drained drylots to optimize growing cattle performance is emphasized.

Table 11.1. Limit-Fed Ration Composition and Analysis

Ration mixture, as-fed basis	
46.5%	Corn silage
47.5%	Ground grain sorghum
6.0%	40% Protein supplement with Rumensin (R-250)
Estimated composition, dry matter basis[1]	
64.9%	Dry matter
81.0 Mcal/cwt	Estimated net energy for maintenance
51.3 Mcal/cwt	Estimated net energy for gain
74.8%	Estimated TDN
12.2%	Crude protein
9.0%	Crude fiber
.45%	Calcium
.30%	Phosphorus

[1]Ration formulated based on analysis of individual feeds.

Table 11.2. Performance of Steers Limit-Fed in Drylot or on Dormant Pasture

Item	Drylot	Pasture
No. steers	106	106
Starting weight, lb	497.5	487.7
Average weight maintained during wintering period	615.0	592.7
Daily gain, lb	2.08[a]	1.82[b]
Daily ration intake:		
As-fed, lb	20.9	21.1
Dry matter, lb	13.6	13.7
Feed dry matter/gain	6.52	7.52

[ab]Means in a row with unlike superscripts differ (P<.01).

LEUKOTOXIN PRODUCTION BY *FUSOBACTERIUM NECROPHORUM* BIOTYPES

Z. Tan, T. G. Nagaraja,
and M. M. Chengappa[1]

Summary

Fusobacterium necrophorum biotypes A and B were grown anaerobically to detect their leukotoxin production. Both biotypes exerted the highest leukotoxic effect on bovine leukocytes in the late logarithmic and early stationary growth phases. Biotype A produced more leukotoxin than biotype B throughout all phases of bacterial growth. Results are consistent with the findings that biotype A is more virulent than biotype B.

(Key Words: Leukotoxin, *F. necrophorum*, Biotype, Growth Phase, Liver Abscesses.)

Introduction

Liver abscesses in feedlot cattle result in condemnation of over three million livers annually. The principal causative agent is *F. necrophorum*, a normal inhabitant of the rumen. This bacterium secretes leukotoxin, a substance that kills leukocytes and suppresses the body defense functions, allowing the establishment of the bacterium in the liver. Therefore, leukotoxin may be an important factor contributing to the pathogenesis of liver abscesses in cattle.

Two biotypes of *F. necrophorum* have been described. Biotype A is found most frequently in liver abscesses. Biotype B, which predominates in ruminal contents, is also isolated from liver abscesses. However, it is usually found in mixed infections and is considered less pathogenic than biotype A. We determined leukotoxin production of both biotypes in different growth phases.

Experimental Procedures

F. necrophorum biotypes A 25 and B 35 were isolated previously from liver abscesses collected at a packing plant. Bacteria were grown aerobically in brain heart infusion (BHI) broth. Samples were collected at 0, 2, 4, 6, 8, 10, 12, 30, and 45 hr for measurements of growth (colony counts) and for assay of leukotoxin production.

Culture supernatants prepared by centrifugation were used for leukotoxin assay. Polymorphonuclear neutrophil (PMN) leukocytes were isolated from cattle blood and labeled with ^{51}Cr-sodium chromate. Labeled cell suspensions were mixed with culture supernatants,

[1]KSU Department of Laboratory Medicine.

incubated for 2 hr, and centrifuged. Supernatants were harvested by an automatic supernatant collection system. The release of radioactivity into the supernatant, indicating leukotoxicity (percentage of cell lysis), was measured in a gamma counter.

Results and Discussion

The leukotoxicities of biotypes A and B at different stages of growth are shown in Figure 12.1. Both biotypes A and B showed the same trend of toxin production in relation to bacterial growth. The percentage of toxicity increased with increasing bacterial growth, was highest at the late logarithmic and early stationary growth phases, and then began to decline. Leukotoxicity completely disappeared after 30 hr incubation, implying that bacteria possibly secreted proteolytic enzyme(s) that destroyed the toxin.

Biotype A produced more leukotoxin than biotype B at both the logarithmic and stationary growth phases. This may be one of the reasons why biotype A is more virulent and more frequently encountered in liver abscesses.

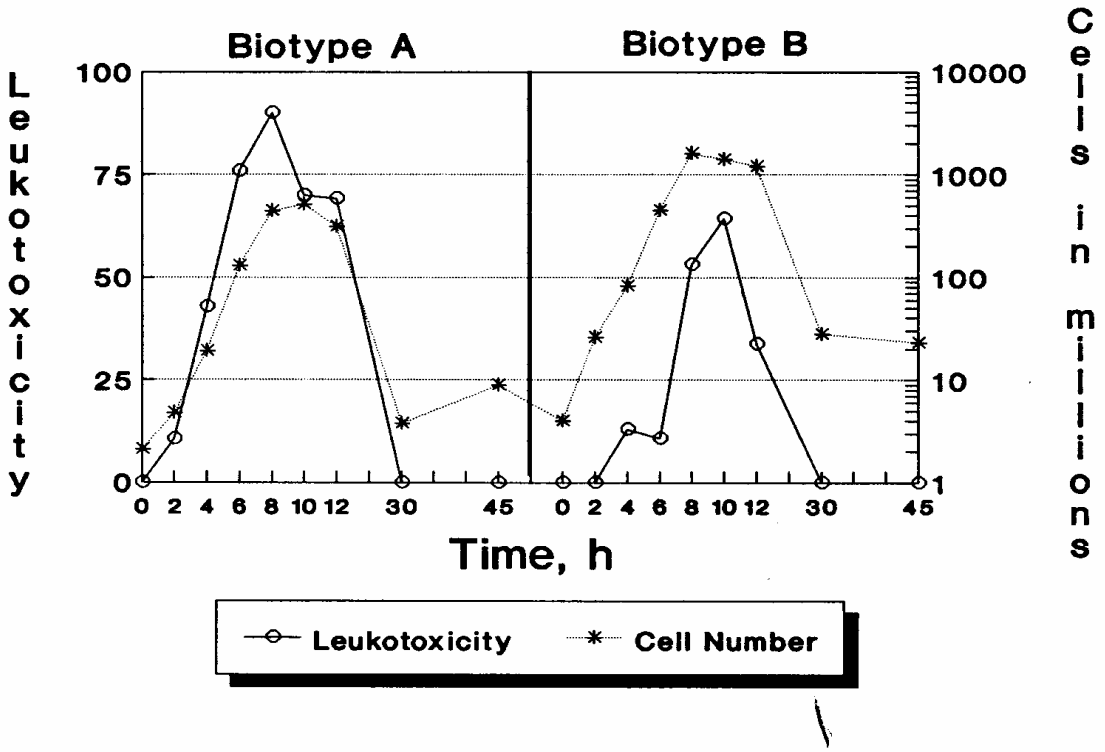

Figure 12.1. Leukotoxin Production in *Fusobacterium necrophorum* Biotypes A and B

EFFECTS OF FINAPLIX®, SYNOVEX-S®, AND RALGRO® IMPLANTS, SINGULARLY OR IN COMBINATIONS, ON PERFORMANCE, CARCASS TRAITS, AND LONGISSIMUS PALATABILITY OF HOLSTEIN STEERS[1]

J. K. Apple, M. E. Dikeman, D. D. Simms, C. L. Kastner, and G. L. Kuhl

Summary

Over the entire feeding period (249 d), Finaplix® (F) plus Synovex-S® (S)-implanted steers had higher (P<.05) daily gains than F+Ralgro® (R), F, and control (C) steers. All treatments produced higher (P<.05) daily gains than C, with the exception of F. The only feed efficiency differences were during the fourth implant period, when F steers were more (P<.05) efficient than F+R or C steers. The F+S and F+R steers had higher (P<.05) masculinity scores than S and C steers. Carcasses of F+S steers were heavier (P<.05) than those of F and C steers. The F+S steers had larger (P<.05) ribeyes than R, F, and C steers. Also, F+S steers tended (P=.07) to have lower yield grades than S, R, or C steers. Even though marbling scores and quality grades were similar (P>.05) among treatments, only 50% of F+S carcasses graded low Choice or higher compared to a range of 75 to 100% for the other treatments. The only meat palatability differences were tenderness scores; steaks from S and F+R steers were less tender (P<.07) than those from R and C steers.

(Key Words: Holsteins, Implants, Performance, Carcass Traits, Meat Palatability.)

Introduction

Consumer demand for beef with little "waste" fat and adequate "taste" fat has increased cattle industry interest in feeding Holsteins. A high percentage of Holstein carcasses grade Choice with desirable fat thickness but have a low muscle-to-bone ratio and small ribeyes in comparison to beef breeds.

Finaplix (F), an implant containing the androgenic anabolic-steroid, trenbolone acetate, has been shown to increase muscle-to-bone ratio and ribeye area and to decrease fat thickness and marbling in beef breeds. This is particularly true when it is combined with an estrogenic implant such as Ralgro (R) or Synovex-S (S). Therefore, our objectives were to determine the effects of serial implanting Holstein steers with F, R, or S, as well as combinations of F+R and F+S, on (1) animal performance and masculinity; (2) carcass traits; and (3) ribeye steak palatability.

Experimental Procedures

Seventy-two Holstein steers (3 to 5 mo of age) with an average weight of 400 lb were weighed and allotted to pens of four steers each. Pens were assigned randomly to one of six treatments: (1) non-implanted controls (C); (2) implanted with R; (3) implanted with S; (4)

[1]Partial funding provided by Pitman-Moore, Terre Haute, Indiana.

implanted with F; (5) implanted with R and F in opposite ears; and (6) implanted with S and F in opposite ears. Steers were reimplanted on days 56, 112, and 168 of the feeding trial.

Steers were fed increasing proportions (six steps) of concentrate for 77 d; the final diet consisted of 76% rolled milo, 18% sorghum silage, and 6% supplement. Steers were fed to appetite twice daily for a total of 249 d. Two steers died, and one steer was removed for reasons not related to the treatments.

Steers were scored for masculinity (1=steer and 5=very masculine) 24 hr before slaughter. Cattle were slaughtered at the Excel Corp. packing plant in Dodge City, Kansas. USDA quality and yield grade data were obtained at 24 h postmortem. Ribs were removed and shipped to the K.S.U. Meats Laboratory and aged until 6 d postmortem. One-inch-thick ribeye (RE) steaks were removed for sensory panel evaluations and Warner-Bratzler shear force determinations.

Results and Discussion

Average daily gain and feed efficiency data are presented in Table 13.1. During the second implant period (from 56 d to 112 d), F+S steers gained faster ($P<.05$) than F, R, and C steers, but not S and F+R steers. The S and F+R steers also gained faster ($P<.05$) than C steers. No significant differences were observed in ADG among treatment groups during the third and fourth implant periods. Over the entire feeding period (249 d), the F+S group had a higher ($P<.05$) ADG than F+R, F, and C groups; the C group gained slower ($P<.05$) than all groups with the exception of the F group.

Table 13.1. Effects of Implant Treatments on Average Daily Gains and Feed Efficiency of Holstein Steers at Specified Implant Periods

Item	C[a]	F	R	S	F+S	F+R
Average daily gain, lb						
0 to 56 d	3.06[c]	3.48[b]	3.37[b]	3.37[b]	3.65[b]	3.54[b]
56 to 112 d	3.45[d]	3.61[cd]	3.70[cd]	3.89[bc]	4.09[b]	3.85[bc]
112 to 168 d	2.55	2.51	2.75	2.62	2.86	2.75
168 to 249 d	1.98	2.09	2.27	2.24	2.18	1.98
0 to 249 d	2.68[d]	2.84[cd]	2.95[bc]	2.95[bc]	3.08[b]	2.93[c]
Feed/gain, DM basis						
0 to 56 d	5.4	5.1	5.0	4.7	4.7	4.9
56 to 112 d	5.7	5.6	5.6	5.3	5.5	5.8
112 to 168 d	7.6	7.7	7.6	7.9	7.7	7.9
168 to 249 d	9.3[bc]	8.2[d]	8.4[cd]	9.2[bcd]	8.9[bcd]	9.9[b]
0 to 249 d	6.9	6.5	6.5	6.6	6.5	6.9

[a]C=Control; F=Finaplix; R=Ralgro; S=Synovex-S.
[bcd]Mean values in the same row with different superscript letters differ ($P<.05$).

There were no significant differences in feed-to-gain ratios among treatment groups during the first three implant periods. However, during the last implant period, F steers gained more ($P<.05$) efficiently than F+R or C steers. Also, R steers were more efficient ($P<.05$) than F+R steers. Control, S, F+S, and F+R treatment groups had similar feed conversions.

Masculinity scores, carcass traits, and sensory panel characteristics are presented in Table 13.2. Steers implanted with F+S and F+R were more ($P<.05$) masculine than S and C steers; F and R steers were intermediate in masculinity. Carcasses of R, S, and F+S steers were heavier ($P<.05$) than those of F and C steers. Carcasses of F+R steers were heavier ($P<.05$) than those of C steers but were not different from those of F steers. F+S steers had larger ($P<.05$) ribeyes than R, F, and C steers; ribeyes of F+R, F+S, and S steers were similar. Marbling scores and quality grades were not affected by implant treatment. However, only 50% of the F+S carcasses graded low Choice or higher, compared with 75 to 100% Choice for the other treatments.

Implanting had no effects on flavor, juiciness, detectable connective tissue or off-flavors. However, sensory panel scores for tenderness tended ($P=.07$) to be lower for steaks from S and F+R steers than steaks from R and C steers.

Table 13.2. Effects of Implant Treatments on Masculinity, Quality Traits, Yield Grade Traits, and Palatability Characteristics of Holstein Steers

Item	C[a]	F	R	S	F+S	F+R
Masculinity score[b]	1.5[f]	1.9[ef]	1.7[ef]	1.5[f]	2.1[e]	2.0[e]
Quality grade[c]	226	227	219	207	200	213
Choice, %	100	75	82	90	50	83
Dressing percent	59.6	59.1	60.0	60.2	60.0	59.7
Carcass wt, lb.	638[g]	654[fg]	681[e]	691[e]	700[e]	675[ef]
Fat thickness, in.	.27	.22	.29	.28	.23	.27
Ribeye area, in^2	10.3[g]	11.1[fg]	10.9[fg]	11.2[ef]	12.0[e]	11.4[fg]
Kidney knob, %	2.96	3.38	3.01	2.94	2.54	2.75
USDA yield grade	3.0[i]	2.8[hi]	3.0[i]	2.9[i]	2.5[h]	2.7[hi]
Shear force, lb	8.8	9.0	8.8	8.7	9.5	9.6
Flavor intensity[d]	6.1	6.1	6.2	6.0	5.9	5.9
Juiciness[d]	5.9	6.1	6.1	5.6	5.7	5.7
Tenderness[d]	6.5[h]	6.3[hi]	6.6[h]	6.1[i]	6.3[hi]	6.1[i]

[a]C=Control; F=Finaplix; R=Ralgro; S=Synovex-S.
[b]1=steer; 2=slightly masculine . . . 5=very masculine.
[c]0-99=USDA Standard; 100-199=USDA Select; 200-299=USDA Choice.
[d]1=extremely bland, extremely dry and extremely tough . . . 5=slightly intense, slightly juicy and slightly tender . . . 8=extremely intense, extremely juicy and extremely tender.
[efg]Mean values in the same row with different superscript letters differ ($P<.05$).
[hi]Mean values in the same row with different superscript letters differ ($P=.07$).

EVALUATION OF ATTRIBUTES AFFECTING TENDERNESS DIFFERENCES BETWEEN *BOS TAURUS* AND *BOS INDICUS* CATTLE[1]

G. Whipple[2], M. Koohmaraie[2], M. E. Dikeman, J. D. Crouse[2], M. C. Hunt, and R. D. Klemm[3]

Summary

Biological tenderness differences between longissimus muscles from 3/8 and 5/8 Sahiwal (*Bos indicus*) × Hereford-Angus and from Hereford-Angus (*Bos taurus*) were evaluated. No significant breed cross effects were observed for carcass traits or rates of pH and temperature decline. Loin steaks from Hereford × Angus had lower ($P<.05$) shear-force values and higher ($P<.05$) taste panel tenderness scores at 1 and 14 d postmortem. No breed effects existed for muscle fiber sarcomere length, muscle fiber type, muscle collagen, cathepsin enzyme activity, or calcium-dependent protease-I and -II activity. However, calcium-dependent protease inhibitor activity at 24 hr postmortem was greater ($P<.01$) in Sahiwal-crosses than for Hereford-Angus. Less protein degradation, which causes tenderization during aging, occurred in Sahiwal-crosses by d 14 than in Hereford-Angus at d 1 postmortem. Therefore, mechanisms involving calcium-dependent protease and its inhibitor may be the principal factors causing tenderness differences between *Bos indicus* and *Bos taurus* breeds.

(Key Words: Beef, Tenderness, *Bos indicus*, Calcium-dependent Protease, Inhibitor.)

Introduction

Bos indicus breeds are often used in crossbreeding programs, because they provide the maximum amount of hybrid vigor when crossed with *Bos taurus* breeds. However, meat from *Bos indicus* breeds is often less tender than meat from *Bos taurus* breeds. Since tenderness is a major palatability trait that determines consumer acceptability, it is important to understand what causes meat from these animals to be less tender.

Factors that influence meat tenderness may include USDA quality grade, postmortem rates of pH and temperature decline, muscle fiber sarcomere length and type, collagen content and solubility, and activity of proteases involved in postmortem tenderization (calcium-dependent proteases and cathepsins). Therefore, our objective was to examine all of these traits in an attempt to explain why meat from *Bos indicus* cattle is less tender than that from *Bos taurus*.

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[1]Conducted in cooperation with the USDA, ARS, Roman L. Hruska U.S. Meat Animal Research Center, Clay Center, Nebraska.

[2]USDA, ARS, Roman L. Hruska U.S. Meat Animal Research Center, Clay Center, Nebraska.
[3]KSU Department of Anatomy.

Experimental Procedures

We utilized seven heifers and four steers that were 5/8 Sahiwal × 3/8 Hereford (H), Angus (A), or H × A, three heifers and three steers that were 3/8 Sahiwal, and five heifers and five steers that were H × A. Calves were weaned at 6 to 8 mo of age and fed an alfalfa haylage and corn silage diet for 4 mo. Cattle then were fed a corn and corn silage finishing diet until 15 to 17 mo of age. Cattle were selected randomly and slaughtered (three to four animals each week) for a 7-wk period. Within 1 hr postmortem, loin (longissimus) muscle samples were taken for early measurements of muscle pH and calcium-dependent protease (CDP)-I, CDP-II, and CDP inhibitor activities. At 24 hr and at 14 d postmortem, loin samples were taken to measure various biological traits (Table 14.1).

Table 14.1. Loin Muscle Traits Evaluated and Times of Measurement

Traits	Times of measurement, postmortem
Temperature and pH	0, 3, 6, 9, 12, and 24 hr
Warner-Bratzler shear force	1 and 14 d
Taste panel evaluation	1 and 14 d
Calcium dependent protease-I and -II and CDP inhibitor activities	0 and 24 hr
Cathepsin B and B+L activities	1 and 14 d
Muscle fiber sarcomere length	24 hr
Type and area of muscle fibers	24 hr
Soluble and total collagen	1 and 14 d
Free-water-soluble calcium	24 hr
Extent of protein degradation (gel electrophoresis)	0, 1, and 14 d

Results and Discussion

All breed crosses had similar (P>.10) USDA quality and yield grades, with averages of high Select and 3.2, respectively. Also, breed crosses had similar (P>.05) lean color; lean firmness; lean texture; maturity scores; dressing percentages; marbling scores; fat thicknesses; and percentages of kidney, pelvic, and heart fat. In our study, no marbling score differences were found among breed-crosses, although *Bos indicus* cattle typically have lower marbling scores. Our marbling scores were confirmed by chemical analysis of intramuscular fat.

Significant loin steak tenderness differences were found among breed-crosses (Table 14.2). H × A were more tender (P<.05) at both d 1 and d 14 than 5/8 and 3/8 Sahiwals, as revealed by Warner-Bratzler shear-force values. In addition, trained taste panelists scored H × A as being more tender (P<.05).

Of all biological traits measured, CDP inhibitor activity at 24 hr was the only trait to differ among breed-crosses (Table 14.2). The 5/8 and 3/8 Sahiwals had more CDP inhibitor activity at 24 hr postmortem than Hereford × Angus. Less protein degradation occurred during aging in Sahiwal-crosses than in H × A. Thus, the response to aging must be somehow related to the activity of CDP inhibitor. Because CDP is known to degrade muscle proteins, the mechanism for its effectiveness during aging must be different between breeds, whether it be

CDP inhibitor or other unknown protease(s). However, these results emphasize the importance of CDP and CDP inhibitor in relation to beef loin tenderness and show that further studies must be conducted to enhance our understanding of the mechanism(s) involved.

Table 14.2. Muscle Trait Least-squares Means by Breed-cross

Traits	Breed-cross		
	Hereford × Angus	3/8 Sahiwal	5/8 Sahiwal
Warner-Bratzler shear force, kg			
d 1	7.0[b]	9.3[c]	9.6[c]
d 14	4.7[b]	6.4[c]	7.7[d]
Taste-panel tenderness scores[a]			
d 1	4.6[b]	3.6[c]	3.6[d]
d 14	5.9[b]	5.0[c]	4.4[d]
Muscle fiber sarcomere length, μm	1.83	1.76	1.75
Free-water-soluble calcium content, μg/g	10.8	8.6	9.5
Soluble collagen, %			
d 1	13.6	14.1	14.2
d 14	16.7	14.1	16.5
Total collagen, mg/g			
d 1	2.9	2.6	2.8
d 2	3.1	2.7	3.0
Cathepsin B activity, pmole/g/min			
d 1	32.4	27.9	34.3
d 14	30.5	29.0	34.7
Cathepsin B+L activity, pmole/g/min			
d 1	41.7	38.3	44.4
d 14	41.5	41.0	46.6
Calcium-dependent protease-I activity/100 g muscle[e]			
0 hr	113	109	101
24 hr	35	45	35
Calcium-dependent protease-II activity/100 g muscle[e]			
0 hr	106	92	98
24 hr	109	116	110
Calcium-dependent protease inhibitor activity/ 100 g muscle[f]			
0 hr	398	351	366
24 hr	136[b]	196[c]	209[c]

[a]A score of 6 = moderately tender, 5 = slightly tender, 4 = slightly tough, 3 = moderately tough.
[bcd]Numbers in a row with different superscripts differ (P<.05).
[e]Defined as the units of enzyme catalyzing an increase of 1.0 absorbance unit.
[f]Defined as the amount that inhibited 1.0 unit of purified CDP-II activity.

PRELIMINARY CARCASS AND MEAT RESEARCH RESULTS FROM CYCLE IV OF THE CATTLE GERM PLASM EVALUATION PROGRAM[1]

M. E. Dikeman, L. V. Cundiff[2], R. M. Koch[3], K. E. Gregory[2], and J. D. Crouse[2]

Summary

Preliminary data representing two of five calf crops in Cycle IV of the Germ Plasm Evaluation Program are reported. Carcass and meat data from 454 steers produced by mating 11 sire breeds to Hereford and Angus dams were obtained. Hereford (H) and Angus (A) sires born in the late 1960's (original) and also 1982 to 1984 (new) were compared. Steers sired by the new sample of H and A sires were heavier at slaughter than those of original sires, whereas marbling and percentages of trimmed retail product (% TRP) have not changed. HA and AH had lower % TRP than most crosses. Longhorn crosses were lightest of all crosses and were average for % TRP and % Choice. Shorthorn crosses were similar to new HA and AH in % TRP and had a higher % Choice than all crosses. Piedmontese crosses were lighter and dressed higher than new HA and AH. A low percentage graded Choice, but they excelled in muscling, trimness, and % TRP. Steaks from Piedmontese crosses were more tender than those from most breeds. Salers crosses had similar weights, less fat, larger ribeyes, and higher % TRP than new HA and AH, but a lower % Choice. Nellore crosses excelled in dressing percentage but had the least tender steaks.

Breeds differed significantly in slaughter and carcass weights, dressing percentages, carcass composition, marbling, and meat tenderness. Breeds did not rank the same for marbling as they did for tenderness.

(Key Words: Breeds, Performance, Carcass Traits, Tenderness, Meat.)

Introduction

Market demands have changed significantly over the last two decades and likely will continue to change in the future. Thus, breeds representing different biological types need to be characterized for carcass and meat traits. In addition, genetic changes of currently popular breeds need to be evaluated. This report focuses on carcass and meat traits of different biological types of cattle.

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[1]This article was written from preliminary research results presented at the 1989 American Society of Animal Science Meetings. Data are from two of five calf crops in Cycle IV of the Germ Plasm Evaluation Program being conducted at the Roman L. Hruska U.S. Meat Animal Research Center, Clay Center, Nebraska. Michael E. Dikeman is a collaborator on the carcass retail product data collection.

[2]USDA, ARS, Roman L. Hruska U.S. Meat Animal Research Center, Clay Center, Nebraska.
[3]Professor of Animal Science, University of Nebraska.

Experimental Procedures

Cycle IV of the Germ Plasm Evaluation Program began in 1985. These preliminary results are from two of five calf crops to be evaluated through 1990. Data are for 454 F_1 crosses obtained by mating Longhorn, Salers, Piedmontese, Galloway, Nellore, Charolais, Gelbvieh, Pinzgauer, Hereford, and Angus sires (about 30 sires per breed) to Hereford and Angus dams. Original Hereford (H) and Angus (A) sires used in Cycle I (1969 and 1970) have been used as reference sires throughout the program. H and A sires born from 1982 to 1984 (new) were also utilized to evaluate genetic trends in these breeds. Charolais, Gelbvieh, and Pinzgauer sires were included to increase ties to previous cycles of the program. Cows were bred AI for 45 d and then run with clean-up bulls for 21 d. Calves were born from mid-March to late May and were weaned at about 200 d of age. Steers (castrated at birth) were fed two backgrounding diets containing 2.7 Mcal ME/kg until about 700 lb, at which time they were placed on a 70% corn, 25% corn silage, 5% supplement diet (DM basis, 3.04 Mcal ME/kg). They were fed this diet until they were slaughtered serially in four groups about 3 wk apart, beginning at about 13½ mo of age.

Carcass USDA yield and quality grade data were obtained, and one side of each carcass was fabricated into boneless, retail cuts trimmed to 0.30 in. fat thickness. Retail cuts were then trimmed free of fat (0.00 in.) and reweighed. A rib steak from each carcass was cooked and sheared with a Warner-Bratzler shear device.

Results and Discussion

Data in Tables 15.1 and 15.2 show that new HA and AH crosses had heavier final and carcass weights than original HA and AH crosses, whereas dressing percent (Dr%) and percentage grading USDA Choice (% Choice) were similar. On the other hand, ribeye area did not increase, so ribeye area/cwt carcass tended to decrease. Both the original and new HA and AH and Shorthorn crosses had the lowest percentages of trimmed retail product (% TRP) at both 0.3 and 0.0 in. fat trim. Original HA and AH had lower ribeye shear values than current HA and AH.

Pinzgauer crosses were comparable to new HA and AH in weights but had lower Dr% and a lower % Choice. They had less fat thickness and somewhat higher % TRP than HA and AH. Gelbvieh crosses were slightly heavier than new HA and AH, had similar Dr%, and had a much lower % Choice. They had considerably less fat, larger ribeyes, and higher % TRP. Shear values were average. Charolais crosses had the heaviest weights of all crosses, average Dr%, and a lower % Choice than HA and AH. They had less fat, larger ribeyes, and higher % TRP than HA and AH. Shear values were about average.

Longhorn crosses had the lightest weights of all crosses, below average Dr%, and a lower % Choice than HA and AH. They had less fat and higher % TRP than HA and AH. Ribeye areas/cwt carcass were larger than those of new HA and AH. Shear values were about average. Galloway crosses were heavier than Longhorn crosses, but lighter than all other crosses. Dr% and % Choice were about average. Ribeyes were similar to those of HA and AH but they had less fat and higher % TRP. Shear values were average. Shorthorn crosses tended to be heavier than new HA and AH, and had similar Dr%. They had higher marbling scores and a higher % Choice than all other crosses. They were similar to new HA and AH in fat thickness, ribeyes, and % TRP.

Table 15.1. Mean Final Weight, Carcass Weight, Dressing Percentage, Marbling Score, and Percentage Grading USDA Choice of Breed-crosses

Breed group	No. steers	Final wt, lb	Carcass wt, lb	Dressing %	Marbling score[a]	% USDA Choice
Original HA and AH	32	1,064	665	62.5	Sm^{25}	71
New HA and AH	41	1,122	699	62.3	Sm^{16}	67
Pinzgauer crosses	50	1,129	690	61.0	Sm^{00}	47
Gelbvieh crosses	65	1,139	709	62.1	Sl^{87}	32
Charolais crosses	36	1,186	737	62.1	Sl^{79}	40
Longhorn crosses	38	961	596	61.9	Sl^{98}	52
Galloway crosses	32	1,012	636	62.8	Sl^{97}	49
Shorthorn crosses	43	1,149	715	62.2	Sm^{57}	83
Piedmontese crosses	37	1,060	683	64.4	Sl^{60}	28
Salers crosses	36	1,122	707	62.9	Sl^{78}	35
Nellore crosses	44	1,100	720	65.3	Sl^{68}	29
Mean LSD .05		40	26	.7	25	19

[a]Slight = Sl^{00} to Sl^{99}, Small = Sm^{00} to Sm^{99}.

Piedmontese crosses were lighter than new HA and AH, but had significantly higher Dr%. They had much lower % Choice than HA and AH. They had less fat thickness and larger ribeyes than all crosses and yielded the highest % TRP of all crosses. Their high Dr% was apparently due to their superior muscling. Interestingly, they had lower ribeye shear values than most crosses, even though they had the least fat thickness and had low marbling scores.

Salers crosses were similar in weights to new HA and AH, and their Dr% was slightly above average. They had much lower % Choice than HA and AH. Salers crosses had less fat thickness, larger ribeyes, and higher % TRP than HA and AH. Their tenderness was about average.

Nellore crosses were intermediate in final live weight to original and new HA and AH, but their carcass weights tended to be heavier because of their exceptionally high Dr%. Their % Choice was very low and comparable to that of Piedmontese crosses. They had larger ribeyes and higher % TRP than HA and AH. Shear values for Nellores were distinctly higher than for all other crosses, which would probably result in consumer complaints about toughness. Breeds did not rank the same for marbling as they did for tenderness.

Table 15.2. Mean Fat Thickness, Ribeye Area, Kidney Knob, Retail Product, and Shear Force of Breed-crosses

Breed group	Fat thickness, in.	REA[a]	Kidney knob, %	Retail product, % .30 in. fat	Retail product, % .00 in. fat	W.B. shear force, lb[b]
Original HA and AH	.60	11.1	2.8	70.5	64.6	12.0
New HA and AH	.56	11.0	2.5	71.0	65.2	13.7
Pinzgauer crosses	.41	11.4	2.9	72.3	67.0	12.3
Gelbvieh crosses	.36	12.2	2.6	73.8	68.5	13.5
Charolais crosses	.41	12.5	2.9	73.3	68.1	13.8
Longhorn crosses	.38	10.8	2.8	73.2	67.7	13.4
Galloway crosses	.47	11.1	2.6	73.4	67.8	13.3
Shorthorn crosses	.51	11.1	2.8	70.6	65.0	13.3
Piedmontese crosses	.27	13.4	2.3	77.8	73.3	11.6
Salers crosses	.43	11.9	2.8	73.6	68.2	14.0
Nellore crosses	.53	11.7	2.8	73.1	67.6	16.3
Mean LSD .05	.06	.5	.3	1.0	1.1	1.5

[a]Ribeye area, sq. in.
[b]Higher Warner-Bratzler (W.B.) shear values mean less tender meat.

The cattle Germ Plasm Evaluation (GPE) research program began with the 1969 breeding season. The primary objective is to characterize different biological types of cattle for economically important traits from conception to consumption. This research program is the largest, most comprehensive one of its kind, and results from it are utilized around the world. Each cycle involves different breeds and/or biological types; cycle IV is the most recent.

The basic procedure involves mating Hereford and Angus cows to representative sires of different breeds. Steer progeny are finished and slaughtered serially from about 13 1/2 mo to 16 mo of age. Carcasses are fabricated into closely trimmed retail cuts and meat is evaluated for palatability. Heifer mates are retained and evaluated for maternal traits.

Michael E. Dikeman has cooperated on the carcass and meat aspects of the GPE program since the first progeny were slaughtered in 1971. Carcass steer progeny will have been obtained when cycle IV is completed. Results from this project are useful to researchers, cattlemen and meat processors alike.

PREDICTING BEEF CARCASS RETAIL YIELD FROM HOT CARCASS TRAITS

J. K. Apple, M. E. Dikeman, L. V. Cundiff[1], and J. W. Wise[2]

Summary

Hot carcasses from 288 steers were used to develop equations to predict weights and percentages of trimmed retail cuts, and trimmable fat yields from hot carcass traits. Independent variables examined were: (1) 12-13th rib fat probe; (2) 10-11th rib fat probe; (3) external fat score; (4) percent kidney knob; (5) hindquarter muscling score, and (6) carcass weight. Right sides of carcasses were fabricated into boneless cuts trimmed to .3 in. fat and weighed. Then, cuts were totally trimmed (.0 in.) and reweighed. Multiple regression equations developed from these variables accounted for 95 and 90% of the variation in total weight of retail cuts at .3 and .0 in. trim levels, respectively. Furthermore, equations accounted for 58 and 52% of the variation in percent yield of trimmed retail cuts at .3 and 0 in. trim levels, respectively. Equations developed for trimmable fat accounted for 74 to 76% of the variation in pounds and percentages at both trim levels. Our "hot carcass" equations were equivalent to USDA equations that are based on chilled, ribbed-carcass traits in their ability to predict yields of trimmed retail cuts and trimmable fat.

(Key Words: Hot Beef Carcass, Fat Probe, External Fat Score, Retail Yield, Regression Equations, Carcass Traits.)

Introduction

Hot processing and hot-fat trimming of beef carcasses are two practices that warrant consideration by the beef processing industry. Economical benefits of trimming and fabricating hot carcasses include reduced energy costs, space requirements, and labor. However, a barrier to the widespread application of these practices is the inability to yield and(or) quality grade hot carcasses.

USDA yield grades accurately predict yields of boneless, closely trimmed retail cuts. Data are taken on ribbed, chilled carcasses at the same time quality grades are determined. If carcasses are hot-fat trimmed, USDA yield grades cannot be assigned, but quality grades can. Our objective was to determine if subjective and objective measurements of fat and muscling on hot carcasses could be used to accurately predict yields of trimmed retail cuts and fat trim, and thus allow yield grading of hot carcasses.

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[2]USDA, Washington, DC.

Experimental Procedures

Data were obtained from 288 carcasses from steers sired by 11 sire breeds mated to Hereford and Angus dams. Steers were slaughtered at the Roman L. Hruska U.S. Meat Animal Research Center's abattoir. After carcasses were washed, hot carcass data were obtained. Fat depth (in.) was taken between the 12th and 13th ribs (12RFD) at about 4.7 in. from the dorsal spinous processes and also between the 10th and 11th ribs (10RFD) at about 4 in. from the dorsal spinous processes. Overall carcass fatness was appraised visually and assigned an external fat score (EFS) from 0 to 9 (0=none and 9=excessively thick). Percent kidney knob (%KK) was estimated to the nearest .1%. Hindquarter muscling (HQMS) was scored [on a scale from 1 to 10 (1=extremely thin and 10=extremely thick)] independently of weight and frame size .

At 24 hr postmortem, carcasses were ribbed, and cold carcass data were obtained. Fat depth at the 12th rib over the ribeye was measured and adjusted for abnormal fat deposits over the carcass. Ribeye area was measured on the right side, and %KK was estimated to .1%. Then, USDA equations were used to predict trimmed retail cuts and fat trim.

The right side of each carcass was fabricated into boneless, trimmed retail cuts. Cuts were trimmed to .3 in. fat cover, weighed, then trimmed free of all surface fat (.0 in.) and reweighed. Weights of fat trim also were recorded.

Results and Discussion

Regression equations formulated from hot carcass measurements are reported in Table 16.1. That table presents the constants, calculated from our hot carcass measurements, that can be used in equations to predict the yield of retail cuts or fat trim. The R^2 values show the relationship between calculated and observed values for hot carcass and USDA chilled carcass data, respectively. For example, the regression equation using 12RFD, EFS, %KK, HQMS and carcass weight (CWt), obtained on hot carcasses, appeared to be as accurate in predicting total pounds of trimmed retail cuts at .3 in. fat trim as the USDA equation using chilled carcass measurements (R^2=.95 vs R^2=.96, respectively).

We conclude that hot carcass data can be used to predict yields of trimmed retail cuts and trimmable fat with similar accuracy to chilled carcass data used in the present (USDA) system.

Table 16.1. Equation Constants and R^2 Values for Predicting Pounds[a] and Percentages of Closely Trimmed Retail Cuts and Trimmable Fat

Item	Y intercept	12 RFD	10 RFD	EFS	%KK	HQMS	CWt	R^2
.3 TRC[bc], lb	14.9	−16.9	—	−3.8	−2.9	2.4	.34	.95[e]
.3 TRC, lb (USDA)								.96[f]
.3 TRC, %	76.5	−3.76	−3.16	−.96	−.98	.5	—	.58
.3 TRC, % (USDA)								.58
.0 TRC, lb	25.5	—	−17.2	−5.7	−3.6	2.87	.3	.90
.0 TRC, lb (USDA)								.91
.0 TRC, %	73.4	—	−6.1	−1.6	−1.3	.66	—	.52
.0 TRC, % (USDA)								.54
.3 Fat[d], lb	−43.76	18.7	10.11	4.6	3.26	−1.95	.09	.85
.3 Fat, lb (USDA)								.84
.3 Fat, %	−.91	5.4	3.4	1.2	.96	−.55	.01	.76
.3 Fat, % (USDA)								.75
.0 Fat, lb	−38.4	22.6	18.2	4.7	2.4	−1.5	.09	.84
.0 Fat, lb (USDA)								.87
.0 Fat, %	5.1	6.7	5.7	1.3	.76	−.34	—	.74
.0 Fat, % (USDA)								.79

[a]Equations for predicting pounds were developed from side weights; to calculate carcass pounds, multiply by 2 as in the example equation below.
[b]Trimmed retail cuts.
[c]Example equation: lb retail cuts, trimmed to .3 in. = 2 [14.9 − 16.9(12RFD) − 3.8(EFS) − 2.9(%KK) + 2.4(HGMS) + .34(CWt)].
[d]Trimmable fat.
[e]Relationship of predicted to actual value, hot carcass data.
[f]Relationship of predicted to actual value, current USDA cold carcass data.

EFFECTS OF PROCESSING VARIABLES ON IRIDESCENCE IN PRECOOKED BEEF

H. Wang, D. H. Kropf,
M. C. Hunt, and C. L. Kastner

Summary

Beef semitendinosus (ST) muscles with injected water (3 or 10% of raw muscle weight) and phosphate (0.3%) were cooked to final internal temperatures of 130 (held at 130 for 121 min), 140 (held at 140 for 12 min), 145, or 155°F, then sliced at 30, 45, 120, 130, or 145°F by either a dull or a sharp slicer. Biceps femoris (BF) muscles had the same treatment but only at 3% water addition. Controls were uninjected muscles from the opposite side of the carcass. For ST muscles (all with 0.3% added phosphate), 3% added water resulted in less iridescence than controls and those containing 10% added water. Iridescence was also lowered by cooking to 130°F (held for 121 min), slicing at 30°F, or slicing with a dull slicer blade. Iridescence varied ($P<.05$) among muscles from different carcasses under the same cooking and slicing conditions. BF muscles had much less iridescence than ST muscles. Our results show that processing-cooking-slicing alterations can help reduce iridescence, especially for the ST (eye of round) muscle.

(Key Words: Iridescence, Phosphate, Internal Temperature, Cooking Temperature, Slicing Temperature, Slicer Blade.)

Introduction

Iridescence is an unusual, brilliant, mother-of-pearl or rainbow appearance in nature and is due to a physical effect on light rays. The most common colors of iridescence in precooked beef, corned beef, or pastrami are green, yellow, or orange-red. Because iridescence is very similar to discoloration caused by metabolic by-products of microorganisms, meat purchasers and quality control personnel sometimes mistake iridescence for microbial deterioration and reject the products. For example, green iridescence has been confused with the green derivatives of myoglobin that may be caused by hydrogen sulfide or hydrogen peroxide from microorganisms.

Our objective was to determine the influence of processing variables (added water and phosphate, final internal temperature, slicing temperature, and sharpness of slicer blade) on iridescence in precooked beef.

Experimental Procedures

In the first study, using five pairs of ST muscles, one muscle in each pair was injected with 3% water plus .3% phosphate based on raw muscle weight. The other muscle was a control (no added water or phosphate). Curafos 11-2 (90% sodium tripolyphosphate and 10%

sodium hexametaphosphate, pH 8.9 to 9.8), a commercial food phosphate, was used. In the second study, using four pairs of ST muscles, the injection levels of water and phosphate were 10% and 0.3%. Samples were stored at 40°F for 3 d after injection to obtain a uniform distribution of solution. Four pairs of BF muscles were treated in the same way, but with only 3% water.

Each muscle pair was cooked in a smokehouse at 100 to 165°F and 80% relative humidity with a randomly selected transverse slice of each muscle cooked to a final internal temperature of 130 (held at 130 for 121 min), 140 (held at 140 for 12 min), 145, or 155°F. Holding times are required by federal regulations.

Cooked meat was sliced at five different temperatures: 30, 45, 120, 130, or 145°F. Samples were not sliced if the final internal temperature of meat was lower than the assigned slicing temperature. Two slicers were used, one with a sharp blade and the other with a dull blade. Cooked meat pieces were randomly assigned to the sharp or dull blade. Sliced samples were vacuum packaged.

Iridescence was scored (6-point scale) by eight panelists, based on both intensity and area of iridescence, with a higher score meaning more intense or a larger area of iridescence. The final score for each slice was the average of the scores for intensity and area.

Results and Discussion

With phosphate constant at 0.3%, the average iridescence score of ST muscle was lower ($P<.05$) for 3% than 10% added water or the control, which had not been injected (Figure 17.1). The lowest temperature (130°F, held for 121 min) resulted in less iridescence than other cooking temperatures (Figure 17.2).

Samples sliced at 30°F or 145°F had less iridescence than those sliced at intermediate temperatures (Figure 17.3).

Meat sliced by a sharp blade had more ($P<.05$) iridescence than that sliced by dull blade (Figure 17.4).

Iridescence differed ($P<.05$) among the ST muscle sets from different carcasses under the same cooking and slicing conditions (Figure 17.4). BF muscles had much less iridescence than ST muscles under the same cooking conditions.

Our results show that processing alterations can help reduce iridescence, especially in ST muscle.

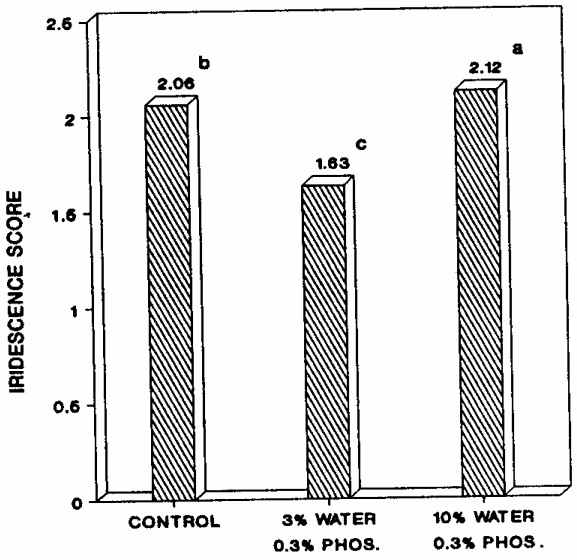


Figure 17.1. Effect of Added Water and Phosphate (ST Muscle)

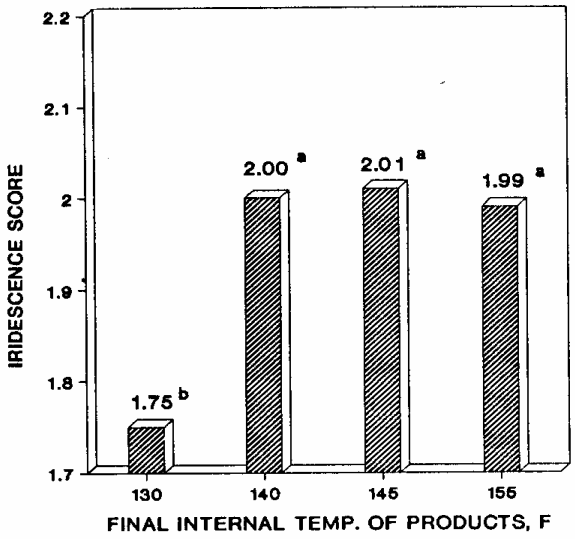


Figure 17.2 Effect of Final Internal Cooking Temperature (ST Muscle)

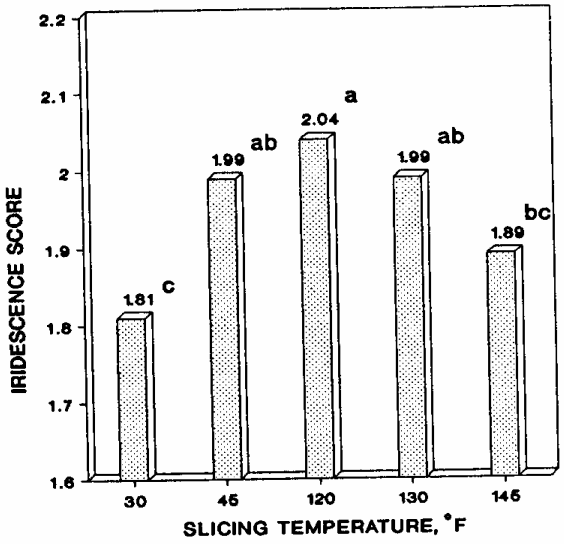


Figure 17.3. Effect of Slicing Temperature (ST Muscle)

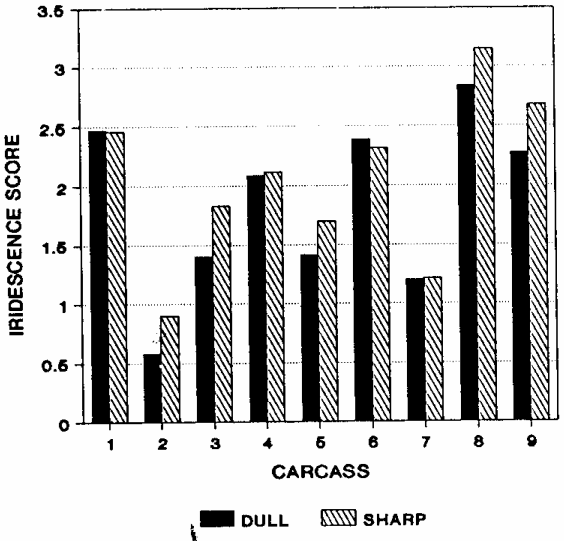


Figure 17.4. Effect of Sharpness of Slicer Blade (ST Muscle)

EFFECTS OF RUMEN-ESCAPE LIPID IN A RANGE SUPPLEMENT ON POSTPARTUM REPRODUCTIVE FUNCTION IN BEEF COWS[1,2]

R. B. Hightshoe, R. C. Cochran, L. R. Corah, D. L. Harmon, and G. H. Kiracofe

Summary

Postpartum cows receiving a range supplement containing rumen-escape lipid exhibited altered hormone and cholesterol levels compared to cows not fed lipid. Sixty-seven percent of lipid-fed cows exhibited a normal (18.2 d) first estrous cycle vs 33% for cows not receiving lipid. Incorporation of rumen-escape lipid into range supplements appears to significantly improve postpartum reproductive characteristics.

(Key Words: Rumen-escape Lipid, Estrous Cycle, Cholesterol, Postpartum.)

Introduction

Early return to cyclicity in the postpartum period can improve overall reproductive efficiency in beef cows. More cows cycling at the beginning of the breeding season should result in a higher average weaning weight, because more calves are born early in the calving period. Research at other universities suggests that inclusion of dietary lipid could hasten the postpartum return to estrus. Our objective was to evaluate whether the incorporation of rumen-escape lipid into a range supplement would significantly alter postpartum reproductive characteristics in beef cows.

Experimental Procedures

Twelve multiparous, Simmental cows were stratified by weight and body condition score and assigned randomly to receive a control (C) or lipid (L) supplement. The C supplement was 76% grain sorghum and 24% soybean meal. The L supplement was 34% Megalac® (calcium salts of fatty acids), 17% grain sorghum, and 49% soybean meal. By feeding L at .5% of body weight and C at .67% of body weight, the supplements provided each cow an equal daily quantity of protein and energy. Enough prairie hay was fed so that supplement plus prairie hay intake equaled the net energy for maintenance requirement for heavy milking beef cows in early lactation. Supplement feeding and daily blood collection began at parturition. Calves were permanently removed from cows at approximately 25 d postpartum in order to induce estrus. Length of first postpartum estrous cycle was determined by visual observation every 6 hr

[1]This research was supported in part by a grant from Church and Dwight Co., Princeton, New Jersey.

[2]Appreciation is expressed to Randy Perry, Twig Marston, Kelly Heath, and John Mussman for their invaluable assistance in conducting this trial.

beginning at calf removal and by changes in serum progesterone (P_4) concentration. Concentration of luteinizing hormone (LH) was determined in serum collected every 15 min for 6 hr at three periods; 12 hr before calf removal and 48 and 96 hr after calf removal. Serum P_4, estradiol 17β (E_2), and plasma cholesterol were determined in daily blood samples.

Results and Discussion

Ten of 12 cows exhibited estrus within 96 hr after calf removal. Sixty-seven percent of L-fed cows exhibited a normal (18.2 d) first estrous cycle vs 33% of C-fed cows. Cows receiving L had higher (P=.06) mean concentration of LH for the three sample periods than cows receiving C (Table 18.1). The L-fed cows also tended (P=.13) to have increased LH pulse frequency. Concentration of E_2 5 d before the first and second ovulations was higher (P=.008) for the C cows. Plasma cholesterol was elevated (P=.01) in L-fed cows.

A high percentage of beef cows experience a premature regression of the corpus luteum in their first postpartum estrus, leading to a short cycle of between 8 to 12 d. The ability of the L-fed cows to exhibit a normal first estrous cycle suggests that lipid feeding may have prompted normal luteal function. Although the mechanism involved remains unclear, it is apparent from this and other studies that lipid feeding is capable of enhancing luteal function in the postpartum cow.

Table 18.1. Effects of Rumen-Escape Lipid in a Supplement on Postpartum Reproductive Characteristics in Beef Cows

Item	Control	Lipid	Standard error
Mean LH, ng/ml serum	1.12[a]	1.47[b]	.11
LH pulse frequency no.	3[c]	11[d]	.14
Estradiol concentration, pg/ml serum	2.30[e]	1.63[f]	.136
Plasma cholesterol, mg/dl plasma	98.4[e]	213.8[f]	14.4
% Cows exhibiting normal estrus	33	67	

[ab]Row means differ (P=.06).
[cd]Row means tend to differ (P=.13).
[ef]Row means differ (P=.05).

EFFECTS OF DIETARY ENERGY ON REPRODUCTIVE FUNCTION AND PRODUCTION IN SUCKLED BEEF COWS[1]

R. C. Perry, L. R. Corah, W. E. Beal[2], G. H. Kiracofe, R. C. Cochran, J. S. Stevenson, D. D. Simms, and J. R. Brethour[3]

Summary

Twenty-eight Hereford × Angus cows were utilized to determine the effects of dietary energy level before and after calving on reproductive function and production in suckled beef cows. Low levels of dietary energy before calving resulted in losses of body composition prior to calving, reduced calf birth weight, lengthened intervals from calving to ovulation, and decreased milk production and calf weight at 70 d of age ($P<.05$). Low levels of dietary energy after calving decreased measures of body composition after calving, reduced the percentage of cows that ovulated following calving, and decreased cow milk production and calf weight at 70 d of age ($P<.05$). We conclude that dietary energy before and after calving impacts the reproductive function and production of suckled beef cows.

(Key Words: Prepartum, Postpartum, Energy, Reproduction, Ultrasound.)

Introduction

Along with many other factors, the length of the breeding season and the percentage of cows calving early in the calving season influence the efficiency of beef production. Both are factors that can be influenced by good reproductive management. However, a high percentage of cows must be cycling at the start of the breeding season.

Body condition at calving time, which is affected by nutrition, heavily influences the number of cows cycling at the start of the breeding season. The objectives of this study were to determine the influence of level of dietary energy before and after calving on reproductive function and production of suckled beef cows.

Experimental Procedures

Twenty-eight Hereford × Angus cows received either 70% (Low) or 150% (High) of NRC recommended level of dietary energy either before or after calving, resulting in four treatment combinations (L-L, L-H, H-L, H-H) in a 2×2 factorial arrangement. Diets were similar in content of protein, calcium, and phosphorus. Prepartum diets were fed for

[1]Authors are grateful to S. C. Henderson-Perry, R. B. Hightshoe, T. Ridder, and B. Fox for assistance with data collection.
[2]Virginia Polytechnic Institute and State University.
[3]Fort Hays Branch Experiment Station.

approximately 110 d, and postpartum diets were fed for approximately 20 d after cows resumed cyclicity or up to a maximum of 150 d postpartum.

Ultrasonography was utilized to monitor ovarian follicle size, cervical and uterine involution, and time of ovulation. At 28-d intervals, cows were weighed and scored for body condition, and ultrasonography was used to measure subcutaneous fat and longissimus muscle area. Cows also were weighed and scored for body condition at calving. Cows were observed for estrus thrice daily. Milk production was determined at approximately 60 and 70 d postpartum. On the day preceding each milking, cows and calves were separated for 4 to 6 hr, then placed together until all calves completed nursing and separated again. Approximately 12 hr following the separation, cows were injected IM with 40 IU of oxytocin to stimulate milk letdown and were immediately machine milked. Samples from each milking were analyzed by the Kansas Dairy Herd Improvement Association to determine butterfat, lactose, protein, and somatic cell count. Calf weights were recorded at birth and 70 d of age.

Results and Discussion

Measures of cow performance for the four treatment combinations are shown in Table 19.1. Low levels of dietary energy both before and after calving decreased (P<.05) body weight, body condition, subcutaneous fat, and longissimus muscle area compared with cows fed high

Table 19.1. Effects of Pre- (PR) and Postpartum (PP) Dietary Energy on Cow Performance

Item	Treatment combinations L-L	L-H	H-L	H-H	SE
Initial wt, lb	843	855	848	843	25
Prepartum[1] wt change, lb	-98^{a}	-75^{a}	133^{b}	125^{b}	9
Postpartum[2] wt change, lb	-66^{b}	50^{c}	-206^{a}	-50^{b}	15
Initial body condition[3]	5.0	5.0	5.0	5.0	0.0
PR change in body condition	-2.0^{a}	-1.8^{a}	1.9^{b}	1.8^{b}	.2
PP change in body condition	$-.6^{b}$	1.7^{c}	-3.4^{a}	$-.3^{b}$	.3
Initial subcutaneous fat, mm	3.2	3.7	3.2	3.2	.2
PR change in subcutaneous fat, mm	-1.0^{a}	-1.2^{a}	2.6^{b}	2.3^{b}	.3
PP change in subcutaneous fat, mm	$-.6^{b}$	$.8^{c}$	-3.3^{a}	$.5^{c}$	.3
Initial longissimus muscle area, cm^2	49.6	52.3	52.9	52.7	2.1
PR change in longissimus muscle area, cm^2	-16.5^{a}	-17.9^{a}	-2.6^{b}	-3.7^{b}	3.2
PP change in longissimus muscle area, cm^2	-9.9^{b}	3.3^{c}	-18.9^{a}	$-.5^{c}$	2.4

[1]Prepartum period=approximately 110 d.
[2]Postpartum period=from calving to 10 d after second postpartum ovulation or 150 d.
[3]Scale = 1 to 9; 1=emaciated, 9=obese.
[abcd]Numbers in the same row that do not share a common superscript differ (P<.05).

levels of energy during similar periods. Energy levels prior to calving also affected (P<.05) cow performance following calving. Cows fed low levels of energy before calving lost less body condition and weight when fed low levels after calving and gained more body condition and weight when fed high levels after calving, compared with cows receiving high levels of energy prior to calving.

The effects of dietary energy on reproductive function and production are shown in Table 19.2. Low energy levels prior to calving decreased (P<.01) calf birth weight, cow milk production, and calf weight at 70 d of age compared to cows fed high levels of energy before calving. Low levels of energy after calving also decreased (P<.001) cow milk production and calf weight at 70 d of age compared to cows receiving high levels after calving. Of the measures of milk composition, only percentages of protein and total solids were decreased (P<.01) in cows receiving low levels of energy after calving. Prepartum energy did not influence milk composition. The correlation between cow milk production and calf weight at 70 d was .89 (P=.0001). This correlation is somewhat higher than previous reports; however, because calves were maintained in drylot, milk was the only available source of calf nutrition, which probably explains this strong relationship.

An interaction between pre- and postpartum energy affected (P<.05) both cervical and uterine involution at various times after calving. However, rate of involution was fairly similar among all treatment groups following calving and appeared to be fairly complete by 30 d postpartum. Low levels of energy before calving increased (P=.02) the interval from calving to ovulation. The percentage of cows that ovulated by 150 d postpartum was decreased (P=.002) in cows receiving low compared to high levels of energy after calving. Only one cow exhibited standing estrus associated with the first ovulation following calving; however, all cows exhibited standing estrus at the second ovulation following calving. All cows that ovulated had a short luteal phase between the first and second ovulations.

Table 19.2. Effects of Pre- (PR) and Postpartum (PP) Dietary Energy on Reproductive Function and Production of Cows and Calves

Item	Treatment combinations				SE
	L-L	L-H	H-L	H-H	
Calf birth weight, lb	72.0[a]	77.0[a]	79.3[ab]	85.3[b]	2.7
Calf wt at 70 d of age, lb	112.0[a]	158.4[b]	168.5[b]	202.6[c]	9.0
60-70 d postpartum:					
24-hr milk production, lb	4.1[a]	14.1[b]	11.6[b]	19.9[c]	1.1
Milk fat, %	2.1	2.7	2.2	2.5	.2
Milk protein, %	2.3[a]	2.6[bc]	2.5[ab]	2.7[c]	.1
Milk lactose, %	4.9	4.9	4.9	5.0	.1
Milk total solids, %	9.8[a]	10.7[bc]	10.1[ab]	10.7[c]	.2
PP interval to ovulation, d	—	96[b]	73.5[ab]	74.0[a]	7.1
% cycling by 150 d PP	0[a]	83[b]	29[a]	100[b]	12.5

[abcd]Numbers on the same row that do not share a common superscript differ (P<.05).

CALVES DELAY ESTRUS CYCLES IN POSTPARTUM COWS BY MECHANISMS OTHER THAN SUCKLING

S. D. Viker and G. H. Kiracofe

Summary

It is generally accepted that the suckling stimulus and the interactions between lactation and level of nutrition regulate the interval from calving to cycling in beef cows. However, mastectomized cows (udder removed) kept with their calves had longer postpartum intervals to ovulation and estrus than mastectomized cows without calves. We conclude that ovulation and estrus can be suppressed by some cow-calf interaction that is independent of lactation and suckling.

(Key Words: Cows, Mastectomy, Postpartum Intervals, Calf Influence.)

Introduction

Cows that nurse a calf have longer intervals from calving to ovulation, estrus, and conception than cows without a calf. Mastectomized cows have shorter intervals from calving to estrus than both suckled and nonsuckled intact cows. In all of the above experiments, preventing suckling also involved separating the calf from the cow. Thus, the effect of the calf on the resumption of estrous cycles after calving was not separated from the effect of suckling.

We attempted to separate the effect of cow-calf interaction from suckling and lactation by comparing postpartum reproductive function of mastectomized cows in the presence and absence of their calves.

Experimental Procedures

This experiment involved two calf crops. In the first year, 11, 3-yr-old crossbred Angus cows that had raised one calf each were mastectomized at months 6 to 7 of their second gestation. All calves were removed from cows within 12 hr after birth. The intervals from calving to ovulation, estrus, and conception were measured.

In the second year, eight of the same cows were placed into two equal groups. In one group, the calves were removed at birth, whereas calves in the other group remained with the cows until 46 to 53 d after calving. Calves with their dams were hand fed from a nippled bottle or from a bucket every 12 hr. The two groups of cows were kept in separate drylots about 150 ft apart. Cows without calves could see and hear their calves and other cows but were never in contact with them.

All cows in both years were kept with a fertile bull in a drylot (60 d the first year; 80 d the second year) and fed a diet that maintained a body condition score of at least 6 on a scale of 1 to 9 (9=obese). Observations for estrus were made every 6 hr from calving until cows were determined pregnant or had an estrous cycle of at least 17 d.

Results and Discussion

First Year: All Calves Removed at Birth

The occurrence of estrus, ovulation, and conception after calving in the first year is given in Table 20.1. Based on serum progesterone concentrations, all cows ovulated between 7 and 28 d (average 13.9) after calving. Six of 11 cows showed no signs of estrus in association with the first ovulation, whereas all cows exhibited standing estrus with all subsequent ovulations.

Table 20.1. Interval from Calving to Ovulation, Estrus, and Conception in Mastectomized Cows without Calves

Cow no.	Day of ovulation[a]	Estrual activity[b]	No. of days between ovulations			Day of conception[c]	Length of gestation, d
			1st to 2nd ovulation	2nd to 3rd ovulation	3rd to 4th ovulation		
8	17	Standing	10	9	19	54	281
13	12	None	18	—	—	29	279
19	14	Standing	18	—	—	31	281
22	11	Standing	9	18	—	37	273
24	15	Hyperactive	8	—	—	22	279
30	12	None	14	39	—	open	—
39	12	None	9	—	—	20	276
45	15	Standing	19	25	—	58	282
83	28	None	14	—	—	41	279
101	10	None	8	—	—	17	283
123	7	None	8	19	21	open	—
Average	13.9	—	12.3	22.0	20	24.3	279.2

[a]Day of calving was Day 0. Time of ovulation was recorded as 1 d after the onset of estrus or 3 d before an abrupt rise in serum progesterone concentration if standing estrus was not observed.

[b]Activity associated with the first ovulation; a standing estrus was observed with all subsequent ovulations.

[c]All cows were exposed to a fertile bull for 60 d after calving.

Second Year: Effect of Calf

Data in Table 20.2 depict the intervals from calving to ovulation, estrus, and conception for cows that were kept with their calves and for those whose calves were removed at birth. Cows in both groups had body condition scores of approximately 7.

Table 20.2. A Comparison of the Intervals from Calving to Ovulation, Estrus, and Conception in Mastectomized Cows with and without Calves

Cow no.	Day of calf removal[a]	Day of ovulation[b]	Estrual activity[c]	No. of days between ovulations: 1st to 2nd ovulation	No. of days between ovulations: 2nd to 3rd ovulation	Day of conception[d]
13	0	14	None	20	—	33
19	0	14	None	7	—	20
24	0	22	None	8	—	29
45	0	14	Standing	8	19	40
22	46	50	Standing	8	—	57
39	47	51	Hyperactive	7	—	57
83	51	54	Standing	7	—	60
101	53	54	Hyperactive	7	—	60

[a]Day of calving = Day 0.
[b]Day of ovulation was recorded as 1 d after the onset of estrus or 3 d before an abrupt rise in serum progesterone concentration if standing estrus was not observed.
[c]Activity associated with the first ovulation; a standing estrus was observed with all subsequent ovulations.
[d]Average intervals from calving to ovulation, estrus, and conception between cows with calves and cows without calves differed ($P<.005$).

Average intervals from calving to ovulation, estrus, and conception for cows whose calves had been removed were similar ($P>.2$) between years (first year, 13.9, 20.1, and 34.3 d vs second year, 16.0, 24.0, and 30.5 d, respectively). However, none of the cows left with their calves ovulated, expressed any signs of estrus, or conceived while their calves were present. After calves were removed, all cows ovulated within the next 4 d, exhibited estrus within the next 10 d, and conceived within the next 11 d.

It has not been determined whether tactile stimuli, cow-calf bonding, or some other cow/calf interaction is necessary for the inhibition of ovulation. However, it is clear that direct stimulation of the teat or mammary gland is not essential for the calf to inhibit estrous cycles.

We conclude that ovulation and estrus can be suppressed by some cow-calf interaction that is independent of lactation and suckling. In mastectomized cows, this suppression can last for at least 50 d after calving.

DIAGNOSIS OF FREEMARTINISM IN HEIFERS BORN CO-TWIN TO A BULL

B. L. Larson and G. H. Kiracofe

Summary

The wide variance in anatomical characteristics among heifers born co-twin to a bull make diagnosis of freemartinism by measurements of vaginal length or the distance between the anus and vulva unreliable. Change in serum luteinizing hormone (LH) in response to injection of estrogen or gonadotropin releasing hormone (GnRH) is different in freemartins compared to normal heifers but is also an unreliable predictor of freemartinism. Presently, the most conclusive way to establish freemartinism in a heifer born co-twin to a bull is to measure the percentage of XX and XY chromosomes in cells from whole blood, which is a specialized and expensive procedure.

(Key Words: Freemartin, Twins, XY Chromosome, Chimer.)

Introduction

Approximately 2% of all cattle pregnancies result in twins, half of which are male-female pairs. Most females born co-twin to a bull are sterile freemartins, but up to 10% can be fertile. Freemartinism occurs when vascular connections occur between the male and female fetal membranes. These connections, or chorionic anastomoses, allow hormones from the male to pass to the female fetus and, in turn, adversely affect the development of the female reproductive tract and hormonal regulatory centers in the hypothalamus and/or the pituitary gland. Producers would benefit if a simple procedure could be developed to test for freemartinism in heifers born co-twin to a bull. Historically, measuring vaginal length and the distance between the anus and vulva have been used to determine freemartinism. We tested these methods of measurement, assayed LH response to an injection of estrogen or GnRH, and also tested for the percentage of XX and XY chromosomes (chimerism) in blood cells as predictors of freemartinism.

Experimental Procedures

Four heifers born co-twin to a bull and four single heifers from the same ranches were measured six times between 4 and 20 mo of age. Vaginal length was measured by inserting a lubricated probe as far as possible into the vagina with minimal force. The distance between the anus and vulva was measured from the bottom of the anus to the top of the vulva. The same heifers were used to study serum LH response to intramuscular injections of estrogen and GnRH both before and after puberty. Concentrations of LH was measured each 2 to 4 hr from 8 hr before to 32 hr after treatment with estrogen. Luteinizing hormone was also measured

4 hr before treatment; at the time of treatment; and at 1, 3, and 5 hr after treatment with GnRH.

Results and Discussion

Vaginal length and distance between the anus and vulva in normal heifers were quite uniform. Analysis of multiple measurements of freemartins showed that some individuals had smaller than normal genital measurements, some had longer than normal measurements, and others had vaginal length and anal-vulva distance measurements similar to normal heifers. This discrepancy makes a simple external measurement an inaccurate diagnosis of freemartinism in most cases.

Normal heifers exhibit a surge in LH about 16 hr after estrogen and 1 hr after GnRH injection. Other researchers have shown that freemartins respond differently to estrogen injections. Our data agree; we saw no consistency among freemartins in their responses. Some heifers showed a normal LH surge, and others showed a delayed surge or sometimes no surge in LH following estrogen. Similar results were seen following injections of GnRH. These results suggest that freemartins have different degrees of "female responses" ranging from almost normal female to almost normal male. Thus, LH responses are poor predictors of freemartinism.

The most accurate predictor of freemartinism is to examine tissue or blood chromosomes. Females should have 100% XX sex chromosomes, and males should have 100% XY sex chromosomes. If a female has even one XY chromosome, the condition is called chimerism and is an accurate predictor of clinical freemartinism. The disadvantages to this method are that only a few laboratories can run the test and the cost is at least $50 per sample. All four heifers born co-twin to a bull in our experiment were blood chimeras. The percent chimerism ranged from 30 to 80% of cells having XY chromosomes. The percent chimerism did not correlate to abnormal external measurements nor to hormonal differences from normal heifers. When reproductive tracts were examined at slaughter, all four heifers born co-twin to a bull had abnormalities that would have prevented conception.

Although some heifers born co-twin to a bull are easily identified as freemartins because of gross abnormalities of external genitalia, many freemartins do not have noticeable external changes. The lack of consistent physical and hormonal differences from normal heifers means that an accurate, quick, and inexpensive diagnostic procedure is unavailable at this time. If a heifer born co-twin to a bull does not have noticeable genital abnormalities, the most accurate test is for blood cell chimerism.

COW/CALF PROFITABILITY: CASE STUDIES OF KANSAS CATTLE PRODUCERS

D. D. Simms and T. T. Marston

Summary

Cost/return analyses of 56 Kansas cow/calf operations were summarized to determine the major factors influencing 1987 and 1988 cow herd profitability. Gross returns and costs on a per cow unit basis were extremely variable, with the bottom 1/3 of these operations essentially breaking even, whereas the high 1/3 profitability group averaged $228.40 per head in net cash returns. Both operating and fixed costs were major determinants of profitability. Reproductive rate (calves weaned per cow exposed) was the major production variable affecting profitability.

(Key Words: Cows, Profitability, Economics, BEEFpro.)

Introduction

During 1987 and 1988, Extension personnel conducted numerous economic analyses of cow herds using the BEEFpro cattle management computer program, with emphasis on developing a thorough cost/return analysis. This paper summarizes these analyses and illustrates the key factors that influence cow herd profitability.

Experimental Procedures

The information summarized here was collected in individual consultation sessions, with every effort made to obtain accurate cost and return information. It represents the records from 56 Kansas cow herds in 1987 and 1988—relatively profitable years in the cow/calf business. As an aid in identifying the factors distinguishing the least profitable from the most profitable, the herds were divided into three profitability groups based on net cash returns per cow unit.

Results and Discussion

Table 22.1 shows the financial and production characteristics of the cow herds, separated by profitability group. Surprisingly, there was no difference in gross returns between the bottom and middle 1/3 profitability groups. The high 1/3 profitability group had higher gross returns because they had higher reproductive rates and heavier calves at weaning. These factors combined to yield more pounds of calf weaned per cow exposed.

Table 22.1. Characteristics of 56 Kansas Cow/Calf Operations in 1987 and 1988 on a Per Cow Unit Basis

Item	Profitability group		
	Bottom 1/3	Middle 1/3	Upper 1/3
Gross returns, $	369.99	369.19	408.60
Operating costs, $[1]	236.48	208.53	148.24
Fixed costs, $[2]	134.25	44.19	31.96
Net returns, $	−.74	116.47	228.40
No. cows/herd	96	102	146
Average weaning wt, lb	521	503	550
Calf crop (weaned/exposed), %	84.9	86.9	91.9
Pounds of calf/cow exposed	442	437	505
Principal and interest payments/cow, $	111.84	37.73	22.01
Operator investment/cow, $	1,497.00	1,465.00	1,817.00
Total investment/cow, $	2,677.00	2,379.00	2,007.00
Investment in building and equipment/cow, $	107.29	97.81	87.63
Feed costs (cash), $[3]	161.98	163.58	104.00

[1]Includes all cash costs plus fair market value of all home-raised feedstuffs.
[2]Includes all principal and interest payments as well as other cash fixed costs.
[3]Includes a fair market value for home-grown feedstuffs, but does not include any value for owned pasture land.

A review of the management practices employed by the high profitability operations indicates that they were:

1. utilizing cows matched to their resources,
2. utilizing a systematic crossbreeding system,
3. providing adequate nutrition during crucial reproductive periods,
4. using performance information in bull selection,
5. minimizing calving difficulty,
6. making maximum use of low-quality roughages and aftermath feeds, and
7. optimizing the use of protein and mineral supplements.

Although there were some differences in gross returns among profitability groups, the major differences were in operating and fixed costs. The greater operating costs of the bottom 1/3 profitability group were largely because of higher feed costs, which resulted from more pasture rental or less usage of inexpensive, low quality roughages. The higher fixed costs resulted mainly from higher principal and interest payments.

The upper 1/3 group had a higher operator investment per cow but lower total investment than the other groups. The bottom 1/3 typically utilized more pasture per cow unit than the upper 1/3. The exact reason for this difference is unclear.

An interesting aspect of this analysis is the range in returns and costs. For example, gross returns varied from $251.29 to $582.71 on a per cow unit basis. Obviously, this means that reproductive rates and weaning weights varied tremendously. Operating costs varied from $34.84 to $373.50 per cow unit, whereas fixed costs varied from $0.00 to $348.03 per cow unit. Since the cost side of the profit equation had the greatest impact on profitability, these data indicate that producers must analyze their input costs and reduce them where possible. Net returns varied from $−197.46 to $248.48 per cow unit. This indicates that there is tremendous potential to improve profitability in most Kansas cattle operations.

It is also worth noting that 1/3 of the cow herds included in this study were not profitable in 1987 and 1988, which were considered highly profitable years for the cow/calf segment of the industry. This is particularly ominous when one considers how unprofitable these operations will be when calf prices decline as a function of the cattle cycle.

SEVENTEEN YEARS OF KANSAS CENTRAL BULL TESTS

R. R. Schalles, B. J. Ward,
K. O. Zoellner, and L. C. Martin

Summary

Weights, frame scores, scrotal circumferences, and prices of bulls increased significantly over 17 years. Angus had the greatest increase in birth weight, average daily gain (ADG) during test, adjusted yearling weight, and frame score, whereas Simmental had the greatest increase in adjusted weaning weight. Backfat and ribeye area decreased over this period. Large frame score had the greatest effect on increasing sale price of bulls. Gelbvieh bulls with heavy birth weights sold for less, whereas heavy birth weight Limousin and Polled Hereford bulls sold for more. Rank correlations indicated a significant change in rank between 112- and 140-d ADG. About 20% of the 140-d ADG information was obtained during the last 28 d of the test.

(Key Words: Bull Test, Performance.)

Introduction

The economics of beef production over the last 20 years and consumer desire for lean beef have dictated a change in the genotype of cattle used for breeding. The Kansas Central Bull Tests have helped facilitate this change by providing a uniform post-weaning environment, under which superior bulls can be identified and selected.

Experimental Procedures

Data were collected from 11,494 bulls of 32 breeds that completed the Kansas Central Bull Tests over a 17-yr period. The first test was initiated at Beloit in June, 1971; a second test was started at Yates Center in 1975 and moved to Potwin in 1982.

Bulls were delivered to the test station about 3 wk before the start of the test at an average age of 224 d and were fed in groups of approximately 50 head of the same breed or breeds with similar genotypes. The starting ration had a moderate energy density (NEm = 68 to 80, NEg = 39 to 48 Mcal/cwt) with increasing energy density in the final ration (NEm = 74 to 90, NEg = 46 to 57 Mcal/cwt). Bulls were weighed on two consecutive days at the start and end of the 140-d test, and once on d 56 and d 112. Ribeye area and backfat were estimated by ultrasonic imaging. Birth weight, weaning weight, adjusted weaning weight, and pedigree information were provided by the breeders.

Most analyses were conducted using 2,282 Angus (AN), 745 Charolais (CH), 445 Gelbvieh (GV), 991 Hereford (HH), 448 Limousin (LM), 757 Polled Hereford (HP), and 5,189 Simmental (SM) bulls. Least Squares analysis was used with the effects of birth year, breed,

season of test, test location, and age of bull held constant. Percentage of breed and polled character were analyzed for Charolais, Gelbvieh, Limousin, and Simmental bulls. Rank correlations were calculated between 112- and 140-d average daily gains (ADG).

Results and Discussion

Bull performance

Pre-test performance was provided by the bull consignors. Sufficient birth weight data were not available until 1975. Charolais, Gelbvieh, and Simmental bulls had the heaviest weights at birth, weaning (Table 23.1), and at the start of tests. Angus had the greatest increase in birth weight (1.2 lbs per year), whereas Charolais, Gelbvieh and Limousin had a slight decrease. Simmental had the greatest increase in adjusted weaning weight (9.3 lb per year), and Charolais had the smallest increase (2.6 lb per year). Age at the start of test and weaning weight ratio were very similar among breeds, with the Angus being the oldest and Gelbvieh the youngest. The greatest within-herd weaning weight selection was placed on Herefords. Starting test weight has increased 79 lb since the 1970-born calves. Weaning weight ratio and starting test age have both decreased slightly. Spring-born calves (those tested in the winter) were heavier at both birth and weaning than fall-born calves.

The 140-d test ADG increased within all breeds

Table 23.1. Least Squares Mean Birth Weight and Adjusted Weaning Weight by Breed and Year

Birth year	Breed						
	AN	CH	GV	HH	LM	HP	SM
	birth weight, lb						
1975	73	85	—		77	71	84
1976	73	89	—	74	80	67	88
1977	73	84	—	81	89	73	90
1978	71	94	96	81	84	74	89
1979	70	87	81	84	78	73	91
1980	75	89	—	84	82	76	91
1981	75	94	81	82	89	79	93
1982	77	86	82	85	78	83	91
1983	79	90	86	83	78	81	91
1984	80	87	86	83	78	82	92
1985	81	89	87	87	77	82	93
1986	78	90	89	86	78	80	92
	adjusted weaning weight, lb						
1970	502	494	—	491	578	—	540
1971	547	615	—	491	520	514	527
1972	507	591	—	511	543	523	525
1973	490	611	596	499	505	502	540
1974	496	586	532	488	507	475	550
1975	502	582	—	500	518	465	550
1976	522	563	—	516	570	477	560
1977	529	606	—	536	514	482	563
1978	519	595	686	531	532	481	564
1979	532	632	627	542	582	493	592
1980	540	619	—	558	607	524	617
1981	555	598	621	584	612	531	626
1982	548	617	622	584	557	529	620
1983	547	610	614	541	565	540	607
1984	556	634	608	547	610	552	624
1985	576	626	615	570	633	569	661
1986	594	634	641	562	653	558	664

AN = Angus, CH = Charolais, GV = Gelbvieh, HH = Hereford, LM = Limousin, HP = Polled Hereford, and SM = Simmental.

over the years (Table 23.2), with Angus having the greatest increase and Limousin the least. Adjusted 365-d weight had similar increases, with Angus, Simmental, and Hereford having the greatest increases and Charolais the least. Charolais and Simmental had the heaviest 365-d adjusted weights and Polled Hereford, Hereford, Angus, and Limousin had the lightest.

Over the 17 years, ribeye area and backfat decreased, while scrotal circumference and frame score increased (Table 23.3). Charolais and Limousin had the largest ribeye areas and Hereford, Polled Hereford, and Angus had the smallest. The British breeds had the most backfat, whereas the Continental breeds had the least. Scrotal circumference increased from 1974 through 1986, with Angus, Simmental, and Gelbvieh having the largest scrotal circumferences and Limousin the smallest. Frame score increased from an average of 3.4 in 1973 to 5.9 in 1986. Simmental, Charolais, and Gelbvieh were the largest frame bulls and had the least increases over the 17 years; British breeds had the smallest frames and showed the greatest increases.

Bulls born earlier in the calving season had lighter birth weights, heavier actual weaning and starting test

Table 23.2. Least Squares Mean 140-day Average Daily Gain and Adjusted 365-day Weight of Bulls

Birth year	AN	CH	GV	HH	LM	HP	SM
	140-d average daily gain, lb						
1970	2.49	3.28	—	2.62	2.36	—	3.20
1971	2.78	3.15	—	2.68	3.23	2.63	3.52
1972	2.51	2.87	—	2.51	2.68	2.39	3.00
1973	2.56	3.12	3.02	2.83	2.72	2.71	3.18
1974	2.88	3.47	3.26	2.91	3.28	2.80	3.49
1975	3.01	3.51	—	2.91	3.37	2.80	3.61
1976	2.84	3.36	—	2.74	2.99	2.76	3.43
1977	2.96	3.19	—	2.88	2.86	2.91	3.27
1978	2.66	2.85	2.55	2.65	2.51	2.66	2.94
1979	2.81	3.16	3.10	2.71	2.88	2.77	3.29
1980	3.05	3.45	—	3.05	3.01	3.06	3.65
1981	3.26	3.64	3.68	3.14	3.33	3.11	3.54
1982	3.25	3.41	3.20	3.20	3.12	3.20	3.40
1983	3.22	3.57	3.14	3.29	3.15	3.27	3.51
1984	3.51	3.90	3.64	3.32	3.39	3.45	3.72
1985	3.64	3.96	3.63	3.42	3.37	3.33	3.82
1986	3.48	3.68	3.37	3.36	3.13	3.05	3.51
	365-d weight, lb						
1970	941	—	—	—	931	—	1027
1971	896	1042	—	906	—	894	1076
1972	892	1036	—	839	—	926	954
1973	915	1158	1007	938	1008	960	1031
1974	937	1079	1009	925	954	905	1055
1975	939	1067	—	937	979	882	1060
1976	970	1046	—	934	1007	894	1061
1977	918	1050	—	950	910	908	1039
1978	942	1022	1128	916	910	890	1015
1979	986	1077	1056	956	997	904	1063
1980	1000	1113	—	1001	1015	963	1138
1981	1006	1091	1133	997	1049	971	1114
1982	995	1097	1060	1029	998	988	1096
1983	1051	1089	1038	980	981	988	1084
1984	1095	1171	1107	1032	1059	1034	1144
1985	1070	1203	1148	1062	1128	1020	1211
1986	1097	1141	1123	1045	1071	1000	1161

AN = Angus, CH = Charolais, GV = Gelbvieh, HH = Hereford, LM = Limousin, HP = Polled Hereford and SM = Simmental.

weights, but lighter adjusted weaning weights. Older bulls gained slightly faster on test and had heavier weights per day of age, larger ribeyes, more backfat, and larger scrotal circumferences at the end of test. Larger frame bulls were heavier at all weights; however, the increase in weight per unit of increase in frame score was less with the larger frame bulls, with little increase in weights above frame score 9. Larger frame bulls had smaller ribeyes and less backfat.

Few differences were found between bulls of various percentage breeding within the Charolais, Gelbvieh, Limousin, and Simmental breeds. Perhaps the heterosis within the lower percentage bulls offset the breeding value differences between foundation and purebred animals used in the breeds. Few differences were found between polled and horned bulls of these breeds.

Table 23.3. Least Square Mean Ribeye, Backfat, Scrotal Circumference and Frame Score of Bulls.

	Ribeye area, sq. in.	Backfat, in.	Scrotal circumference, cm	Frame score
Birth year				
1973	13.4	0.28	—	3.4
1974	12.5	0.28	31.7	3.5
1975	12.3	0.28	32.1	4.0
1976	12.1	0.26	33.2	4.5
1977	11.6	0.23	33.9	4.7
1978	11.7	0.21	35.0	4.2
1979	11.7	0.24	34.2	4.9
1980	12.8	0.21	34.4	5.2
1981	12.3	0.22	34.9	5.2
1982	11.8	0.22	34.9	5.2
1983	11.3	0.20	35.1	5.2
1984	12.1	0.20	36.0	5.5
1985	—	0.19	34.2	6.0
1986	—	0.17	34.6	5.9
Breed				
Angus	11.7	0.30	35.2	4.1
Charolais	12.8	0.17	33.7	5.7
Gelbvieh	12.2	0.18	35.0	5.2
Hereford	11.5	0.29	34.4	4.0
Limousin	12.7	0.18	31.9	5.0
Polled Hereford	11.6	0.31	34.0	3.8
Simmental	12.3	0.18	35.0	5.8

Price of bulls

Bull prices more than doubled over the 17-yr period, with the lowest prices paid for the 1974-born bulls and highest for the 1986-born bulls. No adjustments were made for inflation or supply/demand conditions influencing the cattle market. Simmental and Gelbvieh were the highest selling breeds (Table 23.4). Bulls on the winter test (sold in the spring) averaged $112 more than bulls sold in the fall; bulls at Beloit sold for $187 more than bulls at Yates Center and $308 more than those at Potwin. Buyers of Gelbvieh bulls discriminated against large birth weights (−$12/lb increase), whereas buyers of Limousin and Polled Hereford bulls paid $13 and $10 more for each lb increase in birth weight. Bulls with heavier adjusted weaning weights and larger weaning weight ratios received higher prices in all breeds. Larger frame bulls sold for more money in all breeds, with per unit increases in frame score ranging from $214 in Polled Hereford to $422 in Gelbvieh. The value of .1 lb increase

in ADG on test varied from $.20 in Limousin to $4.08 in Charolais; an increase of one lb of yearling weight had a value of approximately $3.

112- vs 140-day test

The simple correlation between 112- and 140-d ADG is high (.91), because the gain made the first 112 d is part of the gain made over the 140 d. Correlations of the ranking of bulls at the two times are independent of this part- whole relationship and are given (Table 23.5) for Angus, Charolais, Hereford, and Simmental at the three locations. The rank correlations were generally less than .8 and indicated a significant change in rank among bulls during the last 28 d of the test. Approximately 80% of the 140-d gain information had been obtained by 112 d, and the other 20% was obtained during the last 28 d.

Table 23.4. Average Prices Paid for Bulls ($)

Birth year	Breeds						
	AN	CH	GV	HH	LM	HP	SM
1970	615	574	—	498	—	—	738
1971	732	836	—	568	521	688	805
1972	969	712	—	819	705	937	869
1973	792	912	1125	919	821	873	1100
1974	651	405	316	655	408	576	482
1975	653	577	—	564	520	621	714
1976	746	527	—	605	573	574	766
1977	1022	1140	—	1060	870	752	1189
1978	1484	1538	1000	1219	1340	1000	1706
1979	1312	1276	1025	1159	1192	1030	1420
1980	1201	1184	—	899	1425	832	1507
1981	1058	858	1625	892	688	952	1472
1982	1158	1032	1680	1101	1330	912	1287
1983	1063	1326	1471	1168	1075	915	1204
1984	1180	1618	1468	927	1284	845	1104
1985	1209	1011	1237	714	1002	922	1270
1986	1739	1694	1517	1225	1414	1192	1441

AN = Angus, CH = Charolais, GV = Gelbvieh, HH = Hereford, LM = Limousin, HP = Polled Hereford and SM = Simmental.

Table 23.5. Rank Correlations: 112- vs 140-day ADG

Breed	Location		
	Beloit	Potwin	Yates Center
Angus	.753	.767	.774
Charolais	.779	.811	.783
Hereford	.731	.755	.837
Simmental	.790	.642	.791

There was a significant change in rank of bulls during the last 28 days of the test.

MANAGING BEEF GENOTYPES FOR PROFIT: A COMPUTER SIMULATION

R. R. Schalles, L. C. Martin, and K. O. Zoellner

Summary

In a computer simulation based on KSU data, cattle bred and managed to be moved directly from weaning to feedlot and slaughtered at a young age produced the greatest profit. Cattle that were too small or too large and management systems that increased age at slaughter were less profitable.

This accelerated system of production allows a producer to take advantage of superior genetics and the economic opportunities they provide, especially with retained ownership. The beef industry has the opportunity to continue to produce quality beef, while reducing days to slaughter by taking advantage of the higher efficiency of feed conversion of younger animals. In addition, less shrink, lower trucking costs, fewer sick days, a reduction in medication, lower marketing costs, and reduced interest costs are associated with the accelerated production system. With the availability of EPDs, there is little reason for profit minded cow-calf producers to wean calves that are not of acceptable size to enter the feedlot after the weaning process.

(Key Words: Beef Genotype-management Interactions, Economics, Simulation.)

Introduction

To maximize profit from a beef production system, the management system must match the genotype. Competitively priced edible proteins necessitate that the beef industry evaluate alternative production systems and genotypes to be competitive.

A number of trials have been completed examining the feasibility of accelerated management systems (moving weaned calves directly to the feedlot) compared with conventional systems in which cattle are grown for various periods before finishing. Schalles (1983, KAES Rep. of Prog. 427) found no difference between the systems in feed energy required to produce a pound of retail cuts; however, when yardage, facilities, labor, and interest were considered, faster gaining cattle and accelerated management programs were more economical. Lambert et al. (1984, KAES Rep. of Prog. 448) found that calves required 1.2 lb less feed per lb of gain and were 155 d younger at slaughter, making them more profitable than yearlings. Breed groups in the Kansas Steer Futurity (Lambert, 1984, KAES Rep. of Prog. 448) with the ability to gain rapidly and grade choice were the most profitable. Dikeman et al. (1985, J. Anim. Sci.) compared Angus × Hereford (AH) crossbred steers to steers that were 3/8 Simmental, 1/4 Chianina, 3/8 Angus or Hereford (SC) on a conventional vs accelerated management system. The SC steers on the accelerated system had the lowest break-even live price and lowest cost/lb

retail product. Schalles et al. (1989, KAES Rep. of Prog. 567) compared fast-growth genotype steers placed on a high energy ration one month after weaning to slow-growth genotypes on a growing ration for 155 d followed by a 62-d finishing ration. The fast-growth steers produced heavier, higher quality carcasses in less time and at a greater profit than the slow-growth steers.

Experimental Procedures

Three biological genotypes for growth and mature size, and two management systems (conventional vs accelerated) were evaluated using Kansas research data cited in the introduction as inputs for the Colorado State University cow herd simulation program. The three genotypes simulated were mature cow weights of 1,600 lb (LARGE), 1,250 lb (MEDIUM), and 900 lb (SMALL), with all cows in body condition score 5. The relative rate of maturity was the same for all genotypes. A 60-d June/July breeding season was used. Steer calves, cull heifer calves, and open yearling heifers were fed out. The conventional system (WGF) included November 1 weaning, winter growing, summer grazing, and finishing. The accelerated system (ACC) involved October 1 weaning and going directly to the feedlot for

Table 24.1. Herd, Production, and Economic Data

Item	Biological type					
	Large		Medium		Small	
	WGF	ACC	WGF	ACC	WGF	ACC
Mature cow wt, lb	1600	1600	1250	1250	900	900
Frame score	9-10	9-10	5-6	5-6	2-3	2-3
Cows/640 acres grass[a]	37.7	50.8	43.2	57.1	66.0	81.5
Steer adjusted 205 wt, lb	672	672	555	555	353	353
Maximum milk, lb	24	24	22	22	16	16
Dystocia, %	18.6	18.9	6.6	6.7	5.4	5.4
Calf death, %	5.5	5.5	4.2	4.2	4.1	4.1
Post birth death, %	3.2	3.8	2.2	2.5	2.1	2.4
Total death, %	8.7	9.3	6.4	6.7	6.2	6.5
Heifers pregnant, %	88.6	87.8	90.4	89.5	90.8	90.0
Two-yr-olds pregnant, %	81.6	81.4	86.6	86.2	86.6	86.1
Cows pregnant, %	82.5	80.7	88.3	88.0	87.8	87.7
Replacement females, %	29.6	30.9	23.2	23.7	23.2	23.7
Cull cows, %	20.9	21.6	16.8	17.0	17.0	17.2
Total TDN, lb[a]	14,152	11,875	11,550	9,281	7,990	6,569
Total feed cost[a], $	727	641	566	476	400	332
Return above feed[a], $	233	217	232	257	171	64
Return/acre above feed, $	14	17	16	23	18	8

[a]Cow unit = the cow, her % of progeny and replacement heifers.

finishing. All steers and heifers were slaughtered at approximately .4 in. backfat. Body components of growth (fill, bone, muscle, fat, and other) were calculated to evaluate muscle mass production by the genotype-management system combinations. To make land resource comparisons, cow numbers were adjusted based on cow size, milk production, percentage replacement heifers, and management system and presented as cows per 640 acres of grass.

Results and Discussion

As cow size and milk production increased, the number of cows per section of grass decreased (Table 24.1). From 23% (with SMALL cows) to 35% (with LARGE cows) more cows could be kept under the ACC system. The SMALL and MEDIUM cattle had higher pregnancy rates and lower death loss rates than LARGE, necessitating a lower percentage of heifers to be saved for replacements. The WGF management system required more feed (TDN) per cow than the ACC system and the feed cost per cow decreased with smaller size cows. Considerable more muscle mass per cow unit was produced by the LARGE cows. More muscle mass per cow was produced by the WGF system; however, more muscle per acre was produced with the ACC system. Steers from the LARGE and MEDIUM cows on the WGF system received a price discount because of heavy carcasses, whereas steers from SMALL cows on the ACC system received a discount because of light carcasses. Steers from the MEDIUM cows on the ACC system and from SMALL cows on the WGF system produced carcasses within the weight range of maximum price. The highest return above feed cost, both per acre and per cow, was from MEDIUM cows on the ACC system. The lowest returns were from the SMALL cows on the ACC system.

RELATIONSHIP OF MILK PRODUCTION IN ANGUS AND SIMMENTAL COWS WITH MILK EXPECTED PROGENY DIFFERENCES (EPDs) AND CALF WEANING WEIGHT

T. T. Marston, D. D. Simms, R. R. Schalles, K. O. Zoellner, L. C. Martin, and G. M. Fink[1]

Summary

Spring and fall calving Angus (n=86) and Simmental (n=96) cows at three different locations in Kansas were used to evaluate the relationships between milk production, Milk Expected Progeny Difference (Milk EPD), and calf weaning weight. A change of 1 lb in Milk EPD resulted in 4.95 lb change in calf weaning weight in Angus and 4.60 lb in Simmental. Each lb increase in Milk EPD predicted a 69.87 lb increase in total lactation milk production in Angus and 70.74 lb in Simmentals. Positive correlations were .40 and .64 between Milk EPD and total milk produced per lactation and .24 and .49 between Milk EPD and calf weaning weight for Angus and Simmental, respectively. Milk EPDs can be used as genetic selection tools to influence milk production levels and make corresponding changes in calf weaning weights.

(Key Words: Angus, Simmental, Milk, Lactation, Calf Weaning Weight, Milk Expected Progeny Differences.)

Introduction

Milk production is a major factor influencing calf weaning weight. The ability to predict milk production is useful in improving calf weaning weight and would aid in matching milk production levels to the environment. The development of Milk EPDs has provided both commercial and purebred cattle producers with estimates of the milking ability of an individual's daughters expressed in lb of calf weaned. Milk EPDs predict the genetic difference in average 205-d weight of a individual's daughters' progeny related to milking ability. Because the industry is concerned about the validity of these predictions, we initiated this study to determine the relationships between Milk EPD, milk production, and calf weaning weight.

Experimental Procedures

Milk production in spring- and fall-calving, purebred Angus and Simmental cows was measured at three different locations. Milking took place at approximately 60, 120, and 180 d postpartum. On the day preceding each milking, cows and calves were separated for 4 to 6 hr,

[1]The authors express appreciation to Joe Mertz, Manhattan, Bob Dickinson, Gorham, and Henry Gardiner, Ashland, for their assistance in data collection. Further appreciation is expressed to the American Angus Association, St. Joseph, Missouri, and the American Simmental Association, Bozeman, Montana, for their financial support and for providing Expected Progeny Differences.

then placed together until all calves completed nursing and separated again. Approximately 12 hr following the separation, cows were injected IM with 40 IU of oxytocin to stimulate milk letdown and were immediately machine milked. Samples from each milking were analyzed by the Kansas Dairy Herd Improvement Association to determine butterfat, lactose, protein, and somatic cell count.

Twenty-four hr milk production was estimated by doubling the 12-hr production, which had been adjusted for time of separation from the calf. Daily milk production values were used to calculate lactation curves using the equation $Y(n)=Ae^{kn}$, where n=week of lactation, Y=daily milk production in kg, e=base of natural logarithms, and A and k are constants defining the shape of the lactation curve. Total milk production per lactation was estimated from each cow's individual curve.

Spring calves were born from late February to mid April, and the cow/calf pairs were grazed on native bluestem pastures throughout the summer without creep feed. Fall Simmental calves were born from late August to early October; cow/calf pairs were supplemented with a milo-based energy ration and sudan hay as they grazed dormant short grass pasture and crop residues. In addition, fall Simmental calves received an energy creep feed. All calf weaning weights were measured at approximately 205 d of age.

Expected Progeny Differences were provided by the American Angus Association, St. Joseph, Missouri, and the American Simmental Association, Bozeman, Montana.

Results and Discussion

Correlations between milk production, calf weaning weight, and Milk EPD are presented in Table 25.1 by breed, location, calving season, and year. The positive correlations indicate that Milk EPDs can be used in predicting milk production. Similarly, cows that produced heavier calves at weaning possessed higher Milk EPDs. Environmental conditions affected total milk production and its relationships with calf weaning weight and Milk EPD, but we were unable to compute the magnitude of those effects.

A 1 lb change in Milk EPD resulted in 4.95 lb and 4.60 lb changes in Angus and Simmental calf weaning weights, respectively. Total milk production changed 69.87 lb in Angus and 70.74 lb in Simmental with each corresponding 1 lb change in Milk EPD.

Angus averaged 3,524 lb of milk production per lactation, with an avg Milk EPD of 1.92 lb. Simmentals averaged 3,773 lb of milk production per lactation, with an avg Milk EPD of 2.89 lb. Figure 25.1 represents the milk production predicted from Milk EPDs by breed.

Table 25.1. Correlations between Milk Production, Weaning Weight and Milk EPD by Location

Comparison	Angus			Simmental				
	Sp88 A[1]	Sp89 A	Total	F88 B[1]	Sp88 C[1]	Sp88 A	Sp89 A	Total
	correlation coefficient							
Total milk production and weaning weight	.61	.25	.40	.62	.23	.57	.51	.61
Total milk production and milk EPD	.42	.34	.38	.28	.77	.48	.55	.40
Milk EPD and weaning weight	.30	.17	.24	.44	.55	.55	.45	.44

[1]A, B, and C represent different herd locations in the fall (F) and spring (Sp) of 1988 and 1989.

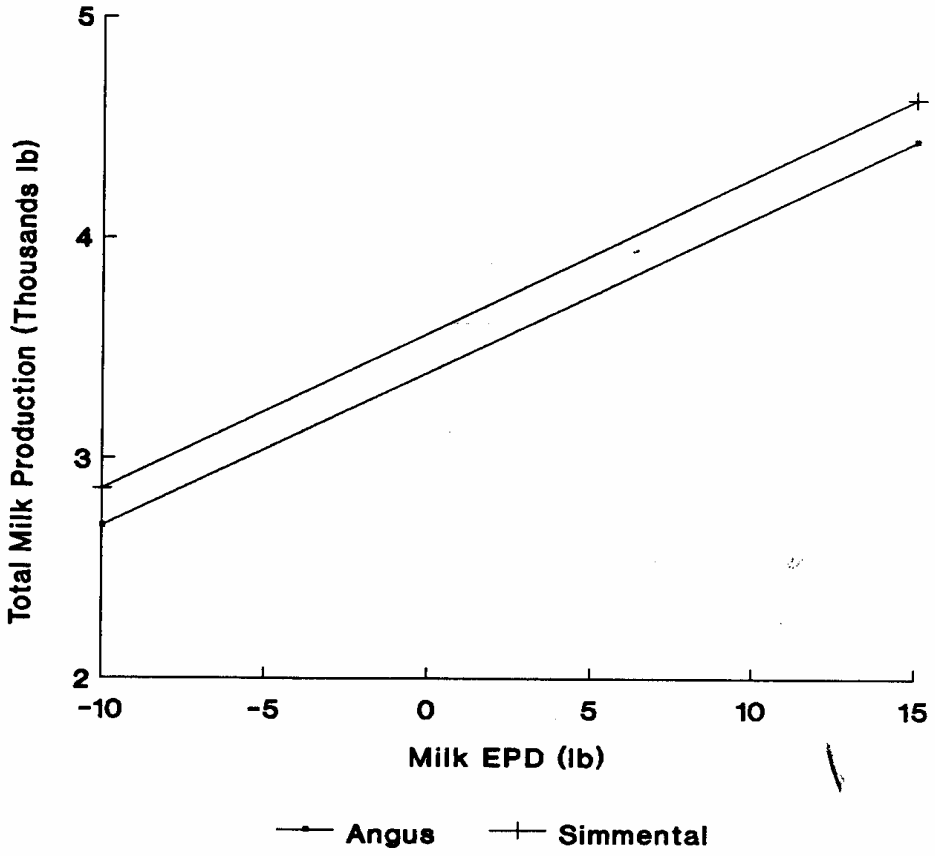


Figure 25.1. Relationship of Milk EPD and Total Milk Production

COMPARISON OF STEER FEEDLOT PERFORMANCE AND CARCASS TRAIT UNIFORMITY BY METHOD OF SORTING[1]

P. L. Houghton[2], D. D. Simms, and J. J. Higgins[3]

Summary

Long yearling steers (n=997) of various biological types from two origins were used to test performance and carcass trait uniformity of unsorted cattle, visually sorted cattle, and cattle sorted by ultrasound and hip height. No significant differences (P>.05) in initial backfat uniformity were identified between sorted and unsorted groups; however, very little variation existed across all treatments (.17±.033 in.). Initial backfat had positive linear relationships with initial weight and carcass backfat and negative linear relationships with days on feed and daily gain (P<.05). These data indicate a reliable measurement of initial backfat could be useful for predicting days on feed and/or carcass backfat in long yearling steers, but economic usefulness will depend upon the variability of the cattle and the method of grouping.

(Key Words: Feedlot, Ultrasound, Sorting, Carcass Traits.)

Introduction

Feedlot managers need to be able to identify feeder cattle that will consistently produce carcasses of similar weight with acceptable yield and quality grades. In an effort to meet these needs, many managers have expressed an interest in sorting incoming feedlot cattle into outcome groups to 1) improve production efficiency, 2) improve product uniformity, 3) increase total cattle fed annually, and 4) accurately project days on feed. Previous trials conducted by Kansas State University scientists have indicated potential benefits of sorting feeder cattle by ultrasound; however, some questions remain. Among these are: 1) How does visual sorting of feeder cattle compare to sorting by ultrasound? and 2) Will sorting by ultrasound be effective with cattle of diverse genetic and management backgrounds? This trial was designed to answer these specific questions.

[1]Sincere appreciation is expressed to Decatur County Feed Yard, Oberlin, for providing cattle, facilities, and management; and to Frank Schwulst, Chuck McNall, Tom Ridder, Dan Waldner, Conley Wright, Bill Able, Dave Nichols, Dan Miller, and Warren Weibert for their assistance in data collection.

[2]Northwest Kansas Research-Extension Center.
[3]Department of Statistics.

Experimental Procedures

Long yearling steers (n=997) of various biological types from two origins were used to evaluate feedlot performance and carcass trait uniformity of unsorted cattle (n=100), visually sorted cattle (n=448), and cattle sorted by ultrasound and hip height (n=449). All steers were individually identified, weighed, measured for hip height (HH), and ultrasonically measured for backfat (BF) during normal feedlot processing. Four evaluators independently appraised the visually sorted steers for backfat and hip height. Sorted cattle were grouped as follows: 1) small framed (SF, ≤47 in. HH), light conditioned (LC, ≤.16 in. BF); 2) SF, heavy conditioned (HC, ≥.20 in. BF); 3) large framed (LF, >47 in. HH), LC; and 4) LF, HC. Visually sorted steers were penned according to backfat and hip height estimates of the most experienced visual evaluator. Visually and ultrasound-sorted cattle were penned separately according to the groups above into eight pens. Unsorted controls were grouped into two pens. All steers were subjected to identical management and were slaughtered by pen when a random 15% sample of cattle in each pen averaged .40 in. backfat measured by ultrasound.

Results and Discussion

Days on feed ranged from 83 to 97 d. Unsorted control cattle were fed for an average of 92.5 days. Carcass yield grades of the sorted cattle were consistent, ranging only from 2.3 to 2.8 by pen. Average yield grade for the control groups equaled 2.55.

Correlations (r) between visual and ultrasound estimates of initial backfat ranged from .24 to .37. Visual estimates of hip height were more accurate, with correlations to measured hip height ranging from .50 to .70. Ultrasonic measurement of initial backfat was more highly related to carcass backfat (r=.39) than to visual estimations of initial backfat (r=.16 to .33). Visual and ultrasonic measurements of initial backfat were negatively correlated to days on feed and were virtually identical (r=-.36 and -.33, respectively). Cattle origin had no relationship to days on feed (P>.05), but biological type (HH) was related to days on feed (P<.05).

In order to test the uniformity of performance factors and carcass traits, variances of the means were statistically tested. Table 26.1 lists these factors by method of sorting (unsorted, visual, and ultrasound).

Table 26.1. Steer Performance Factors and Carcass Traits by Method of Sorting

Item	Treatment		
	Control	Visual	Ultrasound
Initial backfat, in.	.17 ± .033	.17 ± .035	.17 ± .032
Daily gain, lb	3.9 ± .9	3.8 ± .7	3.8 ± .7
Carcass backfat, in.	.44 ± .14	.40 ± .10	.44 ± .12
Yield grade	2.5 ± .6	2.4 ± .8	2.6 ± .6

Although visually and ultrasound-sorted cattle were slightly more uniform for certain traits, no significant differences were found when daily gain and carcass uniformity were tested across treatments. This might be partially explained by the fact that these cattle had very uniform backfats upon arrival at the feedlot (average backfat = .17±.033 in. across all treatments), and thus significant

differences in feedlot performance or carcass trait uniformity were unlikely. Likewise, this initial backfat uniformity resulted in all of the treatment groups being marketed over a relatively short period of time (14 d), so an economic advantage from differences in days on feed was unlikely.

However, when carcass trait means were segregated by initial backfat (Table 26.2), negative linear relationships were seen with days on feed and daily gain. In addition, there were positive linear relationships of initial backfat with initial weight and carcass backfat ($P<.05$). It is especially interesting to note the strong linear relationship that existed between initial backfat measured by ultrasound and carcass backfat measured at the slaughter plant. A strong linear relationship also existed between initial backfat and initial weight, making it appear that initial weight might be nearly as useful as initial backfat in predicting days on feed. It is important to realize, however, that these cattle were subjected to identical management procedures on pasture for 3 to 4 mo before they entered the feed yard. This could lead to a stronger relationship between initial weight and initial backfat than one might expect in cattle coming from diverse backgrounding environments.

Table 26.2. Feedlot Performance and Carcass Trait Means by Initial Backfat

	Initial backfat, in.[a]					
Item	.08	.12	.16	.20	.24	.28
Initial wt, lb	770 ± 95	780 ± 83	796 ± 70	820 ± 65	824 ± 69	847 ± 52
Average daily gain, lb	4.13 ± 1.18	3.94 ± .73	3.80 ± .70	3.80 ± .75	3.69 ± .60	3.46 ± .05
Days on feed	93 ± 4	93 ± 4	92 ± 4	88 ± 5	88 ± 4	88 ± 1
Carcass backfat	.32 ± .10	.36 ± .10	.41 ± .10	.45 ± .11	.53 ± .12	.57 ± .06

[a]Backfat (measured by ultrasound) and weights determined at the time cattle were processed into the feedlot.

In conclusion, there was no economic benefit associated with sorting, probably because of the initial uniformity of the cattle and the method of grouping. However, it appears likely that initial backfat can be used to predict days on feed and/or carcass backfat in long yearling steers. In addition, visual sorting resulted in similar variability at slaughter to sorting by ultrasound and hip height. This might be due to the fact that when cattle were sorted by ultrasound, a single backfat measurement was used as the basis for sorting, whereas visual appraisers had the opportunity to evaluate the entire animal. Ultrasound may be helpful, however, as a training tool for inexperienced visual evaluators.

EVALUATION OF WHEAT MIDDLINGS-BASED SUPPLEMENTS AT DIFFERENT CRUDE PROTEIN CONCENTRATIONS FOR CATTLE CONSUMING WINTER RANGE FORAGE[1]

G. D. Sunvold, R. C. Cochran, and E. S. Vanzant

Summary

Influence of increasing crude protein concentration in a wheat middlings-based supplement was evaluated in an intake/digestion trial. Protein-supplemented steers demonstrated increased (P<.01) intake of dormant, bluestem-range forage when compared with unsupplemented steers. Although increasing concentration of supplemental crude protein from 15 to 20% substantially increased (P<.01) forage and total dry matter intake, only slight increases in forage and total dry matter intake occurred when the concentration exceeded 20%. Protein supplementation increased (P<.01) fiber and dry matter digestibilities. Additionally, fiber digestibility tended (P=.087) to increase with increasing crude protein concentration of the supplement. Results suggest that when feeding a wheat middlings-based supplement, the crude protein concentration should be 20% or higher to optimize use of poor-quality forage.

(Key Words: Protein, Supplementation, Wheat Middlings, Intake, Digestibility, Winter Range.)

Introduction

Kansas leads the nation in quantity of wheat produced (17.3% of the U.S. total from 1985 to 1988) and wheat flour milled (13.4% of the U.S. total from 1985 to 1988). Approximately 25% of the wheat milled is left as the by-product, wheat middlings or mill feed. Wheat middlings are often reasonably priced and included in commercial range cattle supplements. Past research has demonstrated that protein supplementation increases forage intake and digestibility and, thus, performance of cattle grazing dormant winter-range. Protein supplementation research using wheat middlings-based supplements has also demonstrated potential for improving the intake and digestibility of dormant range forage over those of unsupplemented cattle. However, it is unclear whether increasing the crude protein concentration of wheat middlings-based supplements would improve their efficacy. Therefore, an experiment was conducted to evaluate the forage intake and digestibility responses to wheat middlings-based supplements containing increasing concentrations of crude protein.

Experimental Procedures

Sixteen ruminally cannulated, Hereford × Angus steers averaging 928 lb were randomly assigned within weight groups to one of four treatments: 1) control (no supplement); 2) 15.4%

[1]The authors express sincere appreciation to Gary Ritter, Wayne Adolph, and the student employees at the Range/Cow-calf unit for their invaluable assistance in conducting this trial.

crude protein supplement; 3) 20.7% crude protein supplement; 4) 25.4% crude protein supplement. All protein supplements consisted of 60% wheat middlings and 40% soybean meal and grain sorghum. Soybean meal to grain sorghum ratios were adjusted to alter the crude protein concentration of the supplements. All supplements were fed at 3.7 lb/head/d and contained similar metabolizable energy levels (3.9 Mcal/head/d). Dormant, winter-harvested, bluestem-range forage (2.0% crude protein) was fed to each steer at 130% of its previous 5-d intake. Steers were housed in individual pens. The trial consisted of a 14-d adaptation period, a 7-d intake measurement period, and a 7-d total fecal collection period. Forage and grain offered, forage refusals, and fecal output were weighed and sampled daily, analyzed for dry matter, and stored for analyses.

Results and Discussion

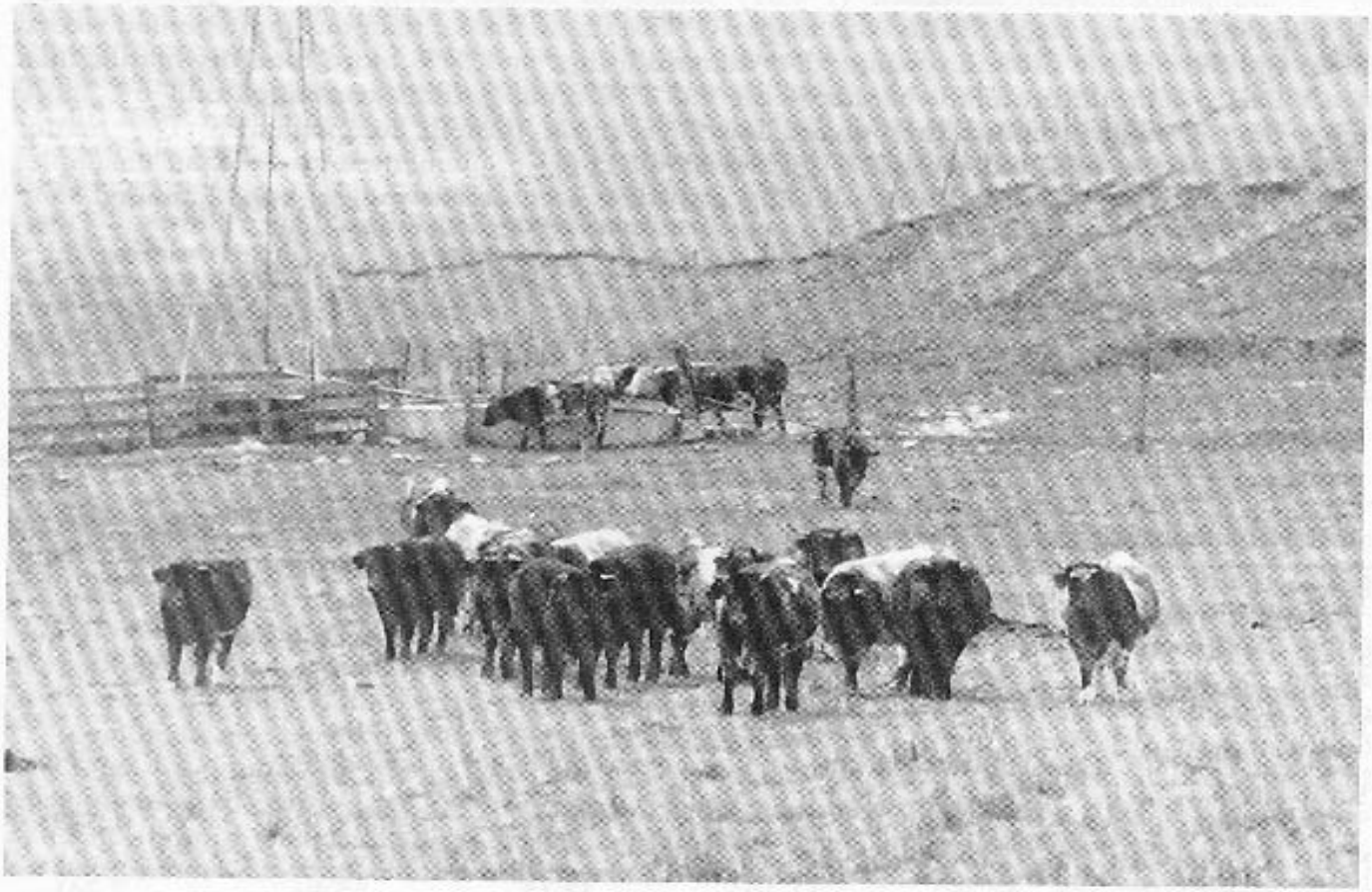
Supplementation increased (P<.01) intake of range forage by 44% (Table 27.1). Supplemented steers displayed an 80% higher (P<.01) total intake than unsupplemented steers. Steers fed 20% crude protein consumed 45% more forage and 34% more total dry matter than steers fed 15% crude protein, whereas steers fed 25% crude protein consumed only 5% more forage and total dry matter than steers fed 20% crude protein supplements. Dry matter digestibility of the total diet was 42% greater (P<.01) in supplemented steers than unsupplemented steers. Similarly, fiber digestibility was 15% greater (P<.01) in supplemented than

Table 27.1. Influence of Supplemental Protein Sources on Intake, Diet Digestibility, and Fiber Digestibility of Dormant, Bluestem-range Forage

Item	None	Supplement			SE[a]
		15% Crude protein	20% Crude protein	25% Crude protein	
Forage DM[b] intake, % BW[c]	1.03	1.12	1.62	1.70	.096
Supplement DM intake, % BW	—	.37	.37	.38	—
Total DM intake, % BW[c]	1.03	1.49	1.99	2.08	.096
Total DM digestibility, %[d]	34.70	49.28	48.84	49.78	1.589
Neutral Detergent fiber digestibility, %[e]	46.18	51.19	53.15	55.49	2.241

[a]SE = standard error.
[b]DM = dry matter.
[c]Supplemented greater than unsupplemented (P<.01); quadratic response (P<.05) within supplemented groups.
[d]Supplemented greater than unsupplemented (P<.01).
[e]Supplemented greater than unsupplemented (P<.01); linear response (P=.087) within supplemented groups.

unsupplemented steers. Fiber digestibility tended (P=.087) to increase with increasing crude protein concentration of the supplement. Increases in forage intake and digestibility with protein supplementation agree with previous research. The positive impact of protein supplementation on forage use and the observed enhancement of forage intake and digestibility when supplement crude protein concentration was increased also are in agreement with previous research. Therefore, when wheat middlings are used as the major feedstuff in a range supplement, the crude protein concentration frequently will need to be adjusted upward (20% or greater) to optimize range forage use.



LEVEL AND METHOD OF FEEDING DEHYDRATED ALFALFA PELLETS AS A PROTEIN SUPPLEMENT FOR BEEF COWS GRAZING WINTER FLINT HILLS RANGE[1]

E. S. Vanzant, R. C. Cochran, and L. R. Corah

Summary

Four winter protein supplementation schemes were studied using 116 beef cows grazing Flint Hills range. The treatments were: 1) 4.0 lb soybean meal/sorghum grain (27.3% crude protein (CP)) per head daily (SS), 2) 4.0 lb dehydrated alfalfa pellets (DEHY; 20.0% CP) per head daily (LO-DEHY), 3) 5.5 lb DEHY per head daily (HI-DEHY), and 4) DEHY fed at levels calculated to provide 4.0 lb per head daily with less fed in early winter and more fed in late winter (STAGGER-DEHY). The HI-DEHY and SS treatments resulted in higher ($P<.05$) weight gains and smaller ($P<.05$) losses in body condition before calving than the other two treatments. The HI-DEHY group had less cumulative weight loss ($P<.05$) at calving than the SS group. Cow performance was similar ($P>.10$) for the LO-DEHY and STAGGER-DEHY groups. Cow reproductive performance and calf birth weights and average daily gains were unaffected ($P>.10$) by the treatments. All of the supplementation schemes evaluated in this experiment appeared relatively satisfactory, given the initial condition of the cows. However, the higher levels of nutrient supplementation (HI-DEHY and SS; 1 lb CP/d) would probably sustain reproductive performance at a higher level over an extended period of time. Additionally, when DEHY was fed at the low level, altering the schedule of feeding over the winter did not appear to affect cow performance.

(Key Words: Cows, Protein Supplements, Dehydrated Alfalfa Pellets, Winter Range.)

Introduction

Kansas State research has shown that dehydrated alfalfa pellets, when compared with a grain/soybean meal supplement containing a moderate concentration of crude protein (CP; 26%), may increase pre-calving weight gain and decrease weight loss at calving in beef cows grazing native winter range. However, the CP concentration of dehydrated alfalfa is lower than that of typical grain/soybean meal-based supplements, requiring higher levels of dehydrated alfalfa to achieve similar daily CP intakes. One objective of this experiment, therefore, was to determine if animal performance could be maintained at similar levels by supplementing with the same amount of dehydrated alfalfa pellets (20% CP) and soybean meal/sorghum grain (27% CP) or whether increasing the level of dehydrated alfalfa to provide similar amounts of crude protein was necessary. Additionally, the requirements of beef cows for protein and energy are known to increase as the animal nears parturition. Feeding low levels of supplements early in

[1]Appreciation is extended to W. R. Adolph, G. A. Ritter, W. D. Root, and J. R. Bradley for their helpful assistance in conducting this experiment.

the winter and increasing the amount fed as cows near parturition could increase the efficiency of the utilization of the supplemental nutrients. Therefore, the second objective of this experiment was to determine if altering the feeding schedule of the dehydrated alfalfa pellets to more closely match the requirements of the cows would impact the performance of beef cows grazing winter Flint Hills range.

Experimental Procedures

Four protein supplementation schemes were studied using 116 pregnant, Hereford × Angus cows (avg initial wt = 1110 lb; avg initial body condition = 6.1). The treatments were: 1) 4 lb soybean meal/sorghum grain supplement per head daily (27.3% crude protein), 2) 5.5 lb DEHY (20.0% crude protein) per head daily, 3) 4 lb DEHY per head daily, and 4) DEHY fed at a level calculated to provide an average of 4.0 lb/head daily, with amounts fed staggered over the grazing period. For the STAGGER-DEHY treatment, the following feeding schedule was followed: 2 lb/head daily from November 29 to December 30, 3 lb/head daily until January 29, and 5.5 lb/head daily until calving. The average calving date was several days earlier than expected from estimated fetal ages (from August 30 palpation). Therefore, the average supplement consumption for STAGGER-DEHY was 3.8 lb/d. The SS and HI-DEHY treatments each supplied 1 lb of CP/head/d, whereas the LO-DEHY and the STAGGER-DEHY treatments each provided an average of .7 lb CP/head/d. Supplementation began on November 29 and continued until calving (avg calving date = March 11), after which cows were supplemented with 10 lb alfalfa hay/d until sufficient new grass growth was available (approximately the end of April). The three experimental pastures were dominated by big bluestem (*Andropogon gerardii*), indiangrass (*Sorghastrum nutans*), and little bluestem (*Andropogon scoparius*). Each pasture contained animals from all four treatments. These groups were rotated through the pastures every 28 d. The animals in each pasture were gathered daily and sorted into treatment groups prior to being bunk-fed the appropriate supplements.

The cows were weighed and scored for body condition (scale: 1 = extremely thin, 9 = extremely fat) on d 0, 85, 102 (within 48 hr postpartum), 167, and 259 (d 0 = November 29), following an overnight stand without access to food or water. Cows were pasture mated as a single herd to a group of four Angus bulls. The breeding season began on May 15 and continued for 60 d thereafter. Calves were weighed within 48 hr of birth and on d 167 and 259 of the experiment. Pregnancy and approximate fetal ages were determined by rectal palpation (August 30), and conception dates were estimated from the fetal ages.

Results and Discussion

In the prepartum period, cows consuming supplements that provided 1 lb of CP per head daily (HI-DEHY and SS) gained more weight ($P<.05$; Table 28.1) and lost less body condition ($P<.05$; Table 28.1) than cows fed the supplements providing .7 lb CP per head daily (LO-DEHY and STAGGER-DEHY). In the 100 d prepartum, the groups receiving 1 lb of supplemental CP gained an average of 40 lb and lost an average of .25 points in condition, while the other two groups merely maintained their body weights and lost an average of .65 units in condition. Immediately postpartum, the cows on the HI-DEHY supplement had smaller weight losses ($P<.05$) than any of the other groups. However, by the beginning of the breeding

season (d 167), the HI-DEHY and SS supplemented cows had similar (P>.10) cumulative weight losses, which were lower (P<.05) than those of the LOW-DEHY and STAGGER-DEHY groups. Staggering the feeding of DEHY across the winter did not impact cow performance. Cow weight and condition changes were similar (P>.10) for the LO-DEHY and STAGGER-DEHY treatments at all times.

In spite of the differences noted in body weight and condition score, the treatments did not influence (P>.10) reproductive performance of the cows (Table 28.2). Total pregnancy rate averaged 98.3%, and the average calving interval was 365 d. Although numerically the HI-DEHY and SS groups had more cows bred in the first third of the breeding season, these differences were not statistically significant. Calf birth weights and ADGs were similar (P>.10) among treatments.

Table 28.1. Effect of Type, Level, and Method of Winter Protein Supplementation on Cumulative Weight Changes and Body Condition Changes in Beef Cows

Day of experiment	HI-DEHY	SS	STAGGER-DEHY	LO-DEHY	SE[a]
Weight changes					
Starting weight	1104	1101	1117	1116	42
85	56[c]	41[c]	2[d]	8[d]	11
102 (calving)	−123[c]	−157[d]	−181[d]	−170[d]	16
167 (breeding)	−140[c]	−145[c]	−177[d]	−169[d]	11
259 (trial end)	7	3	−13	−22	11
Condition score changes					
Starting CS[b]	6.0	6.1	6.1	6.1	.2
85	−.3[c]	−.2[c]	−.7[d]	−.6[d]	.1
102 (calving)	−.4[c]	−.4[c]	−.9[d]	−.8[d]	.1
167 (breeding)	−.7	−.8	−1.1	−1.0	.1
259 (trial end)	.1	−.1	−.2	−.1	.2

[a]SE = standard error of the difference between means.
[b]CS = body condition score on a scale of 1-9.
[cd]means within a row with different superscripts differ (P<.05).

Table 28.2. Effect of Type, Level, and Method of Winter Protein Supplementation on Calf Performance and Reproductive Performance of Cows

Item	HI-DEHY	SS	STAGGER-DEHY	LO-DEHY	SE[a]
No. cows	28	29	29	30	—
Calf birth wt, lb	85	84	87	83	4
65-d calf ADG[b], lb	1.7	1.7	1.7	1.6	.1
157-d calf ADG[b], lb	2.1	2.1	2.1	2.0	.1
Pregnancy rate[c], %	100.0	96.6	96.6	100.0	—
Calving interval[c], d	364	363	364	369	6
Percent bred in each 1/3 of breeding season[c]					
First	71.4	78.6	60.7	63.3	—
Second	21.4	17.9	32.1	30.0	—
Third	7.2	3.5	7.2	6.7	—

[a]SE = standard error.
[b]ADG = average daily gain.
[c]Estimated from fetal ages determined by rectal palpation.

EFFECT OF PREGNANCY ON FORAGE INTAKE AND UTILIZATION IN SPRING-CALVING BEEF HEIFERS WINTERED ON FLINT HILLS RANGE[1]

E. S. Vanzant and R. C. Cochran

Summary

Six ruminally and eight bi-fistulated (ruminal and esophageal), 2-yr-old beef heifers were used to study the effects of pregnancy on forage intake and utilization under grazing conditions. During the third trimester of gestation, pregnant heifers ate more ($P<.05$) forage than nonpregnant heifers and maintained similar ($P>.10$) levels of organic matter and fiber digestibility. As calving neared, pregnant animals had higher ($P<.05$) rates of passage and tended to have lower ruminal capacity ($P=.15$) and digesta fill ($P=.14$) than nonpregnant animals. Differences in quality of diet selected by the two groups were minimal.

(Key Words: Heifers, Pregnancy, Intake, Digestibility, Winter Range.)

Introduction

Because the intake of grazing ruminants is believed to be frequently limited by ruminal capacity, it has been suggested that, in pregnant cows, the growing fetus may displace ruminal volume and cause a decrease in intake. However, little information is available on the magnitude of changes in forage intake and utilization in pregnant beef cows grazing winter range. The objective of this experiment was to determine the differences in intake, ruminal digesta volume, ruminal capacity, and forage utilization between nonpregnant and pregnant heifers grazing Flint Hills range during the last third of gestation.

Experimental Procedures

Six ruminally and eight bi-fistulated (ruminal and esophageal) Hereford × Angus heifers were used to determine the effects of pregnancy on forage intake and utilization under grazing conditions. Three ruminally and four bi-fistulated heifers were synchronized and bred to a single Angus bull. One pregnant bi-fistulated heifer aborted during early pregnancy. The heifers calved within a 16-d period (avg calving date = 2/11/89). The nonpregnant heifers served as a control. The experiment consisted of four periods (P1 = 11/3 to 11/15/88; P2 = 12/6 to 12/17/88; P3 = 1/16 to 1/27/89; P4 = 2/24 to 3/10/89). All heifers grazed the same Flint Hills range pasture. Dehydrated alfalfa pellets were supplemented at .5% BW daily in P1, P2, and P3 and at .75% BW in P4. Grazed forage samples, collected from esophageal fistulas, were analyzed for concentrations of neutral detergent fiber, indigestible acid detergent fiber (IADF), crude protein, and acid detergent insoluble nitrogen (an estimator of unavailable nitrogen).

[1]Appreciation is expressed to G. A. Ritter, W. R. Adolph, W. D. Root and J. R. Bradley for their contributions to this experiment.

Fecal output was determined by continuously pumping an indigestible marker, cobalt EDTA, into the rumen and measuring the concentration of the marker in fecal samples. Digestibility was determined from the feed:feces ratio of IADF concentration. Digestibility and fecal output measures were used to determine intake of grazed forage. Ruminal fill was assessed by manually emptying rumens, and ruminal capacity was a measure of the amount of water that could be pumped into the empty rumen.

Results and Discussion

There was a tendency (P=.16) for intake differences between pregnant and nonpregnant heifers to be influenced by period (Figure 29.1), with an average of 21% higher (P<.05) forage intake in pregnant heifers in P1, P2, and P4 and similar (P>.10) forage intake between the two groups in P3. Digestibility of organic matter and neutral detergent fiber was unaffected (P>.10) by pregnancy status. Fifteen days before calving (P3), pregnant animals tended to have lower ruminal capacity (P=.15) and ruminal digesta fill (P=.14) than nonpregnant animals (Table 29.1). Ruminal capacity and fill did not differ (P>.10) between pregnant and nonpregnant animals at 88 (P1) or 56 d (P2) before calving or at 13 d after calving (P4). Pregnant animals also had higher (P<.05) rates of passage of indigestible fiber through the digestive tract at 56 (P2) and 15 d (P3) before calving, whereas passage rates did not differ (P>.10) 88 d before (P1) or 13 d after calving (P4).

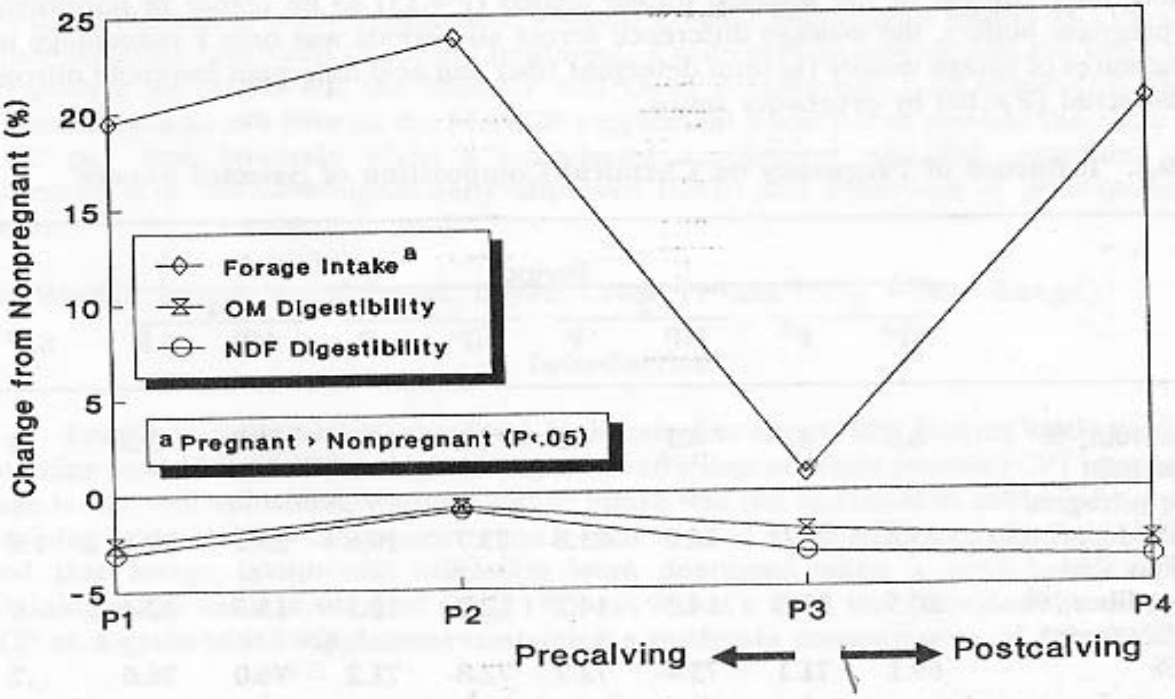


Figure 29.1. Forage Intake, Organic Matter (OM) Digestibility, and Neutral Detergent Fiber (NDF) Digestibility of Pregnant Heifers as a Percentage of Nonpregnant Heifers at Three Periods Pre- and One Period Post-calving

Table 29.1. Influence of Pregnancy on Ruminal Capacity, Digesta Fill, and Indigestible Fiber Passage

Item	Period 1		2		3		4		SE[c]
	NP[a]	P[b]	NP	P	NP	P	NP	P	
Ruminal capacity, gal[d]	32.0	32.0	29.5	29.4	32.8	29.8	32.4	33.8	2.0
Ruminal digesta fill, lb[d]	120.1	129.6	127.9	127.7	128.3	111.3	137.1	135.9	11.0
Indigestible fiber passage, %/h[d]	3.9	4.3	3.9[e]	5.2[f]	3.9[e]	5.2[f]	3.9	4.2	.5

[a]NP = nonpregnant. [b]P = pregnant. [c]SE = standard error.
[d]Pregnancy status by period interaction (P<.10).
[ef]Means within a row and within the same period with different superscripts differ (P<.05).

Only slight differences existed between pregnant and nonpregnant cows in diet selection (Table 29.2). Eighty-eight days before calving (P1), nonpregnant cows selected a diet 1.8 percentage units higher in crude protein than pregnant cows, whereas both groups selected forage of similar (P>.10) crude protein concentration during all other periods. Although the indigestible fiber content of the selected forage tended (P=.15) to be higher in nonpregnant than in pregnant heifers, the average difference across all periods was only 1 percentage unit. Other measures of forage quality (neutral detergent fiber and acid detergent insoluble nitrogen) were unaffected (P>.10) by pregnancy status.

Table 29.2. Influence of Pregnancy on Chemical Composition of Selected Forage

Item	Period 1		2		3		4		SE[c]
	NP[a]	P[b]	NP	P	NP	P	NP	P	
Crude protein, %[d]	6.5[e]	4.7[f]	4.1	4.2	4.0	3.7	3.8	3.5	.3
Acid detergent Insoluble nitrogen, % of crude protein	25.8	26.0	24.0	21.8	23.7	19.8	23.1	22.8	1.5
Indigestible acid Detergent fiber, %	20.5	17.8	14.3	14.2	12.7	12.3	13.5	12.4	.9
Neutral detergent fiber, %	69.1	71.1	73.4	72.7	72.8	71.2	76.0	76.6	.7

[a]NP = nonpregnant. [b]P = pregnant. [c]SE = standard error.
[d]Pregnancy status by period interaction (P<.10).
[ef]Means within a row and within the same period with different superscripts differ (P<.05).

EFFECT OF PROTEIN SUPPLEMENTATION ON DORMANT, BLUESTEM-RANGE FORAGE INTAKE AND DIGESTION AND PROTEIN FLOW TO THE SMALL INTESTINE IN STEERS

S. M. Hannah, R. C. Cochran,
D. L. Harmon, and E. S. Vanzant

Summary

A digestion trial was conducted to determine dormant, bluestem-range forage intake, digestion, and protein flow to the small intestine in steers receiving different crude protein (CP) supplements. Dietary treatments were 1) control: no supplement; 2) low protein supplement (Low-CP): SBM + grain sorghum supplement containing 13% CP; 3) moderate protein supplement (Mod-CP): SBM + grain sorghum supplement containing 26% CP; and 4) dehydrated alfalfa pellets supplement (Dehy): supplement containing 17.5% CP. Forage intake increased an average of 36% in steers supplemented with Mod-CP and Dehy, compared to the forage intake of control steers. Forage intake of steers receiving Low-CP supplement was similar to that of control steers.

Total tract digestion of forage fiber increased 8% when Mod-CP and Dehy supplements were fed compared to control treatment, whereas Low-CP supplement caused an 11% decrease in fiber digestion compared to control treatment. Crude protein flowing into the small intestine was greatest for steers fed the Mod-CP and Dehy supplements. In conclusion, the Dehy supplement was as effective as the Mod-CP supplement when fed to provide the same amount of CP per day; however, when a grain-based supplement was fed, increasing the CP concentration above 20% significantly improved intake and utilization of poor-quality range forage.

(Key Words: Protein Supplements, Intake, Crude Protein Flow, Winter Range.)

Introduction

Previous research at Kansas State University has shown that feeding cattle supplements containing moderate (26%) or high (39%) concentrations of crude protein (CP) increased their forage intake and utilization, whereas forage intake was not increased in cattle fed supplements containing a low (13%) CP concentration. DelCurto et al. (KAES Rep. of Prog. 539, p. 29) noted that forage intake and utilization were depressed when a grain-based supplement containing a low concentration of CP (11%) was fed at a level that provided the same amount of CP as a grain-based supplement containing a moderate concentration of CP (22%).

The protein:energy ratio in grain-based protein supplements appeared to have a major influence on forage intake and utilization. In contrast, Kansas State University research has also shown that cattle fed a fiber-based supplement (dehydrated alfalfa) showed similar performance to those receiving a grain-based supplement with a moderate CP concentration, when both were fed to provide equivalent amounts of CP. Although previous studies have examined the effect of protein supplementation on animal performance, information is limited regarding how such

supplements elicit their responses. The objectives of this study were to measure the amount of digestion in different segments of the intestinal tract and to monitor the protein flowing into the small intestine when different protein supplements were fed to steers consuming dormant, bluestem-range forage.

Experimental Procedures

Four Holstein steers, ruminally and intestinally cannulated, with an average weight of 967 lb, were used in a 4x4 Latin square design digestibility experiment. The four dietary treatments examined were 1) control: no supplement; 2) low protein supplement (Low-CP): SBM + grain sorghum supplement containing 13% CP; 3) moderate protein supplement (Mod-CP): SBM + grain sorghum supplement containing 26% CP; and 4) dehydrated alfalfa pellets supplement (Dehy): supplement containing 17.5% CP. The Low-CP and Mod-CP supplements were fed at 4 lb/d, whereas Dehy was fed at 5.9 lb/d, so that the Dehy and Mod-CP supplements would provide the same amount of CP (1.04 lb CP/d). Dehydrated alfalfa pellets came from a third cutting of mid-bloom hay. The hay fed was dormant, bluestem-range forage with a CP concentration of 2.3%. The hay was fed at 130% of the previous day's consumption. At 8 A.M. and 8 P.M., steers were fed half of their daily allotment of supplement and forage. Each data collection period lasted 30 d. After each collection period, steers were switched to a different dietary treatment, until each steer had received each treatment.

Results and Discussion

Intake of dormant, bluestem-range forage was increased ($P<.01$) 42% by the Mod-CP supplement and 29% by the Dehy supplement, but was not increased by the Low-CP supplement (Table 30.1). Because of the addition of the supplements to the diet, total dietary dry matter (DM) intake was increased ($P<.01$) over control by 47, 89, and 100% for Low-CP, Mod-CP and Dehy supplements, respectively. Ruminal DM digestibility was increased ($P<.01$) 98% with Mod-CP and Dehy supplements compared with control and increased 59% compared with Low-CP supplement. Ruminal fiber digestion was not significantly affected by treatments but numerically averaged 22% lower for the Low-CP supplement than all other treatments. All supplements increased ($P<.05$) total dietary DM digestibility by an average of 28% over control.

In contrast to DM digestion, fiber digestion for the Low-CP supplement tended to be lower (11%; $P=.15$) than that for the control treatment and averaged 21% lower than the Mod-CP and Dehy supplement treatments. Fiber digestion was 8% greater for Mod-CP and Dehy supplements compared with the control. Forage intake and digestion results of this experiment agree with previous studies. Increased forage intake with the Mod-CP and Dehy treatments was closely associated with the amount of CP reaching the small intestine. Supplementation with Mod-CP and Dehy increased ($P<.01$) CP flow to the small intestine over the control treatment 116 and 129%, respectively, whereas the Low-CP supplement only increased CP flow by 61%.

Based upon the results from this trial and previous Kansas State research that evaluated the interaction of protein and energy levels in supplements, it appears that when grain-based supplements are fed, the crude protein concentration should be in the moderate to high range (greater than 20% CP on a dry matter basis). This approach should ensure optimal use of poor-quality range forage by supplemented cattle. In contrast, although the CP concentration in the fiber-based supplement (dehydrated alfalfa pellets) was lower than would be desirable for

Table 30.1. Effect of Supplemental Protein on DM Intake, DM and Fiber Digestibility, and CP Flow to the Small Intestine in Steers

Item	Control	Low-CP	Mod-CP	Dehy	SE[1]
DM intake, % BW[2]					
Forage	.76[a]	.75[a]	1.08[b]	.98[b]	.05
Supplement	0	.37	.36	.54	
Total	.76[a]	1.12[b]	1.44[c]	1.52[c]	.04
Ruminal digestibility,%					
DM	19.72[a]	24.53[a]	38.96[b]	39.07[b]	2.85
Fiber[3]	50.62	43.18	55.63	52.76	4.45
Total tract digestibility, %					
DM	43.56[d]	53.81[e]	59.06[e]	54.26[e]	2.90
Fiber[3]	54.21[fg]	48.50[f]	59.68[g]	57.70[g]	3.06
CP flow to the small intestine, g/d	273.6[a]	441.2[b]	591.4[c]	627.4[c]	45.0

[1]Standard error.
[2]BW = body weight.
[3]Neutral detergent fiber digestibility.
[abc]Row means without a common superscript differ (P<.01).
[de]Row means without a common superscript differ (P<.05).
[fg]Row means without a common superscript differ (P=.15).

a grain-based supplement, the influence on forage use was similar to that of the Mod-CP supplement, as long as enough Dehy was fed to provide the same amount of CP per day.

INFLUENCE OF SUPPLEMENTATION METHOD ON FORAGE USE AND GRAZING BEHAVIOR OF BEEF CATTLE GRAZING BLUESTEM RANGE[1,2]

S. D. Brandyberry, R. C. Cochran, E. S. Vanzant, T. DelCurto, J. E. Schneider[3], and L. R. Corah

Summary

Fifteen ruminally and 12 esophageally fistulated steers were used in two 28-d trials (late summer and early winter) to determine the influence of method of supplementation on forage use and grazing behavior. Treatments were: 1) self-feeding supplement with salt to limit intake; 2) daily hand-feeding supplement and salt; 3) daily hand-feeding supplement without salt. Forage intake was not affected by season or supplementation method; however, total diet organic matter digestibility was higher in the late summer ($P<.01$) and lower when steers received supplement without salt ($P<.05$). Supplementation method did not affect the time that animals spent grazing or the distance travelled; however, both were greater ($P<.01$) during the summer period. Self-feeding supplement did not appear to adversely affect forage use in grazing beef steers.

(Key Words: Protein Supplements, Rangelands, Grazing Behavior, Stockers.)

Introduction

During times when forages decrease in quality, supplements are often offered to grazing cattle to improve forage utilization. Typically, such supplements are hand-fed. Self-feeding supplements may be a desirable alternative in situations where labor is limited or cattle are widely dispersed. However, using limiting agents, such as salt, to control supplement intake may influence forage use. Therefore, the objectives of this study were to evaluate the influence of the method of supplementation on forage use and grazing behavior.

Experimental Procedures

Fifteen ruminally and 12 esophageally fistulated crossbred steers (avg. wt. = 695 and 881 lb, respectively) were blocked by weight at the start of the late summer period and assigned to one of the following treatments: 1) self-feeding supplement (via Calan gates) with salt as a limiting agent (SFS); 2) daily hand-feeding supplement with steers receiving the same amount of salt as consumed by the SFS group (HFS); 3) daily hand-feeding supplement without salt (HNS). The supplement was a soybean meal and grain sorghum mix and was formulated to contain 28% crude protein (CP). Supplement intake by the SFS group was restricted to 2.5 lb

[1]This research was funded in part by a grant from the Ralston Purina Co., St. Louis, Missouri.
[2]The authors express appreciation to Gary Ritter, Wayne Adolph, and the student employees at the Range/Cow-Calf Unit for their invaluable assistance in conducting this trial.
[3]Department of Surgery and Medicine.

per head daily with .50 and .88 pounds of salt per day during the summer and winter, respectively. Supplement and salt intake in hand-fed groups was based on the previous day's consumption by the SFS group. In order to ensure that each treatment group could develop and follow their "normal" behavioral patterns without being influenced by other treatments, groups grazed three separate but contiguous bluestem-range pastures of approximately 10 acres each. Steers were rotated among these pastures twice weekly, in order to remove pasture effects. The first 28-d trial began in mid-August and consisted of a 14-d adaptation period, a 7-d behavior observation period (which included a 3-d, 24-h observation period to determine the frequency with which cattle visited the self-feeders), a 7-d fecal collection period, a 3-d esophageal collection period (concurrent with the fecal sampling period), and a 1-d ruminal sampling period. Steers' rumens were evacuated on d 25 of the study. Esophageal collections were taken at 7:00 A.M. on d 15, 16, and 17 of the trial. Each group grazed each pasture during the collection period. The second 28-d trial began in late December and followed the same format.

Results and Discussion

The quality of forage selected by the steers (Table 31.1) was largely unaffected by the method of supplementation, although the self-fed group did select a diet with slightly less fiber ($P<.05$) than the group that received supplement without salt. The fiber and lignin concentrations in the diets selected were higher ($P<.05$) and crude protein concentrations were lower ($P<.05$) in the winter diets compared with summer diets. Neither season nor supplementation method influenced forage organic matter (OM) intake, which averaged 1.64% of body weight (Table 31.2). However, total diet OM digestibility was higher in the summer ($P<.01$; Table 31.2) and was lower ($P<.05$) when steers received supplement without salt. Neutral detergent fiber digestibility was higher ($P<.01$) in the summer than winter, but did not differ among treatments. Ruminal fill and passage characteristics were only moderately influenced by treatments. Steers spent more time and travelled further while grazing ($P<.01$) during the summer than the winter. However, supplementation method did not affect either of these. The 24-hr observations indicated that the SFS steers usually ate from the self-feeders in the afternoon (12:00 to 4:00 P.M.), although on some days steers were observed to

Table 31.1. Chemical Composition of Grazed Forage

Item, % OM	SFS	HFS	HNS	SE[a]	Summer	Winter	SE[a]
Lignin	6.97	6.32	6.05	.004	5.63[d]	7.26[e]	.004
NDF	70.72[b]	72.43[bc]	74.64[c]	1.27	69.91[d]	75.28[e]	1.20
CP	7.17	6.48	6.72	.50	7.96[d]	5.62[e]	.43

[a]SE = standard error.
[bc]Means with different superscripts within supplementation method differ ($P<.05$).
[de]Means with different superscripts within season differ ($P<.05$).

Table 31.2. Influence of Supplementation Method and Season on Organic Matter Digestibility (OMD), Intake (OMI), Neutral Detergent Fiber (NDF) Digestibility, and Grazing Behavior

	Supplementation method				Season		
	Self-fed	Hand-fed					
Item	Salt	Salt	No salt	SE[a]	Summer	Winter	SE[a]
OMD, %							
Total	62.3[b]	60.8[b]	58.1[c]	.79	65.2[d]	55.7[e]	.51
OMI, % BW							
Forage	1.68	1.56	1.69	.08	1.61	1.68	.05
Supplement	.26	.24	.24	.05	.28[d]	.22[e]	.01
Total	1.94	1.81	1.92	.09	1.89	1.89	.06
NDF digestibility, %	59.0	59.2	58.3	.01	62.2[d]	55.5[e]	.01
Distance travelled, miles/d	2.15	2.06	1.99	.07	2.38[d]	1.76[e]	.04
Grazing time, hr/d	8.42	8.36	8.74	.47	9.08[d]	7.94[e]	.16

[a]SE = standard error.
[bc]Row means among supplementation methods differ (P<.10).
[de]Row means between seasons differ (P<.01).

also spend a short amount of time at the self-feeder from 9:00 to 10:00 in the morning. Typically, the steers would spend approximately 3 to 5 min actually eating from the self-feeder but would rest in the vicinity of the self-feeder for an hour or more after eating.

In conclusion, self-feeding a supplement with a moderate crude protein concentration appeared to be as effective as hand-feeding. Although including salt in the supplement and altering the method of supplementation influenced seasonal forage use, no significant adverse effects of self-feeding, as opposed to hand-feeding, were found.

INCREASING LEVELS OF GRAIN SUPPLEMENTATION FOR INTENSIVE-EARLY STOCKED STEERS: TWO-YEAR SUMMARY

R. C. Cochran, C. E. Owensby, R. T. Brandt, Jr., E. S. Vanzant, and E. M. Clary[1]

Summary

During the first 2 yr of a 4-yr experiment, increasing the level of grain sorghum supplementation (from 2 to 4 lb/d) for steers managed within an intensive-early stocking program tended to increase average daily gain in direct proportion to supplement level (2.3 (no supplement) to 2.5 and 2.7 lb/d, respectively). During both years, the amount of grass remaining in the pastures after the cattle were removed (July 15) and at the end of the growing season (October 1) was greater when cattle were supplemented with 4 lb of grain sorghum. Level of supplementation for grazing steers did not influence subsequent feedlot performance.

(Key Words: Intensive-early Stocking, Supplementation, Grain Sorghum, Stockers.)

Introduction

Information regarding the value of grain supplementation for stockers managed within an intensive-early stocking system is unavailable. Knowledge of how such practices would affect pasture characteristics as well as animal performance during the grazing and finishing phases is needed to assist producers in making decisions regarding the application of supplementation to intensive-early stocking. A 4-yr study was initiated with the objective of monitoring average daily gain and changes in forage production when intensive-early stocked steers were supplemented with increasing levels of grain sorghum. In addition, during the second year, subsequent feedlot performance was monitored. This report represents a compilation of the first 2 yr of data from that study.

Experimental Procedures

British × Zebu crossbred steers were randomly assigned to six, 60-acre pastures during each of the 2 yr. Stocking rate (1.5 acres/550 lb steer) was equal among pastures. In addition, number of steers per pasture was adjusted depending on the starting weight of the steers to ensure that the same stocking rate (lb/acre) was maintained for each of the years. Pastures were randomly assigned to three treatments (two pastures/treatment): 1) no supplementation; 2) 2 lb rolled grain sorghum supplement per head; 3) 4 lb rolled grain sorghum supplement per head. Supplemented groups were bunk-fed daily at approximately 1:00 to 2:00 pm. All pastures were burned in late April, and subsequently steers grazed the pastures from early May through

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

mid-July. Weights were taken after an overnight stand without feed or water at trial initiation, mid-June and trial termination. Conversion efficiency (lb feed/lb extra gain) was calculated by dividing the quantity of supplement fed to a treatment group during a given period by the amount of gain above that of unsupplemented steers during the same period. Steers were implanted during initial processing and had access to a Bovatec®/mineral mixture during the entire trial. Consumption of the Bovatec/mineral mixture was not different (P>.10) among treatments or years and averaged .15 lb/d (approximately 110 mg Bovatec/head/d). Forage production was measured in the pastures at the end of the grazing period (July 15) and at the end of the growing season (October 1). Production was determined by clipping 10, ½ m^2 frames at random locations within different range sites in each pasture. Following grazing, steers were allotted to a finishing trial in order to ascertain whether weight differences among treatments at the end of the grazing period would be maintained throughout the finishing period.

Results

Average daily gain during the early period (May to early June) was largely unaffected by supplementation (Figure 32.1); however, gain increased (P=.09) in direct proportion to the level of supplement during the latter grazing period (June 10 to July 15), which resulted in a trend toward increased gain over the entire grazing period. Because the level of supplement offered was fixed, the conversion efficiencies followed the same pattern as average daily gain. Conversion efficiency during the early grazing period was poor (2 lb = 59:1 and 4 lb = 12:1) but improved considerably during the latter part of the intensive-early stocking period (2 lb = 5:1 and 4 lb = 7:1). Conversion efficiency for the entire grazing period was 9.6:1 and 9.1:1 for the 2 lb and 4 lb groups, respectively. Using an assumed cost for rolled grain sorghum of $80.00/ton, the feed cost for each additional pound of gain would be 38 and 36 cents/lb for the 2 lb and 4 lb treatments, respectively. Given that the cost of labor would be relatively similar regardless of level of supplement fed, the 4 lb treatment appeared preferable in that the labor costs were spread over a larger amount of gain. Subsequent performance in the feedlot was not influenced by the supplementation treatments applied during the grazing period (Table 32.1). The numerical spread in off-pasture weights among the treatment groups was maintained throughout the finishing period.

Table 32.1. Influence of Supplement Level during the Grazing Period on Subsequent Performance in the Feedlot

Item	Grain level (lb/d) 0	2	4	Standard error	Probability value Linear	Quadratic
Initial weight, lb	753	770	792	19	.24	.92
Final weight, lb	1163	1177	1198	16	.23	.85
Dry matter intake, lb/d	21.1	21.52	1.5	.35	.42	.65
Average daily gain, lb/d	3.5	3.5	3.5	.07	.74	.88
Feed/gain	6.0	6.1	6.2	.14	.39	.65

Quantity of grass remaining in the pastures during the second year after the steers were removed was greater (P<.10) for those pastures where steers received 4 lb of supplement (Figure 32.2). Quantity of forbs in the pastures was similar among treatments in mid-July. When measured at the end of the growing season, the same patterns were evident except that the quantity of forbs was less (P<.10) in the pastures where steers were supplemented. In contrast to observations from confinement trials, which indicated that forage intake was not affected by supplementation level, the increased quantity of grass remaining in the pastures when steers were supplemented suggests that the supplement did substitute for forage to some degree and, thus, reduced grazing pressure. Forage production during the first 2 yr of this study was less than 50% of normal because of drought conditions. These conditions may have modified the supplement's influence on digestive physiology and forage intake. This project will continue for 2 more years in hopes of monitoring responses under varying environmental conditions.

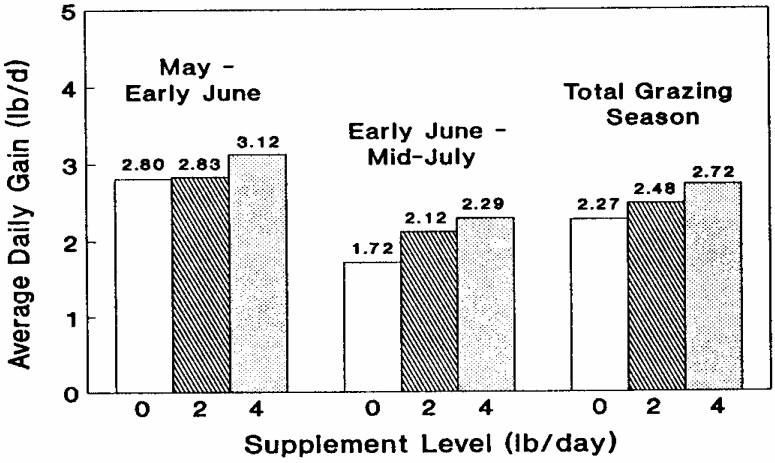


Figure 32.1. Influence of Level of Grain Supplementation on the Average Daily Gain of Intensive-early Stocked Steers — Two-year Summary (linear increase in gain with increasing supplement level; P=.09 for early June to mid-July and P=.20 for the total grazing period).

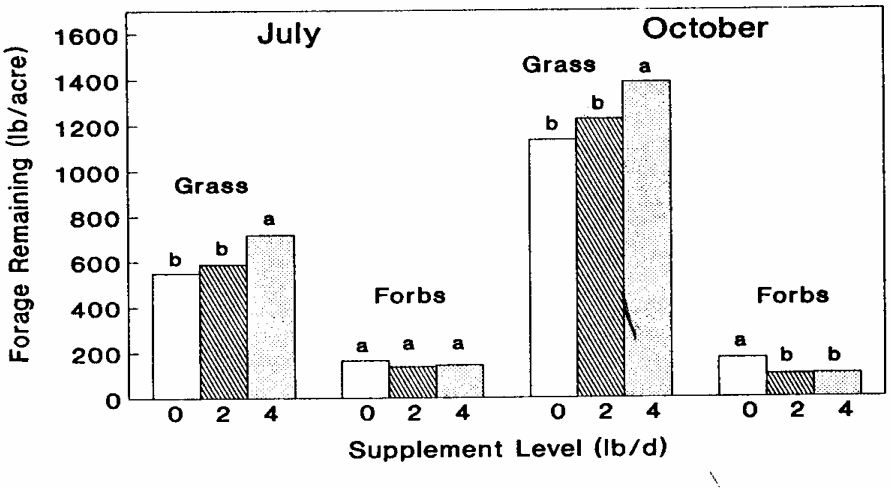


Figure 32.2. Influence of Level of Grain Supplementation on the Forage Remaining in Intensive-early Stocked Pastures at Mid-July and Early October (columns within forage type accompanied by different letters differ, P<.10).

EFFECT OF NIACIN SUPPLEMENTATION OF STOCKERS GRAZING TALL FESCUE PASTURES[1]

F. K. Brazle[2], K. P. Coffey[3], L. R. Corah, and J. Moyer[4]

Summary

In three trials, there was no gain response by stockers offered supplemental niacin while grazing tall fescue pasture in the spring or fall. There was a trend toward lower body temperatures for niacin-supplemented cattle, but this was not significant. Niacin fed at 2 to 4 g per head daily did not reduce the fescue endophyte fungus problem.

(Key Words: Niacin, Fescue, Endophyte, Stockers.)

Introduction

When fed at high levels, niacin helps dissipate body heat by stimulating peripheral vasodilation. Research with stressed calves shipped off of fescue pastures has shown increased gains when niacin was added to the receiving diet. This suggests that niacin may help reduce the heat stress and resulting gain reduction caused by the endophyte fungus in tall fescue. The objective was to determine if supplemental niacin fed to cattle grazing tall fescue pastures would improve average daily gain and moderate body temperature.

Experimental Procedures

In Trial I, 125 mixed-breed steers were allotted randomly on March 31 to either niacin or control groups. Each group was fed 2.6 lb of grain, with or without 4 g of niacin per head daily. There were two pastures per treatment. Steers were stocked at one steer/acre and grazed 65% endophyte-infected tall fescue pastures until May 16. Dry weather caused the trial to be terminated after 45 days. The steers were individually weighed, and their body temperatures were recorded at the start and end of the trial.

In Trial II, 200 mixed-breed steers were individually weighed and allotted randomly on October 10 to either a niacin bolus or control group. Half of each group of steers was assigned randomly to either a 30% or an 80% endophyte fungus-infected tall fescue pasture. Each steer in the niacin group was given a niacin bolus on d 1 and d 32 of the 64-d trial. Boluses were

[1]Sincere appreciation is expressed to Lonza, Inc. for funding support; to 3-G Farms, Uniontown, and Sheldon Delange, Girard, for providing cattle and facilities; and to Glenn Newcomer, Extension Agricultural Agent, Bourbon County, and Dean Stites, Extension Agricultural Agent, Crawford County.
[2]Extension Livestock Specialist, Southeast Kansas.
[3]Beef Research Scientist, Southeast Kansas Experiment Station.
[4]Forage Research Scientist, Southeast Kansas Experiment Station.

designed to release 2 g of niacin/day. In addition, all steers received 3 lb of grain sorghum per head daily. The steers were weighed off trial on December 13.

In Trial III, 40 mixed-breed heifers were weighed and allotted randomly on October 4 to either a niacin-supplemented or control group. Half of each group was assigned randomly to either a Mo-96 (fungus-free) tall fescue pasture or a K-31 (70% fungus-infected) tall fescue pasture. Niacin was added to a mineral mixture, and the heifers consumed approximately 4 g of niacin/day during the 63-d trial. The heifers were weighed individually, and body temperatures were recorded at the start and end of the trial.

Analysis of variance (SAS) was used to analyze the data, and the results are reported as least squares means.

Results

There was no difference (P>.05) in daily gain between niacin-supplemented and control groups in any of the three trials (Tables 33.1, 33.2, and 33.3). In Trials I and III, body temperature of the niacin-supplemented cattle tended to be lower, but the difference was not statistically significant.

In order for appetite and performance to improve on fungus-infected pastures, a substantial reduction in the normally elevated body temperature likely would have to occur. This was not the case in these spring and fall trials. However, a summer trial might have different results. For stocker cattle grazing tall fescue primarily in the spring and fall, a niacin supplement does not appear to be beneficial, at least at the 2 to 4 g/d level used in these trials.

Table 33.1. Effect of Niacin in a Grain Supplement on Steer Performance while Grazing Tall Fescue Pastures (Trial I)

Item	Control	Niacin
No. steers	60	65
Starting wt, lb	748	744
Daily gain, lb	1.37	1.35
Body temp., °F	103.4	103.2

Table 33.2. Effect of Niacin Bolus on Steer Gains while Grazing Tall Fescue Pastures (Trial II)

Item	Control	Niacin bolus
No. steers	100	100
Starting wt, lb	574	573
Daily gain, lb	1.25	1.25

Gain data were pooled across pastures with 30 and 80% endophyte infestations.

Table 33.3. Effect of Niacin in Mineral Mixture on Heifer Gains while Grazing High and Low Endophyte Tall Fescue Pastures

	Endophyte-free pasture		High-endophyte pasture	
Item	Control	Niacin	Control	Niacin
No. heifers	10	10	10	10
Starting wt, lb	608	610	609	606
Daily gain, lb	1.26	1.04	.81	.84
Body temperature, °F	103.6	103.3	103.4	102.9

EFFECTS OF AMAFERM® (*ASPERGILLUS ORYZAE* FERMENTATION EXTRACT) ON PERFORMANCE AND BODY TEMPERATURE OF STOCKERS FED DIETS WITH OR WITHOUT FESCUE ENDOPHYTE[1]

K. P. Coffey[2], F. K. Brazle[3], and J. L. Moyer[2]

Summary

Sixty-four stocker steers were offered endophyte-free fescue hay ad libitum, with either bromegrass or high-endophyte fescue seed screenings and supplements with or without Amaferm® (*Aspergillus oryzae* fermentation extract). Steers offered bromegrass seed screenings gained faster (P<.01), consumed more feed (P<.01), and converted feed dry matter to gain more efficiently (P<.01) than those fed fescue seed screenings. Amaferm did not affect stocker performance or reduce rectal temperature. Therefore, feeding high-endophyte fescue screenings reduced intake and daily gain, and Amaferm did not offset those effects.

(Key Words: Amaferm®, *Aspergillus oryzae*, Fescue, Endophyte, Stockers.)

Introduction

Tall fescue is one of the most important cool-season forages in the United States, providing over 35 million acres of forage for livestock. Cattle grazing fescue typically exhibit a number of symptoms including reduced feed intake, weight gain, and milk production; higher rectal temperature and respiration rate; and reduced serum prolactin level. These symptoms have been attributed to the presence of the endophytic fungus *Acremonium coenophialum*. *Aspergillus oryzae* fermentation extract (Amaferm) has been shown to reduce rectal temperature and improve dry matter digestibility in cattle. The objective of our experiment was to evaluate the effects of Amaferm on cattle consuming forage diets supplemented with high endophyte and endophyte-free grass seed screenings.

Experimental Procedures

Sixty-four black or black-baldy steers averaging 569 lb were allotted by weight to 16 groups of four head each and placed in drylot pens located at the Mound Valley research facility. All groups were offered endophyte-free tall fescue hay ad libitum for 90 d beginning on June 30. The pen replicates were assigned randomly to receive either fescue or bromegrass seed screenings offered at 4 lb/head daily. Pens of cattle within each screening type were

[1]Sincere appreciation is expressed to Biozyme Enterprises, Inc., St. Joseph, Missouri for providing product and financial assistance; and to Richard Porter, Reading, Kansas for providing cattle to conduct the study.
[2]Southeast Kansas Branch Experiment Station, Parsons, Kansas.
[3]Extension Livestock Specialist, Southeast Kansas.

offered 2 lb per head daily of a soybean hull supplement, which contained essential macro and trace minerals, either with or without 2 g of Amaferm.

Initial and final weights are the means of weights taken in the morning on 2 consecutive days. Rectal temperatures were measured at 14-d intervals throughout the study beginning at 7 A.M., with the exception of September 7, when measuring began at 1 P.M.

Results and Discussion

Steers offered brome seed screenings were 32 lb heavier (P<.01) at the end of the 90-d feeding period, gained .39 lb/d faster (P<.01), consumed 1.5 lb more (P<.01) feed dry matter per day, and produced each pound of gain on 12 lb less (P<.01) feed dry matter than steers offered fescue seed screenings (Table 34.1). Amaferm did not affect those parameters, and there were no interactions with screenings type.

Rectal temperatures were higher (P<.01) from steers offered fescue screenings on July 27 and tended to be higher (P<.10) on September 7 and September 21 than those from steers offered brome screenings (Table 34.2). Steers offered Amaferm tended (P<.10) to have higher temperatures than control steers on July 13 and August 11. Otherwise, temperatures were similar among treatments.

In this study, feeding endophyte-infected fescue screenings reduced weight gain, forage intake, and feed conversion, and Amaferm did not offset these adverse effects.

Table 34.1. Performance of Steers Offered Fescue or Bromegrass Screenings with or without Amaferm

Item	Screenings type		Supplement	
	Brome	Fescue	Control	Amaferm
Initial wt., lb	568	571	568	571
Final wt., lb[a]	645	613	629	629
Total gain, lb[a]	77.1	42.7	61.1	58.7
Daily gain, lb[a]	.86	.47	.68	.65
DM intake, lb/d[a]	14.3	12.8	13.7	13.4
Feed/gain[a]	16.9	28.9	23.5	22.3

[a]Brome vs. fescue screenings (P<.01).

Table 34.2. Rectal Temperatures From Steers Offered Fescue or Bromegrass Screenings with or without Amaferm

Date	Screenings type		Supplement	
	Brome	Fescue	Control	Amaferm
June 30	103.4	103.3	103.3	103.4
July 13[c]	102.6	102.7	102.5	102.8
July 27[a]	103.1	103.9	103.4	103.6
August 11[c]	101.5	101.6	101.3	101.7
August 24	103.2	103.0	102.9	103.3
September 7[b]	105.1	105.7	105.3	105.5
September 21[b]	100.9	101.4	101.2	101.1
September 28	102.0	102.5	102.2	102.3

[a]Brome vs fescue screenings (P<.01).
[b]Brome vs fescue screenings (P<.10).
[c]Control vs Amaferm (P<.10).

EFFECT OF DECCOX® IN A FREE-CHOICE, GRAIN-MINERAL MIXTURE ON PERFORMANCE OF YEARLINGS GRAZING NATIVE RANGE[1]

F. K. Brazle[2]

Summary

Including Deccox® in a free-choice, intake-limiting, grain-mineral mixture tended to increase grazing stocker gains and substantially reduced the percentage of newly arrived cattle treated for sickness and the number of treatments required per animal.

(Key Words: Deccox®, Bulls, Native Grass, Mineral, Health.)

Introduction

Research has shown improved gain and reduced sickness when the coccidiostat, Deccox®, is included in starting rations for newly purchased calves. The greatest response often occurs during the first month when Deccox is fed to highly stressed calves, such as recently castrated bulls. The objective of this study was to evaluate the effect of Deccox in a free-choice, grain-mineral mixture fed to newly purchased yearlings grazing native grass pasture.

Experimental Procedures

On April 15, 106 mixed-breed yearlings, consisting of half steers and bulls and averaging 608 lb, were shipped 300 miles from Missouri to Kansas. The cattle were processed at arrival, and the bulls were castrated with a knife. They were vaccinated with IBR, BVD, PI3, and 4-way Blackleg; dewormed with Levamisole®; deloused with Lysoff®; and implanted with Ralgro®. The steers and freshly castrated bulls were each allotted to either Deccox or control treatments. A grain-mineral mixture, with or without Deccox (Table 35.1), was offered free-choice to the cattle. Salt was added as an

Table 35.1. Composition of Free-choice Grain-mineral Mixtures

Ingredient	Control	Deccox
	---- lb per ton ----	
Dicalcium phosphate	80.0	80.0
Liquid molasses	100.0	100.0
Deccox 6% premix	—	16.5
Salt	450.0	450.0
Ground grain sorghum	1,370.0	1,353.5

[1]Sincere appreciation is expressed to Rhone-Poulenc, Inc., Atlanta, Georgia, for providing funding for this study.
[2]Extension Livestock Specialist, Southeast Kansas.

intake limiter. The steers and newly castrated bulls were assigned separately to eight, 35-acre intensive-early grazed, native grass pastures stocked at 2.5 acres/head. The groups of cattle were rotated among pastures to minimize pasture influences. The yearlings were checked for sickness daily and treated when visual signs of illness occurred. Supplement intake was measured twice a week. The steers were reweighed on May 17 and June 13. Data were analyzed by analysis of variance, and results are reported as least squares means.

Results and Discussion

The Deccox-fed yearlings consumed slightly more of the grain-mineral mixture than controls (.91 vs .79 lb/d) during the first 14 d. However, overall consumption levels were not significantly different. The average consumption of active drug was 225 mg per head daily. The Deccox-fed cattle tended to gain faster throughout the 59-d trial (Table 35.2) and had a significantly lower incidence of sickness and medications required per animal. All of the sickness occurred during the first 2 wk of the trial. There was no interaction between sex status and Deccox treatment.

These results suggest that Deccox can be used in a self-feeding system that limits intake but still maintains adequate Deccox intake by grazing cattle. The data also indicate that the slight gain response to Deccox continued throughout the 59-d period, not just during the first month after arrival.

Table 35.2. Effect of Deccox in a Free-choice, Grain-mineral Mixture on the Gain and Health of Grazing Yearlings

Ingredient	Control	Deccox
No. cattle	53	53
Starting wt, lb	613	612
Daily gain, lb		
First 32 d	2.6	2.7
Second 27 d	2.2	2.4
Overall 59 d	2.4	2.6
Percentage sick cattle	34.6[b]	12.1[a]
No. medications required/head	1.5[d]	.8[c]
Daily supplement intake, lb	1.0	1.0

[ab]Means in a row with unlike superscripts differ ($P<.015$).
[cd]Means in a row with unlike superscripts differ ($P<.13$).

ENSILEABILITY OF ALFALFA: CUTTING, MATURITY, AND TREATMENT EFFECTS[1]

J. L. Curtis, C. Lin, and K. K. Bolsen

Summary

Analysis of ensiling characteristics from late-bud, 10% bloom, and 50% bloom alfalfa, taken within each of four cuttings identified higher pre-ensiled dry matter (DM) content during the first two cuttings, whereas crop buffer capacity was weakest during the third cutting and subsequently strongest throughout the fourth cutting. Initial pH was lowest at the first cutting and increased with each cutting thereafter.

Dry matter increased linearly within maturity, whereas late-bud maturity had the highest buffer capacity and initial pH. From hr 24 until d 90, the pH values were consistently highest for late-bud and lowest for 50% bloom silage.

Treatments receiving 2% dextrose showed a slightly higher DM. At each of seven laboratory silo opening times, a combination of added dextrose and a lactic acid bacteria inoculant yielded the lowest pH; inoculant alone gave the next lowest pH values through hr 48. From d 3 to 90, pH's were consistently highest for control silages, followed by inoculant, dextrose, and dextrose + inoculant combined.

(Key Words: Alfalfa, Silage, Inoculant, Dextrose.)

Introduction

Alfalfa is usually harvested and stored either as hay or silage. Advantages for storing alfalfa as silage compared to hay include less field leaf loss, fewer weather delays at harvest, and adaptability to mechanized feeding in large-scale beef and dairy operations.

Considerable research effort has been devoted to improving yield and quality of alfalfa as a hay crop, as evidenced by over 200 new alfalfa cultivars certified for seed production in the U.S. and Canada since 1973. However, to our knowledge, no cultivars have been developed specifically for enhanced silage quality. Therefore, the major objective of this ongoing research is to identify basic biochemical and agronomic differences between acceptable and unacceptable alfalfa silages, with the ultimate goal of increasing animal production through better quality alfalfa silage.

[1]Partial financial assistance and the inoculant, Biomate®, were provided by Chr. Hansen's Bio Systems, Milwaukee, Wisconsin.

Experimental Procedures

This study examined the effects of cutting (2nd through 5th), maturity (late-bud, 10% bloom, and 50% bloom), and ensiling treatment (inoculant, dextrose, and inoculant + dextrose) on ensiling characteristics of alfalfa. A second-year stand of Cody alfalfa, established in August, 1987, near the Kansas State University campus, was harvested between June 20 and October 22, 1989. At each cutting and maturity, the crop was swathed at about 11 a.m., field-wilted for 3 to 6 hr, and then chopped with a Field Queen forage harvester. Within each cutting, the maturities were assigned in a randomized complete block design to three replicate 30 × 280 ft plots.

PVC laboratory silos, treatment methods, and silo-filling techniques were similar to those described on page 105 of this report. The Biomate® inoculant, which contains *Lactobacillus plantarum* and *Pediococcus cerevisiae*, was applied according to the manufacturer's recommendation and provided about 1.5×10^5 colony-forming units of lactic acid bacteria/g of crop. Dextrose was applied at 2% of the crop dry matter. Duplicate or triplicate laboratory silos were opened at 12, 24, and 48 hr and 3, 7, 42, and 90 d post-filling. Buffer capacity (BC) of pre-ensiled material was determined by homogenizing 15 g of fresh material in 250 ml of distilled water in a blender for 1.5 min, then lowering the pH to 3.0 with .1 N HCl, and raising it back to 4.0 with .1 N NaOH. Buffer capacity was defined as meq. of NaOH required to raise the pH of 100 g of crop DM from 4.0 to 6.0. Pre- and post-ensiled material was extracted for pH determination by placing 25 g into 250 ml of distilled water and recording the pH 2 hr later.

Information about the indigenous microflora on all 12 alfalfas and their development during the ensiling process for the second and fourth cutting silages is found on page 118 of this report.

Results and Discussion

Dry matter and BC of the pre-ensiled material and pH over time during the ensiling process are presented in Table 36.1. In several previous studies with alfalfa, rate of pH decline and end-product silage pH were closely related to the efficiency of the fermentation process (KAES Reports of Progress 514, 539, 567, and 568). There appeared to be enough fermentable carbohydrate available for the indigenous and added (inoculant) microbial populations to lower the pH (via acid production) to below 5.0 in the first 48 hr. However, from d 3 to 90 the dextrose-containing silages had significantly lower pH values than inoculated or control silages. The inoculant + dextrose treatment gave the lowest ($P<.05$) pH at all seven opening times, which clearly shows that supplemental lactic acid bacteria were needed to ferment the added substrate.

Stage of maturity significantly affected pre-ensiled crop DM content and BC and rate of pH decline from 24 hr to 90 d post-filling. The late-bud-stage alfalfa had the lowest DM content and highest BC and gave the highest silage pH values at every opening time after hr 12.

Cutting also influenced ($P<.05$) crop DM, BC, and silage pH — the fourth cutting was the wettest (26.1 % DM) and had the highest BC; the second cutting was the driest (37.5 %

DM); and the third cutting had the lowest BC. Although the fourth cutting silages had the lowest pH's at 12 and 24 hr post-filling, they were unstable and their pH values stayed above 5.0 through d 90.

Percent relative humidity and swath-level air temperature data were recorded during the field-wilting period for each of the 12 harvests. There were no significant differences in mean relative humidity between cuttings or maturities. However, the mean wilting-period temperature for the fifth cuttings (72°F) was lower than that for the previous three cuttings.

Table 36.1. Main Effects of Treatment, Maturity, and Cutting on the Composition of Pre-ensiled Alfalfa and pH during the Ensiling Process

Item and time post-filling	Treatment[1]				Maturity			Cutting[2]			
	Cont	Inoc	Dex	Dex+ Inoc	Late-bud	10% bloom	50% bloom	2nd	3rd	4th	5th
Dry matter, %	32.4^{b}	32.3^{b}	32.7^{a}	32.6^{a}	28.7^{c}	34.2^{b}	34.6^{a}	37.5^{a}	36.1^{b}	26.1^{d}	30.3^{c}
Buffer capacity[3]	40.5^{a}	39.0^{ab}	37.9^{b}	39.4^{ab}	45.3^{a}	36.6^{b}	35.7^{b}	43.2^{b}	30.7^{d}	48.0^{a}	35.1^{c}
	---------- pH ----------										
Initial	5.84^{ab}	5.85^{a}	5.84^{ab}	5.83^{b}	5.89^{a}	5.81^{c}	5.82^{b}	5.74^{d}	5.77^{c}	5.85^{b}	6.00^{a}
Hr 12	5.57^{a}	5.38^{c}	5.53^{b}	5.32^{d}	5.42^{b}	5.50^{a}	5.43^{b}	5.40^{c}	5.49^{b}	5.11^{d}	5.80^{a}
Hr 24	5.35^{a}	5.05^{c}	5.24^{b}	4.82^{d}	5.26^{a}	5.07^{b}	5.01^{c}	5.01^{c}	5.11^{b}	4.90^{d}	5.50^{a}
Hr 48	5.21^{a}	4.91^{c}	4.97^{b}	4.60^{d}	5.14^{a}	4.84^{b}	4.79^{c}	4.85^{b}	4.84^{b}	5.24^{a}	4.85^{b}
Day 3	5.16^{a}	4.94^{b}	4.86^{c}	4.58^{d}	5.16^{a}	4.80^{b}	4.69^{c}	4.82^{b}	4.83^{b}	5.26^{a}	4.67^{c}
Day 7	5.16^{a}	5.01^{b}	4.83^{c}	4.61^{d}	5.30^{a}	4.79^{b}	4.62^{c}	5.01^{b}	4.84^{c}	5.22^{a}	4.53^{d}
Day 42	4.97^{a}	4.92^{b}	4.72^{c}	4.64^{d}	5.18^{a}	4.71^{b}	4.54^{c}	4.85^{b}	4.69^{c}	5.11^{a}	4.65^{d}
Day 90	4.94^{a}	4.90^{b}	4.71^{c}	4.65^{d}	5.13^{a}	4.71^{b}	4.57^{c}	4.77^{b}	4.66^{d}	5.08^{a}	4.69^{c}

[1]Cont= control, Inoc = inoculant, and Dex = dextrose.
[2]Second cutting was taken between June 20 and July 7; third cutting, between July 21 and August 2; fourth cutting, between August 25 and September 1; and fifth cutting, between September 25 and October 22.
[3]Milliequivalents of NaOH per 100 g of crop DM required to raise the pH from 4.0 to 6.0.
[abcd]Means on a line within a treatment, maturity, and cutting with different superscripts differ ($P<.05$).

EFFECT OF INOCULANT AND ENZYME ADDITIVES ON PRESERVATION AND NUTRITIVE VALUE OF ALFALFA SILAGE[1,2,3,4,5]

J. S. White, K. K. Bolsen, and R. A. Hart

Summary

Lactic acid bacteria (LAB) inoculants[2,5] and several enzyme additives[3,4] were evaluated in various combinations using fifth cutting alfalfa. The field-wilted crop was characterized by a high buffer capacity (63.0 meq/100 g of DM), low fermentable carbohydrate (5.4% of the DM), and a high number of indigenous LAB (over one million per g). In contrast to several previous studies, the inoculants and enzymes had very little effect on rate and efficiency of fermentation. The 90-d treated silages had similar fiber and digestibility values, compared to the control. Treated silages tended to have higher lactic acid values, but all silages had relatively high acetic acid and ethanol contents, which indicate an inefficient ensiling process.

(Key Words: Alfalfa, Silage, Inoculant, Enzymes.)

Introduction

Alfalfa is one of the most difficult crops to successfully preserve as silage because of its high buffering capacity, wide range in moisture contents, and often low level of water soluble carbohydrates. Inoculants and, to a lesser degree, enzymes have improved silage fermentation efficiency and nutritive value in several previous studies. Our objective was to further document the effect of various inoculant and enzyme treatments on alfalfa silage quality.

Experimental Procedures

The eight treatments are shown in Table 37.1. Silages were made from fifth cutting alfalfa on September 9, 1988. The laboratory silos used were 4 × 14 in. PVC pipes closed with Jim-Caps on each end; the Cap on the top was fitted with a Bunsen valve to allow CO_2

[1]Partial financial assistance was provided by Chr. Hansen's Bio Systems, Milwaukee, Wisconsin; Genencor, South San Francisco, California; Finnsugar Bioproducts, Inc., Schaumburg, Illinois; and Medipharm USA, Des Moines, Iowa.

[2]Biomate® was provided by Chr. Hansen's Bio Systems and contains *Lactobacillus plantarum* and *Pediococcus cerevisiae*.

[3]Cytolase® enzyme-containing product was provided by Genencor.

[4]Clampzyme® was provided by Finnsugar Bioproducts and contains cellulases, hemicellulases, and glucose oxidase. Amylase and pectinase enzymes were provided by Finnsugar.

[5]Medipharm PF Soluble® was provided by Medipharm USA and contains *Lactobacillus plantarum, L. acidophilus, Pediococcus sp.,* and *Streptococcus faecium* M-74.

to escape. For filling, 100 lb of chopped alfalfa was placed on a plastic sheet, and the treatments were applied and mixed thoroughly. All enzymes were added according to the manufacturers' recommendations. After all treatments were prepared, the silos were filled as rapidly as possible on an alternating schedule, which distributed the time from harvest to silo filling equally across treatments and replications. The silos were filled with a hydraulic press, which compacted them to similar densities and excluded air. The silos were stored at ambient temperature, and three silos from each treatment were opened at .5, 1, 3, 7, 14, and 90 d post-ensiling for evaluation.

Table 37.1. Description of the Eight Treatments Compared

Treatment no.	Description
1	Control (untreated)
2	Medipharm PF (Med PF)[1]
3	Amylase (Amyl)
4	Amyl + Clampzyme (Clamp) + Pectinase (Pect)
5	Med PF + Amyl + Clamp + Pect
6	Cytolase (Cyto)
7	Biomate[2]
8	Biomate + Cyto

[1]Med PF provided 1.9×10^5 CFU of LAB per g of crop.
[2]Biomate provided 1.5×10^5 CFU of LAB per g of crop.

Microbial profiles were determined for the alfalfa and inoculants. Post-harvested, pre-ensiled samples were aseptically weighed, macerated in a Waring blender, and diluted with sterile phosphate buffer. The indigenous (naturally occurring) lactic acid bacteria on the crop were determined. Samples were added to MRS broth, plated, and incubated for 3 d at 37 C. Mesophilic bacteria (aerobes and facultative anaerobes) were plated on Standard Plate Count agar (Difco) and incubated for 3 d at 37 C. Yeast and mold counts were done by using potato dextrose agar with tetracycline and chloramphenicol added to kill bacteria. Plates were incubated for 3 d at 21 C. All results were converted to colony-forming units (CFU) per g of crop.

Analyses pre-ensiling were forage dry matter (DM), pH, water soluble carbohydrates (WSC), buffer capacity (BC), crude protein, acid detergent fiber (ADF), and neutral detergent fiber (NDF). Silages fermented for .5 to 14 d were analyzed for pH, lactic acid, volatile fatty acids (VFAs), and ethanol. Ninety-day end point silages were analyzed for crude protein, ADF, NDF, WSC, pH, lactic acid, VFAs, ethanol, ammonia-nitrogen, and DM content.

Silage aerobic stability was determined by placing about 2 lb of silage into expanded, plastic-lined polystyrene buckets, putting the buckets in a temperature controlled room (65 F), and monitoring the temperature of the silage mass twice daily for 10 d. If a silage's temperature rose 10 F over ambient, it was considered aerobically unstable. Aerobic stability was the number of hours between the initial exposure to air and the onset of heating. Silage digestibility was measured using the *in vitro* DM disappearance, two-stage, Terry and Tilley technique.

Statistical analyses were done for a random complete block design with three replications. Mean responses for each treatment were compared by analysis of variance, and means were separated by Least Significant Difference. No interactions are reported.

Results and Discussion

Presented in Table 37.2 are the microbial and chemical profiles of the pre-ensiled alfalfa. The field-wilted crop contained 37.2% DM and was characterized by a high buffer capacity, low water soluble carbohydrates, and a high number of lactic acid bacteria.

Presented in Tables 37.3 and 37.4 are results for the fermentation dynamics and the 90-d chemical composition and in vitro DM digestibility of the silages.

All silages fermented rather quickly, reaching pH values between 4.9 and 5.0 and lactic acid contents between 4.5 and 5.0% by the third day post-filling. However, the silages were not stable, with acetic acid and ethanol levels increasing nearly two- to threefold from d 3 to 90. The inoculant and enzyme combination silages (treatments 5 and 8) were the most efficiently preserved, as evidenced by the lowest pHs, highest lactic to acetic acid ratios, and lowest ethanol values. Chemical composition, in vitro DM digestibility, and DM recovery were not affected by silage treatment. All eight silages were highly stable in air and did not heat or deteriorate during the 10 d of exposure.

Table 37.2. Microbial and Chemical Profile of the Pre-ensiled, Pre-treated Alfalfa

Item	Profile
	-- CFU/g of alfalfa --
Lactic acid bacteria	3.3×10^6
Mesophilic bacteria	7.2×10^7
Yeasts	2.5×10^4
Molds	5.7×10^4
Dry matter, %	37.2
pH	5.98
Buffer capacity[1]	63.9
	--% of the alfalfa DM--
Crude protein	19.1
Neutral detergent fiber	34.1
Acid detergent fiber	26.8
Water soluble carbohydrates	5.4

[1]Milliequivalents of NaOH per 100 g of crop DM required to raise the pH from 4.0 to 6.0.

These results are inconsistent with the majority of our alfalfa silage studies in 1986 and 1987 (KAES Reports of Progress 514, 539, and 568), when silages were improved by inoculant and/or inoculant + enzyme additions. However, in three of five other studies conducted in 1988, inoculants alone failed to produce better alfalfa silages. The drought conditions could have contributed to the difficulties in successfully ensiling alfalfa in 1988.

Several studies are currently in progress to better understand the many crop and environmental factors that influence the "ensileability" of alfalfa (see pages 102 and 105 of this report).

Table 37.3. pH and Chemical Composition over Time for the Eight Alfalfa Silages

Time post-filling, days	Item[1]	Control	Med PF	Amyl	Amyl+ Clamp +Pect	Med PF+ Amyl+ Clamp +Pect	Cyto	Bio-mate	Cyto+ Bio-mate	LSD[2]
.5	pH	5.50	5.45	5.47	5.43	5.47	5.49	5.44	5.42	.01
	LA	.52	.63	.58	.62	.70	.64	.71	.69	.04
	AA	.47	.52	.49	.48	.50	.51	.56	.54	.04
	ETOH	.123	.134	.124	.136	.130	.129	.144	.126	.04
	NH_3-N	.023	.024	.024	.024	.024	.022	.024	.024	.002
1	pH	5.03	5.00	5.04	5.02	5.02	5.04	4.93	4.92	.01
	LA	1.85	2.22	1.86	1.83	2.08	2.12	2.40	2.29	.06
	AA	.72	.73	.63	.80	.74	.71	.61	.71	.04
	ETOH	.294	.279	.294	.291	.290	.288	.254	.272	.07
	NH_3-N	.053	.052	.052	.048	.049	.047	.050	.050	.003
3	pH	4.99	4.95	4.94	4.89	4.87	4.92	4.89	4.90	.01
	LA	4.84	4.98	4.67	5.04	5.28	5.44	4.57	4.69	.11
	AA	1.84	1.76	1.84	1.88	1.81	2.22	1.90	1.74	.08
	ETOH	.353	.326	.354	.352	.328	.410	.324	.302	.03
	NH_3-N	.172	.168	.171	.171	.167	.175	.159	.159	.008
7	pH	4.97	4.95	4.92	4.90	4.87	4.92	4.92	4.87	.01
	LA	4.75	4.36	5.26	5.12	5.44	5.50	5.59	6.17	.39
	AA	2.46	2.30	2.32	2.33	2.21	2.47	2.33	2.38	.34
	ETOH	.411	.387	.411	.373	.330	.468	.340	.358	.04
	NH_3-N	.226	.228	.233	.230	.229	.240	.235	.231	.020
14	pH	4.95	4.94	4.91	4.90	4.82	4.91	4.92	4.86	.01
	LA	5.33	5.31	5.71	5.75	5.37	5.68	5.69	6.03	.44
	AA	2.81	2.63	2.64	2.85	2.44	2.67	2.76	2.54	.11
	ETOH	.492	.468	.480	.518	.376	.482	.400	.370	.03
	NH_3-N	.293	.291	.285	.285	.260	.284	.293	.265	.019
90	pH	4.91	4.88	4.90	4.86	4.80	4.76	4.90	4.72	.01
	LA	4.26	4.70	3.62	5.36	5.92	5.69	4.66	5.71	.25
	AA	4.35	4.20	5.22	4.32	4.67	4.18	4.66	4.14	.63
	ETOH	.511	.464	.500	.514	.435	.531	.421	.390	.07
	NH_3-N	.340	.324	.330	.315	.332	.322	.332	.321	.029

[1]LA = lactic acid, AA = acetic acid, ETOH = ethanol, and NH_3-N = ammonia nitrogen. All values are reported as a percent of the silage dry matter.
[2]Least significant difference.

Table 37.4. Chemical Composition, Digestibility, and DM Recovery for the Eight Alfalfa Silages

Item[1,2]	Control	Med PF	Amyl	Amyl+ Clamp +Pect	Med PF+ Amyl+ Clamp +Pect	Cyto	Bio-mate	Cyto+ Bio-mate	LSD[3]
Dry matter, %	35.4	35.4	35.5	35.1	35.9	35.1	35.1	34.4	—
	---------- % of the silage DM ----------								
CP	19.3	19.5	19.9	19.4	19.5	19.4	19.2	19.3	.5
NDF	34.8	36.0	35.4	35.7	35.4	35.3	37.9	35.5	1.9
ADF	27.1	27.4	27.8	29.2	28.0	29.2	30.3	30.2	1.6
IVDMD	67.4	68.0	69.7	68.2	67.4	68.6	69.1	67.3	2.8
DM recovery	94.5	94.7	94.3	93.1	94.9	94.0	95.7	93.8	1.2

[1]CP = crude protein, NDF = neutral detergent fiber, ADF = acid detergent fiber, and IVDMD = in vitro dry matter disappearance.
[2]DM recovery is expressed as a percent of the dry matter ensiled.
[3]Least significant difference.

AN EVALUATION OF SEVEN PIONEER CORN HYBRIDS FOR SILAGE AND A COMPARISON OF IRRIGATED VS DRYLAND SILAGES[1,2]

D. G. Tiemann, K. K. Bolsen, R. Suazo, and D. Johnson[3]

Summary

Seven Pioneer corn hybrids and one grain sorghum hybrid were grown under both irrigated and dryland conditions in 1988 and compared for agronomic and silage quality traits. Corn hybrid silage yields ranged from 4.5 to 7.6 tons of dry matter (DM) per acre (mean, 5.8 tons) and grain yield, from 64 to 115 bu per acre (mean, 87 bu). Pre-ensiled DM content of the corn hybrids ranged from 26.7 to 33.0% (mean, 29.5%) and plant height from 82 to 108 in. (mean, 94 in.). In a digestion trial with sheep, apparent DM digestibility ranged from 66.0 to 71.0% (mean 69.6%); voluntary intake from 1,104 to 1,220 g of DM per d (mean 1,163 g); and digestible DM intake from 754 to 862 g per d (mean 810 g). The ranges all contained significant differences, indicating that corn hybrid selection will likely influence agronomic and silage quality traits and subsequent animal performance per acre. Agronomic performance and nutritive value of the irrigated and dryland grain sorghums were similar. However, both grain sorghums had superior silage and grain yields compared to the dryland corns.

(Key Words: Corn, Hybrid, Silage, Irrigated, Dryland.)

Introduction

Silage production in the United States is dominated by corn. Approximately 80 million tons of corn silage are produced annually, including 1.5 million tons in Kansas. Producers who grow their own corn or cattlemen who purchase corn for silage tend to select corn hybrids based upon their grain-producing character. The nutritive value of these silages depends upon the management of the crop during harvest and ensiling, and silage quality factors such as digestibility, voluntary intake, fermentation products, and crude protein and fiber content. The objectives of our study were: (1) to measure selected agronomic and silage quality characteristics of seven Pioneer corn hybrids and (2) to identify those hybrid characteristics that are associated with a superior silage. A grain sorghum hybrid was included for comparison.

[1]Partial financial assistance was provided by Pioneer Hi-Bred International, Inc., North American Seed Division, Des Moines, Iowa.
[2]The authors express sincere appreciation to Dr. Wes Kezar and Dr. Clive Holland of Pioneer Hi-Bred for their technical assistance during this study.
[3]Department of Statistics, Kansas State University.

Experimental Procedures

Seven Pioneer corn hybrids and one Pioneer grain sorghum hybrid (8358) were grown in 1988. The corn hybrids, 3389, 3379, 3377, 3343, 3295, 3168, and 3124, were all mid- to late-maturing and were selected by Pioneer to represent relatively wide genetic diversity among their higher grain-producing hybrids.

The hybrids were grown under both irrigated and dryland conditions on a silt loam soil near the Kansas State University campus in Manhattan. The corn hybrids were planted on May 6; the grain sorghum hybrid, on May 26. Prior to planting, 100 lb/acre of anhydrous ammonia was applied. Soil tests indicated that phosphorus and potassium were adequate. Furadan 15G® insecticide was applied in the furrows at planting, followed the next day by Ramrod® pre-emergence herbicide. The hybrids were randomly assigned to plots in a split-plot design, each with three replicates. Each plot had six rows 30 in. apart, 125 ft long. All corn hybrid plots were harvested when the kernels at the center of the ear reached the two-thirds milk line stage of maturity. The grain sorghum was harvested in the late-dough stage of kernel maturity. All corns were harvested during the week of August 8; the sorghums during the week of August 24.

Agronomic data collected for each corn and grain sorghum plot included plant height and whole-plant dry matter (DM) content. Plant height was measured to the tallest point on the tassel or the grain head. Whole-plant silage yield was determined by harvesting three inside rows of each plot with a Field Queen forage harvester. After harvest, the chopped material was inoculated with Pioneer 1174 inoculant and ensiled in plastic-lined, 55-gal pilot silos stored at ambient temperature for approximately 200 d. The two outside rows were left as borders, and 15 plants were hand-cut from the remaining row and weighed to determine the relative stover, grain, and cob fractions. The ears from the 15 plants were separated and frozen until shelling. The remaining stover, including the husks, was weighed and frozen until the plants were chopped. The ears were shelled with an "antique" seed corn sheller, and the stover was chopped with a Kemp chipper-shredder. The plant parts were then dried in a forced-air drying oven.

Thirty-six crossbred wether lambs (avg wt of 71 lb) were blocked by weight and randomly assigned to each silage (four per silage) in a four-period voluntary intake and digestion trial. Each period had a 10-d preliminary phase, a 7-d voluntary intake phase, a 2-d adjustment to 90% of voluntary intake, and a 7-d fecal collection phase. The rations were 90% silage and 10% supplement on a DM basis. All were formulated to 11.5% protein and met NRC requirements for vitamins and minerals. Between periods, the lambs were randomly reassigned to the silages.

Results and Discussion

Presented in Tables 38.1 and 38.2 are the agronomic results. Since no significant interactions existed between growth conditions (irrigated vs dryland) and hybrid for the seven corns, only data for main effects are presented. Rainfall from May 6 to August 13 totalled 9.5 in., which was about 5.0 in. below the average for Manhattan. Virtually no rain fell during the

3½ weeks prior to harvesting the corns and most of the dryland hybrids were showing drought stress.

Whole-plant corn DM content ranged from 26.7 to 33.0%, with a difference (P<.05) between irrigated (27.9%) and dryland (31.0%) conditions. Irrigated corn averaged 37.6% grain; dryland, 34.7% (P<.05). The corn hybrid with the highest percentage grain was 3379 and the lowest was 3295. The irrigated hybrids averaged 11.6% cob; dryland hybrids averaged 12.1 percent. The corn hybrid with the highest percent stover was 3343; 3379 had the lowest.

Plant height ranged from 82 to 108 in. among both irrigated and dryland corn hybrids. The tallest irrigated hybrids were 3295 and 3343; the shortest was 3377. Dryland hybrids tended to be shorter than their irrigated counterparts. The tallest dryland hybrid was 3124; the shortest were 3168 and 3389. Whole-plant DM yield ranged from 4.5 to 7.6 tons per acre among the irrigated and dryland hybrids, with an average of 5.8 tons. The irrigated hybrid 3168 had the highest whole-plant DM yield; 3377 dryland had the lowest. The average grain and stover yields were 89 bu per acre and 2.9 tons per acre, respectively. The irrigated hybrid 3168 also had the highest grain and stover DM yields, whereas dryland 3343 had the lowest grain yield, and irrigated 3377 had the lowest stover DM yield.

Table 38.1. Plant Height, DM Content, and Plant Part Percentages: Irrigated vs Dryland and Hybrid Effects

Effect	Plant height, in.	Whole-plant DM, %	Plant part: Grain	Plant part: Stover	Plant part: Cob
			--- %, DM basis ---		
Corn					
Irrigated	103[a]	27.9[a]	37.6[a]	51.3	11.1
Dryland	86[b]	30.9[b]	34.7[b]	53.5	11.8
Corn hybrid					
3389	93	30.5	38.4	51.3	10.3
3379	93	29.9	40.8	48.1	11.1
3377	92	30.8	38.5	50.8	10.7
3343	100	27.4	33.8	54.8	11.4
3295	101	28.5	32.6	54.6	12.8
3168	92	30.7	34.8	53.5	11.7
3124	90	28.5	34.3	53.7	12.0
LSD (P<.05)[1]	4.4	1.4	2.4	2.7	1.0
					Head without grain
Grain sorghum					
Irrigated	48	32.5	36.9	48.1	15.0
Dryland	45	36.4	39.2	46.5	14.3

[1]The LSD (least significant difference) is valid only within corn hybrids.
[ab]Irrigated vs dryland means differ (P<.05).

The irrigated and dryland grain sorghums yielded more whole-plant DM and grain than the dryland corn hybrids and had higher DM content than all of their corn hybrid counterparts.

The results of the voluntary intake and digestion trial with sheep are also presented in Table 38.2. The interactions between growth conditions and hybrid for intake and digestibility were not significant, so only main effects are presented. Voluntary intake and intake of digestible DM were similar for irrigated and dryland silages. However, irrigated corn silages had lower (P<.05) DM digestibilities. Among the corn hybrids, 3379, 3124, 3389, and 3168 had

the highest intake of digestible DM (voluntary intake × DM digestibility); 3343 the lowest. Although the grain sorghum silages had the highest voluntary DM intakes (P<.05), DM digestibilities were the lowest (P<.05).

Table 38.2. Silage, Grain, and Stover Yields; Voluntary Intake and Digestibility by Sheep: Irrigated vs Dryland and Hybrid Effects

Effect	Whole-plant DM yield, tons/acre	Grain yield, bu/acre[1]	Stover DM yield, tons/acre	Voluntary intake DM, g/d	Voluntary intake DM, g/MBW[2]	DM digestibility %	Digestible DM intake, g/d
Corn							
Irrigated	6.8[a]	107[a]	3.5[a]	1159	82.6	68.8[b]	798
Dryland	4.8[b]	70[b]	2.6[b]	1168	82.5	70.3[c]	821
Corn hybrid							
3389	5.8	92	2.8	1202	85.7	69.3	833
3379	5.7	98	2.7	1220	85.8	70.7	862
3377	5.5	90	2.7	1105	80.8	70.3	777
3343	5.8	83	3.2	1121	78.2	67.3	755
3295	5.6	77	3.1	1095	77.8	70.3	772
3168	6.1	90	3.3	1184	83.5	69.7	825
3124	6.1	89	3.3	1218	85.9	69.6	848
LSD (P<.05)[3]	.74	11.7	.38	79.7	5.5	1.14	59.2
Grain sorghum							
Irrigated	5.5	98	2.6	1284	76.8	61.9	798
Dryland	5.5	86	2.8	1230	84.3	61.5	754

[1]Adjusted to 15.5% moisture.
[2]MBW = metabolic body wt ($kg^{.75}$).
[3]The LSD (least significant difference) is valid only within corn hybrids.
[ab]Irrigated vs dryland means differ (P<.05).

CHARACTERISTICS OF THE INDIGENOUS MICROFLORA FROM FIVE SILAGE CROPS IN 1987[1]

R. A. Hart, F. Niroomand, K. K. Bolsen,
M. A. Lubinski[2], and W. R. Aimutis[2]

Summary

Indigenous lactic acid bacteria (LAB) were isolated from five silage crops in the 1987 growing season: wheat, alfalfa, corn, interseeded grain sorghum and soybeans, and forage sorghum. All crops had post-harvest LAB counts that exceeded 5×10^5 colony-forming units/g. There were no significant correlations between rate of fermentation during the first 7 d post-ensiling and the indigenous LAB counts. However, corn and sorghum, which fermented rapidly, had higher populations of homofermentative LAB, and the isolates showed higher rod to cocci ratios compared to the other three crops. Most of the homofermentative rods isolated were *Lactobacillus plantarum*, and most of those isolates had slow growth rates and narrow growth temperature ranges. A variety of heterofermentative lactobacilli were isolated from all five crops. Two unidentifiable *Streptococcus* species were isolated from wheat and alfalfa.

(Key Words: Microflora, Silage, Lactic Acid Bacteria.)

Introduction

In the absence of supplemental LAB, silage fermentation is controlled primarily by the indigenous (naturally occurring) microflora present when the crop enters the silo. Several researchers have studied the indigenous microflora from individual crops, but to our knowledge, few have reported comprehensive results involving several crops in one geographical region. Our objectives were to isolate and identify indigenous LAB from several Kansas crops during the 1987 growing season. These isolates were then compared to each other and to commercial silage inoculant strains for growth rates, temperature optima, and acid-producing capabilities.

Experimental Procedures

All five silages made were from crops grown under dryland conditions near Manhattan in 1987. A description of the crops and their chemical compositions are presented in Table 39.1. The LAB isolated from the post-harvested, pre-ensiled samples of the five crops were identified and characterized according to the diagram shown in Figure 39.1. The five crops

[1]Partial financial and laboratory assistance and commercial silage inoculant strains were provided by Chr. Hansen's Bio Systems, Milwaukee, Wisconsin.
[2]Project Leader and Research and Development Manager, respectively, Chr. Hansen's Bio Systems.

Table 39.1. Description, Harvest Date, Stage of Maturity, and Chemical Composition of the Five Silage Crops

Item	Arkan wheat	Riley alfalfa	Pioneer 3183 corn	DeKalb 42 sorghum + Pershing soybeans	Pioneer 947 forage sorghum
Harvest date	June 4	July 31	August 19	August 22	September 4
Stage of maturity	Dough	10% bloom	Mid-dent	Late-dough	Late-dough
Dry matter, %	41.0	39.6	37.5	34.4	35.2
Buffer capacity[1]	27.3	54.5	18.3	25.2	27.7
	---------- % of the crop DM ----------				
Crude protein	10.9	20.6	6.0	16.9	7.2
Acid detergent fiber	31.4	31.2	23.9	29.2	27.2
Water soluble carbohydrates	9.2	4.7	8.6	7.2	8.0

[1]Milliequivalents of NaOH per 100 g of crop DM required to raise the pH from 4.0 to 6.0.

105 of this report.

Results and Discussion

Results of the study are presented in Tables 39.2 through 39.5. Wheat and alfalfa underwent much slower fermentations than the other three crops (Table 39.2). All five silages reached sufficiently low pH values for acceptable preservation, and all were lactic acid-dominant silages. Corn and sorghum, crops that typically ferment rapidly, had the highest proportion of homofermentative LAB (Table 39.3). Homofermentative LAB are preferred over heterofermentative LAB because the former ferments sugars almost entirely to lac-

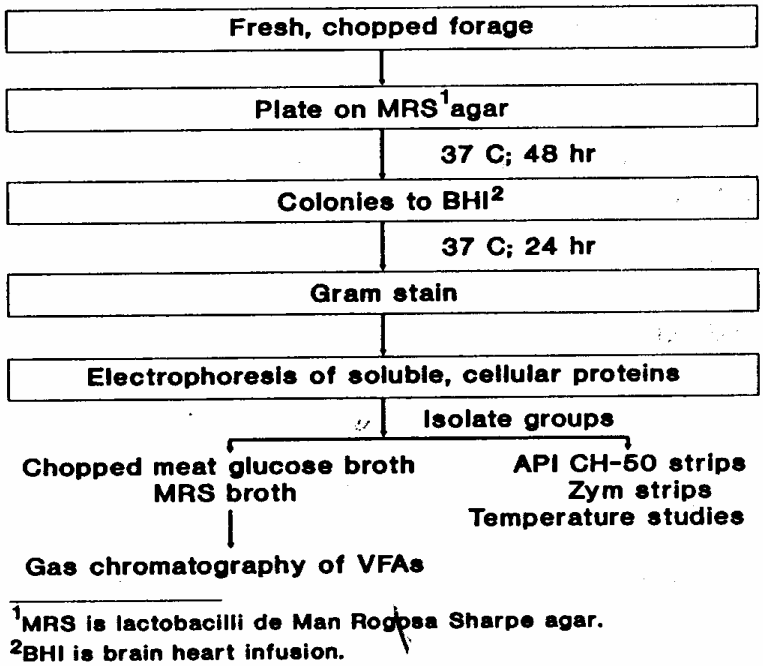


Figure 39.1. Isolation, Identification, and Characterization of the LAB Present on the Five Silage Crops

tic acid, whereas the latter ferments sugars to lactic acid and other products, principally acetic acid, ethanol, and carbon dioxide.

Four of the five crops had LAB populations predominated by *L. plantarum* (Table 39.4). The exception, alfalfa, was dominated by unidentified *Streptococcus*. Growth studies with indigenous isolates of *L. plantarum* and *Pediococcus* species showed that some had growth rates comparable to commercial silage inoculant strains (Table 39.5). However, a greater percentage of isolates was slower growing, had a narrower temperature range for growth, and did not produce as much acid as the commercial strains.

These data support our recommendation that properly selected strains of supplemental (commercial) LAB be added to silage crops to assure a rapid, efficient silage fermentation over a wide range of environmental and silage-making conditions.

Table 39.2. pH and Chemical Composition Over Time for the Five Silages

Time post-filling and item[1,2]		Wheat	Alfalfa	Corn	Sorghum + soybeans	Forage sorghum
Hour 12:	pH	—	5.86	4.72	5.91	4.75
	LA	—	.43	.68	.23	1.04
Hour 24:	pH	5.76	5.66	4.24	4.92	4.65
	LA	.90	.60	1.95	.72	1.87
Hour 48:	pH	5.66	5.47	3.94	4.21	4.41
	LA	1.79	1.34	3.70	3.29	3.67
Day 4:	pH	5.10	5.40	—	4.17	4.22
	LA	2.24	2.13	—	5.12	4.80
Day 90:	pH	4.23	4.98	3.81	4.09	4.10
	LA	5.58	4.47	5.05	6.23	5.60
	AA	1.40	2.69	1.27	3.12	1.42
	ETOH	.17	.24	1.41	.54	.70
	NH_3-N	.17	.30	.07	.13	.07

[1]LA = lactic acid; AA = acetic acid; ETOH = ethanol; and NH_3-N = ammonia-nitrogen.
[2]Acids, ethanol, and NH_3-N are percent of the silage dry matter.

Table 39.3. Numbers and Characteristics of the LAB Isolated from the Five Silage Crops

Item	Wheat	Alfalfa	Corn	Sorghum + soybeans	Forage sorghum
	------ colony-forming units/g of crop -------				
LAB count	5.0×10^6	8.6×10^5	5.0×10^5	4.5×10^6	5.8×10^6
	---------- % of the LAB isolated ----------				
Rods	50.0	64.3	88.2	84.2	75.0
Cocci	50.0	35.7	11.8	15.8	25.0
Homofermentative	60.0	35.7	82.3	78.9	91.7
Heterofermentative	40.0	64.3	17.7	21.1	8.3
Grow at 15 C	10.0	57.0	94.1	100.0	100.0
Grow at 47 C	40.0	0	0	0	0

Table 39.4. Indigenous LAB Identified from the Five Silage Crops[1]

Wheat	Alfalfa
L. plantarum (20)[2]	*Streptococcus* B[3] (29)
L. cellobiosus (20)	*L. plantarum* (21)
Leu. mesenteroides (20)	*L. brevis* (21)
Streptococcus A[3] (20)	*L. cellobiosus* (14)
L. casei (10)	*L. casei* ssp. *pseudoplantarum* (7)
P. pentosaceous (10)	*S. faecium* (7)
Corn	**Sorghum + soybeans**
L. plantarum (76)	*L. plantarum* (42)
L. brevis (6)	*L. curvatus* (16)
L. fermentum (6)	*P. cerevisiae* (10)
P. pentosaceous (6)	*L. brevis* (10)
Leu. dextranicum (6)	*L. buchneri* (5)
Sorghum	*L. fermentum* (5)
L. plantarum (42)	*L. leichmanii* (5)
L. curvatus (24)	*P. acidilactici* (5)
P. pentosaceous (16)	
P. acidilactici (8)	
L. brevis (8)	

[1]L. = Lactobacillus; P. = Pediococcus; S. = Streptococcus; Leu. = Leuconostoc.
[2]Percentage of the isolates identified as that species from this crop.
[3]Strains identified by a capital letter are unrecognized species of that genus. *Streptococcus* A closely resembled *S. faecalis*. *Streptococcus* B closely resembled *S. faecium*.

Table 39.5. Comparison of Indigenous *L. plantarum* and *Pediococcus* Species Present on the Five Silage Crops to Commercial Silage Inoculant (CSI) Strains

Item	Growth rate[1]	pH[2]	Temp. range[3], °C	Optimum temp.[3], °C
L. plantarum				
wheat	.210	3.7	23-43	40
alfalfa	.185	3.9	23-40	37
corn	.220	3.6	20-45	40
sorghum + soybeans	.230	3.7	20-45	37
sorghum	.200	3.7	23-43	37
CSI	.225	3.6	20-43	40
Pediococcus				
wheat	.185	4.3	15-35	30
alfalfa	.160	4.4	15-35	30
corn	.175	4.3	15-30	30
sorghum + soybeans	.190	4.4	20-35	30
sorghum	.180	4.2	20-35	30
CSI	.190	4.2	15-40	32

[1]Absorbance (abs.) recorded at 600 nm. Growth rate = (abs. at 12 hr − abs. at 0 hr)/12.
[2]pH of ENS medium after 24 hr of incubation at optimum temperature. The ENS medium is a minimal bacteriological medium which is similar in composition to grass forages.
[3]Temperature range and optimum temperature studies done in ENS medium.

INDIGENOUS MICROFLORA ON ALFALFA AND CORN, AND POPULATION CHANGES DURING ENSILING[1,2]

C. Lin, R. A. Hart, K. K. Bolsen, J. T. Dickerson, and J. L. Curtis

Summary

Lactic acid bacteria (LAB), Enterobacteriaceae, yeasts, molds, and lactate-using yeasts were examined on four cuttings of alfalfa, each at three maturity stages, and three corn hybrids in 1989. In addition, microflora population changes were traced during ensiling for the second and fourth cutting alfalfas and the three corn hybrids.

Enterobacteriaceae were predominant on alfalfa; yeasts, molds, and Enterobacteriaceae predominated on corn. Higher proportions of lactate-using yeast were found on corn than alfalfa. Lactic acid bacteria comprised a small (10^4 to 10^5 CFU/g) proportion of the total (10^6) populations, with streptococci the main indigenous LAB group. Lactobacilli, pediococci, and leuconostoc were the minor groups, and their occurrence was variable, particularly on alfalfa. Cutting and maturity of alfalfa did not have a significant effect on the indigenous microflora. The chopping process significantly increased the numbers of microorganisms, but wilting alfalfa did not affect the populations.

Once the crops were ensiled, LAB grew extremely fast, and reached maximum numbers at 3 d post-ensiling. Yeast and mold counts showed a continuous reduction as ensiling progressed, and this was much more pronounced in alfalfa than corn.

(Key Words: Alfalfa, Corn, Microflora, Silage.)

Introduction

The indigenous microflora present on forages is responsible for silage fermentation, unless a commercial inoculant is added. These indigenous (or epiphytic) microorganisms are naturally occurring on all crops and mainly comprise bacteria and fungi. Lactic acid bacteria (LAB) ferment carbohydrates to lactic acid, which lowers the pH of the ensiled crop. Enterobacteriaceae, yeasts, and molds are naturally present on most crops, and their existence in silage is usually considered detrimental. Enterobacteriaceae, called acetic acid bacteria, ferment carbohydrates to acetic acid, resulting in a slowing-down of the silage pH drop. Yeasts and molds not only compete with LAB for carbohydrates, but ferment lactic acid, leading to

[1]Partial financial assistance and technical support were provided by Chr. Hansen's Bio Systems, Milwaukee, Wisconsin, and Pioneer Hi-Bred International, Inc., Microbial Genetics Division, Des Moines, Iowa.

[2]Technical assistance was given by Dr. Gunter Pahlow, Institute of Grassland and Forage Research, Braunschweig, Federal Republic of Germany.

increased pH and increased dry matter loss. Yeasts, particularly lactate-using yeasts, also contribute to the aerobic instability of silage.

Only limited information is available concerning the indigenous microflora on the silage crops grown in Kansas (see page 114 of this report). Our purposes were to qualitate and quantitate the indigenous microorganisms present on alfalfa and whole-plant corn in 1989, and to trace the development (i.e., changes) of the microbial population during the ensiling process.

Experimental Procedures

A second-year stand of Cody alfalfa was examined in 1989 at second, third, fourth, and fifth cuttings and at the late-bud, 10% bloom, and 50% bloom maturity stages within each cutting. Three Pioneer corn hybrids (3389, 3377, and 3379) were grown under irrigation and harvested at two-thirds milk line kernel maturity.

Three alfalfa samples (standing crop, windrow prior to chopping, and post-chopping) and two corn samples (standing crop and post-chopping) were taken from the center of each field. Alfalfa was wilted in the swath for 4 to 6 hr prior to chopping. Chopped crops were ensiled in PVC laboratory silos by procedures described on page 105 of this report. Three silos were opened at 1, 3, 7, 42, and 90 d post-ensiling. Six and 12 hr openings were added to the corn silage sampling schedule.

Microbial evaluations. Standing crop and windrow samples were cut with scissors prior to making the dilutions. Fifty grams of each sample was weighed into a blender jar containing 450 ml sterile buffer and homogenized for 40 sec. Tenfold dilutions were then made with sterile buffer, and the following microorganisms were counted:

Lactic acid bacteria. Rogosa SL medium (Difco) was used for lactobacilli, pediococci, and leuconostoc counts. Plates were overlaid with the same medium and incubated at 37 C for 2 d. Streptococci were enumerated in Slanetz & Bartley medium (Oxiod) after incubation at 37 C for 2 d.

Enterobacteriaceae. Violet red bile agar (Difco) plus 1% glucose was employed, using a pour plate technique. Incubations were at 37 C for 2 d.

Yeasts and molds. Malt agar (Difco) was used, with penicillin and streptomycin (60 μg/ml) to kill bacteria. Counts were made following incubation at 21 C for 2 d.

Lactate-using yeasts. Yeast nitrogen base agar (Difco) was used, with lactic acid as the sole source of energy. The plates were incubated at 30 C for 3 d.

The 12 alfalfa silages examined here were also used in the study found on page 102 of this report.

Results and Discussion

Presented in Table 40.1 are the indigenous microbial profiles on the 12 harvests of alfalfa and three hybrids of corn. Enterobacteriaceae were predominant on both alfalfa and corn. Lactic acid bacteria comprised a small proportion of the total microbial populations on

Table 40.1. Indigenous Microflora on Alfalfa and Corn

Crop	Cutting or hybrid	Maturity	Lactobacilli, pediococci, and leuconostoc	Strepto-cocci	Total lactic acid bacteria[1]	Entero-bacter-iaceae	Yeasts and molds	Lactate-using yeasts
			---------- log_{10} colony-forming units/g of crop[2] ----------					
Alfalfa	2	Late-bud	1.00	1.30	1.48	5.93	4.32	—
		10% bloom	2.65	3.30	3.39	6.05	5.58	4.59
		50% bloom	3.53	3.88	4.04	5.82	5.40	4.80
	3	Late-bud	1.30	2.04	2.11	5.02	3.70	3.86
		10% bloom	4.70	4.66	4.98	5.74	4.36	3.55
		50% bloom	3.38	4.76	4.78	6.03	5.28	4.80
	4	Late-bud	3.32	3.66	3.83	5.73	5.14	3.46
		10% bloom	2.23	3.72	3.73	5.44	5.10	3.56
		50% bloom	4.05	5.07	5.11	5.69	5.26	3.56
	5	Late-bud	1.30	3.07	3.08	6.83	4.82	2.79
		10% bloom	<1.00	2.48	2.49	6.11	3.70	2.73
		50% bloom	<1.00	2.18	2.20	3.00	3.70	2.32
	Average		3.76	4.31	4.41	6.06	5.08	4.23
Corn	3389		3.08	2.88	3.29	5.32	5.28	3.54
	3377		4.68	4.72	5.00	6.16	6.67	6.50
	3379		3.17	5.35	5.35	6.89	7.24	6.56
	Average		4.23	4.96	5.04	6.50	6.85	6.36

[1]Sum of lactobacilli, pediococci, leuconostocs, and streptococci.
[2]Log_{10} of 1 = 10, log_{10} of 3 = 1,000, log_{10} of 6 = 1,000,000.

alfalfa, and streptococci were the main lactic acid bacteria. Lactobacilli, pediococci, and leuconostoc counts were small and extremely variable, particularly among the alfalfas. The higher numbers of indigenous LAB on corn compared to alfalfa were principally due to streptococci. All three corn hybrids showed relatively high yeast and mold populations.

Neither cutting nor maturity of alfalfa significantly influenced the indigenous microflora ($P>.05$; Table 40.2). The third and fourth cuttings did have numerically (but not significantly) higher populations of LAB than the second and fifth.

The chopping process significantly increased LAB and Enterobacteriaceae ($P<.05$) populations (Table 40.3) for both alfalfa and corn. However, the indigenous microflora of alfalfa was not affected by wilting in the field prior to chopping.

As expected, dramatic changes in the microflora occurred during the ensiling process (Table 40.4). The LAB quickly proliferated, and lactobacilli, pediococci, and leuconostoc grew as rapidly as streptococci in the early stages. The LAB population was maximum (10^9/g) at 3

Table 40.2. Effects of Cutting and Maturity on Indigenous Microflora on Alfalfa

Item	Lactobacilli, pediococci, and leuconostoc	Strepto-cocci	Total lactic acid bacteria[1]	Entero-bacteri-aceae	Yeasts and molds	Lactate-using yeasts
	---------- log_{10} colony-forming units/g of crop[2] ----------					
Cutting						
2	3.11	3.51	3.65	5.95	5.34	4.71[a]
3	4.24	4.54	4.72	5.76	4.86	4.39[ab]
4	3.65	4.63	4.67	5.66	5.18	3.53[b]
5	1.78	2.73	2.78	6.43	4.41	2.65[b]
Maturity						
Late-bud	2.74	3.17	3.31	6.31	4.76	3.56
10% bloom	4.10	4.13	4.42	5.92	5.13	4.06
50% bloom	3.63	4.66	4.70	5.75	5.20	4.51

[1]Sum of lactobacilli, pediococci, leuconostocs, and streptococci.
[2]Log_{10} of 1 = 10, log_{10} of 3 = 1,000, log_{10} of 6 = 1,000,000.
[ab]Values among cuttings with different superscripts differ (P<.05).

Table 40.3. Effect of Pre-treatments on Indigenous Microflora of Alfalfa and Corn

Crop	Population	Standing	Windrow	Post-chopping
		-- log_{10} colony-forming units/g of crop[2] --		
Alfalfa	Lactobacilli, pediococci, and leuconostoc	3.76[b]	3.08[b]	5.10[a]
	Streptococci	4.31[b]	4.25[b]	5.22[a]
	Total LAB[1]	4.41[b]	4.28[b]	5.46[a]
	Enterobacteriaceae	6.06[b]	6.32[ab]	6.70[a]
	Yeasts and molds	5.08	5.00	5.30
	Lactate-using yeasts	4.23	3.79	6.41
Corn	Lactobacilli, pediococci, and leuconostoc	4.23[b]	—	6.24[a]
	Streptococci	4.96	—	6.85
	Total LAB[1]	5.04[b]	—	7.00[a]
	Enterobacteriaceae	6.50[b]	—	7.49[a]
	Yeasts and molds	6.85	—	7.12
	Lactate-using yeasts	6.36	—	6.65

[1]Sum of lactobacilli, pediococci, leuconostocs, and streptococci.
[2]Log_{10} of 1 = 10, log_{10} of 3 = 1,000, log_{10} of 6 = 1,000,000.
[ab]Values in the same row with different superscripts differ (P<.05).

d post-ensiling. There were no significant differences between alfalfa and corn silages, even though the LAB counts were much higher on corn at the time of ensiling. Lactic acid bacteria numbers tended to decrease, particularly after d 7, with streptococci showing a faster decline than lactobacilli, pediococci, and leuconostoc. Yeast and mold counts tended to decrease as ensiling progressed, and this was much more pronounced with alfalfa than corn.

Numerous European studies have shown that the indigenous LAB counts on grasses and legumes are variable and much lower than our results for alfalfa and corn. Geography and/or climatic effects likely contribute to these differences. Our observation of more LAB on the standing corn than alfalfa could reflect a crop influence related to substrate, especially soluble carbohydrates. A proliferation of LAB at the early stages of ensiling is essential, if good preservation and minimum nutrient loss are to be achieved.

Other European results have indicated that Enterobacteriaceae dominate silage microflora during the first few days of ensiling and then are replaced by LAB. However, this did not occur in our studies; Enterobacteriaceae numbers declined after d 1 in both alfalfa and corn. Enterobacteriaceae and molds are sensitive to low pH, which prevents their growth, but yeasts survive a pH as low as 2.5. If yeasts proliferate during the ensiling process, the silage may be unstable when exposed to air, especially in silages rich in soluble carbohydrates and/or lactic acid.

Table 40.4. Changes in the Indigenous Microflora of Second and Fourth Cutting Alfalfa and Corn during the Ensiling Process

Silage	Population	Time of fermentation, d							
		0	1/4	1/2	1	3	7	42	90*
		---------- log_{10} colony-forming units/g of crop[2] ----------							
Alfalfa	Lactobacilli, pediococci, and leuconostoc	5.30	—	—	8.92	9.45	9.29	8.43	8.38
	Streptococci	5.30	—	—	8.97	9.17	8.93	7.63	7.05
	Total LAB[1]	5.60	—	—	9.25	9.67	9.45	8.49	8.40
	Enterobacteriaceae	6.84	—	—	7.12	6.65	6.08	2.30	0.00
	Yeasts and molds	5.90	—	—	5.49	4.37	3.76	1.08	1.30
	Lactate-using yeasts	4.53	—	—	—	—	—	1.00	1.00
Corn	Lactobacilli, pediococci, and leuconostoc	6.24	7.63	8.43	8.89	9.04	8.81	7.62	5.00
	Streptococci	6.85	7.84	8.31	8.77	8.82	8.44	5.78	3.60
	Total LAB[1]	7.00	8.05	8.67	9.13	9.24	8.97	7.62	5.00
	Enterobacteriaceae	7.49	7.48	7.05	7.32	5.15	5.16	4.56	2.30
	Yeasts and molds	7.12	7.18	6.90	6.74	5.26	5.77	6.36	4.16
	Lactate-using yeasts	6.65	—	—	—	—	—	6.33	3.58

[1]Sum of lactobacilli, pediococci, leuconostocs, and streptococci.
[2]Log_{10} of 1 = 10, log_{10} of 3 = 1,000, log_{10} of 6 = 1,000,000.
*120 d for corn silage.

YIELD AND NUTRITIONAL QUALITY OF NINE SUMMER ANNUAL FORAGES[1]

P. D. Hartman[2], G. L. Kuhl
J. P. Shroyes[3], and D. L. Fjel1[4]

Summary

Nine summer annual forages were studied to evaluate yield and nutritional quality differences resulting from forage type and cultivar when cut at two stages of maturity. Substantial dry matter yield and quality differences were observed among the six hybrid pearl millets tested. Several hybrid pearl millets gave comparable dry matter yields to the sorghum-sudans at boot and headed stages of growth. Hybrid pearl millets were much higher in crude protein than the hybrid sorghum-sudans and sudangrass. Although yield increased markedly between boot and headed cutting stages, nutritional value declined greatly. Nitrate levels were excessively high in all forages when harvested at the boot stage in July, and several were still above safe levels at the headed stage. Therefore, nitrate and feed quality testing is recommended for safe and efficient utilization of summer annual forages.

(Key Words: Summer Annuals, Pearl Millet, Sudan, Yield, Forage Quality, Nitrate.)

Introduction

In 1989, many acres of wheat failed, so livestock producers statewide planted additional acres to summer annuals such as Sudan and pearl millet as replacement crops. These drought- and heat-tolerant crops can provide excellent forage during summer months in Kansas, when other grasses have declined in production and quality. However, insufficient research exists on the relative productivity of commercially available cultivars, especially with regard to hybrid pearl millets. This study compared the yields and nutritional values of Piper sudangrass, two sorghum-sudans, and six cultivars of pearl millet cut at two stages of growth.

Experimental Procedures

An on-farm demonstration plot was established in Pratt County to evaluate forage yield and quality of nine annual forages, harvested at either boot or headed stages of maturity. Forage cultivars tested were Piper sudangrass; Chieftain and Haygrazer, hybrid sorghum-sudans; and Mil-X, Mil-Hy 300, Milgrazer, Tifleaf 1, Horsepower, and Mil-Hy 99, hybrid pearl millets.

[1]Sincere appreciation is expressed Lee Wilson, Pratt, for providing land, equipment, and assistance in data collection and to Peterson Laboratories, Hutchinson, for laboratory analyses.
[2]Pratt County Extension Agricultural Agent.
[3]Extension Crop Production Specialist, Dept. of Agronomy.
[4]Extension Crops and Soils Specialist, South Central Kansas.

All forages were planted on June 15, 1989 in 8-in. rows at a seeding rate of 15 lb per acre. The cultivar plots were planted in a failed wheat field without additional fertilization.

The forages were harvested at the boot or heading growth stages on July 20 and September 5, respectively. Forages were cut at three replicated sites per cultivar plot at 2 in. above ground level. Samples of the freshly cut material were analyzed for nutritional quality.

Results and Discussion

Substantial differences in forage dry matter yield and height were found among the pearl millet cultivars at both harvest stages. Mil-Hy 300 and Horsepower hybrid pearl millets, in particular, gave comparable dry matter yields to the hybrid sorghum-sudans at both cuttings (Table 41.1). The pearl millets were much higher in protein than the hybrid sorghum-sudans and sudangrass cultivars at both cuttings.

As expected, forage height and yield increased markedly from the boot to headed plant cutting stages for all cultivars (Table 41.1). However, forage feeding value, as indicated by crude protein, acid detergent fiber and most minerals, declined substantially with advancing plant maturity. Protein content dropped more sharply in Sudan-based forages than in the pearl millets between the two cutting stages, likely a reflection of millets' greater leafiness. Surprisingly, the phosphorus content of the pearl millets generally increased with plant maturity.

Very high nitrate levels were found in all forages harvested at the boot stage and in several cultivars cut at heading (Table 41.2). Piper sudangrass declined more rapidly in nitrate between cutting stages than the pearl millets in this study. Nitrate levels exceeding 6,000 to 9,000 ppm (NO_3, dry basis) are considered potentially toxic to cattle fed all-roughage rations. The high levels found in this study are surprising, considering the results of a soil test taken on September 5, the last harvest date. Soil nitrogen was only 6 lb/acre, whereas phosphorus and potassium were 87 and 260 lb/acre, respectively. Soil moisture conditions were generally good during the growing season, as indicated by forage yields, although a dry spell occurred around the time of the boot stage harvest. A partial explanation of the higher than expected nitrate levels relates to the short (2 in.) stubble height employed in gathering the yield data. In general, about two-thirds of total plant nitrate accumulates in the bottom one-third of the plant. Thus, if a 6 to 7 in. stubble height, typical of multiple cutting recommendations, had been used, nitrate levels likely would have been less alarming. Moreover, the relatively cool summer and overcast mornings preceding the harvest dates may have contributed to nitrate accumulation in these summer annuals of tropical origin.

Prussic acid (cyanide) levels were very low in all forages evaluated (Table 41.2). Normally, levels less than 500 to 600 ppm cyanide on a dry basis are considered safe. In contrast to the sorghums and sudans, hybrid pearl millet cultivars are not considered to accumulate toxic prussic acid levels.

In summary, the competitive yield and higher nutritional value of selected hybrid pearl millets relative to the other summer annuals evaluated indicates that they should be considered seriously for summer forage production, particularly in multiple harvesting programs, if environmental and agronomic considerations permit.

Table 41.1. Yield and Nutritional Quality of Nine Summer Annual Forages

Forage type/ cultivar	Stage of growth	Height, in.	Dry matter yield, lb/acre	Dry matter, %	Crude protein, % of DM	Acid detergent fiber, % of DM
Sudangrass						
Piper	Boot	50	4,285	17.6	12.3	32.4
	Headed	79	6,448	27.4	8.8	43.0
Hybrid sorghum-sudan						
Haygrazer 2	Boot	56	4,510	14.7	13.8	32.0
	Headed	90	10,871	25.2	6.5	37.0
Chieftain	Boot	56	5,605	15.4	13.3	32.4
	Headed	84	8,232	24.9	8.0	36.3
Hybrid pearl millet						
Mil-X	Boot	33	3,578	17.6	18.1	29.9
	Headed	50	6,714	20.5	14.6	36.7
Mil-Hy 300	Boot	37	4,229	16.6	14.2	33.4
	Headed	74	10,096	20.1	11.1	34.0
Milgrazer	Boot	30	4,234	16.2	17.2	31.3
	Headed	49	7,069	16.2	15.0	37.6
Tifleaf 1	Boot	32	3,408	15.4	17.9	30.9
	Headed	49	7,810	16.7	14.6	37.2
Horsepower	Boot	44	5,380	20.2	16.0	32.6
	Headed	72	9,975	21.0	10.4	38.4
Mil-Hy 99	Boot	40	3,828	22.9	15.0	32.8
	Headed	69	7,827	19.0	12.0	38.2

Table 41.2. Mineral, Nitrate, and Prussic Acid Content of Summer Annuals-Dry Basis

Forage type/ cultivar	Stage of growth	Calcium %	Phos-phorus, %	Potas-sium, %	Magne-sium, %	Nitrate, ppm NO_3	Prussic acid, ppm HCN
Sudangrass							
Piper	Boot	.48	.20	2.87	.31	22,700	25
	Headed	.52	.18	1.64	.29	3,600	31
Hybrid Sorghum-Sudan							
Haygrazer 2	Boot	.52	.20	3.37	.44	36,700	68
	Headed	.36	.20	1.47	.29	5,000	36
Chieftain	Boot	.49	.19	2.98	.45	33,000	73
	Headed	.40	.20	1.97	.26	8,400	35
Hybrid Pearl Millet							
Mil-X	Boot	.72	.23	4.02	.44	33,000	72
	Headed	.63	.39	2.88	.37	9,000	45
Mil-Hy 300	Boot	.60	.21	4.24	.46	33,000	70
	Headed	.45	.25	2.72	.40	11,600	62
Milgrazer	Boot	.63	.24	4.51	.50	43,000	82
	Headed	.55	.37	4.17	.52	19,000	32
Tifleaf 1	Boot	.60	.22	4.56	.44	41,000	47
	Headed	.48	.36	4.10	.38	18,000	29
Horsepower	Boot	.62	.25	4.18	.48	32,000	22
	Headed	.43	.24	2.64	.40	16,000	38
Mil-Hy 99	Boot	.63	.22	3.94	.43	26,600	24
	Headed	.63	.26	3.23	.44	18,000	46

NITRATE VARIATION IN SUDAN HAY BALES FROM THE SAME FIELD[1]

C. H. Garten[2]

Summary

Individual large round bales of sudan hay from the same cutting and field ranged from 1,525 to 6,250 ppm nitrate (NO_3), with an average of 2,764 ppm. These results illustrate the substantial variability that can occur in the nitrate content of forage packages because of location in the field and serves to caution producers when feeding such forages.

(Key Words: Nitrate, Sudan, Forage Testing.)

Introduction

Many Kansas producers grow summer annuals such as sudan for dry forage. Because of stress caused from drought, chemicals, or lack of sunlight, many types of forage can accumulate nitrate. If forage is harvested with nitrate (NO_3) levels higher than 6,000 parts per million (ppm; dry matter basis) and used as the only feed source, the potential exists for nitrate toxicity and cattle losses.

This study was conducted to determine the degree of nitrate variability present from bale to bale in sudan hay harvested off the same field.

Experimental Procedures

Forage sudan was planted in late June and grown under dryland conditions on an upland Crete silt loam soil near Niles, Kansas. One week before planting, 30 lb of actual nitrogen was applied per acre. The sudan was drilled in 8-in. rows. The site suffered from lack of moisture and chinch bugs. Height of the sudan across the field varied from 2 to 6 ft at cutting time. The majority of the field was fully mature and headed. The sudan was swathed in late September and baled into 23 large round bales weighing 700 to 800 lb. All bales were stored outside on the ground. On February 9, each bale was sampled separately by probing at 10 locations around each bale with a Penn State Forage Sampler. The samples were analyzed for nitrate at the KSU Veterinary Diagnostic Laboratory.

[1]Appreciation is expressed to Jim Pangrac, Niles, for providing forage and assistance in data collection.

[2]Saline County Extension Director.

Results and Discussion

The nitrate (NO_3) content of the 23 bales averaged 2,764 ppm but varied from 1,525 to 6,250 ppm on an as-fed basis (Table 42.1). Thus, the nitrate level in individual sudan bales from the same field varied more than twofold from the average. These results stress the importance of thorough forage sampling and conservative application of nitrate test results, recognizing that substantial variation among forage packages exists.

As this study demonstrates, a perplexing variation in the nitrate content and possible toxicity of different forage bales off the same field can occur. What causes this inconsistency? Certainly, heterogeneity in soil type and topography, and improvements such as terrace channels can contribute to diverse fertility and moisture conditions across the same field. In addition, such effects as fertilizer spreader overlap and herbicide drift can cause variations in plant physiology, and they may operate parallel to plant rows. Thus, at harvest time, a single large round bale made parallel to the crop rows could contain a much higher nitrate content than a bale produced a few feet to the left or right. You may have tested a sample of the bales in the field for excessive nitrate levels, but you may not have tested the one or two that will do the damage!

Table 42.1. Nitrate Variability among Sudan Hay Bales from the Same Field

Bale number	Nitrate content, ppm NO_3
1	1,800
2	2,250
3	1,565
4	2,060
5	2,175
6	2,400
7	5,250
8	6,250
9	1,950
10	1,540
11	3,200
12	4,400
13	3,100
14	3,095
15	3,700
16	3,225
17	1,525
18	2,175
19	2,825
20	2,025
21	3,000
22	2,540
23	1,525
Average	2,764

INDEX OF KEY WORDS

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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 higher average daily gains than those on treatment Y, but variability within treatments may indicate that the differences in production between X and Y were not the result of the treatment alone. Statistical analysis lets researchers calculate the probability that such differences are from chance rather than from treatment.

In some articles, you will see the notation "P<.05." That means the probability of the differences resulting from 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 and the probability exceeds 95% that the difference resulted from the treatments applied.

Some papers report correlations or measures of the relationship between traits. The relationship may be positive (both traits tend to get larger or smaller together) or negative (as one trait gets larger, the other gets smaller). A perfect correlation is one (+1 or −1). If there is no relationship, the correlation is zero.

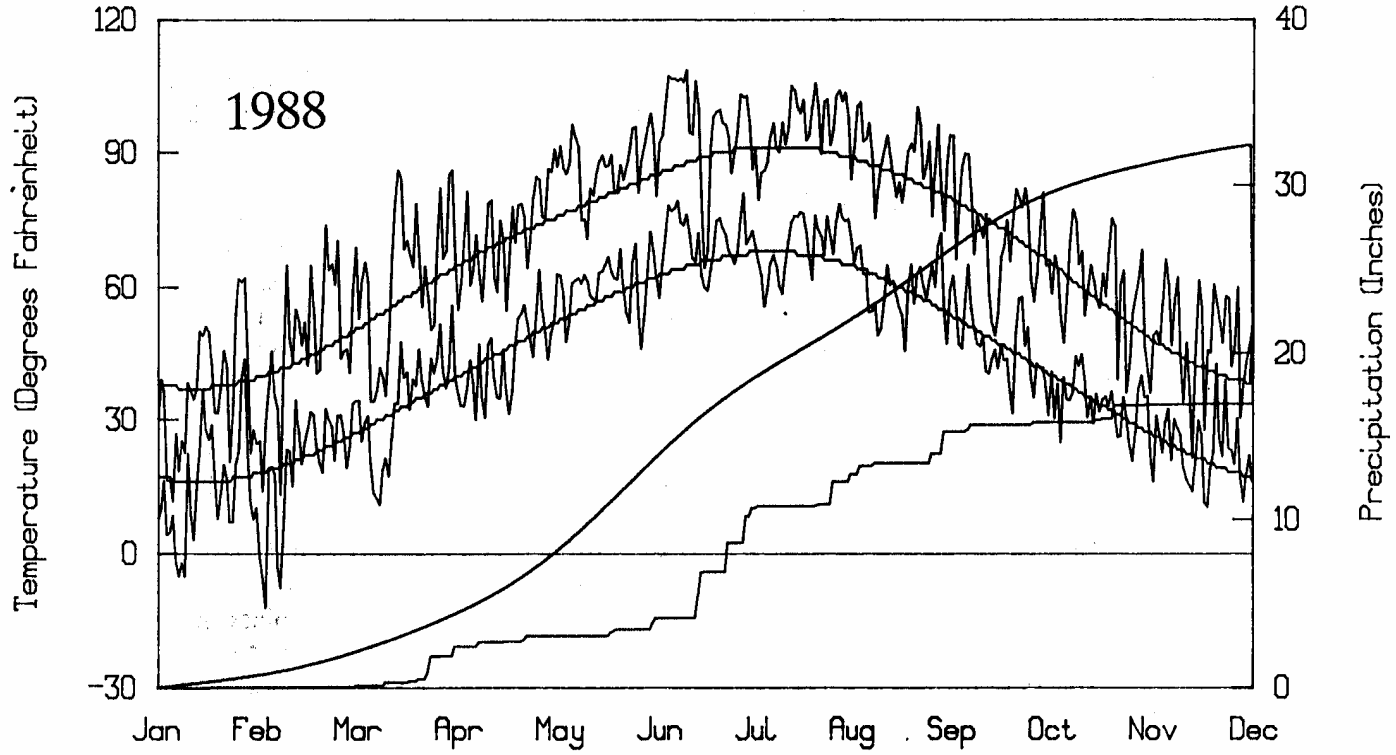
In other papers, you may see an average given as 2.5 ± .1. The 2.5 is the average; .1 is the "standard error." The standard error is calculated to be 68% certain that the real average (with unlimited number of animals) would fall within one standard error from the average; in this case between 2.4 and 2.6.

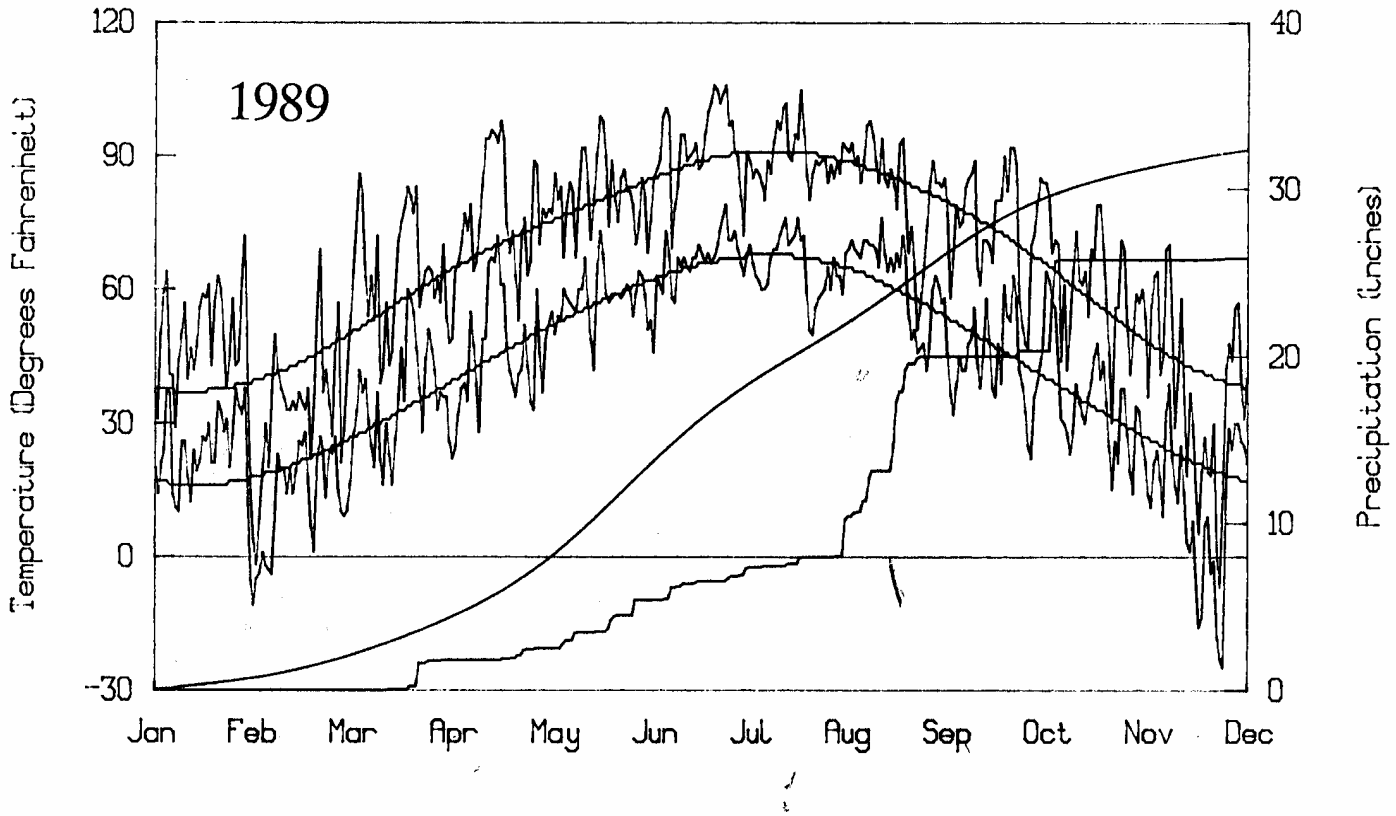
Many animals per treatment, replicating treatments several times, and using uniform animals increase the probability of finding real differences when they exist. Statistical analysis allows more valid interpretation of the results, regardless of the number of animals. In the research reported herein,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

WEATHER DATA, 1988-1989

On the following page are graphs of 1988 and 1989 Manhattan weather, produced by the Kansas Agricultural Experiment Station Weather Data Library. The smooth line that starts in the lower left hand corner of each graph is the normal accumulated precipitation. The rough line represents actual precipitation. A long horizontal section of that line represents time during which no precipitation occurred. 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 for the past five years.





Graphical Weather Summary for Manhattan, Kansas

ACKNOWLEDGMENTS

Listed below are individuals, organizations, and firms that have contributed to this year's beef research program through financial support, product donations or services. We appreciate your help!

American Cyanamid Co., Princeton, New Jersey
Beecham Laboratories, Bristol, Tennessee
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Black Diamond Custom Feeders, Herrington, Kansas
Brink's Brangus, Eureka, Kansas
Cargill Molasses Division, Minneapolis, Minnesota
Cattlemen's Beef Promotion and Research Board, Chicago, Illinois
Ceva Laboratories, Overland Park, Kansas
Chr. Hansen's Bio Systems, Milwaukee, Wisconsin
Church & Dwight Company, Inc., Piscataway, New Jersey
C-I-L, Inc., London, Ontario, Canada
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Ellis County Feeders, Hays, Kansas
Excel Corporation, Wichita and Dodge City, Kansas
Farmland Industries, Inc., Kansas City, Missouri
Finnsugar Bioproducts, Inc., Schaumburg, Illinois
First National Bank, Wichita, Kansas
Fuel, Inc., Hugoton, Kansas
Genencor, Inc., South San Francisco, California
Great Lakes Biochemical Co., Inc., Milwaukee, Wisconsin
International Silo Association, Lenexa, Kansas
Hatchet Brand and Cattle, Pratt, Kansas
Hoechst-Roussel Agri-Vet, Inc., Somerville, New Jersey
IMC Pitman-Moore, Inc., Terre Haute, Indiana
IBP, Emporia and Finney County, Kansas
International Brangus Breeders Association, Inc., San Antonio, Texas
Iowa Limestone Company, Des Moines, Iowa
Kansas Beef Council, Topeka, Kansas
Kansas Technological Enterprise Corp., Topeka, Kansas
Kemin Industries, Inc., Des Moines, Iowa
Livestock and Meat Industry Council, Inc. (LMIC), Manhattan, Kansas
Medipharm USA, Des Moines, Iowa
National Byproducts, Wichita, Kansas
National Cattlemen's Association Foundation, Denver, Colorado
National Farms, Inc., Kansas City, Missouri
National Live Stock and Meat Board, Chicago, Illinois
Pfizer, Inc., Lee's Summit, Missouri
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Pioneer Hi-Bred International, Inc., North American Seed Division, Des Moines, Iowa
Richard Porter, Reading, Kansas
Pratt Feeders, Pratt, Kansas
Purina Mills, Inc., St. Louis, Missouri
Ray Rouse & Associates, Cincinnati, Ohio
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The Upjohn Company, Kalamazoo, Michigan
Paul Zimmer, Kansas City, Kansas

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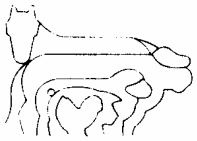

The Livestock & Meat Industry Council, Inc.

THE DON L. GOOD ENDOWMENT FOR EXCELLENCE IN ANIMAL AGRICULTURE

A one million dollar endowment in honor of Dr. Don L. Good will be established by friends and agri-businesses in the Livestock and Meat Industry Council, Inc. as our share of the "Essential Edge Campaign."

All funds of the Livestock and Meat Industry Council are managed by the KSU Foundation and donors receive credit from both.

Earnings from these funds will be used for:

1. Student scholarships.
2. Judging teams and other student educational activities.
3. Bringing in outstanding scholars for student seminars.
4. Providing support for student travel to visit other countries, farms, feedlots, and agri-businesses.
5. Purchasing teaching aids when appropriate.
6. Faculty training in specific research areas of benefit to the livestock industry.
7. Bringing outstanding research and teaching professionals in for student and faculty enrichment.
8. Providing seed money for needed research projects.

Animal agriculture is the largest industry in Kansas and dollars given to this project will return great dividends to the industry through research and trained people. This endowed fund will help give Kansas the leading edge in global competition. The LMIC is asking livestock producers, agribusiness people, and friends of the livestock and meat industry for liberal contributions to the LMIC for the Essential Edge Campaign. Gifts can be cash, livestock, other gifts-in-kind, or land. Land gifts can be set up as a unitrust that affords the donor a tax deduction and provides for a life income. This offers you the opportunity to invest in your future and in your children's future.

The names of those donating $1,000, $5,000, $10,000, $25,000, $50,000 and $100,000 or more will be placed on an appropriate plaque in Weber Hall. Pledges can be made for 1990, 1991, and 1992. This $1,000,000 will provide great returns to animal agriculture and to future generations.

Send your pledge or check to:

The Livestock and Meat Industry Council, Inc.
Weber Hall - Kansas State University
Manhattan, KS 66506

There is no better investment for you, your children, and their children.

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