Oklahoma State University

ANIMAL SCIENCE DEPARTMENT

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April 18, 1986

TO: Livestock Producers
Livestock Agribusiness Segment
Researchers & Educators
Others in Animal Agriculture

RE: 1986 Animal Science Research Report (ASRR)

As always, we are proud to present our annual Animal Science Research Report, a summary of research accomplished during the past year.

Scientists in the Animal Science Department aim their research efforts at solving problems of animal agriculture, but realistically their research results are of little value until utilized by clientele.

This is indeed the age of technology (knowledge), and there has never been a time when application of all available technology has been more important to the survival and profitability of those engaged in all phases of animal agriculture. Unfortunately, the adoption rate of available technology is often discouragingly low, ranging from 30% for cow-calf and 75% for dairy, swine and feedlot to 90% for poultry.

Our hope is that the new technology contained in this report will be used quickly, for the benefit of animal agriculture.

Yours truly,

Robert Totusek, PAS
Head, Animal Science Department

RT/csw

CENTENNIAL DECADE
1980 • 1990

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Confidence in Research Results

Variability among animals can lead to problems in interpreting experimental results. When animals on one treatment gain more rapidly than those on another treatment, it may be that, by chance the animals on the first treatment were faster gaining animals than those on the second, or it may be that the first treatment caused the animals to gain faster. Scientists use statistical analysis procedures to calculate the probability that such differences are due to chance rather than treatment.

In some of the articles in the Animal Science Research Report, the writers state that two averages are "significantly different" or the notation "$P < .05$" is used. This means that the probability the differences referred to in the article resulted from chance is less than 5 in 100. In other words it is quite unlikely that the results obtained were due to chance and it is likely that the treatment caused the differences that were observed.

In some articles there are tables of values with a $\pm$ and another value, such as: $3.6 \pm .5$. The 3.6 is called the mean, or average, of the sample of animals that was studied and is an estimate of the mean of the larger group of animals from which the sample came. The .5 is called the standard error and is a measure of the precision of the estimation procedure. This means that the probability is .68 that the value being estimated by the sample mean is within one standard error of the estimate.

Some papers report "correlation" coefficients. These are measures of positive or negative relationships between traits or variables. Positive relationships mean that when one variable is higher than average the other variable tends to also be higher than average. Negative correlations mean that larger than average values in one trait are associated with smaller than average values of the other trait. Correlations range from -1 for negative to $+1$ for positive relationships. The nearer the values are to 1 or -1 the stronger the relationship. When a correlation is statistically significant there is strong evidence that the relationship found was not due to chance. Correlation does not mean cause and effect but rather gives us insight into potential relationships between traits.

Statistical analysis procedures benefit scientists by helping them place the proper amount of confidence in their experimental results. Readers of these research reports can also benefit from the proper interpretation of the statements from the statistical analysis.

Purpose for Publication

The information given in this publication is for education purposes only. The articles have been subjected to peer review for scientific merit, adequacy of experimental procedures and correctness of interpretation. Mention of a trademark, proprietary product or vendor does not constitute a guarantee or warranty of the product nor does it imply its approval or disapproval to the exclusion of other products of vendors that may also be available.

Some chemicals and products used in the research have not been approved for commercial use at the time of this publication. Research is necessary to determine the value as well as the safety of new products and procedures. The value of products tested may not be similar under other feeding or management conditions.

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HETEROSIS AND BREED EFFECTS FOR FOUR BREEDS OF SWINE: 1.POSTWEANING PERFORMANCE

D.G. McLaren[1], D.S. Buchanan[2] and R.K. Johnson[3]

Story in Brief

Individual heterosis and breed effects for postweaning average daily gain, off-test age and probed backfat thickness were estimated from data on 1,664 pigs produced by all possible purebred and two breed cross matings involving the Duroc, Yorkshire, Landrace and Spotted breeds. Specific heterosis estimates for average daily gain and off-test age were highly significant and reasonably consistent between crosses. Overall heterosis estimates were .15 lb/day (10.5%) for average daily gain, -14 days (7.5%) for off-test age and .03 in (3.2%) for backfat thickness. Duroc and Spotted sired pigs grew faster and were younger off-test than Yorkshire and Landrace sired pigs. Landrace sired pigs probed fatter, and Duroc sired pigs leaner than pigs with Spotted or Yorkshire sires. Breed of dam effects for average daily gain were similar to breed of sire effects. Overall these results indicated the importance of heterosis for growth rate, and the relative advantage of the Duroc for faster, leaner postweaning gain.

(Key Words: Swine, Growth Rate, Probed Backfat, Heterosis, Breed Differences.)

Introduction

Crossbreeding is widely used in commercial swine enterprises. Its benefits are heterosis, the advantage of the crossbred over the average of the respective purebreds, and breed complementarity, the optimum combining of breeds so that the outstanding characteristics of each breed will be expressed.

There has been extensive research on the effects of heterosis and evaluation of some breeds of swine. The available information on breeds such as the Spotted and Landrace breeds is not as plentiful. A project aimed at evaluating purebred and crossbred performance of Duroc, Yorkshire, Landrace and Spotted breeds of swine was conducted at the Oklahoma Agricultural Experiment Station between 1976 and 1979. As part of this project purebred and two breed cross litters were produced over five consecutive farrowing seasons starting in the fall of 1976 at the Experimental Swine Farm, Stillwater.

Purebred and crossbred litter performance results have been reported previously (Gaugler et al, 1984). This report will summarize the postweaning performance data from pigs farrowed during the fall of 1976 and the spring and fall of 1977 and 1978 at Stillwater.

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[1]Former Graduate Assistant [2]Associate Professor [3]Professor, University of Nebraska

Materials and Methods

Purebred Duroc, Yorkshire, Landrace and Spotted males and females were mated in all possible combinations to produce purebred and two-breed cross offspring. Foundation boars and gilts of each breed were obtained from several different sources, and semi-annual introduction of at least one new boar of each breed was practiced in order to maintain a broad genetic base in the purebred herds. Each purebred herd consisted of seven to nine boars and 30 to 35 females.

Boars were randomly mated to at least one female of each purebred type. Distribution of animal numbers by breed group is given in Table 1. Spring litters were farrowed in March and April, fall litters in September and October. Pigs had access to creep feed from between 2 and 3 weeks of age, and were weaned at approximately 6 weeks of age. The two heaviest boars at weaning from at least four litters of each breed group were left intact. All other males were castrated. At approximately 8 weeks of age, barrows and some of the gilts were moved to pasture lots, stocking approximately 50 pigs per lot. The remaining gilts were randomly allotted within litter to be grouped in pens of 10 and fed in an open-front confinement building adjacent to pens containing the boars.

Pigs were fed a 14% crude protein corn or sorghum grain based diet from approximately 8 weeks of age until the end of the test period. Gilts were weighed off-test and probed for backfat thickness at approximately 200 lb. Boars and barrows were weighed off-test and probed at approximately 220 lb. Complete gain-test records (average daily gain, off-test age and probed backfat thickness) were collected on 976 gilts, 403 boars and 285 barrows. The data were analyzed using a procedure which allowed estimation of breed and crossbred group means while accounting for the effects of litter, year-season farrowed, sex and parity of the dam as well as some two factor interactions.

Table 1. Number of pigs by breed group.

	Breed of dam			
Breed of sire	D	Y	L	S
Duroc (D)	125	85	110	102
Yorkshire (Y)	107	93	108	90
Landrace (L)	101	87	142	87
Spotted (S)	107	109	102	109

Results and Discussion

Heterosis estimates are given in Table 2. Specific estimates for average daily gain and off-test age were all highly significant and reasonably consistent between crosses. Although specific estimates for probed backfat thickness were not significantly different from zero,

Table 2. Individual heterosis estimates for postweaning performance.

Reciprocal crosses	Average daily gain lb/day	(%)	Off-test age days	(%)	Probed backfat in.	(%)
D x Y	.17**	(12.0)	-16.2**	(-8.6)	.031	(3.1)
D x L	.16**	(11.3)	-14.4**	(-7.7)	.033	(3.2)
D x S	.16**	(10.7)	-13.1**	(-7.1)	.048+	(4.8)
Y x L	.12**	(8.5)	-11.9**	(-6.2)	.040+	(3.9)
Y x S	.13**	(9.3)	-12.9*	(-6.8)	.015	(1.5)
L x S	.16**	(11.0)	-16.4**	(-8.8)	.029	(2.7)
Overall	.15**	(10.5)	-14.1**	(-7.5)	.033*	(3.2)

[a]D=Duroc, Y=Yorkshire, L=Landrace, S=Spotted.
+P<.10
*P<.05
**P<.01

overall heterosis was significant. Overall performance of crossbreds as a deviation from the contemporary purebred mean was .15 lb/day (10.5%) for postweaning average daily gain; -14 days (7.5%) for off-test age and .03 in (3.2%) for probed backfat thickness.

Breed of sire and breed of dam effects for postweaning performance traits are given in Table 3. Duroc and Spotted sired pigs gained approximately .04 lb/day faster, and reached off-test weight approximately 4.5 days earlier, than Yorkshire and Landrace sired pigs. Landrace sired pigs probed 1.05 in fatter than pigs with Duroc sires, with Yorkshire and Spotted sired pigs somewhat intermediate. Breed of dam effects for average daily gain, apart from a nonsignificant change

Table 3. Breed effects[a] for postweaning traits.

	Average daily gain, lb/day	Off-test age, days	Probed backfat, in
Overall mean	1.547	177.15	1.046
		Breed of sire	
Duroc	.026	-2.03	-.057
Yorkshire	-.018	2.64	-.009
Landrace	-.026	1.90	.048
Spotted	.019	- 2.51	.017
		Breed of dam	
Duroc	.021	-2.56	.026
Yorkshire	-.021	3.89	-.029
Landrace	-.013	-0.29	.019
Spotted	.013	-1.04	-.016

[a]Breed group averages, as deviations from the overall mean.

in rank between Yorkshire and Landrace, were similar to breed of sire effects. Pigs with Duroc dams took 6.5 fewer days to reach final weight than those with Yorkshire dams. Pigs with Spotted and Landrace dams were approximately 2 days older off-test than those with Duroc dams. Breed of dam differences were not significant for probed backfat thickness.

Results of this study indicated a moderate crossbred advantage for postweaning average daily gain and for age off-test, with low individual heterosis for probed backfat thickness. The superiority of Duroc sired pigs for average daily gain and probed backfat thickness suggests utility of the Duroc as a sire breed. While Spotted sired pigs gained well they were also fat.

Gaugler et al. (1984) reported Landrace and Yorkshire to be superior for litter productivity traits, relative to Duroc and Spotted dams. Taken in conjunction with these results, the finishing data provided further support for use of the Yorkshire and Landrace as dam breeds in crossbreeding systems involving the Duroc. Such crosses produced leaner pigs when the Yorkshire and Landrace were used as the dam breed.

Literature Cited

Gaugler, H. R. et al. 1984. Sow productivity comparisons for four breeds of swine:Purebred and crossbred litters. J. Anim. Sci. 59:941.

HETEROSIS AND BREED EFFECTS FOR FOUR BREEDS OF SWINE
II. CARCASS TRAITS.

D. G. McLaren[1], D. S. Buchanan[2], R. K. Johnson[3] and L.E. Walters[4]

Story in Brief

Individual heterosis and breed effects for a number of carcass traits were obtained by analysis of data collected on 269 barrow carcasses. Barrows represented all possible purebred and two breed crosses involving the Duroc, Yorkshire, Landrace and Spotted breeds. Of 72 specific heterosis estimates only seven were significantly different from zero, apparently at random. Overall heterosis estimates for the carcass traits studied were not significantly different from zero. Breed of sire effects were significant and reflected the superiority of Duroc sired pigs for carcass backfat, loin muscle area, lean cuts yield and muscle quality (marbling and firmness). Maternal effects were found to be important for carcass composition in crosses involving the Duroc. Such crosses produced leaner more heavily muscled carcasses where the Yorkshire, Landrace and Spotted were used as the dam breed.

(Key Words: Swine, Carcass Traits, Heterosis, Breed Differences, Maternal Effects.)

Introduction

A project aimed at evaluating purebred and crossbred performance of Duroc, Yorkshire, Landrace and Spotted breeds of swine was conducted at the Oklahoma Agricultural Experiment Station between 1976 and 1979. As part of this project, purebred and two breed cross litters were produced over five consecutive farrowing seasons starting in the fall of 1976 at the Experimental Swine Farm, Stillwater.

Purebred and crossbred litter performance results have been reported previously (Gaugler et al, 1984). This report will summarize the carcass performance data from barrows farrowed during the fall of 1976 and the spring and fall of 1977 and 1978 at Stillwater.

Materials and Methods

Purebred Duroc, Yorkshire, Landrace and Spotted males and females were mated in all possible combinations to produce purebred and two-breed cross offspring. Herd establishment and management practices are described in the first part of this report (McLaren et al., 1986).

Barrows were weighed off-test at approximately 220 lb and slaughtered at the Oklahoma State Meat Laboratory. Live slaughter weight (adjusted for differences in gut weight) and carcass weight, length, backfat, loin muscle area, quality scores and weight of belly and closely trimmed lean cuts (ham, shoulder and loin) were recorded for

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[1]Former Graduate Assistant [2]Associate Professor [3]Professor, University of Nebraska [4]Professor Emeritus

Table 1. Number of carcasses by breed group.

Breed of sire	Breed of dam			
	D	Y	L	S
Duroc (D)	15	14	20	15
Yorkshire (Y)	21	11	19	17
Landrace (L)	19	13	20	18
Spotted (S)	16	21	17	13

269 barrows (210 crossbred and 59 purebred). Distribution of carcass numbers by breed group is given in Table 1. One loin chop from each carcass was scored subjectively for marbling, firmness and color. Scores were integers between one and seven. One represented muscle devoid of marbling that was very soft and pale, seven represented very firm very dark muscle with abundant marbling. Backfat was measured at the first rib, last rib and last lumbar vertebra and averaged. Carcasses were chilled for at least 24 hr before measurements were made.

The data were analyzed using a procedure which allowed the effects of sire, year-season farrowed, breed of sire, breed of dam and the breed of sire x breed of dam interaction to be accounted for as well as the adjusted live slaughter weight.

Results and Discussion

Reported experimental estimates of individual heterosis, (the difference between crossbreds and the average of the parental pure breeds) for carcass traits have in general been small and nonsignificant. Such was the case for estimates obtained in the present study. Two of six specific heterosis estimates for carcass weight and one each for weight of ham, loin and total lean cuts (all three for different crosses) were significantly different from zero. One specific heterosis estimate for loin muscle area and one for carcass length were also significant. No specific estimates for backfat, weight of shoulder or belly, or for quality scores were significant. Overall heterosis estimates for the 12 carcass traits measured were all nonsignificant.

Breed of sire and breed of dam effects for some of the carcass traits analyzed are given in Table 2. The largest differences among sire breed effects were due to superiority of the Duroc as a sire breed. Duroc sired pigs were significantly leaner, with larger loin muscle areas, heavier hams, shoulders and loins and increased marbling and firmness scores than were Yorkshire, Landrace or Spotted sired pigs. Spotted sired pigs had the shortest yet heaviest carcasses (adjusted to a constant slaughter weight).

Dam breed effects were generally dissimilar to breed of sire effects, indicating maternal effects were important for carcass traits. Yorkshire was the most favorable dam breed for total lean cuts yield, while pigs with Duroc and Landrace dams had the lowest yield and those with Spotted dams were intermediate. Duroc and Spotted dam breed effects for marbling and firmness were superior to Yorkshire, and Yorkshire superior to Landrace.

Table 2. Breed effects[a] for carcass traits in purebred and crossbred barrows of four breeds.

Breed	Length in	Backfat in	Loin eye area in^2	Total lean cuts lb	Belly lb.	Marbling units
Overall mean	31.40	1.29	4.58	88.84	18.63	3.58
			Breed of sire			
Duroc	-.07	-.10	.49	4.09	-.87	.51
Yorkshire	.15	.04	-.16	-.18	-.04	-.34
Landrace	.19	-.00	-.16	-2.55	.47	-.24
Spotted	-.27	.06	-.17	-1.36	.44	.07
			Breed of Dam			
Duroc	-.13	.04	-.05	-.96	.36	.31
Yorkshire	.12	-.06	.10	1.81	-.01	-.19
Landrace	.03	.04	-.07	-1.10	-.21	-.41
Spotted	-.02	-.02	.02	.25	-.14	.29

[a]Deviations from the overall mean

Although maternal effects for carcass composition in swine appear to be important, the mechanism by which such effects operate is obscure. It has been suggested that prenatal influences on fetuses might result in developmental differences that carry over to slaughter. This hypothesis seems reasonable given that number of muscle fibers appears to be essentially established by parturition and that most, if not all, extramuscular fat cells are present at birth. Experiments involving embryo transfer would be required in order to test this hypothesis.

Results of this study indicated little or no individual heterosis for carcass traits. The superiority of Duroc sired pigs for backfat thickness, loin muscle area and yield of lean cuts, in addition to rate of gain (McLaren et al, 1986) and feed efficiency (McLaren et al, 1985), suggests utility of the Duroc as a sire breed.

Gaugler et al. (1984) reported Landrace and Yorkshire to be superior for litter productivity traits, relative to Duroc and Spotted dams. Taken in conjunction with these results, the finishing and carcass data provided further evidence as to the utility of the Yorkshire and Landrace as maternal breeds in crossbreeding systems involving the Duroc. Such crosses produced leaner more heavily muscled carcasses where the Yorkshire and Landrace were used as the dam breed.

The potential role of the Spotted breed in efficient commercial pork production systems is unclear. If more than one sire breed is required, it is important that each breed has desirable characteristics. Thus a breed excelling in carcass merit while adequate in other respects might seem to be a logical adjunct to the Duroc. The Spotted breed did not fit this role.

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PERFORMANCE OF PROGENY SIRED BY SUPERIOR AND INFERIOR INDEXING CENTRAL TEST STATION HAMPSHIRE AND DUROC BOARS

R.O. Bates[1], D.S. Buchanan[2] and R. Vencl[3]

Story In Brief

Hampshire and Duroc boars were purchased from central test stations in pairs with each pair including a high indexing and a low indexing boar. Boars were evaluated for an index which combined average daily gain, feed efficiency and probe backfat thickness. Offspring of high indexing Hampshire boars were 5 units better for the index and were slightly superior, on the average, for average daily gain and backfat thickness. Gilts sired by high indexing Duroc boars grew faster, were fatter and were 4 points better for the index than gilts by low indexing Duroc boars, while barrows by high indexing Duroc boars were slower growing, leaner and not significantly different for the index than barrows sired by low indexing Duroc boars. These results indicate that high indexing central test station boars can be a supplement to, but should not replace, a good on-farm testing program.

(Key Words: Swine, Test Station, Growth, Efficiency, Backfat)

Introduction

Central test stations serve a two-fold purpose as a demonstration of uniform performance testing methods and as a possible source of replacement boars for both seedstock and commercial herds. The index for which tested boars are evaluated was constructed from results of experiments where animals were maintained in one environment. Little evidence exists on how well expectations of performance based on experimental results relate to the performance of progeny sired by central test station boars with varying pre-test management. This study was conducted to compare progeny of high and low indexing central test station boars under near commercial production conditions.

Materials and Methods

A two year study was conducted comparing progeny of high and low indexing Hampshire and Duroc central test station boars purchased in Iowa, Missouri, Nebraska and Oklahoma. Boars were evaluated for an index, recommended by the National Swine Improvement Federation for test stations (Hubbard, 1981). The index is $I=100 + 60(G-\bar{G})-75(F-\bar{F})-70(B-\bar{B})$ where G is average daily gain, F is feed efficiency (lbs feed/lb gain) and B is average backfat thickness. Symbols with bars over them represent contemporary central test station means. Boars were purchased in pairs with one having an index greater than 118 and the other having an index value less than 90. The index has a mean of 100 and 75% of the boars will have index values between 125 and 75. Boars with an index value of less than 80 are usually excluded from the sale.

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[1]Former Graduate Assistant [2]Associate Professor [3]Herdsman

The first year 12 high indexing and 12 low indexing Hampshire boars were purchased and were mated to three- and four-breed cross gilts while the second year 13 high indexing and 12 low indexing Duroc boars were purchased and mated to gilts produced the previous year. The performance of the purchased boars is summarized in Table 1.

Approximately 99 females were farrowed during each of two farrowing seasons per year. Gilts were farrowed in a central farrowing barn and litters were weaned at 42 days of age. Performance test began at approximately 56 days of age with pigs penned in groups of 12 to 18. Pigs were fed a 16% crude protein ration until average pig weight in the pen was 120 pounds when the ration was changed to 14% crude protein. Pigs were weighed weekly and were removed from the pen as they reached 220 pounds. Fat thickness was measured by ultrasound at the shoulder, last rib and last lumber vertebra at the end of test. Feed efficiency (lbs feed/lb gain) was measured on a pen basis. A barrow was randomly selected from each litter for carcass evaluation. The first year 132 barrows were slaughtered while the second year 136 were slaughtered. There were 730 pigs that completed test and had an index calculated the first year, while 1032 pigs met the same criteria the second year. Data were analyzed so that the effects of sex, farrowing season and breed of dam were accounted for when making comparisons among progeny sired by high and low indexing boars.

Table 1. Average performance of boars purchased from test stations[a].

Season[a]	Average Daily Gain (lbs)	Feed Efficiency (lbs.feed/lb.gain)	Probe Backfat thickness(in)	Index
		High Indexing Boars		
Fall 1979[b]	2.27	2.34	.73	131
Spring 1980	2.18	2.55	.69	128
Fall 1980	2.27	2.25	.77	137
Spring 1981[b]	2.38	2.52	.71	129
		Low Indexing Boars		
Fall 1979	1.81	2.62	.74	83
Spring 1980	1.87	2.84	.71	87
Fall 1980	1.92	2.59	.87	83
Spring 1981	1.96	2.68	.85	83

[a]Hampshire boars were purchased the first two seasons while Duroc boars were purchased the last two.

[b]Two boars did not leave offspring.

Results and Discussion

The performance of barrows and gilts sired by high and low indexing boars is given in Tables 2-6. Only small differences were found between progeny sired by high and low indexing Hampshire boars for average daily gain and probe backfat thickness (Table 2). Pigs sired by high indexing Hampshire boars were more feed efficient in the fall born litters, while the reverse was true for the spring born litters (Table 3). Progeny

Table 2. Post-weaning performance of progeny sired by high and low indexing central test station Hampshire boars.

	No.	Sire Group: High Index	Sire Group: Low Index
Average Daily Gain (lb/day)	868	1.43[a]	1.41[a]
Probe Backfat Thickness (in)	826	.91[a]	.92[a]
Index	730	103[a]	98[b]

[ab]Means in rows that have different superscripts differ significantly.

Table 3. Feed consumption and efficiency of progeny sired by high and low indexing central test station Hampshire boars.

	Season of birth	No. of pens	Sire Group: High Index	Sire Group: Low Index
Feed Efficiency (lb feed/lb gain)	spring	24	3.06[a]	2.82[b]
Average Daily Feed Consumed (lb/day)	spring	24	3.97[a]	3.35[b]
Feed Efficiency (lbs.feed/lbs.gain)	fall	42	3.06	3.15
Average Daily Feed Consumed (lb)	fall	42	3.95	4.17

[ab]Means in rows with different superscripts differ significantly.

sired by high indexing Hampshire boars did have a larger index value than did pigs sired by low indexing Hampshire boars indicating that the small average advantages for the component traits did accumulate when all traits were combined in the index. Mean growth rate and backfat thickness values of pigs sired by Duroc boars were different for barrows and gilts so the results are presented separately by sex. Gilts sired by high indexing Duroc boars were faster growing, fatter and had a higher average index score than those gilts sired by low indexing Duroc boars (Table 4). Barrows, on the other hand, sired by high indexing Duroc boars grew slower, were leaner and were not different for the evaluation index compared to barrows of low indexing Duroc boars. Progeny sired by high indexing Duroc boars and out of gilts sired by high indexing Hampshire boars were more efficient and ate less feed when compared to progeny sired by low indexing Duroc boars that were out of gilts sired by high indexing Hampshire boars (Table 5). The converse was true of

Table 4. Post-weaning performance of gilt and barrow progeny sired by high and low indexing central test station Duroc boars.

	Sex	No.	Sire Group High Index	Sire Group Low Index
Average Daily Gain (lb/day)	gilt	629	1.52[a]	1.46[b]
Probe Backfat thickness(in)	gilt	622	.87[a]	.83[b]
Index	gilt	600	102[a]	98[b]
Average Daily Gain (lb/day)	barrow	452	1.59[a]	1.61[b]
Probe Backfat Thickness (in)	barrow	448	.90[a]	.93[b]
Index	barrow	432	102[a]	102[a]

[ab]Means in rows that have different superscripts differ significantly.

Table 5. Feed consumption and efficiency of progeny sired by high and low indexing central test station Duroc boars.

	Maternal grandsire	No. of pens	Sire Group High Index	Sire Group Low Index
Feed Efficiency (lbs.feed/lb.gain)	high index	39	2.61[a]	2.96[b]
Average Daily Feed Consumed (lbs)	high index	39	4.06[a]	4.59[b]
Feed Efficiency (lbs feed/lb gain)	low index	42	3.06[a]	2.73[b]
Average Daily Feed Consumed (lbs)	low index	42	4.76[a]	4.08[b]

[ab]Means in rows with different superscripts differ significantly.

Table 6. Carcass backfat thickness and percent muscle of barrows sired by high and low indexing central test station boars.

	No.	Sire Group: High Index	Sire Group: Low Index
Hampshire sired barrows	132		
Backfat thickness (in)		1.05	1.05
Percent Muscle (%)		53.64	53.73
Duroc sired barrows	136		
Backfat thickness (in)		1.05[a]	1.11[b]
Percent Muscle (%)		54.77[a]	54.21[b]

[ab]Means in rows with different superscripts differ significantly.

progeny out of gilts sired by low indexing Hampshire boars with those progeny sired by low indexing Duroc boars being more feed efficient and eating less than progeny sired by high indexing Duroc boars. Barrows sired by high vs low indexing Hampshires were no different compared to each other for carcass backfat thickness and percent muscle; however, high indexing Duroc sired barrows were leaner and had more muscle when compared to barrows sired by low indexing Duroc boars (Table 6).

The expected heritability for the evaluation index, based on average literature estimates of heritabilities of the traits and genetic correlations among the traits is .37. The realized or actual heritability of the index computed from the high vs. low comparison was .16. This loss in selection efficiency can be partially explained by the boars having differing pre-test management and the offspring of the boars being raised in a different environment and under different management conditions than that of their sires.

Progeny sired by high indexing boars were superior for the evaluation index when compared to progeny of sires that were inferior for the index although the differences were not large. Commercial producers purchasing high indexing test station boars can expect subsequent offspring to be above average for the index and over time to show favorable response for its component traits. It is, however, probably important to use the performance of the boars in the test station in conjunction with an awareness of the on-farm testing program conducted with the owner. The purchase of superior indexing central test station boars should complement a good within herd performance testing program.

Literature Cited

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A COMPARISON OF 140 DAY VS SHORTER TEST PERIODS FOR EVALUATING AVERAGE DAILY GAIN IN BEEF BULLS AT CENTRAL TEST STATIONS

D.S. Buchanan[1] and C.A. McPeake[1]

Story in Brief

Average daily gains of 655 beef bulls from six breeds were used to evaluate the utility of test periods less than 140 days for evaluation of growth rate in centrally tested bulls. All data were obtained at the Oklahoma Beef Incorporated Bull Test Station. Correlations were obtained for 84 day average daily gain or 112 day average daily gain with average daily gain for the entire test period of 140 days. The average correlation between 84 day average daily gain with 140 day average daily gain was .82 with a range of .78 to .86 for the six breed groups. The average correlation between 112 day average daily gain with 140 day average daily gain was .91 with a range of .88 to .94. These results provide a preliminary recommendation to decrease the length of the test period for centrally tested beef bulls from 140 to 112 days.

(Key Words: Beef, Test Station, Daily Gain, Correlation, Selection)

Introduction

Central bull testing stations serve the useful function of evaluating beef bulls from different herds for growth rate under conditions which are as uniform as possible. Breeders can use the information to highlight their own testing program or, if enough bulls from one herd are tested, can use the information to help evaluate the genetic potential for growth rate in their herd. The Beef Improvement Federation recommends a 140 day test period for evaluation of average daily gain (Hubbard et al. 1981). Since testing bulls off-farm is an increasingly expensive activity, there has been some interest in using shorter test periods in central test stations. The purpose of this research was to compare measurement of average daily gain over the entire 140 day test to measuring average daily gain for 112 or 84 days.

Materials and Methods

Performance records of 655 bulls tested from the fall of 1983 through the spring of 1985 at the Oklahoma Beef Incorporated (OBI) bull testing station were analyzed. The bulls represented 6 breeds: Angus, Brangus, Charolais, Hereford, Limousin and Polled Hereford. The numbers of bulls in each breed, along with the average on-test weight and average weights after 84, 112 and 140 days on test are shown in Table 1. These weights should not be used to compare the average growth rates of bulls from different breeds since bulls of different breeds are not managed in an identical manner.

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Table 1. Number of bulls and average weights of bulls tested at the Oklahoma Beef Incorporated bull testing station.

Breed	n	weights			
		on-test	84 days	112 days	140 days
Angus	180	637.14	978.88	1087.01	1187.34
Brangus	83	668.16	986.19	1077.82	1164.57
Charolais	98	659.11	1024.36	1136.12	1221.38
Hereford	98	687.55	1022.84	1118.38	1204.24
Limousin	78	726.35	1041.95	1149.51	1235.82
Polled Hereford	118	675.89	1011.01	1105.00	1191.85

Bulls were brought to the test station between seven and eight months of age. They were allowed two to three weeks to acclimate to the station and the higher energy rations that were used for the actual test. On-test weight was obtained by weighing the bulls twice (two days apart) and averaging the two weights. Official on-test day was designated as the day between the days for the two weights. All bulls were weighed every 28 days throughout the test period until the off-test point when they were weighed on days 139 and 141. These weights were also averaged to obtain the official off-test weight at 140 days.

Each OBI breed group develops its own guidelines for management and feeding of the bulls. Angus and Brangus bulls were fed a commercially prepared ration containing corn and oats as the concentrate, soybean and cottonseed meal as a protein supplement and cottonseed hulls as a roughage. This diet contained 73.3% total digestible nutrients (TDN) and 12% crude protein. Bulls from the other four breeds were fed a ration with similar components but with a lower TDN (67.7%) and a higher crude protein (13.4%). Angus and Polled Hereford bulls were fed in self feeders that were replenished whenever necessary. Bulls from the other breeds were fed twice daily in fence-line bunk feeders.

Average daily gain (ADG) to 84, 112 and 140 days was calculated by dividing a bull's weight change by the appropriate number of days. The utility of 84 or 112 day ADG was evaluated by calculating correlations between them and 140 day ADG. A high correlation (>.8) indicates that the shorter period ADG was nearly as useful as the ADG calculated from the full test period of 140 days.

Results and Discussion

Correlations of 84 or 112 day ADG with ADG calculated from the full test period of 140 days are shown in Table 2. These correlations suggest that both 84 day and 112 day ADG would be quite useful in predicting 140 day ADG. The correlations were particularly high between 112 and 140 day ADG. Despite differences in inherent growth rate and management of the breeds the correlations were quite uniform between breeds.

Correlations of this magnitude indicate that nearly as much could be learned about average daily gain of beef bulls with a 112 day test as is currently learned with a 140 day test. This has several practical benefits. If bulls were fed fewer days the expense of testing would be diminished. Many seedstock producers feel that testing bulls off-farm is

Table 2. Correlations of 84 or 112 day average daily gain with 140 day average daily gain in centrally tested beef bulls.

Breed	Correlations	
	84 and 140 days	112 and 140 days
Angus	.78	.93
Brangus	.85	.94
Charolais	.86	.88
Hereford	.81	.91
Limousin	.83	.89
Polled Hereford	.86	.92
Pooled	.82	.91

too expensive when similar information can be obtained by keeping the bulls at home. There is also some concern that bulls fed a high energy ration for 140 days require a long conditioning period before they are ready to turn in with the cows. If bulls were on test for fewer days they would probably require less time to get into breeding condition and could be used for breeding at a younger age. Test stations with limited space could also test more bulls since each bull would be on test for a shorter time period.

These results provide a preliminary recommendation that shorter test periods may be appropriate for central bull test stations. Before such a change is implemented more information is needed, particularly for bulls fed a lower energy ration. Bulls in this study were fed for maximum growth. Bulls on a lower energy ration may require more time to provide an accurate evaluation of growth potential.

Literature Cited

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COMPARISON OF LIMOUSIN AND GELBVIEH AS TERMINAL CROSS SIRE BREEDS

E.D. Tinker[1], R.R. Frahm[2], H.G. Dolezal[3] and S.G. May[1]

Story in Brief

Twenty-eight bulls of each the Limousin and Gelbvieh breeds were compared for use as terminal sires by mating bulls of both breeds to various two-breed cross cows to produce 417 steers and 360 heifers in 1982, 1983, 1984 and 1985. Overall performance as terminal sires was similar for both breeds and none of the differences for individual traits were significant. Birth weights averaged 86 lbs and there was 5.2% difficult calvings. Average weaning weight was 544 lbs. After weaning, the 1982 and 1984 calf crops were placed on a self-fed, corn based finishing diet until an estimated low choice quality grade was attained. Mean feedlot average daily gain, slaughter weight and feed efficiency were 2.84 lbs/day, 1206 lbs and 6.99 lbs feed/lb liveweight gain, respectively. Hot carcass weight averaged 754 lbs and carcass weight per day of age was 1.67 lbs. Carcasses from calves sired by both breeds were quite desirable. The majority graded low choice and the means for external fat thickness, kidney, heart and pelvic fat and rib eye area were .48 in, 2.75% and 14.0 sq in, respectively. All performance and carcass traits were similar for the two sire breeds, and both breeds would be very satisfactory for use as terminal cross sires.

(Key Words: Crossbreeding, Terminal Sire, Limousin, Gelbvieh)

Introduction

Many studies have demonstrated the advantages of crossbreeding for increasing the efficiency of beef production. Implementing a crossbreeding plan which utilizes a terminal sire provides the opportunity to make greatest use of breed complementarity. Such a plan can utilize the superior growth rate of the larger breeds while maintaining a cow herd of smaller, more efficient animals. The purpose of this study is to compare the Limousin and Gelbvieh breeds for use as terminal sires, and is part of a study being conducted at the Oklahoma Agricultural Experiment Station on lifetime productivity of various two-breed cross cows.

Experimental Procedure

Each year seven purebred bulls from each the Limousin and Gelbvieh breeds were selected by the North American Limousin Foundation and American Gelbvieh Association, respectively, with semen from each bull supplied by the owner. Cows from each of eight breed groups (Hereford x Angus, Angus x Hereford, Brown Swiss x Angus, Brown Swiss x Hereford,

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[1]Graduate Student [2]Professor [3]Assistant Professor

Simmental x Angus, Simmental x Hereford, Jersey x Angus and Jersey x Hereford) were randomly assigned to individual bulls so that all bulls received approximately the same number of cows in each breed group and age. Only mature cows were involved and ranged in age from 7 to 9 years of age at calving time in 1982 and from 10 to 12 years of age in 1985.

Calves were born primarily in February and March. Birth weights were recorded and all calvings were assigned a difficulty score from 1 to 5 (1=no difficulty, 5=caesarian birth) by the herdsman. Calves were raised by their dams on native tall grass and bermudagrass pastures on the north side of the Lake Carl Blackwell Research Range west of Stillwater until weaning at an average age of 205 days. Weaning weights were recorded the day of weaning and a panel of three people assigned scores to each calf for conformation (muscling) and condition.

Calves born in 1982 and 1984 were transported to the Southwestern Livestock and Forage Research Station at El Reno, OK the day of weaning. The 1982 calves were placed in the feedlot the following day, with their actual weaning weights used as weight on test. In 1984 the calves were given a brief period for adjustment to surroundings and diet before shrunk weights were obtained for weight on test. In both years the cattle were allocated into pens based on sex and breed group. The ration presented in Table 1 was fed ad libitum. As the cattle approached slaughter condition they were individually weighed and evaluated every two weeks. Cattle were individually selected for slaughter when an estimated low choice quality grade had been attained. Shrunk weights were obtained before transport to a commercial slaughter plant. Carcasses were chilled for 48 hours before collection of carcass data.

Table 1. Finishing ration.

Ingredient	Percent in ration
Corn	78
Alfalfa	8
Cottonseed hulls	4
Molasses	5
Supplemental pellets[a]	5
Total	100

[a]Supplemental pellets consisted of 67.6% soybean oil meal (44%), 12% urea, 10% calcium carbonate, 8% salt plus Aurofac, vitamin A and trace minerals.

Results and Discussion

Sire breed means for performance and carcass traits were averaged over crossbred cow groups and sexes, and are presented in Table 2. A total of 777 calves were born in the four year period (1982-1984). Mean performances for the two sire breeds were similar for all traits evaluated and none of the differences were significant ($P>.10$).

Table 2. Three-breed cross calves sired by Gelbvieh and Limousin bulls.

Trait	Breed of sire[a]		Difference*
	Gelbvieh	Limousin	Gelbvieh-Limousin
Performance to weaning:			
Number of animals	366	411	---
Birthweight, lb	87.2	84.9	2.3
% difficult calving[b]	4.8	5.6	-.8
Calving difficulty score[c]	1.09	1.17	-.08
% death loss at birth or shortly after	2.48	1.69	.79
Preweaning ADG, lb/day[d]	2.29	2.17	.12
205-day weaning wt, lb[d]	557.5	530.5	27.0
Weaning conformation score[de]	13.4	13.5	-.1
Weaning condition score[df]	5.5	5.3	.2
Feedlot performance:			
Number of animals	192	217	---
Yearling weight, lb[d]	985	960	25
Weight on test, lbs[d]	551	524	27
Days in feedlot	232	238	-6
Average daily gain, lb/day[g]	2.83	2.84	-.01
Slaughter weight, lb[h]	1208	1204	4
Feed efficiency, lb feed/lb gain[g]	6.90	7.08	-.18
Carcass traits:			
Number of animals	192	217	---
Carcass weight, lb[h]	756	753	3
Carcass weight/day of age	1.68	1.65	.03
Dressing %[h]	62.1	62.9	-.8
Single fat thickness, in	.45	.50	-.05
KHP fat, %[h]	2.77	2.73	.04
Marbling score[i]	4.8	4.8	0
Carcass grade[j]	9.7	9.4	.3
Ribeye area, sq in	13.9	14.0	-.1
Cutability, %	50.8	50.5	.3

[a]Means averaged over years and sexes.
[b]% calving with calving difficulty scores 3, 4 or 5.
[c]Calving difficulty: 1=no difficulty, 2=little difficulty, 3=moderate difficulty, 4=major difficulty, 5=caesarian.
[d]Trait adjusted for age of calf.
[e]Conformation score equivalents: 12=low choice, 13=average choice, 14=high choice.
[f]Condition score equivalents: 1=very thin, 5=average to 9=very fat.
[g]Trait adjusted to a constant weight on test.
[h]Trait adjusted to a constant marbling score.
[i]Marbling score equivalents: 4=slight, 5=small.
[j]Carcass grade equivalents: 9=high good, 10=low choice.
*No differences are significant at the .10 level of probability.

The calves averaged 86 lbs at birth, which is not excessively large, particularly for mature cows. The low percentage of cows requiring assistance calving (5.2%) was probably due to only mature cows being involved in this study. If younger cows were involved (less than five years old) more calving difficulty could probably be expected.

Both sire breeds produced very acceptable calves at weaning, with an average weaning weight of 544 lbs and average conformation score of 13.4 (13=average choice). The Gelbvieh sired calves showed a nonsignificant advantage at weaning time of 27 lbs. All weaning traits were adjusted to a constant age of 205 days.

Only calves born in two of the years (1982 and 1984) were finished out in order to obtain feedlot and carcass data. In those two years 409 calves (218 steers and 191 heifers) were evaluated for feedlot performance and carcass traits. Performance was similar for progeny of each sire breed and was quite desirable. Gelbvieh sired calves maintained their nonsignificant advantage of 27 lbs at weaning through yearling weight (985 vs 960 lbs). Average daily gain and feed efficiency for the feedlot period were adjusted to a constant on test weight of 540 lbs. Average daily gain was 2.84 lbs and 6.99 lbs feed/lb of liveweight gain were required. Slaughter weight was adjusted to a constant marbling score of small, with a resulting average of 1206 lbs.

The inability in some cases to accurately determine when the cattle had reached the desired low choice quality grade resulted in the Gelbvieh sired calves having a slight advantage (nonsignificant) in carcass grade. Some of these cattle should have been left on feed a few more days, which probably would have increased slightly the difference in days on feed between the two sire breeds. Slaughter weight would not be affected since it was adjusted to the desired marbling score. The carcasses produced were very acceptable, with an average rib eye area of 14.0 sq in and an average quality grade of 9.5 (9=high good, 10=low choice). Means for 12th rib external fat thickness and cutability were .48 in and 50.7, respectively. Hot carcass weight, dressing percent and percent KHP fat were adjusted to a constant marbling score of small, with means of 754 lbs, 62.5% and 2.75%, respectively.

Results from this study indicate that both Limousin and Gelbvieh perform well as terminal sire breeds. Both breeds sired calves with good growth, feed conversion and carcass traits. The small differences between the two breeds would indicate that decisions on which to use as a terminal sire need to be based as much on the genetic merit of individual bulls available, and the price at which they can be obtained, as the breed of the bull.

PERFORMANCE OF 0, 1/4 AND 1/2 BRAHMAN CROSSBRED CALVES IN SPRING AND FALL CALVING SYSTEMS

R.C. Bolton[1], R.R. Frahm[2], J.W. Castree[3] and S.W. Coleman[4]

Story in Brief

Performance to weaning was evaluated on 499 spring-born and 423 fall-born calves of five different crossbred groups (Angus x Hereford, 1/4 Brahman:1/4 Hereford:1/2 Angus, 1/4 Brahman:1/4 Angus:1/2 Hereford, Brahman x Angus, Brahman x Hereford) over a three year period. Averaged over crossbred groups the 205-day weaning weight of spring-born calves was 43 lb heavier than the 240-day weight of fall-born calves.

Interactions between percent Brahman and season of birth were significant for all traits measured except birth weight. In the spring calving group, 1/4 and 1/2 Brahman calves were 20 and 40 lb heavier than 0 Brahman calves, respectively, while in the fall calving group the three levels of Brahman breeding had similar weaning weights. Hip height increased as the percent Brahman increased in both seasons. Averaged over both spring and fall, 1/4 and 1/2 Brahman calves were .7 and 2.1 in. taller, respectively, than 0 Brahman calves.

For growth traits through weaning, these data indicated a general advantage as proportion of Brahman breeding increased with the advantage being of greater magnitude for spring-born calves. Within each crossbred group spring-born calves out-performed fall-born calves.

(Key Words: Genotype-Environment Interaction, Brahman, Crossbreeding)

Introduction

Different genetic types of cattle have been used as a means of increasing production efficiency. However, the production environment also plays a major role in determining efficiency, and different types of cattle may perform best in different environments. This genotype-environment interaction is the basis for a study currently being conducted at the Oklahoma Agricultural Experiment Station. In order to determine possible interactions between genotypes (crossbred cow type) and environments (season of calving), this project was designed to use crossbred cows with different proportions of Brahman breeding managed under spring and fall calving systems. The performance of the crossbred calves produced in the initial phase of this long-term project was used to evaluate the effects of proportion of Brahman breeding by season of birth interactions on growth of crossbred calves up to weaning.

Materials and Methods

Angus and Hereford cows were randomly assigned to spring or fall calving groups and mated to Angus, Hereford, Brahman, Brahman x Angus and Brahman x Hereford bulls to produce calves that were 0 Brahman

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[1]Graduate Assistant [2]Professor [3]Herdsman [4]Research Nutritionist, USDA-ARS

Table 1. Significance levels of factors in the analysis of variance.

Source	Trait					
	Birth	Preweaning	Weaning			
	Wt.	ADG	Wt.	Hip ht.	Conf.	Cond.
Genotype[a]:						
Crossbred Group (A)	**	**	**	**	**	**
Proportion Brahman (B)	**	*	**	**	**	**
Season of Calving (C):	NS	**	**	NS	NS	NS
Genotype x Environment[a]:						
AxC	*	**	**	*	**	**
BxC	NS	**	**	**	**	**

[a]Two separate analyses: one with genotype identified as 5 crossbred groups, the other with genotype identified as 3 levels of Brahman breeding (0, 1/4 and 1/2).
*Effect is significant at the .05 level of probability.
**Effect is significant at the .01 level of probability.
NS Effect is not significant (probability>.05)

(Angus x Hereford and Hereford x Angus), 1/4 Brahman (1/4 Brahman:1/4 Hereford:1/2 Angus and 1/4 Brahman:1/4 Angus:1/2 Hereford) and 1/2 Brahman (1/2 Brahman:1/2 Angus and 1/2 Brahman:1/2 Hereford). The same set of three bulls of each sire breed were used for spring and fall calving groups in the same year, with a different set of bulls used each year. During the three-year foundation period of the project, 499 and 423 calves were produced in the spring and fall calving seasons, respectively.

Spring calves were born from February through April, and fall calves were born from September through November. Birth weights were recorded within 24 hours of birth. Calves remained with their dams on native tallgrass and bermudagrass pastures at the Southwestern Livestock and Forage Research Station near El Reno, and neither group was creep fed. Spring- and fall-born calves were weaned at an average age of 205 and 240 days, respectively. Average weaning dates for the three years were September 25 and May 20 for spring and fall calves, respectively. Calf weights, hip heights, condition and conformation scores were determined at weaning.

The data were analyzed to determine the effect of crossbred group, percent Brahman, season of birth and crossbred group or percent Brahman by season of birth interactions.

Results and Discussion

In general, birth weight tended to increase with increased level of Brahman breeding (Figure 1). Even though the birthweight of spring versus fall calving reversed ranking between 1/4 and 1/2 Brahman calves, the differences were small and the interaction between season of birth and proportion of Brahman was not significant. Birth weight means for the various crossbred groups born in spring and fall are presented in

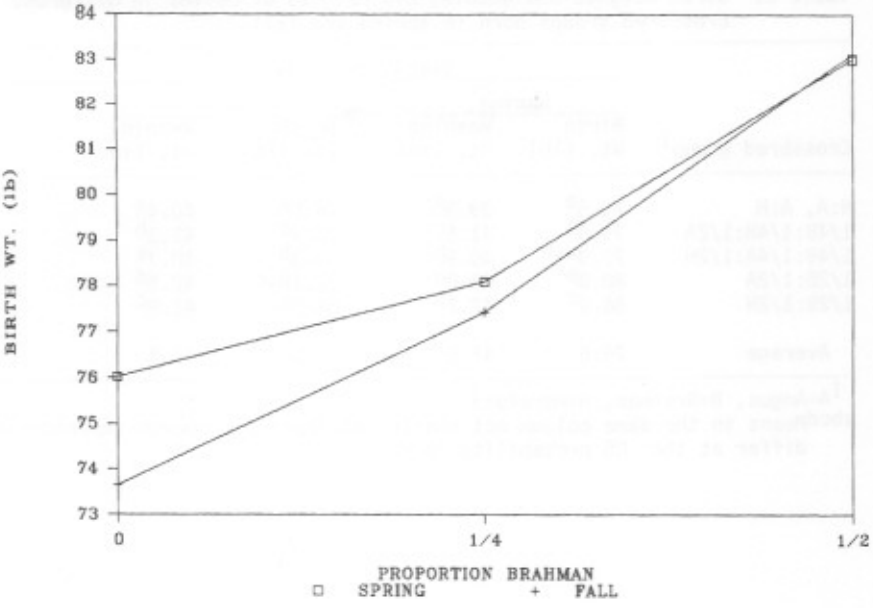


Figure 1. Birth weights of calves with different proportions of Brahman breeding.

Table 2. There was a significant interaction for birth weight between crossbred group and season of birth, with 1/4 Brahman calves that were 1/2 Angus weighing about the same as 1/4 Brahman:1/2 Herefords in the spring calving group but weighing 3.6 lb less in the fall calving group; Brahman x Angus calves weighed 6 lb less than Brahman x Hereford calves in the spring group, but there were no major differences between these two crossbred groups in the fall.

Genotype by environment interactions were significant ($P<.05$) for all five remaining traits studied, meaning that differences between crossbred groups or between levels of Brahman breeding vary depending upon whether the calves were born in spring or fall. Therefore, comparisons between calf breed groups will be compared separately for spring and fall calving groups. In general, interactions between breed of sire and breed of dam were not significant. Thus, it was appropriate to combine the performance of crossbred groups into levels of Brahman breeding (0, 1/4 or 1/2).

Average preweaning daily gain and weaning weight for 0, 1/4, and 1/2 Brahman calves are presented in Figures 2 and 3, respectively. Spring-born calves showed an increase both in daily gain and adjusted weaning weight as proportion of Brahman increased, with 1/4 and 1/2 Brahman calves gaining .07 and .15 lb more per day than 0 Brahman calves (1.74 lb/day) and weighing 20 and 40 lb more at weaning (0 Brahman=430 lb). Proportion of Brahman did not affect the average daily gain or weaning weight of fall-born calves. Spring-born calves outgained and outweighed fall-born calves of the same crossbred group and of the same proportion of Brahman. On the average, the 205-day weaning weight of

Table 2. Birth weights and weaning hip heights of calves in different crossbred groups born in spring and fall.

Crossbred group[1]	Season of Birth			
	Spring		Fall	
	Birth Wt. (lb)	Weaning Ht. (in)	Birth Wt. (lb)	Weaning Ht. (in.)
H:A, A:H	75.5[a]	39.9[a]	74.0[a]	40.4[a]
1/4B:1/4H:1/2A	79.0[b]	41.5[c]	75.7[a]	41.3[b]
1/4B:1/4A:1/2H	77.3[a,b]	40.9[b]	79.3[b]	40.7[a]
1/2B:1/2A	80.0[b]	43.0[d]	82.1[b,c]	42.5[d]
1/2B:1/2H	86.0[c]	42.7[d]	84.0[c]	41.9[c]
Average	79.6	41.6	79.0	41.4

[1]A=Angus, B=Brahman, H=Hereford

[abcd]Means in the same column not sharing at least one common superscript differ at the .05 probability level.

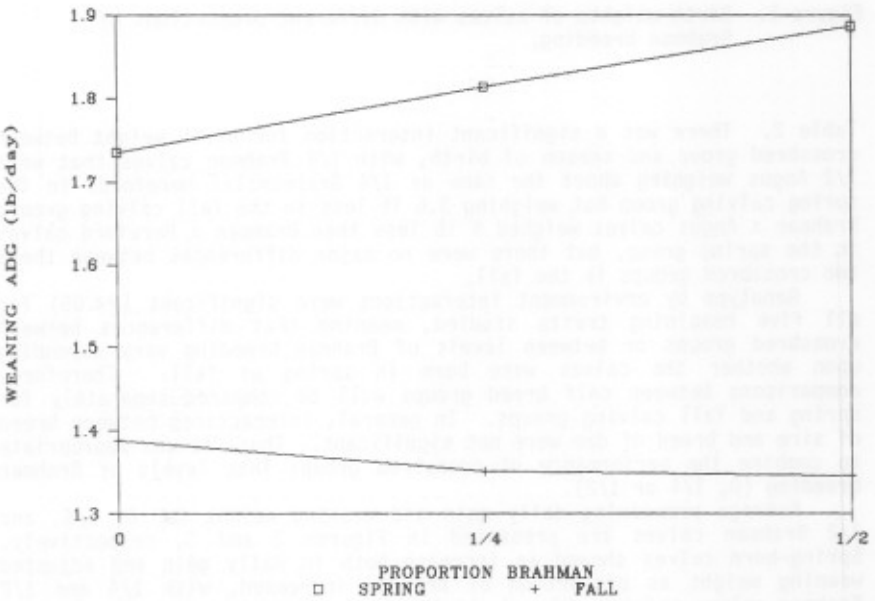


Figure 2. Preweaning daily gains of calves with different proportions of Brahman breeding.

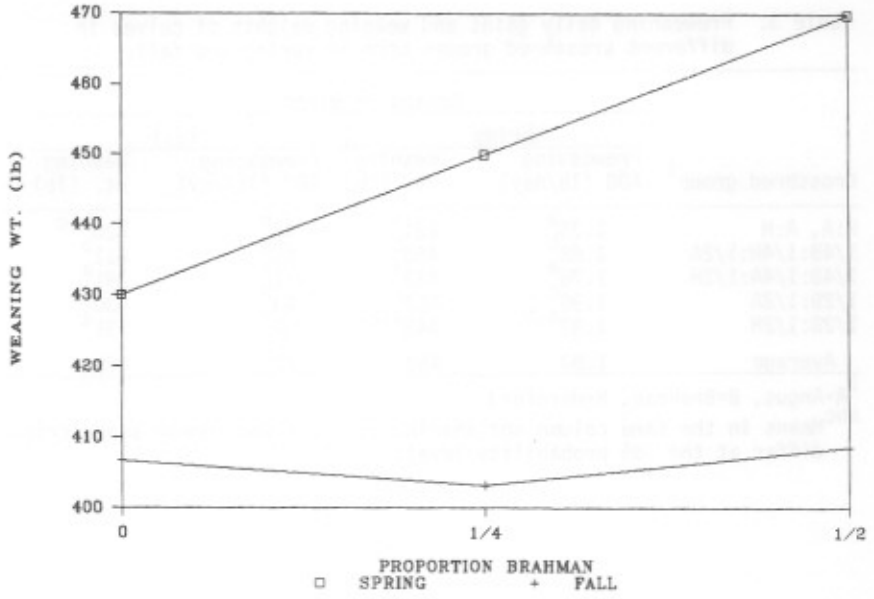


Figure 3. Adjusted weaning weights of calves with different proportions of Brahman breeding.

the spring-born calves was 43 lb heavier than the 240-day weaning weight of the fall-born calves.

Preweaning daily gains and weaning weights of calves in different crossbred groups born in spring and fall are presented in Table 3. Among 1/4 and 1/2 Brahman calves born in the spring, those calves that were 1/2 Angus outgained those that were 1/2 Hereford by .10 and .14 lb/day, respectively, and weighed 27 and 35 lb more at weaning; in the fall group, they gained .09 and .13 lb/day more and were 20 and 38 lb heavier at weaning.

In the spring calving group, age-adjusted hip height increased as percent of Brahman increased (Figure 4), with 1/4 and 1/2 Brahman calves being 0.99 and 2.58 in. taller than 0 Brahman calves (40.25 in.). In the fall-born group, hip heights of 0 and 1/4 Brahman calves were similar while 1/2 Brahman calves were 1.48 and 1.12 in taller than 0 and 1/4 Brahman calves, respectively. Hip heights of 0 and 1/4 Brahman calves were similar when compared across calving seasons, while 1/2 Brahman calves were .74 in taller in the spring calving group than in the fall calving group. Hip heights for the various crossbred groups are presented in Table 2. Hip heights of 1/4 Brahman:1/2 Angus calves were .62 in. greater than for 1/4 Brahman:1/2 Hereford calves (40.92 in.) in the spring group, but there were no large differences between Brahman x Angus and Brahman x Hereford calves. In the fall group, 1/2 Angus calves in both 1/4 and 1/2 Brahman groups were taller than 1/2 Hereford calves (.58 and .55 in., respectively).

Table 3. Preweaning daily gains and weaning weights of calves in different crossbred groups born in spring and fall.

Crossbred group[1]	Season of Birth			
	Spring		Fall	
	Preweaning ADG (lb/day)	Weaning Wt. (lb)	Preweaning ADG (lb/day)	Weaning Wt. (lb)
H:A, A:H	1.75^{a}	434^{a}	1.42^{b}	$420^{b,c}$
1/4B:1/4H:1/2A	1.86^{b}	460^{b}	1.40^{b}	411^{b}
1/4B:1/4A:1/2H	1.76^{a}	433^{a}	1.31^{a}	391^{a}
1/2B:1/2A	1.96^{c}	483^{c}	1.43^{b}	430^{c}
1/2B:1/2H	$1.82^{a,b}$	$448^{a,b}$	1.30^{a}	391^{a}
Average	1.83	452	1.37	409

[1] A=Angus, B=Brahman, H=Hereford

[abc] Means in the same column not sharing at least one common superscript differ at the .05 probability level.

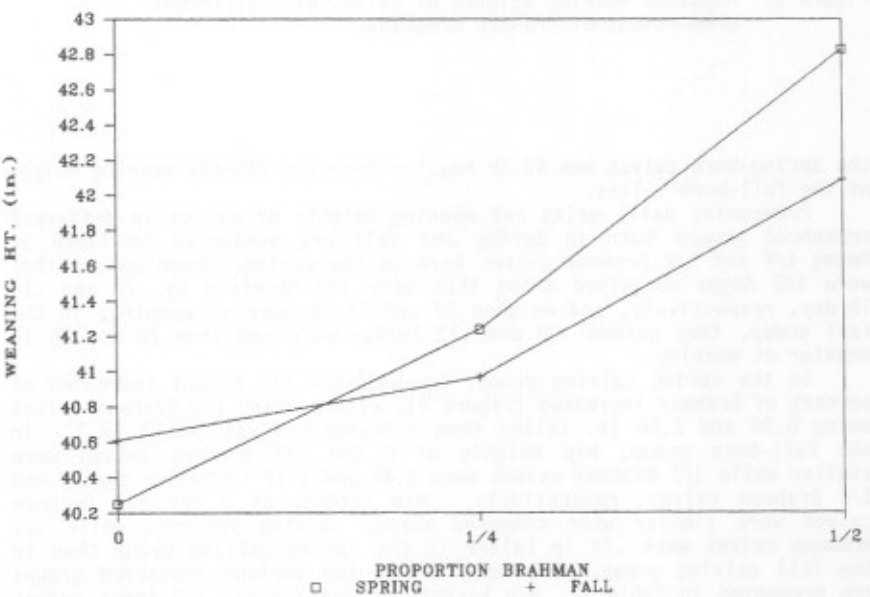


Figure 4. Weaning hip heights of calves with different proportions of Brahman breeding.

Conformation scores for 0, 1/4 and 1/2 Brahman calves (Figure 5) were similar in the spring calving group, while in the fall calving group conformation scores of 1/4 and 1/2 Brahman calves were .3 and .6 units lower than those of 0 Brahman calves (13.1). Comparisons of the same percent Brahman groups showed that 0 Brahman calves had lower scores in the spring calving group than in the fall calving group, there was no difference between spring and fall groups for 1/4 Brahman calves, and 1/2 Brahman calves born in the spring had higher conformation scores than 1/2 Brahman calves born in the fall.

Condition scores of spring-born calves were similar for all three levels of Brahman breeding. For fall-born calves, condition scores decreased with increased proportion of Brahman breeding, with 0 Brahman calves scoring .3 and .6 units higher than 1/4 and 1/2 Brahman calves, respectively (Figure 6). Comparing spring versus fall calving seasons, 0 Brahman calves had scores .2 units lower in the spring system than in the fall, 1/4 Brahman calves had similar scores, and 1/2 Brahman calves had scores .2 units higher in the spring calving group than in the fall group.

Conformation and condition scores of calves in different crossbred groups born in spring and fall are presented in Table 4. Conformation scores of 1/4 and 1/2 Brahman calves that were 1/2 Hereford were .3 and .4 units lower than their 1/2 Angus counterparts in both spring and fall calving groups and, in the spring group, were similar to scores for 0 Brahman calves. Condition scores of spring-born calves did not vary

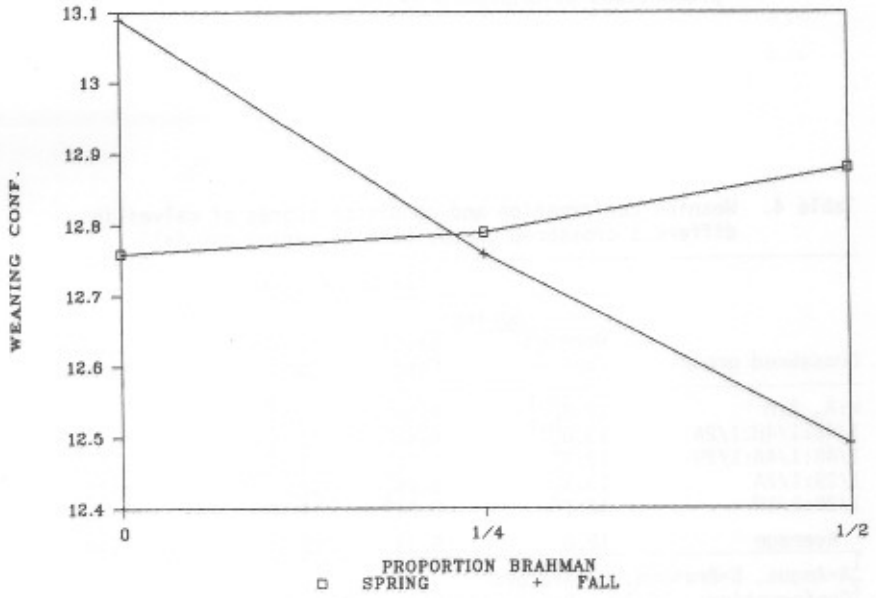


Figure 5. Weaning conformation scores of calves with different proportions of Brahman breeding.

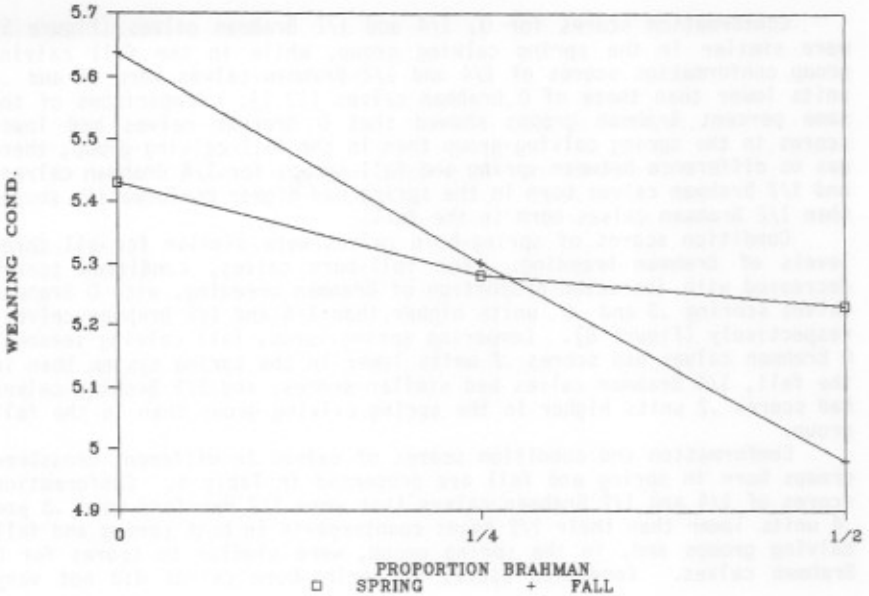


Figure 6. Weaning condition scores of calves with different proportions of Brahman breeding.

Table 4. Weaning conformation and condition scores of calves in different crossbred groups born in spring and fall.

	Season of Birth			
	Spring		Fall	
Crossbred group[1]	Weaning Conf.[2]	Weaning Cond.[3]	Weaning Conf.	Weaning Cond.
H:A, A:H	$12.8^{a,b}$	5.55^{b}	13.2^{d}	6.02^{c}
1/4B:1/4H:1/2A	$13.0^{b,c}$	$5.41^{a,b}$	12.9^{c}	5.29^{b}
1/4B:1/4A:1/2H	12.7^{a}	5.21^{a}	$12.6^{a,b}$	5.27^{b}
1/2B:1/2A	13.1^{c}	5.24^{a}	$12.7^{b,c}$	5.15^{b}
1/2B:1/2H	12.7^{a}	5.24^{a}	12.3^{a}	4.85^{a}
Average	12.8	5.33	12.7	5.32

[1]A=Angus, B=Brahman, H=Hereford
[2]Conformation: 12=low choice, 13=average choice.
[3]Condition: 1=thin to 9=fat with 5=average choice.
[abcd]Means in the same column not sharing at least one common superscript differ at the .05 probability level.

within 1/4 and 1/2 Brahman groups. In the fall calving group, there was no difference in condition score within 1/4 Brahman calves, while Brahman X Angus calves scored .3 units higher than did Brahman x Hereford calves (4.85).

In summary, these data indicated that traits through weaning were improved as level of Brahman breeding increased, with a greater improvement of Brahman crossbred calves over 0 Brahman calves evident in the spring calving group. Spring-born calves of all crossbred groups have an advantage over fall-born calves. Since interactions between level of Brahman breeding and season of birth exist, the use of different crossbred types should be carefully evaluated for the type of management system.

Some differences were observed between crossbred calves with the same proportion of Brahman breeding (1/4 Brahman:1/4 Hereford:1/2 Angus versus 1/4 Brahman:1/4 Angus:1/2 Hereford and Brahman X Angus versus Brahman x Hereford), with calves out of Angus dams showing an advantage in some traits. This may in part be explained by the fact that preweaning traits reflect not only the genetic merit of the calf but also the maternal ability of the dam.

SELECTION FOR INCREASED WEANING OR YEARLING WEIGHT IN ANGUS CATTLE. I. MEASUREMENT OF SELECTION APPLIED

D.K. Aaron[1], R.R. Frahm[2] and D.S. Buchanan[3]

Story in Brief

A long-term study was conducted to evaluate direct and correlated responses to selection for increased weaning or yearling weight. The objective of this portion of the study was to measure the amount of selection applied during 14 years of selection for growth traits in Angus cattle. Three fifty-cow, four-sire lines were selected from 1965-1979 for heaviest individual weaning weight, heaviest yearling weight or a combination of individual and progeny weaning weights, respectively. A fourth line, of similar size, was maintained as an unselected control line to monitor yearly environmental changes.

Over the 14-year period, 3.87 and 3.72 generations of selection occurred in the weaning and yearling weight lines, respectively. The progeny test line was terminated in 1978 and 2.68 generations of selection had occurred to that point. Mean cumulative selection differentials, which measure the amount of selection applied, in 1979 were 169 lb for weaning weight in the weaning weight line and 296 lb for yearling weight in the yearling weight line. Selection pressure accumulated at the rate of 12.3 and 21.4 lb/yr. for weaning and yearling weight respectively. Indirect selection for yearling weight in the weaning weight line and weaning weight in the yearling weight line were 72 and 70 percent, respectively, as effective as direct selection for weaning weight in the weaning weight line and yearling weight in the yearling weight line.

(Key Words: Beef Cattle, Selection Differential, Weaning Weight, Yearling Weight, Angus)

Introduction

Selection is one of the primary forces by which breeders can change the genetic composition of their herds. The increasing demand for faster growing, more efficient cattle has made selection for growth rate an important objective for the beef industry. While many selection experiments have demonstrated the effectiveness of selection for growth rate in poultry and laboratory animals, few such studies have been conducted with livestock species such as beef cattle. Therefore, a long-term study was initiated in 1960 at the Oklahoma Agricultural Experiment Station to evaluate direct and correlated responses to selection for increased weaning or yearling weight in beef cattle. The objective of this portion of the study was to measure the selection pressure applied during 14 years of selection for growth traits in Angus cattle.

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[1] Assistant Professor, Univ. of Kentucky [2] Professor
[3] Associate Professor

Materials and Methods

Three selection lines and an unselected control line were established from a common base of Angus cattle. Foundation cows, typical for the Angus breed, were obtained from several herds and randomly allotted to four 50-cow lines in 1963. Twenty-five foundation sires were used across lines from 1963 through 1966. First selections within the lines were made from the 1965 calf crop. Selection criteria for replacement breeding animals were heaviest individual 205-day weaning weight in the weaning weight line (WWL), heaviest individual 365-day (bulls) and 425-day (heifers) yearling weight in the yearling weight line (YWL) and a combination of heaviest individual and progeny 205-day weaning weights in the progeny test line (PTL).

The fourth line was maintained as an unselected control line (CL) and replacement breeding animals were chosen to have as near zero selection differentials for both weaning and yearling weight as possible. Originally, the CL was designed as a progeny test line for yearling weight; however, in 1969 it was converted to a control line to monitor yearly environmental changes. Since only two calf crops had been sired by progeny-tested bulls up to that point, very little selection had actually been practiced. Ideally, a control line has no selection pressure applied to any traits, thus the only fluctuations in average animal performance should be environmental or nongenetic in nature. Differences between select and control lines should represent genetic change resulting from selection.

Fifty breeding age females were maintained in each of the four lines. In order to maintain a 20 percent replacement rate, 10 cows were culled each year and replaced with the 10 highest ranking pregnant heifers based on line criteria. Initially, the 13 highest ranking heifers in each line (zero selection differentials for both weaning and yearling weight in the CL) were bred to selected bulls as yearlings. Of the 13 heifers exposed, the top 10 diagnosed pregnant following the breeding season were selected to remain in the line.

Each year two bulls were selected in the WWL, YWL and CL based on the respective line criteria. Bulls were first used as two year olds through the 1970 breeding season and as yearlings in subsequent years. As a result of this change in procedure, no bulls were selected from the 1969 calf crop. In the PTL five bulls were selected on the basis of individual weaning weight and mated to cows in an Angus test herd. Two bulls were subsequently selected on the basis of progeny weaning weight. Bulls were three years old when they were first mated to cows in the PTL. This procedure was followed in the PTL from 1966 through 1976; thereafter, two bulls were selected each year based on individual performance. Only the last two calf crops in this line were sired by bulls that had not been progeny tested. Selected bulls in all lines were used for two years. Thus, four bulls were used per year in each line, two being used for the first time and two being used for the second time. The total numbers of sires selected were 28, 26, 22 and 29 for the WWL, YWL, PTL and CL, respectively.

Cattle were maintained at the Southwestern Livestock and Forage Research Station at El Reno, OK. All lines were managed as a single herd except during the breeding season and every effort was made to ensure as uniform an environment as possible for all cattle. Calves were born from February through April each year. Within 24 hours after birth, all calves were tagged and tattooed for identification and birth weights were recorded. Calves were allowed to run with their dams on native range and bermudagrass pasture and received no creep feed. In

winter, cows had access to wheat pasture and milo stubble and were supplemented with prairie hay, alfalfa or cottonseed cake whenever necessary. Calves were weaned at an average age of 205 days. Following a two-week warm up period after weaning, bull calves were put on full feed for a 140-day gain test. Heifer calves were placed on wheat pasture and supplemented with prairie hay, alfalfa and concentrate to gain approximately .75 to 1.00 lb/day. Long yearling weights were determined on the heifers at an average age of 425 days.

Complete performance data were collected on all calves through 365 days for bulls and 425 days for heifers. Performance data through yearling age were collected on 694, 691, 666 and 698 calves in the WWL, YWL, PTL and CL, respectively. Traits evaluated were birth weight (BW), preweaning daily gain (WDG), weaning weight (WW), weaning conformation grade (WG), weaning condition score (WC), weaning to yearling daily gain (YDG), yearling weight (YW), yearling conformation grade (YG) and yearling condition score (YC). Weaning weights were adjusted to a 205-day basis and then adjusted for age of dam. Yearling weights (365-day for bulls and 425-day for heifers) were calculated by multiplying YDG by 160 for bulls and 220 for heifers and adding the 205-day age of dam adjusted WW.

Results and Discussion

Generations of Selection

The first selections were made from the 1965 calf crop and over the following 14-year period 3.87 and 3.72 generations of selection occurred in the WWL and YWL, respectively. Generation turnover in the CL was slightly slower with 3.40 generations of selection occurring by the time the 1979 calf crop was produced. The PTL was terminated with the 1978 calf crop and 2.68 generations of selection had occurred. Generation turnover in this line was slower because of the additional time required for the progeny test data to finalize selections.

Cumulative Selection Applied

The average cumulative selection differential (CSD) for a trait measures the total amount of selection that has accumulated through the parents of calves born in a given year. The average CSD's realized by the 1979 calf crop are presented in both actual and standard measure in Tables 1 and 2 for the WWL and YWL, respectively. Expressing CSD's in standard measure allows comparisons to be made among the various traits. Values are presented as the amount attributed to sires (S), the amount attributed to dams (D) and the parent average (M). Also, the parent average was regressed on year to give an estimate to the average yearly selection pressure for each trait during the 14-year period. Corresponding values for the CL are presented in Table 3.

Direct selection pressure accumulated at a fairly steady rate in both the WWL and YWL. In the WWL, selection pressure for WW accumulated at the rate of 12.3 lb/yr and for the average of parents producing calves in 1979, the total amount of selection pressure which had been applied since the beginning of the study was 169 lb (3.75 phenotypic standard deviations). Corresponding values for YW in the YWL were 21.4 lb/yr and 296 lb (3.87 phenotypic standard deviations). Expressed on a per generation basis, selection pressure accumulated at rates of .97 and 1.00 phenotypic standard deviations per generation for WW in the WWL and YW in the YWL (Table 4).

Table 1. Cumulative selection differentials for sires (S), dams (D) and parent average (M) in the weaning weight line.

Trait	Type	Average cumulative selection differential (1979) Actual Measure	Standard Measure[a]	Regression of Actual Measure on Year
Birth weight (lb)	S	12.2	1.5	
	D	13.3	1.7	
	M	12.8	1.6	.92 ± .10
Preweaning daily gain (lb/day)	S	.9	4.4	
	D	.6	3.1	
	M	.8	3.7	.05 ± .002
Weaning weight (lb)	S	203.9	4.4	
	D	133.7	3.1	
	M	168.8	3.8	12.26 ± .53
Weaning conformation grade[b]	S	1.5	2.2	
	D	1.1	1.7	
	M	1.3	1.9	.08 ± .01
Weaning condition score[c]	S	1.5	2.3	
	D	1.2	1.9	
	M	1.3	2.1	.09 ± .004
Weaning to yearling daily gain (lb/day)	S	.3	.8	
	D	.1	.4	
	M	.2	.6	.01 ± .003
Yearling weight (lb)	S	250.2	3.1	
	D	146.6	2.3	
	M	198.4	2.7	13.07 ± .66
Yearling conformation grade[b]	S	1.5	2.0	
	D	1.1	1.6	
	M	1.3	1.8	.09 ± .01
Yearling condition score[c]	S	.8	1.3	
	D	.5	.8	
	M	.7	1.0	.04 ± .004

[a]Standard measure is expressed in phenotypic standard deviation units.
[b]Conformation grade on a 17 point scale with 12=low choice, 13=average choice.
[c]Condition score on a 9 point scale with 1=thin to 9=very fat.

Although the primary selection criterion was either WW or YW, other traits also underwent some selection pressure as a result of genetic relationships among the traits. It is of particular interest to evaluate the correlated CSD's for YW in the WWL and WW in the YWL. If appreciable selection pressure can be applied for YW by selecting for WW then considerable time and money may be saved by selecting animals at weaning versus at a year of age. In the WWL, the average correlated CSD for YW was 198 lb (2.71 phenotypic standard deviations). This was 72 percent as effective as direct selection for YW in the YWL. Similarily, the selection pressure for WW in the YWL increased 70 percent (140 lb) as fast as direct selection for WW in the WWL.

Table 2. Cumulative selection differentials for sires (S), dams (D) and parent average (M) in the yearling weight line.

Trait	Type	Average cumulative selection differential (1979)		Regression of Actual Measure on Year
		Actual Measure	Standard Measure[a]	
Birth weight (lb)	S	15.4	1.8	
	D	12.1	1.5	
	M	13.8	1.7	1.03 ± .08
Preweaning daily gain (lb/day)	S	.8	3.4	
	D	.4	2.3	
	M	.6	2.9	.04 ± .002
Weaning weight (lb)	S	173.7	3.5	
	D	106.7	2.4	
	M	140.2	3.0	9.28 ± .52
Weaning conformation grade[b]	S	1.8	2.2	
	D	1.0	1.2	
	M	1.4	1.7	.08 ± .01
Weaning condition score[c]	S	1.3	2.1	
	D	.5	.7	
	M	.9	1.4	.05 ± .01
Weaning to yearling daily gain (lb/day)	S	1.2	3.6	
	D	.9	2.8	
	M	1.1	3.2	.08 ± .003
Yearling weight (lb)	S	362.6	4.4	
	D	230.4	3.4	
	M	296.5	3.9	21.38 ± .87
Yearling conformation grade[b]	S	3.2	4.4	
	D	1.8	2.5	
	M	2.5	3.4	.17 ± .01
Yearling condition score[c]	S	1.3	2.1	
	D	.9	1.5	
	M	1.1	1.8	.08 ± .01

[a]Standard measure is expressed in phenotypic standard deviation units.
[b]Conformation grade on a 17 point scale with 12=low choice, 13=average choice.
[c]Condition score on a 9 point scale with 1=thin to 9=very fat.

Correlated CSD's for the remaining traits accumulated at slower rates. Unfortunately, selection pressure for BW increased at the rate of .92 lb/yr in the WWL and 1.03 lb/yr in the YWL. Conformation grades and condition scores also showed a slight increase in selection pressure. This is of particular interest because of industry concern that selection for growth traits might result in the deterioration of conformation unless conformation is included in the selection program.

As shown in Table 3, a slight amount of selection occurred in the CL. Average parent CSD's increased slightly each year for all traits except BW. This may be partly explained by the small amount of selection which occurred prior to the time this line was converted to an unselected control line.

Table 3. Cumulative selection differentials for sires (S), dams (D) and parent average (M) in the control line.

Trait	Type	Average cumulative selection differential (1979) Actual Measure	Standard Measure[a]	Regression of Actual Measure on Year
Birth weight (lb)	S	-.1	0.0	
	D	1.4	.2	
	M	.6	.1	-.01 ± .05
Preweaning daily gain (lb/day)	S	0.0	0.0	
	D	.1	.4	
	M	0.0	.2	.002 ± .001
Weaning weight (lb)	S	-3.1	0.0	
	D	14.7	.4	
	M	5.8	.2	.50 ± .17
Weaning conformation grade[b]	S	.2	.4	
	D	.2	.3	
	M	.2	.3	.02 ± .01
Weaning condition score[c]	S	.3	.4	
	D	.1	.1	
	M	.2	.2	.01 ± .004
Weaning to yearling daily gain (lb/day)	S	.3	1.1	
	D	.2	1.0	
	M	.3	1.1	.02 ± .003
Yearling weight (lb)	S	38.5	.6	
	D	48.2	.8	
	M	43.3	.7	2.73 ± .54
Yearling conformation grade[b]	S	.6	.8	
	D	.9	1.2	
	M	.7	1.0	.05 ± .01
Yearling condition score[c]	S	.3	.3	
	D	.7	1.1	
	M	.5	.7	.03 ± .01

[a]Standard measure is expressed in phenotypic standard deviation units.
[b]Conformation grade on a 17 point scale with 12=low choice, 13=average choice.
[c]Condition score on a 9 point scale with 1=thin to 9=very fat.

Selection differentials calculated this way would not be appropriate for measuring selection pressure in the PTL. Thus, CSD's are not presented for this line. The progeny test line is described as part of the overall design of this study in order that the genetic progress obtained in this line can be compared with that obtained in the other lines in the second article of this series on selection for increased weaning or yearling weight.

Actual versus Potential Selection

Selection differentials per generation were calculated for selected sires (S) and selected dams (D) by averaging the individual selection

Table 4. Actual and potential selection differentials for weaning weight and yearling weight per generation for selected sires (S), selected dams (D) and midparents (M), expressed in standard measure[a].

Line	Item	Trait			
		Weaning weight		Yearling weight	
		Actual	Potential	Actual	Potential
Weaning weight line	S	1.30	1.43	.81	.84
	D	.64	.79	.54	.61
	M	.97	1.11	.67	.73
Yearling weight line	S	1.12	1.15	1.52	1.51
	D	.37	.66	.49	.75
	M	.74	.91	1.00	1.13

[a]Standard measure is expressed in phenotypic standard deviation units.

differentials for sires and dams of all progeny excluding those from foundation parents. Potential selection differentials were calculated by averaging individual deviations of the bulls and heifers (two bulls and 10 heifers per line) with the largest values based on line criteria in each line each year. Comparing actual and potential selection differentials provides an estimate of the proportion of the possible selection that was actually applied toward the primary trait in each line. Although strict adherence to selection criteria was attempted throughout the study, some high ranking individuals may have been culled because of development of serious unsoundness, illness or death prior to their use in the selection line, or in heifers, reproductive failure during the first breeding season. Actual and potential selection differentials (in standard measure) for WW and YW are presented in Table 4 for the WWL and YWL.

In the WWL, the actual selection differentials per generation for WW were 91 and 81 percent of the potential for sires and dams, respectively. Corresponding values for YW in the YWL were 100 and 65 percent, respectively. In the YWL, top ranked bulls for YW sired progeny in all cases; however, the potential selection realized for dams was quite low. In both lines, the primary reason for loss of selection pressure in heifers was reproductive failure during the first breeding season.

Total selection pressure is a result of both sire and dam selection. The proportion of selection pressure attributable to selected sires versus selected dams was evaluated by comparing the relative magnitude of the parent average selection differential (M) due to sires (S) and dams (D). The proportion of selection pressure attributable to selected sires in this study was 67 percent for WW in the WWL and 76 percent for YW in the YWL. Generally, sire selection accounts for a greater proportion of the total selection pressure. The increased importance of dam selection in this study may have been a result of the fairly rapid replacement rate for females in these lines (10/50 cows per line per year).

SELECTION FOR INCREASED WEANING OR YEARLING WEIGHT IN ANGUS CATTLE. II. EVALUATION OF RESPONSE

D.K. Aaron[1], R.R. Frahm[2], and D.S. Buchanan[3]

Story in Brief

Three 50-cow, 4-sire lines of Angus cattle were selected for individual weaning weight, individual yearling weight or a combination of individual and progeny weaning weights as part of a long term selection project. Also, a contemporary Angus control line was maintained to monitor yearly environmental changes. The objective of this portion of this study was to evaluate direct and correlated responses, measured as deviations from the unselected control, after 14 years of selection for increased weaning or yearling weight.

Genetic responses, averaged over sexes, for weaning weight and yearling weight, respectively, were 3.61 and 4.89 lb/yr in the weaning weight line, 3.81 and 7.89 lb/yr in the yearling weight line and 4.81 and 8.33 lb/yr in the progeny test line. Positive correlated responses of .55, 1.03 and .67 lb/yr were observed for birth weight in the weaning weight, yearling weight and progeny test lines, respectively. Slight positive correlated responses were observed for conformation grades in all three lines. Realized heritabilities were .29 for weaning weight and .37 for yearling weight and the realized genetic correlation between weaning weight and yearling weight was .81. All genetic responses and realized heritabilities may have been slightly underestimated since a small amount of selection occurred for weaning weight and yearling weight in the control line.

(Key Words: Beef Cattle, Selection Response, Weaning Weight, Yearling Weight, Angus).

Introduction

Genetic change brought about by selection is often complicated to evaluate since the observed change in performance is the result of both genetic and environmental factors. Thus, separation of observed change into its component parts is a primary concern in the analysis of selection experiments. One way to eliminate environmental trend from the observed change is to use an unselected control population, maintained and reproduced in the same environment as the selection lines. Ideally, a control line has no selection pressure applied to any trait, thus the only fluctuations in average animal performance should be environmental or non-genetic in nature. Differences between the select and control lines should represent genetic response to selection.

Control populations have often been used in selection experiments involving laboratory animals; however, few such studies have been conducted with livestock. The objective of this portion of the study was to evaluate direct and correlated responses, measured as deviations

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[3]Associate Professor

from an unselected control, after 14 years of selection for increased weaning or yearling weight in Angus cattle.

Materials and Methods

Three selection lines and an unselected control line were established from a common base of Angus cattle in 1963 as part of a long-term selection project at the Oklahoma Agricultural Experiment Station. Selection criteria were heaviest individual 205-day weaning weight (WWL), heaviest individual 365-day (bulls) or 425-day (heifers) yearling weight (YWL) and a combination of heaviest individual and progeny 205-day weaning weights (PTL). Bulls and heifers in the control line (CL) were chosen to have as near zero selection differentials as possible for both weaning and yearling weight. First selections were made from the 1965 calf crop and continued through 1979 in all lines except the PTL which was terminated with the 1978 calf crop. Fifty cows were maintained in each line with two bulls and 10 heifers being selected on line criteria within each line each year. Selected bulls were used for two years.

Performance data through yearling age was collected on 694, 691, 666 and 698 calves in the WWL, PTL and CL, respectively. Performance traits analyzed were birth weight (BW), preweaning average daily gain (WDG), weaning weight (WW), weaning conformation grade (WG), weaning condition score (WC), weaning to yearling daily gain (YDG), yearling weight (YW), yearling conformation grade (YG) and yearling condition score (YC). Weaning weights were adjusted to a 205-day basis and then adjusted for age of dam. Yearling weights (365-day for bulls and 425-day for heifers) were calculated by multiplying YDG by 160 for bulls and 220 for heifers and adding 205-day age of dam adjusted WW.

More detailed descriptions of line formation and management were presented in the first article of this series.

Results and Discussion

Phenotypic Trends

Annual phenotypic trends for each line are presented in Figures 1-3 for BW, WW, and YW. Generally, the selection lines followed similar patterns of phenotypic response. A negative trend was observed for BW in all lines except YWL. Also, growth traits exhibited negative trends with the exception of YDG and YW in the selection lines. Phenotypic trends for conformation grades and condition scores were positive in all lines. To help clarify phenotypic time trends, regression coefficients of performance on year, averaged over sexes, are given in Table 1 for the nine traits evaluated in each line.

Genetic Trends

Phenotypic trends are the result of both genetic and environmental factors; however, phenotypic trend in the CL should be a reflection of environmental trend. Thus, genetic trends in the selection lines were calculated as deviations from the CL. Annual genetic trends for WW, averaged over sexes, for the three selection lines are depicted graphically in Figure 4. Generally, the lines progressed at similar rates over time, improving until the 1978 calf crop. Figures 5 and 6

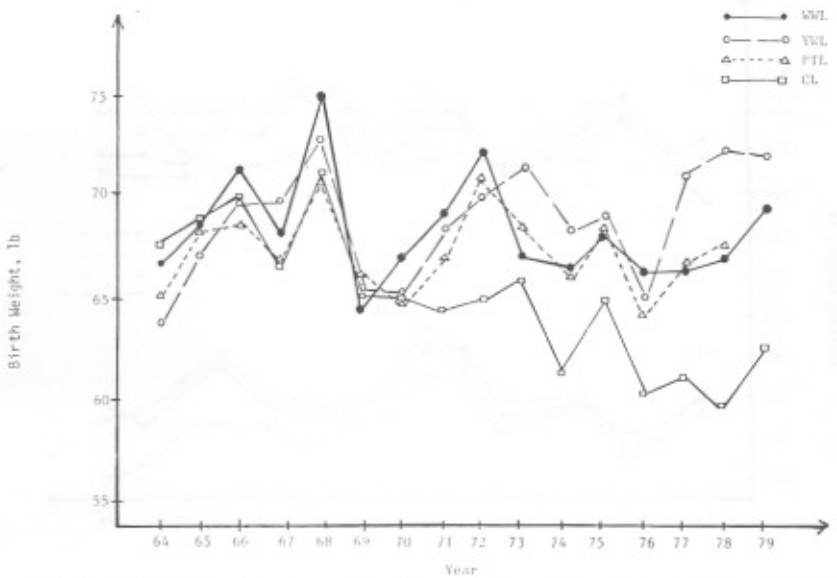


Figure 1. Annual phenotypic means for birth weight averaged over sex.

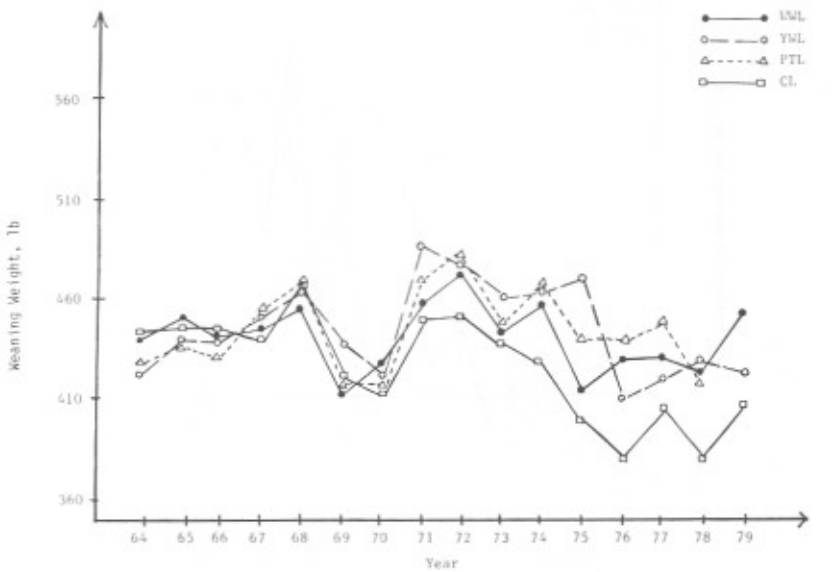


Figure 2. Annual phenotypic means for 205-day weaning weight averaged over sex.

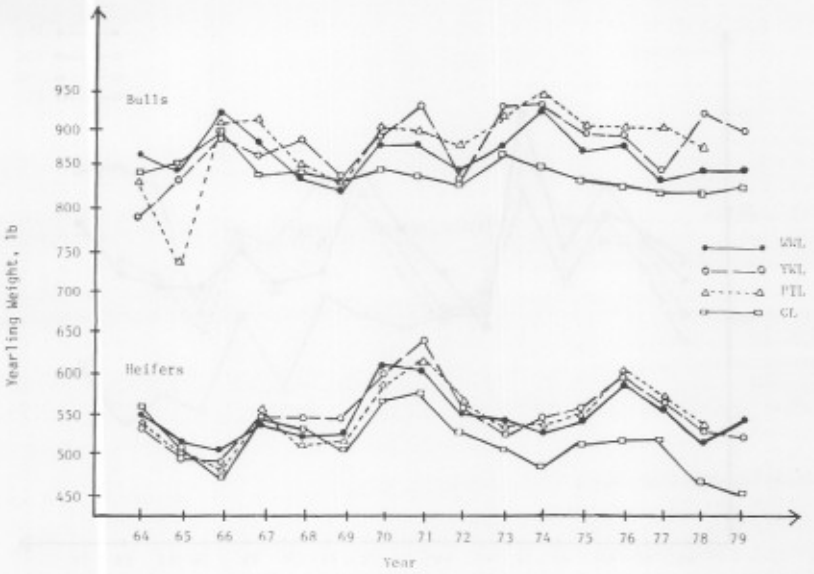


Figure 3. Annual phenotypic means for yearling weight for bulls (365-day) and heifers (425-day).

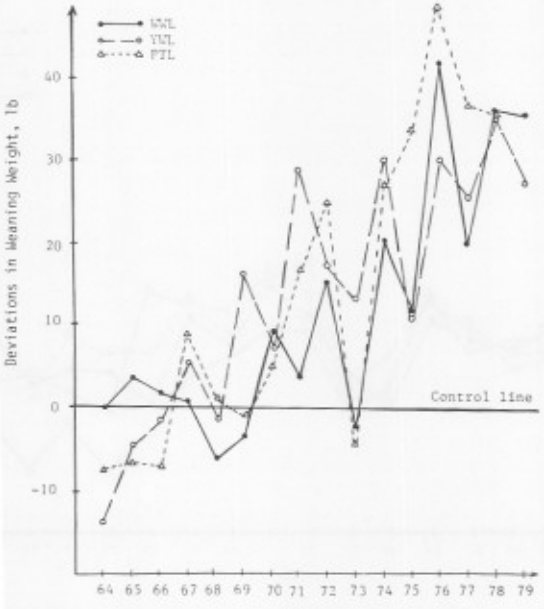


Figure 4. Annual genetic trend for 205-day weaning weight averaged over sex as deviations from control.

Table 1. Coefficients of regression of performance on year averaged over sex.

Trait	Line[a]			
	WWL	YWL	PTL	CL
Birth weight (lb/yr)	-.195	.285	-.080	-.749
Preweaning daily gain (lb/day/yr)	-.003	-.008	.005	-.017
Weaning weight (lb/yr)	-.712	-.517	.481	-4.326
Weaning conformation grade[b]	.074	.064	.076	.050
Weaning condition score[c]	.097	.068	.087	-.065
Weaning to yearling daily gain(lb/day/yr)	.005	.022	.021	-.003
Yearling weight (lb/yr)	.0003	2.992	3.431	-4.894
Yearling conformation grade[b]	.082	.091	.072	.059
Yearling condition score[c]	.064	.065	.066	.066

[a]WWL=weaning weight line, YWL=yearling weight line, PTL=progeny test line, CL=control line.
[b]Conformation grade on a 17 point scale with 13=average choice.
[c]Condition score on a 9 point scale with 1=thin to 9=very fat.

represent genetic trends for YW of bulls and heifers, respectively. Again, the annual genetic trends for the selection lines followed similar patterns; however, YW means for bulls were more eratic than for heifers.

Annual genetic trends in each line are presented in Table 2 by sex and averaged over sexes. In general, genetic trends followed a similar pattern for both sexes with genetic response tending to be larger for bulls. However, genetic responses for conformation grades and condition scores were higher for heifers.

Genetic responses, averaged over sexes, for WW and YW, respectively, were 3.61 and 4.89 lb/yr in the WWL and 3.81 and 7.89 lb/yr in the YWL. Thus, the correlated response in WW from selection for YW was greater than the response obtained by directly selecting for WW. Conversely, the correlated response in YW from selection for WW was only 62 percent as effective as direct selection for YW. Unfortunately, positive correlated responses of .55 and 1.03 lb/yr were observed for BW in the WWL and YWL, respectively. In both lines, slight positive correlated responses were observed for WG, WC and YG with very little change observed for YC.

Annual genetic responses, averaged over sexes, were also evaluated in the PTL. Direct response for WW was 4.81 lb/yr and correlated response for YW was 8.33 lb/yr. Both values are larger than the

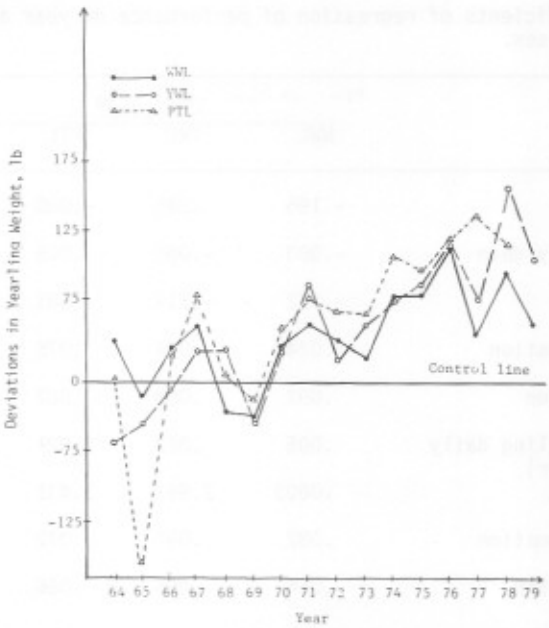


Figure 5. Annual genetic trend for 365-day yearling weight of bulls as deviations from control.

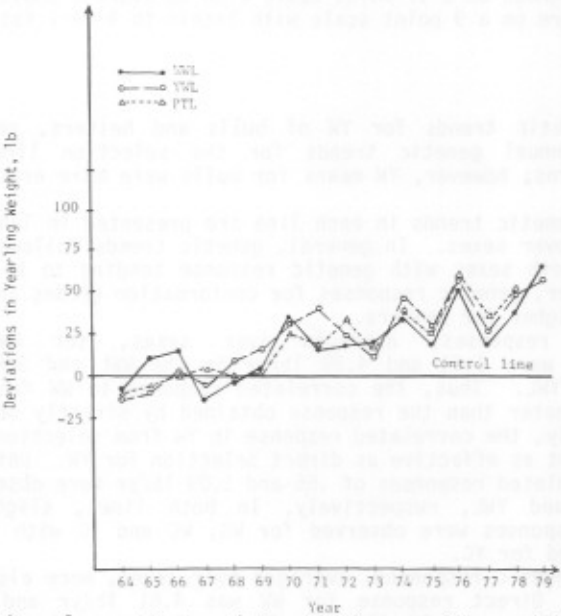


Figure 6. Annual genetic trend for 425-day yearling weight for heifers as deviations from control.

Table 2. Estimates of genetic trend per year from differences between selection and control lines.

Trait	Line[a] WWL Bulls	WWL Heifers	WWL Avg.	YWL Bulls	YWL Heifers	YWL Avg.	PTL Bulls	PTL Heifers	PTL Avg.
Birth weight (lb)	.55	.56	.55	1.15	.91	1.03	.75	.59	.67
Preweaning gain (lb/day)	.01	.01	.01	.01	.01	.01	.02	.02	.02
Weaning weight (lb)	4.24	2.99	3.61	4.81	2.82	3.81	5.28	4.34	4.81
Weaning conf. grade[b]	.01	.01	.03	.01	.01	.01	.02	.03	.03
Weaning cond. score[c]	.02	.05	.03	.00	.01	.00	.02	.03	.02
Weaning-to yearling gain(lb/day)	.01	.01	.01	.04	.01	.03	.03	.01	.02
Yearling weight (lb)	5.64	4.14	4.89	10.85	4.92	7.89	10.01	6.64	8.33
Yearling conf. grade[b]	.02	.03	.03	.03	.03	.03	.00	.03	.02
Yearling cond. score[c]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

[a]WWL=weaning weight line, YWL=yearling weight line, PTL=progeny test line.
[b]Conformation grade on a 17 point scale with 13=average choice.
[c]Condition score on a 9 point scale with 1=thin to 9=very fat.

respective genetic responses observed in the WWL and YWL. Birth weight showed a positive genetic response intermediate to that observed in the WWL and YWL while responses in conformation grades and condition scores were similar in all lines.

Realized heritabilities based on genetic response and mean cumulative selection differentials were .29 for WW and .37 for YW. These realized heritabilities may have been slightly underestimated since a small amount of selection occurred for WW and YW in the early years of the study. The realized genetic correlation between WW and YW was .81.

Conclusions

Results obtained from this study indicate that selection for WW or YW should result in improved growth rate in beef cattle. Selection for YW appears to be the most effective for increasing both WW and YW; however, larger increases in BW result as well. Although selection for WW based on a combination of individual and progeny test information resulted in larger responses in WW and YW per year, the added expense of progeny testing may limit its practicality. The high genetic correlation between WW and YW (.81) will allow breeders to use WW as an effective early culling procedure even if the primary selection objective is to increase YW. In selection programs designed to increase growth rate some attention should be given to minimizing the correlated response of increased BW.

COMPARISON OF ONE AND TWO COMPARTMENT MODELS FOR PREDICTION OF FECAL OUTPUT OF CATTLE GRAZING WHEAT PASTURE

J. W. Oltjen[1], G. W. Horn[2] and T. L. Mader[3]

Story in Brief

External markers may be used to estimate fecal output, a measure used to estimate forage intake of grazing cattle. However, the mathematical model used to fit the marker excretion curves may influence fecal output estimates. Steers grazing wheat pasture, with and without supplemental low-quality forage, were dosed with Yb-labelled wheat forage, and one and two compartment models with time delays were fit to the fecal Yb concentration data. Overall, fit of the marker data was improved by using the two compartment model. Fecal outputs predicted for the two compartment model were generally more precise (lower residual standard deviation) but less accurate, due to a tendency for underprediction. In cases where the one compartment model fit the marker data poorly, fecal output was overestimated. No systematic effect due to lack of fit was observed for the two compartment model. Also, no loss of precision for estimates of fecal output was observed with increasing lack of fit for the two compartment model.

(Key Words: Compartment Models, Wheat Pasture, Fecal Output)

Introduction

External markers may be used to estimate rate of passage, fecal output, and subsequently forage intake of grazing ruminants. However, controversy has arisen over the choice of model used to make these estimates. Both the one and two compartment models with time delays have been used with varying degrees of success in fitting marker data and identifying model parameters. The objective of this research was to compare the one and two compartment model estimates of total fecal output with observed values for cattle grazing wheat pasture.

Materials and Methods

Three groups of steers (291 kg body weight) were assigned to supplement treatments in a 3X3 Latin square design. Supplement treatments were ad libitum access to wheat straw and wheat pasture, ad libitum access to sorghum-sudan hay and wheat pasture, and ad libitum access to only wheat pasture. The three time periods were fall grazing before winter wheat dormancy (December through mid-January), winter dormancy (mid-January through February), and lush spring growth (March). Each period consisted of 11 day adaptation and 5 day fecal collection phases. At the beginning of the collection phase, steers were dosed with 195 g wheat forage dry matter labelled with 1.6 g Yb. Feces was sampled 6, 10, 14, 24, 30, 36, 48, 58, 72, 82, 96, 106 and 120 hours later. Yb was determined by atomic absorption spectroscopy. One and

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two compartment models (Ellis et al., 1979) were fit to the fecal Yb excretion curves using a modified Marquardt method to estimate rate constants (k_i) and lag time (Tau). Predicted daily fecal output of steers was calculated as follows for the one compartment model

$$(\text{Marker dose} / k_0) * 24 \text{ h}$$

and for the two compartment model

$$(\text{Marker dose} / k_0) * k_2 * 24 \text{ h}$$

Actual (observed) fecal output of steers was measured by total collection with fecal collection bags.

Results and Discussion

The marker excretion data was best fit to the two compartment model (Table 1). Average mean square error was 7531 and 2148 (mg Yb/kg fecal dry matter)^2 for the one and two compartment models, respectively. Simple correlation coefficients (r) for predicted and observed fecal outputs were .71 and .84 for the 27 one and two compartment model observations, respectively (Table 1 and Figure 1). Residual (predicted-observed) fecal outputs were analyzed and found to be unrelated to either supplement treatment, period or steer weight for either model ($P>.15$). The lower residual standard deviation for the two compartment model (Table 1) reflects more precise estimates although the two compartment model estimate may have been more biased, due to a tendency for underprediction (Figure 2). This underprediction corresponds to a 9% loss of Yb marker. Thus, the bias would disappear if estimated initial marker concentration values were increased by this amount.

As fecal output increased, the two compartment model tended to underestimate fecal output ($r=-.40$, Table 2). However, this was due to one anomalous observation where both models overestimated fecal output by about .7 kg (Figure 2). Residual fecal output was related to mean square error for the one compartment model ($P<.001$) but not for the two compartment model ($P>.25$). Residual fecal output was also related to estimated parameter values for the one compartment model ($P<.01$). In cases where the one compartment model fit the marker data poorly, fecal output was overestimated (Figure 3). No systematic effect due to lack

Table 1. Comparison of the one and two compartment models' fit of marker excretion data and prediction of fecal output.

Item	Compartments One	Two
Average marker mean square error $(mg/kg)^2$	7531	2148
Predicted fecal output		
Correlation with observed	.71	.84
Mean residual (predicted-observed)	.003	-.159
Standard deviation residual	.383	.230

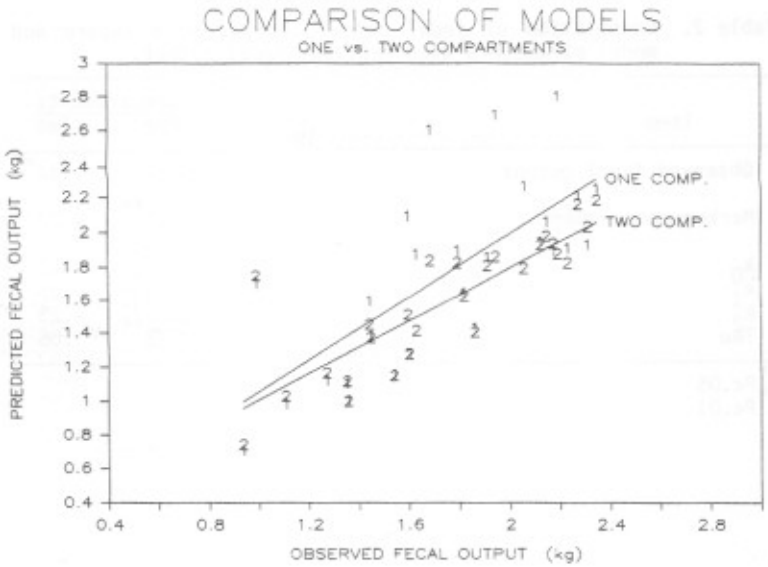


Figure 1. Relationship between predicted and observed fecal output for the one (1) and two (2) compartment models with best fit linear regression lines for steers grazing wheat pasture.

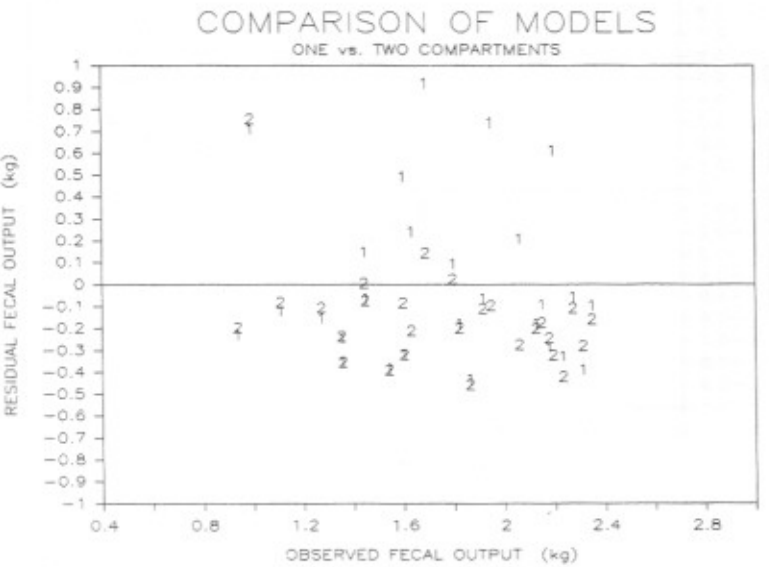


Figure 2. Relationship between residual and observed fecal output for the one (1) and two (2) compartment models for steers grazing wheat pasture.

Table 2. Correlation of fecal output, marker mean square and model parameters with residual fecal output.

Item	Compartments	
	One	Two
Observed fecal output	-.07	-.40*
Marker mean square	.72**	-.22
k_0	-.61**	-.33
k_1	.54	-.05
k_2	---	-.23
Tau	.73**	.05

*P<.05
**P<.01

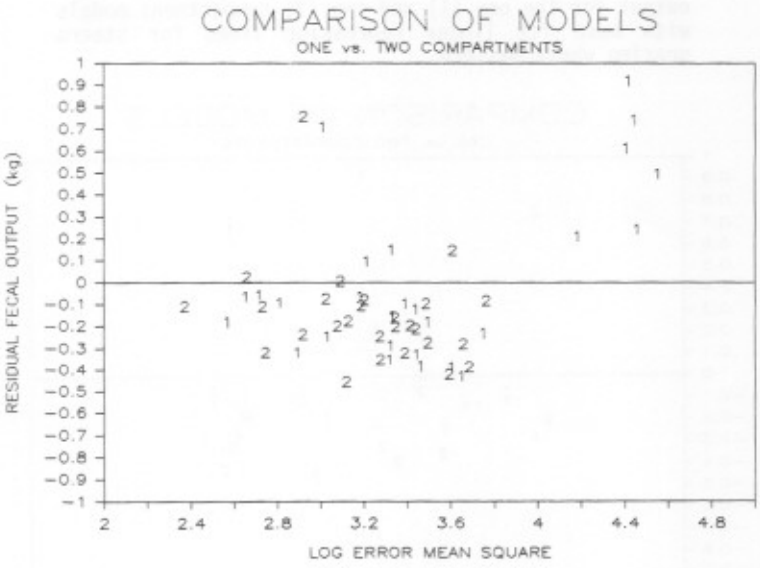


Figure 3. Relationship between residual fecal output and log error mean square of marker excretion data for the one (1) and two (2) compartment models for steers grazing wheat pasture.

of fit was observed for the two compartment model. Also, no loss of precision for estimates of fecal output was observed with increasing lack of fit of the two compartment model. In conclusion, this study suggests that although the use of either model has limitations, parameters estimated using the two compartment model should be used for estimation of fecal output when the two compartment model best fits marker concentration data.

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EFFECT OF A GROWTH REGULATOR ON FORAGE PRODUCTION, QUALITY AND GROWING POINT ELONGATION IN WHEAT

T. Svejcar[1], S. Christiansen[1] and W. A. Phillips[2]

Story in Brief

Winter wheat was treated with an experimental plant growth regulator at rates of 0, 5, 10, 20, and 30 g/ha at jointing (March 20). Height of growing points, total forage production, regrowth forage production, and forage quality were measured during the grazeout period (late spring). Height of growing points and canopy height were both reduced by the plant growth regulator, particularly at the higher rates. Total forage production was reduced by plant growth regulator four weeks after application (April 17), but treatment differences were not present 11 weeks after application (June 4). Regrowth of wheat mowed to 5 cm on April 18 was greater after 11 weeks of growth for the 20 and 30 g/ha treatments than the lower rates or controls. Thus, the plant growth regulator has the potential to improve regrowth during the grazeout period. Plant growth regulator application improved forage quality early in the grazeout period (April 17), but by June 4 there was no consistent effect of plant growth regulator on quality of either total forage or regrowth forage.

(Key Words: Wheat Pasture, Grazeout, Regrowth, Forage Quality)

Introduction

The use of winter wheat as a dual crop, capable of producing forage for livestock gains and grain has achieved considerable popularity in Oklahoma. This system allows producers to consider cattle and grain markets in making management decisions. The option to grazeout wheat, that is, to use it for pasture until it is no longer capable of supporting livestock and forsaking the grain crop, adds flexibility. When grain prices are low (as they have been) and cattle prices are reasonable, grazeout is a viable alternative to grain production. However, availability and quality of forage generally pose limitations to maintenance of livestock gains during the latter portion of the grazeout period. During this time there is relatively little leaf production and much of the wheat plant's effort goes to seedhead production. However, it may be possible to use a plant growth regulator (PGR) to alter the development pattern of wheat and improve the quantity and/or quality of regrowth in a grazeout system. One advantage of using a PGR is the flexibility it allows. The decision to use a PGR need not be made until just prior to jointing, at which point the amount of grazeout acreage can be determined based on market trends, availability of complementary forages, current climatic and soil conditions, etc.

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Materials and Methods

The experimental PGR ACP-1900 (American Cyanamid[3]) was applied to winter wheat (cv. Tam 101) on March 20, 1985, just prior to jointing. The experiment was designed as a randomized block (3 blocks) with five treatments (0, 5, 10, 20, and 30 g/ha PGR). A surfactant (0.25% v/v) was added to the application mix. Each experimental unit was 3x3 m, with 1 m borders.

Height of growing point was measured at about weekly intervals from 10 days after application until early May. The measurements were taken on primary tillers, and represent the height of growing point above the root/shoot junction. This provided a more consistent measurement than height above ground level, because of the irregularity of the soil surface. However, at a height of 3-5 cm the growing points were at ground level. Four subsamples were taken in each experimental unit on each date. Height to the top of the canopy was measured on April 19, again with 4 subsamples per experimental unit.

Forage production was measured on April 17 by clipping all the wheat in 1/4 m^2 quadrats to ground level. Half of each plot was mowed to 5 cm on April 18, and both the mowed and unmowed portion of each plot were sampled for production on June 4. Two quadrats per experimental unit were taken on each date.

The samples clipped for forage production were also analyzed for neutral detergent fiber (NDF) and acid detergent fiber (ADF).

Results and Discussion

The PGR altered the growth pattern of winter wheat, especially at the two higher rates. Growing point elongation and canopy height were both reduced by the PGR (Table 1). The reduced canopy height on April 19 resulted in lower total forage production (Table 2). The 20 and 30 g/ha rates caused browning of the leaf tips which may account for the lower

Table 1. Height of growing point and canopy height of winter wheat treated with several levels of the plant growth regulator ACP-1900, on March 20.

	Height of growing point (cm)					Canopy Height (cm)
Level	April 1	April 8	April 15	April 23	May 2	April 19
0	10.7^{a}	15.3^{a}	25.6^{a}	40.6^{a}	60.3^{a}	61.9^{a}
5	9.7^{b}	13.2^{ab}	22.0^{ab}	35.5^{b}	59.3^{a}	57.7^{ab}
10	8.8^{b}	13.6^{abc}	22.1^{ab}	33.4^{bc}	56.5^{a}	55.5^{b}
20	8.3^{b}	12.0^{bc}	17.9^{bc}	30.7^{cd}	47.9^{b}	50.0^{c}
30	7.4^{b}	11.0^{c}	15.6^{c}	27.0^{d}	47.9^{b}	43.1^{d}

^{abcd}Means in a column with different superscripts differ statistically ($P<0.05$).

Table 2. Forage production (kg/ha) and quality of winter wheat with several levels of the plant growth regulator ACP-1900. Neutral detergent fiber (NDF) and acid detergent fiber (ADF) were from wheat forage clipped on April 17 or June 4. Regrowth was from plants that had been mowed to 5 cm on April 18.

	April 17			June 4			(REGROWTH) June 4		
Level	NDF	ADF	kg/ha	NDF	ADF	kg/ha	NDF	ADF	kg/ha
0	53.7^{a}	32.4^{a}	5964^{a}	68.0^{a}	43.1^{ab}	10,720^{a}	59.9^{b}	41.6^{a}	1780^{a}
5	52.6^{ab}	31.2^{ab}	4948^{ab}	65.1^{a}	41.7^{ab}	11,932^{a}	61.5^{a}	41.7^{a}	1440^{a}
10	52.1^{ab}	30.7^{ab}	4352^{bc}	64.4^{a}	38.9^{b}	12,404^{a}	62.6^{a}	43.5^{a}	1384^{a}
20	50.8^{bc}	29.9^{bc}	3992^{bc}	65.3^{a}	41.7^{ab}	11,160^{a}	59.4^{b}	43.4^{a}	2524^{b}
30	49.5^{c}	29.0^{c}	3272^{c}	69.0^{a}	45.8^{a}	10,528^{a}	60.1^{b}	43.0^{a}	2864^{b}

^{abc}Means in a column with different superscripts differ statistically ($P<.05$).

production. However, by June 4 there were no significant differences between treatments, indicating that treated plants had higher growth rates during the April 17 to June 4 period.

The important question regarding use of PGR during grazeout is not how it affects the growth of an intact wheat plant, but rather how it affects regrowth of grazed plants. In this study we used a severe mowing treatment to evaluate regrowth, and the higher rates of PGR application did produce significantly more regrowth during late spring (Table 2). Although the true test is response under grazing, the PGR showed potential for improving regrowth in a grazeout system.

Forage quality improved with the 30g/ha application rate on April 17 (Table 2). However, by June 4 the effects of PGR on forage quality were inconsistent for both total and regrowth forage. NDF was lower for regrowth forage, but the ADF values were very similar. This is surprising because regrowth is generally higher in quality than herbage from an uncut stand. However, our sampling frequency was such that we would have missed any beneficial effects of plant growth regulator soon after clipping.

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[3]Mention of a tradename does not indicate endorsement by USDA.

INFLUENCE OF HEAT TREATMENT OF SOYBEAN MEAL ON RUMINAL NITROGEN ESCAPE AND UTILIZATION BY LACTATING DAIRY COWS

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Story In Brief

Diets containing either commercial soybean meal or soybean meal which had been heat treated were fed to five lactating dairy cows with duodenal T-type cannulas to estimate the amount of feed nitrogen which escaped ruminal degradation under typical production conditions. Diet dry matter consisted of 60 percent concentrate, 12 percent prairie hay and 28 percent sorghum silage formulated to provide 0.76 Mcal NE_l/lb. Protein from soybean meal accounted for 61 percent of the total protein intake. Nitrogen solubilities of commercial and extra-heat soybean meal were 19.3 and 11.2 percent of total nitrogen. Digestibilities of dietary organic matter were similar in the rumen (55.0 versus 52.5), post-ruminally (37.1 versus 37.6) and in the total tract (72.4 versus 71.5 percent) for diets containing the two meals. Dry matter intake, milk yield, chemical composition of milk, and total nitrogen, microbial nitrogen and ammonia nitrogen entering the duodenum also were similar. Of the total feed nitrogen, slightly more escaped ruminal degradation for the extra-heat than the commercial soybean meal diet (58.1 versus 56.1 percent). If one attributes the difference in escape of total nitrogen in the diet to the soybean meal alone, escape calculates to be increased by 2.6 percent due to heat treatment. The extra heating of soybean meal did not significantly increase ruminal escape of feed protein or milk production of lactating cows.

(Key Words: Soybean Meal, Rumen, Nitrogen Escape, Processing.)

Introduction

Providing the protein is digestible in the small intestine and the amino acid composition is balanced, the value of dietary protein to ruminants is influenced largely by the proportion of the protein which escapes ruminal degradation. Modifying proteins to increase their resistance to microbial attack and loss in the rumen has been of commercial interest. Heat treatment may increase ruminal escape. Heat-treated proteins that are relatively resistant to ruminal degradation yet available in the small intestine have proven useful in diets for young growing ruminants and high producing dairy cows (Netemeyer et al., 1982). Factors such as heating time, temperature and flow rate are important to optimize the conditions for ruminal protection. A poor combination of these factors may overprotect a protein so that it is neither fermented in the rumen nor digested in the small intestine.

The objective of our study was to measure ruminal escape of feed nitrogen in diets containing regular and heat-treated soybean meal.

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Materials and Methods

Soybean meals, prepared by the flash desolventizing system and classified according to protein dispersibility index (PDI), were obtained from a commercial manufacturer. PDI, a measurement of the degree of heat treatment, was 10 for the heat-treated soybean meal (HSBM) and 40 for the regular soybean meal (SBM). Both were fed in a ruminal nitrogen escape study to measure the amount of feed nitrogen that escaped degradation in the rumen. Diets were formulated to provide 0.76 Mcal net energy for lactation (NE_l) per lb of dry matter (Table 1). Soybean meals comprised 31 percent of the total concentrate mixture used in the study and protein from SBM accounted for 61 percent of the total protein intake. Diets were formulated to meet National Research Council (NRC, 1978) feeding standards. Diet dry matter consisted of 60 percent grain mix, 28 percent sorghum silage and 12 percent prairie hay.

Prior to initiation of the study, five mature cows (four Holstein and one Ayrshire) weighing approximately 1203 lb were fitted with T-type cannulas in the duodenum proximal to the bile duct. These lactating cows were used to estimate the amount of feed nitrogen which escaped ruminal degradation. After calving, cows were adjusted to diets with a 60:40 concentrate to forage ratio and were continued on diets with this percentage of concentrates throughout the study from week 4 to 22 of lactation.

Cows were fed in individual stalls three times daily (0300, 1100, 1900 hours) and feed weights were recorded daily. Cows were fed the test diets 2 wk prior to each two 4-day sampling period. Duodenal and fecal samples were obtained at 0300, 1100 and 1900 hours on day 4 through day 7 of each sampling period. During each period, ruminal fluid was collected from a ruminally cannulated cow fed each experimental diet for isolation of ruminal bacteria. Samples of the concentrate mixtures, sorghum silage, sudangrass hay and refused feed were collected each week and analyzed for dry matter, protein, ash and

Table 1. Ingredient composition and characteristics of diet dry matter.

Item	Treatment	
	SBM	HSBM
Ingredients, %		
Corn, ground	36.57	36.57
Soybean meal (PDI-40)	19.2	0
Soybean meal (PDI-10)	0	19.2
Molasses, cane	3.0	3.0
Dicalcium phosphate	.6	.6
Limestone	.6	.6
Salt, trace mineralized	.03	.03
Sorghum silage	28.0	28.0
Prairie hay	12.0	12.0
Protein, % of DM	17.6	17.6
Solubility of SBM-N in .15 M NaCl	19.3	11.2
NE_l (Mcal/lb of DM), calculated	.76	.76

chromium. Milk yields were recorded twice daily at 0700 and 1900 hours. Milk samples were collected for four consecutive milkings each week, composited, and analyzed for milk fat and total protein. Lyophilized bacteria and dried duodenal samples were analyzed for nucleic acid-N which was used as a microbial marker. Daily amounts of feed DM and N flowing past the duodenal cannula were calculated by subtracting the microbial contribution from the total DM and non-ammonia N flows.

Results and Discussion

Results of this experiment were presented previously (Ward et al., 1982). More details are provided in this report and more values regarding ruminal escape of feed protein have been calculated. Dry matter intake averaged about 45 lb/day but was not significantly affected by diet (Table 2). Body weight gain tended to be somewhat higher with the HSBM than the SBM diet. Production of fat corrected milk was almost identical for cows fed the two diets.

Ruminal organic matter (OM) digestion, unadjusted or adjusted for microbial OM, for the two diets was similar (Table 3). The proportion of organic matter digestion occurring in the rumen was slightly lower for the heat treated diet than the regular soybean meal diet (74.5 vs 76.3 percent). Extent of post-ruminal digestion and total tract organic matter digestion were similar (37.6 vs 37.1 percent and 71.5 vs 72.4 percent, respectively). Apparent and true OM digestibilities indicated that diets were fermented to similar extents in the rumen.

Nitrogen intake, flows and digestibilities were determined based on chromic oxide as an indigestible flow marker. Amounts of total N, microbial N and ammonia entering the duodenum were similar for both treatments (Table 4). Feed nitrogen escaping ruminal degradation was slightly higher for HSBM than the SBM diet (336 vs 327 g/day, respectively). Assuming other diet ingredients were equally degraded in the two diets, and non-ammonia, non-microbial N flow was increased

Table 2. Responses of cows fed regular and heat treated soybean meal.

Item	Treatment	
	SBM	HSBM
Number of measurements	10	10
Feed intake		
Dry matter, lb/day	44.5	44.9
Total protein, lb/day	7.9	7.9
Protein, % of DM	17.8	17.6
Weight change, lb/day	0.11	0.25
Milk, lb/day	54.8	55.0
Fat, %	3.15	3.15
Protein, %	3.16	3.16
FCM[a], lb/day	47.1	47.4
Milk/feed DM	1.23	1.23

[a]FCM = 0.4 (milk/day) + 15 (lb fat/day).

Table 3. Organic matter digestion in cows fed regular and heat treated soybean meal.

Item	Treatment	
	SBM	HSBM
Organic matter flow, g/day		
Intake	18784	18966
Duodenal		
Total	8405	8832
Non-microbial	7243	7643
Fecal	5188	5337
Organic matter digestion, %		
Rumen		
Unadjusted	55.0	53.3
Adjusted	61.4	59.7
Of total tract	76.3	74.5
Postruminal		
Of diet	17.4	18.2
Of duodenal flow	37.1	37.6
Total tract	72.4	71.5

Table 4. Nitrogen (N) digestion in cows fed regular and heat treated soybean meal.

Item	Treatment	
	SBM	HSBM
Intake, g/d		
Total	578	577
Soybean meal N	353	352
Leaving abomasum, g/d		
Total N	453.2	467.6
Microbial N	99.8	102.9
Ammonia	26.4	28.7
Non-ammonia, non-microbial	327.0	336.0
Feces, g/d	166.8	172.9
Feed N bypass, %	56.1	58.1
Ruminal digestion, %		
Unadjusted	21.8	18.7
Adjusted[a]	34.7	31.8
Microbial efficiency, g		
Microbial N/kg OM truly digested in rumen	14.1	13.5
Ruminal digestion, % of total	30.2	26.7
Post-ruminal digestion, % of input	62.7	62.1
Total tract digestion, %[b]	71.3	69.8
Expected total digestion[b], %	73.2	73.0

[a]Adjusted for microbial and ammonia nitrogen.
[b]Calculated as: % digestible protein = [.9 (% crude protein)-3]/% crude protein.

by 9 g daily from the 352 g of N from soybean meal. Hence, SBM N escape was increased by 2.6 percentage units by heat treatment. This change is very small. Fecal nitrogen was 6.1 g greater with the HSBM than the SBM diet making total tract digestibility slightly lower with HSBM than for SBM. Microbial efficiency, g of microbial N/kg OM truly digested in the rumen, 13.5 and 14.1 for the two groups, was not affected by soybean meal treatment but was lower than most reported values.

None of the nitrogen and organic matter parameters measured were significantly altered by heat treatment of SBM. The percentage of ruminal escape of total feed nitrogen was only slightly higher in cows fed extra heat SBM compared to the control group (58.1 vs 56.1 percent). Hence, the extra heating applied in processing of the soybean meal available for this trial appeared to be ineffective in protecting soybean meal from ruminal degradation. More extensive heating of whole soybeans or SBM has been shown to increase escape of SBM protein in other trials (Plegge et al., 1985; Stern et al., 1985). Availability of N in the small intestine was not measured directly, but total postruminal digestion was not reduced greatly. Variation in processing methods may be responsible for this difference.

Based on these data and those of a previous continuous feeding trial, heat treatment of soybean meal did not markedly increase the amount of feed protein escaping ruminal degradation. The escape values obtained with lactating cows consuming a 60 percent concentrate ration at high levels of intake are higher than commonly reported. Ruminal escape of soybean protein must have been near 50 percent to achieve the duodenal N flow values attained. The high concentrate level may be partly responsible for the high escape value as indicated by Ward et al. (1986).

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RUMINAL ESCAPE, TURNOVER RATE AND IN SITU DISAPPEARANCE OF SOYBEAN MEAL PROTEIN IN LACTATING COWS FED DIETS AT TWO CONCENTRATE TO FORAGE RATIOS

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Story in Brief

Diets with two concentrate to forage ratios supplemented with either urea or soybean meal were fed to six lactating dairy cows equipped with duodenal cannulas. Diets contained 65 or 35 percent of dry matter as concentrate with the remainder being sorghum silage and alfalfa hay. With 65 and 35 percent concentrate diets 46 and 18 percent of the soybean meal protein fed escaped ruminal digestion. Post-ruminal digestion of nitrogen, as a percent of that reaching the small intestine, averaged 62 to 75 percent. Ruminal passage rates for soybean meal were similar (8.7 vs 8.3 percent/hour) while ruminal degradation rates (percent/hour) for soybean meal nitrogen were 5.3 and 10.7 for the 65 and 35 percent concentrate diets, respectively. Predicted ruminal escape of soybean protein, based on these passage and degradation rates and nitrogen solubility (9.8 percent) were 56.1 and 39.3 for the 65 and 35 percent concentrate diets. Ruminal escape of soybean protein increased as concentrate level increased due to less rapid microbial digestion in the rumen with the higher concentrate ration.

(Key Words: Soybean Meal, Nitrogen, Escape, Ruminants.)

Introduction

Escape values for soybean meal (SBM) nitrogen range from 10 to 61 percent (NRC, 1985). Most of these values have been determined with sheep or cattle fed roughage diets at low levels of feed intake. Only one dairy cow trial (Goetsch and Owens, 1985) has estimated ruminal escape (35 percent) but their calculations were based on an assumed escape value of 60 percent for corn grain protein. Hence, this value may not apply to more typical dairy diets. Using a mean escape value to formulate diets for dairy cattle remains tenuous due to the variation in escape values. Further, extent of protein degradation in the rumen is not constant but varies with certain dietary factors (dry matter intake and feed particle size) which in turn can alter ruminal pH, microbial activity and passage rate (Weakley et al., 1983). Relative importance of these factors has not been measured in lactating cows.

The objective of this study was to directly estimate the proportion of soybean meal protein which escaped ruminal degradation with two levels of dietary roughage and determine the effects of roughage level on ruminal digestion and turnover rates.

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Materials and Methods

Two months prior to calving, six dairy cows were surgically prepared with T-type cannulae in the duodenum proximal to the pancreatic and bile ducts. Cows were rotated among the four diets which consisted of two concentrate to forage ratios of 65:35 and 35:65 with protein or protein equivalent, from either urea or SBM. Diets were each fed for 2-week periods with data being collected the final 5 days of each period.

Diets consisted of a concentrate mixture, alfalfa hay and sorghum silage (Table 1). The concentrate mixture consisted of ground corn plus either soybean meal or urea plus corn starch (Table 2) so that the percentage of corn remained constant between test diets. Formulation of diets in this manner permitted soybean meal escaping rumen degradation to be estimated by difference after subtracting microbial protein from total duodenal nitrogen.

The complete mixed diets were fed to cows at 0400 and 1800 hours each day. Chromic oxide was included as an indigestible flow marker, however indigestible neutral detergent fiber (INDF) was used as a marker to calculate duodenal digesta flow of organic matter and nitrogen. Samples of the concentrate, sorghum silage and alfalfa hay and feed refused were collected each week and analyzed for dry matter and protein. Milk yields were recorded twice daily at 0600 and 1800 hours. Milk samples were collected for four consecutive milkings each week, composited, and analyzed for milk fat and total protein.

One rumen fistulated cow randomly assigned to a treatment sequence of the diets was used for isolation of bacteria which was analyzed for total nitrogen (N) and for nucleic acid-N. This cow was also used to evaluate rate of ruminal digestion of SBM from dacron bags suspended in the rumen.

On day 5 of each collection period, 250 g of soybean meal labeled with ytterbium (Yb) were fed to each intestinally cannulated cow. Starting 12 h post feeding, approximately 400 ml of duodenal digesta were collected every 12 h for 2 d. Duodenal samples were analyzed for Yb. On day 7 of the collection period, approximately 250 ml of rumen fluid were collected by stomach tube from each intestinally cannulated cow for ammonia determination.

Table 1. Composition of diet used in SBM nitrogen ruminal escape experiment.

	Percent concentrate diet			
	65		35	
Item	SBM	U	SBM	U
	% dry matter			
Ingredient				
Sorghum silage	17.5	17.5	32.5	32.5
Alfalfa hay, chopped	17.5	17.5	32.5	32.5
Concentrate (Table 2)	65	65	35	35
Crude protein	14.6	12.9	14.5	12.4

Table 2. Composition of concentrate portion of diets used in SBM nitrogen ruminal escape experiment.

	Percent concentrate diet			
	65		35	
Item	SBM	U	SBM	U
	% dry matter			
Ingredient				
Corn, ground	68.6	68.6	58.8	58.8
Soybean meal	17.6	----	27.4	----
Cornstarch	----	15.6	----	25.0
Cottonseed hulls	3.9	3.9	3.9	3.9
Urea	----	2.0	----	2.4
Molasses, cane	4.9	4.9	4.9	4.9
Dicalcium phosphate	2.0	2.0	2.0	2.0
Salt, trace mineralized	1.0	1.0	1.0	1.0
Chromic oxide	2.0	2.0	2.0	2.0
Crude protein	16.2	13.7	20.0	14.2

Results and Discussion

Mean ruminal passage rates for soybean meal labeled with ytterbium were 7.9 to 8.7 percent/h (Table 3). These means are higher than the 4.9 percent/h for lactating dairy cows ad libitum fed a basal diet of 60 percent alfalfa hay and 40 percent concentrate (Stern et al., 1983) but similar to estimates of 6.0 to 7.7 percent/h for grain in the rumen of lactating cows fed diets containing 50 percent alfalfa hay diets (Eickelberger et al., 1985) and somewhat greater than the 5.8 percent estimated for SBM with a 50 percent concentrate, 30 percent corn silage diet (Erdman, 1981). Passage rate in the present trial tended to be slightly higher with the high concentrate than with low concentrate diet.

Table 3. Rates of passage of soybean meal and of digestion in dacron bags suspended in the rumen.

			Percent concentrate in diet			
			65		35	
Feed	Component	Rate measurement	SBM	U	SBM	U
			%/h			
SBM	Yb	Passage	8.7	8.6	8.3	7.9
	DM	Digestion	6.7	6.3	5.3	10.6
	N	Digestion	5.3	3.2	10.7	6.0
Alfalfa hay	DM	Digestion	1.3	1.0	1.1	1.5
	N	Digestion	1.8	2.1	2.6	1.3
Sorghum silage	DM	Digestion	0.4	0.3	1.3	1.5
	N	Digestion	2.0	1.0	2.6	2.0

Rates of nitrogen disappearance in the rumen for soybean meal (Table 3) tended to be lower when the high concentrate diet was fed. Rates of dry matter digestion of alfalfa hay and sorghum silage also tended to be higher with the higher roughage diet. Protein content and diet composition presumably altered the ruminal flora or fauna so that rate of ruminal digestion was altered. Ruminal digestion rate for plant proteins previously has been reported to be greater with a high roughage than with a high concentrate diet (Weakley et al., 1983).

Rate of protein digestion from soybean meal tended to be higher if SBM was included in the diet with the 65 percent concentrate diet. Loerch et al. (1983) reported that nitrogen digestion from SBM in situ was greater with SBM in the diet. This could reflect microbial adaptation to degrade SBM or other changes in microbial activity in the rumen which increased rate of destruction of all protein sources.

Ruminal escape of N was predicted from these data using the equation:

$$E = k_p/(k_p + k_d);$$

where K_p and k_d are fractional passage and digestion rates. Using values from Table 3 as applied to total N in SBM, predicted escape values are 62 and 44 percent for the 65 and 35 percent concentrate diets. If soluble N of SBM is deducted prior to calculations, predicted escape values become 56 and 39 percent, respectively. Since rate of passage (k_p) was unchanged, the entire difference in predicted escape is due to a faster rate of digestion with the higher roughage diet.

In Vivo Trial

Mean dry matter (DM) intake ranged from 35.7 to 40.5 lb/day for the treatment groups (Table 4). DM intake was highest ($P<.01$) for cows receiving the low concentrate diet with urea. DM intake may have increased to compensate for the lower crude protein content and caloric density of this diet. Body weight gain tended to be greater with the high concentrate diets. Ruminal ammonia levels tended to be higher with the lower concentrate diets and with soybean meal in the diet. Added corn starch, being rapidly and completely digested, may have increased ammonia utilization by ruminal microbes and decreased ammonia concentrations in the rumen.

Mean daily milk yield, milk fat and milk protein for the experimental diets ranged from 42.5 to 50.9 lb, 3.7 to 3.8 percent and 3.4 to 3.8 percent (Table 4). Mean milk yield tended to be higher with the high concentrate diets reflecting the higher protein and caloric density of these diets. Fat-corrected milk production was higher when cows were fed the 65 percent than when fed the 35 percent concentrate diet ($P<.02$).

Duodenal flow of OM was variable across diets ($P>.37$) and non-microbial N flow reflected differences in OM intake (Table 5). Post-ruminal digestion, as a percentage of duodenal flow, was greater with the 65 percent concentrate diet ($P<.01$). Total tract OM digestion, based on chromic oxide as an indigestible marker, tended to be higher for the high concentrate diets. Total tract digestibilities were lower than anticipated for these diets as compared with values reported by Goetsch and Owens (1985).

Ruminal digestion of OM averaged 48 percent, higher than many values reported in previous studies. OM digestion in the stomach as a percentage of OM intake in other studies has generally ranged from 27 to 48 percent. In most studies with intestinally-cannulated cows,

Table 4. Responses of cows fed experimental diets.

Item	Percent concentrate diet			
	65		35	
	SBM	U	SBM	U
Dry matter intake, lb/day	36.6	35.7	36.8	40.5
Protein, % of DM	14.9	13.3	15.7	13.6
Total protein intake, lb/day	5.44	4.76	5.77	5.53
Weight change, lb/day	0.1	0.1	0.0	0.0
Ruminal NH_3-N, mg/dl	8.6	5.7	11.7	7.8
Production				
Milk, lb/day	50.9	46.3	43.6	42.5
Fat, %	3.7	3.7	3.7	3.8
Protein, %	3.5	3.4	3.7	3.7
FCM[a]	47.8	44.3	41.2	41.4

[a]FCM = 0.4 x lb milk/day + 15 x lb fat/day.

Table 5. Organic matter digestion in cows fed diets at two concentrate to forage ratios with or without SBM.

	Percent concentrate in diet			
	65		35	
	SBM	U	SBM	U
Organic matter intake, g/d	15372	15162	15316	16984
Leaving abomasum, g/d				
Total	8205	6670	7461	8913
Non-microbial	5956	4892	5615	6498
Ruminal digestion, %				
Unadjusted	46.0	53.7	49.1	42.6
Adjusted[a]	60.7	65.8	61.8	58.1
Feces, g/d	6362.6	6812.6	7788.1	8382.7
Post-ruminal digestion, % of input	60.3[b]	53.7[bc]	42.7[cd]	48.9[d]
Total tract digestion	59.5	55.6	48.6	52.1

[a]Adjusted for microbial contribution.
[bcd]Means in a row with different superscripts differ (P<.05).

daily dry matter intake has been restricted to 12 to 22 lb. Such intakes are low for lactating dairy cows. Many studies have shown that as feed intake increases, the flow of digesta through the forestomachs increases which reduces the portion of OM digested in the rumen.

Nitrogen flow at the duodenum and digestibility were calculated based on INDF as the digesta flow marker (Table 6). To determine the

Table 6. Nitrogen (N) digestion in cows fed diets at two concentrate to forage ratios with or without SBM.

Item	Percent concentrate in diets			
	65		35	
	SBM	U	SBM	U
Intake, g/d				
Total	374.7	321.5	400.7	365.6
SBM	142.9	0	123.3	0
Leaving abomasum, g/d				
Total	393.3	272.6	336.1	374.5
Microbial N	206.9	154.4	163.1	204.1
Ammonia N	22.8	20.3	21.3	41.1
Non-ammonia, non-microbial	163.6	98.0	151.6	129.4
Ruminal digestion, %				
Unadjusted	- 1.0	-17.2	-15.6	- 1.0
Adjusted[a]	59.2	69.7	62.4	64.6
Dietary N escape, excluding urea	43.7	43.2	37.8	44.1
SBM escape, %	45.9	---	18.0	---
Escape of non-SBM protein	42.3	43.2	46.7	44.1
Microbial efficiency, g N/kg OM	24.1	17.4	18.7	23.2
Feces, g/d	192.4	184.6	232.4	233.1
Post-ruminal digestion, % of input	74.8	69.4	62.2	66.6
Total tract digestion, %	52.5	46.5	43.8	43.7
Expected total tract N digestion, %[b]	69.0	67.4	70.6	68.1

[a]Adjusted for microbial and ammonia N.
[b]Calculated as: % digestible protein = (.9(% CP)-3)/% CP.

amount of soybean meal escaping ruminal degradation, urea plus corn starch was substituted for soybean meal at each concentrate level. To help prevent urea toxicity, total N in the urea diets was lower than in the SBM diets but enough urea was added to the diets to maintain adequate N for microbial synthesis. Based on composition of bacteria isolated from rumen fluid of the cow fed the experimental diets, N levels appeared to be adequate. Both chemical composition and microbial efficiency (g N per kg OM truly digested in the rumen) were not significantly altered by diet ($P>.51$). Bacterial efficiencies were similar to those reported by Goetsch and Owens (1985).

Non-ammonia non-microbial nitrogen passage to the duodenum tended to be greater with dietary SBM and with the 65 than the 35 percent concentrate diets. This is due to the increase in dietary protein escaping degradation in the rumen. Based on the differences in N flow leaving the abomasum between diets supplemented versus not supplemented with SBM, 45.9 percent and 18.0 percent of the dietary SBM protein escaped ruminal degradation with the 65 and 35 percent concentrate diets, respectively. Goetsch and Owens (1985) calculated soybean protein bypass to be 35 percent with dairy cows fed a 60 percent concentrate diet at 2.9 percent of body weight daily. These values are much higher than the 20 and 14 percent escape values reported by Weakley (1983) for 80 and 40 percent concentrate diets. He assumed ruminal escape of corn protein to be 60 percent for calculation purposes, where-

as in this trial ruminal escape of soybean protein was estimated directly rather than by replacement of corn protein in the diet. Zinn and Owens (1983) reported SBM bypass values of 43 and 24 percent with 80 and 40 percent concentrate diets, again assuming that corn protein escape was 60 percent. In our study, decreasing concentrate level from 65 to 35 percent decreased ruminal escape of SBM nitrogen by 28 percentage units or 61 percent. By difference, bypass of the non-soybean meal, non-urea fraction of the diet for the four diets was 42.3, 43.2, 46.7 and 44.1 percent. If escape of protein from corn grain had been 60 percent, escape of protein from non-corn, non- SBM sources (silage plus hay) calculates to be 23.0, 25.0, 43.3 and 39.8.

Most previous ruminal escape values for SBM have been confounded by other dietary protein sources. Though our escape values differ from those reported from other studies, our values are more direct estimates of ruminal escape at two concentrate to forage ratios than have previously been determined and are supported by nitrogen disappearance measurements from dacron bags. Few escape estimates are available for high-producing cows fed diets varying the forage to concentrate ratios at high levels of dry matter intakes. Based on results from this trial, using one single, constant value for ruminal escape of dietary soybean meal is imprecise. Escape values for protein sources to be used in formulating diets should be adjusted for concentrate level and feed intake level.

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EFFECT OF DIFFERENT LEVELS OF WHEAT IN CONCENTRATE MIXTURE ON RESPONSES OF LACTATING DAIRY COWS FED SORGHUM SILAGE AS THE ONLY FORAGE

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Story in Brief

A feeding trial was conducted to compare the performance of 21 lactating cows fed concentrate mixtures containing different amounts of wheat included in a complete ration with sorghum silage as the only forage. The concentrate mixtures contained 0, 40, and 60 percent hard red winter wheat with the latter level representing the highest percent that can be used and still maintain protein, fiber and energy content of the total ration at an acceptable level. Cows were assigned near the peak of lactation to treatment sequences of a switchback design with three 4-wk periods. Total dry matter consumption was similar for all treatment groups. No incidence of off-feed or other indication of digestive disorders was noted with wheat intake averaging 13.6 and 20.2 lb per day for cows fed the 40 and 60 percent wheat mixtures. There was a linear decrease in milk yield (63.4, 61.6, and 60.1 lb/day) with a slight increase in fat test as percentage of wheat in the concentrate increased. Milk protein percentage did not differ among treatments. Also, the amount of wheat in the ration had no effect on body weight and condition score changes, rumen pH, rumen ammonia, rumen volatile fatty acids, and blood plasma urea.

High levels of wheat can be utilized in a complete mixed ration wherein sorghum silage is the only forage; however, economic feasibility varies and should be considered.

(Key Words: Wheat, Feed Intake, Milk Yield, Dairy Cows.)

Introduction

In Oklahoma, an abundant supply of wheat is generally available for livestock feeding. At times, the price is competitive with that of other feed grains used as an energy source in dairy rations. When this is the situation, wheat can be used to advantage in formulating high energy rations for lactating dairy cows. However, the extent to which other grains can be replaced by wheat in dairy rations has not been well defined because much of the research on feeding wheat was conducted using cows producing considerably less milk and fed much less concentrates than is common in the industry today.

McPherson and Waldern (1969) found that cows fed alfalfa hay plus concentrate mixtures containing from 20 to 93% Gaines soft white wheat had no problems with "off-feed" and no significant differences in milk production attributable to amount of wheat in the ration. However, their results may not be applicable to herds with higher milk production or where cows are fed hard red winter wheat rather than soft white wheat. Cunningham et al. (1970) fed lactating cows concentrate mixtures containing corn and either 33.3 or 66.7% of two varieties of soft red winter wheat. A combination of alfalfa hay and corn silage (about 1:2.8

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on a dry basis) comprised the forage component of the ration. For cows fed either the low or high protein variety of wheat, milk yield was significantly lower when wheat comprised 66.7% of the concentrate than when half as much wheat was used.

This experiment was conducted to determine the extent to which hard red winter wheat can be utilized in a complete mixed ration for lactating cows where sorghum silage is the only forage. Also, the effect of different levels of wheat in the concentrate mix on ruminal fermentation was evaluated.

Materials and Methods

Twenty-one Holstein cows in their second or greater lactation were used in a feeding trial starting 6 to 10 weeks postpartum to compare concentrate mixtures containing 0, 40, and 60% hard red winter wheat. Wheat replaced corn and some soybean meal. The highest level represented the highest percent that can be used and still maintain protein, fiber and energy content of the total ration at an acceptable level (Table 1). Cows were fed a complete mixed ration consisting of 55% concentrate and 45% sorghum silage on a dry basis. Calculated analysis for the total ration was 15.5% crude protein, 71.4 Mcal net energy for lactation (NE_{ℓ})/100 lb and 16.5% crude fiber. The three mixtures were calculated to be isocaloric and isonitrogenous.

Table 1. Concentrate mixtures fed with sorghum silage[1].

	Percent Wheat in Mix		
Composition	0	40	60
Ingredients (%, as fed)			
Corn, ground	53	18	--
Wheat, ground[2]	--	40	60
Soybean meal	30	25	23
Fixed portion[3]	17	17	17
Calculated analysis (as fed)			
Net energy, Mcal/100 lb	73.0	73.3	73.4
Total protein, %	20.2	20.0	20.1
Crude fiber, %	5.5	5.7	5.7

[1]Conc:forage, 55:45 (dry basis); total ration (dry): NE_{ℓ} 71.4 Mcal/100 lb; protein 15.5%; fiber 16.4%.

[2]Hard red winter wheat, no. 2 grade, test wt. 60 lb/bu.

[3]Fixed portion of concentrate mix: cottonseed meal 4, cottonseed hulls 4, oats 4, limestone 1.5, dicalcium phosphate 1.25, sodium bicarbonate 1.0, salt .75, and magnesium oxide .50%.

A switchback design with three 4-wk periods was used. The first two weeks for adaptation and the last two weeks of each period were used for comparisons among treatments. The cows were assigned to three blocks based on date of calving and then randomly to treatment sequences. Rations were fed to individual cows in three portions at 8-hour intervals. Milk weights were recorded daily and samples were taken at four consecutive milkings each week to determine fat and protein percentage. Feed weighbacks for each cow were taken daily and composited on a weekly basis for determination of dry matter and crude protein content. A sample of silage and each concentrate mixture also were analyzed for these components each week so that intake could be calculated. Each cow was weighed prior to the trial and on two consecutive days during the last week of each period. Body condition of each cow was evaluated initially and on the last day of each period using the scoring system described by Aalseth et al. (1983).

During the last week of each period, 3 to 4 hours after the 11:00 AM feeding, a sample of rumen fluid was taken by stomach tube to determine pH, ammonia and volatile fatty acid (VFA) concentration. A sample of blood from the median caudal vein was also taken to determine plasma urea concentration.

Results and Discussion

Feed intake was not affected by the amount of hard red winter wheat in a complete ration with sorghum silage as the only forage (Table 2). Intake of wheat averaged approximately 13.6 and 20.2 lb per day for cows fed the 40 and 60% wheat mixtures, on an as-fed basis. No problems were encountered with feed intake or clinical acidosis, even though concentrate intake averaged more than 30 lb/cow/day for the entire trial. Similarly, McPherson and Waldern (1969) observed that cows had no problems with "off-feed" or acidosis even when fed a concentrate mixture with 93% wheat so that consumption of wheat was over 25 lb/cow/day. In their experiments, Gaines soft white wheat was used and alfalfa hay was the only forage in the ration. It seems apparent that high levels of wheat can be utilized in a complete mixed ration wherein sorghum silage is the only forage if good management practices are followed in regard to adaptation of cows to such rations. In our trial, the cows were adjusted to new rations over a period of 5 days. Also, mineral buffers, sodium bicarbonate and magnesium oxide, were included in the concentrate mixtures for the purpose of stabilizing conditions in the rumen to reduce the likelihood of digestive disorders.

There was a linear decrease ($P<.0002$) in milk yield as the amount of wheat in the ration increased (Table 2), although milk yield of cows fed the highest level of wheat was sustained at a high level, i.e., 60 lb/day. Similarly, Cunningham et al. (1970) observed that milk yield was significantly lower ($P<.05$) when soft red winter wheat comprised 66.7 compared to 33.3% of a concentrate mixture (59.4 vs. 62.0 and 56.5 vs. 60.1 lb/day). In contrast, in a trial wherein concentrate rations contained 20 to 93% Gaines soft white wheat, McPherson and Waldern (1969) observed no significant difference among groups with an overall average milk production of 51.4 lb/day. However, milk yield was moderately low in their experiment compared to others previously mentioned and wheat replaced barley rather than corn in the concentrate mixtures. In our trial, wherein wheat replaced corn and some soybean meal (Table 1), the amount of lysine in the ration which was calculated to reach the small intestine was reduced. Whether or not this is a factor affecting

Table 2. Responses of cows fed different levels of wheat.

Item	Percent Wheat in Mix		
	0	40	60
Dry matter intake, lb/day			
Concentrate mix	30.5	30.4	30.0
Silage	25.0	24.7	24.2
Total	55.5	55.1	54.2
Protein intake			
lb/day	8.07	8.03	8.08
% of NRC requirement	124	127	128
Wheat intake (as-fed), lb/day	0	13.6	20.2
Milk Yield			
Milk, lb/day[a]	63.4	61.5	60.0
Fat test, %	3.68	3.71	3.81
Protein, %	3.15	3.12	3.15
Weight change, lb/4-wk period	1.7	21.3	-4.2
Condition score change	.3	.2	.1

[a]Significant linear trend (P<.0001).

[b]Significant linear trend (P<.05).

the performance of cows fed large amounts of wheat remains to be determined by further research.

Milk fat test increased slightly as wheat in the ration increased, but may have been simply a reflection of the decrease in milk production (Table 2). The amount of wheat in the ration had no effect on milk protein. No significant difference was observed among levels of wheat in regard to body weight and condition score changes of the cows. Also, rumen pH, ammonia, VFA concentration, and blood plasma urea were similar for cows fed different amounts of wheat. The ratio of molar percentages of acetic to propionic acids was 3.1:1 across treatments and was adequate for maintenance of normal milk fat test.

The economics of feeding wheat where sorghum silage constitutes the only forage merits consideration. Small differences among treatments were observed in feed intake; therefore, the same amount of intake was assumed for each ration in the economic analysis. Thus, the economic feasibility of feeding wheat was estimated on the basis of observed responses in milk yield and current milk and feed prices. A concentrate mixture containing 40% wheat, replacing 35 lb corn and 5 lb soybean meal, must cost 62 ¢/cwt less than a typical corn-soybean meal mixture to give the same return over feed cost (Table 3). Similarly, a concentrate mixture containing 60% wheat must cost about 92 ¢/cwt less to obtain equal return over feed cost. With current prices (Jan. '86) for corn and soybean meal, wheat would need to be priced around $4.65/cwt to make the substitution profitable. On the other hand, if corn were priced at $6.40/cwt and soybean meal at $9.25/cwt as it was March '85, it would be feasible to use wheat priced around $5.25/cwt. At times the

Table 3. Economics of feeding wheat with sorghum silage as the only forage.

Item	Wheat in Conc. Mix, %		
	0	40	60
Amount of milk, lb/cow/day	63.4	61.5	60.0
Value of milk produced per day, $[a]	8.02	7.81	7.71
Feed Costs			
Conc. mix, $/100 lb[b]	7.22	6.98	6.89
Silage, $/100 lb	1.25	1.25	1.25
Daily ration consumed, $	3.25	3.17	3.14
Return over feed costs/cow, $[ab]	4.77	4.64	4.57
Price needed for same return as with control ration			
Conc. mix, $/100 lb		6.60	6.30
Wheat price[c]		4.67	4.65

[a]Milk priced at $12.36/cwt for 3.5% test, with 16 ¢ differential.

[b]Ingredient prices (January 1986) per 100 lb: wheat $5.12, corn $5.74, soybean meal $9.50, oats $5.90, cottonseed meal $9.25, cottonseed hulls $2.70, limestone $4.00, dicalcium phosphate $20.50, sodium bicarbonate $18.00, salt $4.40, and magnesium oxide $17.00.

[c]Assuming all other ingredient prices are those indicated above.

price of wheat is competitive with that of other feed grains used as an energy source in dairy rations and can be used to an advantage. Although it is possible to use high levels of wheat in formulating high energy rations for lactating dairy cows where sorghum silage is the only forage, the economic feasibility of doing so should be considered. In future research it should be possible to identify the factor(s) responsible for reduced milk yield when cows are fed complete rations containing a large amount of wheat and sorghum silage as the only forage. If so, it is likely that cost effective measures for overcoming this problem can be developed.

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INFLUENCE OF DIFFERENT LEVELS OF WHEAT IN THE CONCENTRATE MIXTURE ON PRODUCTION RESPONSES OF LACTATING DAIRY COWS FED ALFALFA HAY AS THE ONLY FORAGE

M.A. Faldet[1], L.J. Bush[2] and G.D. Adams[3]

Story in Brief

A feeding trial was conducted to compare the performance of 24 lactating dairy cows fed concentrate mixtures containing 0, 40, 60 and 80% of hard red winter wheat with alfalfa hay comprising the only forage in the ration. Intake of both concentrate and hay was lower when cows were fed the rations containing wheat; however, there was very little difference among rations containing different amounts of wheat. No problems were noted with feed refusals or clinical acidosis. Milk yield declined as the amount of wheat in the concentrate increased (66.9, 65.5, 65.1, 63.7 lb/cow/day). Milk fat test percent decreased linearly as the percentage of wheat in the concentrate increased, whereas milk protein percentage was not affected by treatment. Also, the amount of wheat in the ration had no effect on body weight and condition score change.

Considering the decrease in feed intake as well as the decrease in milk yield and fat test of cows fed the different levels of wheat, the highest return over feed costs was obtained with the ration containing 40% wheat in the concentrate mixture. With current ingredient prices, wheat would need to be valued at about $4.75/cwt to give a return over feed cost equal to that obtained with the ration without wheat when cows are fed concentrate mixtures containing 60 or 80% wheat. However, if one assumes that with adequate fiber in the ration no depression in fat test would occur, and milk yield would be the same as observed, it can be calculated that feeding wheat would be profitable at all the different levels.

(Key Words: Wheat, Alfalfa Hay, Feed Intake, Milk Yield, Dairy Cows.)

Introduction

Wheat is often competitive in price with other feed grains used as an energy source in dairy rations. Therefore, there is a need to more clearly define the limits to which wheat can be included safely in rations for high producing dairy cows and to identify management factors that are important in successful use of large amounts of wheat. This information would be valuable in designing feeding programs for dairymen in Oklahoma and other areas where substantial quantities of wheat are produced.

Tommervik and Waldern (1969) compared the nutritive value of Gaines soft white wheat to corn, oats, barley, milo and a mixed concentrate ration for dairy cows. Each of the five single grain mixtures contained 95.7% of the respective grains and was pelleted. The complete ration consisted of 45% concentrate and 55% alfalfa hay with consumption of

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grain dry matter averaging 17.4 lb/day for the cows fed wheat. They noted negligible differences among the concentrates as to palatability or effect on milk production and composition. McPherson and Waldern (1969) noted no problems with "off-feed" and no significant differences over all treatments in daily milk production when they fed alfalfa hay plus concentrate mixtures containing from 20 to 93% Gaines soft white wheat.

Results from these earlier experiments may not be applicable today since they were conducted using cows producing considerably less milk and fed much less concentrates than is common in the industry today. Also, results may differ when cows are fed hard red winter wheat rather than soft white wheat. Our experiment was conducted to help define the extent to which hard red winter wheat can replace other grains in rations for lactating dairy cows while utilizing alfalfa hay as the only forage.

Materials and Methods

Twenty-four Holstein cows (12 in first lactation and 12 in second or later lactation) were used in a feeding trial starting 6 to 10 weeks postpartum to compare concentrate mixtures containing 0, 40, 60 and 80% hard red winter wheat. The 80% level of wheat represents the maximum that can be used if protein, net energy and fiber levels are maintained at an acceptable level. The rations were adjusted as necessary to maintain consumption of the desired ratio of 55% concentrate to 45% alfalfa hay on a dry basis. The four concentrate mixtures were calculated to be isocaloric and isonitrogenous (Table 1) with total ration calculated to have 72.5 Mcal net energy for lactation (NE_{ℓ})/lb, 16.5% protein, and 17.0% crude fiber on a dry basis.

A switchback design was used, with three 4-week periods. The first two weeks of each period were allowed for adjustment to rations and recovery from possible carry-over effects. Data collected the final two weeks of each period were used for comparisons among treatments. The cows were assigned to two blocks based on lactation number and then assigned randomly to treatment sequences. Alfalfa hay was fed twice daily separate from the concentrate mixtures. Weighbacks of both concentrate and alfalfa hay were composited on a weekly basis for analysis of dry matter (DM) and crude protein (CP). Milk weights were recorded at each milking and samples were taken at four consecutive milkings each week for determination of protein and fat content. Body weights were recorded on two consecutive days before the trial and during the last week of each period. Body condition also was evaluated prior to the beginning of the trial and during the last week of each period using the system described by Aalseth et al. (1983).

At the end of each period, rumen samples were taken 3 to 4 hours after the 3:30 AM concentrate feeding to determine rumen pH, rumen ammonia, individual rumen volatile fatty acids (VFA), and rumen lactic acid concentration. Also, at this time a blood sample was taken from the median caudal vein to determine plasma urea concentration.

Results and Discussion

Intake of both concentrate and hay was affected by the amount of hard red winter wheat in the concentrate mix, being lower for the cows fed the rations containing wheat (Table 2). However, there was very

Table 1. Concentrate mixtures fed with alfalfa hay[1].

Composition	Percent Wheat in Mix			
	0	40	60	80
Ingredient (%, as fed)				
Wheat, ground	--	40	60	80
Corn, ground	75	38	19	--
Cottonseed meal	12	6.5	3.5	2
Oats, ground	4	6.5	8.5	9
Fixed portion[2]	9	9	9	9
Calculated analysis, as fed				
Net energy, Mcal/100 lb	74.7	74.9	74.9	75.0
Crude fiber, %	5.5	5.5	5.5	5.6
Total protein, %	12.4	12.2	12.0	12.4
Soluble nitrogen, % of total N[3]	17.0	19.1	20.7	18.0
Acid detergent fiber, % dry basis	6.9	6.5	6.4	7.9

[1]Conc:hay, 55:45; total ration (dry): NE_{ℓ} 72.5 Mcal/100 lb; protein, 16.5%; crude fiber, 17.0%.
[2]Fixed portion: cottonseed hulls 5, dicalcium phosphate 1.75, sodium bicarbonate 1.0, salt .75 and magnesium oxide .50%.
[3]Solubility in borate-phosphate buffer.

little difference among rations containing different levels of wheat. No problems were noted with clinical acidosis or digestive disorders in cows on any of the treatments. Intake of wheat averaged 10.4, 15.2, and 19.7 lb/day on as-fed basis for cows fed the 40, 60 and 80% wheat mixtures, respectively. Similarly, no problems with "off-feed" or acidosis were observed by McPherson and Waldern (1969) with cows fed levels from 20 to 93% of Gaines soft white wheat in the concentrate mix and fed alfalfa hay at a rate of 1 lb to 100 lb of body weight. At the highest level, wheat intake was over 25 lb/cow/day. It seems reasonable to conclude that wheat can be incorporated in a nutrition scheme for dairy cows; however, some management factors are important in successful use of large amounts of wheat in dairy rations. In our protocol a 5-day adaptation period was used to bring cows up to 100% of each respective ration when ration changes were made. Also, sodium bicarbonate and magnesium oxide were added to the concentrate mixtures (Table 1) to prevent digestive disorders.

Milk yield declined as the amount of wheat in the concentrate increased (Table 2). However, milk yield of cows in their second or greater lactation was still sustained at a high production level, i.e., 78.3 lb/day, even when fed the concentrate mixture with 80% wheat. Milk yield of the control group was 82.1 lb/day. Cows in their first lactation averaged 49.0 lb/day when fed the high-wheat ration, compared to 51.6 lb/day for controls. Similarly, Cunningham et al. (1970) reported

Table 2. Feed intake and milk yield by cows.

Item	Percent Wheat in Mix			
	0	40	60	80
DM Intake, lb/day				
Concentrate mix	25.0	23.1	22.6	21.9
Hay	19.4	17.7	17.0	17.2
Total	44.0	40.8	39.6	39.1
Protein Intake				
Total protein, lb/day	7.26	6.60	6.47	6.40
TP, % of NRC req.	117	110	110	111
Milk Yield				
Milk, lb/day[a]	66.9	65.5	65.1	63.7
Fat test, %[b]	2.82	2.74	2.53	2.56
Protein, %	2.74	2.78	2.82	2.83

[a]Linear trend approaching statistical significance ($P < .08$).
[b]Significant linear trend ($P < .006$).

that cows produced less milk when soft red winter wheat comprised 66.7% of a concentrate mix than when it was 33.3% of the mixture. In contrast, McPherson and Waldern (1969) reported that milk production was similar for cows fed concentrate mixtures containing 20 to 93% Gaines soft white wheat. In our trial, milk fat test declined linearly as the percentage of wheat in the concentrate mixture increased (Table 2). The reason for the decline is not known; however, fat test was low for all the groups. This presumably was due to the total ration being lower in fiber than is needed to maintain normal milk fat content. The rations were calculated to contain 17% crude fiber on a dry basis, but the alfalfa hay used in the experiment was higher in quality than assumed in the calculations making total fiber content of the ration lower than expected. The percentage of concentrate in the ration consumed, i.e., about 56% on a dry basis, was within acceptable limits for dairy cow rations. Milk protein did not differ among treatments.

An economic analysis was performed to determine whether or not wheat can be used to an advantage in formulating rations for dairy cows under the conditions existing in our trial. Less feed was consumed when wheat was included in the concentrate mixtures; therefore, reduced intake of both alfalfa hay and concentrate was considered. The daily ration ingredient cost per animal declined from $2.70 for cows consuming the control ration without wheat to $2.26 for cows fed the concentrate with 80% wheat. In our trial the highest return over feed ingredient costs was for the group fed the concentrate mixture containing 40% wheat (Table 3). The decline in milk yield and fat test of cows fed concentrate mixes containing 60 and 80% wheat was such that with current prices for other ingredients (Jan '86), wheat would need to be valued at about $4.75/cwt to produce equal returns over feed cost. However, with

Table 3. Economics of feeding wheat with alfalfa hay as the only forage.

Item	Wheat in Conc. Mix			
	0	40	60	80
Amount of milk, lb/day	66.9	65.5	65.1	63.7
Value of milk produced per day, $[a]	7.54	7.30	7.04	6.92
Feed ingredient costs[b]				
Conc. mix, $/100 lb	6.44	6.21	6.08	6.00
Alfalfa hay, $/100 lb	4.00	4.00	4.00	4.00
Daily ration consumed, $	2.70	2.43	2.32	2.26
Return per day over feed costs, $[a,b]	4.84	4.87	4.72	4.66
Price needed for same return as with control ration				
Conc. mix, $/100 lb			5.60	5.26
Wheat, $/100 lb			4.82	4.70

[a]Milk priced at $12.36/cwt for 3.5%, with 16¢ differential.
[b]With wheat @ $5.62, corn @ $5.74, cottonseed meal @ $9.25, and oats @ $5.90/cwt (Jan. 22, 1986).

Table 4. Responses of cows fed experimental rations.

Item	Percent Wheat in Mix			
	0	40	60	80
Weight change, lb/4-wk period	7.8	-5.5	24.1	30.6
Condition score change	0.07	0.15	-0.28	-0.10
Ruminal fluid pH[a]	6.65	6.42	6.41	6.09

[a]Significant linear trend ($P<.05$).

corn priced at $6.40/cwt and cottonseed meal at $8.44/cwt as they were in March '85, it would be economically feasible to use wheat priced around $5.30/cwt. Also, if one assumes that with adequate fiber in the ration no depression in fat test would occur and milk yield would be the same as observed in our experiment, it can be calculated that feeding wheat would be profitable at all the different levels with current feed ingredient prices.

The amount of wheat in the ration had no effect on body weight and condition score changes (Table 4). However, ruminal pH was lower in cows fed the different levels of wheat than in those fed the control ration. Nevertheless, the pH values were well above the level generally observed to be associated with problems of digestive disorders or "off-feed" in cows fed large amounts of grain.

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Feed Intake Effects on Egg Quality of Nonstressed and Heat Stressed Layers

R. Vasquez[1] and R.G. Teeter[2]

Story in Brief

The effects of feed intake and environment on 5 egg quality parameters were estimated by force feeding layers housed under thermoneutral (24 C) and heat stressed (35 C) environments. Feed intake levels evaluated included 70, 85, 100 and 115% of thermoneutral ad libitum consumption. Heat stress depressed egg weight (3.2%), shell weight (7.4%), shell thickness (9.3%), specific gravity (1%) and albumin height (11.2%). Increasing feed consumption of heat stressed layers by force feeding increased egg weight (2.6%), shell weight (.4%), shell thickness (.7%), specific gravity (.2%) and albumin height (8.7%). However, layer mortality increased linearly with intake. Layers housed in a thermoneutral environment force fed at the 70% ad libitum consumption level had reduced egg weight (5.0%) and albumin height (13%) while other parameters remained nearly constant. Increasing feed intake of thermoneutral layers to 115% ad libitum was without effect. Data indicate that increasing feed consumption of heat stressed layers enables partial recovery of egg quality.

(Key Words: Layers, Heat Stress, Egg Quality, Feed Intake.)

Introduction

Environmental factors are well known to influence egg shell quality. Heat stress and feed intake have been of particular interest in the past decades. Shell quality and feed consumption decline when ambient temperature is increased above the zone of thermoneutrality. This decline is in part due to a decline in feed consumption and to the physiological changes that the birds undergo during heat stress.

The present study was initiated to investigate the effects of four different levels of feed intake at two environmental temperatures on egg quality parameters.

Materials and Methods

In this study, 151 72-wk old shaver layers were obtained from a commercial producer and placed in individual metabolism cages in two environmental chambers. Birds in each chamber were divided in five different groups. Birds were assigned to each treatment in a completely randomized design. Birds were allowed to adapt to the chambers for a period of 8 days, and fed a basal diet during which test values were obtained for all the egg quality parameters. During this period one chamber was maintained at a constant 24 C with 55% relative humidity (RH), while the ambient temperature of the other chamber was increased daily until it reached 36 C with 55% RH. Both chambers were kept under 16 hour timed lighting. A different dietary level was then force fed to

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[1]Graduate Assistant [2]Associate Professor

Table 1. Composition of basal diet.

Ingredient	% of diet
Ground corn	59.5
Soybean meal	21.0
Calcium carbonate	8.4
Alfalfa	2.5
Dicalcium phosphate	2.6
Salt	.5
Vitamin Pre-mix	.35
D-L-methionine	.10
Trace minerals	.05
Fat	5.0

each group in both chambers for a period of 10 days. Control groups were fed basal diet (Table 1) ad libitum, while the other groups were force fed at 70, 85, 100 and 115% of what the ad libitum feed consumption was for the control group at thermoneutral conditions. Force feeding was accomplished by inserting a tygon tube into the bird's crop, and delivering the required amount of feed. This amount was determined by weighing the force feeding gun before and after delivery of the feed (Teeter et al., 1984). Birds were force fed three times daily during the trial.

Feed consumption, body weight, egg weight, specific gravity, albumin height, shell weight, shell thickness and mortality data were recorded during the experimental period.

Results and Discussion

The effects of environment on the parameters studies on birds fed ad libitum are summarized in Table 2. In this study, birds fed ad libitum and exposed to heat stress reduced feed intake by approximately

Table 2. Egg quality on birds fed ad libitum.

	24 C	35 C
Feed intake (% body wt)	7.800[a]	5.470[b]
Body wt change (g)	38.300[a]	-42.100[b]
Egg weight (g)	65.423[a]	62.598[b]
Shell weight (g)	8.338[a]	7.765[b]
Specific gravity	1.079[a]	1.065[b]
Albumin height (mm)	5.650[a]	4.553[b]
Shell thickness (mm)	0.014[a]	0.012[b]

[a,b]Means within a row with unlike superscripts significantly differ ($P<.05$).

30% ($P<.05$). As a result layers under thermoneutral environment gained weight as compared with layers under heat stress who lost weight significantly. Equalizing feed intake across the 2 environmental temperatures resulted in the layers within the heat stress environment gaining significantly more body weight (Figure 1). Equalizing feed intake at 5.5% resulted in depressed egg weight at both environmental temperatures. Increasing feed intake to thermoneutral ad libitum consumption level significantly ($P<.05$) enhanced egg weight. This enhancement was maintained through 115% of ad libitum consumption within the thermoneutral environment. However, increasing feed consumption to the 115% level in the birds under heat stress significantly ($P<.05$) depressed egg weight (Figure 2). Increasing feed intake within both environments did not

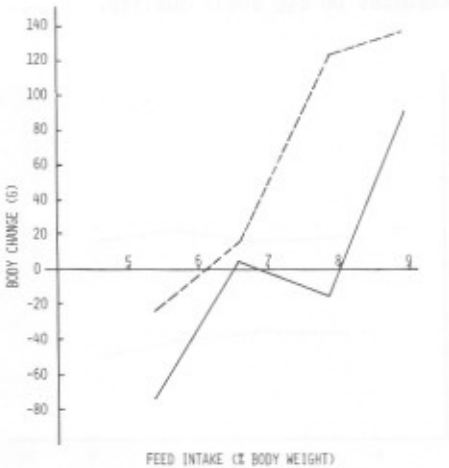


Figure 1. Body change.

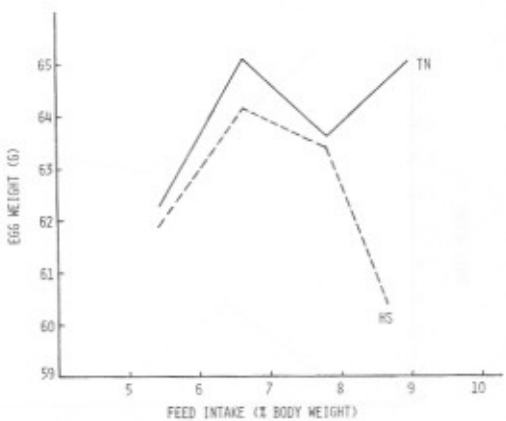


Figure 2. Egg weight.

have an effect on shell thickness (Figure 3) or shell weight (Figure 4). Specific gravity, on the other hand, was significantly ($P<.05$) elevated when birds under heat stress environment were fed at 115% level (Figure 5). Albumin height (Figure 6) was highly and positively correlated with different levels of feed intake in both thermoneutral and heat stressed environments.

These results indicate that increasing feed intake above ad libitum tends to increase egg quality on layers housed under heat stressed environments. At thermoneutral environment, reducing feed intake by 15% did not have any adverse results on egg quality, suggesting that limiting feed intake of birds housed under thermoneutral environment might be of value. However, long term studies would be necessary to determine the influence of feed intake on overall egg production, and the effect of egg production responses on egg shell quality.

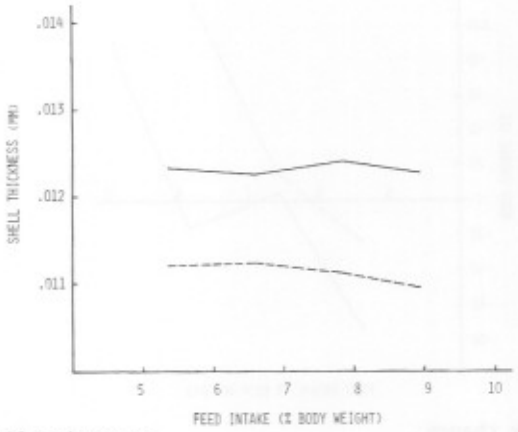


Figure 3. Shell thickness.

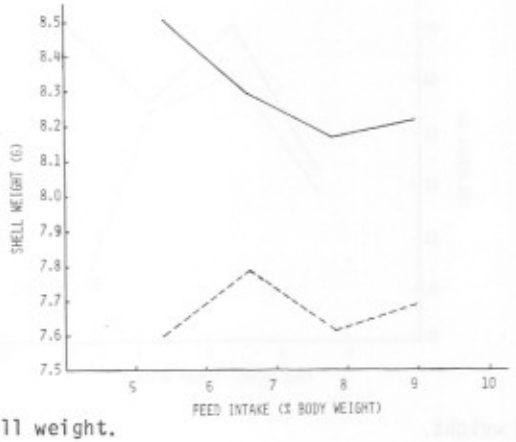


Figure 4. Shell weight.

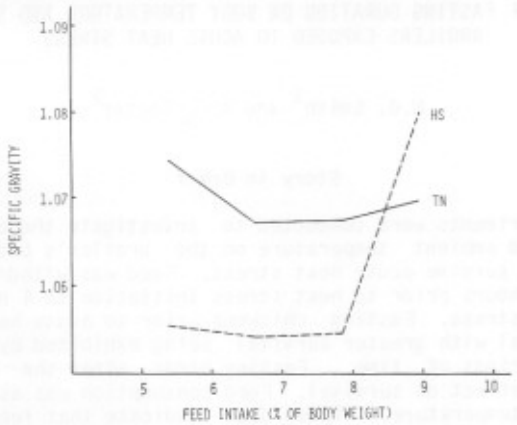


Figure 5. Specific gravity.

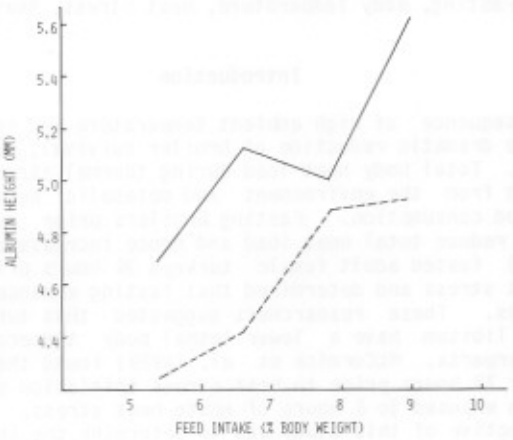


Figure 6. Albumin height.

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INFLUENCE OF FASTING DURATION ON BODY TEMPERATURE AND SURVIVAL OF BROILERS EXPOSED TO ACUTE HEAT STRESS

M.O. Smith[1] and R.G. Teeter[2]

Story in Brief

Two experiments were conducted to investigate the effect of feed consumption and ambient temperature on the broiler's body temperature and ability to survive acute heat stress. Feed was withdrawn at various times from 24 hours prior to heat stress initiation to 4 hours after the onset of heat stress. Fasting chickens prior to acute heat stress increased survival with greater survival being exhibited by birds fasted for longer periods of time. Fasting birds after the onset of heat stress had no effect on survival. Feed consumption was associated with elevated body temperature. These data indicate that feed restriction from 0 to 24 hours prior to the onset of life threatening acute heat stress reduces mortality, while feed restriction after the onset of acute heat stress has limited value.

(Key Words: Fasting, Body Temperature, Heat Stress, Survival.)

Introduction

One consequence of high ambient temperature and relative humidity stress is the dramatic reduction of broiler survival, presumably due to hyperthermia. Total body heat load during thermal stress is a combination of heat from the environment and metabolic heat produced as a result of food consumption. Fasting broilers prior to or during heat stress could reduce total heat load and hence increase survival. Kohne et al. (1973) fasted adult female turkeys 24 hours prior to the onset of acute heat stress and determined that fasting enhanced survival time by 10 minutes. These researchers suggested that turkeys with feed available ad libitum have a lower lethal body temperature than their fasted counterparts. McCormick et al. (1979) found that chicks fasted for 24, 48 or 72 hours prior to heat stress initiation showed increased survival when exposed to 6 hours of acute heat stress.

The objective of this study was to determine the influence of feed withdrawal time on body temperature and survival of broiler chickens exposed to acute heat stress.

Materials and Methods

Arbor Acre x Vantress chicks were raised on rice hull litter and fed a corn-soybean meal starter diet for the first six weeks post-hatching. On the first day of the sixth week, birds were sexed, weighed and randomly allotted to treatments within an environmental chamber under continuous lighting. Six chicks (3 males, 3 females) were housed in each wire floored battery compartment and compartments were randomly assigned to treatment groups (10 replicates per treatment). Week six

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was used to adapt birds to test rations (Table 1) and to gradually alter environmental conditions to cycle between 26.6 and 35 C. These growth-limiting conditions were maintained until the first day of week seven, when the upper limit of the cycling temperature was increased to 38.8 C such that survival was threatened. Water consumption from a continuously available common source was monitored. Body temperature was monitored by inserting the probe of an electronic thermometer into the cloaca for 30 seconds.

The first experiment evaluated the relationship between fasting duration prior to stress initiation and the chicken's ability to survive acute heat stress. Birds were fasted for 24, 12, 6 or 0 hours prior to life threatening heat stress (38.8 C and 55% relative humidity). Percent survival, feed consumption and water consumption were recorded for 24 hours after the initiation of heat stress.

In order to further define the effect of feed withdrawal on broiler survival, additional fasting times were evaluated in the second experiment. Feed was removed at 12, 6 and 3 hours prior to the onset of heat stress, at heat stress initiation, and at 2, 3 and 4 hours after. Body temperature was measured at 3 hours before the onset of heat stress and at 2 and 4 hours after. Percent survival, feed consumption and water consumption were monitored as before.

Table 1. Composition of the grower ration used in experiments 1 and 2.

Ingredient	Numerical Name[1]	%
Ground Corn	4-02-931	57
Soybean Meal (44%)	5-04-604	22
Fish Meal (Menhaden)	5-02-009	9
Tallow	4-08-127	5
Ground Alfalfa	1-00-023	2.7
Dicalcium Phosphate	6-01-080	2.5
Calcium Carbonate	6-01-069	.9
Vitamin Mix[2]	--	.4
Salt	6-14-013	.3
Trace Mineral Mix[3]	--	.1
D-L-Methionine	--	.1

[1]Atlas of Nutritional Data on United States and Canadian Feeds.

[2]Mix contained Vit. A, 3,527,360 I.U.; Vit D_3, 1,322,760 I.U.; Vit E, 11,905 I.U.; Vit B_{12}, 3.5 mg; Riboflavin 2,205 mg; Niacin 6614 mg; d-Panthothenic Acid, 7055 mg; Choline, 176,368 mg; Menadione, 291 mg; Folic Acid, 441 mg; Pyridoxine, 882 mg; Thiamine, 882 mg; d-Biotin, 44 mg per Kg.

[3]Mix contained Manganese, 12.0%; Zinc, 8.0%; Iron, 6.0%; Copper, 1.0%; Iodine, .1%; Calcium, 18%.

Results and Discussion

Fasting birds prior to acute heat stress increased survival (Table 2). The earlier the time of fasting commenced, the greater the survival in both experiments. Feed consumption (Table 3) was invariably greater when feed continued to be present. Thus, though broilers will reduce

Table 2. Effects of feed withdrawal time on broiler ability to survive acute heat stress (experiments 1 and 2).

Time of feed withdrawal relative to stress initiation[1]	Ambient temperature at feed withdrawal	Survival (%) Experiment 1	Survival (%) Experiment 2
not withdrawn	--	51.6^{b}	45.2^{d}
4 hr after	38.8	--	48.7^{cd}
3 hr after	36.6	--	49.0^{cd}
2 hr after	35.0	--	48.7^{cd}
0	32.2	--	60.2^{bc}
3 hr before	26.7	--	67.7^{ab}
6 hr before	26.7	80.0^{a}	70.0^{ab}
12 hr before	26.7	86.7^{a}	81.7^{a}
24 hr before	26.7	92.0^{a}	--

[1]Heat stress was defined as an environment providing 32.2 C and 55% relative humidity.

[abcd]Means within an experiment with unlike superscripts differ ($P<.05$).

Table 3. Effects of feed withdrawal time on broiler feed and water consumption 24 hr prior to acute heat stress exposure.

Duration of Feed withdrawal Relative to Stress Initiation[1]	Cumulative Feed Consumption (g)/chick Exp. 1	Cumulative Feed Consumption (g)/chick Exp. 2	Cumulative Water Consumption (g)/chick Exp. 1	Cumulative Water Consumption (g)/chick Exp. 2
not withdrawn	192^{a}	181^{a}	1021	820
4 hr after	--	133^{b}	--	705
3 hr after	--	117^{b}	--	673
2 hr after	--	113^{b}	--	688
0	--	100^{bc}	--	620
3 hr before	--	85^{bc}	--	537
6 hr before	117^{b}	71^{bc}	643	560
12 hr before	67^{c}	42^{c}	545	567
24 hr before	0^{d}	--	454	--

[1]Heat stress was defined as an environment providing 32.2 C and 55% relative humidity.

[abcd]Means within a column with unlike superscripts differ ($P<.05$).

feed consumption in response to long-term heat stress, their ability to adapt to acute stress appears limited. Voluntary water consumption decreased with increasing fasting time and also with reduced feed consumption, despite its continuous availability. Feed consumption was associated with elevated body temperature (Table 4) and appeared additive with high environmental temperature.

The data reported in this study suggest that feed consumption and elevated ambient temperature increase body temperature of broilers and that the effects of feed consumption and high environmental temperature on body temperature are additive. Although it appears that fasting lowers body temperature, reduces water consumption and increases the ability of broiler chickens to survive acute heat stress, it must be recognized that other metabolic alterations such as ketoacidosis may be involved.

Table 4. Effects of feed withdrawal on broiler body temperature (C) in experiment 2.

Time of Feed withdrawal relative to stress initiation	Body temperature measurement relative to heat stress[1]		
	3 hr before	2 hr after	4 hr after
not withdrawn	40.3^{fg}	41.3^{cd}	42.6^{a}
4 hr after	40.2^{g}	41.3^{cd}	42.5^{a}
3 hr after	40.2^{g}	41.3^{cd}	42.4^{a}
2 hr after	40.4^{efg}	40.7^{e}	41.7^{b}
0 hr	40.3^{fg}	40.6^{ef}	41.7^{b}
3 hr before	40.3^{hi}	40.6^{efg}	41.6^{bc}
6 hr before	39.8^{i}	40.4^{gh}	41.2^{d}
12 hr before	39.6^{i}	40.1^{gh}	40.6^{ef}

[1]Chamber surroundings 3 hr before, 2 hr after and 4 hr after the onset of acute stress were 26.7, 35 and 38.8 C respectively with relative humidity maintained at 55%.

^{abcdefghi}Means with unlike superscripts differ ($P<.05$).

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EFFECT OF ALTERING THE RATIO OF DRY ROLLED CORN TO HIGH MOISTURE HARVESTED SORGHUM GRAIN ON SITE AND EXTENT OF STARCH DIGESTION IN HEIFERS

M.N. Streeter[1], D.G. Wagner[2], C.A. Hibberd[3], and M.R. Putnam[4]

Story in Brief

Dry rolled corn and high moisture harvested sorghum grain were fed in diets of 100% dry rolled corn, 75:25, 50:50, 25:75 and 100% high moisture sorghum grain to determine their effect on site and extent of starch digestion. Diets were fed at 2% of body weight (dry basis) in a 5x5 Latin square using Hereford-Angus heifers (693 lb) equipped with ruminal, duodenal and ileal T-type cannulae. Total tract starch digestibility decreased linearly with more high moisture sorhgum grain. Starch disappearance (g/day) from the rumen decreased quadratically with more high moisture sorghum grain (average of 82.7% across all blends). No difference was noted at the ileum (86.2%). Starch digestion in the small intestine was low for all diets, averaging only 21.4% of starch entry and 3.8% of starch intake. As in the rumen, fermentation of starch in the large intestine decreased linearly with more high moisture sorghum grain. Quantitatively, the large intestine was a more important site of disappearance than the small intestine (4.8% vs 3.8% of starch intake). The greatest benefit of blending may be reduced processing, decreasing ration cost.

(Key Words: Sorghum Grain, Corn Blends, Starch Digestibility)

Introduction

High moisture sorghum grain (HMS) deserves consideration as an energy source in feedlot diets because of increasing sorghum production, the rising cost of grain processing and declining production of irrigated corn. Blending of high moisture and dry grains does occur, but price rather than digestibility or cattle performance usually dictates the ratio between grain types. Little work has been conducted to determine the effect of blending dry and high moisture grains on site and extent of starch digestion, although speculation has been great based on indicated improvements in animal performance. A combination of fermentable high moisture sorghum and dry coarsely rolled corn (DRC) may maximize starch fermentation in the rumen, digestion in the small intestine and digestion in the total tract while minimizing fermentation in the large intestine. No work exists using blends of dry coarsely rolled corn and high moisture harvested sorghum. The objective of this study, therefore, was to determine the effects of altering the ratio of dry coarsely rolled corn to high moisture harvested sorghum grain on site and extent of starch digestion.

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Materials and Methods

Five diets (Table 1) were created using ground high moisture harvested sorghum grain (HMS) and dry rolled corn (DRC). Blends of DRC:HMS were 100% DRC, 75:25, 50:50, 25:75 and 100% HMS (DM basis), denoted as 0, 25, 50, 75 and 100, respectively. Initial analyses indicated urea could not be used as the only nitrogen supplement. Therefore, soybean meal was added at equal levels to all diets, and urea used to balance for crude protein.

Blends were fed twice daily at 2% of body weight (DM basis) to five Hereford-Angus heifers (693 lbs), fitted with ruminal, duodenal, and ideal T-type cannulae. A 5x5 Latin square was used with periods lasting 10 days. Days 1 through 7 were for adaptation and days 8 through 10 were for digesta and fecal sample collection. Feed samples were ground through a 1 mm screen in a Udy mill, using dry ice to facilitate grinding, and stored at -20 C prior to analyses. Digesta and fecal samples were dried using a lyophilizer prior to grinding through a 1 mm screen in a Udy mill. Samples were analyzed for all or part of the following: dry matter, starch (glucose polymers), crude protein, sodium chloride soluble nitrogen, pepsin insoluble nitrogen and chromium. Starch digestibility was determined by chromic oxide ratios. Orthogonal polynonials were used to determine the relationship between least squares means of blends.

Results and Discussion

Starch ($P < .10$), crude protein ($P < .05$) and pepsin insoluble nitrogen ($P < .01$) content of the complete mixed feeds responded quadratically with less DRC (Table 2). Sodium chloride soluble nitrogen

Table 1. Ration composition of experimental diets.

	DRC:HMS				
Ingredient (%DM)	0	25	50	75	100
Dry rolled corn	83.2	62.6	41.8	20.9	0.0
High moisture sorghum	0	20.8	41.8	62.7	83.8
Cottonseed hulls	8.0	8.0	8.0	8.0	8.0
Soybean meal	5.2	5.2	5.2	5.2	5.2
Urea	1.0	.87	.76	.65	.53
Supplement					
Dicalcium phosphate	.44	.44	.44	.44	.44
Calcium carbonate	.93	.93	.93	.93	.93
Potassium chloride	.57	.57	.57	.57	.57
Sodium sulfate	.17	.14	.13	.11	.09
Trace mineral salt	.25	.25	.25	.25	.25
Chronic oxide	.20	.20	.20	.20	.20
Vitamin A (IU/kg)	2200				

Table 2. Chemical characteristics of grains and feeds.

Item	DRC:HMS 0	25	50	75	100
Grain					
Starch	78.5				84.0
Crude protein	9.5				9.8
NaCL soluble nitrogen[a]	13.9	23.3	36.8	50.7	61.8
Pepsin insoluble nitrogen[b]	14.2	13.2	10.5	8.7	6.7
Feed					
Starch[c]	66.5	65.7	65.8	66.5	71.0
Crude protein[d]	12.8	14.0	13.8	13.4	12.9
Nacl soluble nitrogen[a]	37.6	39.9	43.7	52.8	51.4
Pepsin insoluble nitrogen[e]	12.3	11.1	9.2	10.2	8.8

[a]Cubic (P<.05).
[b]Linear (P<.01).
[c]Quadratic (P<.10).
[d]Quadratic (P<.05).
[e]Quatric (P<.01).

content of the complete mixed feeds increased (P<.05) cubically with more HMS. High moisture harvesting of grains generally causes an increase in sodium chloride soluble nitrogen and a decrease in pepsin insoluble nitrogen (PIN) level.

Total tract starch digestiblity (Table 3) tended to decrease (P<.10) linearly with more HMS. Although a statistical linear decline was observed, total tract starch digestiblity appeared to remain relatively constant through blend 50 (92.4, 92.4, 93.0, 89.5 and 88.2 on 0, 25, 50, 75 and 100%, respectively) and decline with higher levels of HMS. Reports for blends of high moisture and dry rolled corn have generally suggested improved performance with more high moisture corn. However, comparisons between DRC:HMS blends and corn blends are probably not valid due to physical and chemical differences between corn and sorghum grains.

Starch digestion (% of entry) in the rumen did not appear to be influenced by the level of HMS. An increase in starch digestion in the rumen may have been anticipated with a high moisture grain based on information obtained with other processing methods. However, differences in the type of grain (corn vs sorghum) were probably an important factor. Since starch intake increased somewhat with more HMS, ruminal starch disappearance values on a percentage basis are perhaps hard to interpret; therefore, the actual amount of starch disappearing (g/d) from the rumen may be a better indicator of digestion. Starch disappearance (g/d) from the rumen increased (P<.05) quadratically with the inclusion of HMS in the blend, suggesting the occurrence of some associative effects between DRC and HMS. Associative effects may be caused by changes in the solubility of DRC and HMS proteins, altering starch availability.

Table 3. Site and extent of starch digestion of DRC:HMS blends.

Item	0	25	50	75	100
Starch intake (g/day)	4136	4079	4138	4204	4495
Starch disappearance (Rumen)					
g/day[a]	3542	3371	3476	3316	3709
% of intake	85.6	82.6	84.0	78.9	82.5
Starch disappearance (Ileum)					
% of intake	85.6	88.0	87.5	83.9	86.1
% of total tract	93.4	95.3	94.1	93.6	97.6
Starch disappearance (SI)					
g/day	71.2	220.3	140.1	209.3	161.5
% of entry	13.4	32.6	13.8	24.6	22.6
% of intake	1.7	5.4	3.4	5.0	3.6
Starch disappearance (LI)					
g/day	250.6	178.5	227.4	238.4	93.8
% of entry[b]	53.8	38.4	43.0	22.8	9.4
% of intake	6.1	4.4	5.5	5.7	2.1
Starch disappearance (Total tract)					
g/day	3823.7	3769.4	3847.8	3764.4	3964.5
% of intake	92.4	92.4	93.0	89.5	88.2

[a]Quadratic ($P<.05$).
[b]Linear ($P<.05$).
[c]Linear ($P<.10$).

Starch disappearance through the ileum (% of intake) did not differ statistically with increasing HMS, averaging 86.2%. Starch digestion (% of total tract disappearance) was nearly complete (94.8%) at the ileum.

Starch digestion in the small intestine, like digestion through the ileum, did not respond statistically to increasing levels of HMS. Starch digestion, therein, averaged a low of 21.4% of starch entering the small intestine. Quantitatively, the rumen (82.7% of starch intake) was a much more important site of digestion than the small intestine (3.8% of starch intake). Starch digestion in the small intestine may have been limited by extensive digestion in the rumen, resulting in only that starch deeply imbedded in protein matrix being presented to the small intestine for digestion.

Fermentation of starch in the large intestine (% of entry) declined ($P<.05$) linearly, with more HMS, from 53.8% (100% DRC) to 9.4% (100% HMS), representing from 6.1% to 2.1% of total starch consumption. Decreased starch fermentation in the large intestine may have been caused by more protein matrix and lower protein solubility in the sorghum grain. Quantitatively, the large intestine was a more important site of starch digestion (average of 4.8% of total starch intake) than the small intestine (3.8%). From an energetic standpoint, starch digested in the small intestine would be more efficient to the animal, while starch fermentation in the large intestine may result in an energy loss in the form of undigested microbial organic matter.

Microbial fermentation in the rumen and large intestine appeared to be more responsive to the ratio of DRC to HMS than digestion in the small intestine. These results suggest that HMS can be included in a blend; however, starch digestion appeared to decline especially when HMS represented 75% or more of the grain. One of the greatest benefits of blending may be economic. If processing costs can be reduced for a portion of the ration, while performance is improved or maintained, the cost of gain should be reduced. Further studies with other blends may be beneficial in improving digestibility and performance, while decreasing ration costs.

IN VITRO DRY MATTER DISAPPEARANCE AND IN VITRO GAS PRODUCTION OF SORGHUM GRAIN VARIETIES

M.N. Streeter[1], D.G. Wagner[2], C.A. Hibberd[3] and D.S. Buchanan[4]

Story in Brief

Dwarf Redlan, 1133, Darset and millrun sorghum grain varieties were finely ground prior to determination of composition, in vitro dry matter disappearance and in vitro gas production. Dwarf Redlan is a non-bird resistant sorghum grain with a waxy endosperm. Darset and 1133 are bird resistant-high tannin varieties differing in endosperm, Darset having a normal and 1133 a waxy endosperm. Millrun was a commercially purchased non-bird resistant sorghum with a normal endosperm. In vitro dry matter disappearance was determined to assess differences between sorghum varieties and the inhibitory influence of tannin on rumen microbes. Mean in vitro dry matter disappearance values were lower (36.4%) when rumen fluid was obtained from a heifer consuming Darset (high tannin) sorghum than when obtained from a heifer consuming millrun sorghum (40.9%). Averaged across rumen fluid source, 1133 (35.4%) and Darset (30.9%) bird resistant varieties were less digestible than non-bird resistant Dwarf Redlan (44.3%) and millrun (44.0%). In vitro gas production (12 hours) further suggests that starch in non-bird resistant varieties, Dwarf Redlan (85.1 ml gas/g dry matter) and millrun (77.2), is more available to enzymatic degradation than in bird resistant varieties, 1133 (65.2) and Darset (52.2). A waxy endosperm appears to enhance in vitro dry matter disappearance and in vitro gas production and may offer potential for partially overcoming the detrimental effects of high tannin levels.

(Key Words: Sorghum Grain, Endosperm Type, Dry Matter Disappearance)

Introduction

The importance of sorghum grain as an energy source in feedlot diets should increase as irrigated corn production declines. Declining water tables, increasing costs of irrigation and increasing water demands in the High Plains should make sorghum an increasingly important feed grain. Sorghum grain varieties differ greatly in physical characteristics, digestibility and resulting animal performance. Identification and production of nutritionally improved sorghum varieties will result in improvements in feeding value. The following study was conducted to identify differences in in vitro dry matter disappearance and in vitro gas production of four widely divergent sorghum grain varieties.

Materials and Methods

Dwarf Redlan (Dwf), 1133 and Darset (Dar) pureline sorghum grain

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varieties were grown under dryland conditions at the Perkins Agronomy Experiment Station, Perkins, OK. A fourth, millrun (Mr), was purchased commercially through the OSU feedmill. Origin and genetic background of the Mr were unknown, but appeared representative of that normally purchased on a commercial basis (normal endosperm, non-bird resistant). Observable physical characteristics are listed in Table 1.

Grains were analyzed for dry matter, crude protein, starch, tannin (catechin equivalents/g DM), sodium chloride soluble and pepsin insoluble nitrogen. In vitro dry matter disappearance (IVDMD) was determined using 1 g of grain which had been ground through a 20 mesh (1mm) screen in a laboratory Wiley mill. Ruminal fluid was obtained from two different heifers in each of four replications. One heifer consumed a bird resistant sorghum grain (Dar), the other a non-bird resistant sorghum grain (Mr). Varities were incubated in each fluid to determine if microbial populations differed in their ability to digest grain due to high tannin diets.

In vitro gas production (IVGP) of the grains was determined by measuring the CO_2 produced when 1 g of grain was incubated with .25 g of commercial baker's yeast and 10ml of a 0.1% (w/v) amyloglucosidase solution at 39 C. Gas production measurements were made hourly from 0 to 6 h and at 12 h after initial incubation. Gas productions at 6 and 12 h are presented.

Results and Discussion

The protein and starch contents of the grains are shown in Table 2. Significant differences ($P< .01$) in protein were noted. Darset (72.1%) contained the least, Mr (78.8%) the greatest, and 1133 (76.4%) and Dwf (77.1%) intermediate amounts of starch. Condensed tannin content of bird resistant grains was greater ($P< .01$) than for non-bird resistant varieties. Sodium chloride soluble nitrogen was highest for non-bird resistant varieties. Moreover, waxy bird resistant 1133 (4.3%) had a greater soluble nitrogen content than normal bird resistant Dar (2.1%). Waxy endosperm may cause an increase in protein solubility,

Table 1. Descriptive characteristics of sorghum grain.

			- Endosperm -		
Sorghum variety	Abbreviation	Pericarp color	Color	Starch type	Testa layer[a]
Dwarf Redlan	Dwf	red	white	waxy	absent
1133	1133	brown	yellow	waxy	present
Darset	Dar	brown	white	normal	present
Millrun	Mr	mixed	non-descript	normal	absent

[a]Presence of a testa layer indicative of high tannin content and bird resistance.

Table 2. Chemical composition of sorghum grain varieties (dry matter basis).

Item (%)	1133	Dar	Dwf	Mr
Crude Protein[abcd]	12.0	13.2	12.4	10.3
Starch	76.4	72.1	77.1	78.8
Tannin (cat.eq.1g)[e]	1.24	1.44	0.0	0.0
NaCl soluble protein	4.2	2.1	7.5	7.4
Pepsin insoluble nitrogen[bdfg]	18.3	22.0	13.3	13.8

[a]Interaction (P<.01).
[b]Dar vs Mr (P<.01).
[c]Dwf vs Mr (P<.01).
[d]1133 vs Dar (P<.01).
[e]1133 & Dar vs Dwf & Mr (P<.01).
[f]Interaction (P<.01).
[g]1133 vs Dwf (P<.01).

resulting in increased starch availability. Pepsin insoluble nitrogen (PIN) content was greater (P<.01) for Dar (22.0%) than 1133 (18.3%). Within waxy and normal varieties, the bird resistant 1133 contained more (P<.01) PIN than Dwf and Dar more (P<.01) than Mr. Condensed tannins may be responsible for or related to the increased PIN.

Sorghum varieties incubated in ruminal fluid from heifers fed a bird resistant sorghum tended to result in lower IVDMD than when the same varieties were incubated in fluid obtained from a heifer fed Mr (Figure 1; Table 3). Rumen microbes appeared to be inhibited by high tannin levels. IVDMD (averaged across fluid source), within bird resistance, was lower (P<.01) for normal Dar (30.9%) than waxy 1133 (35.4%). The branched nature of amylopectin present in waxy endosperm appears to facilitate a greater starch availability. Additionally, IVDMD for waxy Dwf (non-bird resistant) was greater (P<.01) than waxy 1133 (bird resistant). Within normal varieties, Mr (44.0%) had a greater (P<.01) IVDMD than Dar (30.9%). Condensed tannins and greater PIN appear to limit digestion of bird resistant varieties.

IVGP measured at 6 and 12 h showed similar results; therefore, only data obtained at 12 h is discussed. Bird resistant varieties, 1133 (65.2 ml gas/g DM) and Dar (52.2) produced less (P<.01) CO_2 than non-bird resistant varieties, Dwf (85.1) and Mr (77.2). Tannins and/or protein insolubility of bird resistant varieties appeared to limit enzymatic starch liberation resulting in lower gas production. Tannin may also adversely affect the yeast, inhibiting fermentation of free glucose into CO_2 and water. Varieties with a waxy endosperm (1133 and Dwf) produced more (P<.01) CO_2 than their bird resistant or non-bird resistant normal (Dar and Mr) counterparts. This further suggests that grains with waxy endosperm have greater starch availability. Moreover, the waxy trait appears to offset part of the negative influence of the bird resistant characteristic. Greater starch availability may result from increased protein solubility and/or the higher amylopectin content in waxy types.

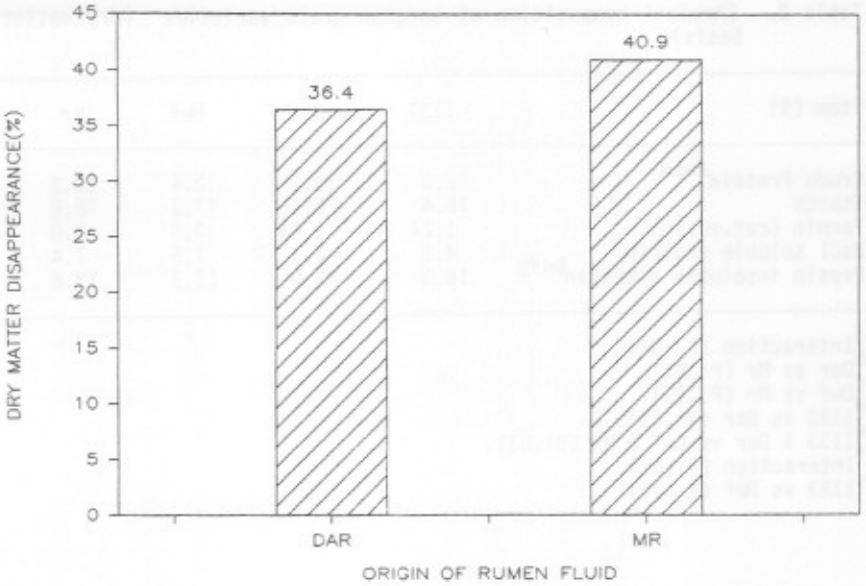


Figure 1. Comparison of fluid sources.

Table 3. IVDMD & IVGP of sorghum grain varieties.

Item	1133	Dar	Dwf	Mr
IVDMD (% averaged across variety & w/n fluid)[a]		36.4		40.9
IVDMD (% averaged across fluid)[bcde]	35.4	30.9	44.3	44.0
IVGP (ml gas/g DM)				
6h[fg]	48.4	37.5	64.9	53.5
12h[fg]	65.2	52.2	85.1	77.2

[a]Dar fluid vs Mr fluid (.10 P<.25).
[b]Interaction (P<.05).
[c]1133 vs Dar (P<.01).
[d]1133 vs Dwf (P<.01).
[e]Dar vs Mr (P<.01).
[f]1133 & Dar vs Dwf & Mr (P<.01).
[g]1133 & Dwf vs Dar & Mr (P<.01).

The bird resistant characteristic decreased both IVDMD and IVGP. Rumen bacteria appeared to be inhibited by high tannin levels under conditions of this study. Waxy endosperm may offer a useful method of partially overcoming some of the detrimental effects of the bird resistant characteristic. However, IVDMD and IVGP for 1133 (bird resistant, waxy) were still below the values obtained with the non-bird resistant sorghum grain varieties. Further study to identify the specific characteristics of bird resistant sorghum grain responsible for decreased IVDMD and IVGP and combinations of bird resistant and waxy traits may be beneficial in future improvement of sorghum grain.

THE RELATIONSHIP OF BODY COMPOSITION AND FEED INTAKE OF BEEF STEERS

J. C. Hyer[1], J. W. Oltjen[2] and F. N. Owens[3]

Story in Brief

Feed intake usually declines from a relatively constant plateau as fed cattle near slaughter weight. To investigate how this decline is related to body fat, a dynamic computer growth model was used to simulate body composition of a large group of feedlot steers for which periodic feed intake and body weight gain data were available. Feed intake decreased at lower body weights for animals put on feed at lower initial weights. However, the observed decline in intake occurred within a relatively narrow range of empty body fat (32 $\pm$ 1%) in steers regardless of initial feedlot weight. This suggests that body fat stores exert feedback control to reduce feed intake.

(Key Words: Growth Model, Empty Body Fat, Body Weight)

Introduction

So that most cattle will grade choice or above, a decline in dry matter intake is often observed as cattle near finished weight. Reduced feed intake is of concern to cattle feeders because it reduces rate of gain and efficiency. The mechanism responsible for this decline in intake is not known, although the lipostatic or "set point" theory of intake regulation suggests that animals regulate their energy intake to maintain a certain body composition. Alternatively, the ability of the rumen or intestines to expand after a meal may be limited by the presence of intraabdominal fat (McDonald et al., 1981). The objective of this research was to determine whether the decline in intake which occurs late in the feeding period of beef steers was directly related to body composition (empty body fat).

Materials and Methods

Feedlot data used in this study have been summarized in previous research (Thornton et al., 1985). From that data set, records representing 444 pens of commercial feedlot steers, primarily British and British crossbreds were used (Table 1). For analysis, pens were grouped into five classes based on initial feedlot weight. Observation of dry matter intake and body weight at 14 day intervals were used. Pens of steers with less than three observations or pens with no initial observations before thirty days on feed were excluded from the data set. A dynamic computer growth model (Oltjen, 1986) was used to simulate mean empty body fat for the average animal in each pen. Model inputs included starting feedlot weight, condition score, frame size, sex, time on feed, energy concentration of the ration, an implant factor and feed intake. An iterative computer program adjusted the energy concentration of the ration so that predicted final weight of the steers was within one pound

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Table 1. Description of beef steers by initial weight classes.

Weight Class: Item	502 Mean	502 SD	616 Mean	616 SD	709 Mean	709 SD	801 Mean	801 SD	921 Mean	921 SD
Pens	20		116		233		69		6	
Days on Feed	103	17	108	32	96	26	91	20	88	7
Weight (lb):										
Initial	502	17	616	27	709	29	801	28	921	47
Final	768	62	946	105	1003	88	1080	77	1200	54
Daily gain (lb/day)	2.54	.22	3.02	.30	3.04	.26	3.03	.33	3.13	.30

of observed weight. Adjustments were needed because pen feed intakes were greater than predicted from published equations (Thornton et al., 1985). Regression analysis was used to relate feed intake with days on feed, body weight and empty body fat.

Results and Discussion

Mean dry matter intakes as smoothed by the model for the various initial weight classes are plotted against days on feed in figure 1. In general, feed intake increased to a plateau which was higher for steers with heavier starting weights. Plateaus began at 63, 48, 45, 44, and 47 days for the 502, 616, 709, 801 and 921 weight groups, respectively. Note that the lightest weight steers (502 lb) reached a plateau much later than other groups. After the initial plateau, intake remained relatively constant until late in the feeding period at which time intake declines were noted for all groups except the 502 lb group. Feed intake declined with fewer days on feed for steers with heavier initial weights. To adjust for these weight differences, intakes are also plotted against body weight (Figure 2). Steers with lighter starting weights tended to reach intake plateaus at lighter weights. The decline in feed intake also occurred at lighter weights for steers with lighter initial weights.

The relationship between empty body fat calculated from the model of Oltjen (1986) and feed intake is shown in figure 3. Intakes for all groups except the 502 lb group declined within a narrow range of

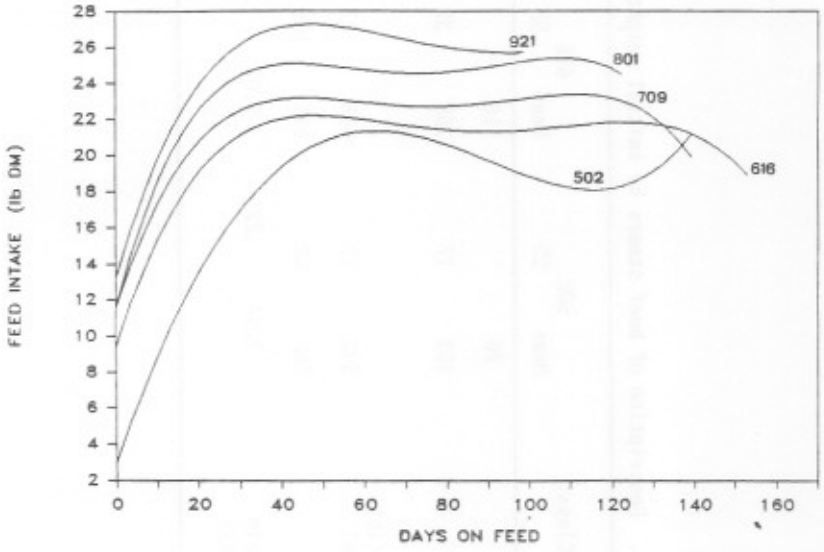


Figure 1. Relationship between feed intake and days on feed for different initial weight classes.

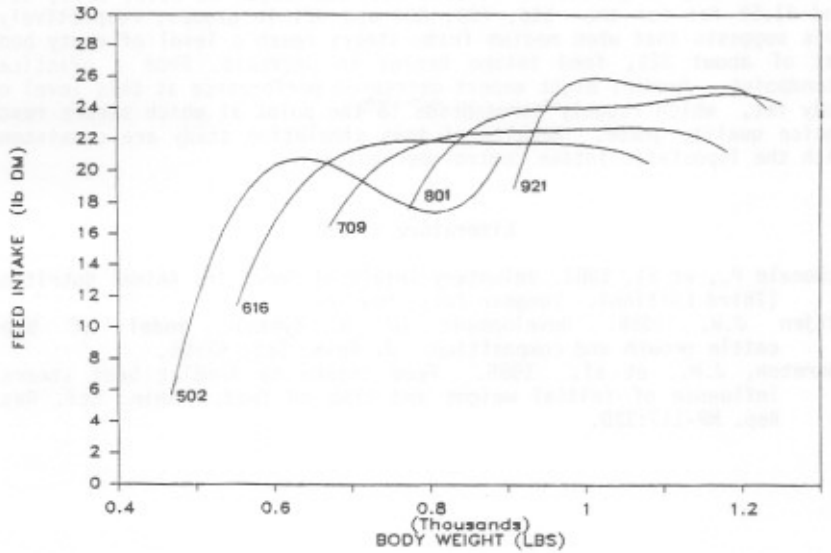


Figure 2. Relationship between feed intake and body weight for different initial weight classes.

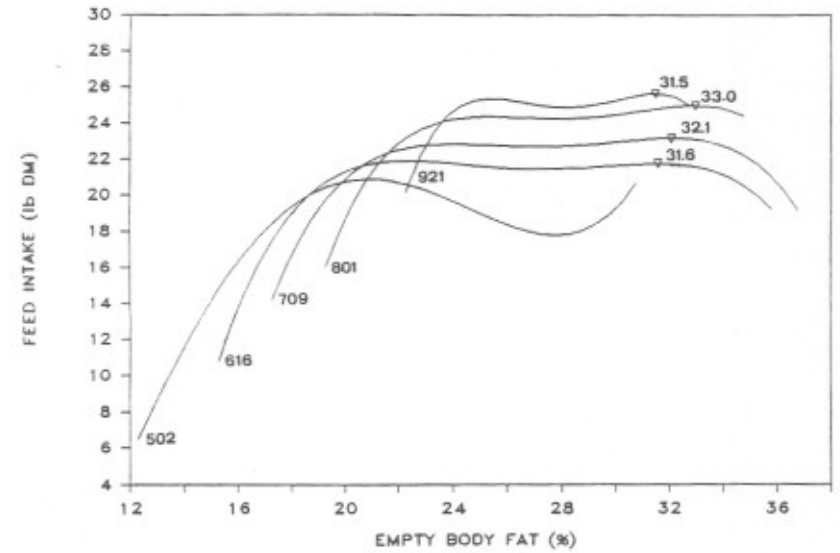


Figure 3. Relationship between feed intake and predicted empty body fat for different initial weights classes. Empty body fat at feed intake decline given by ▽.

predicted body composition. Intake declines began at 31.6, 32.1, 33.0 and 31.5% fat for the 616, 709, 801 and 921 lb groups, respectively. This suggests that when medium frame steers reach a level of empty body fat of about 32%, feed intake begins to decrease. From a practical standpoint, feeders might expect decreased performance at this level of body fat, which roughly corresponds to the point at which steers reach choice quality grade. Results of this simulation study are consistent with the lipostatic intake control mechanism.

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BEEF CATTLE FEED INTAKE AND GROWTH: APPLICATION OF AN EMPIRICAL BAYES DERIVATION OF THE KALMAN FILTER APPLIED TO A NONLINEAR DYNAMIC MODEL

J. W. Oltjen[1] and F. N. Owens[2]

Story in Brief

The empirical Bayes derivation of the Kalman filter has been applied to a nonlinear dynamic, mechanistic model of beef cattle feed intake and growth. This recursive procedure updates predictions of cattle feed intake and gain by multiplying the model's estimates by appropriate factors based on the statistical weighting of previous and current observation of animal performance. When the empirical Bayes procedure was applied to 200 pens of feedlot cattle, predictions of daily feed intake and weight gain for the whole feeding period made after only two observations of intake and gain were 41 and 26% more precise than original estimates. Mean absolute error for predictions of daily intake and gain after two observations were .42 and .14 kg/d. These estimates were .84 and .18 kg/d more precise than model predictions without adjustment after two periods for intake and gain, respectively. This improvement in precision demonstrates how a general model can be adjusted based on initial observations to fit performance in a specific situation.

(Key Words: Bayes Statistics, Beef Cattle Growth, Dynamic Models)

Introduction

Models often combine a series of observed relationships to describe the general relationships among factors. Hence, the derived model is general and imprecise as applied to an individual case. Yet predicting future behavior is one of a model's most important functions. As opposed to more empirical regression models which are calculated from the observed data, dynamic models based on the underlying mechanism of a system can be used to estimate response beyond that used to derive the model (Oltjen, 1984). Even though regression provides a precise estimate within the range of data available to estimate the regression parameters, extrapolating beyond this range is very risky. Mechanistic models (those based on fundamental biological relationships), on the other hand, can be extrapolated with some confidence. Extrapolation accuracy depends simply on the accuracy of the model's simulation of the fundamental biology. Application of such complex models to predict future system behavior can be enhanced by adjusting the model based on information of prior behavior of similar systems and current observation of the system under consideration using empirical Bayes procedures (Allen and Jordan, 1982). The necessary tool is called the Kalman filter, a recursive procedure for the prediction of the state of a linear dynamic system (Kalman, 1960). Direct application requires adaptation to nonlinear systems. Although the Kalman filter has been applied to many problems in control engineering and physical science, its application to biological problems has been limited (Meinhold and

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Singpurwalla, 1983). It has been applied to a dynamic linear system of bovine lactation yield (Goodall and Sprevak, 1985). The researchers found the method gave accurate estimates of total milk yield after only a few observations during the very early stages of lactation. The objective of this research was to develop the theoretical basis for application of the empirical Bayes derivation of the Kalman filter to dynamic systems described by nonlinear sets of differential equations. The theory was tested by applying it to a nonlinear, dynamic system of animal growth and development.

Materials and Methods

Generally, the approach is similar to that for linear systems (Harrison and Stevens, 1976). In order to apply the linear theory, the variables from the dynamic model which are easily observed in the biological system are identified. For each of these variables, a linear function relating predicted and actual values is assumed. Parameters of this function are updated using the Bayesian Kalman filter based on the earlier observations. The updated function is used to modify the model to predict future behavior. To implement this procedure, initial values for the parameters and their variance-covariance matrix must be specified. If no previous information is available, they are set to represent no deviation between the predicted and observed values. Their variance is the identity matrix which allows the incoming observations to dictate convergence. However, where data is available or the procedure has been applied previously, the initial values are used to more properly weight the Bayes estimates.

To test this theory, dynamic models of bovine growth and composition (Oltjen, 1983) and feed intake (Plegge et al., 1984) were integrated. The growth model is based on the mechanistic relationships between increasing cell numbers and cell size, genetic potential, energy expenditure and environmental influences (eg. feed intake) of a growing and maturing animal. Nutrient intake is brought into the system with the daily feed intake model, which, in contrast to the growth model, is an empirical fit of a large data set which includes the effects of body weight, initial feeding period weight, feed metabolizeable energy and implant treatment. Average daily body weight gain and feed dry matter intake form the set of observable variables to be tested in the Bayes procedure. The linear function used was a simple multiplicative adjustment for both variables.

The test data set consisted of feed intake and body weight gain for 200 pens of typical feedlot steers fed in research trials at Oklahoma State University at period intervals (usually 28 days, Table 1). Initial values for the linear function's parameters were determined using preliminary analysis of data from 18 additional independent pens not used in the empirical Bayes analysis.

For evaluation, the model was run for the entire feeding period both without any adjustment (M) and using the empirical Bayes procedure (eB). Another multiplicative adjustment was tested which was based on the least-squares mean estimation procedure (LS) in which each period's performance was used to establish adjustments which were multiplied by model estimates to predict feed intake and gain. Thus, LS could not be estimated until after the first period's performance had been observed. The recursive eB and LS procedures were applied at the beginning of each period using the latest period's best estimate.

Table 1. Description of the steer data used for analysis.

Item	Number of pens	Mean	Standard deviation	Range
Days on feed	200	141.5	26.2	111 - 201
Periods (final day)				
1	200	36.7	11.9	27 - 57
2	200	74.6	23.9	55 - 121
3	176	101.3	21.1	83 - 140
4	130	121.1	11.2	111 - 147
5	50	140.0	.0	140 - 140
6	50	166.9	3.3	160 - 169
7	24	199.1	2.5	196 - 201
Weight (kg)				
Initial	200	290.0	41.6	193 - 357
Final	200	496.3	25.6	420 - 549
Daily gain	200	1.47	.13	1.18 - 1.79
Feed dry matter				
Intake (kg/d)	200	8.88	.85	7.07 - 10.80
ME (Mcal/kg)	200	3.08	.12	2.90 - 3.57

Two measures were evaluated. First predictions of daily feed intake and weight gain for each period for M, eB and LS were compared with the period's observed feed intake and weight gain. The second comparison was between observed and predicted feed intake and weight gain for the entire feeding period. The relationship among residual and absolute residual errors with time on feed were examined by regression analysis. Higher order terms for days on feed and analysis by period also were included in a sensitivity analysis of residual errors.

Results and Discussion

The unadjusted model (M) underpredicted both feed intake and daily gain for each period (Table 2). Similarly, total feeding period performance was better than the initial model predicted (Table 3). However, errors of prediction for daily feed intake and gain in each feeding period and for total time on feed demonstrate one advantage of using the empirical Bayes procedure, particularly for estimating performance at the end of the first few periods. The residual inaccuracy based on eB was less than the bias of M or LS for all feed intake and most gain predictions made for periods 2 through 5. Only estimates for period 2 and 5 daily gain and period 5 total feeding period gain were lower for M or LS procedures. In general, eB standard deviations also were smaller during the first few periods, particularly as related to the LS procedure. As fewer pens with 5 or more periods were available, these estimates are less reliable. The rapid decrease in bias and improvement in precision of the eB procedure by including only one observation of performance (period 2 estimate) demonstrates the immediate usefulness of the empirical Bayes procedure.

The least-squares procedure required several observations before accurate predictions were obtained (Figures 1 and 2). At the beginning of period 2, mean absolute errors for eB were .12 and .33 kg/d less than

Table 2. Residual (predicted-observed) daily feed intake and gain for individual feeding periods using model (M) and least-squares (LS) or empirical Bayes (eB) adjusted model estimates.

Period	Number of Pens	Feed intake (kg/d)						Daily gain (kg/d)					
		M		LS		eB		M		LS		eB	
		Mean	(SD)	Mean	(SD)	Mean	(SD)	Mean	(SD)	Mean	(SD)	Mean	(SD)
1	200	-1.40	(1.14)	--	--	-.63	(1.25)	-.48	(.37)	--	--	-.30	(.39)
2	200	-1.48	(1.23)	.76	(2.02)	-.09	(1.05)	-.19	(.31)	.88	(1.11)	.21	(.29)
3	176	-1.15	(1.03)	.56	(.76)	.42	(.69)	-.37	(.28)	.15	(.39)	.08	(.32)
4	130	-1.03	(.89)	.42	(1.03)	.35	(.93)	-.26	(.27)	.10	(.33)	.10	(.30)
5	50	-1.25	(.91)	.92	(.51)	.79	(.56)	-.24	(.22)	.09	(.26)	.18	(.27)
6	50	-.71	(1.00)	1.06	(.75)	.96	(.71)	.04	(.35)	.24	(.36)	.32	(.37)
7	24	.32	(.66)	1.54	(.78)	1.57	(.73)	.29	(.17)	.41	(.21)	.50	(.23)

Table 3. Residual (predicted-observed) daily feed intake and gain for the total feeding period using model (M) and least-squares (LS) or empirical Bayes (eB) adjusted model estimates.

Period	Number of Pens	Feed intake (kg/d)						Daily gain (kg/d)					
		M		LS		eB		M		LS		eB	
		Mean	(SD)	Mean	(SD)	Mean	(SD)	Mean	(SD)	Mean	(SD)	Mean	(SD)
1	200	-1.12	(.84)	--	--	-.23	(.82)	-.26	(.22)	--	--	-.05	(.22)
2	200	-1.12	(.84)	.31	(.89)	.16	(.66)	-.26	(.22)	.46	(.53)	.14	(.23)
3	176	-1.23	(.81)	.43	(.58)	.20	(.50)	-.31	(.18)	.18	(.27)	.09	(.17)
4	130	-1.10	(.79)	.25	(.43)	.19	(.40)	-.28	(.18)	.06	(.13)	.06	(.18)
5	50	-1.51	(.86)	.33	(.19)	.31	(.29)	-.25	(.11)	.04	(.09)	.11	(.08)
6	50	-1.51	(.86)	.11	(.17)	.16	(.23)	-.25	(.11)	-.01	(.07)	.26	(.18)
7	24	-1.13	(.94)	-.02	(.18)	.15	(.11)	-.23	(.12)	-.04	(.07)	.22	(.25)

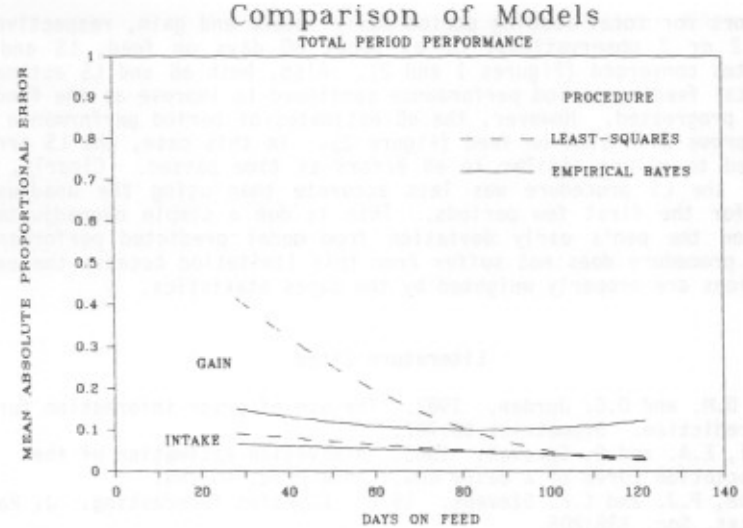


Figure 1. Comparison of least-squares and empirical Bayes procedure mean absolute proportional prediction error of total feeding period feed intake and body weight gain as days on feed increase.

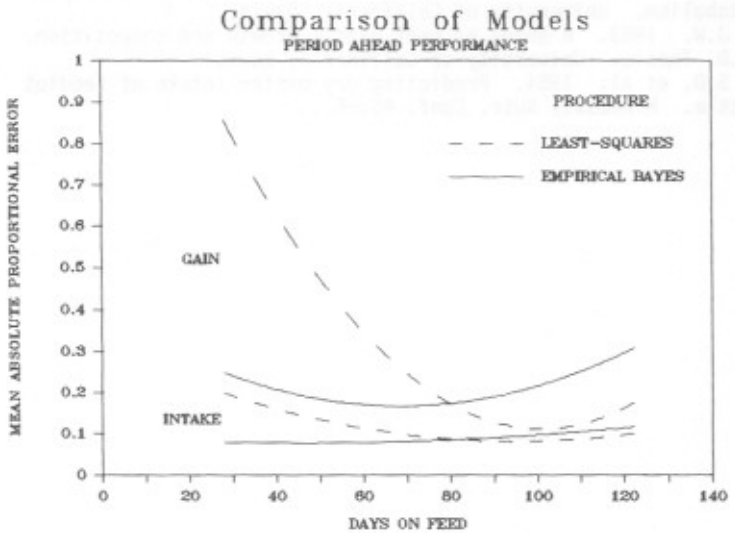


Figure 2. Comparison of least-squares and empirical Bayes procedure mean absolute proportional prediction error of period ahead feed intake and body weight gain as days on feed increase.

LS errors for total feeding period daily intake and gain, respectively. After 2 or 3 observations, or at about 80 days on feed, LS and eB estimates converged (Figures 1 and 2). Also, both eB and LS estimates for total feeding period performance continued to improve as the feeding period progressed. However, the eB estimates of period performance did not improve with time on feed (Figure 2). In this case, the LS errors declined to values similar to eB errors as time passed. Clearly, the use of the LS procedure was less accurate than using the unadjusted model for the first few periods. This is due a simple overadjustment based on the pen's early deviation from model predicted performance; the eB procedure does not suffer from this limitation because the early deviations are properly weighted by the Bayes statistics.

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METABOLIZABLE ENERGY OF STEAM FLAKED AND ROLLED WHEAT AND CORN IN FEEDLOT RATIONS

J.J. Martin[1], C.A. Strasia[2], D.R. Gill[3], F.N. Owens[4], D. Lyles[5], and E.R. Herbel[5]

Story in Brief

Crossbred implanted yearling steers (240) averaging 331 kg were fed diets with 81 to 82% dry rolled hard red winter wheat, steam flaked hard red winter wheat, dry rolled corn, and steam flaked corn for 138 to 149 days. Diets contained monensin (30 g/ton), tylosin (90 mg/hd/d) and 12% roughage. Daily gains and quality grades were lower for cattle fed rolled wheat than for those fed flaked wheat, flaked corn or rolled corn. Fat thickness, KPH and yield grade were lowest for cattle fed wheat diets. Flaking grain reduced feed consumption by 3.8 and 5.9% and improved feed/gain by 7.2 and 2.9% for diets with wheat and corn, respectively. Calculated metabolizable energy from grain alone, as estimated from animal performance by running the net energy equations backward, tended to be only slightly greater for flaked than rolled grain, and tended to be very slightly greater for corn than wheat.

(Key Words: Grain Processing, Wheat, Corn, Metabolizable Energy, Steers)

Introduction

Low prices for hard red winter wheat have renewed interest in replacing other grains with wheat in diets for finishing beef cattle. Martin et al. (1985) demonstrated that the metabolizable energy of a feedlot finishing diet with rolled corn (RC) was increased by replacing 50% or 75% of the rolled corn with rolled wheat (RW). This advantage for wheat conflicts with the tabular values (NRC, 1984) which indicate that dry corn grain has approximately 102% the metabolizable energy content of wheat. Gill et al. (1981), using corn based diets, indicated that both rate and efficiency of gain of finishing cattle can be improved by lowering roughage levels to 12% or below. Proper types of grain and roughage, methods of processing, and use of ionophores may permit use of roughage levels lower than 12% in finishing cattle diets. Ionophores decrease problems with bloat and acidosis (Bartley et al., 1983), and method of grain processing alters ration consumption and performance of feedlot animals (Ramirez et al., 1985). This trial was conducted to determine the relative metabolizable energy values of finishing diets with wheat or corn grains in dry rolled or steam flaked forms.

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Materials and Methods

Hereford, Angus, and crossbred steers (240) were amassed from auction barns in Guymon and Texhoma, Oklahoma and Amarillo, Texas. Steers were trucked to Panhandle State University, Goodwell, Oklahoma, placed in a drylot and maintained on hay until the trial was initiated. One week was required to purchase all animals of the weight and quality needed. Animals were weighed individually, received routine feedlot vaccinations, wormed with injectable Tramisol, ear tagged and implanted with Synovex-S. A second Synovex-S implant was administered 56 days later.

Initial shrunk weight averaged 730 pounds. Steers were blocked by weight into four groups (793, 744, 715 and 669 lb) and randomly allocated within block to four treatments. A total of 16 pens (4 per treatment) with 15 animals per pen were used in this experiment. The composition of the finishing diets is shown in Table 1. Animals were gradually switched from the initial diet (40% roughage) to the finishing diet (12% roughage) during the first 21 days of the study by a stepwise decrease in the level of cottonseed hulls in the diet. Roughage was 7% cottonseed hulls and 2.5% pelleted alfalfa, and 2.5% roughage was in the supplement. Cracked grains were cracked with a roller mill at Panhandle State University. Steam flaked wheat (FW) was trucked approximately 10 miles from the Freeman Feedlot, Texhoma, Texas each evening, and steam flaked corn (FC) was trucked from the Texas County Feedlot, Guymon, Oklahoma each morning. Initial weights were shrunk and animals were weighed full on days 28, 56, 84 and 118 and shrunk weights were calculated by subtracting 4% to calculate weight gain. Final shrunk weight was calculated from hot carcass weight assuming that dressing percentage was 62%.

After being fed for 138 days (two heavy replicates) or 149 days (two light replicates), cattle were trucked to Booker Custom Pack, Booker, Texas for slaughter. Hot carcass weights, fat thickness at the 12th rib, marbling score, yield grade, rib eye area and incidence and severity of liver abscesses were recorded.

Results and Discussion

Steer weight gain calculated from carcass weight was greater for the corn than wheat diets by 4.3% and 10.7% for flaked and rolled forms of grain, respectively (Table 2). Steers fed the CW ration had lower gains than cattle fed other diets. These data agree with performance data of Martin et al. (1985), though differences in that study were not significant. Average daily feed consumption was reduced by flaking and lower for wheat than corn diets ($P<.05$). Feed/gain ratios favored flaked grains ($P<.10$).

Rib eye area was smaller ($P<.05$) for steers fed cracked corn. No explanation for this effect is apparent. Quality grade reflected performance data. Steers fed corn produced carcasses with a higher ($P<.05$) quality grade than animals fed wheat.

Fat thickness at the 12th rib, KPH and yield grade was greater for cattle fed corn than wheat. Steers which received the FW ration had a significantly better yield grade ($P<.05$) and less fat cover ($P<.05$) and KHP percent ($P<.01$) than cattle fed FC or CC.

There were no significant ($P<.05$) differences between the treatment groups in the incidence of liver abscesses. Steers on the CW ration had the highest rate of abscessed livers, while the CC treatment

Table 1. Diet composition, as fed basis.

	Diet			
	FW	FC	CW	CC
Ingredients				
Wheat, steam-flaked	82.45			
Wheat, cracked			82.45	
Corn, steam-flaked		80.50		
Corn, cracked				80.50
Cottonseed hulls	7.00	7.00	7.00	7.00
Alfalfa pellets	2.55	2.50	2.55	2.50
Molasses	3.00	3.00	3.00	3.00
Supplement	5.00	7.00	5.00	7.00
Ration Composition, % of dry matter				
Dry matter, %	87.55	85.86	88.30	87.73
Crude protein, %	12.70	11.73	12.70	11.70
Calcium, %	.45	.50	.45	.50
Phosphorus, %	.35	.35	.35	.35
Potassium, %	.75	.75	.75	.75
ME, mcal/kg dry matter	2.97	2.96	2.97	2.96

	Wheat Diets	Corn Diets
Supplement composition, %		
Cottonseed meal	10.35	55.60
Wheat midds	0.00	3.60
Alfalfa meal	59.25	0.00
Calcium carbonate	15.55	12.85
Potassium chloride	0.00	8.55
Dicalcium phosphate	0.00	3.90
Urea	7.70	11.00
Salt	5.75	3.60
Monensin 60	0.47	0.29
Tylosin 40	0.23	0.14
Vitamin A&D[1]	0.32	0.18
Trace mineral[2]	0.40	0.30

[1]Vitamin A 10M I.U./lb; Vitamin D 1M I.U./lb.
[2]Trace Minerals, Percent of TM mix: Mn 7.45; Fe 14.5; Cu 3.74; Co 0.23; Zn 17.60; S 16.15;and I_2 0.23.

had the lowest incidence (Table 2). Steers with abscessed livers generally were higher performing animals. Without an ionophore and an antibiotic in the diet, a higher incidence of liver abscesses would be expected.

The primary goal of this trial was to determine the relative metabolizable energy (ME) values of steam flaked and dry rolled wheat and

Table 2. Effect of grain type and processing method on performance and carcass characteristics.

	Diet			
	FW	FC	CW	CC
No. steers	60	60	60	60
Pens	4	4	4	4
Weight, lb				
Initial	729	731	732	728
56 days	911[b]	918[a]	914[ab]	932[a]
Final	1175[ab]	1200[ab]	1166[b]	1212[a]
Carcass	728[ab]	744[ab]	723[b]	751[a]
Average daily gain, lb	3.11[a]	3.25[a]	3.00[b]	3.36[a]
Average daily feed, lb				
0-56	19.1[b]	18.9[b]	19.8[b]	22.0[b]
57-end	20.6[b]	21.6[a]	21.5[a]	21.8[a]
Total	20.0[c]	20.6[bc]	20.8[b]	21.9[a]
Feed/gain				
0-56	5.88	5.68	6.11	6.03
57-end	6.82[ab]	6.69[a]	7.50[b]	6.81[ab]
0-end	6.43[ab]	6.29[a]	6.93[b]	6.48[ab]
NEg, Mcal/cwt	60.7	61.8	57.0	59.8
Calculated metabolizable energy, Mcal/kg diet dry matter	3.05	3.09	2.93	3.02
Average ribeye area, sq in	12.9[a]	13.1[a]	13.1[a]	12.4[b]
Fat thickness, in	.53[ab]	.60[a]	.51[b]	.64[a]
KPH,%[d]	1.89	2.06	1.83	2.09
Yield grade	2.8[c]	3.0[b]	2.7[c]	3.4[a]
Yield 4 and 5, %	3[b]	15[ab]	2[b]	23[a]
Quality grade	11.03[a]	11.32[a]	10.32[b]	11.38[a]
Percent choice	30	15	3	20
Liver abscesses				
Score	.25	.20	.22	.07
Incidence	13	10	15	7
Feed cost of gain, $/cwt	41.70	44.16	43.18	44.36

[ab]Means within a row with different superscripts differ (P<.05).
[c]10 = Good plus; 11 = Choice minus.

Table 3. Energy calculations.

	Diet				
	FW	FC	CW	CC	Average
Diet ME, mcal/kg	3.05	3.09	2.93	3.02	----
Diet, relative ME	.987	1.000	.951	.977	----
Grain, % of diet	82	81	82	81	----
Grain, relative ME	.984	1.00	.940	.972	----
Flaking effect, %	+4.7	+2.9	---	---	+3.8
Grain effect, %	---	+1.6	---	+3.4	+2.5
Estimated grain ME[a]	3.31	3.44	3.16	3.35	
Values from NRC (1984)	3.22	3.44	3.22	3.25	

[a]Calculated by subtracting ME values for other dietary ingredients.

corn. The ME values for diet dry matter were calculated as described by the following equations:

$E = 2.54\ NEm + 2.4178$ feed in kg;
$F = NEg - 2.54$ feed in kg;
$G = 2.4178\ NEm$;

where $NEg = (.04871$ gain in kg $+ .00629$ gain in kg $*$ gain in kg)

$* \text{weight in kg}^{3/4}$;

$NEm = .0705 * \text{weight in kg}^{3/4}$

then:

NEm of diet $= [-E - (E^2 - 4FG)]^{.5} / 2F$;
and ME of diet $= [2.2577 - \log 10\ (77/\text{NEm of feed})] / .2213$

The FW and FC rations had ME values 4.1 and 2.3% higher than CW and CC, respectively, suggesting that flaking was slightly beneficial to both grains. On the average, wheat diets had 98% the energy value of corn diets. Per unit of grain, these advantages for flaking over rolling and corn over wheat are 4.7 and 2.9%, respectively (Table 3). Consequently, for energy, wheat and corn were essentially equal in feeding value for these rations which contained 12.0% roughage with the major roughage source being cottonseed hulls. Different roughage sources and levels may alter the efficiency of energy utilization. Calculated energy values (Table 3) were almost identical to those listed by the NRC (1984).

The feed cost of gain based on corn at $3.36 per bushel and wheat at $3.33 per bushel was $41.70, $44.16, $43.18, and $44.36 for FW, FC, CW and CC, respectively. Wheat, irrespective of processing method, produced gains for $1.82/cwt less than corn. FW produced gains for $2.46/cwt less than FC, while CW cost $1.18/cwt less to feed. Though efficiency of gain and feed cost were improved by flaking, flaking of wheat would be justified only if the flaking cost was under 4.7% of the cost of wheat. For corn, the breakeven cost of flaking would be 3.4% of the cost of corn.

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A COMPARISON OF LASALOCID AND SALINOMYCIN IN FEEDLOT STEERS

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D.R. Gill[4] and D.L. Marr[5]

Story In Brief

Eight hundred fifty eight Louisiana crossbred steers were divided into three weight groups and fed a popped milo feedlot ration with either Lasalocid (30 g/ton) or Salinomycin (10 g/ton). Average daily feed consumption was significantly greater (4.4% or .89 pounds/hd/d) with Salinomycin. Average daily gain at 65 days was 4% greater with Salinomycin while feed conversion was similar with the two ionophores. Final daily gain was 4.6% greater with Salinomycin while efficiency favored cattle fed Salinomycin by 3.1% and 2.5% on the light and medium weight blocks. Final live weights also favored animals fed Salinomycin. The greatest difference occurred in the heavy steer group where the pens receiving Salinomycin were marketed three weeks ahead of the pen of animals fed Lasalocid. Liver abscess incidence (14.4% to 54.0%) reflected typical industry levels without dietary antibiotics and was not altered by the ionophore source.

(Key Words: Lasalocid, Salinomycin, Popped Milo, Steers)

Introduction

Salinomycin has been fed to beef animals only in research trials. The ionophore has been fed with whole shelled, rolled and cracked corn, steam flaked corn or milo, high moisture corn and corn silage, but it has not been fed with popped milo. Previous data from Gill et al. (1984), Martin et al. (1984), Hicks et al. (1985) and Strasia and Jordan (1985) indicate that processing method, roughage type, percent roughage in the ration or grain combinations can influence the efficacy of ionophores.

Materials and Methods

Eight hundred fifty eight Louisiana crossbred steers which had been on native grass pasture near Clayton, New Mexico for approximately 75 days, were trucked to the Clayton Cattle Feeders lot. Some arrived at the feedlot December 12, 1984 and the remainder arrived January 7, 1985. On arrival, all steers received routine feedlot vaccinations, ear tags and a Synovex-S implant. A second Synovex-S implant was administered 65 days later.

Initial average pen weights for the 6 pens were respectively: light block, 529 and 536 pounds; medium block, 576 and 586 pounds; and heavy block, 625 and 644 pounds. These pens were randomly assigned to

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treatment for this study. The calculated composition of the finishing diet was: NEm = 80 Mcal/cwt; NEg = 50 Mcal/cwt; crude protein = 11.7%; calcium = .55%; phosphorus = .35%; potassium = .6%; salt = .4%; and either Lasalocid at 30 g/ton or Salinomycin at 10 g/ton. Animals were gradually switched from the starting diet (45% roughage) to the finishing diet (20% roughage). Each entire pen of cattle was weighed initially, at 65 days and upon termination of the study. A 4% pencil shrink was applied to calculate shrunk weights and shrunk weight gains.

When cattle reached 1000-1050 pounds shrunk, the pens were marketed by the standard feedlot practice. The study had three pens per treatment, one of each weight group. When a pen of animals was sold, the pen with matching weight was weighed off test. Hence, days on test were identical for corresponding treatments but total days prior to slaughter differed. Liver abscess data were obtained with the cooperation of USDA/FSIS veterinarians. Treatments were compared on a pen mean basis by Analysis of Variance.

Results and Discussion

Daily feed intake were summarized monthly and for each ten day feeding period, (Table 1). Feed consumption was 4.4% higher ($P<.05$) for the Salinomycin treatment. However, in the lighter weight replicate, animals receiving Lasalocid consumed .7% (.14 lb/hd/d) more feed. This Salinomycin pen of cattle suffered from respiratory infections which resulted in the death of two animals during the first two weeks of the study. Consumption decreased markedly during the 2-10-85 to 2-20-85 period, possibly due to sub-zero temperatures during this time span.

Daily gain to 65 days was higher with Lasalocid in the light replication (.19 lb//hd/d) but lower (.24 lb and .46 lb) in the heavier weight groups, respectively. The feed efficiencies at 65 days were identical with the two ionophores (Table 3).

Pens of cattle which received Salinomycin reached acceptable slaughter weight more quickly than the pens which received Lasalocid (Tables 2 and 3). At termination of the study, gains favored Salinomycin pens (Table 3). Feed efficiency was superior for Salinomycin in the light and medium group (Table 2), but for the heavy cattle, despite 7.6% slower gain, cattle fed Lasalocid were 5.9% more efficient. Although

Table 1. Monthly feed consumption.

Weight Group	Lasalocid			Salinomycin		
	Light	Medium	Heavy	Light	Medium	Heavy
Month:						
December[a]	18.37	19.86		17.77	19.75	
January	19.16[a]	19.28[a]	20.78	19.53[a]	20.94[a]	23.37
February	18.84	18.67	20.32	17.57	18.42	21.99
March	20.44	19.98	19.93	20.01	21.51	23.19
April	21.66	20.45	20.36	21.45	22.08	23.17
May	21.56	21.62	20.26	21.11	21.52	21.64
June	20.21	20.96		19.78	20.61	

[a]Reflects starting dates of 12-12-84 and 1-7-85.

Table 2. Gains, efficiencies and liver abscess data.

Weight Group	Lasalocid			Salinomycin		
	Light	Medium	Heavy	Light	Medium	Heavy
Number steers	207	102	124	198	102	125
Initial wt, lb	529	586	625	536	576	644
65 day ADG, lb	2.66	2.58	2.46	2.47	2.82	2.92
65 day feed/gain	7.14	7.57	7.77	7.50	7.19	7.50
Days fed	206	198	155	206	198	155
Final gain, lb	505	472	349	517	489	376
Final wt, lb	1034	1058	974	1053	1065	1020
Final ADG	2.45	2.32	2.25	2.51	2.47	2.42
Final ADF	20.03	19.95	19.96	19.89	20.68	22.61
Final feed/gain	8.17	8.60	8.88	7.92	8.39	9.32
Liver abscesses, %	53.8	44.6	26.8	54.0	52.9	14.4

[a]All weights are reported after a 4% pencil shrink and feed data is "as fed".

Table 3. Ionophore comparisons[a].

	Lasalocid	Salinomycin
Number steers	433	425
Days fed	190	190
Initial wt, lb	570	577
Final wt, lb	1022	1046
Final gain, lb	453	469
65 day ADG, lb	2.53	2.63
Final ADG, lb	2.36	2.47
Mean feed intake, lb	19.99	20.88
65 day feed/gain	7.42	7.42
Final feed/gain	8.47	8.44
Liver abscesses, %	43.9	41.31

[a].All weights are reported after a 4% pencil shrink and feed data is "as fed".

the Salinomycin pen was ready for slaughter in early May, no bids were tendered until June. Feed consumption by these animals began its decline in May.

The liver abscess incidence is similar to current industry average for cattle on feed for a long time which have not received an antibiotic in their feed. Condemnations due to flukes averaged 6%. This is high considering that these cattle came from the Southeastern U.S. Ionophore had no significant impact on liver abscess incidence.

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RUMINAL ESCAPE METHIONINE AND LYSINE FOR FINISHING STEERS

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Story in Brief

Two hundred forty feedlot steers (319 kg) were stratified into 6 weight groups, placed in 30 pens and fed an 86% cracked corn, 7% cottonseed hull, urea supplemented 10.5% protein diet containing 5 different levels of coated D,L-methionine (0 to 20 g/d) plus L-lysine (0 to 16 g/d) for 130 days. Plasma levels of these two amino acids at day 56 was increased with supplementation indicating that the Kodak polymer coating delivered amino acids to the small intestine. But plasma lysine and methionine concentrations increased even with the lowest level of supplemental amino acids. This suggests that these two amino acids were not deficient for these cattle. No responses in gain or feed efficiency to supplemental amino acids were detected. Results indicate that the polymer coating system increased supply of amino acids to the small intestine, but with a urea supplemented corn diet, supply of lysine and methionine did not limit rate or efficiency of gain by yearling steers.

(Key Words: Methionine, Lysine, Ruminal Escape, Steers)

Introduction

The amino acids available for production by ruminant animals are provided by both dietary protein which bypasses or escapes fermentation in the rumen plus microbial protein which is synthesized within the rumen. Protein from corn is notably low in lysine while microbial protein is deficient in methionine plus cystine. If these two amino acids actually are deficient for production, rate of production should increase if they are supplemented. Because these amino acids are rapidly destroyed in the rumen (Schelling et al., 1967), they need to be protected by a coating to escape ruminal fermentation as has been developed by chemists at Eastman Kodak (Papas et al., 1984). The objective of this experiment was to determine the responses in growth rate and feed efficiency by finishing feedlot steers to several levels of supplemental coated lysine and methionine.

Materials and Methods

Two hundred forty Charolais and Charolais crossbred steers averaging 703 lb were divided into 6 weight groups (633, 668, 686, 715, 739 and 777 lb means) for feeding at Goodwell, Oklahoma. Each weight block was subdivided into 5 different pens of 8 steers each and fed different levels of a mixture of methionine plus lysine coated to increase ruminal escape. The coating is an experimental compound being

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Table 1. Diet dry matter ingredients and composition.[a]

Ingredient	Percentage	
Corn, cracked	87.0-86.4	
Cottonseed hulls	7.0	
Protected amino acids	0-.575	
Supplement pellet	6.0	
Milo, ground		2.55
Wheat middlings		.70
Molasses, dried		.45
Urea		.50
Calcium carbonate		.90
Dicalcium phosphate		.25
Potassium chloride		.30
Salt		.30
Rumensin-60		.03
Vitamin A		.01
Trace minerals		.01

[a]Designed to provide 60.9 mcal NEg per hundred pounds, 10.5% protein, [b].61% potassium, .47% calcium, .32% phosphorus.
[b]D,L-Methionine levels were 0, .05, .10, .15 and .20% with L-lysine levels of 0, .04, .08, .12 and .16% of the diet for the 5 treatments, respectively.

produced and tested by Eastman Kodak, Kingsport, Tennessee. A total of 6 pens (48 steers), one from each weight group, received each level of the supplemental amino acids. Respective levels of supplemental D,L-methionine and L-lysine were 0 and 0; 5 and 4; 10 and 8; 15 and 12; and 20 and 16 grams per animal per day based on a mean feed intake of 22 lb of dry matter for the trial. Steers were weighed shrunk initially and at the end of the 130 day trial, and full at 28 day intervals. Full weight was multiplied by .96 to determine shrunk weights to calculate rate of gain. Final weight also was calculated from carcass weight by dividing by .62. On day 56, blood samples were obtained from two steers per pen and plasma was analyzed for free methionine and lysine content.

Results and Discussion

Performance results by supplemental level of escape amino acids are presented in Table 2. Supplemental amino acids had no significant effect on weight gain, feed intake or feed efficiency of these steers. However, plasma concentrations of both methionine and lysine increased with supplemental coated amino acids. Simply supplementing the diet with uncoated methionine and lysine does not increase their plasma concentrations in ruminants due to destruction of these amino acids in the rumen (Schelling et al., 1967). Hence, this elevation is proof that coating increased the amount of these two amino acids absorbed by the animal. Therefore, the coating must have delivered these amino acids to the small intestine for absorption as suggested from incubation of the coated amino acids in buffer versus in acid (Papas et al., 1984).

Table 2. Influence of amino acid supplementation on steer performance.

	Amino Acid Level (Methionine/Lysine)				
	0/0	5/9.4	10/18.7	15/28.1	20/37.5
Weight, lb:					
Starting	701	704	704	704	702
56 days	909	913	905	903	899
130 days	1098	1096	1085	1083	1091
Carcass	694	692	686	685	690
Gain, lb/day:					
Live	3.06	3.02	2.93	2.91	3.00
Carcass	3.22	3.17	3.10	3.08	3.16
DM intake, lb/day:					
0-56	22.1	21.8	21.4	21.0	21.2
57-130	22.9	22.6	22.4	22.5	23.2
0-130	22.6	22.3	22.0	21.9	22.3
Feed/gain:					
0-56	7.24	7.13	7.27	7.35	7.37
57-130	7.52	7.61	7.69	7.73	7.52
0-130, live	7.39	7.39	7.50	7.54	7.45
0-130, carcass	7.02	7.02	7.11	7.14	7.06
Plasma lysine, ng/ml	11.9^{a}	15.9^{bc}	13.3^{ab}	14.7^{abc}	17.3^{c}
Plasma methionine, ng/ml	4.1^{a}	7.7^{b}	7.2^{b}	7.9^{b}	10.3^{c}

^{ab}Means with different superscripts differ ($P<.05$).

Plasma concentrations of amino acids will increase only if the quantity supplied exceeds the amount required. Hence, the increase in plasma concentrations at the lowest level of supplementation implies that the basal diet probably was not deficient in these two amino acids. This can explain why performance was not improved by increasing the supply of these amino acids. The need for these amino acids should be much greater for lactating cows and younger growing animals which secrete or deposit protein at faster rates. If the diet were lower in methionine (corn protein is quite high) or bacterial protein supply were reduced (bacterial protein is high in lysine), response might have been positive. Responses to supplemental amino acids have been more favorable with diets not containing cottonseed hulls.

Table 3 presents carcass characteristics of these steers. Again, no favorable responses to supplemental amino acids were detected.

Performance of steers which were grouped into different starting weights is presented in Table 4. Rate of gain early in the feeding period, especially the first 28 days, favored cattle weighing over 675 lb, but weight gains of the heaviest cattle slowed during the last part of the feeding period. Feed intake was consistently higher for heavier cattle. The difference in feed intake between the lightest and heaviest group averaged 5.6 pounds per day during the first 28 days but decreased to 1.6 pounds during the final 14 days on feed.

Table 3. Carcass measurements by amino acid treatment.

	Amino Acid Level (Methionine/Lysine)				
	0/0	5/9.4	10/18.7	15/28.1	20/37.5
Dressing percentage	63.2	63.1	63.1	63.2	63.2
Rib eye area, sq. inches	12.6^{ab}	12.3^{ab}	12.7^{a}	12.4^{ab}	12.2^{b}
Fat thickness at 12th rib, in.	.50^{b}	.56^{ab}	.51^{ab}	.58^{a}	.57^{ab}
Kidney, heart, pelvic fat, %	2.35	2.36	2.38	2.32	2.43
Marbling score[c]	13.4	13.4	13.0	13.1	13.5
Yield grade	2.81	3.07	2.78	3.06	3.12
Liver abscess:					
Incidence, %	33	17	31	36	31
Score[d]	.62	.35	.73	.83	.73
Choice, %	73	81	77	77	69

^{ab}Means with different superscripts differ (P<.05).
[c]Choice minus = 13; good plus = 12.
[d]Minor abscess = 1; severe abscess = 3.

Table 4. Performance by inital weight group.

	Weight Grouping						Weight Effect[a]
	1	2	3	4	5	6	
Weight, lb:							
Starting	633^{b}	668^{c}	686^{cd}	715^{d}	739^{e}	777^{f}	L
56 days	825^{b}	873^{c}	895^{cd}	911de	942^{e}	987^{f}	L
130 days	1016^{b}	1055^{c}	1089^{cd}	1094de	1028^{e}	1163^{f}	L
Carcass	632^{b}	663^{c}	690^{d}	694^{d}	718^{e}	738^{e}	L
Gain, lb/day:							
0-56	2.84	3.02	3.10	2.85	2.96	3.05	
57-130	3.02	2.94	3.11	2.96	3.01	2.91	
0-130, live	2.94	2.97	3.11	2.91	2.99	2.97	L
0-133, carcass	2.90	3.02	3.21	3.04	3.15	3.11	LQ
DM intake, lb/day:							
0-56	19.0^{b}	21.0^{c}	22.5^{d}	20.8^{c}	21.7^{d}	23.9^{e}	
57-130	22.1^{b}	22.3^{cd}	23.1^{de}	22.3^{cd}	22.9^{de}	23.6^{e}	l
0-130	20.8^{b}	21.8^{cd}	22.9^{de}	21.7^{cd}	22.4^{de}	23.8^{e}	L
Feed/gain:							
0-56	6.70^{b}	7.01^{b}	7.29^{bc}	7.31^{bc}	7.37^{bc}	7.95^{c}	L
57-130	7.34^{b}	7.598^{b}	7.45^{b}	7.54^{b}	7.63^{b}	8.13^{c}	L
0-130, live	7.06^{b}	7.33^{bc}	7.36^{bc}	7.44^{bc}	7.51^{c}	8.02^{d}	L
0-130, carcass	6.98^{b}	7.07^{b}	6.96^{b}	6.97^{b}	6.97^{b}	7.49^{c}	LQ

[a]L=Linear effect (P<.05); l=Linear effect (P<.10); Q=Quadratic effect (P<.05); q=Quadratic effect (P<.10).
^{b,c,d,e,f,g}Means with different superscripts differ (P<.05).

Overall feed intake was increased by over 2 lb/100 lb difference in starting weight. Maximum feed intake occurred during the third month on feed for all weight groups and declined thereafter, especially for the heavier cattle. Intake curves were quite similar to those developed previously (Thornton et al., 1985).

Feed efficiency on a live weight basis favored cattle with a lighter starting weight by up to 13%. But expressed on a carcass weight basis, feed efficiency differences were smaller with a maximum difference of less than 8%. This reduction is due to the higher dressing percentage of heavier cattle (Table 5). Usually attributed to increased fatness, the increased dressing percentage in this study could not be completely attributed to increased fat thickness or internal fat. Yield grade, an inverse index of the percentage of the carcass in closely trimmed lean cuts, did not decrease markedly for heavier steers. These relationships suggest that feed efficiency on a carcass weight or product basis is altered less by initial weight than is efficiency as expressed on a live weight gain basis. These differences in dressing percentage altered live value by over 12% in this study. Rather than having cattle buyers attempt to predict dressing percentage of live cattle, producers would be more legitimately rewarded for cattle with a higher dressing percentage if a reward-discount system were available to adjust for dressing percentage. This would be one step toward grade and yield pricing but would avoid grading and re-grading inconsistencies.

Table 5. Carcass measurements by weight group.

	Weight Grouping						Weight Effect[a]
	1	2	3	4	5	6	
Dressing percent	62.3[b]	62.8[bc]	63.4[cd]	63.5[cd]	63.7[d]	63.5[cd]	LQ
Rib eye area, in^2	11.9[b]	12.2[bc]	12.6[cd]	12.6[cd]	12.7[d]	12.7[d]	Lq
Fat thickness, in	.48[b]	.55[bc]	.58[c]	.55[bc]	.55[bc]	.54[bc]	Q
Kidney, heart, pelvic fat, %	2.35	2.45	2.39	2.39	2.34	2.30	
Marbling score	13.0	13.1	13.3	13.2	13.5	13.5	l
Yield grade	2.8	3.0	3.0	3.0	3.0	3.0	l
Liver abscess:							
Incidence, %	32	38	25	30	15	38	
Score	.75	.92	.55	.53	.30	.85	
Choice, %	70	72	68	78	85	80	

[a]L=Linear effect (P<.05); l=Linear effect (P<.10); Q=Quadratic effect (P<.05); q=Quadratic effect (P<.10).
[b,c,d]Means in a row with different superscripts differ (P<.05).

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EFFECT OF OVARIAN AUTOGRAFT ON FEEDLOT HEIFER PERFORMANCE

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Story in Brief

Forty-five yearling Hereford heifers were (1) left intact and implanted with Synovex-H (2) spayed through the flank and autografted without implant or (3) spayed through the flank and autografted, and implanted with a Compudose implant. Eight Hereford and Hereford cross steers were implanted with Compudose. Animals were fasted for approximately 12 hours after arrival at the Hitch feedlot. Animals received normal feedyard processing. Animals from the four treatments were placed on feed in a single pen following processing and moved through the standard step up program to the final 64 Mcal (NEg) ration.

Carcass adjusted average daily gain favored, respectively, Steers (2.96); Normal implanted heifers (2.81); Implanted autograft heifers (2.47) and Non-implanted autograft heifers (2.14). Average daily gain was depressed 31.3% by autografting heifers but this was reduced to 13.8% by implanting. Rib eye area, fat thickness, kidney heart and pelvic fat, and quality grade was not affected by treatment. Minimal concentrations of estradiol in the plasma of non-implanted autografted heifers indicates that autografts did not have follicles producing significant quantities of estrogen.

(Key Words: Spay, Autograft, Average Daily Gain, Steer, Heifer)

Introduction

Spaying of heifers has been used by producers as a means of guaranteeing that animals are not pregnant and to possibly enhance animal performance as a result of elimination of estrous activity. Hastings (1984) reported a spayed heifer study employing the ovarian autograft procedure where a 1/8 inch square portion of ovarian tissue was implanted subserosally in the rumen wall. Auto and heterovarian transplants were reported by Griffin and Randel (1978) and Acosta et al. (1982). These procedures involved transplants to either the uterus or parotid regions and resulted in estrogenic production. The procedure of transplanting ovarian tissue onto the rumen wall should produce estrogenic activity into the portal circulation thereby eliminating the side effects of the autograft (Hastings, 1984). The North Dakota data indicate that spayed females, spay/autografted females and steers were processed according to treatment, implanted with Ralgro and run on grass for approximately 180 days, then subsequently placed in commercial feedlot, sorted into the respective treatments, implanted with Compudose and fed for 155 days. Daily gain results favored the implanted autografted heifers by 2.5% over steers and 13.6% over spay/implanted heifers (Hastings, 1984). These data indicate a significant improvement in profitability.

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Materials and Methods

Forty-five yearling Hereford heifers and eight Hereford and Hereford cross steers were purchased at the Guymon sale barn and trucked 10 miles to the Hitch Feedlot on January 16, 1985. All animals were fasted for 12 hours after arrival at the feedlot. The animals received routine feedlot vaccinations and were ear tagged in both ears. The heifers were pregnancy checked prior to assignment to treatment. The cattle were randomly allotted at the processing chute to the following treatments: (1) Spay/Autograft/No Implant, (2) Spay/Autograft/Compudose, and (3) Intact/Synovex-H. The steers were processed as they passed through the chute.

The heifers to be spayed and autografted were prepared for surgery prior to entry into the handling chute. Preparation involved clipping the hair and scrubbing with Novasan. Local anesthetic was administered with a multiple dose syringe. Biopsy instruments were kept in a sterile isotonic solution with gentamycin. An incision was made through the flank and the ovariectomy performed with scissors. The 1/8 square inch of ovarian tissue was then prepared for the implant. The ovarian tissue was slipped subserosally in the rumen wall two inches with alligator forceps. The incision was closed with a Cruciate suture.

Animals were individually weighed after processing and these weights were computed back to purchase weight. Initial weights by treatment are shown in Table 1. Following weighing, all treatments were placed in a common pen. Individual animal weights were again taken on day 14 to measure the effects of surgery on animal performance and each subsequent 28 days interval to slaughter. Blood samples were taken from animals at the final weighing by venous puncture and placed in heparinized tubes. Sample tubes were immediately cooled in ice. The samples were centrifuged and supernatant decanted for estrogen assay.

After feeding for 117 days, the cattle were trucked for slaughter to Booker, Texas where an attempt was made to recover the implants. The following data were collected: hot carcass weight, rib eye area, KPH, fat thickness at the 12th rib and quality grade. Live performance and carcass characteristics were compared by least squares analysis (Steele & Torrie, 1960).

Table 1. Periodic weight changes of either intact or autografted females vs. steers.

	Treatments			
	Intact Synovex-H	Spay/Autograft No Implant	Spay/Autograft Compudose	Steers Compudose
Number Animals	15	15	15	8
Initial wt, lb	606	592	614	746
ADG, lb/hd/d:				
0-14 day	.98	.28	.16	2.22
0-52 day	2.32	1.78	2.30	3.13
14-52 day	2.82	2.44	3.28	3.46
0-80 day	2.50	2.10	2.50	2.40
52-80 day	2.72	2.52	2.50	2.94
0-Final	2.60	2.00	2.68	2.70
62% carcass adjusted ADG, lb/hd/d	2.81	2.14	2.47	2.96

Results and Discussion

The steers and intact females performed for the duration of the trial as expected of quality feedlot animals (Table 1). It is evident that surgery produced a significant depression of performance, although by day 52 recovery appeared complete and gain for the next period appeared to reflect compensatory gain, especially in the spay/autograft/compudose treatment. The 117 day final weights indicate that the implanted autografted heifers were performing similarly to steers and equal or slightly superior to the intact females. However, when gain is adjusted to a equal dressing percentage, the autografted animals with or without an implant were decidedly inferior to either the intact females or steers.

Carcass parameters favored steers (Table 2). Fat thickness over the 12th rib was slightly greater, but not significantly different than the heifers. Yield grade was slightly lower than all heifer groups, but still acceptable. Seven of eight steers had quality grades of choice, but there were no significant differences between quality grades.

Among heifers, all carcass parameters were either similar or favored the intact heifers. KPH appeared to be lower in the intacts, followed by implanted autografted and the non-implanted autografted heifers.

Estradiol concentrations in plasma of animals at the end of the feeding period were influenced by treatments. Intact heifers implanted with Synovex-H had greater ($P<.0001$) concentrations of estradiol than animals on the other three treatments. In addition, heifers that were spayed/autografted and implanted with Compudose had greater ($P<.09$) concentrations of estradiol than heifers that were spayed and auto-

Table 2. Performance and carcass characteristics of steers and intact heifers -vs- spayed and ovarian autografted females.

	Treatments			
	Intact Synovex-H	Spay/Autograft No Implant	Spay/Autograft Compudose	Steers Compudose
Initial wt, lb	606	592	614	746
62% carcass adj final wt	935	842	899	1092
ADG, lb	2.81	2.14	2.47	2.96
Hot carcass wt, lb	580	522	558	677
KPH, %	2.4	2.6	2.5	2.2
Fat thickness, inches	.38[a]	.35[b]	.30[ab]	.46
REA, sq in	11.90	11.04	11.48	13.00
Yield grade	2.32	2.34	2.19	2.50
Quality grade[1]	11.93	11.86	11.57	11.88
Estradiol in plasma, pg/ml	27.6	2.5	8.5	5.4

[1]Quality Grade: 12 = C-.
[ab]Means with different superscripts differ ($P<0.05$).

grafted but not implanted. The minimal concentrations of estradiol in the spayed/autografted heifers (equivalent to the amount of estradiol present during the luteal phase of the estrous cycle) indicate that the autografted heifers did not have follicles producing significant quantities of estradiol. Concentrations of estradiol in the plasma were not significantly correlated with any of the carcass traits.

Estradiol concentrations at the end of the feeding period in all heifers were correlated with average daily gain (r=.40). The major source of estradiol in the spayed-autografted heifers was the implant with possibly some estradiol secretion by the adrenal. The greater concentrations of estradiol in the intact implanted heifers could be from ovarian follicles as well as from the implant.

The spay/autograft technique used with a normal feeding period and feedlot processing procedure does not appear to be an economically viable alternative to feeding intact females or steers.

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EFFECT OF SUPPLEMENTAL POTASSIUM ON SUMMER PERFORMANCE OF COMMERCIAL FEEDLOT STEERS

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Story in Brief

Red and white-bodied crossbred steers in a commercial feedlot were fed three levels of dietary potassium [.77 (basal), .89 and 1.01% of diet dry matter] during 42 to 56 days of late summer to check effects on heat stress and performance. Four groups of uniform steers were subdivided into 4 pens (a total of 787 steers) fed .77 and .89% potassium while 3 pens (300 steers) received the 1.01% dietary potassium. Daily gain, feed consumption and feed efficiency tended to be improved with supplemental potassium. Cost per pound of gain, cost per head per day, respiration rates, and body surface temperatures were not significantly affected by treatment. Increasing the dietary potassium level above 0.77% of diet dry matter for summer feeding of finishing steers did not significantly alter metabolism or performance of steers. Summer temperatures were generally mild during the study which may have biased the results of this trial. Further research to assess the effect of supplemental potassium upon the performance of heat stressed feedlot steers is warranted.

(Key Words: Potassium Chloride, Heat Stress, Respiration Rate, Body Surface Temperature, Feedlot Steers.)

Introduction

Currently, the National Research Council recommends a dietary potassium level of .65% for beef cattle. Feedlot diets containing high levels of grain often require potassium supplementation. In addition, severe heat stress has the potential (Beede et al., 1983) to increase potassium loss through sweating. Heat-stressed feedlot steers exhibit reduced feed intake and weight gain. Potassium deficiency can decrease feed intake and rate of gain, but specific deficiency symptoms are not readily apparent. Thus, the heat stressed feedlot steer may be potassium deficient.

Milk production by dairy cows, under the stress of high environmental temperatures, has been increased with supplemental potassium. Feed intake and milk yields were both increased (Beede et al., 1983). Work with steers has been less favorable (Beede et al., 1985). Survival of heat-stressed broilers also can be increased with higher potassium intake (Smith and Teeter, 1986). Most studies showing benefits to elevated potassium intake by finishing cattle have been conducted during the summer.

The objective of this trial was to examine the effect of supplemental potassium upon the performance of commercial feedlot steers during the late summer.

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Materials and Methods

One-thousand-eighty-seven crossbred steers of 4 groups with similar initial weight, background, and ownership were placed in 11 commercial feedlot pens containing 44 to 134 steers per pen. Pens were located near Garden City, Kansas and were equipped with a tear drop waste disposal system. When the environmental temperature exceeded 80 degrees Farenheit, a sprinkler system automatically switched on for 5 minutes each half hour.

The trial began July 24, and the cattle were slaughtered from September 5 to September 19, 1985. Three diets (Table 1) were fed. The basal diet contained no supplemental potassium but by calculation provided .6% potassium. The other two diets were formulated to contain .8 or 1.0% potassium from supplemental KCl added to the ration in a slurry delivered from a micro-ingredient machine. Samples of the ration were analyzed, and the potassium content was determined to be .77, .89 and 1.01% of dry matter for the three diets. The analyzed values of potassium between diets were closer than expected from calculated values based on the amount of potassium added. Commercial analysis showed similar values.

On September 6 at 1:30 and 4:30 pm heat stress was checked. Respiration rates and surface temperatures of seven to fifteen steers per pen were monitored as described by Arp et al. (1983).

To calculate initial and final mean weights from full pen weights, a 4% pencil shrink was applied. All animal performance calculations were based upon these values. Data were subjected to analysis of variance using the Statistical Analysis System, and Duncan's Multiple Range test was used to separate means. Linear and quadratic effects of treatments were checked using the general linear model of the Statistical Analysis System.

Table 1. Composition of basal finishing ration.

Ingredient	Percent of dry matter
Alfalfa-stover[a]	4.86
Corn silage	2.10
Supplement	4.86
Corn hominy	11.30
Wheat, dry rolled	30.60
Corn, high moisture	42.42
Fat blend[b]	3.80
Micro-ingredients[c]	---

[a]Blend of 75% alfalfa hay and 25% milo stover.
[b]Blend is 70% vegetable oil and 30% animal fat.
[c]To provide dietary potassium levels of .77, .89 or 1.01% from addition of potassium chloride at 0, 6.1 or 12.2 pounds per ton of feed.

Results and Discussion

All pens of steers had mean daily gains exceeding three pounds per day, and differences between treatment groups were small. Average daily gain (Table 2) for the total feed period tended to be increased with added potassium. Gains of the steers fed the two higher levels of potassium were almost identical (3.11 and 3.12 lb per day). This conflicts with research from Florida (Beede et al., 1985) in which gains tended to decrease when potassium level in the diet increased above .65%. Elevated potassium intakes can increase live weight gain of broilers by 46% under severe and chronic day-night heat stress.

Most of the increase in the gains of the steers receiving the supplemental potassium is attributable to increased feed consumption. Steers receiving the two higher potassium levels consumed 1.6% more feed than steers fed the basal diet. In other research, increasing potassium from .66 to 1.08% of the ration increased feed intake by heat stressed lactating dairy cows. In a Florida trial with beef steers, in contrast, increasing potassium from .7 to 1.1% of the diet decreased feed consumption by 2.5%.

Feed efficiency of the steers tended to be improved, with a .3% increase with each increment in the level of dietary potassium. Potassium supplementation has increased the feed efficiencies of severely heat stressed broilers by 15.4%. With yearling steers fed during the summer with cycling temperature stress, feed efficiencies tended to be decreased by .83% with dietary potassium levels of 1.1% in one trial. Whether the duration of the heat stress (i.e., chronic vs cycling temperature) impacts the potassium response is not known.

Feed cost per pound of gain was similar between steers consuming the .89 and 1.01% potassium diets. Feed cost per pound of gain for the steers fed the basal diet was .06 to .07 cents lower which may be attributed to the differences in feed efficiency noted earlier. If K loss increases with heat stress, one would expect that cellular hydration and thereby feed efficiency could be altered. Cost per head per day included feed and yardage expenses. The cost tended to increase with the steers receiving supplemental potassium due to increased feed consumption by steers fed the higher levels of potassium.

Under ambient environmental temperatures, the respiration rates of a dairy cow standing at rest or laying are approximately 29 and 35 respirations per minute, respectively. Respiration rate increases under heat stress. Rates of 130 respirations per minute have been noted in lactating dairy cows under unshaded conditions, and treatment means

Table 2. Animal performance of steers fed three dietary levels of potassium.

Item	K level, percent of dry matter		
	.77	.89	1.01
Daily gain, lb/day	3.05	3.11	3.12
Daily feed consumption, lb/day	20.03	20.36	20.37
Feed/lb gain	6.62	6.60	6.58
Cost/lb gain, cents	49.61	49.55	49.54
Cost/head/day, dollars	1.50	1.53	1.54

Table 3. Physical measurements of steers fed three dietary levels of potassium.

Item	K level, percent of dry matter		
	.77	.89	1.01
Respiration rate, 1:30 pm	79	77	76
Respiration rate, 4:30 pm	67	69	67
Body surface temperature 1:30 pm, Degrees Farenheit	104	101	101
Body surface temperature, 4:30 pm, Degrees Farenheit	101	101	104

reported by Arp et al. (1983) approached 140 breaths per minute. Increased "panting" may reduce blood pH and indirectly reduce the buffering properties of saliva which lowers ruminal pH. In addition, panting may contribute to a salivary loss of up to 40 pounds per day, resulting in a loss of 1.8 to 2.9 ounces of minerals.

Respiration rates of the steers in the current trial were elevated above the normal range but were not as high as expected during a very hot, sunny day. The high temperature reached day of measurement was 96 degrees Farenheit; the low temperature was 56 degrees. Relative humidity was 71%. Respiration rates of the steers did not change with the level of dietary potassium.

No significant differences in body surface temperatures of the steers were detected. Unlike respiration rates, body surface temperatures did not decline at the 4:30 pm observation. Added potassium may have reduced heat load slightly which in turn allowed feed intake to increase which resulted in similar respiration rates and surface temperatures.

Results from this trial indicate that metabolism and performance of the feedlot steers was not significantly improved by elevated levels of potassium. However, the trial began relatively late in the summer, and summer temperatures were much milder than normal (Table 4). Further research needs to be conducted under more severe environmental temperatures to further examine the effect of supplemental potassium on heat-stressed feedlot cattle.

Table 4. Climatic measurements during the trial.

Month	Temperatures		Relative humidity
	Average high	Average low	
July	92.0	63.3	79
August	87.2	60.2	88
September	78.0	52.1	88

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EFFECT OF SUPPLEMENTAL POTASSIUM AND MONENSIN ON RUMINAL DIGESTION AND PASSAGE RATES

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Story in Brief

Four ruminally cannulated cattle (1005 lb) were fed 63 percent milo diets to determine the effects of potassium and monensin on ruminal digestion and in situ disappearance of corn and soybean meal. Treatments included two levels of potassium (.64 or .86 percent) and monensin (0 or 27 ppm). Ruminal buffering capacity and concentrations of sodium, potassium and total volatile fatty acids were not affected by treatment. Potassium supplementation depressed ruminal isobutyrate and increased ruminal liquid passage rates by 15 percent. Monensin depressed ruminal ammonia-nitrogen, and acetate, butyrate and valerate while increasing propionate and isovalerate. Passage rates of milo and prairie hay tended to be faster when monensin was fed. Added monensin did not alter ruminal dry matter disappearance of corn but tended to increase ruminal disappearance of dry matter and nitrogen from soybean meal. This may have been due to a higher ruminal pH with monensin supplementation. As ruminal pH increased, digestion rates of soybean meal dry matter and nitrogen increased. No interactions between potassium and monensin were detected. Results indicate that potassium supplementation does not alter effects of monensin on digestion.

(Key Words: In Situ, Potassium Chloride, Monensin, Feedlot, Rate of Passage.)

Introduction

Monensin is widely used in feedlot diets. Monensin generally improves feed efficiency, depresses feed intake and has little effect on the daily gain of feedlot cattle. Monensin increases the proportion of propionate produced in the rumen and often increases the quantity of dietary protein that escapes degradation in the rumen by forming complexes with certain minerals [potassium (K) and sodium (Na)]. Hence, monensin feeding modifies protein and mineral availability (NRC, 1984). Interactions between dietary mineral levels and monensin have been detected in microbiological and mineral balance studies, but interactions in the rumen and in feedlot performance have not been reported.

This study was designed to detect effects and interactions of K and monensin on ruminal digestion and passage rate of ruminal fluid and particles.

Materials and Methods

Two Angus-Hereford heifers (1043 lb) and two Brahman-Hereford cross steers (968 lb) fitted with large ruminal cannulas were fed each of 4 diets to determine the impact of K and monensin on digestion of a

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70 percent concentrate, complete mixed diet. The four diets (Table 1) were: the basal (B) diet (calculated to provide .57 percent endogenous K); the basal diet plus 27 ppm monensin (M); the basal diet plus supplemental potassium (K) from potassium chloride to provide .95 percent K; and the basal ration supplemented with both K and monensin (KM) (with .95 percent K and 27 ppm monensin). The K contents analyzed .65, .87, .62 and .85 percent K for the B, K, M and KM diets. Daily dry matter intake of each animal was restricted to 1.25 percent of the animal's initial shrunk weight.

Periods, during which each diet was fed, lasted 21 days with sampling of rumen contents on days 19 through 21 of each of the 4 periods. Feed samples were collected on days 19 through 21, composited within each diet and period, and analyzed for dry matter, ash, nitrogen (N), starch, K and Na.

On day 19, rumen samples were obtained before feeding and 1, 3, 6 and 9 hours later. Ruminal samples were analyzed for pH, ammonia-N (NH_3-N), volatile fatty acids (VFA), buffering capacity, K and Na.

To determine diet effects on ruminal digestion rate, beginning on day 19, dacron bags containing 1.5 g of soybean meal or ground corn were suspended in the rumen for 4, 12 or 24 h for each of the diets. Upon removal from the rumen, the bags were washed, dried, weighed and nitrogen content was determined.

Animals were stalled in metabolism crates and fed twice daily at 0800 and 2000 h. For estimating passage rates from the rumen, whole rumen fluid was sampled at 0800 on day 20, and 150 g of milo labeled with ytterbium and 100 g of prairie hay labeled with dysprosium were added to the diet for each animal, and a fluid marker (100 ml of CoEDTA plus 150 ml distilled water) was dosed into the rumen. Rumen fluid samples were withdrawn 6, 12, 18, 24, 30 and 36 hours after the dosing meal and dried, ground, and analyzed for dry matter, ash, cobalt (Co), ytterbium (Yb) and dysprosium (Dy) concentrations.

Table 1. Composition of finishing diets with varying amounts of dietary potassium and monensin.

Item	Diets [ab]			
	B	K	M	KM
Dry rolled sorghum	63.43	62.70	63.41	62.68
Sun-cured prairie hay	15.00	15.00	15.00	15.00
Cottonseed hulls	15.00	15.00	15.00	15.00
Cottonseed meal	5.50	5.50	5.50	5.50
Trace mineralized salt	.50	.50	.50	.50
Limestone	.57	.57	.57	.57
Potassium chloride	.00	.73	.00	.73
Monensin	.00	.00	.02	.02

[a]Basal (B) = .65% K analyzed.
Potassium (K) = .87% K analyzed.
Monensin (M) = .62% K analyzed and 27 ppm monensin.
Potassium and monensin (KM) = .85% K analyzed and 27 ppm monensin.
[b]Diets analyzed 32.6% starch, and 10.2% crude protein.

Results and Discussion

Intakes of various nutrients are presented in Table 2. Analyzed sodium intake was 30 percent greater ($P<.05$) with the K or K-monensin diets. This is due partly to the fact that monensin was added in the form of monensin sodium but mainly because the commercial KCl added contained between 1.5 and 2.5 percent Na.

Ruminal fluid K and Na concentrations averaged over 5 sampling times did not differ significantly with diet though ruminal K tended to be greater with elevated K intake. The consistency in ruminal concentrations of K and Na across all treatments was surprising and probably reflects recycling of Na and K to the rumen. Recycling of Na and K to the rumen in another study was 19 to 26 g Na and 3 to 10 g K daily (Doran et al.,1985). In this trial, K recycling into the rumen, calculated from K concentration and liquid passage rate, was from 65 to 88 g daily.

Table 2. Dietary intake and ruminal measurements.

Item	Diets			
	B	K	M	KM
Dietary intake				
Organic matter, g/d	5284	5257	5286	5266
Starch, g/d	1850	1854	1776	1671
Nitrogen, g/d	88.7	90.8	88.7	89.3
Potassium, g/d	35.60	47.30	33.94	46.43
Sodium, g/d	5.50	7.28	5.93	7.58
Dietary K:Na ratio	6.59	6.66	5.72	7.49
Ruminal fluid				
Potassium, ppm	2447	2551	2283	2747
Sodium, ppm	2018	2050	2394	1848
Potassium:Na ratio	1.51	1.62	1.15	1.70
Ruminal passage rate				
Liquid, (Co) %/h	2.95	3.39	2.87	3.32
Solids				
Milo, (Yb) %/h	1.73	1.96	1.98	2.24
Prairie hay, (Dy) %/h	2.48	2.22	2.50	2.57
Rumen volume, liter[a]	71.7	65.8	62.0	60.8
Rumen outflow, liter/h	2.1	2.2	1.8	2.0
Ammonia-N, mg/dl	6.59[b]	5.55[b]	4.25[c]	4.02[c]
pH	6.26	6.13	6.39	6.32
Buffering capacity (ml HCl needed to change 40 ml strained rumen fluid from pH 7.0 to pH 5.0)	45.9	48.6	46.8	45.2

[a]Rumen volumes were estimated from relative zero time intercepts of Co.

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

Monensin supplementation did not alter (P>.05) ruminal concentrations of either K or Na. Previously, monensin supplementation has had conflicting effects on ruminal fluid K and has not altered ruminal Na. In one trial at a lower K intake (35 percent of this trial) monensin supplementation increased ruminal fluid K levels by 21.6 percent. In a second trial (at a similar K level to our trial) monensin supplementation decreased the ruminal fluid K level. In a third trial at a K level similar to the current trial, monensin supplementation did not alter ruminal fluid K concentration.

The ruminal K:Na ratio did not differ significantly among treatments, but as the ruminal K levels increased, ruminal Na levels tended to decrease. Ruminal fluid concentrations of K and Na were inversely related (r=-.96; P<.0001) as has been suggested from other studies. Possibly osmotic pressure regulates absorption or outflow of both ions. Prior research has indicated that dietary K added in the presence of lasalocid will reduce ruminal fluid Na concentrations. This tendency was apparent with monensin in our study.

Liquid passage rate was 15 percent faster (P<.07) with K supplementation, agreeing with other research reports. Ruminal outflow was correlated positively with the ruminal ratio of K:Na (r=.47; P<.07) tending to increase as K increased. Fluid dilution rate and particulate passage rate for Yb-labeled milo tended to increase together (r=.59; P<.02). Presumably, higher potassium intakes increased urinary K excretion which in turn increased water intake and rumen fluid dilution rate. Higher ruminal K:Na ratios also increased ruminal volume (r=.52; P<.04). In this study, ruminal outflow of liquid (Figure 1) and ruminal liquid volume increased together (r=.53; P<.03), possibly due to increased water consumption.

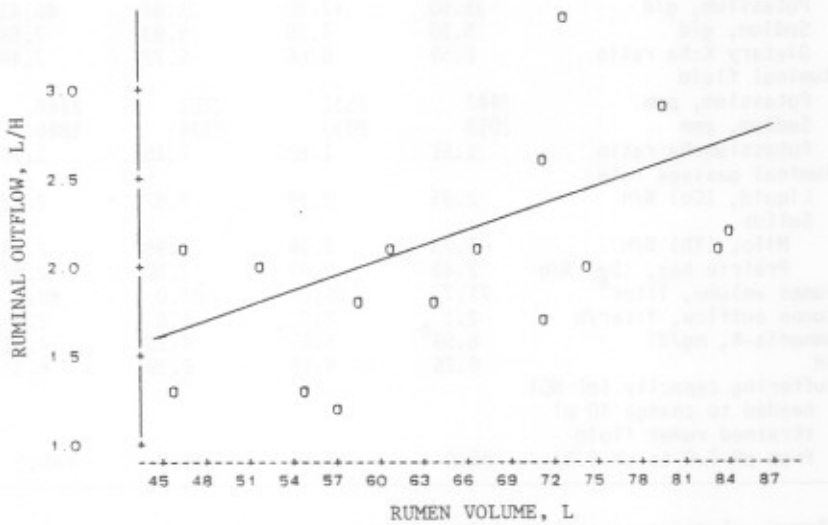


Figure 1. Ruminal outflow (O) vs ruminal volume.

Passage rate of both milo and prairie hay from the rumen tended to increase with K supplementation with the fastest passage with the K-monensin diet. Solids passage rate also tended to increase with added monensin. This contradicts results of previous reports in which monensin has decreased passage rates of both the liquids and solids. Differences in passage rates among these trials may be due to differences in rumen volume or K:Na ratios in the rumen. Passage rate of milo from the rumen and the ruminal K:Na ratio were negatively related ($r=-.52$; $P<.04$).

Estimated rumen volumes in this trial tended to be reduced with monensin supplementation ($P<.12$). This effect has been noted in other trials at similar feed intake levels. In the current trial, as rumen volume tended to increase (Figure 2) the passage rates of milo and prairie hay tended to decrease ($r=-.45$; $P<.08$ and $r=-.29$; $P<.28$). The relation between fluid passage rate and rumen volume was low ($r=-.16$; $P<.56$). Volatile fatty acid concentration changes discussed below could be partly attributed to changes in ruminal volume.

With all four diets, the passage rate for milo was slower than for prairie hay. This is inconsistent with the theory that smaller particles leave the rumen rapidly. Possibly, milo particles became lodged in the ruminal raft which reduced their passage rate.

Ruminal ammonia-N levels were lower ($P<.03$) with the monensin-supplemented diets as is often reported. Ruminal ammonia decreases are consistent with the suggestion that monensin depresses protein breakdown in the rumen. No K by monensin interaction was evident ($P>.05$) for ruminal ammonia, which agrees with other trials. Ruminal ammonia-N levels and ruminal pH were negatively correlated ($r=-.47$; $P<.07$). At higher pH levels, as occurred with monensin supplementation, ruminal ammonia-N is more rapidly absorbed from the rumen which reduces the ruminal ammonia-N level.

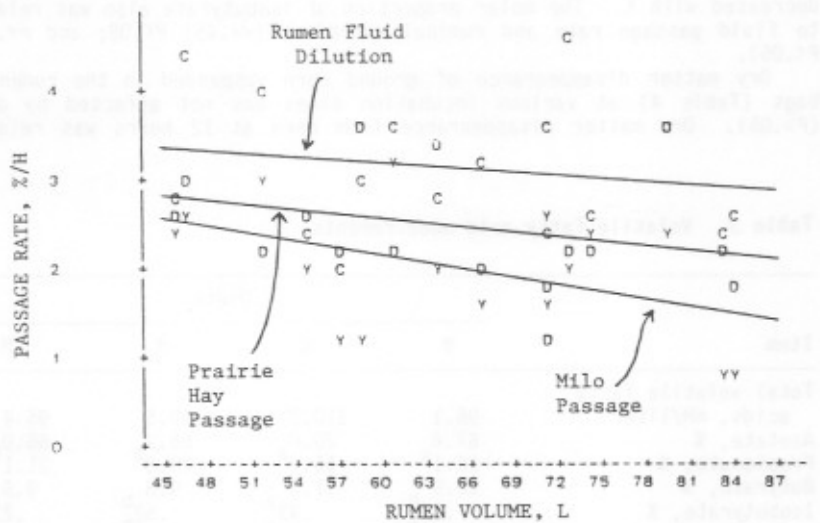


Figure 2. Rumen fluid dilution (C), milo passage rate (Y), and prairie hay passage rate (D) vs ruminal volume.

Ruminal pH tended to be higher with monensin supplementation ($P<.11$), possibly due to decreased production of volatile fatty acids or lactate. Increases with monensin are common but usually slight. All pH values in this experiment were higher than would be expected for a 70 percent concentrate diet which may be due to the low feed intakes used.

Buffering capacity was not altered by treatment ($P>.05$). Treatments with a higher initial pH and lower volatile fatty acid concentrations tended to have the lower buffering capacities. Mean ruminal pH and buffering capacity were negatively related ($r=-.56$; $P<.02$) while total volatile fatty acid concentration and buffering capacity were positively related ($r=.49$; $P<.05$). This tends to refute the theory that added KCl acts to buffer ruminal contents. Though KCl like $CaCl_2$ tended to reduce ruminal pH, potassium acetate or carbonate should have greater impact on buffering capacity. Ruminal pH and buffering capacity in this study appeared attributable primarily to VFA concentrations.

Total volatile fatty acid concentration (Table 3) was similar ($P>.05$) across treatments. However, ratios were altered with monensin supplementation. Monensin increased the molar proportion of propionate ($P<.01$) by 31.3 percent but tended to decrease ($P<.06$) molar proportions of acetate and butyrate (4.6 percent and 18.3 percent). These results agree with previous reports.

Addition of K did not significantly alter ($P>.05$) the ruminal acetate:propionate ratio similar to other reports. However, K supplementation decreased the molar percentage of isobutyrate, and monensin supplementation decreased the molar proportion of valerate ($P<.01$) and increased isovalerate ($P<.05$). A K by monensin interaction further depressed the proportion of valerate ($P<.04$). Reductions in isovalerate reflect reduced protein degradation differences suggesting that protein catabolism in the rumen was increased with monensin but decreased with K. The molar proportion of isobutyrate also was related to fluid passage rate and ruminal ammonia-N ($r=.45$; $P<.08$; and $r=.50$; $P<.05$).

Dry matter disappearance of ground corn suspended in the rumen in bags (Table 4) at various incubation times was not affected by diet ($P>.05$). Dry matter disappearance from corn at 12 hours was related

Table 3. Volatile fatty acid measurements.

Item	Diets			
	B	K	M	KM
Total volatile fatty acids, mM/liter	96.1	110.8	98.5	95.4
Acetate, %	67.6	70.0	65.2	66.0
Propionate, %	16.1[a]	15.9[a]	20.8[b]	21.1[b]
Butyrate, %	12.9	11.0	9.8	9.8
Isobutyrate, %	.51[b]	.43[a]	.52[b]	.23[a]
Valerate, %	.92[a]	.97[a]	.86[b]	.70[c]
Isovalerate, %	1.93[b]	1.76[b]	2.85[a]	2.07[a]

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

Table 4. Effect of potassium and monensin on rate of in situ dry matter and nitrogen disappearance.

Item	Diets			
	B	K	M	KM
Digestible corn DM available, %	76.5	74.7	75.1	75.2
Digestion rate of corn DM, %/h	1.41	1.25	1.32	1.49
Digestible soybean meal DM available, %	68.8	69.0	63.9	64.2
Digestion rate of soybean meal DM, %/h	1.72	1.87	2.12	1.82
Digestible soybean meal N available, %	89.7	84.7	79.0	86.2
Digestion rate of soybean meal N, %/h	2.00	1.65	2.53	2.61

positively with liquid and solids passage rates ($r=.57$; $P<.02$; and $r=.46$; $P<.07$). Possibly increased water intake or water movement into the rumen with added K tended to remove the soluble corn residues at a faster rate. Disappearance of corn at 24 hours of incubation remained weakly related with solids passage rate ($r=.25$; $P<.36$). The zero time intercept was about 25 percent (Figure 3) suggesting that about 25 percent of the corn dry matter was lost from bags as soluble residues and small particles during the first few hours of incubation. Only the less soluble, larger particles remained to be digested thereafter.

Dry matter disappearance from dacron bags should be a relative index of dry matter digestibility. Previous trials have detected no effect of K on in vivo dry matter digestibility. In contrast, some previous research suggests that monensin increases in vivo dry matter digestibility. The discrepancy in digestion rates between in situ disappearance of this trial and previous in vivo trials may be due to several factors. First, in vivo dry matter digestion encompasses all diet components including starch, nitrogen and ADF. In contrast, corn is primarily starch, so in situ disappearance primarily reflects starch digestion. Secondly, previous trials have primarily reported total tract dry matter digestibility while this trial relates only to ruminal dry matter digestibility. Earlier trials with monensin have yielded contradictory results of ruminal dry matter digestibility.

Dry matter (Figure 4) and nitrogen disappearance (Table 4) of soybean meal were not significantly altered by diet ($P>.05$), though ruminal digestion of nitrogen (Figure 5) tended to be increased with addition of monensin to the diet ($P<.07$). This result contradicts most earlier research in which monensin has been reported to reduce ruminal digestion of dietary protein and increase protein escape. Usually, however, total flow of N from the rumen is not increased with monensin as microbial protein flow generally decreases in an amount similar to the increase in feed N passage. If monensin changed composition of

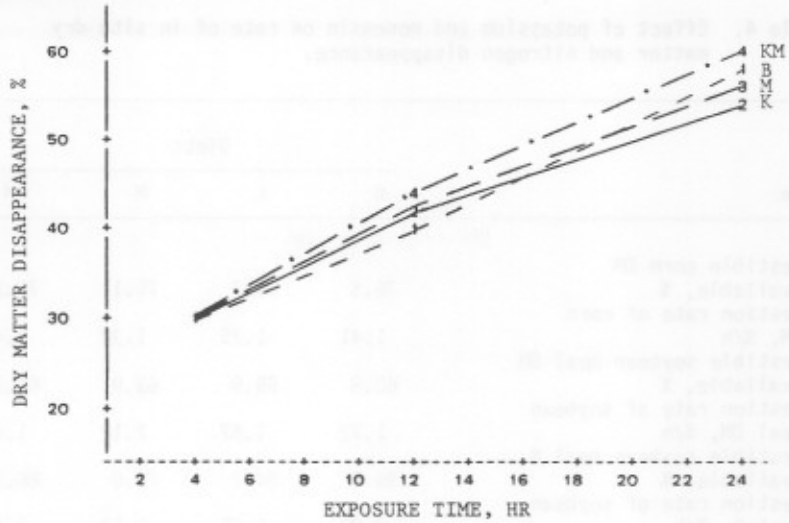


Figure 3. Dry matter disappearance of ground corn from dacron bags suspended in the rumen of cattle for 4, 12 or 24 hours.

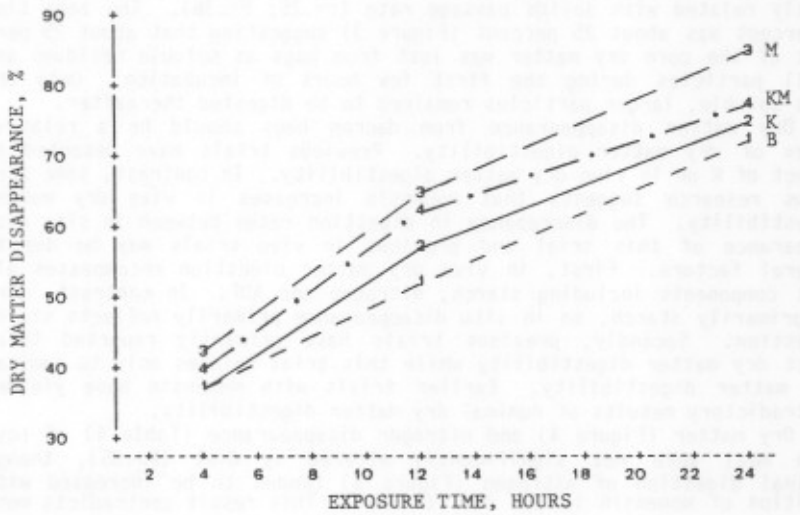


Figure 4. Dry matter disappearance of soybean meal from dacron bags suspended in the rumen of cattle for 4, 12 or 24 hours.

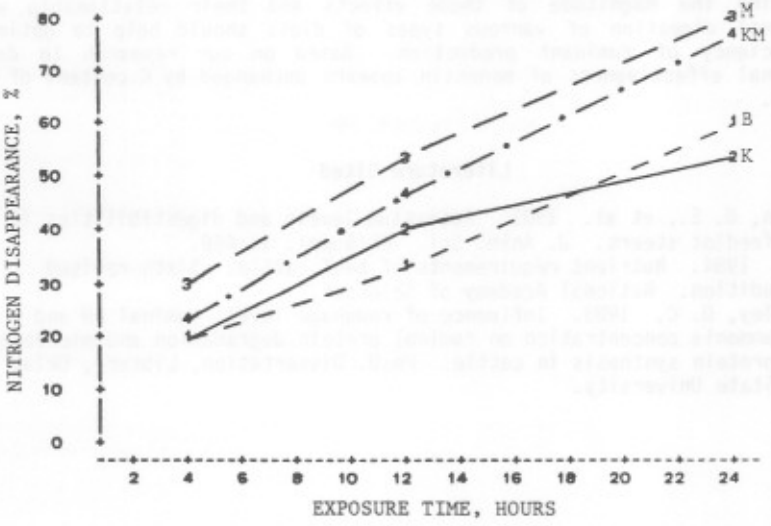


Figure 5. Nitrogen disappearance of soybean meal from dacron bags suspended in the rumen of cattle for 4, 12 or 24 hours.

ruminal microbes, microbial flow would be underestimated while ruminal escape of feed protein would be overestimated in vivo.

Increased disappearance of soybean meal nitrogen with monensin supplementation could be due to increased ruminal pH. Ruminal pH was related positively with dry matter and nitrogen disappearance of the soybean meal at 24 hour ruminal incubation ($r=.63$; $P<.009$ and $r=.71$; $P<.002$). Whether the interaction of pH with protein degradation is due to (a) altered solubility of the feed protein, (b) reproportioning of microbial species, or (c) altered proteolytic activity of existing species remains undetermined (Weakley, 1983). A second explanation for increased escape of soybean meal nitrogen with monensin supplementation relates to ruminal retention time. Passage rates of particles increased with monensin supplementation. If particulate passage rate is increased, escape in vivo could increase, despite an increased rate of N digestion in the rumen. In situ nitrogen digestibility at 24 hours was related positively to passage rate of Yb-labeled milo and Dy-labeled prairie hay ($r=.53$; $P<.04$ and $r=.45$; $P<.08$).

In conclusion, results from this study indicate that K did not alter the effect of monensin on measured ruminal factors. Though some researchers have shown that K can alter effects of ionophores on mineral levels and retention and on viability of ruminal microbes, added K generally does not alter effects of ionophores on feed efficiency in feeding studies. An interaction would be expected if all the effects of monensin relate to alteration in ion transport but ionophores have a number of effects, some of which can be enhanced or countered by added K. In this study, these changes include ruminal pH (increased with monensin, possibly reduced by K), ruminal fluid dilution rate (increased by K and reduced by monensin) and particulate passage rate (increased by both K and monensin). Further research to

examine the magnitude of these effects and their relationship with ruminal digestion of various types of diets should help to optimize efficiency of ruminant production. Based on our research to date, ruminal effectiveness of monensin appears unchanged by K content of the diet.

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THIAMIN AND $MgKSO_4$ SUPPLEMENTATION FOR STEERS FED CONCENTRATE DIETS[1]

A.L. Goetsch[2] and F.N. Owens[3]

Story in Brief

Ruminal escape of thiamin with and without supplemental $MgKSO_4$ (1.8 percent of diet dry matter) was measured with mature steers. Thiamin escape averaged 53 percent, but thiamin flow to the small intestine was reduced by 29 percent by addition of $MgKSO_4$ to the diet. Thiamin supplementation alone markedly decreased ruminal disappearance of fed organic matter and nitrogen and total tract disappearance of starch and nitrogen, and increased rumen microbial efficiency, but $MgKSO_4$ addition to the high thiamin diet reversed these effects of thiamin. Thiamin supplementation of the diet without added $MgKSO_4$ tended to elevate plasma thiamin, whereas $MgKSO_4$ addition to the diet with supplemental thiamin tended to lower plasma thiamin. Results indicate that thiamin deficiency in ruminants can be alleviated by supplemental thiamin in the diet but deficiency can be induced by high dietary $MgKSO_4$.

(Key Words: $MgKSO_4$, Sulfate, Thiamin, Site of Digestion, Cattle.)

Introduction

Polioencephalomalacia (PEM) is a persistent problem with feedlot cattle. Ruminal escape of dietary thiamin is suggested to be about 52 percent whereas ruminal synthesis is about 8 mg per kg digestible or organic matter consumed (Zinn et al., 1986). Both may decrease with acidic ruminal conditions of cattle fed high grain diets (Miller et al., 1983). Thiamin-HCl often is fed to feedlot cattle if PEM is diagnosed. Problems with PEM have been more prevalent among cattle fed high levels of gypsum (calcium sulfate) or $MgKSO_4$ suggesting that sulfate can precipitate the problem (Sadler et al., 1983). In the rumen, sulfate is reduced to sulfite and sulfide. Sulfite ions can cleave thiamin at the methylene bridge and dislodge the thiazole ring (Brent and Bartley, 1984). This study was conducted to evaluate the ruminal escape of supplemental thiamin and effects of dietary sulfate on thiamin flow to the duodenum of steers fed a finishing diet.

Materials and Methods

Four mature dairy steers (1023 lb) cannulated in the rumen and duodenum were each fed 4 different diets (with or without 1.8 percent supplemental $MgKSO_4$ and with or without addition of 1 g thiamin-HCl per animal per day; Table 1). Diets were formulated to have a

[1]The authors gratefully acknowledge assistance of R. L. Stewart, Roche Chemical Division, Hoffman-La Roche, Inc., Nutley, New Jersey 07110 for partial financial support and thiamin analyses.
[2]Former Research Associate [3]Professor

Table 1. Diet composition.

Ingredient	Diet	
	Basal	Sulfate
Sorghum grain, ground	33.25	31.45
Corn, ground	35.00	34.40
Cottonseed hulls	15.00	15.00
Dehydrated alfalfa	5.00	5.00
Alfalfa hay, ground	3.00	3.00
Soybean meal	1.00	1.60
Molasses	4.00	4.00
Urea	1.00	1.00
Limestone	1.61	1.61
Dicalcium phosphate	.34	.34
Trace mineralized salt	.50	.50
Chromic oxide	.30	.30
$MgKSO_4$	0	1.80
Thiamin	- +	- +

composition similar to that implicated to cause PEM (Sadler et al., 1983). Calculated sulfur contents of the diets without and with added $MgKSO_4$ were .15 and .51 percent (dry matter basis), respectively. The level of $MgKSO_4$ added was about double the 0.8 to 1 percent rate normally fed in finishing cattle diets. Thus, treatments consisted of the basal diet (B), the sulfate diet with no supplemental thiamin added (S), B with supplemental thiamin (T) and S with supplemental thiamin (TS). Chromic oxide was included in the diets as an indigestible marker. Steers were fed on days 1 through 8 at 0900 and 1700 h and at 0900 and 2100 h on d 9 through 15 with daily dry matter intake limited to 1.36 percent of body weight.

Feed, ruminal, duodenal, fecal and plasma samples were collected on days 13 through 15. Samples were analyzed for all or part of the following: DM, ash, nitrogen (N), starch, chromium, nucleic acid-N, ammonia-N and thiamin.

Results and Discussion

The thiamin content of the basal diet ranged from 2.9 to 4.5 ppm compared with a calculated thiamin content of 3.3 ppm. Thiamin supplementation increased its concentration to 5220 ppm.

Thiamin intakes (Table 2) averaged 26 and 951 mg daily without and with added thiamin, respectively. Thiamin feeding increased duodenal flow of thiamin. Ruminal thiamin balance should represent the net difference between synthesis and destruction in the rumen because thiamin is not absorbed from the rumen. Calculated by difference, apparent ruminal escape of dietary thiamin was 60.5 percent without and 45.8 percent with added sulfate. These are quite similar to the escape value (52 percent) reported by Zinn et al. (1986). Added sulfate reduced duodenal thiamin passage from the thiamin diet, possibly due to increased thiamin destruction within the rumen.

Table 2. Thiamin passage.

Item	Diet[a]				Sulfate[b]		Thiamin[c]	
	B	S	T	TS	0	+	0	+
Intake, mg	23.6[d]	28.4[d]	942.8[e]	959.9[e]	483.2	494.1	26.0[d]	951.3[e]
Entering intestine, mg	57.1[d]	38.3[d]	612.8[e]	465.1[e]	335.0	251.7	47.7[d]	539.0[e]
Net appearance in rumen, mg/d	33.6[d]	10.0[d]	-330.0[e]	-494.8[e]	-148.2	-242.4	21.8[d]	-412.4[e]
Apparent escape, % of intake			60.5	45.8				
Apparent synthesis, mg/kg OM digested in total tract	7.6	3.6						
Blood plasma concentration, mg/dl	4.5	8.3	10.3	3.8				

[a]Diet: B = basal; S = sulfate (1.8% $MgKSO_4$ added); T = thiamin (1 g thiamin-HCl added daily); TS = sulfate plus thiamin (1.8% $MgKSO_4$ and 1 g thiamin-HCl added daily).
[b]Sulfate: 0 = no added sulfate; + = sulfate added as 1.8% $MgKSO_4$.
[c]Thiamin: 0 = no added thiamin; + = 1 g thiamin-HCl added daily.
[de]Means in a row with diet, sulfate or thiamin groupings with different superscripts differ ($P<.05$).

With the basal diet, duodenal thiamin flow was 241 percent of intake, but sulfate supplementation of the basal diet reduced duodenal thiamin flow to 135 percent of thiamin intake. These results contrast those of Miller et al. (1983) who reported a net loss of thiamin in the rumen of animals fed high grain diets composed of corn, oats, barley and wheat. With their sorghum grain diet, however, duodenal thiamin passage exceeded intake by 8 mg or 79 percent. In studies by Zinn et al. (1986) with corn-based diets, ruminal outflow consistently exceeded thiamin intake. We used a diet with a lower level of concentrate than used by Miller et al. (1983) which contained both corn and sorghum. In our experiment, synthesis of thiamin, calculated after subtracting for escape of dietary thiamin as cited above, was 7.6 and 3.6 mg per kg digestible organic matter (OM) consumed for diets without and with supplemental sulfate. For the control diet, this value is quite similar to the 8.3 value proposed by Zinn et al. (1986) who fed lower levels of thiamin (20 or 200 mg daily), but thiamin synthesis appeared to be reduced by added sulfate.

Blood plasma thiamin levels (Table 2) were similar for all diets; however, an interaction between sulfate and thiamin supplementation was detected. Sulfate tended to increase plasma thiamin with the basal diet, whereas sulfate tended to depress plasma thiamin with the thiamin diet. This could be due to altered thiamin absorption. Absorption of thiamin is thought to be a carrier-mediated mechanism, with absorption decreasing as the carrier becomes saturated. The drop in plasma thiamin with sulfate supplementation also could reflect effects of sulfate on tissue use or excretion of thiamin.

Thiamin supplementation tended to increase ruminal pH (Table 3). This may be due to depressed ruminal digestion of organic matter with thiamin supplementation or to stimulation of activity of lactate-utilizing ruminal bacteria. A very low pH can cause an acid-shock of ruminal bacteria which results in release of the bacterial cell surface-bound thiaminase I enzyme (Brent and Bartley, 1984). With the high ruminal pH maintained in this study, level of active thiaminase I enzyme in rumen should have been low. The high and stable pH probably reflects the restricted intake of feed and presence of 23 percent

Table 3. Measures of digesta pH.

	Diet[a]				Sulfate[b]		Thiamin[c]	
Item	B	S	T	TS	0	+	0	+
Ruminal pH	6.48	6.46	6.60	6.49	6.54	6.48	6.47	6.55
Duodenal pH	2.43$_d$	2.74$_e$	2.17$_d$	2.57$_e$	2.30$_d$	2.66$_e$	2.59	2.37
Fecal pH	5.98[d]	6.31[e]	5.86[d]	6.37[e]	5.92[d]	6.34[e]	6.15	6.12

[a]Diet: B = basal; S = sulfate (1.8% $MgKSO_4$ added); T = thiamin (1 g thiamin-HCl added daily; TS = sulfate plus thiamin (1.8% $MgKSO_4$ and 1 g thiamin-HCl added daily.

[b]Sulfate: 0 = no added sulfate; + = sulfate added as 1.8% $MgKSO_4$.

[c]Thiamin: 0 = no added thiamin; + = 1 g thiamin-HCl added daily.

[de]Means in a row with diet, sulfate or thiamin groupings with different superscripts differ ($P<.05$).

Table 4. Digestion measures.

Item	Diet[a]				Sulfate[b]		Thiamin[c]	
	B	S	T	TS	0	+	0	+
Organic matter digestion								
Apparent ruminal, % of intake	35.9[d]	34.9[d]	19.9[e]	40.5[d]				
True ruminal, % of intake	45.5[d]	44.1[d]	30.1[e]	49.4[d]				
Postruminal, % of intake	17.6	20.8	31.1	22.1	24.3	21 5	19.2	26.6
Postruminal, % of available	42.5	45.0	52.4	52.2	47.5	48.6	43.8	52.3
Total, % of intake	63.0	64.9	61.3	71.5	62.2	68.2	64.0	66.4
Starch digestion								
Ruminal, % of intake	69.7	71.4	53.5	78.1				
Postruminal, % of intake	20.4	22.4	29.3	17.7	24.9	20.1	21.4	23.5
Postruminal, % of available	65.6	77.9	54.4	76.8	60.0	77.3	71.7	65.6
Total, % of intake	90.2[d]	93.8[d]	82.9[e]	95.8[d]				
Nitrogen disappearance								
Ruminal, % of intake	28.0[d]	24.8[de]	9.9[e]	34.2[d]				
Postruminal, % of intake	28.5	30.4	35.5	30.6	32.0	30.5	29.4	33.1
Postruminal, % of available	62.4	61.2	60.8	65.8	61.8	63.3	61.6	63.5
Total, % of intake	56.6[d]	55.1[de]	45.4[e]	64.8[d]				
Microbial efficiency, g microbial N/kg OM fermented	22.7[d]	20.9[d]	36.3[e]	18.0[d]				

[a]Diet: B = basal; S = sulfate (1.8% $MgKSO_4$ added); T = thiamin (1 g thiamin-HCl added daily); TS = sulfate plus thiamin (1.8% $MgKSO_4$ and 1 g thiamin-HCl added daily).
[b]Sulfate: 0 = no added sulfate; + = sulfate added as 1.8% $MgKSO_4$.
[c]Thiamin: 0 = no added thiamin; + = 1 g thiamin-HCl added daily.
[de]Means in a row with diet, sulfate or thiamin groupings with different superscripts differ (P<.05).

dietary roughage. Duodenal pH was not affected by diet, but pH of feces increased with $MgKSO_4$ supplementation.

The amount of OM digested in the rumen decreased with thiamin addition alone (Table 4) but postruminal and total tract OM digestion was similar for all diets. Interactions between supplementation of thiamin and sulfate also were detected for starch entering the duodenum and exiting the rectum, and for digestion of starch in the rumen and total tract. Total tract starch digestion was lowest for the thiamin diet. Ruminal and total tract disappearance of fed N was lower with the thiamin diet than with the basal and sulfate plus thiamin diets (Table 4) whereas microbial efficiency (Table 4) was greatest for the thiamin diet.

These shifts in ruminal conditions were not anticipated. Thiamin supplementation at a lower level, 20 percent of our supplemental level, with concurrent addition of other B-vitamins to a 44 percent roughage diet for receiving cattle did not alter ruminal digestion in a study by Zinn et al., (1986). Results might differ due either to simultaneous addition of other B-vitamins or to specific effects of a very high level of thiamin supplementation on ruminal digestion or rate of digesta outflow from the rumen. The thiamin effect seems too large to be explained by an increase in the rate of digesta passage from the rumen alone, so altered microbial activity is suspected. All levels should have exceeded microbial requirements for thiamin.

In summary, ruminal escape of dietary thiamin was about 50 percent. Hence, dietary supplementation should be useful to treat PEM. Addition of $MgKSO_4$ to the diet reduced duodenal flow of thiamin due both to reduced escape and reduced ruminal synthesis of thiamin. This depression may explain why PEM is encountered in cattle fed high concentrate diets containing an excessive level of sulfate. $MgKSO_4$ supplementation tended to increase plasma thiamin concentrations with a low thiamin diet but decreased plasma thiamin with a thiamin supplemented diet. It is unknown if or how supplementation of magnesium and potassium along with dietary sulfate might have altered these responses. The depression of ruminal digestion caused by supplementation of the diet with 1 g thiamin-HCl daily was circumvented by dietary sulfate inclusion, but mechanisms responsible for these alterations are unknown at present. Long term effects of occasional thiamin supplementation are unknown. If metabolism, excretion or ruminal degradation were increased, infrequent feeding could theoretically induce PEM. But in this study, ruminal degradation of thiamin did not appear to increase with thiamin feeding.

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EFFECTS OF GRINDING CORN AND HAY ON SITE OF DIGESTION OF HIGH CONCENTRATE DIETS BY BEEF HEIFERS

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Story in Brief

Corn grain was fed whole or ground with prairie hay which was either coarsely chopped, ground through a 1.5 inch screen, or ground through a 1/6 inch screen to cannulated beef heifers (707 lb). Ruminal pH and buffering capacity were greater for whole than ground corn at 2 and 6 hours after feeding reflecting greater saliva flow with the whole corn diets. Passage rate of corn particles from the rumen tended to be lower for whole than ground corn but increased with particle size of the roughage. Long hay had different effects with the two forms of corn. With whole corn, coarser hay increased ruminal digestion of organic matter, starch, protein and fiber but decreased postruminal digestion of organic matter and starch. Effects of long hay on digestion of ground corn were opposite those with whole corn. To increase postruminal supply of starch from ground corn, increasing roughage level or length to the point that intake of energy is depressed may be advantageous. With whole corn, long hay reduced postruminal starch digestion, so lower roughage levels and grinding the roughage should be more useful.

(Key Words: Corn, Roughage Processing, Site of Digestion, Cattle.)

Introduction

Corn and roughage are commercially processed to various degrees. If corn is fed without processing (whole), lower roughage levels are generally recommended as whole corn kernels have an abrasive "roughage effect" in the rumen. Also, high intake of roughage may elevate outflow of intact grain from the rumen. Whole corn and large particles which escape from the rumen are not digested in the intestines. How roughage processing shifts site of digestion between the rumen and intestines is not known. Feed efficiency with whole corn has been superior to flaked corn in some studies (Gill et al., 1980; Lee et al., 1982) but as much as 13 percent inferior in other studies (Lee et al., 1982) for an overall average of 8 percent poorer feed efficiency for whole than steam flaked corn (Hale and Prouty, 1980). Level and type of roughage may be involved. In metabolism trials, source and level of roughage can alter total tract starch digestibility from whole corn (Teeter et al., 1980; Rust and Owens, 1982) though reasons for these effects remain unknown.

Shifting digestion from the rumen to the small intestine may improve energetic efficiency since heat and gas losses in the rumen are reduced, but the quantity of starch which can be digested in the small intestine may be limited. The objective of this study was to determine

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the effect of roughage processing on digestion and passage rate of two forms of corn in 85 percent concentrate diets fed to beef heifers.

Materials and Methods

Six cannulated Hereford x Angus heifers (707 lb) were fed a diet composed of corn (72 percent), prairie hay (15 percent), soybean meal (10 percent), molasses (1.45 percent), limestone (.75 percent), trace mineralized salt (.5 percent) and chromic oxide (.3 percent). Corn was fed whole (W) or ground in a hammermill through a 1/8 inch screen (G), while prairie hay was chopped in a hammermill without a screen (long, L), ground through a 1.5 inch (medium, M) or a 1/6 inch screen (Short, S). The six combinations of corn and hay, designated as GS, GM, GL, WS, WM and WL, were each fed to each of the six heifers in different periods. Heifers were fed equal amounts of feed at 0700 and 1900 hours for a total daily dry matter intake of 1.65 percent of body weight.

Feeding periods lasted 14 days with sampling of the rumen, duodenum and rectum the final 4 days of each period. Samples were analyzed for dry matter, ash, nitrogen (N), starch, acid detergent fiber (ADF), nucleic acid-N, ammonia-N, pH, buffering capacity, chromium and passage rate markers.

Results and Discussion

Ruminal pH was higher for heifers fed whole than ground corn at 2 and 6 hours after feeding (Table 1) whereas duodenal pH was lower for whole than ground corn. Ruminal differences with processing corn grain matched the results of Lee et al. (1982). Fecal pH tended to be lower for ground than whole corn. Roughage type did not affect pH in the rumen, duodenum or rectum. Ruminal ammonia-N concentration in ruminal fluid was similar for all diets.

Ruminal buffering capacity between pH 7 and 5.5 was greater for heifers fed whole than ground corn 2 h after feeding. This may reflect a longer meal and greater mastication with whole corn which would increase flow of saliva and increase ruminal input of buffer from saliva. Slower fermentation of whole than ground corn prevents rapid volatile fatty acid production in the early hours after feeding. Roughage form did not affect buffering capacity at 2 hours, implying that increasing length of dietary roughage may be ineffective to prevent ruminal acidosis. As some of the ruminal buffering is due to the hay present in rumen, an additional amount of hay in the diet should increase rumination which would help prevent acidosis.

At 10 hours postfeeding with ground corn diets, despite small pH differences, buffering capacity was lower for medium and short hay than for long hay which may reflect direct or indirect effects of retained roughage on buffering capacity. But effects of hay particle length on buffering with whole corn diets were opposite those with ground corn.

Nucleic acid-N content of isolated bacterial cells isolated from the rumen was similar for all diets (Table 1) but nitrogen content was greater for WM than for WS and GM diets, and for WL than WS. Ruminal fluid liquid dilution rate was not affected by form of corn or roughage (Table 1). Feeding long prairie hay tended to elevate ruminal volume with ground corn but depress ruminal volume with whole corn. The lower the digestibility of ADF in the rumen, the greater the ruminal volume, possibly due to the fluid imbibed by the roughage.

Table 1. Ruminal pH, isolated bacterial cell composition and passage rate data.

Corn form	Ground			Whole		
Hay form	Ground	Medium	Long	Ground	Medium	Long
Ruminal pH, h after feeding						
2	6.18	6.05	6.20	6.47	6.33	6.43
6	6.28	6.17	6.39	6.47	6.42	6.57
10	6.69	6.37	6.80	6.63	6.53	6.65
Bacterial cell composition						
Nucleic acid-nitrogen,						
% of dry matter	1.50	1.38;	1.47	1.51	1.85	1.62
% of total nitrogen	21.0	21.9	22.2	25.8	23.6	21.9
Nitrogen, % of dry matter	6.86[abc]	5.95[ab]	6.60[abc]	5.89[a]	7.67[c]	7.17[bc]
Ruminal fluid dilution rate, %/h	10.8	9.0	10.0	11.0	10.1	10.4
Ruminal fluid volume, liters	44.9	46.7	62.5	46.5	46.3	40.9
Particulate passage rate, %/h	3.5	3.7	4.0	2.9	3.4	3.5

[abc]Means in a row with differnt superscripts are different.

Passage rate from the rumen was faster ($P<.07$) for ground than whole corn (Table 1). This may be due to differences in density. Settling causes whole grain to be retained in the rumen. Filtration and rejection of coarse particles at the exit point from the rumen also would increase retention time in the rumen. Increasing particle size of hay tended to elevate passage rate of corn particles and shifted digestion from the rumen to the intestines with ground but not with whole corn (Table 2). Passage rate of particles was negatively related to extent of starch digestion in the rumen with diets of ground ($r = -.45$; $P<.06$) but not whole corn. This suggests that more rapid flushing of corn particles through the rumen reduced ruminal starch digestion of ground corn. The increase in passage rate with long hay may be attributable to increased saliva input, but if so, fluid dilution rate should have been elevated. Another explanation would be that long roughage occupies more space in the rumen during and after feeding. This could reduce ruminal space for concentrate and force more rapid exit of concentrate particles from the rumen. Long hay also would have reduced ruminal mixing and thereby increased ruminal exit of the ground grain after a meal as noted previously with low quality range forage (Johnson et al., 1981).

Extent of ruminal digestion of organic matter (OM) with fine and medium ground hays were similar, but both were greater with ground than whole corn. Long hay reduced ruminal digestion of OM with ground corn but increased ruminal digestion with whole corn. Postruminal digestion compensated for differences in ruminal digestion except with the whole corn-long hay diet. Had feed intake or dietary roughage level been higher, postruminal digestion might have been compromised as larger digesta particles would reach the small intestine and accelerate rate of intestinal passage.

Ruminal starch digestion was not altered by roughage form with ground corn (Table 2), but with whole corn, ruminal starch digestion increased with larger size roughage. Total tract starch digestion was lower for whole than ground corn as is often observed. Postruminal starch digestion, as a percentage of intake or of flow to the intestines was lower for whole than ground corn and, with whole corn, was lowest for the long hay as has been noted previously (Lee et al., 1982; Aguirre et al., 1984).

Intestinal digestion with high grain diets often is limited by size and surface area of particles exiting the rumen. Lower postruminal digestion of starch from whole than for ground corn suggests that size of corn particles leaving the rumen was larger with whole than ground corn diets. Grain processing enhanced both ruminal and intestinal digestion of starch reaching the duodenum. Particle size of grain may be more important for starch digestion in the intestines than in the rumen, at least with limited feed intake. In addition, dietary roughage passing from the rumen may reduce intestinal digestion of starch with high concentrate diets. Again roughage source and level may alter this effect. Although longer hay increased ruminal digestion of both starch and fiber when fed with whole corn, fiber particles passing to the intestines may have been longer and elevated passage rate of digesta through the intestines to depress starch disappearance. Rate of passage through the small intestine in another study was accelerated by adding hay but not by adding cottonseed hulls to the diet.

Ruminal disappearance of feed protein was higher and postruminal disappearance of input N was lower for long than short or medium forms of hay with ground corn. Opposite trends were noted for whole corn diets. Treatment effects on ruminal, postruminal and total N

Table 2. Digestion measures.

Corn form	Ground			Whole		
Hay form	Ground	Medium	Long	Ground	Medium	Long
Organic matter digestion						
Apparent ruminal, % of intake	54.6	53.6	45.5	40.9	42.3	59.6
True ruminal, % of intake	63.0	62.3	53.8	52.3	49.9	66.6
Postruminal, % of intake	26.7	26.1	35.3	37.1	36.2	21.2
Postruminal, % of available	56.4	53.3	61.7	59.8	59.0	45.1
Total tract, % of intake	81.3	79.7	80.8	77.9	78.5	80.8
Starch digestion						
Ruminal, % of intake	67.5	62.6	62.8	52.7	61.3	68.4
Postruminal, % ofintake	27.5	31.5	30.8	34.9	28.3	19.3
Postruminal, % of available	82.5	80.7	78.3	68.9	67.4	43.4
Total tract, % of intake	93.6	91.2	92.2	86.8	86.6	83.7
Nitrogen						
Passage, g						
Intake	103.2	101.1	103.4	99.7	102.9	108.4
Entering duodenum						
Total	95.1	85.9	108.7	109.9	119.9	84.4
Microbial	34.4	27.0	34.0	37.4	34.0	29.1
Feed	54.8	54.1	67.6	64.7	79.4	49.4
Exiting rectum	30.2	30.5	30.1	31.3	31.8	28.1
Digestion						
Ruminal, % of intake	45.7	46.6	34.1	32.3	24.1	55.0
Postruminal, % of intake	25.0	23.6	36.3	35.5	44.1	18.4
Postruminal, % of available	67.0	64.2	71.3	70.5	71.7	62.4
Total tract, % of intake	70.7	70.2	70.4	67.7	68.2	73.5
Ruminal acid detergent fiber digestion, %	61.7	46.4	40.6	29.8	53.2	63.5
Microbial efficiency, g microbial nitrogen/kg organic matter fermented	10.8	8.5	13.0	17.0	16.3	9.7

disappearance resemble those observed for organic matter. Digestion of protein in the rumen often is greater if ruminal pH is higher. Though this pattern fits these data for ground corn, it doesn't apply with whole corn diets. Particle size restrictions rather than pH probably had more impact upon ruminal digestion of feed N with whole corn. The high disappearance of N and starch in the rumen for the WL diet probably is responsible for low postruminal disappearance of available N. Total tract digestion of N was similar for all diets. Microbial efficiency tended to be greater for diets with whole than ground corn as was noted by Aguirre et al. (1984) but also tended to decrease as particle length of hay increased.

Digestion of ADF in the rumen tended to be greater for ground than whole corn with short hay, even though ruminal pH tended to be greater for whole corn at 2 hours after feeding. Ruminal pH differences narrowed with time after feeding so that pH at 10 hours after feeding was similar. Also, ruminal pH seldom fell below 6.0, a critical level for survival of fiber-digesting bacteria. Since microbial digestion of concentrate usually precedes attack of roughage, pH during the first few hours after a meal may not depress the total extent of fiber digestion in the rumen. At higher feed intakes or with frequent meals, ruminal fiber digestion can be reduced drastically (Zinn and Owens, 1983) which should increase the effects of level and form of roughage.

Ruminal ADF digestion tended to decrease as hay particle size increased in ground corn diets, whereas the reverse was true for whole corn diets. Differences in rate of fiber digestion and rate of passage are probably responsible. Grinding fiber to make it more accessible will increase rate of fiber digestion or decrease lag time before fiber digestion begins and should increase rate of digestion. Effects with whole corn probably relate to ruminal retention of fiber. Compared with long hay, ground hay has more chance to be flushed out of the rumen before being fully digested. Hence, ruminal separation and layering may be involved. Longer retention of long roughage particles should enhance the extent of fiber digestion in the rumen. Extents of both starch and fiber digestion in the rumen were elevated by long roughage with whole corn but were decreased with ground corn. These interactions deserve further study.

In conclusion, effects of corn processing on site of digestion in beef cattle fed a high grain diet were altered by physical form of the roughage. Increasing hay particle size from a fine to a medium grind had little effect on ruminal digestion with either form of corn. Ruminal digestion of organic matter, starch, protein and fiber were greater for ground than for whole corn with ground hay. With coarsely chopped prairie hay, however, ruminal digestion decreased with ground corn but increased with whole corn; differences in mastication and ruminal outflow rates are probably responsible. To maximize total tract digestion of starch, grinding roughage appears useful. To increase postruminal starch digestion, long hay was beneficial with ground corn but detrimental with whole corn. With whole corn, long hay reduced postruminal starch digestion. Results indicate that effects of processing of grain are dependent on characteristics of the dietary roughage being fed. Research is needed to check these effects with lower dietary roughage levels, with other types of roughage, with higher feed intakes and more frequent feeding.

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WHOLE OR GROUND CORN WITH DIFFERENT ROUGHAGE SOURCES IN HIGH CONCENTRATE DIETS FOR BEEF HEIFERS

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Story in Brief

Two forms of corn (whole or ground) were fed with three roughage sources (chopped alfalfa, cottonseed hulls or chopped prairie hay) to cannulated beef heifers (807 lb) in 90% concentrate diets at a daily dry matter intake level of 1.44% of body weight. Ruminal pH at 2 and 6 h postfeeding was lower for ground than whole corn diets. Ruminal fluid buffering capacity at 2 h after feeding was greater for whole than ground corn diets. Ruminal organic matter and starch digestibilities with ground corn diets tended to be greatest with alfalfa, intermediate with cottonseed hulls and lowest for diets with prairie hay as a source of roughage. The same trends were noted with whole corn for organic matter though ruminal digestion of starch did not vary. Postruminal disappearance of organic matter was lower with the alfalfa diets, making total tract organic matter digestion lower for diets with alfalfa than cottonseed hulls. When fed at 10% of the diet, cottonseed hulls and prairie hay were more valuable than alfalfa hay. Duodenal flow of microbial and feed nitrogen were greater for whole than for ground corn. Ruminal disappearance of feed nitrogen was higher for ground than whole corn diets. This suggests that feeding corn in the whole rather than the ground form will decrease the dietary crude protein requirement and increase the need for urea.

(Key Words: Corn, Grinding, Processing, Roughage Form)

Introduction

Currently, cost, availability and ease of handling are primary considerations for choosing the type of roughage to be used in high grain finishing diets. Chemical and physical attributes of roughage in high concentrate diets have received limited attention. Since roughage processing will influence the propensity for acidosis and site of digestion (Goetsch et al., 1986), roughage processing and source in high grain diets deserves more study. Because specific types of roughage may affect efficiency of digestion of high grain diets differently, the objective of this study was to investigate effects of several types of roughage on site of digestion in beef heifers fed diets containing high amounts of whole or ground corn.

Materials and Methods

Six cannulated Hereford X Angus heifers (807 lb) equipped with ruminal and duodenal cannulas were fed the 6 diets (Table 1) in rotation at a level equal to 1.44% of body weight per day. Corn was fed ground (3mm screen; G) or whole (W), while roughages, included at 10% of diet

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Table 1. Diet composition (percentage of dry matter).

Item	Corn Form and Roughage Source					
	Ground			Whole		
	Alfalfa Hay	Cotton-seed Hulls	Prairie Hay	Alfalfa Hay	Cotton-seed Hulls	Prairie Hay
Corn, ground	87.06	83.04	83.37	-----	-----	-----
Corn, whole	-----	-----	-----	87.06	83.04	83.37
Alfalfa hay	10.00	-----	-----	10.00	-----	-----
Cottonseed hulls	-----	10.00	-----	-----	10.00	-----
Prairie hay	-----	-----	10.00	-----	-----	10.00
Soybean meal	1.20	4.81	4.63	1.20	4.81	4.63
Limestone	.94	1.25	1.20	.94	1.25	1.20
Trace mineralized salt	.50	.50	.50	.50	.50	.50
Chromic oxide	.30	.30	.30	.30	.30	.30

dry matter (DM), were alfalfa hay (chopped through a 3.8 cm screen), cottonseed hulls or prairie hay (chopped through a 3.8 cm screen).

Periods lasted 14 days with the first ten days for adaptation to the new diets and the last four days for sampling of ruminal, duodenal and rectal materials twice each day. Samples were subjected to all or part of the following analyses: DM, ash, nitrogen (N), starch, nucleic acid-N, ammonia-N, pH, buffering capacity and chromium. Buffering capacity was measured by adjusting the pH to 7 and adding acid to decrease pH incrementally.

Results and Discussion

Ruminal pH was greater for whole than ground corn diets at 2 ($P<.05$) and 6 h postfeeding ($P<.12$; Table 2). Greater chewing and rumination of whole corn as well as slower fermentation of whole than ground corn leads to a more constant rumen environment with whole than with processed corn diets. Processed grains promote a peak fermentation activity 1 to 3 h after a meal. Roughage type did not affect, or interact with corn form to affect, ruminal pH. However, at 2 h postfeeding, ruminal pH for diets with alfalfa tended to be lowest of the roughage sources with ground corn but the highest with whole corn. Overall, roughage source did not markedly alter ruminal pH with this low dietary level of roughage though ruminal pH was consistently high due to the low level of feed intake used.

Duodenal pH (Table 2) was lower ($P<.05$) for diets with whole than ground corn as has been observed previously (Goetsch et al., 1986). This may be due to lower total buffering capacity of rumen fluid from steers fed whole corn diets. Fecal pH was lowest ($P<.05$) for the ground corn diet with alfalfa. Production of short chain fatty acids by hindgut microbes has been suggested to be responsible for the lower fecal pH. Postruminal organic matter (OM) digestibilities (Table 3) do not support that concept.

Table 2. Digesta pH and ruminal ammonia-nitrogen concentration and buffering capacity.

Item	Time After Feeding	Corn Form and Roughage Source: Ground Alfalfa Hay	Ground Cottonseed Hulls	Ground Prairie Hay	Whole Alfalfa Hay	Whole Cottonseed Hulls	Whole Prairie Hay
Ruminal pH	2	5.96[a]	6.11[ab]	6.04[a]	6.43[c]	6.31[b]	6.34[bc]
	6	6.25	6.30	6.20	6.52	6.30	6.37
	10	6.53	6.62	6.56	6.58	6.48	6.54
Duodenal pH	Mean	2.58[a]	2.62[b]	2.65[b]	2.43[b]	2.49[b]	2.47[b]
Fecal pH	Mean	5.35[a]	5.76[b]	5.87[b]	5.90[b]	6.03[b]	5.98[b]
Ruminal ammonia-nitrogen concentration, mg/dl							
	2	3.3	5.1	4.4	5.5	7.9	4.1
	6	4.0	4.9	4.4	4.8	6.6	4.5
	10	7.0	5.9	6.8	6.1	6.9	5.6
Ruminal buffering capacity, milli-equivalents of H ions/40 ml fluid							
pH range:							
7.0-6.0	Mean	1.18	1.24	1.18	1.25	1.17	1.21
6.0-5.0	Mean	1.68	1.58	1.59	1.65	1.70	1.58
5.0-3.0	Mean	3.47	3.04	3.38	2.97	3.18	2.98

[abc]Means in a row with different superscripts differ (P<.05).

Ruminal ammonia-N concentrations (Table 2) were reasonably low with all diets reflecting the low level (8.8 to 9.2% protein) and low ruminal degradation of dietary crude protein. Ruminal ammonia-N concentration at 2 h after feeding was greater for whole than ground corn (P<.07). This may reflect reduced breakdown of feed protein or reduced use of ammonia-N in the rumen for microbial growth with whole than ground corn diets. Grinding probably increased energy availability immediately after the meal which increased ammonia utilization and dropped pH shortly after the meal. The concentration of ammonia-N in rumen fluid of heifers fed ground and whole corn diets became more similar as time after feeding increased. Concentration of ammonia-N was not altered by source of roughage. Nitrogen flow to the postruminal digestive tract averaged 90% of consumed N with ground corn and 113% of consumed N with whole corn (Table 3) indicating that recycling of N to the rumen was substantial with whole corn diet. The relatively constant ruminal ammonia-N concentration is probably due to coincident release of available N and energy from OM fermented during the feeding interval together with adequate recycling of N to the rumen to maintain normal microbial digestion.

Ruminal fluid buffering capacity from pH 6 to 7 (Table 2), averaged for samples taken at 2, 6 and 10 h postfeeding, was similar for whole and ground corn diets. Buffering capacity at 2 h tended to be slightly greater for whole than ground corn between 5.5 to 7.0. Differences between whole and ground corn diets in buffering capacity from pH 5.5 to 7 at 2 h after feeding were previously detected in beef heifers fed concentrate diets with 15% prairie hay (Goetsch et al., 1986). From pH

Table 3. Digestion measures.

Item	Corn Form and Roughage Source					
	Ground			Whole		
	Alfalfa Hay	Cotton-seed Hulls	Prairie Hay	Alfalfa Hay	Cotton-seed Hulls	Prairie Hay
Organic matter digestion:						
Apparent ruminal[1]	63.3	59.8	51.5	57.4	56.8	52.3
True ruminal[1]	68.8[a]	64.4[ab]	58.1[b]	65.1[ab]	63.0[ab]	59.2[ab]
Postruminal[2]	17.4[a]	24.3[ab]	31.2[b]	21.6[ab]	27.7[ab]	28.9[ab]
Postruminal[1]	44.7	55.4	58.4	49.0	63.7	59.8
Total tract[1]	80.7	84.1	82.7	79.1	84.5	81.3
Roughage digestibility:						
Calculated[3]	13.4	53.2	37.8	-2.6	57.2	23.8
NRC value	58	42	51	58	42	51
Starch digestion:						
Ruminal[1]	74.9	70.5	61.6	70.6	71.9	67.2
Postruminal[1]	17.6	22.4	31.6	17.1	21.5	21.5
Postruminal[2]	66.0	71.8	69.8	45.9	77.8	60.5
Total tract[1]	92.5	93.0	93.1	87.7	93.4	88.7
Nitrogen passage, g:						
Intake	76.2	76.4	74.2	75.0	75.3	73.1
Entering Duodenum:						
Total	65.0	65.7	73.2	81.1	84.3	86.2
Microbial	26.3	23.2	33.5	38.4	30.6	34.8
Feed	35.7	39.4	35.5	37.6	48.4	47.4
Exiting rectum	29.3	21.9	23.1	28.5	21.8	24.7
Nitrogen digestion:[1]						
Apparent ruminal	10.5	14.6	1.9	-10.3	-12.3	-17.2
True ruminal	50.8	48.4	51.5	48.1	35.7	35.3
Postruminal[2]	50.3	56.8	66.7	71.8	83.1	83.9
Postruminal[1]	47.9	63.5	64.1	62.8	73.8	71.5
Total tract	60.9	71.4	68.6	61.5	70.8	66.7
Microbial efficiency, g microbial/kg organic matter fermented	8.8	7.9	13.5	12.1	10.0	13.3

[1]Percent of intake.
[2]Percent of available.
[3]Calculated by difference using TDN values from NRC (1984) for corn (90%) and soybean meal (84%).
[abc]Means in a row with different superscripts differ ($P<.05$).

5 to 7, the range in which bicarbonate is the primary buffering component, buffering capacity with whole corn diets tended to be greater, but from pH 3 to 5, the range of buffering from volatile fatty acids, buffering was greater with ground corn. These probably reflect differences in salivary bicarbonate input from saliva and salivary dilution of volatile fatty acids. Effects of roughage type within corn form on buffering capacity were minor. With these low levels of dietary roughage, roughage provides little protection from acidotic conditions in the rumen. In a previous study, also, prairie hay of different

lengths in 85% concentrate diets had only minor effects on buffering capacity 2 h after feeding (Goetsch et al., 1986).

Interactions between corn form and roughage type on site of digestion were not detected (P>.05). Ruminal digestion (Table 3) tended to be slightly greater for ground than whole corn diets. Passage of microbial organic matter and N to the duodenum were greater (P<.05) for whole than ground corn diets so that true ruminal OM digestion was similar for the two types of corn. In other experiments, extent of ruminal OM digestion generally has been greater for diets with processed than unprocessed corn, though in most studies more than 10% dietary roughage has been fed. The limited feed intake also may have reduced ruminal escape of corn particles possessing substantial amounts of organic matter. Ruminal organic matter digestion tended to be greatest with alfalfa, intermediate with cottonseed hulls and lowest for prairie hay with both corn forms. Lower cells wall content of alfalfa than cottonseed hulls or prairie hay should have increased ruminal digestion of roughage with alfalfa diets. Less digestible roughages may remain in the rumen longer and increase mastication, saliva flow, rumen motility and ruminal outflow. True ruminal organic matter digestion for prairie hay diets with ground corn was similar to a comparable diet with 15% prairie hay fed at a slightly greater level of intake in a previous experiment (Goetsch et al., 1986).

Extent of ruminal digestion in this experiment was less affected by roughage type with whole than with ground corn diets. Postruminal disappearance of organic matter was lower (P<.05) for alfalfa than cottonseed hull or prairie hay diets. This produced a lower total tract digestion of organic matter for alfalfa than cottonseed hull diets (P<.05). The lower percentage of soybean meal and higher percentage of corn in alfalfa diets (Table 2) also could be involved. Digestibilities for roughage in the diets were calculated assuming that organic matter digestibility of corn and soybean meal were 90 and 84 percent (NRC, 1984). Calculated digestibilities averaged 5.4, 55.2 and 30.8% for alfalfa hay, cottonseed hulls and prairie hay. These compare with literature digestibility values (NRC, 1984) for these three feedstuffs of 58, 42 and 51 percent. Comparison with measured values indicates that in these high concentrate diets, alfalfa had less than 10% of its tabular energy value whereas cottonseed hulls had 131% of its tabular value. Interactions between roughage and grain in the diet may explain why associative effects are observed with some roughages but not others (Rust and Owens, 1981).

Ruminal starch digestion was similar for all three roughages when fed with whole corn (Table 3). With ground corn, digestion of starch in the rumen tended to be greatest with alfalfa, intermediate with cottonseed hulls and lowest with prairie hay paralleling differences in ruminal organic matter digestion. Effects of roughage type with whole corn, however, were quite small. Postruminal starch disappearance of ground corn diets varied inversely with ruminal digestion. Total tract starch digestion tended to be lower for whole corn diets with alfalfa or prairie hay than with cottonseed hulls and was lower (P<.05) for diets with whole than ground corn as previously observed (Goetsch et al., 1986). Postruminal digestion of available starch, similar to organic matter, tended to be lowest with alfalfa diets, probably due primarily to greater digestion of starch in the rumen.

Ruminal disappearance of feed N was higher for whole than for ground corn diets (P<.05; Table 3). Flow of N to the duodenum exceeded intake with whole but not with ground corn diets. Greater passage of undegraded dietary N to the duodenum with whole corn would reduce ruminal ammonia release which should elevate net recycling of N into the

rumen. Feed N passage from the rumen was lower with ground than whole corn diets. This could be due to reduced solubilization of corn protein with a higher ruminal fluid pH or due to greater exposure of the protein due to grinding. But as grinding of corn did not alter ruminal digestibilities of organic matter and starch, it is surprising that grinding should alter protein escape from the grain.

Ruminal incorporation of recycled N is limited by the amount of energy provided by organic matter fermentation in the rumen. With whole corn, a greater portion of the recycled N was incorporated since less N was liberated from the corn in the rumen. Hence, postruminal flows of both microbial ($P<.05$) and feed N ($P<.07$) were greater with whole than with ground corn diets. Increased microbial flow is due entirely to increased efficiency of microbial growth. This could be due to more constant ruminal pH and starch digestion with whole corn diets reducing stress on ruminal microbes or to faster passage rates with whole corn. This also suggests that dietary crude protein requirements with whole corn diets may be lower than with diets of processed corn. Levels of feed intake and roughage which modulate ruminal passage rate and rumen degradation of dietary protein might alter N recycling.

Much of the dietary protein came from corn grain in this study. Dietary escape values for protein bypass for whole and ground corn were between 35 and 50% in this study. This is much lower than most other estimates (55 to 70%) of ruminal escape of corn protein. This may be due in part to the low level of feed intake which reduced rate of particle passage and subjected feed to more extensive ruminal digestion.

Postruminal N disappearance was greater ($P<.05$) for whole than ground corn (Table 3) reflecting greater flow of microbial and feed N to the intestines. Total tract digestion of N was similar for both forms of corn, but lower ($P<.05$) for diets with alfalfa than the other roughage. Greater N from roughage and less from soybean meal with the alfalfa than other roughages may be responsible for this difference.

The efficiency of microbial growth (Table 3) tended to be low suggesting that despite unrestricted ruminal digestion and supposedly adequate levels of ammonia-N, production of microbial protein was limited. This, also, may be due to the low level of feeding used and low passage rate in this experiment. Efficiency of microbial growth tended to be higher with whole than ground corn diets as noted previously (Goetsch et al., 1986).

In summary, roughage type had little effect on ruminal pH and buffering capacity. Extent of ruminal digestion did not vary greatly between forms of corn. Yet, with ground corn, ruminal digestion tended to be greatest with alfalfa, intermediate with cottonseed hulls and lowest with prairie hay as a source of roughage. Roughage type had negligible effects on extent of ruminal digestion with whole corn through total tract digestion was lowest for diets with alfalfa. Ruminal recycling of nitrogen was greatest for whole corn diets while flow of both feed and microbial nitrogen to the postruminal digestive tract was greater with whole than ground corn diets.

Overall, effects of roughage type on site of digestion of concentrate diets with 10% roughage in the diet were minimal. Due to associative effects of roughage with grain, the greater value of a more digestible roughage (alfalfa versus cottonseed hulls) disappears when fed in a high concentrate diet. Rather than placing greater value on a low fiber, high protein roughage source as appears practical with lactating dairy cows fed higher roughage diets, a roughage source in a feedlot diet appears more valuable if it stimulates chewing, rumination and outflow from the rumen without interfering with starch digestion in the small intestine.

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INFLUENCE OF LEVEL OF FEED INTAKE AND ROUGHAGE ON SMALL INTESTINAL DIGESTION AND PASSAGE IN STEERS

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Story in Brief

Seven steers (730 lb) equipped with ruminal, duodenal and ileal cannulas were fed an 80% concentrate diet at three levels of intake (1,0, 1.6 and 2.2% of body weight) or higher (64%) roughage diets of chopped alfalfa hay or cottonseed hulls at 2.2% of body weight. Transit time through the small intestine, measured by first ileal appearance of duodenally dosed phenol red dye, tended to decrease as feed intake increased. Alfalfa hay decreased transit time but cottonseed hulls did not. Duodenal liquid flow was much greater with added alfalfa hay (47 liter/d) than added cottonseed hulls (17 liter/d) and was closely related to nitrogen flow. Though added roughage tended to reduce total tract digestion of starch, it did not reduce fractional digestion of starch in the small intestine. Added roughage, especially alfalfa hay, shifted starch digestion from the rumen to the small intestine. Results indicate that transit time does not limit starch digestion in the small intestine and is not responsible for the reduced total tract starch digestion often observed with higher roughage diets.

(Key Words: Small Intestinal Passage, Digestion, Retention Time.)

Introduction

When starch is digested in the small intestine instead of being fermented in the rumen, absorbed products provide 30 to 50% more energy for ruminants. But digestion in the small intestine is usually under 70%. Possible factors limiting digestion include physical access of the starch, activity of enzymes digesting starch, and time for digestion within the small intestine. Only one study of the impact of diet on rate of passage through the small intestine of ruminants is available (Gregory et al., 1985). As feed intake of sheep increased from 800 to 1600 g per day, retention time in the small intestine decreased by 29% (from 150 to 106 min). It has been suggested the flow rate through the digestive tract is controlled to regulate protein input to the small intestine, since digesta liquid at the duodenum is surprisingly constant in nitrogen (Zinn et al., 1981). As postruminal protein supply decreases, feed could be retained longer in the rumen for more extensive digestion and more synthesis of microbial protein. In contrast, with a high protein diet, need for ruminal digestion is reduced and ruminal outflow could be accelerated. However, direct comparison of liquid outflow from the rumen against duodenal liquid flow in steers revealed a poor relationship (Doran, 1985). This result suggests that instead of regulating flow from the rumen, protein content of digesta may regulate either fluid absorption by the omasum or secretion by the abomasum. Such regulation may alter input of pepsin and HCl and thereby could alter intestinal digestion.

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The objective of this experiment was to determine the influence of level of feed intake [1.0 (basal), 1.6 and 2.2% of body weight] and roughage supplementation [1.2% of body weight addition of cottonseed hulls (CSH) or chopped alfalfa to the basal diet above] on passage time through and digestibility within the small intestine of growing steers.

Materials and Methods

Seven steers (730 lb) equipped with ruminal, duodenal and ileal cannulas were fed specified levels of each of five diets (Table 1) containing the indigestible marker chromic oxide during 6 different 14- day periods. To measure passage rate through the small intestine, a dye (phenol red) was dosed into the duodenal cannula on days 10, 12 and 14 of each period. Two hours after each dosing, the ileal cannula was opened and digesta was collected continuously. When dye first appeared, the time was recorded and passage time was calculated. Plastic beads dosed with the dye appeared simultaneously but proved more difficult to detect. Total duodenal and ileal liquid flow was calculated from passage of chromic oxide and dry matter of digesta samples. On each sampling day, duodenal, ileal and fecal samples were collected, composited within site, steer and period and analyzed for dry matter, starch and chromium.

Table 1. Diets and feed intake.

Treatment	Concentrate level % of body weight	Roughage level % of body weight	Roughage source
1.0	0.80[a]	0.20	Cottonseed hulls
1.6	1.28	0.32	Cottonseed hulls
2.2	1.76	0.44	Cottonseed hulls
2A	0.80	1.40	Alfalfa hay
2C	0.80	1.40	Cottonseed hulls

[a]Concentrate consisted of 63% rolled corn, 14% cottonseed hulls, 10% soybean meal, 6% dehydrated alfalfa pellets, 5% cane molasses, 0.5% limestone, 0.5% salt, 0.1% dicalcium phosphate, 0.1% urea and 0.2% chromic oxide.

Results and Discussion

As level of daily feed intake was increased from 1.0 to 2.2% of body weight, time for passage through the small intestine tended to decrease (Table 2). Substituting alfalfa for concentrate in the diet fed at 2.2% of body weight decreased transit time by 11%. In contrast, adding a similar level of cottonseed hulls to the diet did not accelerate passage rate through the small intestine. Daily liquid flow at the duodenum was greatly increased by alfalfa, as well. This indicates that these two roughage sources differ in their effects on transit time through the small intestine. The higher protein and mineral contents of alfalfa should exert more osmotic pressure, increase fluidity and

bulk and could thereby accelerate passage in a fashion similar to laxatives. Total liquid flow at the duodenum was 2.8 times greater with the alfalfa than the cottonseed hull supplemented diet, but liquid flow at the ileum for the two diets was similar.

Duodenal pH was not altered by diet, but ileal pH declined as intake of concentrate increased. Ileal pH was higher for roughage-supplemented diets. Ileal pH was always considerably above the 6.8 considered ideal for activity of pancreatic amylase for starch digestion.

Fecal pH declined as concentrate intake increased. Alfalfa increased fecal pH but while cottonseed hulls did not. Source and level of roughage altered fecal pH independent of starch concentration in feces. Composition of intestinal contents also varied with intake and roughage source. Dry matter and starch content of duodenal chyme were increased by added roughage, and starch content of ileal material also increased with added roughage.

Starch flows and digestion are presented in Table 2. Though intake of starch was more than doubled at the higher intake levels, flow of starch at the duodenum, ileum and feces was not increased. Starch largely disappeared within the rumen regardless of feed intake level. This agrees with results previously reported with an identical diet by Zinn and Owens (1983).

Addition of alfalfa reduced starch digestibility in the total tract markedly. Most of this depression can be ascribed to reduced ruminal digestion of starch. Added cottonseed hulls depressed ruminal and total tract starch digestion slightly.

Correlations of various factors with residence time in the small intestine across all diets were calculated. The higher the intake of nitrogen and the higher the flow of N at the duodenum, the shorter the transit time through the small intestine ($Cr = -.62$ and $-.36$; $P<.01$ and $P<.08$). Also, the greater the ruminal starch digestion, the longer the residence time of digesta in the small intestine ($r = .43$; $P<.03$). Total liquid flows at the duodenum and at the ileum were closely related to nitrogen flow at these points ($r = .79$ and $.60$; $P<.01$) suggesting that flow is tied somehow to protein content of digesta.

To determine the direct effect of retention time in the small intestine on digestion of starch in the small intestine, correlations across diets were calculated. This relationship proved nonsignificant ($r = -.18$; $P = .47$). Hence, under these test conditions, faster passage through the small intestine did not reduce starch digestibility within the small intestine. Had enzyme activity limited starch digestion in the small intestine, faster passage should have reduced digestibility of starch. With this cracked corn diet, particle size as discussed by Kim and Owens (1985) rather than rate of passage or enzyme activity presumably was the factor which limited starch digestion in the rumen and small intestine.

Table 2. Composition of digesta.

Intake level (% of body weight)	1.0	1.6	2.2	2.2	2.2
Roughage level, %	20	20	20	64	64
Roughage source	CSH	CSH	CSH	Alfalfa	CSH
Time of passage through the small intestine, min	248^{ab}	260^{a}	230^{b}	204^{c}	239^{b}
pH					
Duodenal	3.21_{a}	2.94_{ab}	3.15_{b}	3.06_{a}	3.03_{a}
Ileal	7.60^{a}	7.43^{b}	7.16^{c}	7.83^{a}	7.66^{c}
Fecal	6.83^{a}	6.38^{b}	6.02^{c}	6.78^{a}	6.02^{c}
Dry matter, %					
Duodenal	4.3^{c}	5.0^{b}	5.9^{bc}	6.3^{ab}	8.0^{a}
Ileal	7.5^{ab}	11.1^{a}	7.2^{ab}	6.1^{b}	7.3^{ab}
Liquid flow, L/day					
Duodenal	21.2^{b}	45.5^{a}	35.2^{ab}	47.0^{a}	16.9^{b}
Ileal	4.6	15.6	13.3	12.0	11.1
Starch, % of DM					
Duodenal	12.8^{ab}	9.4^{a}	8.5^{a}	21.9^{c}	18.3^{bc}
Ileal	8.1^{ab}	3.6^{bc}	2.2^{c}	11.6^{a}	12.2^{a}
Fecal	4.2^{a}	4.5^{a}	3.8^{a}	11.8^{b}	11.0^{b}
Starch, g					
Intake	585_{a}	936_{a}	1287_{a}	742_{b}	686_{a}
Duodenal	122^{a}	238^{ab}	202^{a}	583^{b}	251^{ab}
Ileal	37^{ab}	72^{ab}	18^{a}	101^{b}	64^{ab}
Fecal	10.3^{c}	76.0^{ab}	46.8^{bc}	100.4^{a}	39.0^{bc}
Starch digestion, %					
Ruminal	79^{a}	74^{a}	84^{a}	22^{b}	64^{a}
Small intestine	67^{a}	74^{ab}	94^{b}	83^{ab}	79^{ab}
Total tract	98.2^{a}	91.8^{bc}	96.4^{ab}	86.0^{c}	94.4^{ab}

^{abc}Means in a row with different superscripts are significantly different ($P<.05$).

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INFLUENCE OF SUPPLEMENTAL SILAGE ON FORAGE INTAKE AND UTILIZATION OF STOCKER CATTLE GRAZING WHEAT PASTURE

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Story in Brief

Twenty-four fall weaned steers were used in each of three trials on wheat pasture to determine effects of increasing amounts of supplemental silage on forage intake and rate of passage. Steers grazed a common wheat pasture and were fed either 0, .35, .70, or 1.05 lbs silage dry matter/100 lbs body weight. In addition, eight ruminally cannulated Hereford steers were allotted to one of two treatments, 0 or .55 lb silage dry matter/100 lb body weight, to determine effects of supplemental silage on extent and rate of in situ ruminal digestion of wheat forage. Wheat forage intake decreased linearly with increasing amounts of supplemental silage indicating steers were substituting silage for wheat forage. Fill, flow and fecal output increased linearly with increasing levels of silage. The potentially digestible fractions of dry matter and neutral detergent fiber of wheat forage were not influenced by supplemental silage. The extent of ruminal digestion of wheat forage was greater where silage was fed due in part to an increased rate of dry matter and neutral detergent fiber digestion indicating that supplemental silage had a positive associative effect on wheat forage utilization. These results may partially explain the mechanism by which relatively small amounts of supplemental silage allowed stocking densities to be doubled without decreasing weight gains of stocker cattle on wheat pasture.

(Key Words: Wheat Pasture, Stocker Cattle, Supplementation, Silage)

Introduction

Daily gain of stocker cattle is a key figure that affects profitability of stocker cattle enterprises. Because wheat forage is a high quality forage, gains of stocker cattle grazing wheat pasture are potentially good. However, gains of stocker cattle grazing wheat pasture are frequently depressed because of inadequate amounts of available forage during the fall and winter and because of snow and(or) ice cover of wheat forage. Identification of sound supplementation programs may improve gains by adding stability to the existing forage supply. Results of stocker cattle performance trials (Ford et al., 1983; Phillips et al., 1984; and Vogel et al., 1985) have shown that silage supplementation of stocker cattle grazing wheat pasture allowed stocking densities to be doubled without decreasing stocker cattle performance. Results of trials that were conducted concurrently to investigate the effects of increasing amounts of supplemental silage on flow through the gastrointestinal tract, and ruminal digestion of wheat are reported here.

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Materials and Methods

Four trials were conducted from 1982 to 1985. In each of the first 3 trials (1982-1984) 24 fall weaned steers (average BW of 570 lb) grazing a common pasture (5.6 acres) were allotted to one of four treatments in a completely randomized design. Treatment 1 steers received no supplemental silage, while steers of treatments 2,3, and 4 were supplemented with .35, .70, and 1.05 lb silage dry matter (DM)/100 lb body weight (BW), respectively. In trial 4 (1985) eight ruminally cannulated Hereford steers (average BW of 704 lb) were allotted to one of two treatments. Steers of treatment 1 received no supplemental silage while steers of treatment 2 received .55 lb silage DM/100 lbs body weight. Wheat silage was used in trial 1 (1982), whereas sorghum silage was used in trials 2,3, and 4 (1983-1985). Each trial consisted of a 12-day adaptation period and a 4 day experimental period. During the adaptation period, steers were removed from pasture at sunset, immediately placed in individual stalls and fed silage, and placed on pasture the following morning. Daily intakes of silage were recorded. On day 1 of the experimental period, steers were fed 200 grams of ytterbium (Yb)-labelled wheat forage DM in addition to their normal allottment of silage. Fecal grab samples were subsequently taken over a 4-day period. In trial 4 steers were also fed a pulse dosage of 200 grams of dysprosium (Dy)-labelled sorghum silage DM in addition to the Yb-labelled wheat forage. Fecal Yb and Dy concentrations were fit to the one compartment model of Ellis et al. (1979):

$$Y = K_0 * T * e^{-K_1 T}$$

where Y= fecal marker concentration
K_0= initial concentration in the compartment, g/kg
K_1= the time dependant rate constant, 1/h
T= time post dosage minus time delay, h

From these parameters the following were calculated:
Fecal Output (FO), kg/day = (Marker dose,g/K_0)*24
Wheat Forage FO (WFO), kg/day= FO-(Silage DM Intake * Silage Indigestibility)
Flow, %/h = .59636 * K_1
Turnover, h = 1/Flow
Fill, kg = Marker dose, g/(K_0 * K_1 * .59635)

In trial 4 duplicate nylon bags containing 3 grams of wheat forage or 4 grams of sorghum silage were placed in the rumen of each steer for 4, 8, 12, 19, 24, 36, 48, and 60 hours. Dry matter (DM) and NDF disappearance estimates (% of initial amount remaining) for each incubation time were iteratively fit to a nonlinear equation to estimate potential degradability (p)

$$p = a + b(1-e^{-ct})$$

where a= the highly soluble rapidly disappearing fraction
b= that fraction other than "a" that disappears at a constant fractional rate of time
c= digestion rate constant
t= time

Using the fitted constants (i.e. a, b, and c) the effective ruminal degradability (RD) was estimated from the equation of Orskov and McDonald (1979) where:

$$RD = a + bc/(c+k)$$

The rate constant k represents the passage rate constant obtained from the forage intake and passage rate data. When the nonlinear equation

Table 1. Silage and forage composition during forage intake trials on wheat pasture.

Feedstuff	Forage Availability	CP*	IVDMD*	DM,%*	n
	lb DM/acre	-- % of DM --			
Trial 1:					
Wheat silage		9.44	50.73	36.68	8
Wheat forage	484	27.25	74.90	25.80	5
Trial 2:					
Sorghum silage		8.64	56.38	27.92	8
Wheat forage	2076	30.19	77.80	16.13	7
Trial 3:					
Sorghum silage		9.74	50.00	25.44	8
Wheat forage	1613	24.33	75.22	29.70	4
Trial 4:					
Sorghum silage		8.35	56.65	20.14	12
Wheat forage	746	30.25	80.50	17.26	6
SEM	163	.187	2.308	.917	

*CP = crude protein; IVDMD = in vitro dry matter digestibility; DM = dry matter

estimated fraction a to be less than 0, lag time (T) was estimated as $T= -\log((a/b)+1)/c$. Consequently, where fraction a was less than 0, RD was calculated as:

$$RD= (a+b)(c/c+k)e^{-kT}.$$

During each trial silage and wheat forage samples were collected daily, composited across days, and analyzed for dry matter (DM), crude protein (CP), and in vitro dry matter digestibility (IVDMD). In addition, forage availability was estimated by hand clipping 3 one-half square meter plots. The results of these analyses are presented in Table 1.

Results and Discussion

Forage intake and passage rate data from trials 1, 2, and 3 are presented in Figures 1 and 2, respectively. Actual silage consumption for steers of treatments 1 to 4 was 0, .32, .60, and .78 lb DM/100 lb BW. As silage DM consumption increased, WF consumption decreased linearly ($p<.10$) from 2.67 lb DM/100 lb BW for steers of treatment 1 to 2.20 lb DM/100 lb body weight for steers of treatment 4 suggesting that steers were substituting silage for WF. Yet, this was not a direct substitution on a lb for lb basis since total feed (forage + silage) intake increased as the amount of supplemental silage increased. These same trends for forage intake were also observed in trial 4 (Table 2). Wheat forage consumption of steers fed silage decreased by .6 lb DM/100 lb body weight when compared to steers consuming WF alone although total forage intake was similar for steers of both treatments ($p>.05$).

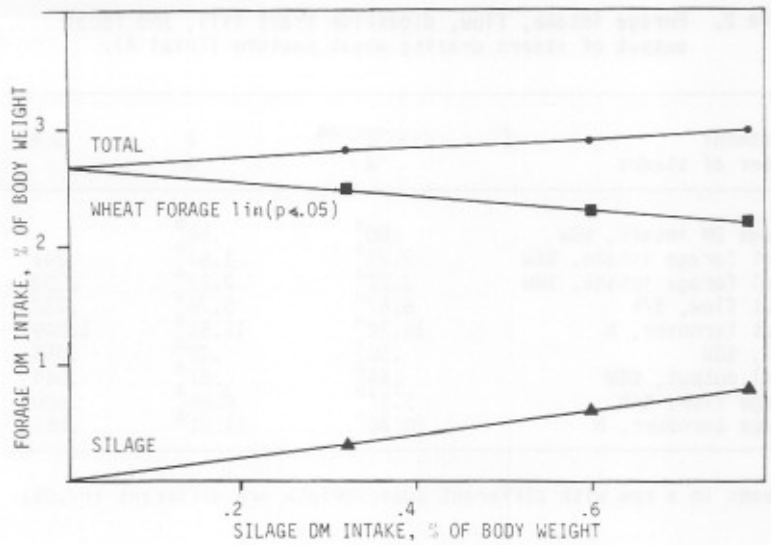


Figure 1. Forage DM intakes of steers grazing wheat pasture (Trials 1, 2, and 3)

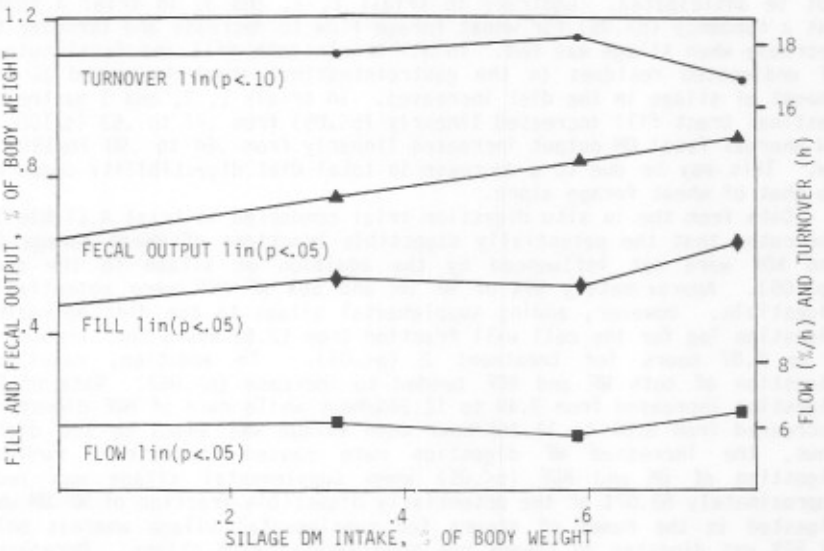


Figure 2. Fill and fecal output of the gastrointestinal tract and flow and turnover of wheat forage (Trials 1, 2, and 3)

Table 2. Forage intake, flow, digestive tract fill, and fecal output of steers grazing wheat pasture (Trial 4).

Treatment	1	2	SEM
Number of steers	4	4	
Silage DM intake, %BW	.00[a]	.55[b]	
Wheat forage intake, %BW	2.27[a]	1.67[a]	.241
Total forage intake, %BW	2.27[a]	2.22[a]	.233
Wheat flow, %/h	6.57[a]	5.78[a]	.732
Wheat turnover, h	16.24[a]	17.51[a]	1.849
Fill, %BW	.30[a]	.42[a]	.056
Fecal output, %BW	.44[a]	.57[a]	.044
Silage flow, %/h	5.17[a]	4.86[a]	.600
Silage turnover, h	20.46[a]	21.01[a]	.861

[ab]Means in a row with different superscripts are different ($p<.05$)

Passage rate data from trials 1, 2, and 3 indicated that turnover decreased ($p<.10$) and flow of wheat forage increased ($p<.05$) linearly with increasing amounts of supplemental silage. Yet, differences among treatments were small and differences in wheat forage utilization would not be anticipated. Contrary to trials 1, 2, and 3, in trial 4 there was a tendency ($p>.05$) for wheat forage flow to decrease and turnover to decrease when silage was fed. In all trials both fill and fecal output of undigested residues in the gastrointestinal tract increased as the amount of silage in the diet increased. In trials 1, 2, and 3 gastrointestinal tract fill increased linearly ($p<.05$) from .47 to .63 lb/100 lb BW whereas fecal DM output increased linearly from .64 to .90 lb/100 lb BW. This may be due to a decrease in total diet digestibility compared to that of wheat forage alone.

Data from the in situ digestion trial conducted in trial 4 (Table 3) indicated that the potentially digestible fractions of wheat forage DM and NDF were not influenced by the addition of silage to the diet ($p>.05$). Approximately 95% of WF DM and 66% WF NDF were potentially digestible. However, adding supplemental silage to the diet decreased digestion lag for the cell wall fraction from 12.63 hours for treatment 1 to 9.07 hours for treatment 2 ($p<.05$). In addition, rates of digestion of both WF and NDF tended to increase ($p>.05$). Rate of DM digestion increased from 8.49 to 12.34%/hour while rate of NDF digestion increased from 8.04 to 11.26%/hour when silage was added to the diet. Thus, the increased WF digestion rate caused increased ruminal digestion of DM and NDF ($p<.05$) when supplemental silage was fed. Approximately 63.07% of the potentially digestible fraction of WF DM was digested in the rumen of steers fed supplemental silage whereas only 52.52% was digested in steers not supplemented with silage. Moreover, there was a 49% increase in digestion of the NDF fraction of wheat forage for steers fed silage. Similar to the wheat forage, the potentially digestible fractions of silage DM and NDF were greater for steers were fed silage ($p<.05$). Yet, the rates of DM and NDF of silage digestion tended to be higher for steers of treatment 1. Consequently,

Table 3. Ruminal digestion of wheat forage and silage of steers on wheat pasture (Trial 4).

Treatment	1	2	SEM
Silage DM intake, %BW	0	.55	
Wheat Forage			
DM			
Potentially digestible, %	95.24[a]	95.38[a]	4.22
Digestion rate, %/h	8.49[a]	12.34[a]	1.63
Digestion lag, h	.769[a]	.519[b]	.82
Ruminal degradability,%	52.52[a]	63.07[b]	2.11
NDF			
Potentially digestible, %	66.06[a]	66.04[a]	4.22
Digestion rate, %/h	8.04[a]	11.26[b]	1.59
Digestion lag, h	12.63[a]	9.07[b]	.95
Ruminal degradability, %	16.71[a]	24.87[b]	2.20
Sorghum Silage			
DM			
Potentially digestible, %	46.07[a]	69.53[b]	.42
Digestion rate, %/h	6.53[a]	4.00[a]	1.63
Ruminal degradability, %	29.93[a]	33.22[a]	2.11
NDF			
Potentially digestible, %	23.53[a]	51.07[b]	4.99
Digestion rate, %/h	7.08[a]	4.08[a]	1.58
Digestion lag, h	11.00[a]	10.77[a]	.95
Ruminal degradability, %	7.78[a]	11.92[a]	2.20

[ab]Means in a row with different superscripts are different ($p<.05$)

extent of ruminal digestion of silage DM and NDF was similar for both treatments.

In conclusion, use of supplemental silage decreased WF intake although total forage intake remained fairly constant. However, the decrease in WF intake appeared to be offset by an increase in WF utilization. These results may partially explain the mechanism by which relatively small amounts of supplemental silage allowed stocking densities to be doubled without decreasing weight gains of stocker cattle on wheat pasture.

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PERFORMANCE OF STOCKER CATTLE ON GRAZE-OUT WHEAT PASTURE AND ECONOMICS OF PARTICIPATION IN THE 1986 GOVERNMENT WHEAT PROGRAM

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Story in Brief

Daily gain and gain/acre of stocker cattle on graze-out wheat pasture were measured over 4 years, and economic comparisons were made using a microcomputer model of various levels of participation in the 1986 government wheat program. Cattle each year consisted of 94 to 96 fleshy yearling steers (mean initial weight 628 lb) that grazed wheat pasture for approximately 65 days each year (March 19 to May 23). Initial stocking densities were 1.75, 1.52, 1.33 and 1.67 steers/acre for years 1 to 4, respectively. Daily weight gain of stocker cattle on graze-out wheat pasture averaged 2.32 lb/head/day with total weight gain averaging 234 lb/acre. Expected net return ($/acre) for various levels of participation in the government program was: -11.40 (non-participation, i.e., grain harvest only), 62.51 (25% acreage reduction program), 71.02 (acreage reduction program + an additional 10% acreage diversion) and 128.22 (maximum diversion). Weight gains of cattle on graze-out wheat pasture are excellent, and net returns per acre were greatly increased by grazing of wheat within the various options of the 1986 government wheat program.

(Key Words: Wheat Pasture, Stocker Cattle, Graze-out)

Introduction

One of the very unique and economically challenging aspects of wheat pasture stocker enterprises relates to the decision to graze-out wheat pasture in the spring. The decision is based on the interplay of forecasted wheat prices, amount and value of weight gains of cattle, and government acreage reduction programs. Stocker cattle that have grazed wheat pasture during the fall and winter are usually healthy, adapted to wheat pasture and can make rapid gains during the graze-out period. In addition, temperatures are higher and forage growth will accumulate to the point that gains should not be limited by the amount of available forage. Rate of weight gain of cattle during graze-out of wheat pasture is usually excellent. Nevertheless, questions frequently arise as to what rate of gain can be expected for cattle during graze-out of wheat pasture. In association with other studies, we have had cattle on wheat pasture during graze-out for the past four years. Performance of the cattle is reported herein. Also, economic comparisons were made using a microcomputer model of various levels of participation in the 1986 government wheat program.

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Materials and Methods

Ninety-four to 96 steers 11 to 13 months of age were used each year. They had grazed wheat pasture during the fall and winter. Breeds were: (Year 1, 1981-1982) Hereford and Brahman crossbred steers with 1/4 Brahman; (Year 2, 1982-1983) Hereford, Angus, and Hereford X Angus; (Year 3, 1983-1984) Hereford, Hereford X Angus, and Limousin crossbred; and (Year 4, 1984-1985) Hereford and Limousin crossbred. Daily gains of the steers during the fall and winter grazing interval on wheat pasture averaged 1.85, 2.30, 2.33 and 1.60 lb/head/day for the four years, respectively. Initial stocking densities during the graze-out trials were 1.75 (1138), 1.52 (856), 1.33 (891) and 1.67 (1055) steers/acre (lb cattle/acre) for years 1 to 4, respectively. The dates during which the wheat pasture graze-out trial was conducted each year are presented in Table 1.

The 1986 Wheat Program alternatives considered were (1) non-participation, (2) 25% diversion (25% acreage reduction program (ARP), (3) ARP + 10% diversion and (4) 50% of the eligible acreage in (3) actually planted (Table 2). For a 100 acre base acreage, 0, 25, 35 and 67.5 acres, respectively, would be grazed and appropriate deficiency and diversion payments are made.

Optimistic, expected (average) and pessimistic returns per head were estimated for stockers using the cattle price and sale weight prospects in Table 2. The sale weight distribution reflects the variability in annual steer gains observed in the study. The chance of a gain or price between the optimistic and pessimistic price is four-in-six, the chance of a yield or price greater than the optimistic level is one-in-six and the chance of a yield or price less than the pessimistic level is one-in-six. Stocking density was assumed constant at 1.5 head/acre for the 60 day graze-out period.

The microcomputer model also considers optimistic, expected and pessimistic cash wheat prices and wheat yields on harvested acres (Table 2). No correlation was assumed among any variables. Inputs for the economic analysis were: purchase and sale price of cattle ($65/cwt + $15/head and $64/cwt); expected cash, loan and target prices ($/bu) of wheat of 2.30, 2.40 and 4.38; wheat yield of 32 (non-participation) or 33.6 bu/acre.

Results and Discussion

Mean initial and final weights and stocker weight gains and gain/acre are presented in Table 1. Daily gains during the wheat pasture graze-out period for years 1 to 4 were 2.05, 2.75, 2.35 and 2.12 lb/head/day, respectively. Gains were exceptionally good in year 2 possibly because of the large amounts of available forage present during graze-out in combination with the lighter initial stocking density (i.e., 856 lb cattle/acre). Weight gain of stocker cattle per acre varied considerable each year. Gain/acre ranged from 191 to 292 lb/acre, and the differences were due primarily to differences in daily gain, initial stocking densities, and amounts of available forage present during graze-out. As stocking density increased, daily gains tended to decrease but total gain/acre increased.

Returns per acre for the complete analysis including wheat and graze-out stockers of the four program alternatives are shown in Table 2. Expected net return ($/acre) for various levels of participation in

Table 1. Mean initial and final weights, daily gain, and gain/acre of steers on graze-out wheat pasture.

Item	Year				Four-year average
	1	2	3	4	
Grazing interval	Mar 26-May 21	Mar 17-May 26	Mar 21-May 23	Mar 7-May 16	
Days grazing	57	70	61	70	64
Stocking density,					
steers/acre	1.75	1.52	1.33	1.67	1.57
lb cattle/acre	1141	852	895	1053	985
Initial wt, lb	651	563	670	632	628
Final wt, lb	768	755	814	780	778
Daily gain, lb	2.05	2.75	2.35	2.12	2.32
Gain/acre, lb	205	292	191	247	234

Table 2. Inputs and Results: Net returns from grain and wheat pasture graze-out of various levels of participation in the 1986 Government Wheat Program.

Inputs:	Stocker Price/cwt $	Stocker selling weight cwt	Stocker Return/head[a] $	Wheat price/bu $	Wheat yield/acre bu
Optimistic	70	7.81	114	2.45	38
Expected	64	7.67	68	2.30	32
Pessimistic	60	7.53	37	2.05	28

Stocker variable costs per head: $423
Stocking density (steers/acre): 1.50

	Level of Participation[b]			
	1 Non-participation	2 25% ARP	3 25% ARP + 10% DIV	4 Plant 50% of option 3
	$ Returns per acre of wheat base			
Optimistic	3.21	81.43	89.94	147.14
Expected	-11.40	62.51	71.02	128.22
Pessimistic	-23.59	49.42	57.92	115.13

[a]Optimistic and pessimistic returns per head are plus and minus one standard deviation of the stocker returns calculated from the joint distribution of stocker weights and prices.
[b]ARP = Acreage Reduction Program; DIV = Diversion.

the government program was: -11.40 (non-participation, i.e., grain harvest only), 62.51 (25% acreage reduction program (ARP)), 71.02 (ARP + an additional 10% acreage diversion) and 128.22 (maximum diversion).

Weight gains of cattle on graze-out wheat pasture were excellent, and net returns per acre were greatly increased by grazing of wheat within the various options of the 1986 government wheat program.

EFFECT OF LASALOCID AND STAGE OF MATURITY OF WHEAT FORAGE ON RUMINAL FERMENTATION OF STEERS

M.A. Andersen[1], J. Zorrilla-Rios[2], G.J. Vogel[1] and G.W. Horn[3]

Story in Brief

The effect of lasalocid and stage of wheat forage maturity on ruminal fermentation of steers grazing wheat pasture was studied during the 1983-84 and 1984-85 wheat pasture grazing seasons. Eight rumen cannulated steers (1000 lb) grazed a common wheat pasture and received 0 or 300 mg lasalocid/head/day. Two periods of wheat pasture maturity were studied. Immature wheat forage representing the lush spring growth period, and mature forage representing forage shortly after flowering. Ruminal ammonia concentrations, the molar proportion of acetate and the acetate to propionate ratio were greater in steers grazing immature forage. Ruminal pH, total volatile fatty acid concentration and the molar proportion of butyrate, valerate, isobutyrate and isovalerate were lower for steers grazing immature wheat forage. Lasalocid supplementation increased ruminal ammonia concentrations, decreased the molar proportion of acetate and increased the molar proportion of propionate. The acetate to propionate ratio was decreased only 6%. Other mechanisms such as shifts in site and extent of nutrient digestion may also be involved in the effect of lasalocid in increasing weight gains of wheat pasture stocker cattle.

(Key Words: Wheat Pasture, Lasalocid, Rumen Fermentation.)

Introduction

Lasalocid is an ionophore that has been shown to increase daily weight gains of stocker cattle grazing winter wheat pasture (Andersen and Horn, 1985). Lasalocid increased ruminal ammonia concentration, however did not affect total volatile fatty acid (VFA) concentration or the molar proportions of acetate, propionate or butyrate. However, rumen fluid samples were collected by aspiration through stomach tube, and detection of differences in molar proportions of VFA may have been masked by unrepresentative samples. Andersen et al. (1985) reported lasalocid increased ruminal ammonia concentration, decreased ruminal acetate concentration, and the acetate to propionate ratio in steers (approximately 1000 lb body wt) receiving 0 or 300 mg lasalocid/day. Rumen fluid samples were taken through rumen cannulas to provide more representative samples. Data on site and extent of nutrient digestion indicated that advancing forage maturity and lasalocid shifted site of digestion to the post-ruminal tract (Zorrilla-Rios et al., 1985). The objective of this study was to obtain additional information relative to effects of lasalocid and stage of forage maturity on rumen fermentation, forage intake, site and extent of nutrient digestion of steers grazing wheat pasture. Effects of lasalocid and wheat forage maturity on rumen fermentation measurements are reported herein.

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Materials and Methods

During the wheat forage grazing periods of March through May of 1984 and 1985, eight rumen fistulated mature Hereford steers grazed a single paddock of wheat pasture (Var. TAM-105) with free access to water and salt. Steers were randomly allotted to one of two treatments, and received ruminal dosages of 0 or 300 mg lasalocid daily in gelatin capsules. During the 1985 grazing season, one steer died prior to completion of the study. Measurements of rumen fermentation were made each year while steers grazed immature and mature wheat forage. Immature wheat forage was grazed during periods of March 7 to 27, 1984 and March 8 to April 1, 1985. Mature wheat forage was grazed during April 22 to May 14, 1984 and April 23 to May 13, 1985.

Rumen fluid was collected once during each period of each year. Fluid was obtained via the rumen fistula and strained through 3 layers of cheesecloth. Ruminal pH was measured immediately with a glass electrode and pH meter, and 100 ml aliquots were acidified with 2 ml of 20% H_2SO_4 and placed in an ice slurry until analyses were conducted for ruminal ammonia concentrations by MgO distillation. Five milliliter aliquots of the rumen fluid were acidified with 1 ml 25% metaphosphoric acid and frozen for later analysis of volatile fatty acid concentrations by gas-liquid chromatography.

Forage samples were obtained by hand clipping during each period of the study and were freeze dried. Nitrogen content of forage was determined by Kjeldahl analysis, NPN content was determined by difference between total nitrogen and protein nitrogen, which was precipitated in a 10% H_2SO_4 and Na-tungstate solution. Soluble nitrogen was determined by Kjeldahl analysis of filtrate following a 1 h incubation in a 2% buffer solution (Ohio Buffer, pH=6.5). In vitro dry matter digestibility (IVDMD) of forage samples was determined following a 48-h incubation with buffered rumen fluid and subsequent 24-h digestion in pepsin and HCl.

Results and Discussion

Chemical composition of wheat forage for years 1 and 2 is reported in Tables 1 and 2, respectively. Wheat forage quality did not vary considerably between years 1 and 2. Wheat forage protein was much higher in immature forage than mature forage, soluble nitrogen:total nitrogen was approximately 35%, IVDMD of wheat forage was about 76% for immature forage, and 66% for mature forage.

Effects of stage of maturity and lasalocid on rumen fermentation are shown in Table 3. A year by period interaction ($P<.10$) occurred for most measurements. However, the rank of mean values for period within each year was not affected, therefore this interaction was ignored and data were pooled across years. Stage of maturity of wheat forage affected all rumen fermentation measurements ($P<.01$), with the exception of the molar proportion of propionic acid. Ruminal pH was greater and ruminal ammonia concentration was lower for steers grazing mature wheat forage. The decrease in ruminal ammonia concentration coincides with lower protein content of mature wheat forage. Total volatile fatty acid (VFA) concentration was lower ($P<.01$) in steers grazing mature wheat forage. However, the molar proportion of acetate was greater, and the proportions of isobutyrate, butyrate, isovalerate and valerate were decreased.

Table 1. Chemical Composition of Wheat Forage Year 1. (Var. TAM-105).

Nutrient	Stage of Forage Maturity[1]	
	Immature	Mature
Dry Matter, %	24.3	22.7
Organic Matter, % of DM	92.5	93.7
Nitrogen, %		
Total	4.39	2.03
Soluble	1.184	0.691
NPN	0.438	0.201
Ratios		
Soluble N/Total N	27.0	34.0
NPN/Total N	10.0	9.9
IVDMD	75.6	66.4
Forage Available (lb/acre)	1642	1566

[1]Immature (March 7-27)
Mature (April 22- May 14)

Table 2. Chemical Composition of Wheat Forage Year 2. (Var. TAM-105).

Nutrient	Stage of Forage Maturity[1]	
	Immature	Mature
Dry Matter, %	23.3	27.1
Organic Matter, % of DM	93.7	95.7
Nitrogen, %		
Total	3.91	2.11
Soluble	1.42	1.00
NPN	0.45	0.32
Soluble N/Total N	36.3	47.4
NPN/Total N	11.5	15.2
IVDMD	76.2	65.7
Forage Available (lb/acre)		3479

[1]Immature (March 8-April 1)
Mature (April 23- May 14)

The effect of lasalocid on rumen fermentation measurements did not interact with stage of maturity or year ($P>.20$), therefore data were pooled across periods and years. Lasalocid did not affect ruminal pH ($P>.15$). Lasalocid increased ruminal ammonia concentrations ($P<.04$) possibly indicating greater ruminal degradation of forage protein. Lasalocid did not affect total VFA concentrations, but decreased the acetate:propionate ratio ($P<.27$) by decreasing the molar proportion of

Table 3. Effect of stage of Maturity of wheat forage and Lasalocid on rumen fermentation of steers.

	Stage of maturity wheat forage		Lasalocid (mg/day)			Level of Significance	
	Immature	Mature	0	300	SE	M	L
Observations	15	15	15	15			
pH	5.8	6.5	6.2	6.2	.06	.01	NS
Ammonia (mg/dl)	54.5	15.0	31.9	37.5	1.77	NS	.04
Volatile Fatty Acids							
Total (mm/l)	161.1	108.4	134.0	131.5	4.5	.01	NS
Molar Proporitons,(%)							
Acetate	59.8	68.6	64.9	63.6	.56	.01	.06
Propionate	19.4	18.9	18.8	19.6	.33	NS	.04
Isobutyrate	1.8	1.1	1.4	1.5	.07	.01	NS
Butyrate	14.7	8.8	11.7	11.8	.43	.01	NS
Isovalerate	2.6	1.5	1.9	2.2	.07	.01	.02
Valerate	1.7	1.1	1.3	1.5	.08	.01	NS
Acetate:Propionate	3.11	3.66	3.49	3.28	.08	.01	.07

NS = non significant (P>.10).

acetate (P<.06) and increasing the molar proportion of propionate (P<.04). Lasalocid did not affect any other rumen fermentation measurements, with the exception of an increase in the molar proportion of isovalerate.

While lasalocid did decrease the acetate:propionate ratio of ruminal fluid, the reduction was small (i.e., about 6%). Other mechanisms such as shifts in site and extent of nutrient digestion, as observed by Zorrilla-Rios et al. (1985), may be involved in the improvement of gains of wheat pasture stocker cattle by lasalocid.

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EFFECT OF POLOXALENE ON PERFORMANCE AND FORAGE INTAKE OF WHEAT PASTURE STOCKER CATTLE

M.A. Andersen[1], G.W. Horn[2] and K.B. Poling[3]

Story in Brief

Twenty-six fall-weaned Angus and Hereford x Angus heifers (mean initial weight 480 lb) grazed a common winter wheat pasture for 100 d during the 1984-85 grazing season. Heifers were fed daily in individual stalls about 1.9 lb of supplement with or without poloxalene. Daily poloxalene intake during the trial was 0 or 1.6 g/100 lb of body weight. Heifers were observed for bloat daily between 1000 and 1200 h. Intake and digestibility of wheat forage were measured once (March 4 to 13) during the trial. Daily gains of heifers were not affected by poloxalene. Digestibility of wheat forage was not affected by poloxalene, however intake of forage DM and OM was increased by poloxalene. Incidence of bloat during the trial was low. Eighteen animal days of bloat were observed for control heifers, whereas only 2 animal days of bloat were observed for heifers fed poloxalene.

(Key Words: Wheat Pasture, Poloxalene, Stocker Cattle, Bloat.)

Introduction

Frothy bloat is a major cause of death of wheat pasture stocker cattle (Clay, 1973). Death losses due to bloat are believed to be about 2.5% of total stockers and have been as high as 20% on some pastures. Studies reported by Bartley et al. (1975) and Clay (1976) have shown that daily feeding of poloxalene at levels of 1 to 2 grams/100 lb body weight significantly reduced the incidence and severity of bloat in wheat pasture stockers. Weight gains of wheat pasture stockers were increased in two of three field trials conducted by Clay (1976) were poloxalene-containing supplements were fed. Control cattle were not fed any supplement so the effect of poloxalene *per se* on weight gains was not measured. Daily gain is a very key figure that affects the profitability of stocker enterprises. Therefore, economic considerations of using poloxalene in wheat pasture stocker programs are greatly influenced by potential effects of poloxalene on cattle performance. The objective of this study was to examine the effect of poloxalene on weight gains and forage intake, and obtain additional information as to the effect of poloxalene on frothy bloat of stocker cattle grazing winter wheat pasture.

Materials and Methods

Twenty-six fall weaned Angus and Hereford x Angus heifers (480 ± 20 lb mean initial weight) were randomly allotted by initial weight and breed to two treatments that consisted of 0 or approximately 2 grams

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poloxalene/100 lb body weight/day. The heifers grazed a common winter wheat pasture for a pre-trial adaptation period of 3 weeks and a 100-day experimental period (1/4/85-4/12/85). The heifers were weighed upon arrival, at the start of the trial, mid-term, and at the conclusion of the trial. All weights were measured following a 15-17 h shrink without feed or water, and daily gains were calculated for two 50-day grazing periods and for the entire 100-day trial.

The wheat pasture (Variety TAM 105) consisted of 36 acres and was divided by electric fencing into 4 paddocks. During the experimental period, the heifers were rotated as a single group among the four paddocks with the objective of always having a relative immature forage for the cattle to graze. The pasture was fertilized with 105 lb/acre of anhydrous ammonia at planting. Hand-clipped forage samples were collected approximately every 2 weeks throughout the trial and dried at 60 C in a forced-air oven. Samples were analyzed for crude protein and neutral detergent fiber concentrations.

The heifers were individually fed daily 1.98 and 1.76[b] lb of supplement, with and without poloxalene, during grazing periods 1 and 2, respectively. The supplement consisted of (as-fed): 75% ground corn, 10% cottonseed hulls, 8% ground alfalfa hay, 7% molasses, plus the appropriate level of poloxalene. Samples of supplements were collected twice weekly and composited within treatments by period for poloxalene analysis by SmithKline Animal Health Products. Theoretical and actual[c] poloxalene intakes during each grazing period were calculated.

Wheat forage intake and digestibility of dry matter (DMD) and organic matter (OMD) were measured once during the study (March 4 to 13). Heifers were bolused with a gelatin capsule containing 4 g chromic oxide powder twice daily (0800 and 1600 h) during a 6-day preliminary and 4-day fecal collection period. Fecal samples were taken from the rectum at time of bolusing and dried in a forced air oven at 60 C. Dried fecal samples were composited by animal and analyzed for chromium concentration by atomic absorption spectrophotometry. Fecal outputs were calculated by the chromium dilution technique. Forage DMD and OMD were determined using indigestible neutral detergent fiber (INDF) as an internal indigestible marker.

All heifers were observed for bloat daily between 1000 and 1200 h and assigned a bloat score as follows:

Bloat Score	Description
0	No indication of bloat
1	Slight distention of left side
2	Marked distention of left side
3	Distention of left and right sides

Analysis of variance of the weight gain and forage intake data was conducted using the General Linear Model Procedure of the Statistical Analysis System for a completely randomized design. Treatment was the only source of variation included in the model.

[b]Theoretical poloxalene concentration of supplement was increased from 5.0 to 7.0 grams/lb.

[c]Calculated from "analyzed" poloxalene concentrations of the supplements.

Results and Discussion

All observations of two heifers of the poloxalene treatment group were deleted from the data because of poor supplement intakes. Mean poloxalene intakes of the remaining heifers are shown in Table 1. Theoretical poloxalene intakes were about 1.9 g/100 lb body weight in both periods of the study. Actual poloxalene intakes were 1.57 and 1.70 g/100 lb body weight during periods 1 and 2, respectively.

Wheat forage protein and NDF concentrations are plotted in Figure 1. Protein concentrations ranged from 20 to 28% of DM, and NDF concentrations ranged from 48 to 59% of DM.

Weight gains of the heifers are shown in Table 2. Poloxalene did not affect ($P>.10$) daily gains of heifers during either grazing period, or during the 100-day trial.

Forage intakes of the heifers are shown in Table 3. Digestibility of forage DM and OM was not affected by poloxalene supplementation ($P>.10$). However, intakes of forage DM and OM were greater ($P<.05$) for heifers receiving poloxalene, possibly due to a reduction in the severity of bloat and(or) intraruminal pressure. Forage intakes of heifers fed poloxalene were increased enough that weight gains should have been increased. Forage intake was measured during the period of lush spring growth of wheat and during the period of highest incidence of bloat (i.e., February 25 to March 24). If the improvement in forage intake by poloxalene is related to and(or) dependent on the occurrence of bloat, forage intake may have been increased for only a relatively short period of the total trial and may not have been increased over a long enough period to affect weight gains. This aspect of the data needs further study.

The incidence of bloat during the trial is shown in Table 4. Overall, the incidence of bloat was low. Eighteen total bloat scores of 1 were recorded for heifers of the control group, and 2 bloat scores of 1 were recorded for heifers fed poloxalene. No bloat scores of 2 or 3 were observed during the study. Six of the twenty bloat scores were recorded during the first week of the study (January 4 to 11, 1985) and 12 of the bloat scores were recorded from March 1 to 24, 1985. The wheat forage of these two periods was, respectively, immature and making rapid spring growth.

Table 1. Poloxalene Intakes (grams/100 lb body weight) of Heifers During the Two Grazing Periods on Wheat Pasture.

Item	Treatment	
	Control	Poloxalene
Number of heifers	13	11
Theoretical		
Jan 4 to Feb 22	0	1.88
Feb 23 to Apr 11	0	1.95
Actual[a]		
Jan 4 to Feb 22	0	1.57
Feb 23 to Apr 11	0	1.70

[a]Actual poloxalene intakes were calculated from analyzed poloxalene concentrations of supplements.

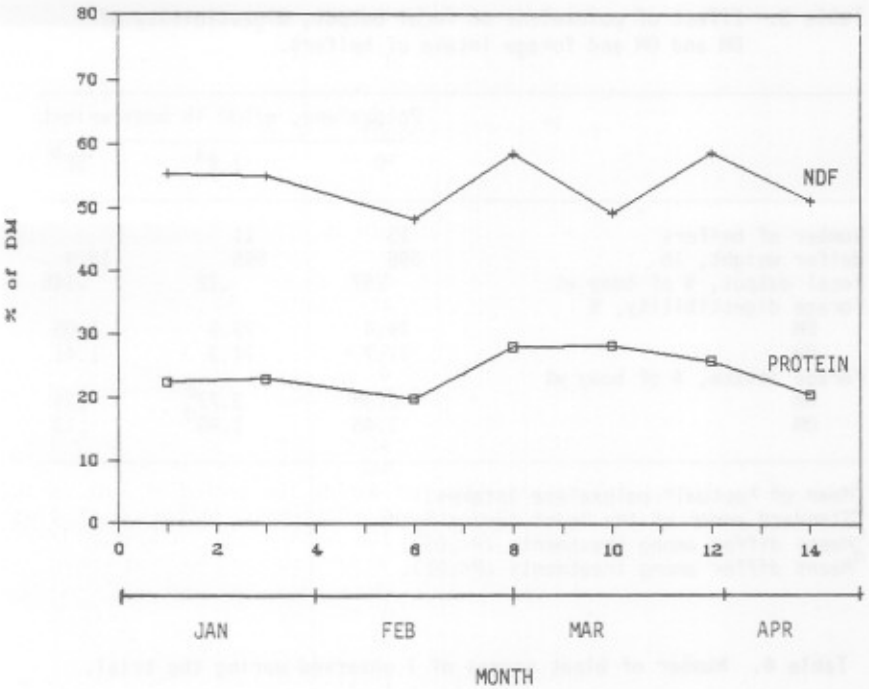


Figure 1. Protein and neutral detergent fiber concentrations (% of DM) of wheat forage samples.

Table 2. Effect of poloxalene on daily gains of heifers[a].

		Poloxalene, g/100 lb body weight		
		0	1.6[b]	SE[c]
Number of heifers		13	11	
Initial weight, lb		475	486	20.1
Daily gains, lb	Days			
1/4/85 - 2/22/85	50	1.84	1.86	.11
2/22/85 - 4/12/85	50	2.16	2.18	.14
Total	100	2.00	2.02	.10

[a]Daily gains were not different (P>.10) among treatments.
[b]Mean of "Actual" poloxalene intakes.
[c]Standard Error of the least square means.

Table 3. Effect of poloxalene on fecal output, digestibility of DM and OM and forage intake of heifers.

	Poloxalene, g/100 lb body weight		
	0	1.6[a]	SE[b]
Number of heifers	13	11	
Heifer weight, lb	596	596	18.9
Fecal output, % of body wt	.57	.72	.145
Forage digestibility, %			
DM	79.4	79.9	1.05
OM	71.7	74.3	1.41
Forage intake, % of body wt			
DM	2.98	3.77[c]	.25
OM	1.46	1.98[d]	.13

[a]Mean of "actual" poloxalene intakes.
[b]Standard error of the least square means.
[c]Means differ among treatments (P<.05).
[d]Means differ among treatments (P<.01).

Table 4. Number of bloat scores of 1 observed during the trial.

	Poloxalene, g/100 lb body wt	
	0	1.6[a]
Number of heifers	13	11
Month		
January[b]	5	1
February	2	0
March	11	1
April[c]	0	0

[a]Mean of "actual" poloxalene intakes.
[b]Beginning January 4, 1985.
[c]Ending April 11, 1985.

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EFFECTS OF MONENSIN, SARSAPONIN™ AND VFA ON IN VITRO DIGESTION OF WHEAT FORAGE

M.A. Funk[1], A.L. Goetsch[2] and F.N. Owens[3]

Story in Brief

Wheat forage digestion was studied using semi-continuous rumen cultures with or without monensin, a mixture of ammonium salts of volatile fatty acids and Sarsaponin™. Monensin at 27.5 ppm reduced nitrogen disappearance by 12 percent, increased digestion of acid detergent fiber by 25 percent, reduced gas production and reduced production of microbial nitrogen by 21 percent. Sarsaponin™ at 66 ppm had effects generally similar to monensin though of slightly lower magnitude. Ammonium salts of volatile fatty acids increased acid detergent fiber digestion slightly and tended to increase nitrogen disappearance but did not improve microbial yield or efficiency. The increases in fiber digestion and decreases in nitrogen disappearance with Sarsaponin™ and monensin are desirable changes with wheat forage diets. Monensin and Sarsaponin™ tended to decrease true digestion of organic matter. However, depressed microbial protein production is undesirable if the total amino acid supply to the intestine limits performance. Hence, these additives would appear most useful to improve protein status if dietary protein is extensively degraded in the rumen. With very low protein diets, these two additives may prove detrimental to protein status contrary to the suggestion of a protein sparing effect of monensin with low protein diets.

(Key Words: In Vitro, Fermentation, Digestion, Wheat Forage, Monensin, Sarsaponin™, Minor Volatile Fatty Acids.)

Introduction

At periods of rapid growth, wheat forage exceeds 20 percent crude protein, and a large proportion of this protein is soluble and rapidly degraded to ammonia in the rumen (Zorrilla-Rios et al., 1985). Supply of fermentable energy in wheat forage may be inadequate to fully use this ammonia, and ammonia losses can be high. Supplementation of wheat forage with a high energy, low protein feed like ground corn should increase capture of ammonia in microbial protein. Recently, rate of gain of cattle grazing wheat was reported to be increased by 0.2 lb/day with supplementation of 0.23 lb/head daily of a high-bypass protein feed (meat meal; Lee, 1985). This suggests that amino acid flow to the intestines may limit performance of cattle grazing wheat and that increased protein escape may prove useful.

Certain feed additives are useful for cattle grazing wheat pasture. Ionophores depress protein and amino acid breakdown in the rumen (Schelling, 1984), and may increase fiber digestion in the rumen and even reduce wheat pasture bloat (Branine et al., 1985). Likewise, sarsapogenins may alter microbial degradation of protein and fiber in the rumen. Branched-chain volatile fatty acids (BCVFA) are essential

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for certain fiber digesting bacteria and have increased milk production of dairy cows fed silage-based diets. This trial was conducted to ascertain the effects of the monensin, Sarsaponin™ and a mixture of BCVFA on fermentation of wheat forage in an in vitro system which simulates digestion in the rumen.

Materials and Methods

Wheat forage to feed the fermenter flasks was hand-clipped on April 21, 1984, dried at 50 C and ground through a 2-mm screen. Wheat forage dry matter contained 17.8 percent protein, 25.6 percent acid detergent fiber and 8.6 percent ash. Treatments consisted of wheat forage alone (CON), CON with 27.5 ppm monensin (MON) added, and CON with either 66 or 99 ppm Sarsaponin™ (trademark of Distributors Processing Inc., Porterville, CA 93257) added (SAR-L and SAR-H) and CON with 1 percent of a mixture of BCVFA added (MFA). The MFA mix consisted of 24 percent ammonium isobutyrate, 17 percent ammonium isovalerate, 17 percent ammonium 2-methylbutyrate, 17 percent ammonium valerate and 26 percent water.

Three semi-continuous in vitro rumen microbial fermentation flasks were fed each diet twice daily for 16 days. After 6 days for culture adaptation, effluent samples were collected for 10 days and analyzed for bacterial and protozoal numbers, dry matter (DM), ash, acid detergent fiber (ADF), nitrogen (N), ammonia-N and nucleic acid-N.

Results and Discussion

Treatments had little effect on bacterial numbers, though numbers of protozoa tended to be lower ($P<.01$) in flasks with MON and SAR-H than in CON cultures (Table 1). Monensin has been reported to inhibit growth of protozoa and certain types of bacteria. Culture pH was lower ($P<.05$) for MON than for the CON diet, possibly because of higher concentrations of VFA from more extensive fiber digestion (Table 2) with added monensin. In vivo, another ionophore, lasalocid also decreased ruminal pH (Andersen and Horn, 1985) due to an increase in total VFA concentration. With other diets, ionophores more typically increase ruminal pH due either to reduced feed intake or reduced acetate production. Culture pH was slightly lower than ruminal pH values previously measured (6.6 to 7.2) in heifers grazing wheat forage (Andersen and Horn, 1985).

Added monensin tended to decrease ($P<.10$) gas production from 6 to 9 h after flasks were fed and total production of gas during the 12-hour feeding interval. This may be associated with decreased production of methane or reduced microbial activity. MFA also tended to decrease total gas production ($P<.06$), mainly during 6 to 9 ($P<.09$) and 9 to 12 hour periods ($P<.05$) after feeding. The low level of Sarsaponin™ also tended to reduce gas accumulation at 6 and 9 hours of fermentation. Changes in gas production observed with MFA and Sarsaponin™ do not appear related to measured changes in digestion and may be partly associated with pH of the fermenter. Lower culture pH values drive more of the CO_2 produced out of solution.

Ammonia-N concentration in all flasks was very low considering the high protein content of the wheat forage. In the rumen, much higher values (8 to 17 mg ammonia-nitrogen per 100 ml) have been reported (Andersen and Horn, 1985). Ammonia was higher ($P<.05$) for MON than for

Table 1. Fermentation characteristics.

Item	Treatments				
	Control	Monensin	Minor fatty acids	Sarsaponin-low	Sarsaponin-high
Bacteria numbers, $x10^{10}$	2.9	2.5	2.7	2.9	3.4
Protozoa numbers, $x10^{4}$	1.3	.6	.9	.8	.6
pH	6.38^{a}	6.34^{b}	6.37^{ab}	3.36^{ab}	6.36^{ab}
Gas production, ml water displaced					
3 h, cumulative	15.4	14.0	14.6	15.3	16.5
6 h, cumulative	25.1	23.6	23.7	23.9	25.7
9 h, cumulative	29.8	27.2	27.4	27.7	29.5
12 h, cumulative	32.4	29.5	28.9	29.6	31.2
3-6 h, interval	9.7	9.5	9.2	8.7	9.2
6-9 h, interval	4.7	3.6	3.6	3.8	3.8
9-12 h, interval	2.6^{a}	2.3^{ab}	1.6^{b}	1.9^{ab}	1.7^{ab}
Ammonia-nitrogen, mg/dl					
.5 h	2.4^{a}	3.1^{b}	3.2^{b}	2.4^{ab}	2.8^{ab}
1 h	2.4^{a}	2.9^{ab}	3.1^{b}	2.4^{a}	2.9^{b}
4 h	1.8^{a}	2.6^{b}	2.8^{b}	2.1^{ab}	2.3^{b}
12 h	2.9^{a}	3.3^{ab}	3.6^{b}	2.9^{ab}	3.4^{ab}
Mean	2.4^{a}	3.0^{b}	3.2^{b}	2.4^{ab}	2.9^{ab}

^{ab}Means in a row with different superscripts differ significantly ($P<.05$).

CON cultures, with larger differences at .5, 1 and 4 h after substrate addition similar to observed effects with lasalocid in the rumen (Andersen and Horn, 1985). With most other diets, ruminal ammonia concentrations are decreased by added monensin. Because MON depressed microbial protein synthesis in our system, the increased ammonia-N in these cultures may reflect decreased utilization of ammonia-N by microbes.

MFA addition increased ammonia-N concentration at all collection times ($P<.05$). This would be expected since these fatty acids were added as ammonium salts. MFA also tended to increase digestion of wheat forage N (Table 2). In previous research with diets lower in N than wheat forage, MFA has either depressed or not altered ruminal ammonia-N levels in vitro and in vivo. Mean ammonia-N concentration as well as concentration at 1, 4 ($P<.05$) and 12 h ($P<.10$) after substrate addition was higher for SAR-H than for CON. Differences in rate of protein degradation or of incorporation of ammonia-N into microbial protein may be responsible.

True organic matter (OM) digestion tended ($P<.11$) to be lower for MON than for CON cultures though extent of ADF digestion was increased (Table 2). Synthesis of microbial N and microbial efficiency tended to decrease ($P<.08$) with added MON as is often observed with monensin in vivo.

Organic matter digestion was not altered by MFA, though again digestion of ADF tended to increase ($P<.09$). Neither microbial N production

Table 2. Digestion measures (for 8 day collection periods).

Item	Treatment				
	Control	Monensin	Minor fatty acids	Sarsaponin-low	Sarsaponin-high
Organic matter					
Input, mg	6815	6815	6806	6815	6815
Outflow, mg					
Total	3514	3515	3530	3519	3470
Feed	2619	2807	2628	2774	2671
Microbial	895	708	902	745	798
Apparent digestion, %	48.4	48.4	48.1	48.4	49.1
True digestion, %	61.6	58.8	61.4	59.3	60.8
Nitrogen					
Input, mg	212.4	212.4	215.7	212.4	212.4
Outflow, mg					
Total	175.2	179.1	170.0	179.6	176.1
Feed	59.6	78.4	47.3	79.0	66.0
Microbial	91.3[a]	72.2[ab]	92.0[b]	76.0[ab]	81.4[ab]
Ammonia	24.3[a]	28.4[ab]	30.7[b]	24.6[ab]	28.6[ab]
Apparent digestion, %	17.5	15.7	21.2	15.4	17.1
True digestion, %	71.9	63.1	78.1	62.8	68.9
Acid detergent fiber					
Input, mg	1907	1907	1904	1907	1907
Outflow, mg	934	694	875	855	907
Digestion, %	51.0[a]	63.6[b]	54.0[ab]	55.2[b]	52.4[ab]
Microbial efficiency, g microbial-N/kg OM fermented	27.7	21.9	28.0	23.1	24.4

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

or microbial efficiency was altered by MFA. MFA may have altered types of microbes in the fermentation flask but not microbial efficiency. Whether addition of MFA could alleviate the reduced microbial efficiency which occurs with monensin feeding is unknown.

True OM digestion decreased linearly ($P<.07$) as Sarsaponin™ level increased. Effects of Sarsaponin™ on digestion in other trials have varied with type of diet and level of Sarsaponin™. Sarsaponin™ at 66 ppm increased ($P<.03$) ADF digestion by 8.2 percent and decreased ($P<.07$) disappearance of feed N by 12.7 percent but the higher Sarsaponin™ level had less effect on these measurements. Increasing the Sarsaponin™ level tended to reduce the effect of Sarsaponin™ on fermentation. Similar decreases in microbial efficiency with added Sarsaponin™ have been observed in some (Goetsch and Owens, 1984; Valdez et al., 1985) but not all (Goetsch et al., 1985; Zinn et al., 1986) trials with cattle.

In summary, monensin and Sarsaponin™ modulated in vitro fermentation of wheat forage. Both compounds elevated extent of digestion of fiber but reduced both catabolism of feed protein and microbial protein synthesis and efficiency. Based on these results, either monensin or Sarsaponin™ would appear to increase ruminal escape of dietary protein and thereby spare dietary protein. But if animals must rely fully or primarily upon microbial matter as a source of protein, either compound may be detrimental to protein status. Increased protein escape may be associated with the decreases in protozoal numbers in the fermentation flask. Whether these additives have similar effects on fermentation of wheat pasture in the rumen needs to be examined, since in vivo, pH is much lower and passage rate is much faster than in these culture flasks.

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CORN VS SOYBEAN HULL SUPPLEMENTS FOR FALL-CALVING BEEF COWS IN WINTER

C.A. Hibberd[1], C.C. Chase[2], and C. Worthington[3]

Story in Brief

Eighty seven Hereford X Angus fall-calving beef cows were supplemented with 1.3 lb cottonseed meal (Negative control), 3.3 lb cottonseed meal (Positive control), 6.2 lb corn-cottonseed meal blend (Corn) or 7.8 lb soybean hulls (Soyhulls) per day. The Positive, Corn and Soyhull supplements supplied 1.34 lb crude protein per day while the Corn and Soyhull supplements provided twice as much TDN (4.8 lb/d) as the Positive control (2.4 lb/d). Cows fed the high energy supplements (Corn or Soyhulls) lost less weight and body condition than the Positive control cattle by the end of the 117-day study. Cows supplemented with Soyhulls, however, lost 31 lb less weight and .3 units less body condition than cows supplemented with Corn. In addition, calves from cows supplemented with either Corn or Soyhulls gained 22 lb more than the Positive control calves by day 117. This study suggests that soybean hull supplements may be a more efficient method of supplying energy to wintering beef cows than traditional corn-based supplements. When the additional 22 lb of calf weight are considered under the current price structure, the use of soybean hulls offers an economic incentive as well.

(Key Words: Fall-Calving Cows, Supplementation, Corn, Soybean Hulls)

Introduction

Nutritional management of fall-calving beef cows in winter presents a major challenge to cow-calf producers. High nutrient requirements, especially with high milking cows, coupled with low forage quality (forage crude protein 2-4%) and extreme environmental factors present a situation where adequate nutrition is necessary to maintain optimal calf growth and cow performance. Frequently, fall-calving cows can be properly maintained through the winter with 3 to 4 lb of a high protein (40% crude protein) supplement. When forage quality or quantity is poor, cows are milking well or environmental factors become severe, cows will require additional energy. Traditional high energy supplements containing large quantities of corn or other high-starch cereal grains may seriously hinder forage utilization. The starch component of cereal grains appears to decrease forage digestibility and intake to the extent that the overall energy status of cows may not be improved. Alternative feed sources composed of highly digestible fiber such as soybean hulls, a byproduct of the soybean milling industry, may truly supplement forage with no detrimental effects on forage utilization. Consequently, the objective of this study was to compare the effectiveness of high energy supplements composed of corn or soybean hulls with a traditional, high protein, cottonseed meal supplement.

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[1]Assistant Professor [2]Former Graduate Assistant [3]Herdsman

Materials and Methods

Eighty seven fall-calving Hereford X Angus cows (average calving date November 2, 1984) were allotted to four supplementation treatments on December 7, 1984 and maintained on dormant native grass range composed primarily of Little Bluestem (Andropogon scorporius) at the Southwest Forage and Livestock Laboratory located near El Reno, Oklahoma. Forage samples collected throughout the study with esophageally cannulated heifers averaged 3.72% crude protein. Cows received only supplement except on days when snow or ice cover necessitated hay feeding (11 days). Calves received no supplemental feed throughout the study.

Four supplements were formulated to test soybean hulls as a digestible fiber feed for wintering, fall-calving beef cows (Table 1). The Positive control, Corn and Soyhull supplements supplied 1.34 lb of crude protein per day. The Corn and Soyhull supplements, however, were designed to provide twice as much TDN (4.8 lb/d) as the Positive control (2.4 lb/d). The Negative control cows were fed 1.3 lb of cottonseed meal per day until March 7, 1985 when they were switched to the Positive control due to extremely poor body condition. The weekly allowance for each supplement was individually fed on six consecutive days, Monday through Saturday. Cow weights, cow body condition score (1=very thin, 9=very fat) and calf weights were recorded every two weeks. Cows were weighed following an 18-hour shrink, calves were weighed full. Data were analyzed by least squares with treatment, sex, pasture and calf age (covariate) included in the model. Data from the Negative control were

Table 1. Supplement composition and daily nutrient supply (As-Is basis).

	Supplement			
	Negative	Positive	Corn	Soyhulls
Ingredient (lb/d)				
Cottonseed meal	1.1	3.2	2.5	---
Corn	---	---	3.6	---
Soybean hulls	---	---	---	7.6
Mineral[a]	.2	.1	.07	.2
Total	1.3	3.3	6.2	7.8
Nutrient supply (lb/d)				
Crude protein	.45	1.34	1.34	1.34
TDN	.8	2.4	4.8	4.8

[a]Supplements were formulated to provide a minimum of 30 g/d calcium, 24 g/d phosphorus, 54 g/d potassium and enough sulfur to maintain a 15:1 nitrogen to sulfur ratio.

excluded from the analysis. Differences between least square treatment means were detected by LSD.

Results and Discussion

Changes in cow weight during the course of the study are illustrated in Figure 1. As would be expected, Negative control cows receiving only 1.3 lb cottonseed meal per day rapidly lost a substantial amount of weight. Once switched to the Positive control on April 7, Negative control cows gained almost 70 lb in only 28 days. Cows on the other three supplements performed similarly until February 14, 1985, when cows fed the Soyhull supplement continued to minimize weight loss while the Corn and Positive control cows lost additional weight. By the end of the 117-day study, Positive control cows had lost 154 lb of body weight and 1.06 units of body condition (Table 2). Cows on the high energy supplements (Corn and Soyhull) lost less ($P<.05$) weight and body condition than cows on the Positive control. Comparing the high energy supplements, cattle fed Soyhulls lost 31 lb less weight ($P<.05$) and .3 unit less body condition ($P<.05$) than Corn-supplemented cows.

The Corn and Soyhull supplements were formulated to provide the same amount of supplemental TDN based on N.R.C. estimates of 64% TDN for soybean hulls and 91% TDN for corn. The Soyhulls performed better than the Corn indicating that either the N.R.C. underestimates the energy value of soybean hulls or that the corn supplement had a detrimental effect on forage utilization. Previous work suggests that supplements containing large quantities of cereal grains can decrease forage

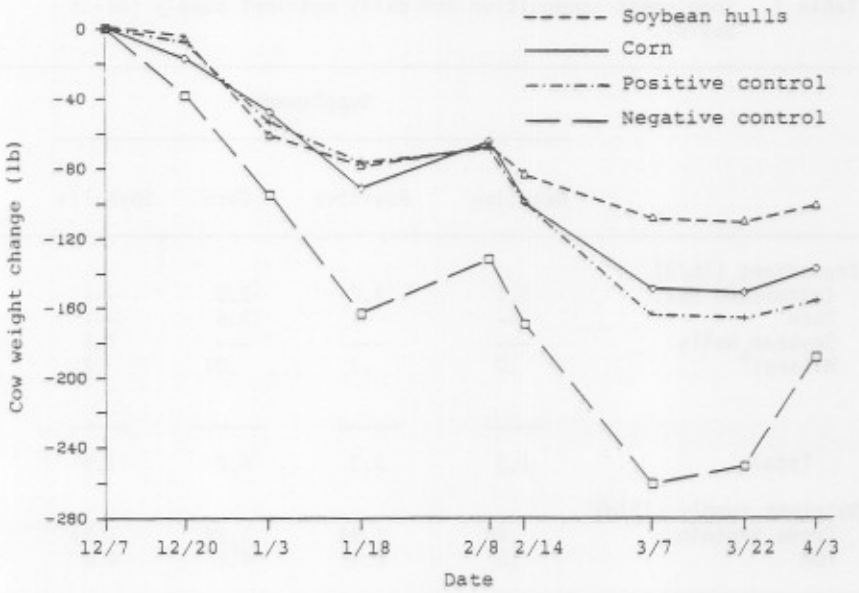


Figure 1. Winter weight change of cows supplemented with 1.3 lb cottonseed meal (Negative), 3.3 lb cottonseed meal (Positive), 6.2 lb corn-cottonseed meal (Corn) or 7.8 lb soybean hulls per day.

Table 2. Productivity of fall-calving cows supplemented with cottonseed meal, corn or soybean hulls.

	Supplement		
	Positive	Corn	Soyhulls
Cows/treatment	27	27	27
Cow weight, lb			
12/7/84	1055$_{a}$	1022$_{a}$	1059$_{b}$
4/3/85	900^{a}	890^{a}	958^{b}
Change	-154^{a}	-132^{b}	-101^{c}
Cow condition			
12/7/84	6.0$_{a}$	5.8$_{ab}$	5.8$_{b}$
4/3/85	4.9^{a}	5.2^{ab}	5.5^{b}
Change	-1.1^{a}	-.6^{b}	-.3^{c}
Calf weight, lb			
12/7/84	136$_{a}$	133$_{b}$	128$_{ab}$
4/3/85	258^{a}	281^{b}	275^{b}
Change	125^{a}	147^{b}	147^{b}

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

digestibility and intake to the extent that little or no improvement in cow performance may be observed. Although cows fed the Corn supplement responded slightly better than the Positive control in this study, their performance did not equal those fed the Soyhulls. Perhaps the low starch and high digestible fiber content of the soybean hulls truly supplemented consumed forage with no detrimental effects on forage digestibility.

Calves nursing cows fed high energy supplements (either Corn or Soyhulls) gained 22 lb more weight ($P<.05$) than the Positive control calves during the trial (Table 2). Additional energy supplied by the Corn and Soyhull supplements apparently stimulated milk production. Energy from the Soyhulls further stimulated cow weight and body condition gain over and above the Corn. Cows fed the high energy supplements appeared to satisfy energy demands for lactation first; additional energy above lactation requirements was apparently diverted to body stores.

Soybean hulls offer an alternative to traditional supplementation programs. They are relatively easy to handle and are currently economically feasible. The use of soybean hulls or other digestible fiber feeds may allow cow-calf producers to efficiently supplement energy to their cows with little or no detrimental effects on forage utilization.

CORN GLUTEN FEED OR SOYBEAN MEAL AS WINTER SUPPLEMENTS FOR PREGNANT BEEF COWS GRAZING NATIVE RANGE

A.T. Fleck[1] and K.S. Lusby[2]

Story in Brief

Ninety mature Hereford cows bred to calve in March and April were divided into five winter supplement treatments. Supplementation began November 20, 1984 and terminated as each cow calved. Treatments were: negative control, 1.1 lb/day soybean meal; positive control, 2.0 lb/day soybean meal; 4.6 lb/day corn gluten feed; 3.2 lb/day of a 2:1 corn gluten feed-soybean meal mixture; and 3.2 lb/day corn gluten feed plus urea. All supplement amounts were increased 50% on January 30, 1985. Supplements were prorated and fed six days per week. Cow weight changes during the trial were -77.3, -23.6, 2.8, 1.0, and -55.8 lb for the negative control, positive control, corn gluten feed, corn gluten feed/soybean meal, and corn gluten feed/urea treatments, respectively. Cow body condition changes were -.96, -.47, -.39, -.49 and -.69, respectively. Conception rates were lower for the negative control group but did not differ between other treatment groups (55 vs 80 to 88%). Calf average daily gains were not significantly affected by treatment. Rumen fluid propionate concentrations were higher and acetate concentrations were lower in cows fed corn gluten feed, and ammonia concentrations were higher in the positive control treatment. Corn gluten feed appears to be an effective energy and protein supplement for beef cattle consuming low quality forage. Adding urea to corn gluten feed was detrimental to cattle performance.

(Key Words: Beef Cows, Winter, Supplements, Corn Gluten Feed, Soybean Meal.)

Introduction

Cattle in Oklahoma are commonly maintained on dormant native range or other low-quality roughage throughout the winter. When low quality forage is plentiful, feeding oil seed meal supplements improves forage digestibility and intake, increasing total energy available to the animal. When the energy requirement cannot be met with protein supplementation alone, the rancher may feed hay or a larger amount of an energy supplement. Feeding hay is often avoided due to the expense and labor involved in both harvesting and feeding hay. Feeding traditional grain-based supplements have often given disappointing results because supplements containing starch tend to reduce forage intake and, therefore, energy intake of the animal. Recent Nebraska research by DeHann et al. (1983) suggests that supplements containing highly digestible fiber sources such as corn gluten feed (CGF) are more efficient at increasing total energy intake of grazing cattle than supplements containing grains. This research evaluates corn gluten feed as an energy and protein supplement for beef cows grazing low quality forage.

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Materials and Methods

Ninety mature Hereford cows bred to calve in March and April were blocked by age, weight, body condition and expected calving date and allotted to five supplement treatment groups. Treatments were negative control, low level of soybean meal (NC/SBM); positive control, higher level of soybean meal (PC/SBM); corn gluten feed (CGF); corn gluten feed/soybean meal blend (CGF/SBM); and corn gluten feed/urea (CGF/Urea). The treatments, supplement compositions, and amounts fed are presented in Table 1. Supplementation began November 20, 1984 and was terminated as each cow calved. All cows grazed as a group on native tallgrass range in north central Oklahoma.

Cattle were gathered from the pasture six days per week and individually fed their respective supplements. Daily feeding rates were prorated for a 6 day per week feeding schedule. Treatments 2 through 5 provide the same daily amount of crude protein. Treatment 1 was fed 1/2 this traditional amount and served as the negative control. The amount of energy varied between treatments depending on supplement source. Cane molasses was added to aid in pelleting. All supplements provided the same daily amounts of calcium, phosphorous, potassium, and vitamin A. Grass hay was fed when snow or ice covered the ground and when temperatures were extremely cold (less than 10°F wind chill).

Cow weights (overnight shrink) and body condition scores were recorded at 28 day intervals until cows neared calving at which time measurements were taken every 14 days. As cows calved they were removed from the trial and their nearest 14 day records were used as the final measurement. Following calving, cows were allotted by condition and precalving treatment to a high or low nutrition group to study the effect of nutrition after calving on cows of different weights and condition. Calving dates, birth weights, and weaning weights were recorded. Calf weaning weights were adjusted for age, sex and age of cow.

Table 1. Supplement composition.

	Treatment				
	NC/SBM	PC/SBM	CGF	CGF/SBM	CGF/UREA
Amount fed, lb/day:					
11/20/84-1/29/85	1.1	2.0	4.6	3.2	3.2
1/30/85-3/26/85	1.6	3.0	6.9	4.8	4.8
Ingredients, %:					
Soybean meal	84.69	93.10	0.00	32.33	0.00
Corn gluten feed	0.00	0.00	96.38	62.66	90.84
Molasses	3.60	3.59	3.58	3.58	3.59
Dical	9.30	13.24	0.00	1.38	1.39
Potassium chloride	2.26	0.00	0.00	0.00	.90
Vitamin A premix	0.15	.07	.04	.05	.04
Urea	0.00	0.00	0.00	0.00	3.24
Composition, %:					
Crude protein	37.43	41.11	17.89	25.90	25.71
TDN	67.92	74.41	73.99	73.94	69.86
Calcium	2.19	.98	.34	.62	.61
Phosphorus	2.25	1.22	.71	.94	.92
Potassium	2.85	1.87	.66	1.08	1.09

Cows were bred by natural service and pregnancy diagnosed by rectal palpation on October 17, 1985.

On day 114 of the trial, rumen fluid samples were taken via stomach tube from 40 randomly selected cows at 1 and 4 hours after supplement feeding. Fluid pH was recorded at the time of collection before storing for later laboratory analyses. Laboratory analyses consisted of VFA determination by gas chromatography and NH_3 determination by the phenol-hypochlorite colorimetric assay.

Results and Discussion

Cow weight and body condition changes are shown in Table 2. One cow was removed from the CGF/SBM treatment group for health reasons unrelated to the trial. Cow weight losses were greater ($P<.01$) for the NC/SBM treatment group than the PC/SBM treatment, demonstrating a protein deficiency did exist. Cows fed corn gluten feed alone (CGF) or the corn gluten feed/soybean meal blend (CGF/SBM) maintained the initial fall weight through the winter period. The PC/SBM, CGF, CGF/SBM and CGF/UREA supplements each provided equal amounts of daily crude protein, yet the consumption of a higher level supplemental TDN in the CGF and CGF/SBM supplements increased the total energy available to the cow. Cows receiving the corn gluten feed and urea supplement (CGF/UREA) lost weight similar to the NC/SBM treatment. Body condition scores reflected weight change; the NC/SBM group had the greatest loss in condition (-.91 units) and the CGF treatment lost the least (-.39 units). All treatments tended to maintain the same differences in weight and body condition to weaning (October 17, 1985).

Cow conception and calf performance is presented in Table 3. The percent of cows conceiving in the breeding season was lower ($P<.11$) for

Table 2. Performance of mature cows and their calves.

	Treatment[a]					
	NC/SBM	PC/SBM	CGF	CGF/SBM	CGF/UREA	Prob.
Number of pairs	18	18	18	17	18	
Initial cow wt, lb, 11/20/85	1041	1047	1048	1044	1040	
Cow wt change, lb, 11/20 to precalving	-77[b]	-24[cd]	3[d]	1[d]	-56[bc]	P<.01
Initial body condition (1-9)	5.8	5.7	5.7	5.7	5.7	
Body condition change	-.96[b]	-.47[c]	-.39[c]	-.49[c]	-.69[bc]	P<.01
Cow wt at weaning, 10/17/85	975.1	993.3	1003.4	998.6	987.8	NS
Cow CS at weaning[e], 10/17/85	5.11	5.11	5.31	5.16	5.13	NS

[a]LS means.
[bcd]Means with different superscript letters differ.
[e]Condition scoring system used was 1 through 9 (1=very thin and 9=very fat).

Table 3. Cow conception rate and calf performance.

	Treatment[a]					
	NC/SBM	PC/SBM	CGF	CGF/SBM	CGF/UREA	Prob.
No. cows exposed to bull	18	16	18	15	17	
Conception rate, %	55.5	87.5	83.3	80.0	88.2	P<.11
Calf birth wt, lb	74.7	76.8	80.0	80.4	76.4	P<.14
Calf ADG, lb/day	1.25	1.40	1.38	1.27	1.32	NS
Calf adj. weaning wt, lb	346	384	377	359	367	P<.19

[a]Least squares means.

the NC/SBM group (55.5%) while 80% or more cows conceived in each of the other four treatment groups. Although calf weaning weights and rates of gain were slightly lower in the NC/SBM treatment groups, calf performance was not significantly affected by previous winter nutritional treatment of the dam.

Rumen volatile fatty acid (VFA) concentrations at 1 and 4 hours after supplementing is presented in Tables 4 and 5, respectively. Regardless of treatment, total VFA's were higher 4 hours after supplements were fed than at 1 hour. At 1 hour after feeding the supplement, the CGF cows had lower (P<.01) concentrations of acetate and higher (P<.01) levels of propionate and butyrate. The same relationship existed at 4 hours after feeding; therefore, the acetate/propionate ratio was lower in the CGF treatment at both 1 and 4 hours after feeding than other treatments.

Table 4. Volatile fatty acid concentration (molar %) in rumen fluid collected one hour post supplementation.

	Treatment[a]					
	NC/SBM	PC/SBM	CGF	CGF/SBM	CGF/UREA	Prob.
Cows sampled	8	7	11	6	8	
Total VFA (μmoles/ml)	55.24_{b}	63.57_{b}	59.61_{c}	60.13_{b}	55.88_{b}	NS
Acetate	75.50^{b}	72.08^{b}	64.03^{c}	69.73^{b}	71.66^{b}	P<.01
Propionate	13.47^{c}	15.52^{c}	22.78^{b}	17.02^{c}	17.12^{c}	P<.01
Isobutyrate	1.47^{bc}	2.06^{b}	$.74^{c}$	1.27^{bc}	1.62^{b}	P<.05
Butyrate	6.86^{c}	7.50^{c}	9.88^{b}	9.18^{bc}	7.07^{c}	P<.01
Isovalerate	1.66	1.80	1.15	1.46	1.31	NS
Valerate	1.03	1.04	1.42	1.32	1.21	NS
Acetate/ propionate	5.72^{b}	4.67^{bc}	2.80^{d}	4.26^{c}	4.28^{c}	P<.01

[a]Least squares means.
[bcd]Means in same row with different superscripts differ.

Table 5. Volatile fatty acid concentration (molar %) in rumen fluid collected four hours post supplementation.

	Treatment[a]					
	NC/SBM	PC/SBM	CGF	CGF/SBM	CGF/UREA	Prob.
Cows sampled	8	7	11	6	8	
Total VFA (μmoles/ml)	57.73^{b}	66.47^{b}	70.67^{c}	60.56^{b}	54.80^{b}	NS
Acetate	71.81^{b}	67.86^{b}	60.74^{c}	66.76^{b}	69.36^{b}	P<.01
Propionate	17.51^{c}	17.73^{c}	24.53^{b}	18.31^{c}	19.30^{c}	P<.01
Isobutyrate	1.40^{bc}	2.11^{b}	1.65^{c}	1.55^{bc}	1.39^{bc}	P<.05
Butyrate	6.25^{d}	8.30^{cd}	11.29^{b}	10.29^{bc}	7.61^{d}	P<.01
Isovalerate	2.01^{bc}	2.46^{b}	1.05^{c}	1.67^{bcd}	1.34^{c}	P<.01
Valerate	1.02^{cd}	1.53^{bc}	1.74^{b}	1.42^{bcd}	1.00^{d}	P<.01
Acetate/ Propionate	4.13^{b}	3.84^{b}	2.49^{c}	3.65^{b}	3.73^{b}	P<.01

[a] Least squares means.
[bcd] Means in same row with superscripts differ.

Rumen pH and ammonia concentrations at 1 and 4 hours after supplementing are presented in Table 6. Rumen pH was lower (P<.01) in the CGF treatment than all other treatments at 4 hours after supplementing. This lower pH may be expected since feeding grain supplements result in pH reduction. It should be noted, however, that all pH levels were still relatively high and would not be expected to seriously affect fiber digestibility. Rumen ammonia concentrations were similar at 1 hour after feeding; however, at 4 hours after feeding rumen fluid ammonia concentrations were higher (P<.05) for cows on the PC/SBM treatment than all other treatments.

Table 6. Ruminal pH and the concentration of ammonia in rumen fluid collected one and four hours post supplementation.

	Treatment[a]					
	NC/SBM	PC/SBM	CGF	CGF/SBM	CGF/UREA	Prob.
Cows sampled	8	7	11	6	8	
Rumen pH:						
1 hr post-feeding	7.47	7.29	7.04	7.19	7.37	P<.2
4 hr post-feeding	7.49^{b}	7.42^{b}	6.84^{c}	7.16^{b}	7.35^{b}	P<.01
Rumen ammonia (mg/dl):						
1 hr post-feeding	13.75	18.80	13.73	17.47	20.53	P<.07
4 hr post-feeding	14.53^{c}	20.94^{b}	10.89^{c}	14.82^{c}	11.32^{c}	P<.05

[a] Least squares means.
[bc] Means in same row with different superscripts differ.

These results suggest that corn gluten feed can be used alone or with soybean meal as a winter protein and energy supplement. The CGF/SBM cows maintained the same weights as the CGF cows on 30% less daily feed; therefore, corn gluten feed was more efficiently utilized when SBM was added to the supplement. Corn gluten feed performed as well as or better than soybean meal in improving or maintaining cow weight, body condition, conception rates, or calf performance. Adding urea to corn gluten feed resulted in increased cow weight loss compared to feeding corn gluten feed alone.

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EFFECTS OF LIMIT-FED HIGH PROTEIN CREEP FEED OR EARLY WEANING ON PERFORMANCE OF FALL-BORN CALVES AND THEIR DAMS

K.S. Lusby[1] and R.P. Wettemann[2]

Story in Brief

Twenty eight fall-calving Hereford and Hereford X Angus calves born in September and October were allotted to Control (no creep and normal weaning), Creep (1 lb/head/day of soybean meal limit fed with 10% salt from Nov. 25 to April 8, normally weaned) or Early Weaning (weaned on December 17). Calves fed salt-limited soybean meal creep gained 51 lb more by April 8 than Control calves. Creep calves consumed 124 lb of soybean meal for a conversion of 2.43 lb creep/lb added weight. Following cessation of creep feeding on April 8, gains of Control and Creep calves were similar until weaning on July 12 and during a subsequent stocker phase from weaning until October 14. Early weaned calves gained rapidly during the 28-day drylot period following weaning but gained slower than Control calves when placed on pasture with hay and supplement during the remainder of winter until weaning in July. During the postweaning stocker phase, all three groups of calves gained at similar rates. Dams of early weaned calves gained significantly more weight during winter and the following summer than dams that nursed calves. Limit-fed high protein creep appears to be an efficient method of increasing weaning weights of fall-born calves on native range. The additional weaning weight was maintained after weaning during a stocker phase. No health problems were noted for calves early weaned in winter. Early weaning of fall calves may be a feasible option when forage is limited for the cow herd or when poor reproduction is expected.

(Key Words: Early Weaning, Creep Feed, Fall Calving, Beef Cattle)

Introduction

Two problems are common with fall-calving programs where dormant forages are the primary feed resource. First, cows must be fed large amounts of supplements and/or hay to maintain weight and reproductive performance. Early weaning of calves near the beginning of breeding season could significantly reduce the feed resources needed for fall-calving cows in years when forage or supplemental feeds were expensive or scarce. Costly purchased feeds could be more efficiently utilized by the calf, and the dry cow would maintain weight on low quality roughages. However, management of early weaned calves during the winter would be critical to success in such a strategy. Secondly, even when calves are raised naturally by the cow, calf gains are low during the winter. Limit-fed high protein creep efficiently increases weaning weights when fed during late summer to spring-born calves (Lusby et al., 1985). If protein creep could stimulate forage intake and digestibility in fall-born calves during the winter, weaning weights might be efficiently increased. The objectives of this trial were to compare cow and calf performance when fall-born calves were either early weaned or

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limit-fed a high protein creep.

Materials and Methods

Twenty eight Hereford and Hereford X Angus calves and their dams were allotted by calving date and breed to three management treatments on November 25, 1984. Calves were born in September and October and grazed native range pastures with their dams. All calves were weighed and individually identified at birth and male calves were castrated by banding. The three management treatments were Control, Creep and Early Weaning. Control calves grazed with their dams and were not creep-fed until weaning on July 12, 1985. Cows were supplemented with 3 lb/day of cottonseed meal from the beginning of the breeding season (November 25 - February 1) to the onset of spring grass in mid-April. Hay was only fed when temperatures were extremely cold or when snow or ice covered forage. A second group of calves (Creep) and their dams were managed the same as Control cattle except that soybean meal was offered in a creep feeding enclosure, accessible only to calves, from November 25 to April 8. When intake of creep reached 1 lb/hd/day, salt (10%) was added to limit intake at the 1 lb level. A third group of calves (Early Wean) was early weaned from their dams on December 17. All calves were vaccinated for Blackleg (Clostridium chauvoei and septicum), IBR, BVD, PI-3 (IM) and Precon-Ph (Pasteurella) on November 25, so that immunity could have been developed before the stress of early weaning. Calves to be early weaned were offered soybean meal creep from November 25 to December 17 in order to teach the calves to eat milled feed. On December 17, Early Weaned calves were hauled 3 miles to the range headquarters where they were fed a mixed ration in a self-feeder (Table 1) for 28 days. After 28 days in drylot, early weaned calves were maintained for the rest of the winter on free-choice prairie hay and 2 lb/hd/day of soybean meal. In order to reduce labor costs, hay to early weaned calves was in the form of large round bales and soybean meal was limit-fed with salt. Hay and soybean meal were withdrawn in April when calves began eating green forage. After early weaning, dams of early weaned calves grazed dormant bermuda pasture for the remainder of the winter and were fed 1 lb/day of cottonseed meal.

From April 8 until July 12, all cows and calves grazed native range without supplement or creep feed. Control and Creep calves were weaned on July 12 and, after a 7-day bawl-out period, were grazed in a stocker

Table 1. Ration fed to early weaned calves in drylot.

Ingredient	Percent As Fed
Cottonseed hulls	30.0
Rolled corn	46.3
Cane molasses	4.0
Soybean meal	18.0
Limestone	1.9
Dicalcium phosphate	.45
Salt	.30
Vitamin A (30,000 IU/gm)	1 lb/ton
Deccox (6%)	1 lb/ton

phase on native range with Early Weaned calves until October 14. During the stocker phase, all calves received 1 lb/hd/day of soybean meal containing 100 mg/lb of Rumensin. Supplement was prorated for feeding on Monday, Wednesday and Friday.

Results and Discussion

Creep Feeding

Creep calves consumed soybean meal at the desired 1 lb/day level within 2 weeks although Creep calves gained only 10 lb more (nonsignificant) than Control calves from November 25 to January 14 (Table 2). From mid-January to mid-March, however, Creep calves gained about 20 lb/month more than Control calves. It is likely that declining milk production of the dams, which would reduce calf weight gains, combined with increased size and forage intake potential of the calves permitted Creep calves to utilize the protein creep feed to advantage.

During the period between March 11 to April 8, winter annual forages grew rapidly and gains of Control calves increased as calves were able to supplement their diet with green forage. Even though Creep calves continued to consume 1 lb/day of soybean meal, gains of creep

Table 2. Performance of control, creep-fed and early weaned calves and their dams.

Item	Control	Creep	Early Weaned	Prob.
No. cow/calf pairs	9	9	10	
Ave. calf birth date	9/22/84	9/22/84	9/19/84	
Calf birth wt, lb	66	72	64	
Initial calf wt, 11/25, lb	162	173	167	
Calf wt changes, lb:				
11/25-12/17	20.5	25.6	26.5	NS
12/17-1/14	30.0[a]	33.3[a]	59.5[b]	.01
1/14-2/11	16.1[a]	35.6[b]	3.7[a]	.01
2/11-3/11	17.8[a]	38.3[b]	19.4[a]	.01
3/11-4/8	43.9	42.2	41.1	NS
4/8-5/6	68.3[a]	76.7[a]	39.5[b]	.01
4/8-7/12	200.1[b]	198.6[b]	131.0[a]	.01
7/12-10/14	135.2	131.8	134.6	NS
Cow wt, 11/25, lb	1082	1040	1074	
Cow wt change, lb				
11/25-5/6	-50.6[b]	-25.6[b]	+21.7[a]	.01
5/6-7/12	122.8[a]	115.6[a]	152.2[b]	.02
Cow condition score[e]	6.2	5.9	6.2	
Cows pregnant/exposed	6/9	8/9	10/10	

[abc]Numbers on a line with like superscript letters do not differ [d](P<.05).

[d]Creep feeding period, 11/25-4/8; Early Weaned calves in drylot, 12/17-1/14; Control and Creep treatment calves nursing with no creep 4/8-7/12; postweaning period on native range with 1 lb/day SBM containing 100 mg/lb Rumensin.

[e]Scale, 1=very thin - 9=very fat.

calves were similar to gains of Control calves. For the total period, Creep calves consumed 124 lb of soybean meal for a conversion of 2.43 lb creep/lb added weight.

These results suggest that protein creep is best utilized when forage quality and/or milk production of the dam are limiting calf gains. With the onset of green winter annuals in mid-March, Control calves were apparently able to consume sufficient protein and energy for increased weight gains. Creep calves were likely also consuming winter annuals and did not utilize additional protein creep for increased gain. Producers should monitor the onset of green forages in the spring and cease protein creep feeding when calves begin consuming green forage.

Gains were similar for Control and Creep calves from the cessation of creep feeding on April 8 until weaning on July 12 (200 vs 199 lb). Although Creep calves gained 51 lb more than Control calves during the winter, Creep calves were still 50 lb heavier than Control calves at weaning. Gains of Control and Creep calves were similar during the mid-July to mid-October stocker phase (135 vs 132 lb). Similar gains from the cessation of creep feeding through weaning and a stocker phase suggest that added weight from creep feeding in winter can be maintained. An important consideration in this study is that the creep calves were not excessively conditioned at the end of creep feeding but had only maintained a moderate rate of gain during the winter.

Early Weaned Calves

No sickness was observed during the 28-day drylot phase following early weaning. This was in spite of weather conditions that varied from sunshine and temperatures in the high 60's (F) to freezing rain. Immunization 3 weeks prior to weaning, which aided in developing immunity prior to weaning, no processing at the time of weaning and teaching the calves to eat by providing creep prior to weaning are all factors which should have reduced stress at early weaning. The weaning ration was palatable and intakes approached 6 lb/hd/day within 2 days after weaning. Average ration intake for the 28-day period was 8.7 lb/head/day and calves gained 2.14 lb/day. The feed conversion was 4.06 lb of feed/lb of gain, which is consistent with efficient conversions seen in previous OSU early weaning studies (Lusby and Wettemann, 1980; Lusby and Parra, 1981). High feed intake, relatively high energy in the ration and small body weight (and maintenance requirement) are all factors that make young calves potentially efficient. These results, along with previous early weaning studies at the Oklahoma Agriculture Experiment Station, show that calves can be successfully early weaned at about 2 months of age with minimal health problems when planning emphasizes reduction of stress.

Early Weaned calves gained only 4 lb (Table 2) during the first 28 days when they were moved from drylot to native pasture and fed 2 lb/hd/day of soybean meal. Calves were not maintained in drylot on a high concentrate ration to normal weaning age because it is not economical due to the labor and feed needed in a drylot program. Raising the Early Weaned calves to normal weaning age with prairie hay and protein supplement represented a relatively low cost and low labor program. From 10 to 20% salt was needed to limit intake in the soybean meal to 2 lb/day. Gains of Early Weaned calves and Control calves were similar from mid-February to mid-April when gains of Control calves were also quite low. Weight gains for Early Weaned calves were significantly lower than gains for Control calves from mid-April to normal weaning time in July (200 vs 131 lb). The reason for the failure of Early

Weaned calves to make compensatory gains during the spring and early summer months when forage quality is high is not known. Gains were identical for Control and Early Weaned calves during the postweaning stocker phase (135 lb).

Cow Performance

As expected, dams of early weaned calves gained significantly more weight during the winter than dams that nursed Control or Creep calves. Early Weaned cows were wintered on pastures with lower quality and quantity of forage and fed one-third the daily protein supplement of cows that nursed calves. All cows with early weaned calves were pregnant following the breeding season compared to 8 of 9 cows with creep calves and 6 of 9 Control cows. Although cow numbers are too small to compare reproductive performance among the 3 groups of cows, the high conception rate for cows with Early Weaned calves is consistent with high reproductive performance when calves are early weaned. During the period from mid-April to normal weaning in July, cows with early weaned calves continued to gain faster than cows nursing calves (152 lb vs 123 and 116 lb).

Early weaning is not recommended for all cow herds every year, but this trial shows that it is a practice that can produce high rebreeding rates while reducing the feed resources needed for fall-calving cows during the winter. The decision whether to use early weaning in a fall-calving herd would depend on the expected rebreeding rate, relative costs of forages and supplements for the cows and costs for labor, health programs and feed resources for early weaned calves.

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COMPARISON OF LIMIT-FED HIGH PROTEIN CREEP FEED AND FREE-CHOICE GRAIN CREEP FOR SPRING-BORN CALVES ON NATIVE RANGE

K.S. Lusby[1]

Story in Brief

Forty-three spring-born Angus, Hereford and Hereford X Angus calves were allotted to three treatment groups: no creep (Control); limit-fed, high protein creep (Protein); or free-choice grain creep (Grain). Creep was offered from June 4 to weaning on October 15. Calves began consuming the grain creep almost immediately but did not consume protein creep at the desired 1 lb/day level until early July. Calf weight gains during the creep feeding period (June 4 to October 15) were 230, 260 and 309 lb for Control, Protein and Grain creep groups. The conversion of creep to added gain was 3.3:1 for Protein creep and 7.8:1 for Grain creep. Cow weight and condition score changes were similar for dams of calves in all groups.

(Key Words: Early Weaning, Creep Feed, Fall Calving, Beef Cattle)

Introduction

Limit-fed, high protein creep has been shown to efficiently increase weaning weights when fed to spring-born calves in late summer (Lusby et al., 1985). The probable action of protein creep is to stimulate forage intake and digestibility during late summer when protein content of the forage is low. Traditional creep feeds have been grain-based and fed free choice, typically at 5-7 lb/day. While free-choice creep feeding has increased calf weaning weights, the conversions of grain to added gain often have not been economically feasible, especially for spring-born calves. The objectives of this trial were to compare cow and calf performance when spring-born calves were creep-fed with either limit-fed, high protein creep or free-choice grain-based creep.

Materials and Methods

Forty-three Angus, Hereford and Hereford X Angus calves and their dams were allotted by calving date and breed to three management treatments on June 4, 1985. Calves were born from late February to late April and grazed native range pastures with their dams. All calves were weighed and individually identified at birth. All male calves except Angus were castrated by banding at birth. The three treatment groups were Control, limit-fed high protein creep (Protein), and free-choice grain based creep (Grain). Composition of the Grain creep is shown in Table 1.

Protein creep calves were first offered straight cottonseed meal in a whirlwind-type mineral feeder surrounded by portable panels. Calves had access to the feeders through creep gates. When intake of

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Table 1. Composition of grain creep ration.

Ingredient	Percent
Cottonseed hulls	19.5
Rolled corn	53.9
Cane molasses	5.8
Soybean meal	19.1
Limestone	.9
Dicalcium phosphate	.4
Salt	.4
Composition, DM basis, %	
Dry matter	86.0
Protein	15.3
TDN	78.0

cottonseed meal reached 1 lb/head/day, salt (10%) was added to limit intake. Grain calves were offered creep in a metal creep feeder with a capacity of 1000 lb. Calf weights and cow weights and condition scores (scale of 1=very thin to 9=very fat) were taken after overnight withdrawal from feed and water. Pastures were rotated twice during the trial which ended on October 15 when all calves were weaned. Data were analyzed by least squares analysis of variance.

Results and Discussion

Calves weighed about 200 lb at the beginning of the study on June 4 (Table 2). One of the objectives of the study was to determine when calves would first begin to consume the limit-fed creep feed. Calves consumed very little cottonseed meal without salt until early July when consumption exceeded 1.0 lb/head/day. At that point, 10% salt was added to the meal and consumption dropped to about 0.5 lb/head/day and remained at that level until early August. During August, daily intakes approached 1.5 lb/head/day. Beginning in September, intake was restricted to 1.0 lb/head/day on a weekly basis by adding the 10% salt-90% cottonseed meal mixture to the feeders twice weekly at a rate to provide 1.0 lb/head/day. Consumption of the Grain creep was about 2.0 lb/head/day from June until mid-July. From mid-July to mid-September, intake of Grain creep was about 6.5 lb/head/day and increased to as much as 9.5 lb/head/day from mid-September to weaning on October 15.

Least squares means for calf weight gains are shown in Table 2. Control calves gained 230 lb (1.73 lb/day) during the 133 day trial period compared to 260 lb (1.95 lb/day) for Protein creep calves and 309 lb (2.32 lb/day) for Grain creep calves ($P<.01$). Protein creep calves consumed 99 lb of cottonseed meal per calf for a conversion of creep to added gain of 3.3:1. Grain creep calves ate 614 lb of feed for a conversion of 7.8 lb of feed per pound of added gain. The efficiency of utilization of the Protein creep in this trial is slightly poorer than seen in previous studies. This is likely because the trial was started early in June when forage quality was high and calves would not be as likely to need additional protein as well as the fact that creep consumption was permitted to increase to 1.5 lb/head/day in August.

Table 2. Effects of protein creep or grain creep on cow and calf performance.

	Control	Protein Creep	Grain Creep	Prob.
No. of calves	15	14	15	
Initial calf weight	201	205	200	
Calf gain, 6/4-10/15[a]	230[b]	260[c]	309[d]	P<.01
Creep/calf, lb (133 days)	---	99	614	
Pound creep/lb added gain	---	3.3	7.8	
Initial cow weight	876	945	898	
Cow wt change, 6/4-10/15[a]	101	88	89	
Initial cow condition score	4.9	5.0	5.0	
Condition score change, 6/4-10/15[a]	.5	.4	.4	
Cows pregnant/cows exposed	13/15	11/14	12/15	

[a]Least squares means.
[bcd]Means on a line with different superscript letters differ (P<.05).

Based on observations with stocker cattle fed high protein supplements in summer, the efficiency of utilization of protein may be expected to decrease as intakes exceed 1.0 lb/head/day. Considering that nursing calves are usually lighter in weight than stocker cattle, the optimum level of protein creep may be even lower than 1.0 lb/head/day but this has not been studied.

Calf creep feeding treatment did not significantly affect cow weight or body condition score changes during the trial. All cows gained weight and body condition during the trial. Pregnancy rates also were similar across treatment groups.

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Spring Burning of Native Grass Pastures for Late-Weaned Fall-Calving Cows

R.R. Scott[1], C.A. Hibberd[2] and C. Worthington[3]

Story in Brief

Thirty-two dry and 32 lactating fall-calving beef cows and calves grazed burned or unburned native range from May 6 through August 1, 1985 to determine if thin, late-weaned cows would respond to the improved nutrient supply provided by burned native grass. Burning effectively increased the body weight and condition of both dry and lactating cows. Lactating cows maintained on burned pastures, however, gained only 24 lb and .33 units of body condition compared to 56 lb and .45 units of body condition for dry cows. Weaned calves grazing burned pasture gained 18 lb more than weaned calves grazing unburned pasture. Burning tended to increase weight gains (14 lb) of suckling calves as well. Suckling calves, however, gained an average of 90 lb more than their weaned counterparts. Spring burning appears to be a viable tool to rapidly improve the weight and body condition of thin cows. Combined with the advantages of delayed weaning, producers should be able to manage cow weight and condition and also capitalize on increased calf performance.

(Key Words: Spring-Burning, Delayed Weaning, Fall-Calving)

Introduction

Dormant native winter range is low in crude protein and TDN. During this time, fall-calving cows typically lose body weight (150+ lb) and body condition (1+ units) due to the low nutritive value of native range. Consequently, many fall-calving cows, especially those with high milk production, enter the spring extremely thin.

When calves are normally weaned, at or about 210 d, thin cows typically regain enough weight and condition to ensure normal calving, lactation and rebreeding performance. Previous work at this station (Hancock et al, 1985) has shown that delayed weaning (285 d) increases calf weight by 59 lb with little effect on subsequent cow performance. Delayed weaning, however, may stress thin cows or cows with high milk production to the extent that adequate body reserves may not be achieved by the fall calving season.

One alternative is to wean thin cows at 210 d although the 59 lb advantage for late-weaned calves would be lost. A second alternative is to improve the quality of the feed supply by spring burning. Burning improves the crude protein and palatability of range grasses. Grazing thin, suckled cows on burned pastures may improve cow performance without sacrificing weaning weight. The objective of this study was to determine if thin, late-weaned fall-calving cows and their calves will respond to spring burning of native range.

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[1]Graduate Student [2]Assistant Professor [3]Herdsman

Materials and Methods

Angus X Hereford cows (921 lb) were bred to Limousin bulls and calved from September through November, 1984. Normal-weaned calves were weaned on April 22, 1985 and fed grass hay plus a weaning ration in drylot until May 6. Delay-weaned calves were weaned at the end of the trial on August 1. Average calf weight at the beginning of the trial was 330 lb. Three native grass pastures were burned on April 11 and 12, 1985. Grazing was initiated on May 6, when regrowth was approximately six inches and continued to August 1, 1985 (87 days). Ninety-two cows were available for the study, however, 64 were chosen on the basis of low initial condition scores which ranged from 3.0 to 5.5. Four groups of cattle (8 dry cows and 8 lactating cows with calves) were randomly assigned to each of four pastures (two burned and two unburned). Pastures were approximately 70 acres and stocking density was 3.1 acres/animal unit. Two groups of weaned calves (16 calves/group) were randomly assigned to two calf pastures (one burned, the other unburned) with a stocking density of 7.3 acres/animal unit. Unburned pastures were predominated by standing, dead little bluestem. Cow weights, body condition scores (1=very thin, 9=very fat), and calf weights were evaluated every three weeks following a 15 hour shrink. Two independent condition scores were averaged for each cow.

Two cows and their calves were removed before the end of the trial because of illness. Consequently, sixty-two cows and calves were used in the statistical analyses. The data were analyzed by least squares procedures. Significant differences between least-square treatment means were detected by Tukey's HSD test.

Results and Discussion

Dry cows grazing burned pastures were 56 lb heavier ($P<.05$) and .45 units of body condition fatter ($P<.05$) than dry cows grazing unburned pasture (Table 1 & 2). Lactating cows grazing burned pastures, however, were only 24 lb heavier ($P<.05$) and .33 units fatter ($P<.05$) than lactating cows grazing unburned pastures. Dry cows rapidly regained weight and body condition, especially when grazing burned pastures. By August 1, most dry cows were in a body condition of 6 or better. Lactating cows, however, gained less weight and body condition as they continued to divert consumed nutrients into milk through the summer. By August 1, 9 of the 16 lactating cows grazing unburned pastures were in a body condition of 5.0 or less compared to only 4 of

Table 1. Changes in body weight of dry and lactating cows grazing burned or unburned native grass pastures.

	Dry cows		Lactating cows	
	No burn	Burn	No burn	Burn
Initial	921	950	905	905
Final	1118$_b$	1205$_a$	1051$_c$	1075$_b$
Weight gain	198^b	254^a	146^c	170^b

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

Table 2. Changes in body condition of dry and lactating cows grazing burned or unburned native grass pastures.

	Dry cows		Lactating cows	
	No burn	Burn	No burn	Burn
Initial	4.79	4.77	4.27	4.43
Final	5.95[b]	6.38[a]	4.86[c]	5.35[b]
Condition gain	1.16[b]	1.61[a]	.59[c]	.92[b]

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

14 lactating cows grazing burned pastures. Fall-calving cows in a body condition of 5.0 or less by August 1 should probably be separated from the rest of the herd and fed additional protein to enhance body condition. Because fewer lactating cows grazing burned pastures were extremely thin, less supplementation would be required.

When grazing burned pastures, weaned calves gained 18 lb more (P<.05) and suckling calves gained 14 lb more than their counterparts grazing unburned pastures (Table 3). Weaned calves grazing burned pastures had access to higher quality forage than weaned calves grazing unburned pastures and thus grew faster. Suckling calves on burned pastures, however, could utilize better quality forage plus additional milk. Although the response to burning was similar for both weaned and suckling calves, suckled calves could have responded to either source of nutrients (forage or milk).

Lactating cows regained less weight (P<.05) and body condition (P<.05) than dry cows (Table 1 & 2). Suckling calves, however, gained 90 lb more (P <.05) than their weaned counterparts. In this study, delaying weaning until August 1 allowed suckling calves to gain an additional 1.0 lb for each day they were left on the cow compared to their weaned counterparts of similar age.

Burning appears to be an effective method to rapidly improve weight and body condition of thin, fall-calving cows. Much of the response to burning was observed in the first six weeks of the study (Figure 1). Normal weaning at 170 d also allows thin cows to improve weight and condition, although the opportunity to market more pounds of weaned weight is lost. Combining delayed weaning (271 d) with spring pasture burning should allow producers to quickly recondition thin cows and also capitalize on improved calf performance.

Table 3. Changes in body weight of weaned and suckling calves grazing burned or unburned native grass pastures.

	Weaned calves		Suckling calves	
	No burn	Burn	No burn	Burn
Initial	326	336	334	330
Final	449	478	550	560
Weight gain	124[c]	142[b]	216[a]	230[a]

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

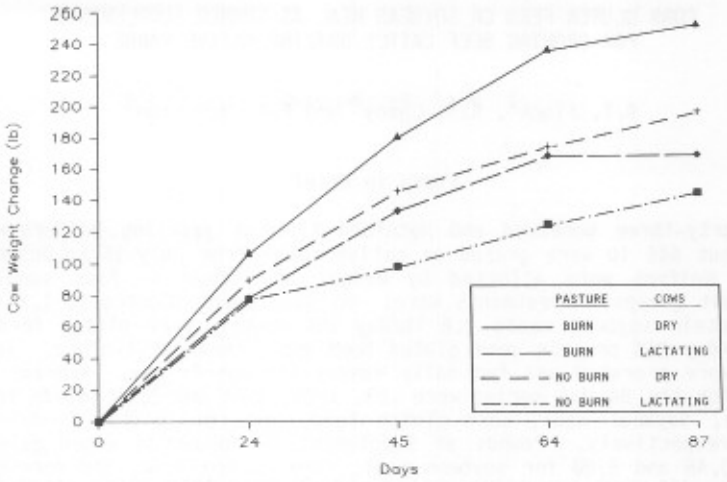


Figure 1. Changes in body weight of dry or lactating cows grazing burned or unburned native grass pastures.

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CORN GLUTEN FEED OR SOYBEAN MEAL AS SUMMER SUPPLEMENTS FOR GROWING BEEF CATTLE GRAZING NATIVE RANGE

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Story in Brief

Forty-three Hereford and Hereford X Angus yearling heifers weighing about 645 lb were grazed on native range from July 16 to October 8, 1985. Heifers were allotted by weight and breed to four supplement treatment groups. Treatments were: no supplement (Control); 1.2 lb/day 41% protein soybean meal; 2.8 lb/day 18% protein corn gluten feed; and 1.9 lb/day 26% protein corn gluten feed and soybean meal blend. Supplements were prorated and fed daily Monday through Friday. Average daily gains for the 84 day period were .83, 1.25, 1.64 and 1.51 pounds for the Control, soybean meal, corn gluten feed, and corn gluten feed/soybean meal, respectively. Pounds of supplement per pound of added gain were 2.88, 3.46 and 2.80 for soybean meal, corn gluten feed, and corn gluten feed/soybean meal, respectively. Based on the weight gains of the corn gluten feed and corn gluten feed/soybean meal, corn gluten feed does not appear to have a negative effect on forage digestibility and intake. The results of this study suggest corn gluten feed effectively increases weight gain on growing beef animals grazing native range in late summer.

(Key Words: Beef Cows, Winter, Supplements, Corn Gluten Feed, Soybean Meal.)

Introduction

As native forage quality declines in late summer and early fall, protein and energy supplements have been shown to increase performance of growing steers and heifers. High protein meals generally increase weight gains of cattle grazing low quality forage more efficiently than energy supplements. In a previous OSU study, Lusby et al. (1982) showed a .4 lb/day increase in daily gain from feeding .8 lb of a 39% protein supplement to 575 lb steers from mid-July to mid-October. The same study showed a .3 lb/day increase in daily gain from feeding 3 lb of a 10% protein/energy supplement made up of corn and soybean meal (SBM). Therefore, the pounds of supplement per pound of added gain were 1.8 for the 39% protein and 8.8 for the 10% protein supplement. A small amount of supplemental protein apparently increases forage intake and digestibility. Feeding energy in the form of corn with the same amount of protein generally reverses this process. The digestion of starch from corn makes the rumen less favorable to bacteria that digest roughages. However, recent Nebraska research (DeHaan et al., 1983) suggests that by-product feeds that contain digestible fiber such as corn gluten feed (CGF) is more efficient at increasing total energy intake of grazing cattle than supplements containing grains. The positive response may be because the same types of bacteria that digest forage also digest the highly digestible fiber fraction of CGF. The objective of this research was to evaluate CGF as a protein and energy supplement for growing beef

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cattle grazing native range in late summer and early fall.

Materials and Methods

The trial was conducted at the Lake Carl Blackwell Range 10 miles west of Stillwater in North Central Oklahoma. Forty-three Hereford and Angus X Hereford heifers, averaging 16 months of age, were allotted by breed and weight to four supplement treatments. Treatments were no supplement (Control), 1.2 lb/day of a 41% protein SBM supplement (SBM), 2.8 lb/day of an 18% protein CGF supplement (CGF), and 1.9 lb/day of a 26% protein CGF and SBM blend (CGF/SBM). Supplement compositions are shown in Table 1. Treatments 2, 3 and 4 provided the same amount of supplemental protein, but varying amounts of supplemental energy. All supplements were fed on Monday through Friday with supplement amounts prorated to give the prescribed daily amount. All heifers grazed a single pasture and were individually fed their respective supplements, from July 16 to October 8, 1985. Heifers were weighed at 28 day intervals after an overnight shrink. A mineral mix containing 55% dicalcium phosphate and 45% salt was provided free choice to all heifers.

Table 1. Supplement composition and feeding rates (as fed).

	Treatment		
	SBM 1.2 lb/day	CGF 2.8 lb/day	CGF/SBM 1.9 lb/day
Ingredients, %:			
Soybean meal	93.10	0.00	32.33
Corn gluten feed	0.00	96.38	62.66
Molasses	3.59	3.58	3.58
Dical	3.24	0.00	1.38
Vitamin A premix	0.07	0.04	0.05
Composition, %:			
Crude protein	41.11	17.89	25.90
TDN	74.41	73.99	73.94
Calcium	0.98	0.34	0.62
Phosphorus	1.22	0.71	0.94
Potassium	1.87	0.66	1.08
Supplied/day in supplement:			
Crude protein, lb	0.49	0.50	0.49
TDN, lb	0.89	2.07	1.40
Calcium, grams	5.34	4.32	5.34
Phosphorus, grams	6.65	9.02	8.11
Potassium, grams	10.19	8.39	9.32

Results and Discussion

Average daily gains were .83, 1.25, 1.64 and 1.51 lb/day for the Control, SBM, CGF and CGF/SBM groups, respectively (Table 2). Heifers fed no supplement gained 70 pounds from July 16 to October 10, 1985.

Table 2. Heifer weights, weight gain and lb supplement/lb added gain.

	Treatment[a]			
	Control 0 lb/day	SBM 1.2 lb/day	CGF 2.8 lb/day	CGF/SBM 1.9 lb/day
No. heifers/treatment	10	11	11	11
Initial wt, 7/16/85	652	644	644	646
Final wt, 10/8/85	722[b]	749[c]	782[d]	773[cd]
Weight gain, lb	70[b]	105[c]	138[d]	127[cd]
Weight gain, lb/day	.83[b]	1.25[c]	1.64[d]	1.51[cd]
Pound supplement/lb added gain	---	2.88	3.46	2.80
Cost/lb of added gain	---	$0.26	$0.20	$0.18

[a]Supplements fed 5 days/week (Monday through Friday).
[bcd]Means with different superscript letters are significantly different (P<.01).

During the 84 day treatment period, feeding 1.2 lb/day of SBM supplement increased gains 35 pounds over the unsupplemented control (105 vs 70), a conversion of 2.88 lb of supplement per pound of added gain. Feeding 2.8 lb of CGF supplement per day improved gains by 68 pounds (138 vs 70) with a conversion of 3.46 lb supplement per pound of added gain. The heifers fed 1.9 lb of CGF/SBM supplement gained 127 lb with a conversion of 2.8 lb of supplement per pound of added gain. The CGF and CGF/SBM supplements which provided additional energy to the animal in the form of digestible fiber had conversions similar to those heifers receiving SBM supplement. This can be compared to a previous OSU study (Lusby et al., 1982) in which 8.8 lb of a corn/SBM supplement were required for each pound of added gain. Supplements in the present study were fed daily Monday through Friday, whereas corn in the previous trial (Lusby et al., 1982) was fed 3 days per week. Therefore, it is not known if feeding corn gluten feed supplements 3 days/week would affect the efficiency of supplement to added gain. The daily feeding of corn supplements would likely improve performance over feeding relatively large amounts less frequently. At a cost of $180/ton (9 cents/lb) for SBM and $116/ton (5.8 cents/lb) for CGF, the feed cost per pound of added gain was $0.26 for the SBM supplemented heifers, $0.20 for the CGF supplemented heifers and $0.18 for the CGF/SBM supplemented heifers.

Temperatures were average and moisture was above average during the trial period. Pastures had abundant forage; total clip samples on an adjacent pasture had crude protein of 5.6, 5.0, 4.4, and 4.4% for July 14, July 25, August 14 and August 31, respectively. The increased gains from feeding a small amount of SBM supplement was likely the result of increased fiber digestibility and forage intake. Based on the weight gains of the CGF and CGF/SBM groups, corn gluten feed does not appear to have a negative effect on forage digestibility and intake; therefore, the consumption of higher levels of supplemental TDN may be increasing the total energy available to the animal.

In summary, the results of this study suggest CGF fed alone or with SBM effectively increase total energy intake by the animal. The feeding of additional energy in the form of highly digestible fiber does not appear to have the negative effects on forage digestibility and intake.

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ADDITION OF BUFFER AND/OR AMMONIA TO CORN-SUPPLEMENTED NATIVE GRASS HAY DIETS

C.C. Chase[1], C.A. Hibberd[2] and F.N. Owens[3]

Story in Brief

Combinations of bicarbonate buffer and ammonia compounds were intraruminally dosed to four mature beef heifers fed low-quality native grass hay supplemented with corn. Four mature beef heifers in individual pens were offered free access to coarsely chopped native grass hay (4.8 percent crude protein) and fed a corn supplement (3.6 lb corn/hd/d) at 0800h. Isomolar solutions of either NaCl, $NaHCO_3$, NH_4Cl or NH_4HCO_3 were infused through the ruminal cannulae four times daily. The combination of ammonia and buffer (NH_4HCO_3) increased hay intake compared to the NaCl and $NaHCO_3$ (21.0 vs 16.3 and 15.0 lb). Hay consumption with NH_4Cl dosing (11.2 lb) was lower than with other compounds, probably due to ruminal acidosis. Ammonia compounds, especially NH_4Cl, increased fiber (NDF) digestibility. Low ruminal ammonia-N levels (< 1 mg/dl) with NaCl and $NaHCO_3$ may have limited bacterial action. Increased hay intake and fiber digestibility with NH_4HCO_3 increased digestible dry matter intake. Buffer alone ($NaHCO_3$) had little effect on ruminal pH when compared to NaCl. Ammonia alone (NH_4Cl) decreased ruminal pH while the combination (NH_4HCO_3) maintained ruminal pH similar to NaCl. Consequently, the depression in hay intake and utilization commonly encountered as a result of supplementation with large amounts of corn (>2 lb/d) may be partially alleviated by the addition of a source of ammonia. Ammonia addition, however, may stimulate fermentation to the extent that buffer addition may be helpful.

(Key Words: Buffer, Ammonia, Intake, Digestibility, Native Grass)

Introduction

Beef cows wintered on native range require energy supplementation when forage supply is inadequate or when energy requirements are increased by inclement weather, stress or lactation. Energy-dense cereal grains and other high starch supplements are commonly fed to provide additional energy for wintering cattle. When starch-based supplements are fed at levels greater than 2 lb/d, digestibility and intake of low-quality grass decrease. This depression has been attributed to low ruminal pH which would inhibit the action of fiber-digesting bacteria or to competition for ammonia which could be overcome with protein supplementation. The objective of this experiment was to determine the response in digestibility and intake of corn-supplemented low-quality native grass hay diets with beef heifers intraruminally dosed with buffer and/or ammonia compounds.

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[1]Former Graduate Assistant [2]Assistant Professor [3]Herdsman

Materials and Methods

Four ruminally cannulated Hereford x Angus heifers (935 lb) were utilized in a 4 x 4 latin square design. Isomolar solutions of NaCl (.24 lb/d), $NaHCO_3$ (.35 lb/d), NH_4Cl (.22 lb/d) or NH_4HCO_3 (.33 lb/d) were intraruminally dosed four times daily (Table 1). Heifers were fed 3.8 lb of a corn supplement each day (Table 2) and offered free access to coarsely chopped (2 in. screen) native grass hay (4.8 percent crude protein, 49.1 percent acid detergent fiber, 71.1 percent neutral detergent fiber). Supplemental nitrogen infusions (NH_4Cl and NH_4HCO_3) supplied an additional .41 lb of crude protein equivalent per day.

Following a 9 d adaptation period, fecal samples were collected at 0700 and 1900 h for four consecutive days. Quantities of supplement and native grass hay offered and refused were weighed and sampled on days 9 through 12. All samples were composited by animal within period, dried and ground (1 mm screen) prior to analysis. Dry matter and neutral detergent fiber digestibilities were estimated using acid-insoluble ash as an indigestible marker.

Table 1. Chemical composition of intraruminally-dosed compounds.

Component	Treatment			
	NaCl	$NaHCO_3$	NH_4Cl	NH_4HCO_3
	lb/d			
Na	.10	.10	-	-
Cl	.15	-	.15	-
HCO_3	-	.25	-	.25
NH_4	-	-	.08	.08
Total	.25	.35	.23	.33

Table 2. Supplement intake and nutrient supply (DM basis).

Supplement intake	lb/d
Corn, ground	3.58
Mineral premix[a]	.26
Total	3.84

Supplemental nutrient supply	lb/d
Crude protein	.31
Starch[b]	2.57
TDN[b]	3.22

[a]Mineral premix contained 63.4% dicalcium phosphate, 15.1% potassium chloride, 20.0% trace mineralized salt and .6% Vitamin A (20,000 IU/d).
[b]Estimated.

On d 13 of each period, rumen samples were obtained at 0900 (1 h postfeeding) and pH immediately measured. Ruminal fluid was strained through four layers of cheesecloth, acidified, frozen and later analyzed for ammonia-N concentration. The data were subjected to least squares analysis and differences between treatment means detected with Tukey's HSD test.

Results and Discussion

Compared to NaCl, dosing of the buffer alone ($NaHCO_3$) tended to decrease NDF digestibility and hay intake (Table 3). The combination of buffer and ammonia (NH_4HCO_3), however, increased ($P<.05$) hay intake by 4.8 lb compared to NaCl dosing. The addition of nitrogen as NH_4Cl decreased ($P<.05$) hay intake compared with the other compounds even though both sources of N, NH_4Cl or NH_4HCO_3, tended to increase fiber digestibility. Part of the increase in digestibility with NH_4Cl can be attributed to decreased forage intake which would slow rate of passage and increase digestibility. Because the two ammonia compounds (NH_4Cl and NH_4HCO_3) increased fiber digestibility, cattle maintained on low-quality forage and fed corn supplements are probably deficient in ruminal ammonia. The very low ruminal ammonia-N concentrations, below 1 mg/dl, with the NaCl and $NaHCO_3$ treatments, suggests that ammonia supply was inadequate for bacterial growth in the rumen.

Despite the increase in digestibility with infused NH_4Cl, hay intake decreased by 32% compared to NaCl. Intraruminal dosing of NH_4Cl decreased ($P<.05$) ruminal pH by .6 units to 6.02. If ruminal pH drops below about 6.2, cellulose-digesting organisms are inhibited. Perhaps ruminal acidosis decreased rate of fiber digestion and hay intake (Table 4).

The combination of ammonia and buffer (NH_4HCO_3) increased ($P<.10$) intake of digestible dry matter by 2.6 lb over the NaCl control. Although digestible dry matter intake (DDMI) is an inexact estimation of energy status, increased DDMI should increase energy balance.

Table 3. Daily intake and digestibility of hay and supplements.

Item	Treatment				SE
	NaCl	$NaHCO_3$	NH_4Cl	NH_4HCO_3	
Hay intake, lb	16.3^{b}	15.0^{b}	11.2^{c}	21.1^{a}	.74
Hay intake, % BW	1.7^{b}	1.6^{b}	1.2^{c}	2.3^{a}	.07
Neutral detergent fiber digestibility, %	43.4^{ab}	40.7^{b}	53.2^{a}	47.1^{ab}	2.34
Dry matter intake, lb	20.1^{b}	18.8^{b}	15.0^{c}	24.9^{a}	.74
Apparent dry matter digestibility, %	49.3^{b}	50.0^{b}	57.8^{a}	50.4^{b}	1.41
Digestible dry matter intake, lb	9.9^{y}	9.4^{y}	8.7^{y}	12.5^{x}	.62

^{a,b,c}Means in rows with different superscripts differ ($P<.05$).
^{x,y}Means in rows with different superscripts differ ($P<.10$).

Table 4. Ruminal fluid parameters (1 hour post-dosing).

Item	Treatment			
	NaCl	$NaCO_3$	NH_4Cl	NH_4HCO_3
Rumen pH,	6.63	6.75	6.02	6.61
Rumen NH_3-N, mg/dl	.51	.44	11.35	8.36

Bicarbonates ($NaHCO_3$ or NH_4HCO_3) did not increase ruminal pH compared to NaCl. Although the primary response in fiber utilization in this study is due to ammonia, the value of the buffer in the NH_4HCO_3 treatment cannot be ignored. With increased fiber digestion due to ammonia, the NH_4HCO_3 provided additional buffering to maintain ruminal pH.

This study suggests that the decrease in hay intake and utilization commonly observed when large amounts of corn (>2 lb/d) are supplemented to cattle consuming low-quality native grass hay is due to an inadequate supply of ruminal nitrogen. By providing a soluble source of nitrogen to meet the microbial demands for ammonia, many of the deleterious effects associated with corn supplementation may be overcome. Consequently, when range supplements are formulated to contain large quantities of cereal grains (starch), the protein content should be high and extremely degradable in the rumen to provide ample ammonia for microbial growth.

VALUE OF PROTEIN IN AMMONIATED STRAW FOR GROWING STEERS

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Story in Brief

The feeding value of crude protein in ammoniated wheat straw was tested in two trials with steers. In trial 1, ammoniation of straw by the stack method increased the crude protein content of straw from 3.66 to 9.13 percent of dry matter. Weight gains of steers limit-fed an ammoniated straw diet with no added soybean meal were similar (about 1 lb/day) to gains of steers fed an untreated straw diet with 1.3 lb/day of soybean meal. Therefore, the crude protein of ammoniated straw had a value equal to that of soybean meal for steers consuming moderate levels of corn (i.e., 0.8 percent of body weight) at a growth rate of 1 lb/day. In trial 2, steers were fed ammoniated straw with corn at 0, 3 or 6 lb/day with or without 1 lb of corn gluten meal. Steers fed untreated straw received 3 lb corn and 1 lb corn gluten meal/day. Ammoniation of straw increased gains of steers from .13 to .83 lb/day. Added corn decreased straw intake but added corn gluten meal did not. Supplementation of ammoniated straw diets with corn gluten meal increased gains of steers by about .8 lb/day. The marked improvement in daily gains of steers, due to supplementation with corn gluten meal, cannot be fully attributed to the slightly increased total feed intake, and may be due to an increased supply of amino acids to the small intestine. With either treated or untreated straw, protein levels below 9.6 percent of dry matter reduced feed intake and gains.

(Key Words: Growing Steers, Wheat Straw, Ammoniation.)

Introduction

Treatment of a low-quality roughage with ammonia frequently (1) increases digestibility of dry matter (DM) by 20 to 40 percent, (2) doubles its crude protein (CP) content and (3) increases voluntary consumption by ruminant livestock by 20 to 35 percent. Increased feed consumption accounts for a large proportion of the increased performance of ruminants fed ammoniated roughages.

Ruminants can potentially utilize the increased nitrogen (crude protein) of ammoniated roughages by transforming the nitrogen (N) into microbial protein if adequate energy is available to the rumen microorganisms for this process. The N/energy ratio of ammoniated roughages is usually excessive. This limits synthesis of microbial protein and, thereby, animal performance.

Adding moderate levels of supplemental energy permits the N of ammoniated roughages to be used which decreases the amounts of supplemental protein needed by animals. The value of ammoniated roughages to spare supplemental protein has not been quantitated.

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At high levels of animal performance, the amount of microbial protein synthesized in the rumen and flowing to the small intestine may be insufficient. The additional need is for protein that is not degraded in the rumen ("bypass" protein). This idea seems appropriate for ammoniated roughage diets because the ammonia contributes only to the ruminal ammonia pool, not to bypass protein.

The objectives of these feeding trials were:

1. To determine the value of the increased crude protein of ammoniated wheat straw to spare a ruminally degraded supplemental protein, soybean meal (SBM), for growing steers.

2. To determine the effect of addition of a higher "bypass" protein, corn gluten meal (CGM), to basal diets of ammoniated wheat straw with various amounts of corn on growth of steers.

Materials and Methods

Straw was ammoniated for both trials by the stack method (4.4 percent NH_3 of as-fed straw).

Trial 1

Thirty-two Beefmaster x Hereford-Angus crossbred steers (634 lb) from one cow herd were allotted by weight into eight blocks of four animals each. Steers within each block were individually penned and randomly assigned to four treatments. Three treatments were untreated wheat straw (US) supplemented with soybean meal (SBM) to supply 70, 80 or 100 percent of the crude protein requirements for steers gaining 1 lb/day. Treatment four was ammoniated wheat straw (AS) plus corn but no SBM. Dry matter intakes of steers on treatment four were limited to those of steers of treatment 3 (i.e., US plus 1.3 lb SBM/head/day). Ground corn was fed at a level of 5.3 to 6.7 lb/head/day to all steers to meet energy requirements for gain. A mineral-vitamin supplement was fed to supply needed Ca, P, S, Mg, K and vitamins A, D and E. Intake of straw was calculated by weighing refusals weekly. Initial and final body weights were recorded after withholding feed and water for 18 hours. At the end of the trial, all steers were fed a maintenance level of alfalfa hay for five days prior to the final shrink to minimize effects of ruminal fill on final body weights.

Trial 2

Fifty-six Charolais x Hereford-Angus crossbred steers (699 lb) from one cow herd were individually allocated by weight to eight blocks of seven animals each. Steers within each block were individually penned and randomly assigned to seven treatments. Six treatments included ammoniated wheat straw with either 0, 3 or 6 lb corn/head/day with or without 1 lb of corn gluten meal (CGM)/head/day. Treatment 7 was untreated wheat straw plus 3 lb corn and 1 lb CGM/head/day. All steers received 1.7 lb/day of a mineral-vitamin supplement that contained approximately 78.0 percent ground corn as the carrier, to provide additional Ca, P, S, Mg, K and vitamins A, D and E. Both types of straw were offered ad libitum. Straw intakes and body weights of steers were measured as in trial 1.

Results and Discussion

Trial 1

Ammoniation of wheat straw more than doubled the crude protein content of the untreated straw (US = 3.66 vs AS = 9.13 percent). Supplementation of untreated wheat straw with SBM up to 1.3 lb/head/day increased voluntary consumption of wheat straw and daily gains of steers (Table 1) suggesting that protein content limited intake and performance on untreated straw diets. Weight gains of steers limit-fed ammoniated wheat straw with no supplemental SBM were similar (i.e., about 1 lb/day) to gains of steers fed untreated wheat straw and the highest level of SBM (Figure 1). Therefore, for steers fed a moderate level of corn (0.8 percent of body weight) at a growth rate of 1 lb/day, the 0.44 lb of crude protein added by ammoniation of wheat straw spared 0.57 lb of protein from SBM.

Calculated net energy and crude protein contents of the diets are shown in Table 1. Diets of untreated straw with 1.3 lb SBM and of ammoniated straw with no supplemental SBM had CP contents of about 9.6 percent of DM. Had the initial CP content of the untreated straw been lower and/or had the ammoniation procedure increased the CP content of the straw less, complete replacement of supplemental SBM might not have been possible.

Trial 2

The effects of ammoniation on the nutritive content of wheat straw, and the chemical composition of the feedstuffs for this trial are shown in Table 2. The increase in both the crude protein content and in vitro dry matter digestibility (IVDMD) of straw from ammoniation was substantially less than expected. This was due to wind blowing part of the plastic sheeting from the stack of ammoniated straw. Commonly, the crude protein content is doubled and IVDMD of straw is increased by about 33 percent by ammoniation.

Feed intakes and performance of steers are shown in Table 3 and Figure 2. Ammoniation of wheat straw increased gains of steers fed 3 lb corn plus 1 lb CGM/day from .13 to .83 lb/day. Straw intake was increased by only 12 percent by ammoniation in this trial. Therefore, the .7 lb increase in daily gain of steers fed ammoniated straw is higher than what would be anticipated from the increased feed intake alone. The limited increase in intake of ammoniated straw in this trial can be partially attributed to incomplete ammoniation of the straw.

Increasing the amount of corn decreased ($P<.01$) intake of ammoniated straw by steers fed diets with and without CGM. For each pound of added corn, straw intake decreased an average of 0.9 lb. Total feed intake and digestible energy intake increased as level of corn increased which increased gains by steers. In contrast, added CGM did not decrease intake of ammoniated straw. Supplementation of the ammoniated straw diets with CGM increased the crude protein contents of the diets from about 6.6 percent to 10.1 percent of DM and increased gains of steers by about .8 lb/day. Since this marked improvement in daily gains from supplementation with CGM cannot be attributed to the slightly increased total feed intake, it must be due to other factors, such as a greater quantity or more balanced supply of amino acids for digestion in the small intestine.

Table 1. Feed intakes, nutrient content of diets and performance of steers fed untreated wheat straw (US) and increasing amounts of soybean meal (SBM) or ammoniated wheat straw (AS) during Trial 1 (90 days).

Straw type:[a] SBM, lb as-fed/head/day:	US 0	US .42	US 1.30	AS[b] 0	SBM linearity (Level of significance)	SEM
No. of animals	8	8	8	8		
Total intake, lb/day						
Dry matter[c]	13.9	14.3	14.6	14.6	NS	.2
Straw DM	7.2	7.6	7.9	8.0	Not tested	----
Corn DM	5.1	4.9	4.1	5.1	Not tested	----
Crude protein	.967	1.12	1.41	1.43	.01	.02
DM intake, % BW	2.10	2.13	2.14	2.13	NS	.03
Straw DM/total, %	51.0	52.6	53.7	53.5	.01	.57
Body weight, lb						
Initial	634	633	638	631	NS	3.5
Final	691	710	729	741	Not tested	----
Average daily gain	.62	.72	.97	.99	.01	.04
Calculated nutrient content (DM basis) of diets						
NE_{Maint}, Mcal/cwt	70.6	69.9	68.6	69.3		
NE_{Gain}, Mcal/cwt	34.8	34.2	33.3	33.4		
Crude protein, %	6.76	7.62	9.64	9.57		

[a]US = untreated wheat straw; AS = ammoniated wheat straw.
[b]Intakes of ammoniated wheat straw by steers were limited to those of treatment 3 (i.e., US plus 1.3 lb SBM/day).
[c]Includes 1.55 lb DM/head/day of a mineral vitamin supplement with 78.0% corn as a carrier.

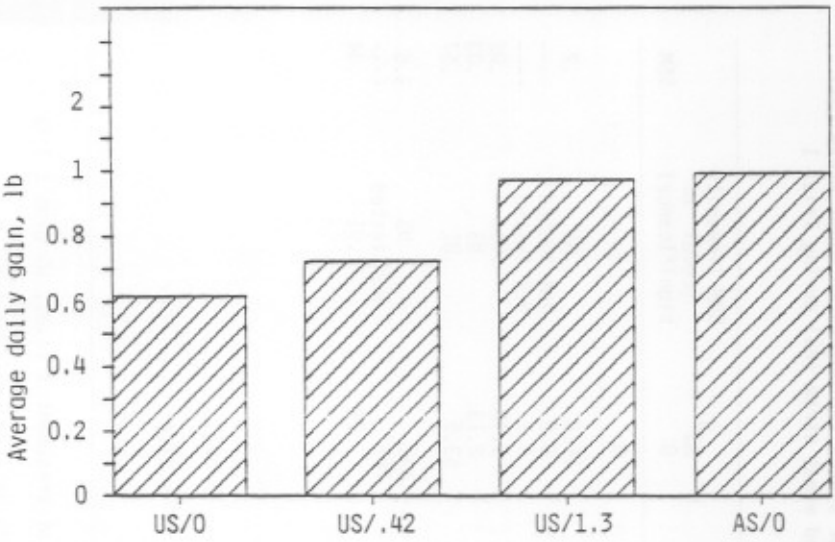


Figure 1. Average daily gains of steers, Trial 1.

TABLE 2. Chemical composition and nutritive content of feedstuffs, Trial 2.

Item	DM basis (%)[a]						
	DM	OM	CP	NDF	ADF	HEM	IVDMD
Untreated straw	87.1	95.7	3.5	81.6	49.0	32.6	44.4
Ammoniated straw	84.7	94.4	5.9	81.7	45.6	36.1	52.6
Corn gluten meal	91.0	97.2	63.9	----	----	----	----
Corn, dry rolled	89.8	98.6	8.8	----	----	----	----
Vitamin/Mineral supplement[b]	92.0	79.6	7.5	----	----	----	----

[a]DM = dry matter; OM = organic matter; CP = crude protein; NDF = neutral detergent fiber; ADF = acid detergent fiber; HEM = hemicellulose; IVDMD = in vitro dry matter digestibility.
[b]Source of Ca, P, S, Mg, K, Vit A, D and E, with 78% corn as the carrier feed.

Table 3. Feed intakes and gains of steers, Trial 2.

	Type of wheat straw							Sources variation			
	Ammoniated						Untreated	AS vs			
Corn, lb/h/day:	0	3	6	0	3	6	3	US	CGM	Corn	SEM
CGM, lb/h/day:	0	0	0	1	1	1	1				
Number of animals	8	8	8	8	8	8	8	Probability level			
Daily feed (as fed[a])											
Total intake[b]											
lb	13.4	15.2	17.6	14.3	16.6	18.6	14.8	.01	.01	.01	.29
% BW (DM basis)	1.70	1.90	2.16	1.75	1.96	2.20	1.87				
Straw, lb	11.7	10.5	9.9	11.6	10.9	9.9	9.2	.01	NS	.01	.34
Straw/total, %	88	70	57	88	70	57	67				
Crude protein intake, lb	.70	.88	1.08	1.27	1.48	1.66	.21	.01	.01	.01	.02
Body weight, lb											
Initial	697	693	699	697	703	700	703	NS	NS	NS	4.23
Final	656	697	723	713	768	784	713	.01	.01	.01	7.33
Avg daily gain, lb	-.52	.05	.27	.19	.83	1.07	.13	.01	.01	.01	.09
Calculated nutrient content (DM basis) of diets											
NE_{maint}, Mcal/cwt	50.5	61.1	68.6	54.1	63.1	70.3	65.0				
NE_{gain}, Mcal/cwt	13.7	24.7	32.5	17.6	27.0	34.5	29.1				
Crude protein, %	6.1	6.6	7.0	10.2	10.1	10.1	9.1				

[a] 89% dry matter.
[b] Includes 1.7 lb/head/day of a mineral-vitamin supplement with 78.0% corn as the carrier.

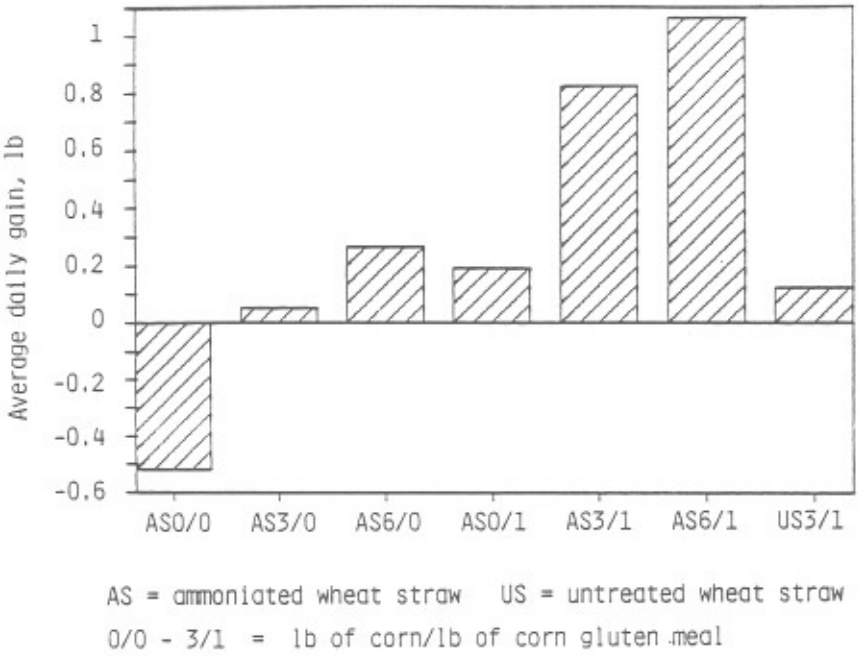


Figure 2. Average daily gains of steers, Trial 2.

Discussion

In both trials, diets based on ammoniated wheat straw supported weight gains of large frame steer calves of about 1 lb/day. Ammoniated wheat straw represented about 55 percent of total DM of the diets. Diets 3 and 4 of trial 1 and diet 6 of trial 2 contained additional energy as corn to reach NE_{Maint} and NE_{Gain} contents of about 69 and 33 Mcal/cwt DM, respectively, and crude protein contents of 9.6 to 10.1 percent of DM. Daily gains of 1 lb/day would be considered marginal in most stocker operations. However, this rate of gain would be acceptable in emergency feeding situations for stocker cattle. Also, feeding programs based on ammoniated wheat straw might be used (1) to add short-term stability to forage programs and (2) to add flexibility in timing the purchase or sale of cattle and thereby aid short-term profit to stocker and/or backgrounding operations.

RUMINAL FILL OF STEERS FED UNTREATED AND AMMONIATED WHEAT STRAW

J. Zorrilla-Rios[1], G.W. Horn[2], M.A. Andersen[3] and G.J. Vogel[3]

Story in Brief

Rumino-reticular contents of mature Hereford steers that were fed untreated or ammoniated wheat straw were evacuated to measure the effect of ammoniation on rumen liquid and particulate volumes and the amounts of free and imbibed liquid. Voluntary intake of straw increased by 30% with ammoniation. Total fluid mass in the rumen was similar with the two straws, but dry matter of rumen contents of steers fed ammoniated straw tended to be lower. Free fluid (% of total fluid) was decreased whereas the amount of fluid imbibed in particulate matter tended to increase in rumen contents of steers fed ammoniated straw. The greater amount of imbibed fluid in particulate matter of ammoniated straw may aid in penetration of the straw by bacteria or microbial enzymes thereby increase rate of digestion and straw intake.

(Key Words: Ruminal Volume, Ammoniated Wheat Straw.)

Introduction

Treatment of low-quality roughage with ammonia typically (1) increases digestibility of dry matter (DM) by 20 to 40%, (2) doubles the crude protein content and (3) increases the voluntary consumption by ruminant livestock by 20 to 35%. Increased consumption can account for a large proportion of the increased performance of ruminants fed ammoniated roughages. Zorrilla-Rios et al. (1985) studied the mechanism by which ammoniation increases intake of wheat straw by cattle and found that ammoniation of wheat straw (1) increases the fragility of straw, (2) increases the extent of in situ disappearance of DM at 6 and 12 hours of incubation and (3) increases both flow rate (L/h) of rumen liquids and dilution rate (%/h) of rumen particulate matter. The objective of this study was to measure the effect of ammoniation of straw on rumen liquid and particulate volumes and determine the relative amounts of free and imbibed liquid.

Materials and Methods

Six mature Hereford steers (1300 to 1495 lb) fitted with large rumen cannulae were housed in individual pens and fed twice daily either untreated (US) or ammoniated (AS) wheat straw in amounts of about 110% of voluntary intake. Wheat straw was ammoniated by the "stack method" as described by Sundstol et al. (1978) with 3.5% ammonia (DM basis) added. Both types of straw were coarsely chopped to lengths of about 2 inches prior to feeding. Steers of both diets were fed 2 lb of a 41% protein-mineral-vitamin A supplement daily. The cross-over

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experimental design used two consecutive 31-day periods that included 20 days for adaptation and 11 days for measurements. Voluntary straw intake was recorded daily, and rumino-reticular contents of each steer were removed 4 to 5 hours after one morning feeding. Whole rumen contents were separated into particulate and "free" liquid fractions by straining total digesta through a wire mesh screen with openings of 3 x 3 mm square. The total particulate fraction was then mixed and DM content of the particulate and "free" liquid fractions was determined by drying to constant weights in forced-air ovens at 65 C. The loss of weight of the particulate fraction during drying was designated as "imbibed" fluid whereas "total fluid" was calculated as free (corrected for suspended DM) plus imbibed fluid. Similarly, total DM was calculated as particulate DM plus DM suspended in the "free" liquid fraction.

Results and Discussion

Ammoniation of wheat straw increased the crude protein content from 3.16 to 9.19% of DM, and increased in vitro dry matter digestibility (IVDMD) from 46.0 to 55.5%. Voluntary intake of straw was increased 30% by ammoniation (Table 1). Steers fed AS had greater amounts (lb) of total solids in rumen contents. Total solids in the rumen, expressed as a percentage of daily straw DM intake, tended to be less with ammoniation though disappearance (passage plus digestion) tended to be lower (5.5 vs 6.0%/h) for ammoniated straw. The total amount of fluid in rumen contents of steers fed the 2 types of straw was similar. Free fluid (expressed as a percentage of total fluid) was decreased and the amount of fluid imbibed in particulate matter tended to be increased in rumen contents of steers fed AS. Physical distention of the rumen may be greater as the relative amount of free and imbibed fluid increases. However, feed intake was not affected by loading the rumen with water in studies of Campling et al. (1961) and Gharib et al. (1970), but water can be absorbed through the rumen wall whereas

Table 1. Least square means of voluntary straw intake and measurements of rumen contents.

Item	Type of straw		SE
	Untreated	Ammoniated	
Straw intake, lb DM.hd.$^{-1}$.d^{-1}	16.1	20.7	.48
Rumen content			
Total solids, lb DM	23.1	27.3	1.28
Total solids:daily straw intake, %	144.3	131.7	8.0
Total fluid, lb	172.5	173.6	4.84
Dry matter, %	11.7	13.5	.55
Free fluid, lb	58.5	43.6	5.94
Free fluid:total fluid, %	33.9	24.4	3.3
Imbibed fluid, lb	115.3	131.1	7.26

ruminal fluid containing salts is less readily absorbed. The greater amount of imbibed fluid in particulate matter of AS may aid inoculation or penetration of the straw by bacteria and thereby increase rate of digestion and straw intake.

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THE EFFECTS OF IVERMECTIN, FENBENDAZOLE OR LEVAMISOLE PHOSPHATE ON PERFORMANCE AND HEALTH OF NEWLY ARRIVED STOCKER CATTLE

D.R. Gill[1], R.A. Smith[2], R.B. Hicks[3], F.T. McCollum[4] and R.L. Ball[5]

Story in Brief

One hundred seventy-six newly received steer and bull calves and yearlings averaging 506 pounds were divided into four treatments as follows: 1) control (not dewormed), 2) ivermectin, 3) fenbendazole, and 4) levamisole phosphate. Daily gain of cattle dewormed with fenbendazole was increased by 68.9% compared to controls during the first 28 days of a 110 day trial (1.79 vs 1.06 lb/hd/day). Deworming with ivermectin increased gains by 22.6% over controls during the same 28 day period. Daily gains were increased by 15.7%, 11.0% and 5.5% above controls with ivermectin, fenbendazole and levamisole phosphate respectively over the entire 110 day trial.

(Key Words: Fenbendazole, Ivermectin, Levamisole Phosphate, Newly Received Cattle, Anthelmintics)

Introduction

The effects of anthelmintics on the performance of newly received stocker cattle have been variable (Davis and Caley, 1979). An anthelmintic is of no benefit if the cattle have minimal parasite burden or if resistance is present. The most pathogenic and economically important internal parasite of cattle is considered to be the abomasal nematode, Ostertagia ostertagi. Traditional anthelmintics have shown limited effectiveness against pre-type II and type II ostertagiasis (Williams et al., 1984).

Ivermectin has shown over 99% efficacy against inhibited larvae of Ostertagia ostertagi (Williams et al. 1981) and against all types of gastro-intestinal nematodes (Benz, 1983). It has been reported to improve weight gains of feeder calves by 11 to 21% (Holste, 1983; Ciordia et al., 1984). The objective of this research was to study the effect of three different anthelmintics on the performance and health of newly arrived stocker cattle.

Materials and Methods

Two truck loads of cattle were purchased by an order buyer from auction barns in south central Oklahoma and shipped to Pawhuska, Oklahoma on March 20 (98 head) and March 27,1985 (78 head). Newly received cattle were weighed individually off the truck, ear tagged, and treated with Lysoff®[a]. Following weighing and tagging, cattle were placed in pens of 20 to 25 animals each and randomly assigned by pen to one of the

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following treatments: control, ivermectin[b] (injected at 91 µg/lb), fenbendazole[c] (2.3 mg/lb), or injectable levamisole phosphate[d] (2 ml/100 lb). Water and native bluestem grass hay were provided free choice until the following morning when the cattle were processed as follows:

1. Body temperature and time were recorded.
2. Cattle were vaccinated with IBR-PI$_3$ (MLV) IM, Leptospira pomona bacterin and Clostridia chauvoei, septicum, novyi, and sordellii bacterin.
3. Cattle being dewormed were treated with their respective anthelmintic.
4. Cattle with odd-numbered ear tags were treated with a microbial culture as part of another study superimposed on this experiment.
5. Cattle were started on antibiotic treatment if clinical signs of illness were detected or if body temperature exceeded 104°F.
6. Sick cattle were placed in a hospital pen and a hospital card was initiated for each calf.

As soon as cattle were placed in their pens, ad libitum access to bluestem grass hay was allowed and a pelleted feed supplement (Table 1) was offered at a rate of 2 lb/hd/day for the first 21 days and 1 lb/hd/day from days 22-28.

After processing, cattle were checked twice daily for signs of illness and treated as necessary as described elsewhere in this publication (Hicks et al., 1986c). On day 28 of the trial cattle were held overnight without feed or water, weighed the following morning and, when necessary, cattle were castrated and horns were tipped. The cattle were then placed on native grass pasture. All cattle were weighed off trial on July 12, 1985. Thus, the first load was on trial 107 days and the second load was on trial 113 days. However, for pooled analysis of the data the length of trial was considered to be the same for both loads.

Table 1. Composition of feed supplement.

Ingredient	IFN[a]	% As Fed
Soybean Meal	5-20-637	88.9
Salt	6-04-152	3.0
Vitamin A - 30,000 IU/Gram		.22
Premix[b]		.18
Cottonseed Meal	5-01-621	5.0
Dicalcium Phosphate	6-01-080	2.75

[a]International Feed Number.
[b]To provide 50 mg decoquinate/lb.

[b]Ivomec®, MSD Agvet, Rahway, NJ 07065.
[c]Panacur®, Hoechst-Roussel Agri-Vet Company, Somerville, NJ 08876.
[d]Tramisol®, Cyanamid Agricultural De Puerto Rico, Inc., Manati, Puerto Rico 00701.

Results and Discussion

Effects of anthelmintics on daily weight gain, sick days and morbidity are shown in Table 2. Daily gain was significantly greater ($P<.01$) for those cattle dewormed with fenbendazole as compared to the other treatment groups during the first 28 days of the trial. However, during the time cattle were on pasture those head dewormed with fenbendazole tended to gain less than the other treatment groups while those cattle treated with ivermectin tended to gain at the fastest rate. Over the entire period, daily gains were 1.47, 1.41, 1.34 and 1.27 lb/head for ivermectin, fenbendazole, levamisole phosphate and control treatments, respectively. No significant difference was observed in the incidence of sickness which was quite low in this experiment.

In conclusion, deworming with ivermectin or fenbendazole increased weight gains by approximately 22.0 and 15.4 pounds, respectively, over the entire period. At a value of $60 per hundred, the added gain for those steers treated with ivermectin would be worth $13.20 per head and $9.24 per head for those treated with fenbendazole. The cost of the ivermectin and fenbendazole is approximately 50 cents per hundred ($2.50 for 500 lb steer) and 25 cents per hundred ($1.25 for 500 lb steer), respectively. Thus, deworming with ivermectin would result in a net increase in value of $10.70 per head and deworming with fenbendazole would result in a net increase in value of $7.99 per head.

Table 2. Effect of anthelmintics on daily gains, sick days and morbidity.

	Control	Ivermectin	Fenbendazole	Levamisole
Number of head	43	44	45	44
Arrival weight, lb	505	505	517	494
Daily gain, lb				
Days 1-28	1.06[a]	1.30[a]	1.79[b]	1.05[a]
Days 29 on	1.35[c]	1.55[d]	1.30[c]	1.41[cd]
Entire period[f]	1.27[c]	1.47[d]	1.41[cd]	1.34[cd]
Sick days[g]	.28	.54	.18	.50
Morbidity, %[g]	4.2	12.9	3.6	9.3

[a,b]Means with different superscripts differ ($P<.01$).
[c,d]Means with different superscripts differ ($P<.10$).
[f]107 days for load #1 and 113 days for load #2.
[g]During first 28 days.

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THE EFFECT OF IVERMECTIN ON HEALTH AND PERFORMANCE OF NEWLY ARRIVED STOCKER CATTLE

R.B. Hicks[1], D.R. Gill[2], R.A. Smith[3] and R.L. Ball[4]

Story in Brief

Eight hundred fifty-five newly received steer and bull calves and yearlings were used in two different experiments to determine the effect of ivermectin on performance and health. In experiment 1, 391 head averaging 462 pounds were divided into two groups. One hundred ninety-three received routine processing on arrival and 198 received routine processing plus ivermectin. Deworming with ivermectin increased daily gains by 28.2% (1.50 vs 1.17 lb/hd). The number of sick days per head decreased slightly with ivermectin (3.5 vs 3.8 days/hd).

In experiment 2, 463 head averaging 480 pounds were divided in two groups. Two hundred twenty-three received routine processing on arrival and 240 received routine processing plus ivermectin. Ivermectin treatment increased daily gains by 31.3% (1.76 vs 1.34 lb/hd). Ivermectin also tended to reduce the number of sick days per head (4.3 vs 5.0 days/hd) and reduce morbidity (48.6 vs 51.3%).

(Key Words: Ivermectin, Newly Received Cattle, Anthelmintics)

Introduction

The effects of anthelmintics on the performance of newly received stocker cattle has been variable (Davis and Caley, 1979). An anthelmintic is of no benefit if the cattle have minimal parasite burden or if resistance is present. The most pathogenic and economically important internal parasite of cattle is considered to be the abomasal nematode, Ostertagia ostertagi. Traditional anthelmintics have shown limited effectiveness against pre-type II and type II ostertagiasis (Williams et al., 1984).

Ivermectin has shown over 99% efficacy against inhibited larvae of Ostertagia ostertagi (Williams et al., 1981) and against all types of gastro-intestinal nematodes (Benz, 1983). It has been reported to improve weight gains of feeder calves by 11 to 21% (Holste, 1983; Ciordia et al., 1984). The objective of this research was to study the effect of ivermectin on the health and performance of newly arrived stocker cattle.

Materials and Methods

In both experiments 1 and 2, this deworming study with ivermectin was superimposed across other research projects. In these experiments, all cattle with odd-numbered ear tags were dewormed with ivermectin[a] (200 µg/kg) and those with even-numbered ear tags served as controls.

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[a]Ivomec®, MSD Agvet, Rahway, NJ 07065.

The experimental animals and procedures followed in these experiments are described elsewhere in this publication (Hicks et al., 1986a, 1986b).

Results and Discussion

Effects of ivermectin on weight gains, sick days, morbidity, and mortality are shown in Table 1. In both experiments average daily gains were significantly increased by treatment with ivermectin. In experiment one gains were increased by 28.2% with ivermectin (1.50 vs 1.17 lb/hd) and in experiment two gains were increased by 31.3% (1.76 vs 1.34 lb/hd). The average number of sick pen days per head tended to decrease in cattle which received ivermectin. Morbidity was high in both groups, but ivermectin tended to reduce it slightly. Ivermectin had no effect on death loss in either experiment.

Table 1. Effect of ivermectin on daily gains, sick days, morbidity and mortality in stressed cattle.

	Experiment 1		Experiment 2	
	Controls	Ivermectin	Controls	Ivermectin
Number of head	193	198	223	240
Number of head never sick	89	92	113	131
Arrival weight, lb	455	466	480	480
Daily gain, lb	1.17[a]	1.50[b]	1.34[a]	1.76[b]
Daily gain of head never sick, lb*	1.56[e]	1.80[f]	1.85[c]	2.42[d]
Sick days*	3.8	3.5	5.0	4.3
Morbidity, %*	53.9	53.5	51.3	48.6
Total Mortality, %	2.6	3.5	5.8	5.0
Mortality excluding treatment schedule A cattle, %	2.6	3.5	1.3	0.8

*Expressed as least square means.
a,b Means within an experiment with different superscripts differ ($P<.001$).
c,d Means within an experiment with different superscripts differ ($P<.05$).
e,f Means within an experiment with different superscripts differ ($P<.10$).

Average daily gains by the sick cattle were also significantly increased by ivermectin in both experiments (Table 2). In experiment one gains were increased by 51.9% (1.23 vs .81 lb/hd) and in experiment two gains increased by 60.6% (1.06 vs .66 lb/hd). The number of sick days per head was not effected by ivermectin. Number of repulls or returns was significantly decreased by ivermectin in experiment two (11.2% vs 24.4%) but not in experiment one.

Table 2. Effect of ivermectin on daily gains, sick days and repulls in sick cattle.

	Experiment 1		Experiment 2	
	Controls	Ivermectin	Controls	Ivermectin
Number of head*	104	106	113	108
Daily gain, lb*	.81[a]	1.23[b]	.66[a]	1.06[b]
Sick days*	7.1	6.9	9.6[d]	9.1
Repulls, %*	23.6	23.5	24.4[d]	11.2[c]

*Expressed as least square means.
[a,b]Means within an experiment with different superscripts differ (P<.001).
[c,d]Means within an experiment with different superscripts differ (P<.05).

The average daily gains for cattle in each truck load are listed in Table 3. In three of the loads, cattle treated with ivermectin gained faster (P<.05) than the control cattle. Load 5 of the interferon experiment is the only load in which control cattle gained more than cattle treated with ivermectin. With some loads, cattle may have been dewormed prior to arrival at the station which could explain why certain loads (MM #1, INF #3 and INF #5) showed no favorable response to ivermectin.

Under the conditions of this study, weight gains of newly arrived cattle were significantly increased by treatment with ivermectin over a 28 day receiving period. Thus, this practice should be economically beneficial for producers if increased gains are retained and cost of treatment remains low.

Table 3. Rate of gain by truck load.

Load[a]	Origin	Arrival Date	Daily Gain, lb[b]	
			Controls	Ivermectin
MM #1	TN	8-12-84	1.45	1.54
INF #1	TN	8-18-84	1.47[c]	2.00[d]
MM #2	AL	9-28-84	1.06[c]	1.83[d]
INF #2	AL	10-11-84	.22[c]	1.74[d]
MM #3	AL	11-03-84	1.54	1.89
INF #3	KY	11-14-84	2.22	2.29
MM #4	TX	12-06-84	.53	.81
INF #4	TX	12-20-84	.92	1.21
INF #5	OK & TX	2-15-85	1.91	1.80

[a]MM= Mass medication experiment, INF= Interferon and RSV vaccine experiment.
[b]Daily gain expressed as least square means.
[c,d]Means with different superscript differ (P<.05).

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THE EFFECT OF VITAMIN E SUPPLEMENTATION ON HEALTH AND PERFORMANCE OF NEWLY ARRIVED STOCKER CATTLE

D.R. Gill[1], R.A. Smith[2], R.B. Hicks[3] and R.L. Ball[4]

Story in Brief

Five hundred two newly received steer and bull calves and yearlings averaging 532 pounds were used in a study to determine the effect of vitamin E supplementation on health and performance over a 28 day receiving period. All cattle had ad libitum access to prairie hay and were fed 2 lb/day of a soybean meal-based pellet for the first 21 days and 1 lb/day during days 22-28 with 252 of the cattle receiving vitamin E in their supplement (800 IU/lb supplement). Cattle fed vitamin E gained 1.17 lb/day compared to .95 lb/day for control cattle. Feed intake was not affected by vitamin E supplementation but cattle fed vitamin E had 28.6% higher gain to feed ratios than control cattle (.063 vs .049 lb gain/lb feed). The number of sick pen days per head was reduced by 15.6% (2.7 vs 3.2 days/head) and morbidity was reduced by 13.4% (37.5 vs 43.3%) with vitamin E supplementation. These data suggest that vitamin E supplementation improved the performance of newly received, stressed cattle.

(Key Words: Vitamin E, Newly Received Cattle, Stressed Cattle)

Introduction

Supplementing vitamin E in pharmacological doses in well balanced diets has been shown to increase humoral antibody production against a variety of particulate and soluble antigens in chickens, mice, turkeys, guinea pigs, and rabbits (Tengerdy, 1980). Studies also have shown that high levels of vitamin E may enhance the immune system of swine, sheep, and horses.

Little research has been conducted on the effects of vitamin E on the health, immune response or performance of beef cattle. Early research showed vitamin E supplementation or injection had no effect on weight gains of feedlot calves (Perry et al., 1968; Totusek et al., 1968). In contrast to these studies Lee et al. (1985) reported that vitamin E supplementation (400 IU/head/day) of the receiving diet of stressed calves improved daily gains ($P<.08$) and feed efficiency ($P<.02$) by 5% and reduced morbidity and mortality by 8% and 50%, respectively.

The vitamin E requirement of young calves is thought to be between 15 and 60 IU/kg of dry diet (NRC, 1984). Normal diets are thought to supply adequate amounts of vitamin E for adult cattle. However, the nutrient needs of stressed cattle may be greater due to reduced feed and water intake and health problems. Therefore, the objective of this research was to study the effect of dietary vitamin E supplementation (800 IU/lb feed) on the health and performance of newly arrived stocker cattle.

[1]Regents Professor [2]Associate Professor, Veterinary Medicine and Surgery [3]Graduate Assistant [4]Herdsman II

Materials and Methods

Six truck loads (trials) of cattle were purchased by order buyers from auction markets in Georgia, Kansas, Mississippi, Oklahoma, and Texas and shipped to Pawhuska, Oklahoma. The arrival date and weight, origin, number of head, and in-transit shrink for each load is summarized in Table 1. The procedures followed for this experiment are described elsewhere in this publication (Hicks et al., 1986).

Table 1. Origin, arrival date, number of head, arrival weight and in-transit shrink for each load of cattle.

Trial	Origin	Arrival Date	Number of Head	Arrival Wt., lb	% Shrink
1	GA	11-12-84	79	548	7.6
2	GA	11-18-84	77	539	9.0
3	MS	2-06-85	91	491	9.7
4	TX & OK	2-12-85	92	519	3.4
5	KS	3-10-85	88	550	4.8
6	KS	3-18-85	76	552	5.1

Results and Discussion

Effects of vitamin E supplementation on weight gains, sick days, morbidity, and mortality are presented in Table 2. Gains in the 28 day receiving period were significantly increased ($P<.01$) by vitamin E supplementation (1.17 vs .95 lb/head/day). Daily gains of those cattle that were never sick were 1.34 and 1.47 lb/head/day for control cattle and cattle fed vitamin E, respectively. The number of sick pen days per head tended to be lower for the cattle fed supplemental vitamin E than for the control cattle (2.7 vs 3.2 days). Morbidity was also lower in these cattle (37.5 vs 43.3%). Death loss was 1.6% in the control cattle and 1.2% in the vitamin E cattle.

Table 2. Effect of vitamin E supplementation on daily gains, sick days, morbidity and mortality in stressed cattle.

	Controls	Vitamin E
Number of head	252	250
Number of head never sick	146	158
Arrival weight, lb	528	537
Average daily gain, lb*	.95[a]	1.17[b]
Daily gain of head never sick, lb*	1.34[a]	1.47[b]
Sick days*	3.2	2.7
Morbidity, %*	43.3	37.5
Mortality, %	1.8	1.6

*Expressed as LSMEANS.
[a,b]Means with different superscripts differ ($P<.01$).

Table 3. Effect of vitamin E supplementation on daily gains, sick days, repulls and response to first treatment in sick cattle.

	Controls	Vitamin E
Number of head	106	92
Average daily gain, lb*	.57	.70
Sick days*	7.0	6.6
Repulls, %*	13.3	17.8
Response to first treatment, %	58.8	61.5

*Expressed as least square means.

Effects of vitamin E supplementation on the health and performance of the sick cattle are reported in Table 3. Those sick cattle fed vitamin E gained .70 lb/day compared to .57 lb/day for sick control cattle. The number of treatment days per head tended to be lower in the vitamin E group (6.6 vs 7.0 days). However, the number of repulls was greater for the vitamin E cattle than for the control cattle (17.8 vs 13.3%). The response to first drug treatment was similar for both treatments (61.5% and 58.8% for vitamin E and controls, respectively).

Feed intakes and gain to feed ratios are reported in Table 4. Vitamin E supplementation did not affect feed intake (17.60 vs 17.58 lb/head/day for vitamin E and control, respectively). However, due to the 23.2% increase in daily gains, feed to gain ratio was increased from .049 to .063 lb gain/lb feed.

Effects of vitamin E supplementation on the health and the performance of cattle with those sick head pulled at time of processing excluded from the analysis are presented in Tables 5 and 6. Excluding these head from the analysis did not change the interpretation of results. With the data analyzed in this manner, cattle fed vitamin E gained 22.2% faster than control cattle ($P<.05$, 1.21 vs .99 kg/head/day). Vitamin E supplementation reduced morbidity by 11.7% (30.9 vs 35.0%) and sick days by 12.5% (2.1 vs 2.4 days/head). In the sick cattle, vitamin E supplementation tended to increase gains and reduce sick days.

Under the conditions of this study, vitamin E supplementation (800 IU/lb supplement or 1600 IU/head/day) significantly increased weight gains and tended to reduce sickness in newly received, stressed stocker cattle. These results are consistent with those reported by Lee et al. (1985). These studies suggest that the vitamin E requirement of stressed cattle is higher than the 33 to 132 IU/lb of dry diet that is suggested by NRC (1984) for young calves. More studies need to be conducted in stressed cattle with different levels of the vitamin to determine its requirement for such cattle.

Table 4. Effect of vitamin E supplementation on feed intake and gain to feed ratio.

	Controls	Vitamin E
Number of pens	6	6
Feed intake, lb*	17.60	17.58
lb gain/lb feed*	.049	.063

*Expressed as least square means.

Table 5. Effect of vitamin E supplementation on daily gains, sick days, morbidity and mortality in stressed cattle with sick head pulled at processing excluded.

	Controls	Vitamin E
Number of head	216	222
Arrival weight, lb	528	539
Average daily gain, lb*	.99[a]	1.21[b]
Sick days*	2.4	2.1
Morbidity, %*	35.0	30.9
Mortality, %	.93	.45

*Expressed as least square means.
[a,b]Means with different superscripts differ (P<.05).

Table 6. Effect of vitamin E supplementation on daily gains, sick days, repulls and response to first treatment in sick cattle with head pulled at processing excluded.

	Controls	Vitamin E
Number of head	68	63
Average daily gain, lb*	.44	.66
Sick days*	6.6	6.2
Repulls, %	8.2	9.5
Response to first treatment, %*	62.9	64.1

*Expressed as least square means.

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THE EFFECT OF LIVE PASTEURELLA HEMOLYTICA VACCINE ON HEALTH AND PERFORMANCE OF NEWLY ARRIVED STOCKER CATTLE

R.A. Smith[1], R.B Hicks[3], D.R. Gill[3], and R.L. Ball[4]

Story in Brief

Five hundred four newly received steer and bull calves and yearlings averaging 530 pounds were divided into two groups. Two hundred fifty-six head received routine processing upon arrival and 248 head received routine processing plus live Pasteurella hemolytica vaccine. Vaccination with live Pasteurella hemolytica vaccine decreased the incidence of sickness by 18% (33.1% for vaccinated cattle vs 40.4% for controls). Sick days also were lower in the vaccinated group (2.2 vs 2.7 days/head) and death loss was decreased by vaccination from 1.2% to 0%. Daily gains were not affected by vaccination in this study.

(Key Words: Pasteurella hemolytica, Bovine Respiratory Disease, Newly Received Cattle)

Introduction

Pasteurella hemolytica has been known to be associated with the shipping fever-bovine respiratory disease (BRD) complex since the 1950's. More recently it was isolated from the pneumonic lungs of feedlot cattle (Martin et al., 1980). It is the most commonly isolated bacterial pathogen from the acutely affected bovine lung (Frank and Smith, 1983).

Over the past 50 years much research as been conducted with Pasteurella bacterins in an effort to control BRD. Wilkie (1980) reviewed studies on the biological control of BRD and concluded that Pasteurella bacterins have no obvious use in control of the disease. Field trials have shown that the bacterins increase morbidity and mortality and decrease weight gains in feedlot cattle (Martin et al., 1980). Recent research with live Pasteurella hemolytica (PH) vaccine has shown more promising results (Purdy et al., 1983). Smith (1983) reported results of field trials in which PH vaccine was used in commercial cattle, preconditioned cattle, and feedlot cattle. It reduced morbidity by 89%, 77%, and 44%, respectively.

The objective of this research was to study the effect of PH vaccine on the health and performance of newly arrived stocker and feeder cattle.

Materials and Methods

Six truck loads (trials) of cattle were purchased by order buyers from auction markets in Georgia, Kansas, Mississippi, Oklahoma, Tennessee, and Texas and shipped to Pawhuska, Oklahoma. The arrival

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[1]Associate Professor, Veterinary Medicine and Surgery [2]Graduate Assistant [3]Regents Professor [4]Herdsman II

Table 1. Origin, arrival date, number of head, arrival weight, and in-transit shrink for each load of cattle.

Trial	Origin	Arrival Date	Number of Head	Arrival Wt., lb	% Shrink
1	TN	9-30-84	80	550	5.8
2	GA	11-18-84	77	539	9.0
3	MS	2-06-85	91	491	9.7
4	TX & OK	2-12-85	92	519	3.4
5	KS	3-10-85	88	550	4.8
6	KS	3-18-85	76	552	5.1

date and weight, origin, number of head, and in-transit shrink for each load is summarized in Table 1. Newly received cattle were weighed individually off the truck, ear tagged, and treated with Lysoff®[a]. Following weighing and tagging, cattle were randomly divided into two groups and placed in separate pens. Water and native bluestem grass hay were provided free choice. The morning following arrival, the cattle were processed as follows:

1. Body temperature and time were recorded.
2. Cattle were vaccinated with IBR-PI$_3$ (MLV) IM, Leptospira pomona bacterin and Clostridia chauvoei, septicum, novyi, and sordellii bacterin.
3. Cattle with even-numbered ear tags were vaccinated intradermally with live Pasteurella hemolytica vaccine[b] (.5 ml/head) and those head with odd-numbered ear tags served as controls.
4. Dewormed with ivermectin[c] (200 µg/kg).
5. Cattle were started on antibiotic treatment if clinical signs of illness were detected or if body temperature exceeded 104°F.
6. For sick cattle, a hospital card was initiated and the calf was placed in a hospital pen.

As soon as cattle were placed in their pens, they had ad libitum access to bluestem grass hay and were offered a pelleted feed supplement (Table 2) at a rate of 2 lb/head/day for the first 21 days and 1 lb/head/day during days 22-28. In Trials 2 through 6, a vitamin E supplementation study was superimposed across this vaccine experiment. In each of these trials, one pen of cattle received a feed supplement containing vitamin E (800 IU/lb) and the other pen received supplement without addition of vitamin E (Table 2). Two hospital pens were maintained so that sick animals received their assigned feed while out of their home pen.

After processing, cattle were checked twice daily for signs of illness. If an animal was suspected to be sick, it was moved to the processing area where its body temperature was determined and a severity of illness score (slight, moderate, or severe) was assigned. If the body temperature exceeded 104°F the animal was considered sick. Animals could also be classified as sick based on clinical signs.

[a]Cutter Laboratories, Shawnee Mission, KS 66201.
[b]PRECON-PH®, AGRI-BIO Corp., Gainsville, GA 30501.
[c]Ivomec®, MSD Agvet, Rahway, NJ 07065.

Table 2. Composition of feed supplements.

Ingredient	IFN[a]	% As Fed Control	% As Fed Vitamin E
Soybean Meal	5-20-637	88.9	88.5
Cottonseed Meal	5-01-621	5.0	5.0
Salt	6-04-152	3.0	3.0
Vitamin E - 220,000 IU/kg[b]		0	.4
Vitamin A - 30,000 IU/Gram		.22	.22
Premix[c]		.18	.11
Dicalcium Phosphate	6-01-080	2.75	2.75

[a]International Feed Number.
[b]To provide 800 IU vitamin E/lb.
[c]To provide 75 mg lasalocid/lb.

Medical treatment for sick animals was determined by the ear tag number which was applied at random on arrival. Treatment schedules were (A) a sequence of antimicrobial drugs listed in Table 3 or (B) an experimental potentiated sulfa (RO5-0037[d]) substituted for Treatment 1 in Table 3. Cattle were initially treated with the first drug in the sequence. If body temperature dropped by 2°F or to less than 104°F, or clinical signs were improved within 24 hours, the drug was continued for two more days. If no improvement was apparent within 24 hours, the next drug in the sequence was applied and the procedure repeated until improvement was detected. Cattle treated by schedule B received RO5-0037 boluses orally (30 mg/lb on day one and 15 mg/lb/day thereafter).

At the end of the 28 day trial, the cattle were held overnight without feed or water, weighed the following morning and, when necessary, cattle were castrated and horns were tipped. Cattle were then returned to the owner.

Table 3. Sequence of drugs used for treatment of BRD.

Treatment No 1:	OXYTETRACYCLINE (Biomycin-C®) subcutaneously - 5 mg/lb. Plus SULFAMETHAZINE BOLUSES (15 gm) 1 bolus/150 lb on day 1. One bolus/300 lb on subsequent days.
Treatment No 2:[a]	ERYTHROMYCIN (Gallamycin®) deep in the muscles - 10 mg/lb.
Treatment No 3:[a]	SPECTINOMYCIN (Spectam®) - 5 mg/lb.
Treatment No 4:[a]	Procaine Penicillin G subcutaneously - 30,000 IU/lb.
Treatment No 5:[a]	TYLAN 200 - 10 mg/lb.

[a]Some of the antimicrobial drugs used in this study were used for extra-label purpose or at extra-label dosages and require a veterinarian-client-patient relationship before use.

[d]Primor®, Hoffman-LaRoche, Inc., Nutley, NJ 07110.

Results and Discussion

Effects of PH vaccine on weight gains, sick days, morbidity, and mortality are shown in Table 4. Average daily gains during the 28 day receiving period were not affected by the administration of PH vaccine. The number of sick days per head was reduced (P>.05) 18.5% in the vaccinated cattle (2.2 vs 2.7 days/head). Morbidity was reduced (P<.10) from 40.4% to 33.1% with PH vaccine (18.1% reduction) and death loss was lower (P<.10) in the PH vaccinated group.

Effects of PH vaccine on the health and performance of the sick cattle are shown in Table 5. Those sick cattle vaccinated with PH vaccine tended to gain slightly faster than those not vaccinated (.64 vs .55 lb/head/day). The number of sick days per head and and the number of repulls tended to be greater in the vaccinated cattle than the nonvaccinated cattle (6.4 vs 6.2 days/head and 16.9 vs 14.4%). Trial two was the only trial in which PH vaccine appeared to increase repulls. The response of sick cattle to first drug treatment was greater in the vaccinated cattle (65.1 vs 52.9%). None of these differences proved significant.

The data were also analyzed with those sick cattle pulled at time of processing excluded from the model (33 control head and 30 PH head) since it would take approximately 24 hours for the vaccine to have an affect on the cattle (Perino, 1985). Effects of PH vaccine on weight gains, sick days, morbidity, and mortality with these head excluded are presented in Table 6. The number of sick pen days per head was

Table 4. Effect of PH vaccine on daily gains, sick days, morbidity and mortality in stressed cattle.

	Controls	PH Vaccine
Number of head	256	248
Number of head never sick	152	165
Arrival weight, lb	530	528
Average daily gain, lb*	.92	.99
Daily gain of head never sick, lb*	1.21	1.23
Sick days*	2.7[b]	2.2[a]
Morbidity, %*	40.4[b]	33.1[a]
Mortality, %	1.2[b]	0.0[a]

*Expressed as least square means.
[a,b]Means with different superscripts differ (P<.10).

Table 5. Effect of PH vaccine on daily gains, sick days, repulls and response to first treatment in sick cattle.

	Controls	PH Vaccine
Number of head	104	83
Average daily gain, lb*	.55	.64
Sick days*	6.2	6.4
Repulls, %*	14.4	16.9
Response to first treatment, %	52.9	65.1

*Expressed as least square means.

Table 6. Effect of PH vaccine on daily gains, sick days, morbidity and mortality in stressed cattle with sick head pulled at processing excluded.

	Controls	PH Vaccine
Number of head	223	218
Arrival weight, lb	515	537
Average daily gain, lb*	.99	1.14
Sick days*	2.1[b]	1.5[a]
Morbidity, %*	32.5[d]	25.1[c]
Mortality, %	.45	0.0

*Expressed as least square means.
[a,b]Means with different superscripts differ (P<.05).
[c,d]Means with different superscripts differ (P<.10).

significantly reduced (P<.05) by 28.6% in the PH vaccinated cattle as compared to the nonvaccinated cattle (1.5 vs 2.1 days). This reduction is greater than was observed with all cattle in the model. Morbidity was 22.8% lower in the PH vaccinated cattle than in the nonvaccinated cattle (25.1 vs 32.5%).

Effects of PH vaccine on the health and performance of the sick cattle with those head pulled at processing excluded are reported in Table 7. The results were quite similar to those observed with all sick head left in the model. The number of repulls for both vaccinated and nonvaccinated cattle was much lower with the data analyzed this way (8.6% for controls and 9.4% for PH cattle). It would appear that most of the cattle requiring retreatment for sickness were originally pulled at processing.

Under the conditions of this study, health and performance of newly arrived cattle tended to be improved by treatment with live Pasteurella hemolytica vaccine. Vaccinated cattle experienced less sickness and required fewer treatments for BRD than nonvaccinated cattle. Smith (1983) in a trial with newly arrived feedlot calves noted greater benefits with PH vaccination (morbidity and treatment days reduced 44 and 40%, respectively) than were observed in this study. These data suggest that PH vaccine can improve the health of stressed cattle.

Table 7. Effect of PH vaccine on daily gains, sick days, repulls and response to first treatment in sick cattle with head pulled at processing excluded.

	Controls	PH Vaccine
Number of head	71	53
Average daily gain, lb*	.46	.55
Sick days*	5.9	5.9
Repulls, %*	8.6	9.4
Response to first treatment, %	52.6	68.3

*Expressed as least square means.

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THE EFFECT OF INTERFERON ON HEALTH AND PERFORMANCE OF NEWLY ARRIVED STOCKER CATTLE

R.B Hicks[1], D.R. Gill[2], R.A. Smith[3] and R.L. Ball[4]

Story in Brief

Three hundred thirty-two newly received steer and bull calves and yearlings averaging 491 pounds were divided into two groups. One hundred seventeen head received routine processing upon arrival and 215 head received routine processing plus intranasal administration of recombinant leukocyte hybrid A/D interferon. Administration of interferon reduced morbidity by 20.6% (39.7% for interferon cattle vs 50.0% for controls). Sick days were reduced by 33.3% with interferon treatment (3.2 vs 4.8 days/hd) and repulls were decreased by 39.5% (11.8 vs 19.5%). Cattle treated with interferon tended to gain faster (11.7%) than control cattle (1.72 vs 1.54 lb/head/day), consumed less feed and had 16.3% higher gain to feed ratios (.107 vs .092 lb gain/lb feed).

(Key Words: Interferon, Newly Received Cattle, Bovine Respiratory Disease)

Introduction

Interferon is a small protein produced or released by animal cells in response to invasion by viral or certain nonviral stimuli which indirectly protects other cells against viral damage by stimulating the production of new antiviral polypeptide or protein (Rosenquist, 1973). Interferon is believed to play an important role in the recovery of host animals from viral infections (Baron et al., 1966) which is independent of the body's specific immune mechanisms (Rosenquist and Loan, 1969).

Viruses of almost every major viral group have been shown to induce and be affected by interferon though some are more efficient stimulators of interferon production or are more sensitive to its actions than others (Rosenquist, 1973). Those viruses most commonly associated with the Bovine Respiratory Disease (BRD) complex that have been shown to induce interferon production are infectious bovine rhinotracheitis (IBR) and parainfluenza-3. Interferon has been shown to protect against heterologous respiratory tract viral infections (Cummins and Rosenquist, 1982). Cummins and Hutcheson (1983) reported that calves orally administered with interferon once daily on the day of and for two days subsequent to IBR virus inoculation gained faster than control calves and calves receiving interferon intravenously or intranasally.

The objective of this research was to study the effect of intranasal administration of recombinant leukocyte hybrid A/D interferon (INF) on the health and performance of newly arrived stocker cattle.

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Materials and Methods

Four truck loads (trials) of cattle were purchased by order buyers from auction markets in Alabama, Kentucky, Texas, and Oklahoma and shipped to Pawhuska, Oklahoma. The arrival date and weight, origin, number of head, and in-transit shrink for each load is summarized in Table 1. Newly received cattle were weighed individually as unloaded, ear tagged and treated with Lysoff®[a]. Following weighing and tagging cattle were placed in pens of 20 to 25 animals each depending on the number of cattle received. Cattle were randomly assigned by pen to one of the following two treatments: controls (received no interferon) or intranasal administration of recombinant leukocyte hybrid A/D interferon at one million units per kg of body weight. Water and native bluestem grass hay were provided free choice. The morning following arrival, the cattle were processed as follows:

1. Body temperature and time were recorded.
2. Cattle were vaccinated with IBR-PI_3 (MLV) IM, Leptospira pomona bacterin and Clostridia chauvoei, septicum, novyi, and sordellii bacterin.
3. Cattle in interferon treatment groups received intranasal administration of interferon.
4. Cattle with odd-numbered ear tags were dewormed with ivermectin[b] (200 µg/kg) and those cattle with even-numbered ear tags served as controls as part of a deworming trial superimposed on this study.
5. Cattle were started on antibiotic treatment if clinical signs of illness were detected or if body temperature exceeded 104°F except for one-third of the cattle which received no treatment if they became sick.
6. For sick cattle, a hospital card was initiated and the calf was placed in a hospital pen.

As soon as cattle were placed in their pens, they had ad libitum access to bluestem hay and were offered a pelleted feed supplement (Table 2) at a rate of 2 lb/head/day for the first 21 days and 1 lb/head/day during days 22-28.

Table 1. Origin, arrival date, number of head, arrival weight and in-transit shrink for each load of cattle.

Trial	Origin	Arrival Date	Number of Head[a]	Arrival Wt., lb	% Shrink
1	AL	10-12-84	98	477	6.9
2	KY	11-14-84	91	506	5.0
3	TX	12-20-84	93	475	6.9
4	OK & TX	2-15-85	87	497	7.4

[a]19 and 18 head from trials 1 and 2, respectively, used in other experiments (not interferon).

[a]Cutter Laboratories, Shawnee Mission, KS 66201.
[b]Ivomec®, MSD Agvet, Rahway, NJ 07065.

Table 2. Composition of feed supplement.

Ingredient	IFN[a]	% As Fed
Soybean Meal	5-20-637	88.9
Salt	6-04-152	3.0
Vitamin A - 30,000 IU/Gram		.22
Premix[b]		.18
Cottonseed Meal	5-01-621	5.0
Dicalcium Phosphate	6-01-080	2.75

[a]International Feed Number.
[b]To provide: 0 for control, 75 mg lasalocid/lb.

After processing, cattle were checked twice daily for signs of illness. If an animal was suspected to be sick, it was moved to the processing area where its body temperature was determined and a severity of illness score (slight, moderate, or severe) was assigned. If the body temperature exceeded 104°F the animal was considered sick. Animals could also be classified as sick based on clinical signs.

Medical treatment for sick animals was determined by the ear tag number which was applied at random on arrival. Treatment schedules were (A) no treatment (negative controls), (B) a sequence of antimicrobial drugs listed in Table 3, or (C) an experimental potentiated sulfa (RO5-0037[c]) substituted for Treatment 1 in Table 3. Cattle treated by schedules B and C were initially treated with the first drug in the sequence. If body temperature dropped by 2°F or to less than 104°F, or clinical signs were improved within 24 hours, the drug was continued for two more days. If no improvement was apparent within 24 hours, the next drug in the sequence was applied and the procedure repeated until improvement was detected. Cattle treated by schedule C received

Table 3. Sequence of drugs used for treatment of BRD.

Treatment No 1:	OXYTETRACYCLINE (Biomycin-C®) subcutaneously - 5 mg/lb. Plus SULFAMETHAZINE BOLUSES (15 gm) 1 bolus/150 lb on day 1. One bolus/300 lb on subsequent days.
Treatment No 2:[a]	ERYTHROMYCIN (Gallamycin®) deep in the muscles - 10 mg/lb.
Treatment No 3:[a]	SPECTINOMYCIN (Spectam®) - 5 mg/lb.
Treatment No 4:[a]	Procaine Penicillin G subcutaneously - 30,000 IU/lb.
Treatment No 5:[a]	TYLAN 200 - 10 mg/lb.

[a]Some of the antimicrobial drugs used in this study were used for extra-label purpose or at extra-label dosages and require a veterinarian-client-patient relationship before use.

[c]Primor®, Hoffman-LaRoche, Inc., Nutley, NJ 07110.

R05-0037 boluses orally (30 mg/lb on day one and 15 mg/lb/day thereafter).

At the end of the 28 day trial, the cattle were held overnight without feed or water, weighed the following morning and, as necessary, cattle were castrated and horns were tipped. Cattle were then returned to the owner.

Results and Discussion

Effects of interferon on weight gains, sick days, morbidity, and mortality across all cattle are presented in Table 4. Average daily gains during the 28 day receiving period were 1.72 lb/day for cattle treated with INF and 1.54 lb/day for the control cattle. The average number of sick pen days per head was significantly decreased ($P<.01$) with INF treatment from 4.8 to 3.2 days. Morbidity was high in both groups, but was lower ($P<.05$) in the INF group (39.7 vs 50.0%). Death loss was decreased in the INF treated group (3.1 vs 4.6%; $P>.05$). The death loss percentage among cattle that were treated when they became ill by treatment schedule B or C was 1.6% in the control cattle and 0% in the cattle treated with INF.

Average daily gains of the cattle that were never sick were 2.20 and 1.98 lb/hd/day for control cattle and cattle treated with INF, respectively. Apparently the increased gains observed in all cattle treated with INF were due to reduced sickness. It appears that interferon does not increase weight gains of cattle that never become sick.

Effects of interferon on the health and performance of the sick cattle are reported in Table 5. Daily gains of the sick cattle were increased by 32.7% with INF administration (1.34 vs 1.01 lb/hd). The number of treatment days per sick head tended to be lower in the INF treated group (9.1 vs 9.7 days) and the number of repulls also tended to be lower in this group (11.8 vs 19.5%). Cattle treated with INF tended

Table 4. Effect of interferon on daily gains, sick days, morbidity and mortality in stressed cattle.

	Controls	Interferon
Number of head	117	215
Number of head never sick	59	126
Arrival weight, lb	491	488
Average daily gain, lb*	1.54	1.72
Daily gain of head never sick, lb*	2.20	1.98
Sick days*	4.8[b]	3.2[a]
Morbidity, %*	50.0[d]	39.7[c]
Total Mortality, %*	47.6	3.1
Mortality excluding treatment schedule A cattle, %*	1.6[f]	0[e]

*Expressed as least square means.
[a,b]Means with different superscripts differ ($P<.01$).
[c,d]Means with different superscripts differ ($P<.05$).
[e,f]Means with different superscripts differ ($P<.10$).

Table 5. Effect of interferon on daily gains, sick days, repulls and response to first treatment in sick cattle.

	Controls	Interferon
Number of head	58	89
Average daily gain, lb*	1.01	1.32
Sick days*	9.7	9.1
Repulls, %*	19.5	11.8
Response to first treatment, %*	43.5	49.3

*Expressed as least square means.

to responded more favorably to first drug treatment (49.3 vs 43.5%). None of these differences were significant.

Feed intakes and gain to feed ratios are presented in Table 6. Interferon treatment reduced feed intake ($P<.05$) from 17.45 to 16.21 lb per head per day. This 7.1% reduction in feed intake combined with the 11.7% increase in daily gains with INF treatment resulted in an improvement ($P<.05$) in gain to feed ratio of 16.3% (.107 vs .092 lb gain/lb feed).

Interferon should begin affecting the animal's non-immune defenses approximately 24 hours after administration (Fulton, 1985). Hence, the data also was analyzed with those cattle pulled as sick at processing excluded from the model (15 control head and 19 INF head) since INF could not have affected the initial sickness in these cattle. Effects of interferon on weight gains, sick days, morbidity, and mortality with these head excluded are summarized in Table 7. Average daily gains tended to be higher in the INF treated group (1.74 vs 1.63 lb/day). Cattle treated with INF had fewer sick days ($P<.01$, 2.5 vs 4.0 days/head) and lower morbidity (35.4 vs 43.8%). Mortality was higher in the cattle treated with INF (3.1 vs 2.4%).

Effects of interferon on the health and performance of sick cattle with those head pulled at processing excluded are presented in Table 8. Cattle treated with INF tended to have higher weight gains (1.36 vs 1.08 lb/head/day), fewer sick days (8.4 vs 9.3 days/hd), and fewer repulls (12.3 vs 21.9%) than control cattle. Response to first drug treatment was also higher in the INF treated group (56.4 vs 51.7%). None of these differences were significant.

Under the conditions of this study health and performance of newly arrived cattle tended to be improved by treatment with intranasal recombinant leukocyte hybrid A/D interferon. Interferon holds promise

Table 6. Effect of interferon on feed intake and gain to feed ratio.

	Controls	Interferon
Number of pens	6	11
Feed intake, lb*	17.45^{b}	16.21^{a}
lb gain/lb feed*	$.092^{a}$	$.107^{b}$

*Expressed as least square means.
a,bMeans with different superscripts differ, ($P<.05$).

Table 7. Effect of interferon on daily gains, sick days, morbidity and mortality in stressed cattle with sick head pulled at processing excluded.

	Controls	Interferon
Number of head	102	194
Arrival weight, lb	491	491
Average daily gain, lb*	1.63	1.74
Sick days*	4.0[b]	2.5[a]
Morbidity, %*	43.8	35.4
Total Mortality, %*	2.4	3.1
Mortality excluding treatment schedule A cattle, %*	1.0	0

*Expressed as least square means.
[a,b]Means with different superscripts differ (P<.01).

Table 8. Effect of interferon on daily gains, sick days, repulls and response to first treatment in sick cattle with head pulled at processing excluded.

	Controls	Interferon
Number of head	43	68
Average daily gain, lb*	1.08	1.36
Sick days*	9.3	8.4
Repulls, %*	21.9	12.3
Response to first treatment, %*	51.7	56.4

*Expressed as least square means.

as a means of reducing sickness and improving health in stressed stocker cattle. However, further studies need to be conducted with INF before definite conclusions concerning its effects and economics can be made.

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THE EFFECT OF A MICROBIAL CULTURE ON HEALTH AND PERFORMANCE OF NEWLY-ARRIVED STOCKER CATTLE

R.B. Hicks[1], D.R. Gill[2], R.A. Smith[3], and R.L. Ball[4]

Story in Brief

Newly-received heifer, steer and bull calves and yearlings (437) were used in four experiments to determine the effect of a microbial culture (Probios®) on performance and health. In each experiment, one group of cattle received routine processing while the other group received routine processing plus the microbial culture. The effects of the microbial culture were not consistent between experiments. These tests failed to detect statistically significant benefits for treating newly received, stressed stocker cattle with a microbial culture at the time of processing. However, there was a trend toward reduced morbidity and slight increases in gain in three of the four experiments.

(Key Words: Newly Received Cattle, Stressed Cattle, Probios®, Microbial Culture)

Introduction

Newly-received stocker calves undergo a variety of stresses such as fasting, transport, assembly, vaccination, castration and dehorning. Such stresses can alter the rumen microflora population (Williams and Mahoney, 1984) resulting in decreased performance and increased morbidity and death loss. Administration of microbial cultures (MC) to repopulate the gut may overcome these changes in the rumen microflora population. Probios® is a microbial culture containing three species of live Lactobacillus bacteria (Lactobacillus acidophilus, plantarum and casei) and one species of Streptococcus bacteria (Streptococcus faecium). Probios® gel administered at processing and fed in the receiving diet for 28 days has reduced morbidity by 28% (Hutcheson et al., 1980) and by 69% (Davis, 1982). Davis (1982) reported that morbidity was reduced by 50% with Probios® gel alone. This study was conducted to determine the effect of a microbial culture on the health and performance of newly arrived stocker and feeder cattle.

Materials and Methods

All cattle were purchased by order buyers from auction markets in Mississippi or Oklahoma City, and shipped by truck to the Pawhuska, Oklahoma Research Station. Animals from five different truckloads were used in trials starting February 16, 1985 (Exp. 1), March 20 and 27, 1985 (Exp. 2), September 12, 1985 (Exp. 3) and October 14, 1985 (Exp. 4). Newly-received cattle were weighed individually off the truck, ear tagged and treated with Lysoff®[a] in experiments 1, 2 and 3. After

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weighing and tagging, cattle were placed in pens of 20 to 25 animals each, depending on the number of cattle received. Water and native bluestem grass hay were available free choice. The morning following arrival, cattle were processed as follows:

1. Body temperature and time were recorded.
2. All cattle were vaccinated with IBR-PI_3 (MLV) IM, *Leptospira pomona* bacterin and *Clostridia chauvoei*, *septicum*, *novyi* and *sordellii* bacterin.
3. One-half the cattle were treated with Probios®[b] while the others were not treated.
4. Exp. 1: As part of a deworming study superimposed across this experiment, cattle with odd-numbered ear tags were dewormed with ivermectin while those cattle with even-numbered ear tags served as controls .
   Exp. 2: As part of a deworming study superimposed across this experiment, cattle were dewormed with ivermectin[c], fenbendazole[d], levamisole phosphate[e] or nothing.
   Exp. 3: All cattle were dewormed with fenbendazole.
   Exp. 4: All cattle were dewormed with ivermectin.
5. Calves received antibiotic treatment if clinical signs of illness were detected or if body temperature exceeded 104°F.
6. Sick calves were placed in a hospital pen and hospital cards were initiated.

Bluestem hay was available at all times and a supplement containing lasalocid or decoquinate (Table 1) was offered at a rate of 2 lb/hd/day for the first 21 days and 1 lb/hd/day during days 22-28.

After processing, cattle were checked twice daily for signs of illness. If an animal was suspected to be sick, it was taken to the processing area where its body temperature was determined and a severity of illness score (slight, moderate or severe) was assigned. If the body temperature exceeded 104°F, the animal was considered to be sick. The animal also could be classified as sick based on clinical signs alone.

Table 1. Composition of feed supplement.

Ingredient	Percent, as fed
Soybean meal	88.9
Salt	3.0
Vitamin A-30,000 IU/gm	.22
Premix[a]	.18
Cottonseed meal	5.0
Dicalcium phosphate	2.75

[a]To provide 50 mg decoquinate/lb in Exp. 1, 2 and 3 or 75 mg lasalocid/lb in Exp. 4.

[b]Pioneer Hi-Bred International, Inc., Johnston, IO 50131.
[c]Ivomec®, MSD Agvet, Rahway, NJ 07065.
[d]Panacur®, Hoechst-Roussel Agri-Vet Company, Somerville, NJ 08876.
[e]Tramisol®, Cyanamid Agricultural De Puerto Rico, Inc., Manati, Puerto Rico 00701.

Medical treatment for sick animals was determined by the ear tag number which was applied at random on arrival. In Exp. 1, 2 and 3, treatment schedules were a sequence of antimicrobial drugs (Schedule A; Table 2) or an experimental potentiated sulfa drug (RO5-0037[f]) substituted for treatment 1 in Table 2 (Schedule B). In Exp. 4, treatment schedules were Schedule A or A with treatments 1 and 3 switched (Schedule C). Initially cattle were treated with the first drug in the sequence. If body temperature dropped 2°F or to less than 104°F, or if clinical signs improved within 24 hours, the first drug was used for two additional days. If no improvement was apparent within 24 hours, the next drug in the sequence was applied and the procedure was repeated until improvement was detected. Cattle treated by schedule B received RO5-0037 boluses orally (30 mg/lb on the first day and 15 mg/lb/day thereafter).

At the end of the 28 day trial, cattle were held overnight without feed or water, weighed the following morning and, as necessary, cattle were castrated and horns were tipped. Cattle were then returned to the owner.

Table 2. Sequence of drugs used for treatment of BRD.

Treatment No. 1:	OXYTETRACYCLINE (Biomycin-C®) subcutaneously - 5 mg/lb. PLUS SULFAMETHAZINE BOLUSES (15 gm) 1 bolus/150 lb on day 1. One bolus/300 lb on subsequent days.
Treatment No 2:[1]	ERYTHROMYCIN (GALLAMYCIN®) deep in the muscles - 10 mg/lb.
Treatment No 3:[1]	SPECTINOMYCIN (Spectam®) 5mg/lb IM.
Treatment No 4:[1]	PROCAINE PENICILLIN G - Subcutaneously - 30,000 IU/lb.
Treatment No 5:[1]	TYLAN 200 - 10 mg/lb IM.

[1]Some of the antimicrobial drugs used in this study were used for extra-label purpose or at extra-label dosages and require a veterinarian-client-patient relationship before use.

Results and Discussion

Least square means for gain, morbidity and sick days are presented in Table 3. No statistical differences (P>.05) were observed in any of the experiments. The effects of MC on daily gains were inconsistent between experiments. In Exp. 1, cattle did not maintain weight gain throughout the 28 day period due to a shortage of hay near the end of the trial . However, cattle receiving MC gained 0.15 lb/day compared to 0.31 lb/day loss for control cattle. Weight gains were not affected by MC in Exp. 2, whereas, gains in Exp. 3 were 61.3% greater with MC (.75 vs 1.21 lb/hd/day). Gains were slightly lower with MC treatment in Exp.

[f]Primor®, Hoffman-LaRoche, Inc., Nutley, NJ 07110.

Table 3. Effect of microbial culture on performance and morbidity of stressed calves.

	Head No.	Daily Gain, lb	Morbidity %	Sick Days
Experiment 1				
Control	34	-0.31	50.5	2.6
MC	36	0.15	30.1	1.5
Experiment 2				
Control	88	1.27	9.9	0.5
MC	88	1.33	5.1	0.2
Experiment 3				
Control	46	.75	66.8	5.2
MC	44	1.21	80.1	5.2
Experiment 4				
Control	50	2.05	81.7	4.4
MC	51	1.81	69.0	4.2

4. Morbidity was reduced by 40.4, 48.5 and 15.5%, respectively, in Exp. 1, 2 and 4, by treatment with MC, whereas, in Exp. 3 MC increased morbidity by 19.9%. The number of sick days per animal purchased was lower with MC in Exp. 1 and 2, though, in Exp. 3 and 4 MC did not affect number of sick days. There was a 1% death loss in Exp. 4 and no death loss occurred in the other trials. Experience with this type of research with over 50 groups of cattle over the past few years has made the research team aware of the fact that with the 437 head of cattle used in this experiment that it is very unlikely that a treatment like MC could have a statistically significant effect on gain because of the the normal variation in the cattle.

The effects of a product like Probios® should show up in morbidity or sick days. If the cattle are too stale (morbidity over 50%) or very fresh (morbidity under 15%), treatments which are often quite beneficial frequently fail to have any effect on the cattle. Three out of the four groups of cattle in this experiment fell in this class.

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THE EFFECT OF MASS MEDICATION ON HEALTH AND PERFORMANCE OF NEWLY ARRIVED STOCKER CATTLE

D.R. Gill[1], R.A. Smith[2], R.B Hicks[3] and R.L. Ball[4]

Story in Brief

A total of 1437 newly received steer and bull calves and yearlings were used in studies to determine the effectiveness of certain mass medication procedures for reducing morbidity due to shipping fever. In one experiment, 1046 head averaging 473 pounds were divided into two groups: one received routine processing on arrival and the other received routine processing plus long-acting oxytetracycline and sustained release sulfadimethoxine. Morbidity was reduced from 33.2% in the non-mass medicated cattle to 14.6% in those receiving mass medication at processing. Mass medication reduced sick days per head from 2.25 to .81, and improved average daily gains and gain to feed ratios by 7.6% (1.56 vs 1.45 lb/head) and 11.2% (.119 vs .107 lb gain/lb feed), respectively.

In the second experiment, 391 head averaging 462 pounds were divided into four groups: 1) Control (routine processing only), 2) Long-acting oxytetracycline, 3) Sustained release sulfadimethoxine, and 4) Long-acting oxytetracycline plus Sustained release sulfadimethoxine. Mass medication with long-acting oxytetracycline, sustained release sulfadimethoxine, and a combination of the two drugs reduced morbidity by 22.1, 10.1, and 11.0%, respectively. Sick days per head was reduced by long-acting oxytetracycline (2.56 days) and long-acting oxytetracycline plus sustained release sulfadimethoxine (3.35 days) as compared to the controls (4.34 days). Mass medication had no effect on average daily gains but reduced feed intake.

(Key Words: Newly Received Cattle, Shipping Fever, Mass Medication)

Introduction

Between two and five percent of newly arrived stocker cattle received in Oklahoma die of stress related diseases, primarily the shipping fever-bovine respiratory disease complex (BRD), shortly after shipping. Morbidity ranges from 0 to 100 percent, with an average probably between 25 and 30 percent. Cattlemen receiving stressed cattle must be prepared with a complete health program to prevent excessive death loss and decreased performance. Because treating BRD is costly, it may be cheaper to prevent its occurrence rather than treat it (NCA, 1979). The administration of intramuscular oxytetracycline for the first three days after arrival of stressed calves in the feedlot has been shown to reduce the incidence of BRD, but this treatment is not always cost effective (Addis et al., 1976; Lofgreen, 1983). A disadvantage to this type of program is that all calves must be run through the chute for three successive days, increasing labor costs. Recently developed long-acting oxytetracycline (LAO) and sustained release sulfas (SRS) eliminate the need of running calves through the chute for three successive days.

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Lofgreen (1983) reported that the administration of both of these drugs to stressed calves at time of arrival reduced morbidity by 90%. The administration of LAO alone has also been shown to reduce morbidity due to BRD in stressed calves (Swafford et al., 1983).

The objective of this study was to evaluate the effect of mass medication with LAO and/or SRS on the health and performance of newly arrived, stressed stocker cattle.

Materials and Methods

Experiment One

Eleven truck loads of cattle in six different months (designated as trials) were assembled by order buyers with the majority coming from auction barns in the southeastern United States and shipped to Pawhuska, Oklahoma. The origin, arrival date and weight, number of head, and in-transit shrink for each load is summarized in Table 1. Newly received cattle were weighed individually off the truck, ear tagged, and poured with famphur systemic insecticide. Following weighing and tagging, cattle were placed in one of nine pens of 20 to 25 animals each, depending on the number of cattle received. Pens were randomly assigned to mass medication (MM) or non-mass medication (NMM) groups. Water and

Table 1. Origin, arrival date, number of head, arrival weight, and in-transit shrink for each load of cattle--Mass medication experiment one.

	Origin	Arrival Date	Number of Head	Arrival Wt., lb	% Shrink
Trial 1					
Truck 1	FL	9-15-83	101	429	11.3
Trial 2					
Truck 2	OK	10-20-83	95	440	8.5
Truck 3	FL	10-20-83	91	484	10.0
Trial 3					
Truck 4	OK	12-01-83	104	440	NA[a]
Truck 5	OK	12-08-83	88	440	NA[a]
Trial 4					
Truck 6	TN	1-10-84	93	491	7.0
Truck 7	TN				
1-12-84			99	482	7.0
Trial 5					
Truck 8	AK	2-18-84	79	532	6.5
Truck 9	AK	2-24-84	90	539	6.0
Trial 6					
Truck 10	MO	3-21-84	101	473	8.0
Truck 11	MO	3-28-84	105	486	NA[a]

[a]NA=not available.

native bluestem grass hay were provided free choice. On the morning following arrival, cattle were processed by pen as follows:

1. Body temperature and time were recorded.
2. Cattle were vaccinated with IBR-PI_3 (MLV) IM, Leptospira pomona bacterin, and Clostridia chauvoei, septicum, novyi, and sordellii bacterin.
3. Dewormed with levamisole gel.
4. Cattle in the MM group received an injection of LAO[a] (10 mg/lb) and SRS[b] boluses (1 bolus-12.5 g/200 lb of body weight).
5. Cattle in the NMM group received antibiotic treatment if clinical signs of illness were detected or if body temperature exceeded 104°F.
6. Hospital card was initiated (NMM).
7. Animals from the NMM group which were not sick and all MM cattle (sick or well) were returned to their home pen. Sick animals from the NMM group were placed in the hospital pen.

As soon as cattle were placed in their pens, they had ad libitum access to prairie hay and were offered a pelleted feed supplement (Table 2) at a rate of 2 lb/head/day for the first 21 days and 1 lb/head/day during days 22-28. The supplements contained 1) no added drugs, 2) lasalocid[c] (75 mg/lb), or 3) decoquinate[d] (50 mg/lb). Three hospital pens were maintained so that sick animals received their assigned feed while out of their home pen.

Mass-medication was assigned at random to either four or five pens in each trial with non-mass medicated cattle being placed in the remainder of the nine pens. In each trial, each feed medication was fed to at least one pen. Numbers of pens assigned to treatment were balanced between trials.

Table 2. Composition of feed supplement.

Ingredient	IFN[a]	% As Fed
Soybean Meal	5-20-637	88.9
Salt	6-04-152	3.0
Vitamin A - 30,000 IU/Gram		.22
Premix[b]		.18
Cottonseed Meal	5-01-621	5.0
Dicalcium Phosphate	6-01-080	2.75

[a]International Feed Number.
[b]To provide: 0 for control, 75 mg lasalocid/lb, or 50 mg decoquinate/lb.

[a]LA-200®, Pfizer, Inc., New York, NY 10017.
[b]Albon-SR®, Hoffman-LaRoche, Inc., Nutley, NJ 07110.
[c]Bovatec®, Hoffman-LaRoche, Inc., Nutley, NJ 07110.
[d]Deccox®, Rhone-Poulenc, Inc., Monmouth Junction, NJ 08852.

After processing, cattle were checked twice daily for signs of illness. If an animal was suspected to be sick, it was taken to the processing area where its body temperature was measured and a severity of illness score (slight, moderate, or severe) was assigned. If the body temperature exceeded 104°F the animal was considered sick. The animal could also be classified as sick based on clinical signs. Cattle receiving mass medication were not removed from their pen if they were detected as sick within the first 24 hours after processing.

Medical treatment for sick animals was determined by the ear tag number which was applied at random on arrival. Treatment schedules assigned to non-mass medicated cattle were: A) no treatment (negative controls), B) a sequence of antimicrobial drugs (Table 3), or C) an experimental potentiated sulfa (R05-0037[e]). Cattle treated by schedule B were initially treated with the first drug in the sequence. If body temperature dropped 2°F or to less than 104°F, or clinical signs were improved within 24 hours, the first drug was continued for two more days. If no improvement was apparent within 24 hours, the next drug in the sequence was used and the process was repeated until improvement was detected. In trials 3, 4, and 5, drug treatments 1 and 3 were reversed so that the first treatment was amoxicillin. Cattle treated by schedule C received R05-0037 boluses orally at 30 mg/lb on day one and 15 mg/lb on days 2-5, regardless of response to therapy. If additional treatment was required at the end of the 5 day treatment, cattle were started on the second drug in the sequence (Table 3). Any mass medicated cattle detected as sick were treated initially with the second drug in the antibiotic sequence.

At the end of the 28 day trial, the cattle were held overnight without feed or water, weighed the following morning and, as necessary, cattle were castrated and horns were tipped. Cattle were then returned to the owner.

Table 3. Sequence of drugs used for treatment of BRD.

Treatment No 1:	OXYTETRACYCLINE (Biomycin-C®) subcutaneously - 5 mg/lb. PLUS SULFAMETHAZINE BOLUSES (Sulmet® - 15 gm) 1 bolus/150 lb on day 1. One bolus/300 lb on subsequent days.
Treatment No 2:[a]	ERYTHROMYCIN (Gallamycin®) deep in the muscles - 10 mg/lb.
Treatment No 3:[a]	AMOXICILLIN (Amoxi-ject®) subcutaneously 5 mg/lb.
Treatment No 4:[a]	Procaine Penicillin G subcutaneously - 30,000 IU/lb.
Treatment No 5:[a]	TYLAN 200 - 10 mg/lb.
Treatment No 6:[a]	SPECTINOMYCIN (Spectam®) - 5 mg/lb.

[a]Some of the antimicrobial drugs used in this study were used for extra-label purpose or at extra-label dosages and require a veterinarian-client-patient relationship before use.

[e]Primor®, Hoffman-LaRoche, Inc., Nutley, NJ 07110.

Experiment Two

Four truck loads (four trials) of cattle were assembled by order buyers from auction barns in Alabama, Tennessee, or Texas and shipped to Pawhuska, Oklahoma. The origin, arrival date and weight, number of head, and in-transit shrink for each load is summarized in Table 4. Newly received cattle were weighed individually off the truck and treated with Lysoff®[f]. Following weighing and tagging, cattle were placed in pens of 20 to 25 animals each depending on the number of cattle received. Cattle were randomly assigned by pen to one of the following treatments: control, receiving no preventative medication; intramuscular injection of LAO at a rate of 10 mg/lb; oral administration of SRS at a rate of 12.5 g (one bolus)/200 lb; or administration of both drugs. Water and native bluestem grass hay were available free choice. The morning following arrival, the cattle were processed in the same manner as those in experiment one with the following exceptions: 1) Cattle with odd-numbered ear tags were dewormed with ivermectin[g] (200 µg/kg) and those with even-numbered ear tags served as controls as part of a deworming trial superimposed on this study and 2) Cattle receiving preventative medication were treated with their respective drugs.

As soon as cattle were placed in their pens, they had ad libitum access to prairie hay and were offered a pelleted feed supplement (Table 2 - with lasalocid) at a rate of 2 lb/head/day for the first 21 days and 1 lb/head/day during days 22-28.

After processing, cattle were checked twice daily for signs of illness as described in experiment one. Calves receiving preventative medication were not pulled if they were detected as sick within the first 48 hours of the trial. Sick cattle were assigned to medication schedule B (Table 3) beginning with treatment 2. In this experiment, spectinomycin replaced amoxicillin as treatment 3. Response to drug treatment was measured in the same manner as it was in experiment one.

At the end of the 28 day trial, the cattle were held overnight without feed or water, weighed the following morning and, as necessary, cattle were castrated and horns were tipped. Cattle were then returned to the owner.

Table 4. Origin, arrival date, number of head, arrival weight, and in-transit shrink for each load of cattle--Mass Medication Experiment Two.

Trial	Origin	Arrival Date	Number of Head	Arrival Wt., lb	% Shrink
1	TN	8-12-84	100	396	NA[a]
2	AL	9-28-84	100	455	7.6
3	AL	11-03-84	95	486	NA[a]
4	TX	12-06-84	96	506	4.3

[a]NA=not available.

[f]Cutter Laboratories, Shawnee Mission, KS 66201.
[g]Ivomec®, MSD Agvet, Rahway, NJ 07065.

Results and Discussion

Experiment One

Effects of mass medication with LAO and SRS on daily gains, sick days, morbidity, and mortality are shown in Table 5. Gains in the 28 day receiving period were significantly (P<.05) increased by mass medication (1.56 vs 1.45 lb/head/day). Gains of those cattle that were never sick were 1.63 and 1.69 lb/head/day for the NMM and MM groups, respectively. The number of sick days per head was reduced (P<.0001) by 64% (.81 vs 2.25 days/head) and morbidity was reduced (P<.0001) by 56% (14.6 vs 33.2%) with the administration of mass medication. These reductions in morbidity and hospital pen days and improvements in gains are consistent with results reported by Lofgreen (1983). Death loss in this experiment was .76% in both control cattle and mass medicated cattle. Another factor influencing (P<.0001) weight gains, sick days, and morbidity was truck load. Apparently, the response of cattle to mass medication was dependent on such factors as the origin of the cattle and degree of previous stress.

Effects of mass medication on feed intake and gain to feed ratio are reported in Table 6. Mass medication reduced (P<.01) feed intakes from 14.67 to 13.73 pounds per head per day. This 6.4% reduction in feed intakes combined with the 7.6% increase in daily gains with mass medication resulted in an improvement in gain to feed ratio of 11.2% (P<.05, .119 vs .107 lb gain/lb feed).

Table 5. Effect of mass medication on daily gains, sick days, morbidity and mortality in stressed cattle--Experiment One.

	Controls	Mass Medication
Number of head	523	523
Number of head never sick	352	442
Arrival weight*, lb	475	473
Daily gain, lb*	1.45[a]	1.56[b]
Daily gain of head never sick, lb*	1.63[d]	1.69[c]
Sick days*	2.25[d]	0.81[c]
Morbidity, %*	33.2[d]	14.6[c]
Total Mortality, %	0.76	0.76
Mortality excluding treatment schedule A cattle, %	0.38	0.76

*Expressed as least square means.
[a,b]Means with different superscripts differ (P<.05).
[c,d]Means with different superscripts differ (P<.0001).

Experiment Two

Effects of mass medication with LAO, SRS, or a combination of the two drugs on daily gains, sick days, morbidity, and mortality in cattle in experiment two are reported in Table 7. None of the mass medication procedures altered (P>.05) average daily gains of the cattle. However,

Table 6. Effect of mass medication on feed intake and gain to feed ratio--Experiment One.

	Controls	Mass Medication
Number of pens	26	25
Feed intake, lb*	14.67[b]	13.73[a]
lb gain/lb feed*	0.107[c]	0.119[d]

*Expressed as least square means.
[a,b]Means with different superscripts differ (P<.01).
[c,d]Means with different superscripts differ (P<.05).

Table 7. Effect of mass medication on daily gains, sick days, morbidity and mortality in stressed cattle--Experiment Two.

	Controls	LAO	SRS	LAO + SRS
Number of head	98	98	98	97
Number of head never sick	39	52	45	45
Arrival weight, lb*	460	462	462	460
Daily gain, lb	1.41	1.36	1.14	1.36
Daily gain of head never sick, lb*	1.65[b]	1.69[a]	1.58[b]	1.80 [ab]
Sick days*	4.34[b]	2.56[a]	4.24[b]	3.35
Morbidity, %*	60.2	46.9	54.1	53.6
Mortality, %	3.1	1.0	6.1	2.1

*Expressed as LSMEANS.
[a,b]Means with different superscripts differ (P<.05).

the cattle treated with SRS tended to have lower gains than all other cattle. Mass medication with a combination of LAO and SRS tended to improve gains of cattle that were never sick (1.80 vs 1.65 lb/head/day). Mass medication with LAO reduced (P<.05) the number of sick days per head by 41% (2.56 vs 4.34 days/head). A combination of LAO and SRS reduced (P>.05) the number of sick days per head by 22.8% (3.35 days/head). Administration of SRS alone did not affect the number of sick days per head (4.24 days). Morbidity was high in this experiment and all of the mass medication procedures only reduced it slightly. The greatest reduction in morbidity occurred with LAO (P<.05) which reduced it by 22.1% (46.9 vs 60.2%). In contrast to the results of experiment one, mass medication with LAO plus SRS in this experiment did not greatly reduce hospital pen days or morbidity.

Effects of the various mass medication treatments on the performance and health of the sick cattle in this experiment are summarized in Table 8. All three of the mass medication procedures tended to reduce the daily gains of the sick cattle with SRS reducing (P<.05) gains by 42.7% (.75 vs 1.30 lb/day). Weight gains were reduced by 22% and 23.7%, respectively, by LAO and LAO plus SRS. The number of treatments per sick head was increased by 17.6% with SRS (8.36 vs 7.11 days/head), whereas, LAO and LAO plus SRS reduced the number of treatments by 19.8%

Table 8. Effect of mass medication on daily gains, sick days, repulls and response to first treatment in sick cattle--Experiment Two.

	Controls	LAO	SRS	LAO + SRS
Number of head*	59	46	53	52
Daily gain, lb*	1.30[b]	1.01[ab]	.75[a]	.99[ab]
Sick days*	7.11[cd]	5.70[c]	8.36[de]	6.71[c]
Repulls, %*	26.9[de]	6.1[c]	40.0[e]	20.7[cd]
Response to first treatment, %*	70.8	76.8	50.0	65.7

*Expressed as LSMEANS.
[a,b]Means with different superscripts differ (P<.05).
[c,d,e]Means with different superscripts differ (P<.01).

Table 9. Effect of mass medication on feed intake and gain to feed ratio--Experiment Two.

	Controls	LAO	SRS	LAO + SRS
Number of pens*	4	4	4	4
Feed intake, lb*	14.76[b]	13.11[a]	13.60[a]	13.40[a]
lb gain/lb feed*	.101	.103	.086	.105

*Expressed as LSMEANS.
[a,b]Means with different superscripts differ (P<.10).

and 5.6%, respectively. Number of repulls (cattle that had to be treated more than once for respiratory disease) was significantly reduced (P<.01) by the administration of LAO (6.1 vs 26.9%) but repulls were increased by SRS by 48.7% (40.0 vs 26.96%). The response to first drug treatment was similar across groups except that SRS reduced response rates by 29.4% (50.0 vs 70.8%).

Feed intakes and gain to feed ratios for the four treatment groups are reported in Table 9. All three mass medication procedures reduced feed intake (P<.10) as compared to the control cattle. Gain to feed ratios were not altered by the administration of LAO or LAO plus SRS but were reduced by 14.9% with SRS medication.

Discussion

Mass medication with LAO and SRS improved weight gains and reduced sick pen days and morbidity in stressed cattle in experiment one. However, this same procedure did not affect the performance or health of cattle in experiment two. These results differed from those expected. One would expect mass medication to be of greater benefit in more morbid cattle than in cattle experiencing little sickness. However, this data suggest that mass medication is of little benefit in very morbid cattle (morbidity >50%).

Neither of these long-acting drugs maintain therapeutic blood levels past four days. Hence, mass medication would have limited benefit if the majority of the cattle became sick after the first week of the receiving period. But, in both of these experiments, the majority of the cattle requiring treatment were pulled within the first four days following processing. Thus, delayed sickness cannot account for the difference in response observed between the two experiments.

In experiment two, the administration of LAO alone reduced the incidence of sickness, the number of sick days per head, and the number of repulls. Since LAO costs only one-half as much as mass medication with both LAO and SRS, its use would be more economically advantageous. The administration of SRS alone tended to impair the health and performance of newly arrived cattle.

The economics of mass medicating cattle depend on the cost and success of conventional treatment, availability of labor, ability to detect sick cattle early, and the health status of cattle received. Mass medication at processing would not be economic for fresh, local cattle which experience delayed illness (7-14 days after arrival). Mass medication should reduce labor and drug costs, and increase performance for cattle which are severely stressed during long shipment.

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THE RESPONSE OF NEWLY ARRIVED STOCKER CATTLE TO DIFFERENT MEDICAL REGIMENS

R.A. Smith[1], R.B. Hicks[2], D.R. Gill[3], and R.L. Ball[4]

Story in Brief

Different medical regimens for treating newly received steer and bull calves were evaluated in three experiments with 524 sick cattle. In experiment one, 173 head of 523 received cattle became sick and were treated as follows: 28 head received oxytetracycline plus sulfamethazine boluses, 35 head received amoxicillin, 67 head received potentiated sulfa boluses, and 43 head served as negative controls (not treated for sickness). The percent responses to the three drug treatments were 82.1%, 45.7%, and 91.0% for oxytetracycline plus sulfamethazine boluses, amoxicillin, and potentiated sulfa boluses, respectively. In experiment two, 219 head of 463 received cattle became sick and were treated as follows: 75 head received oxytetracycline plus sulfamethazine boluses, 83 head received potentiated sulfa boluses, and 61 head served as negative controls. The percent response to the two drugs were 56.0% and 51.1% for oxytetracycline plus sulfamethazine boluses and potentiated sulfa boluses, respectively. The negative controls were sick for more days than either of the treated groups and death loss was much higher (32.8 vs 3.2% of the sick cattle). In experiment three, 237 of 502 cattle were treated with either oxytetracycline plus sulfamethazine boluses (107 head) or potentiated sulfa boluses (130 head). The responses to oxytetracycline plus sulfamethazine boluses and potentiated sulfa boluses were 59.3% and 57.5%, respectively. The percent death losses in the three experiments were .76%, 5.4%, and 1.8%, respectively.

(Key Words: Bovine Respiratory Disease, Newly Received Cattle, Oxytetracycline, Primor, Sulfamethazine)

Introduction

Between two and five percent of newly arrived stocker cattle received in Oklahoma die of stress related diseases, primarily the Bovine Respiratory Disease (BRD) complex, shortly after shipping. Morbidity ranges from 0 to 100 percent with an average between 25 and 30 percent. In order to prevent excessive death loss and decreased performance, sick cattle must respond to drug therapy. Studies have shown that cattle exhibiting signs of BRD respond well to oxytetracycline (OTC) or sulfamethazine treatment (Breeze et al., 1980; Nash, 1983). The potentiated sulfa boluses (PSB) used in this study was an experimental potentiated combination drug employing sulfadimethoxine and ormetoprim in a ratio of 5:1. The objective of this research was to study the response of sick cattle that were treated with either OTC plus sulfamethazine boluses (SB) or PSB.

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Materials and Methods

This research was superimposed across three other studies being conducted at the Pawhuska, Oklahoma Research Station with newly received stocker cattle over 28 day receiving periods. The cattle and experimental procedures used in all three of these experiments are described elsewhere in this publication (Hicks et al., 1986a, 1986b, 1986c).

In all three experiments, medical treatment for sick animals was determined by the ear tag number which was applied at random on arrival. Treatment schedules assigned to sick cattle in Exp. 1 were: A) no treatment (negative controls), B) a sequence of antimicrobial drugs (Table 1), or C) PSB[a]. Cattle treated by schedule B were initially treated with the first drug in the sequence. If body temperature dropped 2°F or to less than 104°F, or clinical signs were improved within 24 hours, the first drug was continued for two more days. If no improvement was apparent within 24 hours, the next drug in the sequence was used and the process was repeated until improvement was detected. In 35 head, drug treatments 1 and 3 were reversed so that the first treatment was amoxicillin. Cattle treated by schedule C received PSB orally at 30 mg/lb on day one and 15 mg/lb on days 2-5, regardless of response to therapy.

Treatment schedules assigned to sick cattle in Exp. 2 were: A) no treatment, B) sequence of antimicrobial drugs (same as in Table 1 except that spectinomycin was substituted for treatment 3), or C) PSB substituted for treatment 1 in sequence. These same treatment schedules were used in Exp. 3 except that no negative control cattle were included. Response to treatment in these two experiments was determined in the same manner as described for Exp. 1.

Table 1. Sequence of drugs used for treatment of BRD.

Treatment No 1:	OXYTETRACYCLINE (Biomycin-C®) subcutaneously - 5 mg/lb. PLUS SULFAMETHAZINE BOLUSES (15 gm) 1 bolus/150 lb on day 1. One bolus/300 lb on subsequent days.
Treatment No 2:[a]	ERYTHROMYCIN (Gallamycin®) deep in the muscles - 10 mg/lb.
Treatment No 3:[a]	AMOXICILLIN (Amoxi-ject®) subcutaneously 5 mg/lb.
Treatment No 4:[a]	Procaine Penicillin G subcutaneously - 30,000 IU/lb.
Treatment No 5:[a]	TYLAN 200 - 10 mg/lb.
Treatment No 6:[a]	SPECTINOMYCIN (Spectam®) - 5 mg/lb.

[a]Some of the antimicrobial drugs used in this study were used for extra-label purpose or at extra-label dosages and require a veterinarian-client-patient relationship before use.

[a]Primor®, Hoffman-LaRoche, Inc., Nutley, NJ 07110.

Results and Discussion

In Exp. 1, cattle treated with PSB or OTC plus SB responded significantly ($P<.05$) better than cattle treated with amoxicillin (Table 2). Only 45.7% of the cattle treated with amoxicillin responded (recovered from sickness), whereas, response rates of 91% and 82.1% were observed in cattle treated with PSB and OTC plus SB, respectively. Cattle treated for sickness gained 30 to 58% faster than negative control cattle (.86 lb/day) with cattle receiving OTC plus SB having the highest weight gains (1.36 lb/day) over the 28 day periods. Cattle treated with PSB had gains similar (1.30 lb/day) to those treated with OTC plus SB. Negative control cattle had a greater number of sick days (8.4 days/head) than treated cattle with the OTC plus SB group having the fewest sick days (5.2 days/head). Number of repulls (cattle that had to be treated more than once for respiratory disease) were highest in the PSB cattle (20.9%). Death loss in the negative control cattle was 4.7% of those getting sick, versus 3.0%, 0%, and 0% of those becoming sick in the PSB, OTC plus SB and amoxicillin groups, respectively.

In contrast to the above results, cattle in Exp. 2 and 3 tended to respond slightly better when treated with OTC plus SB versus PSB. In Exp. 2, 56.0% of the cattle treated for BRD responded to OTC plus SB and 51.1% responded to PSB. The responses in Exp. 3 were similar (59.3% for OTC + SB vs 57.5% for PSB). In these two experiments, daily gains tended to be greater for cattle treated with PSB. The PSB treated head gained 0.04 and 0.20 lb/head more than the OTC plus SB cattle in

Table 2. Effect of different medical regimens on daily gains, sick days, repulls and response to first treatment in sick cattle.

	Head No.	Daily* Gains lb	Sick* Days	Repulls* %	Response* %	Mortality[a] %
Experiment 1						
OTC + SB	43	1.36	5.2	7.1	82.1[e]	0.0
Amoxi	35	1.12	6.9[b]	14.3	45.7[d]	0.0
PSB	37	1.30	6.5[b]	20.9	91.0[e]	3.0
Controls	43	.86	8.4	7.0[c]	----	4.7
Experiment 2						
OTC + SB	75	.84	7.4[f]	24.3	56.0	2.6
PSB	83	.88	8.3[f]	18.5	51.1	3.8
Controls	61	.84	12.2[g]	10.1[c]	----	32.8
Experiment 3						
OTC + SB	107	.59	6.4	19.4	59.3	3.7
PSB	129	.79	7.1	12.8	57.5	3.8

*Expressed as least square means.
[a]Percent of sick cattle.
[b]Protocol required at least a 5 day treatment period.
[c]Many of these cattle never recovered and remained in the sick pen the entire trial
[d,e]Means with different superscripts differ ($P<.01$)
[f,g]Means with different superscripts differ ($P<.05$)

experiments two and three, respectively. However, these same cattle tended to require more treatment days to recover from sickness (Exp. 2- 8.3 vs 7.4 days/head and Exp. 3- 7.1 vs 6.4 days/head). Compared to Exp. 1, the PSB treated cattle had fewer repulls than the OTC plus SB cattle in both Exp. 2 and 3. The death loss in these two experiments was similar for the OTC plus SB and PSB groups. In Exp. 2, the negative control cattle had a greater ($P<.05$) number of sick days than either of the treated groups (12.2 vs 7.9 days/head) and the mortality rate was much greater (32.8% vs 3.2%). In this experiment there was a definite economic advantage with the treatment of sick cattle. The response to treatment in these experiments was much lower than that observed in Exp. 1 probably due to the fact that these cattle were less productive, sicker cattle than those in Exp. 1 as evidenced by lower gains and higher morbidity. Studies done at Pawhuska tend to indicate that morbid, poorer performing cattle are less likely to respond to medical treatment.

Under the conditions of these experiments there were no real differences in the response and performance of sick cattle treated with OTC plus SB or PSB. Either medical regimen is useful in the treatment of newly arrived, stressed cattle showing symptoms of BRD.

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INTENSIVE-EARLY STOCKING ON CROSS TIMBERS RANGELAND, 1985

F. T. McCollum[1], R. L. Gillen[2], D. M. Engle[3] and G. W. Horn[4]

Story in Brief

Intensive-early stocking and summer-long stocking programs were compared using data from 1984 and 1985 grazing trials. In 1985, crossbred steers (avg. initial wt. 547 lbs.) grazed at double the normal stocking density (steer/acre) for 79 days or at normal density for 156 days beginning April 24. Average 79 day gains were 122 lb/steer for the intensive stocking and 141 lb/steer for the normal stocking density. Total weight gain during the summer by steers on the normal stocking regimen was 208.5 lb/head. The combination of poor cattle performance and a weak feeder cattle market in 1985 resulted in estimated losses of $58.67/head and $80.61/head on the intensive and normal stocking programs, respectively. Since twice as many cattle were grazed per unit of land area with the intensive regimen, estimated losses were 46% greater than with normal stocking. Further comparisons of the two grazing programs were made by estimating breakeven gains (lb/steer) and breakeven market prices ($/cwt) for each program using weight gains and market structures for both 1984 and 1985.

(Key Words: Grazing, Feeder Cattle, Rangeland, Intensive Stocking, Performance)

Introduction

Intensive early stocking (IES) is an adaptation of seasonal suitability grazing and involves grazing range areas by growing animals during the period of high forage quality. The intent of an IES program is to maximize gain/acre without reducing individual animal performance; this is accomplished by stocking heavily during the period when forage quality is high (Smith and Owensby, 1978). "Heavy" stocking is implemented by increasing stock density (animal units/acre) rather than stocking rate (animal unit days/acre).

Kansas studies (Launchbaugh et al., 1983) demonstrated that IES can increase gain/acre, maintain or improve range condition and potentially increase profitability of a stocker operation. McCollum et al. (1985) reported an estimated 110% increase in returns for IES versus summer-long stocking of stocker cattle on Cross Timbers rangeland in the first year of a four year study. The following results are from the second year of this study.

Materials and Methods

Four pastures on the Pawhuska Research Station were assigned to either intensive-early stocking (IES) or summerlong stocking (SLS). In 1984, yearlong stocking rates (animal unit days/acre) were estimated for

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each pasture (McCollum et al., 1985). After stocking rates were established, stocking density (animal units/acre) was adjusted to achieve the proper stocking rate under IES and SLS.

On April 24, 1985, 175 head of crossbred steers averaging 548 lb/head were weighed and allocated to one of the four treatment pastures. However, due to problems unrelated to the treatments, one IES and one SLS pasture were removed from the trial. Hence, data from only one IES and one SLS pasture are reported. Steers had free access to mineral supplement and ponded water throughout the trial. In addition, SLS steers were fed 1 lb/hd/day of a 38% protein supplement (with Rumensin) during the last 77 days (7/13 to 9/27) of the summer. All cattle were weighed on the morning of July 12 and SLS cattle were weighed again on the morning of September 20. Weights were taken in the morning after cattle were held off feed and water 12 to 16 hours.

Cost-and-return analyses were based on steer gains, market information from the Oklahoma City National Stockyards and the following assumptions: cattle were purchased in March and placed in a 28-day receiving program (2% death loss, $14/head feed costs, $7/head medical costs), interest rates were 12%, pasture lease was $40/head for 150 days and protein supplement was $150/ton. In addition, costs for labor and implanting were included. Finally, data for both 1984 and 1985 were used to compare the effects of steer performance and market structure on breakeven weight gains and breakeven feeder cattle prices required for IES and SLS.

Results and Discussion

During the first 79 days of the summer, steers gained 122 and 141 lb/head on IES and SLS, respectively (Table 1; 1985). For every pound of gain produced on SLS, IES produced 1.73 lb of gain (122 x 2/141). In order to equalize total gain between treatments, SLS steers would have had to gain 103 lb/head during the final 77 days of summer. Instead, SLS steers gained 66.5 lbs yielding a total summer gain of 208 lb/head. In terms of total beef production, IES produced 17.6% more gain than SLS. These gains are much lower than observed in 1984. The difference between years is not easily explained. Cattle management was similar during both summers. In addition, the summer of 1985 was milder with a better distribution of rainfall than 1984. Pretrial history may have influenced performance in terms of compensatory gains and environmental adaptation.

Total steer gain in 1985 was greater on IES, but total financial loss was also greater (Table 2). This illustrates the fallacy of evaluating systems on the basis of "total production/unit area". In 1985, each steer on IES lost $58.67 while SLS steers lost $80.61/head. Therefore, IES increased losses 46% over SLS since twice as many cattle were pastured on IES. Breakeven market prices for IES and SLS were $70.01/cwt and $68.70/cwt, respectively. Feeder prices, at the end of the IES period, were $61.28/cwt for 665 lb steers while, feeder prices were $58.07/cwt for 780 lb/steers at the end of SLS in September (Table 2).

The estimated losses in 1985 were due to the combined influence of low weight gains and a large negative margin for purchase and market feeder prices. In Table 3, breakeven gains and feeder prices are estimated for 75-day IES and 150-day SLS programs using market structures and steer gain data from 1984 and 1985. These values were derived with estimated costs. Actual producer costs may differ from

Table 1. Weights and gains of steers on intensive-early stocking and summerlong stocking programs.

Grazing Management	Grazing Days	Init. steer wt.	Midsummer[a] Wt.	Midsummer[a] Gain	Summer End[b] Wt.	Summer End[b] Gain	Adj. total gain[c]
		lb/hd					
Intensive early stocking							
1984	84	474.5	681	206.5	--	--	413
1985	79	542	664	122	--	--	244
Seasonlong stocking							
1984	146	476	684.5	208.5	769	84.5	293
1985	156	552	693	141	759	66.5	207.5

[a] 7/20/84, 7/12/85
[b] 9/20/84, 9/27/85
[c] Adjusted total gain = gains adjusted for differences in stocking density, for every 1 steer on SLS, 2 steers were on IES. Thus, adj. gain for IES = midsummer gain x 2 and Adj. gain for SLS = summer end gain x 1.

Table 2. Cost and return analysis for IES and SLS.

	1984 IES	1984 SLS	1985 IES	1985 SLS
Initial wt, lb/hd	475	475	542	552
Initial value, $/cwt	71.23	71.23	72.50	72.50
Initial value, $/hd	338.34	338.34	392.95	400.20
Final wt, lb/hd	682.00	768.00	664.00	759.00
Final value, $/cwt	64.18	61.80	61.28	58.07
Final value $/hd	437.71	474.63	406.89	440.93
Gross return, $/hd	99.37	136.29	13.94	40.73
Cash cost, $/hd	71.27	109.55	72.61	121.34
Net return, $/hd	28.10	26.74	(58.67)	(80.61)
Adj. net return, $[a]	56.20	26.74	(117.34)	(80.61)

[a] Adjusted for differences in stocking density

these estimates. First, note the influence of markets on breakeven gain. Under the 1984 market structure, breakeven gains for IES and SLS were 59 and 81 lb/head lower than breakeven gain in 1985. Although not impossible, it is improbable that stockers would have achieved breakeven weights on either grazing program in 1985. Second, low gaining cattle (1985 gain) did not return a profit in either year under either program. In contrast, cattle that gained well (1984 gain) would have returned a profit in 1984.

Table 3. Projected breakevens for 1984 and 1985 market price structures.

	75 day IES	150 day SLS
1984 Market Structure		
Breakeven gain[a]	158 (2.10)	262 (1.75)
Breakeven price, $/cwt[b]		
1984 steer/gain	62.00 (64.40)	59.08 (61.44)
1985 steer/gain	68.95 (64.71)	67.52 (62.74)
1985 Market Structure		
Breakeven gain[a]	217 (2.90)	344 (2.30)
Breakeven price, $/cwt[b]		
1984 steer/gain	63.48 (61.50)	59.90 (58.38)
1985 steer/gain	70.58 (62.55)	68.47 (59.76)

[a]Breakeven gain/head (breakeven gain/head/day)
[b]Breakeven selling price (Actual market value)

In July, at the end of an IES program, a producer generally has three options 1) sell the cattle, 2) move cattle to another pasture or backgrounding operation, 3) move cattle to a feedlot. In either year with either set of gains, there was no advantage to holding cattle on pasture through late summer (Table 2). The steers had gained 68 to 71% of their total summer gain by mid-July and returns per steer were not increased by the 30% of total gain made from mid-July to late September.

With slow gaining cattle, such as the 1985 cattle, the only chance for a profit was to place the cattle in a feedlot. Cattle that gained well (i.e. 1984 cattle) could have been sold for a good return in July, 1984, but in 1985 the cattle should have been moved to a feedlot. These cattle would have been finished in late November to early December when fed cattle markets had rebounded. Producers considering an IES program should arrange to place the cattle in the feedlot in July. This provides some insurance in the event that summer feeder cattle markets are unusually weak or cattle gain poorly. Despite greater total losses for IES, investment (loss) per head was lower with IES. Hence, the producer would have entered the feeding period with a better position/head than with SLS.

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INFLUENCE OF SUPPLEMENTAL BRANCHED CHAIN FATTY ACIDS ON FORAGE INTAKE AND UTILIZATION BY STEERS

F. T. McCollum[1], Y. K. Kim[2], and F. N. Owens[3]

Story in Brief

The effects of supplemental branched chain volatile fatty acids on utilization of prairie hay were tested using steers in two trials. In trial 1, branched chain acids did not influence ruminal pH or concentrations of ammonia and volatile fatty acids. Ruminal proportions of isobutyrate and isovalerate were increased by the supplement, but the other major acids were not affected. In addition, digestibility of dry matter, fiber and nitrogen were not changed by supplementation. Microbial nitrogen flow to the small intestine and efficiency of growth tended to be reduced when the branched chain acids were added. Addition of the acids to urea-based supplements in trial 2 did not influence voluntary hay intake or the digestibility of dry matter and fiber. In these trials, a deficiency of branched chain fatty acids in the rumen did not limit digestion and intake of prairie hay. These results do not exclude the possibility that acids have postabsorptive effects on metabolism.

(Key Words: Urea, Branched Chain VFA, Low Quality Forage, Intake, Rumen Fermentation)

Introduction

Calcium salts of branched chain volatile fatty acids (BCVFA) are being added to many commercial diets for lactating cows based on research indicating that they increase milk production. In a previous trial with growing steers (D.R. Gill, unpubl. data), ammonium salts of BCVFA had no effect on rate or efficiency of gain. Few tests of BCVFA have involved low quality forages. BCVFA are produced in the rumen by fermentation of amino acids and are required for growth by rumen microbes, especially those which digest cellulose. Since BCVFA are produced from protein, their concentration in the rumen is low if protein intake is low. Levels are particularly low when urea replaces natural proteins in the diet. Some workers have speculated that a ruminal deficiency of BCVFA could limit the value of NPN. If so, supplementing with BCVFA should increase fermentation rate, cellulose digestion and intake of forage. The objective of the following trials was to evaluate the influence of added BCVFA on digestion of low quality prairie hay supplemented with urea.

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[1]Assistant Professor [2]Visiting Scientist [3]Professor

Materials and Methods

Trial 1

Four steers (282 kg) fitted with ruminal and duodenal cannulas were used in a crossover experiment. Approximately 18 g dry matter/kg body weight of chopped, prairie hay (max. particle length = 1 in.; Table 1) was fed each day at 0800 h. At 1000 h, steers were fed 365 g/head of a urea-based supplement with 0 or 30 g of a branched chain volatile fatty acid product (BCVFA; Table 1). Chromic oxide was fed as an indigestible marker.

Each of the two feeding periods lasted 21 days. Rumen, duodenal and fecal samples were collected simultaneously at specific time intervals during the last 3 days of each period. The pH of each sample was determined immediately. Rumen samples were frozen and later analyzed for volatile fatty acids and ammonia nitrogen (NH_3-N). Duodenal and fecal samples were analyzed for dry matter, ash, acid insoluble ash (AIA), nitrogen (N), acid detergent fiber (ADF), chromium and nucleic acid N.

Trial 2

Twelve Hereford steers (336 kg) in individual pens had free access to prairie hay in a crossover experiment. Chopped prairie hay (max. particle length 1 in.; Table 1) was offered daily at 0800 h. Voluntary hay intake was recorded over the last 7 days of each 21 day feeding period. Steers received 500 g/head of a urea-based supplement with or without 30 g of BCVFA added. Supplement was fed at 1000 h daily. Fecal samples were collected from each steer six times during days 19 and 20 of each period and analyzed for AIA.

Results and Discussion

Trial 1

Addition of BCVFA to the supplements had little impact on rumen fermentation products (Table 2). Rumen NH_3-N was consistently below 2 mg/100 ml and may have limited ruminal fermentation and microbial protein synthesis. Previous studies with high roughage rations found that BCVFA had no effect on ruminal NH_3-N (Unmunna et al., 1975; Hefner et al., 1985). Ruminal VFA concentrations were similar for both treatments. Likewise, there were no differences in the relative proportions of acetate, propionate and butyrate in rumen contents. Cook (1985) reviewed several studies in which isoacids have increased acetate production. Our results neither support our refute this point since relative rates of acid removal from the rumen could have masked any differences in total production. Ruminal proportions of isobutyrate and isovalerate were increased (P .05) 7.6 and 3.2 fold, respectively, by BCVFA supplementation. These increases were expected since these acids are components of the BCVFA supplement. Valerate levels tended (P .05) be higher with BCVFA additions.

Total tract digestibilities were calculated using both Cr and AIA as indigestible markers. No effect of BCVFA on total tract DM and ADF digestion was detected. Cook (1985) cited studies showing improved feed digestion with isoacid supplementation, however, in studies by Cline et al. (1966), Unmunna et al. (1975) and Hefner et al. (1985), isoacid

Table 1. Composition of prairie grass hay and supplement[a].

	Hay		Urea Supplement
	Trial 1	Trial 2	
Dry matter, %	94.2	93.1	90.0
Crude protein, % of dry matter	3.6	4.1	34.3
Acid detergent fiber, % of dry matter	41.8	40.4	9.4
	----------% As Fed----------		
Urea			6.4
Corn			42.0
Cottonseed meal			33.5
Alfalfa			5.4
Molasses			2.7
Sodium sulfate			1.1
Potassium chloride			2.0
Dicalcium phosphate			4.3
Trace mineralized salt			2.1
Vitamin A			.5

[a]Branched chain VFA product contained 90% DM, .01% N, min. 89% Ca-salts of isobutyric and 5-carbon acids, min. 15.3% total Ca. Product of Eastman Kodak, Kingsport,TN.

Table 2. Rumen pH, ammonia and volatile fatty acids Trial 1.

	Urea	Urea+BCVFA
pH	6.9	7.0
Ammonia, mg/100 ml	1.7	1.9
Total VFA, mmoles/liter	89.7	91.6
	---------moles/100 moles-------	
Acetate	76.9	76.8
Propionate	14.3	12.5
Butyrate	7.9	8.2
Isobutyrate	.11[a]	.84[b]
Isovalerate	.32[a]	1.01[b]
Valerate	.47[c]	.66[d]

[ab]Row means with different superscripts are different (P<.05).
[cd]Row means with different superscripts are different (P<.07).

Table 3. Intake, digestion and intestinal flow measurements, Trial 1.

Item	Supplement	
	Urea	Urea+BCVFA
Organic matter intake, kg	4.8	4.7
Organic matter digestion		
Ruminal %[a]	30.3[c]	31.4[d]
Total tract %[a]	53.7[c]	51.9[d]
Total tract %[b]	47.8	47.6
Acid detergent fiber digestion		
Ruminal %[a]	47.4	40.8
Total tract %[a]	47.9	46.8
Total tract %[b]	42.2	41.3
Nitrogen		
Passage, g/day		
Intake	48.5	48.5
Entering duodenum		
Total	87.2	79.3
Microbial	59.3	51.1
Feed and NH_3-N	27.9	28.2
Feces	34.8	32.8
Microbial efficiency, g MN/g apparently FOM	.41	.34
Digestion, %		
Ruminal	-78.7	-63.4
Total tract	32.5	28.2

[a] Calculated with Cr marker
[b] Calculated with AIA marker
[cd] Means are different P<.10

supplementation did not alter digestion of dry matter or fiber. Similarly, total tract N digestibility was not altered by BCVFA. This agrees with the results of Cline et al. (1966), Unmunna et al. (1975) and Hefner et al. (1985). Flow of N to the small intestine and total tract digestion of N tended to be reduced by BCVFA supplementation. Efficiency of microbial growth was not increased by BCVFA supplementation. This conflicts with a number of in vitro trials which have suggested that microbial growth is enhanced by BCVFA. In vitro conditions limit crossfeeding and microbial adaptation that can occur in the rumen.

Past studies (Unmunna et al., 1975; Hefner et al., 1985; Cook, 1985) suggested that feeding of isoacids may improve retention of N by cattle and sheep. If BCVFA do not alter ruminal synthesis or digestibility of protein, such responses must be occurring after absorption from the gastrointestinal tract.

Table 4. Hay intake and digestibility, Trial 2.

Item	Supplement	
	Urea	Urea+BCVFA
Steer wt., kg	336	336
Voluntary intake, g/kg BW		
Dry Matter	19.5	19.4
Acid Detergent Fiber	7.9	7.8
Digestibility, %		
Dry Matter	47.5	47.8
Acid Detergent Fiber	42.0	42.4

Trial 2

Adding 30 g BCVFA product to the protein supplement did not increase voluntary hay intake or digestibility of DM and ADF. This supports the results of trial 1.

Intakes of protein supplement were lower than planned. Hence, total protein intake was marginal in both trials and may have limited the response to supplemental BCVFA. Other studies with protein supplemented high roughage diets, have generally failed to show any response to BCVFA in urea-based supplements. If intake and digestiblity are not increased but N retention is, BCVFA supplementation must exert its effects after digestion and absorption. Cook (1985) indicated that BCVFA increased serum growth hormone levels in lactating Holstein cows. This could redirect N flow. Eventually, feed intake would need to increase to meet the increased energy demand.

The factors that limit the value of urea-based supplements for cattle grazing low quality forage remain a mystery. Results of this study would suggest that a ruminal deficiency of BCVFA is not the primary factor limiting the value of urea-based supplements. If responses to BCVFA are metabolic rather than digestive, further performance and N balance studies are needed.

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COTTONSEED MEAL, CORN/UREA AND CORN/UREA WITH SARSAPOGENINS FOR STEERS GRAZING TALLGRASS RANGE IN LATE SUMMER

F.T. McCollum[1] and G.W. Horn[2]

Story in Brief

Sixty steers of mixed breeding (avg. wt. 671 lb) were fed one of three supplements from July 31 to September 27, 1985. Treatments were a) 6.75 lb/hd/wk of a 36% natural protein supplement, b) 9.4 lb/hd/wk of a 29% crude protein corn-urea supplement, c) 9.4 lb/hd/wk of a 28.3% protein corn-urea-sarsapogenin supplement. During the 59 day trial, the steers fed the natural protein supplement gained 62.7 lb/hd, whereas those fed the corn-urea and the corn-urea-sarsasapogenin supplements gained 59.3 and 45.9 lb/hd, respectively. Since there was no gain response to the supplemental energy provided, it is likely that forage digestion was reduced by the corn-urea supplements. In addition, sarsapogenins depressed gains suggesting that the additive further reduced forage digestion and intake.

(Key Words: Steers, Summer Grazing, Range, Supplements, Sarsapogenins, Urea)

Introduction

Over the years, numerous studies have documented the benefits of feeding small amounts of high-protein supplements to cattle grazing range during the late summer. Daily gains are usually increased .2 to .4 lb/hd over unsupplemented cattle. In addition, numerous studies have evaluated the use of nonprotein nitrogen (NPN) compounds in range supplements. In most cases, NPN supplements are inferior to natural protein supplements.

Rapid hydrolysis of urea to ammonia in the rumen may result in inefficient conversion of NPN to microbial protein if sufficient energy is not available. Some researchers have suggested that slower release of ammonia-N from NPN would improve the value of NPN for range cattle. Scientists have recently determined that sarsapogenins, naturally occurring saponins in the yucca plant, contain urease enzyme inhibitors. Depressing ruminal urease activity might enhance the efficiency of utilization of NPN in range supplements (R. Goodall, personal communication). This trial was conducted to compare the weight gain response of steers grazing native range in late summer and fed a high protein supplement, or a medium protein corn/urea supplement with or without sarsapogenins.

Materials and Methods

On July 31, 1985, 60 crossbred steers were weighed (init. wt. 671 lb), randomly sorted into three groups, and placed on one of three native pastures at the Pawhuska Research Station. Predominate forage

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[1]Assistant Professor [2]Professor

Table 1. Composition of supplements.

Item	Natural Protein	Corn/ Urea	Corn/Urea/ Sarsapogenin
	% As-Fed		
Cottonseed meal	92.6	21.5	21.5
Corn	---	61.7	61.7
Molasses	---	4.0	3.9
Urea[a]	---	4.5	4.5
Dicalcium phosphate	4.5	4.6	4.6
Limestone	1.9	.6	.6
Potassium chloride	1.0	2.5	2.5
Sodium sulfate	---	.6	.6
Sarsaponin[b]	---	---	.1
Dry matter, %	90.5	89.3	88.9
	% of DM		
Crude protein	36.3	29.1	28.3
TDN, estimated	71.0	74.0	74.0

[a]Provided 46% of supplement crude protein equivalent.
[b]Carrier for sarsapogenin, Trademark of Distributor's Proc., Inc., Porterville, CA.

species were big and little bluestem (Andropogon gerardii and Schizachyrium scoparius). All steers had been on another common grazing study from late April until mid-July. The supplement treatments were 1) 6.75 lb/hd/wk of a 36% crude protein (CP) natural protein (NP) supplement, 2) 9.4 lb/hd/wk of a 29% CP corn/urea (CU) supplement, and 3) 9.4 lb/hd/wk of the corn/urea supplement containing .1% Sarsaponin[1] (CUS; Table 1). Prorated amounts of the supplements were group-fed in troughs three times weekly. Cattle were rotated among the pastures every ten days to help remove any pasture effects. The cattle were weighed off trial on September 27, 1985. Both initial and final weights were determined after an overnight shrink.

Results and Discussion

During the 59-day trial, steers consuming NP and CU supplements gained similar ($P > .05$) amounts of weight (Table 3). One would normally expect gains of steers supplemented with a small amount of an "all-natural" high-protein supplement to be greater than steers supplemented with an equivalent amount of crude protein from a urea-containing supplement. Average daily gains were at the lower end of the range normally observed for supplemented cattle during this time of year. As noted in Table 2, CU steers consumed .99 lb of supplemental TDN compared to .68 lb supplemental TDN for the NP steers. The similarity in performance, despite the supplemental energy, suggests the CU supplement possibly reduced forage digestion and intake. Perhaps daily feeding of

[1]Carrier for sarsapogenin. Trademark of Distributor's Processing Inc.

Table 2. Supplement intake.

Item	Natural Protein	Corn/ Urea	Corn/Urea/ Sarsapogenin
	----------lb/head (DM basis)----------		
Supplement			
per feeding	2.25	3.13	3.13
per day	.97	1.34	1.34
Supplemental protein			
per day	.35	.39	.38
Supplemental TDN			
per day	.68	.99	.99
Sarsaponin[1]			
mg/day	---	---	681

[1]Trademark of Distributor's Processing, Inc.

Table 3. Steer weights and performance.

Item	Natural Protein	Corn/ Urea	Corn/Urea/ Sarsapogenin	SEM[a]
Initial wt., lb	665	665	683	
Final wt., lb	728	725	729	
59-day gain, lb	62.7[b]	59.3[b]	45.9[c]	3.9
Average daily gain, lb	1.06[b]	1.00[b]	.78[c]	.07

[a] Standard error of the mean; n=20.
[bc] Means with different superscripts are different, P<.05.

CU or CUS would have improved performance. Previous work by Chase and Hibberd (1985) indicated that daily feeding of corn-based supplements to cows consuming prairie hay was preferred to alternate day feeding.

When sarsapogenins were added to the CU supplement, steer daily gain declined (P<.05) .2 to .3 lbs/day (Table 3), reducing total 59-day gain by 27% and 22.5% compared to NP and CU, respectively. The reasons for this decline are not known. A similar response was observed in a previous winter supplementation trial with sarsapogenin (McCollum et al., 1985). The additive may have altered ruminal function. In situ ruminal disappearance of bermudagrass hay in mature Hereford cows fed the same hay declined linearly as the dietary level of Sarsaponin increased (0, 500, 700 and 900 mg Sarsaponin daily) (A. L. Goetsch, personal communication). An effect similar to this in the present trial may have reduced forage intake by the CUS cattle.

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SUPPLEMENTAL CHOLINE AND DICHLORVOS FOR BRED GILTS

W.G. Luce[1], D.S. Buchanan[2], C.V. Maxwell[1], H.E. Jordan[3] and R.O. Bates[4]

Story in Brief

Four trials involving 354 crossbred gilts were conducted to study the effect of supplemental feeding of choline and dichlorvos during gestation on subsequent reproductive performance. Gilts receiving choline farrowed pigs with higher individual birth weights. No significant response from feeding choline and (or) dichlorvos to gestating gilts was noted for number of live pigs born, number alive at 21 or 42 days, survival rate, litter birth weight, individual pig and litter weights at 21 and 42 days and the incidence of spraddle leg pigs. The presence of fecal parasite eggs was extremely low in the feces of the gilts and their respective offspring in all treatments when measured in the first two trials. There was no evidence of an interaction of the effects of choline and dichlorvos for any parameters measured in this study.

(Key Words: Bred Gilts, Reproductive Performance, Choline, Dichlorvos)

Introduction

Two nutritional supplements often reported in the literature as being effective in improving performance when fed to gilts and sows during gestation are choline and dichlorvos (2-2 dichlorovinyl dimethyl phosphate).

Supplementation of choline to sow diets has shown an increase in the number of live pigs farrowed and increased pig survival rate. In previous work at the Oklahoma Agricultural Experiment Station (Maxwell et al., 1978), feeding of 350 mg of choline per pound of diet to sows during the gestation period also resulted in increased pig and litter weaning weight. Dichlorvos supplementation to sow diets has been reported to increase the number of live pigs farrowed, number weaned, increased pig and litter birth weights and increased pig or litter weaning weights.

Many studies suggest that supplementation of choline or dichlorvos may improve reproductive performance in gestating swine. However, research apparently has not been conducted to determine if there is an additive or interactive effect when choline and dichlorvos are used together. This experiment was conducted to determine if there was an additive or interactive effect between choline and dichlorvos.

Materials and Methods

Four trials involving 354 crossbred gilts bred to purebred Duroc boars in trials 1 and 2 and crossbred boars in trials 3 and 4 were

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conducted. In each trial, gilts were randomly alloted to four treatments. Treatments were: (1) a 14% crude protein, sorghum grain-soybean meal diet without supplemental choline or dichlorvos (Table 1); (2) diet 1 + 350 mg of choline per lb of diet fed throughout gestation; (3) diet 1 + 250 mg of dichlorvos fed during the last 30 days of gestation (day 90 to 110) and (4) diet 1 + 350 mg of choline per lb of diet fed throughout gestation and 250 mg of dichlorvos fed during the last 30 days of gestation (day 90 to 110). Sows were fed diets at the initiation of the breeding season.

All gilts were housed in outside dirt lots by treatments during gestation and group fed 5.0 lb of feed per head per day. At day 110 of pregnancy, gilts were moved to individual farrowing crates and litters were penned separately until weaning at 42 days. Beginning at day 110, all gilts were fed a 16% crude protein sorghum grain-soybean meal lactation diet without supplemental choline or dichlorvos (Table 1). After day 3 of the lactation period gilts were self fed for the duration of the 42 day lactation period.

In trials 1 and 2, feces from all gilts were examined for gastrointestinal parasites (ascarids, Trichuris, Coccidia, spiruids, strongyles and strongyloides) approximately 30 days before farrowing and before the addition of dichlorvos to treatments 3 and 4. Fecal examinations were again conducted on each gilt and two randomly selected pigs per litter 42 days post-farrowing.

Table 1. Composition of basal diets.

Ingredients	Gestation %	Lactation %
Sorghum Grain	76.95	71.30
Soybean meal, 44%	14.50	20.20
Ground alfalfa hay	5.00	5.00
Calcium carbonate	1.00	1.05
Dicalcium phosphate	1.60	1.50
Salt	.50	.50
Vitamin trace mineral mix[a]	.25	.25
Antibiotic mix[b]	.20	.20
Calculated analysis, as fed		
Crude protein, %	14.01	16.01
Lysine, %	.62	.77
Calcium, %	.85	.85
Phosphorus, %	.61	.60

[a]Supplied 4,000,000 IU Vitamin A, 400,000 IU vitamin D, 19,000 IU vitamin E, 4 gm riboflavin, 20 gm pantothenic acid, 27 gm niacin, 20 mg vitamin B_{12}, 1 gm menodione sodium bisulfite, 25 gm Mn, 90 gm Fe, 90 gm Se, 1180 mg I, 10 gm Cu and 90 gm Zn per ton of feed.
[b]Supplied 40 gm of tylosin per ton of feed.

Results and Discussion

Feeding choline and (or) dichlorvos to gestating gilts produced no significant differences in the number of live pigs born, number live at 21 and 42 days and percentage survival rate (Table 2).

The effect of feeding both choline and dichlorvos upon individual pig and litter weights at birth, 21 days and 42 days is shown in Table 3. Gilts on treatments receiving choline (2 and 4) farrowed pigs with higher birth weights ($P<.01$) than did those on the other two treatments. Pigs from gilts on treatments 2 and 4 had average birth weights of 3.11 and 3.09 lb, respectively, vs 3.02 and 3.00 lb for treatments 1 and 3. The litter birth weight of pigs farrowed for gilts receiving choline and (or) dichlorvos (treatments 2, 3 and 4), although nonsignificant, also tended to be heavier than those farrowed by the gilts on the control diet (treatment 1). No significant differences were noted for pig and litter weights at 21 or 42 days. Thus, the increased birth weights of pigs from gilts receiving choline did not result in any increased weights at 21 or 42 days.

The lack of improvement in all the reproductive traits measured by feeding choline to the gestating gilts except for birth weight is in contrast to several previously published research reports including former Oklahoma research (Maxwell et al., 1978).

Likewise, the lack of improvement in all the reproductive traits measured by feeding dichlorvos contrasts with several previously reported research studies. No evidence of any interactive effect for choline and dichlorvos existed in this study. However this study does not eliminate the possibility that the effects of choline and dichlorvos are additive.

It has been reported in the popular press that supplemental choline may be beneficial in correcting the spraddle leg conditions observed under field conditions. A low overall incidence of spraddle legs (6.4,

Table 2. The effect of feeding choline and dichlorvos to gestating gilts upon litter size and survival rate.

	Treatments[a]			
	1	2	3	4
Choline:	0	+	0	+
Item Dichlorvos:	0	0	+	+
No. of litters	87	99	76	92
Avg. no. of live pigs at birth	9.62	9.59	9.92	9.70
Avg. no. of live pigs at 21 days	7.82	7.33	7.60	7.38
Survival rate, %	82.16	77.89	77.27	77.24
Avg. no. at 42 days	7.60	6.22	6.38	7.11
Survival rate, %	79.85	76.60	75.47	74.48

[a]No significant differences were noted among treatments.

Table 3. The effect of feeding choline and dichlorvos to gestating gilts upon pig birth weight and gain.

Item	Treatments 1	2	3	4
Choline:	0	+	0	+
Dichlorvos:	0	0	+	+
No. of pigs	853	929	797	887
Pig birth wt., lb	3.02[a]	3.11[b]	3.00[a]	3.09[b]
Litter birth wt., lb	28.95	29.68	29.86	30.03
Pig 21 day wt., lb	11.58	11.55	11.36	11.18
Litter 21 day wt., lb	90.23	84.76	86.74	82.80
Pig 42 day wt., lb	24.58	24.01	24.06	23.97
Litter 42 day wt., lb	186.10	172.76	177.99	171.26

[ab]Treatment means with different superscripts differ (P<.01).

Table 4. The effect of feeding choline to gestating gilts on the prevalence of parasites in the feces of the gilts and offspring[a].

Item	Treatments[b] 1 Gilts	1 Off-spring	2 Gilts	2 Off-spring	3 Gilts	3 Off-spring	4 Gilts	4 Off-spring
Choline:	0		+		0		+	
Dichlorvos:	0		0		+		+	
No. with ascarids eggs	1	2	2	0	0	0	0	0
No. with Trichuris eggs	0	0	3	2	0	0	0	0
No. with coccidia oocysts	0	4	0	1	0	5	0	0

[a]Number of gilts and (offspring) sampled were 42 (84), 49 (98), 37 (74) and 42 (84) for treatments 1 through 4 respectively.
[b]Fecal spriuid, stronglyle, and strongyloide eggs were not found in any of the animal feces sampled.

7.8, 6.8 and 8.1%) of pigs farrowed were noted for treatments 1 through 4 respectively with no significant differences existing among treatments which agrees with other recently published research reports.

Because dichlorvos is a common swine anthelmintic, the presence of fecal parasite eggs was measured in trials 1 and 2. The presence of fecal parasite eggs were extremely low in both gilts and their respective offspring in all treatments when measured in trials 1 and 2 as shown in Table 4. Only ascarid and Trichuris eggs were recovered in the feces of both gilts and weanling pigs. Coccidia were not found in the gilts examined, but a few of the offspring were passing oocysts, as shown in Table 4. Fecal spriuids, strongyles and strongyloides eggs were not found in any of the animal feces sampled.

These data suggest that internal parasites were not a serious problem in this trial and may lead one to suggest that the lack of effect of dichlorvos may be due to the lack of an internal parasite problem. However, Keasling et al. (1974) stated that the improvement of reproductive performance observed in their study was not the result of anthelmintic action of dichlorvos.

Literature Cited

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MUNGBEANS AS A PROTEIN SOURCE FOR GROWING-FINISHING SWINE

C.V. Maxwell[1], D.S. Buchanan[2], W. G. Luce[1], S.A. Norton[3] and R. Vencl[4]

Story in Brief

A study involving 482 pigs was conducted to determine the value of mungbeans as a replacement for soybean meal in growing-finishing swine diets. Pigs averaging 38 lbs and from two growth lines were randomly allotted to three dietary treatments consisting of a control corn-soybean meal diet or the control diet with either one-third or two-thirds of the supplemental lysine from soybean meal replaced by mungbeans (10.15 and 20.65 percent mungbeans in the diet, respectively) in the growing period. During the finishing period, 37.5 and 75 percent of the supplemental lysine from soybean meal was replaced (8.59 and 17.88 percent mungbeans in the diet, respectively). Studies to date with mungbeans suggest that the maximum level of mungbeans which can be effectively utilized by the growing pig is between 25 and 33 percent of the supplemental lysine. (7.5 to 10.15 percent of the diet). For the finishing pig, the maximum level appears to be between 5.6 and 8.6 percent of the diet although some sources of mungbeans may be fed at higher levels.

(Key Words: Mungbeans, Protein Source, Growing-Finishing Swine)

Introduction

Mungbeans represent an attractive alternative protein source for growing-finishing swine since they are available to some swine producers and are high in the limiting amino acid lysine. Previous research at Oklahoma State University indicated that mungbeans can replace a portion of the supplemental lysine in growing-finishing swine diets without affecting performance even though anti-nutritional factors or inhibitors have been shown to be present in raw mungbeans. Earlier trials determined that mungbeans can replace up to 25% of the supplemental lysine in the diet of growing swine (50-120 lbs) and up to 50 percent of the lysine in the diet of finishing swine (120-220 lbs) without affecting performance. However, replacing 50 percent of the supplemental lysine in the growing pig with mungbeans depressed performance. The maximum level of mungbeans which can be fed to finishing swine without affecting performance has not been determined. This study was conducted to determine the effect of replacing between 25 and 50% of the supplemental lysine with mungbeans on performance during the growing phase. Replacement levels higher than 50 percent were tested during the finishing phase.

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Materials and Methods

This study was conducted at the Southwestern Livestock and Forage Research Station, El Reno, Oklahoma in the Fall, 1984. A total of 482 pigs from two growth lines, selected for rapid or slow growth, were randomly allotted to three dietary treatments (Table 1). The three treatments during the growing period were: (1) a corn-soybean meal control diet (2) the control diet with one-third of the supplemental lysine supplied by mungbeans at the expense of soybean (10.15% mungbeans) (3) the control diet with two-thirds of the supplemental lysine supplied by mungbeans at the expense of soybean meal (20.65% mungbeans). During the finishing phase, the diets were: (1) the control corn-soybean meal finishing diet (2) the control diet with 37.6 percent of the supplemental lysine supplied by mungbeans at the expense of soybean meal (8.59 percent mungbeans) (3) the control diet with 75 percent of the supplemental lysine supplied by mungbeans (17.88 percent mungbeans). Diets were formulated to contain 0.75 percent lysine during

Table 1. Composition of experimental rations.

Ingredients	Growing			Finishing		
	Control	MB 33 1/3[a]	MB 66 2/3[b]	Control	MB 37 1/2[c]	MB 75[d]
Corn, yellow	76.87	73.28	69.05	82.32	79.21	75.22
Soybean meal	19.53	12.89	6.59	14.61	9.09	3.75
Mungbeans	---	10.15	20.65	---	8.59	17.88
Dicalcium phosphate	1.64	1.74	1.82	1.50	1.58	1.65
Calcium carbonate	.82	.80	.75	.82	.78	.75
Salt	.40	.40	.40	.40	.40	.40
Vitamin trace-mineral mix[e]	.25	.25	.25	.25	.25	.25
Tylan 10	.50	.50	.50	.10	.10	.10
Calculated composition[f]						
Lysine	.75	.75	.75	.62	.62	.62
Calcium	.75	.75	.75	.70	.70	.70
Phosphorus	.65	.65	.65	.60	.60	.60

[a] One-third of the supplemental lysine was supplied by mungbeans.
[b] Two-thirds of the supplemental lysine was supplied by mungbeans.
[c] Thirty-seven and one-half percent of the supplemental lysine was supplied by mungbeans.
[d] Seventy-five percent of the supplemental lysine was supplied by mungbeans.
[e] Supplied 4,000,000 IU vitamin A, 3,000,000 IU vitamin D, 4g riboflavin, 20g pantothenic acid, 30g niacin, 800g choline chloride, 15mg vitamin B_{12}, 10,000 vitamin E, 2g menadione, 200mg iodine, 90g iron, 20g manganese, 10g copper, 90g zinc and 100mg selenium per ton of feed.
[f] Based upon analyzed value for the lysine level in mungbeans.

the growing period and lysine was reduced to 0.62 percent during the finishing period. Mungbeans were ground moderately fine with the same hammermill and screen size used for grinding the grain portion of the diet. Pigs were housed in indoor concrete pens equipped with self-feeders and waterers.

Results and Discussion

The effect of level of mungbeans on performance during the growing period (38 to 118 lb) is presented in Table 2. Even though a line by treatment interaction was observed for average daily gain ($P<.01$), data from both growth lines were combined since the interaction was the result of the magnitude of the response of the two lines to treatment rather than a change in rank of treatment effects between the two lines. Replacing one third of the lysine from soybean meal with mungbeans (10.15 percent mungbeans in the diet) decreased gain 7.5 percent ($P<.01$). The replacement of two-thirds of the supplemental lysine from soybean meal with mungbeans resulted in a reduction in average daily gain of 12.0 percent ($P<.01$) when compared to pigs fed the control diet. Feed intake and feed efficiency were not significantly affected by dietary treatment, although replacing one-third or two-thirds of the lysine from soybean meal with mungbeans reduced feed efficiency by 5 percent and 8 percent, respectively when compared to pigs fed the control diet. These data suggest that the levels of mungbeans fed in this experiment exceed levels which should be included in the diet of growing swine. This is consistent with previous research (Maxwell et al., 1984) and suggests that the maximum level of mungbeans which can be effectively utilized by the growing pig is between 25 and 33 percent of the supplemental lysine (7.5 to 10.15 percent of the diet).

During the finishing period (Table 3), feeding either 8.59 or 17.88 percent mungbeans in the diet (37.5 and 75 percent supplemental lysine, respectively) reduced average daily gain ($P<.01$) by 5.7 and 7.2 percent, respectively. Similarly, slight, but nonsignificant, decreases in average daily feed intake and feed efficiency were observed. This study indicates that the maximum level of mungbeans which can be effectively utilized by finishing swine is less than 8.59 percent of the diet. These data are not consistent with an earlier trial (Maxwell et al., 1984) which indicated that finishing swine could utilize diets with up to 50% of the supplemental lysine coming from mungbeans (11.75%

Table 2. The effect of mungbeans on feed intake, average daily gain and feed efficiency for the growing phase of production.

Item	Treatment		
	Control	MB 33 1/3	MB 66 2/3
Pigs per treatment, no.	136	167	179
Initial weight, lb	39.78	35.97	38.05
Final weight, lb	120.70	119.08	114.17
Avg. daily gain, lb[a]	1.58[b]	1.46[c]	1.39[d]
Avg. daily feed intake, lb	3.97	3.91	3.84
Lbs. feed/lb gain	2.57	2.70	2.78

[a]Line by treatment interaction ($P<.001$).
[b]Means in same row which do not share a common superscript differ ($P<.01$).

Table 3. The effect of mungbeans on feed intake, average daily gain and feed efficiency for the finishing phase of production.

Item	Control	Treatment MB 37 1/2	MB 75
Pigs per treatment, no.	136	167	179
Initial weight, lb	120.70	119.08	114.17
Final weight, lb	223.14	221.39	218.66
Avg. daily gain, lb	1.94[a]	1.83[b]	1.80[b]
Avg. daily feed intake, lb.	6.21	6.10	5.99
Lbs. feed/lb gain	3.34	3.50	3.45

[ab]Means in the same row which do not share a common superscript differ ($P<.01$).

of the diet) without affecting performance. These differences in response between trials may be explained by variation in source of mungbeans for the two trials.

Literature Cited

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RAW MUNGBEANS AS A PROTEIN SOURCE FOR SWINE GESTATION DIETS

C. V. Maxwell[1], R. O. Bates[2], D. S. Buchanan[3], S. A. Norton[2] and W. G. Luce[1]

Story in Brief

A study involving 280 gilts was conducted to determine the value of mungbeans as a protein source for gestating swine. Gilts from two growth lines were fed either soybean meal or a combination of mungbeans and soybean meal (89% mungbeans and 11% soybean meal) as the protein supplement for sorghum grain based diets during gestation. The study was conducted over three seasons. Gilts fed the mungbean diet gained less weight during gestation and lost less weight during lactation. Pig and litter birth and 21 day weights were lower in gilts fed the mungbean diet in two of the three seasons. Pig and litter weaning weights (42 days) were lower in gilts fed the mungbean diet in all three seasons. No effect of dietary treatment on litter size or survival rate was observed. These data suggest that a level of 19.80 percent mungbeans in the diet of gilts during gestation may adversely affect weight gain and subsequent lactation performance. Additional studies are needed to determine the maximum level of mungbeans which can be fed to gilts during gestation.

(Key Words: Mungbeans, Protein Source, Gestation)

Introduction

Previous research at Oklahoma State University has shown that mungbeans can be used to replace from 25 to 50% of the supplemental lysine from soybean meal (7.5 to 12 percent of the diet) for growing or finishing swine, respectively, without affecting performance. Growth inhibitors present in mungbeans may decrease performance when fed at higher levels. Recent results have shown that raw soybeans can be fed to gestating gilts with no detrimental effects, suggesting that older swine may be less susceptible to inhibitors. Feeding high levels of mungbeans as the protein source for gestating gilts has not been studied. This study was conducted to compare the reproductive performance of gilts fed corn based gestating diets in which the supplemental protein was supplied by soybean meal or a combination of raw mungbeans and soybean meal. Mungbeans were included in the diet at a level at which tryptophan became limiting (supplemental protein was 89% mungbeans and 11% soybean meal).

Experimental Procedures

This study was conducted at the Southwestern Livestock and Forage Station, El Reno, Oklahoma in the 1983 fall and 1984 spring and fall farrowing seasons. A total of 280 crossbred gilts were randomly allotted from two lines selected for rapid or slow growth to two dietary

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[1]Professor [2]Graduate Student [3]Assistant Professor

treatments (Table 1). Treatments were: (1) a sorghum grain based gestation diet in which supplemental protein was supplied by soybean meal (2) a sorghum grain based gestation diet with a combination of raw mungbeans and soybean meal providing the supplemental protein. Mungbeans were included at a level at which tryptophan became limiting (supplemental protein was 89% mungbeans and 11% soybean meal). Mungbeans were ground moderately fine with the same hammermill and screen size used for grinding the grain portion of the diet. Both diets were started at the initiation of the breeding season.

All gilts were housed in outside dirt lots during gestation and group fed five pounds of feed per head per day. At day 110 of pregnancy, gilts were moved to individual farrowing crates, and litters were penned separately until weaned at 42 days. Gilts were fed a common lactation diet (Table 1) once daily (4.5 lb./day) from the time they were moved into individual farrowing stalls at 109 days of gestation. After parturition, gilts were allowed to consume the lactation diet ad libitum for the duration of the 42 day lactation period. All gilts were weighed at breeding, 109 days of gestation and 42 days postpartum, when their litters were weaned. Pig weights and litter size were recorded at birth, 21 and 42 days of age. Pigs had access to creep feed from 21 to 42 days of age.

Table 1. Composition of experimental diets.

Ingredient	Gestation Diet		Lactation Diet
	Control	Mungbean	
Sorghum grain, ground	81.22	73.23	77.84
Soybean meal, 44%	14.39	2.48	17.82
Ground mungbeans	---	19.80	---
Dicalcium phosphate	1.76	1.91	1.68
Calcium carbonate	1.04	.99	1.07
Salt	.34	.34	.34
Vitamin-trace mineral mix[a]	.25	.25	.25
Chlortetracycline[b]	1.00	1.00	1.00
Calculated composition			
Protein, %	13.64	13.03	14.85
Lysine, %	.62	.62	.68
Calcium, %	.84	.84	.84
Phosphorus	.63	.63	.63

[a]Supplied 800,00 IU Vitamin A, 80,000 IU Vitamin D, 3,400 IU Vitamin E, 800 mg riboflavin, 4,000 mg pantothenic acid, 5,400 mg niacin, 4 mg Vitamin B_{12}, 660 mg menadione sodium bisulfite, .4% manganese, 3.0% iron, .004% selenium, .008% iodine, .4% copper and 4.0% zinc per lb of premix

[b]Supplied 200 g. chlortetracycline/ton of complete feed.

Results and Discussion

Feeding mungbeans at a level of 19.80 percent of the diet during gestation reduced ($P < .05$) weight gain (Table 2). Gilts fed the mungbean diet tended to lose less weight during lactation ($P < .10$). The failure of the mungbean diet to support equivalent weight gains suggest that amino acid utilization of mungbeans was depressed since the diet was formulated based upon chemically determined amino acid values (with the exception of tryptophan). This could be due to either poor amino acid availability or proteolytic enzyme inhibitors present in mungbeans.

Mungbeans in the diet during gestation had no effect on litter size at birth, 21 days or 42 days (Table 3). Similarly, survival rate from birth to 21 days, birth to 42 days, or 21 days to 42 days was not affected by source of protein in the diet during gestation.

A season by treatment interaction for individual and litter birth and 21 day weight was detected, therefore results are presented within season (Table 4). During the fall, 1983 season, individual and litter birth weight was lower ($P < .01$ and $P < .05$, respectively) in pigs produced by gilts fed the mungbean diet during gestation compared to those fed the control diet. Similarly, individual 21 day weights were lower ($P < .05$) in pigs from gilts fed the mungbean diet. However, during the spring, 1985 season, pig weights at birth and 21 days were similar among gilts fed either the soybean meal or mungbean diet during gestation. During the fall, 1984 season, all pig weights were adversely affected ($P < .01$) in gilts fed the mungbean diet during gestation. These data suggest that mungbeans fed at a level of 19.80 percent of the diet may adversely affect pig birth weight and gain to 21 days of age. Seasonal effects may be explained by variation in source of mungbeans for the various trials.

The effect of source of protein in the diet during gestation on 42 day pig weight is presented in Table 5. Individual weaning weight (42 days) was reduced in both growth lines fed mungbeans during gestation ($P < .01$). Similarly, litter weight at weaning in both growth lines was lower ($P < .05$) in gilts fed mungbeans when compared to litter weight in

Table 2. The effect of feeding a soybean meal or mungbeans supplemented sorghum grain based diet to gilts during gestation on body weight change.

Item	Diet[a]	
	Control	Mungbean
Gilts per treatment, no.	146	134
Wt. change during gestation, lb.	129.51[a]	121.99[b]
Wt. change during lactation, lb.	-35.46[c]	-28.89[d]

[ab]Means in the same row that do not have a common superscript differ ($P < .05$).
[cd]Means in the same row that do not have a common superscript differ ($P < .10$).

Table 3. The effect of feeding a soybean meal or mungbean supplemented sorghum grain based diet to gilts during gestation on litter weight and survivability.

Item	Diet[a] Control (N=143)	Mungbean (N=137)
Litter Size, (n)		
Birth	9.49	9.52
21 days	7.55	7.45
42 days	7.23	7.40
Survival Rate, (%)		
Birth to 21 days	80.41	79.77
Birth to 42 days	78.17	78.01
21 days to 42 days	97.02	97.42

[a]No differences (P<.05) were noted between diets

Table 4. The effect of feeding the control vs mungbean diet during gestation on pig birth weight and 21 day weight[a].

Year-Season Farrowed	Diet[a] Control	Mungbean
Fall, 1983		
Individual birth wt, lb.	3.30[b]	3.17[c]
Individual 21 day wt, lb.	11.31[d]	10.89[e]
Litter birth wt, lb.	31.50[d]	29.92[e]
Litter 21 day wt, lb.	84.41	82.19
Spring, 1983		
Individual birth wt, lb.	3.37	3.37
Individual 21 day wt, lb.	12.25	12.41
Litter birth wt, lb.	31.66	31.66
Litter 21 day wt, lb.	91.52	92.40
Fall, 1984		
Individual birth wt., lb.	3.21[b]	2.97[c]
Individual 21 day wt., lb.	11.84[b]	10.96[c]
Litter birth wt., lb.	30.65[b]	28.09[c]
Litter 21 day wt., lb.	89.21[b]	82.19[c]

[a] Year-Season by treatment interaction (P<.05).
[bc]Means in the same row that do not have a common superscript differ (P< .01).
[de]Means in the same row that do not have a common superscript differ (P<.05).

Table 5. The effect of feeding the control vs mungbean diet during gestation on individual and litter weaning weight.[a]

Item	Rapid Growth Line Treatment		Slow Growth Line Treatment	
	Control	Mungbeans	Control	Mungbeans
Individual Weaning Wt., lb.	26.33[b]	23.88[c]	22.69[b]	22.03[c]
Litter Weaning Wt., lb.	189.67[d]	170.74[e]	163.85[d]	161.05[e]

[a] Line X treatment interaction (P<.01).
[bc] Means within selection line in the same row that do not have a common superscript differ (P<.01).
[de] Means within selection line in the same row that do not have a common superscript differ (P<.05).

gilts fed the control corn-soybean diet during gestation. However, for both individual weaning weight and litter weaning weight, the magnitude of the decrease in performance was much greater in the rapid growth lines than in the slow growth line resulting in a line by treatment interaction (P<.01). It is evident that depressing effects of mungbeans on pig weight observed at birth and at 21 days continue to weaning.

These data indicate that mungbeans fed at 19.80 percent of the diet during gestation adversely affected weight gain and subsequent lactation performance of gilts. Even though older swine may be less susceptible to inhibitors present in legume seed, it appears that the level of mungbeans used in this experiment exceeded the capacity of gilts to overcome the proteolytic enzyme inhibitors present in mungbeans. Additional studies are needed to determine the level of mungbeans which can be utilized by gestating gilts without adversely affecting performance.

EFFECT OF SYNCHROMATE-B ON ESTROUS RESPONSE AND PREGNANCY RATE IN BRAHMAN CROSSBRED BEEF COWS

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Story in Brief

Mature crossbred beef cows were used to evaluate the effect of Synchromate-B on estrous synchronization and pregnancy rate in postpartum cows with 0-Brahman, 1/4 Brahman, or 1/2 Brahman breeding. All cows were greater than 35 days postpartum at the start of the study. Cows were palpated for ovarian activity (presence of a corpus luteum) and randomly assigned within breed group to either synchronization with the Synchromate-B program or to Control (21 day AI breeding period). Calves were removed from cows for 48 hours in both groups on the day implants were removed (Day 9) from synchronized cows. Synchronized cows were observed for estrus and bred 12 hours after observed estrus; those not seen in estrus were bred 56 hours after implant removal. A 21-day breeding period was initiated in Control cows on Day 11. Within 48 hours of implant removal, 85% of synchronized cows exhibited estrus; whereas, 28%, 64% and 82% of the Control cows exhibited estrus by week 1, 2 and 3, respectively. Pregnancy rate was similar among breed groups within a treatment; however, pregnancy rate was significantly lower in the synchronized group when compared with Controls. Brahman crossbred cattle can be effectively synchronized for spring breeding; however, a lower pregnancy rate should be expected in a synchronization program compared to breeding on natural estrus.

Key Words: (Synchromate-B, Pregnancy Rate, Estrus, Brahman)

Introduction

Previous research has shown that Brahman heifers synchronized with Synchromate-B will exhibit estrus and ovulate. However, the synchronized heifers had a lower pregnancy rate when compared with control heifers bred on natural estrus. It was suggested that the reduced pregnancy rate may be due to altered timing of luteinizing hormone release in the synchronized heifers. With the increasing popularity of Brahman crossbred cattle in the Southern region, we were interested in determining the effect of Synchromate-B on synchronization and pregnancy rate in mature, postpartum Brahman crossbred cows.

Materials and Methods

One hundred forty-nine mature crossbred beef cows composed of 0-Brahman (Hereford-Angus and Angus-Hereford), 1/4-Brahman (1/4-Brahman 1/2-Angus 1/4-Hereford or 1/4-Brahman 1/2-Hereford 1/4-Angus), and 1/2-

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Brahman (Brahman-Angus and Brahman-Hereford) breeding were used in this study. Beginning in early May, ovarian activity was determined by rectal palpation of corpora lutea. Cows were then randomly assigned to either a Control or Synchromate-B treatment group, with approximately the same number of cows with ovarian activity assigned to each group and breed division.

Cows in the synchronized group were injected and implanted as specified by manufacturers instructions on Day 1 of the trial. Forty-eight hour calf removal was initiated on Day 9 in all cows from both treatment groups. At this time implants were removed and tail heads of synchronized cows were chalked with a Paint-Stik to aid in estrous detection. Estrous activity was detected by visual observation and signs of chalk removal from the tail head. Synchromate-B treatment cows were inseminated 12 hours after observed estrus or 56 hours after implant removal if estrus was not detected. All calves were returned to their dams after the synchronized cows were inseminated.

Estrous detection was initiated in Control cows on the day calves were returned to their dams. Gomer bulls fitted with chin ball markers were utilized to aid in estrous detection. Cows were inseminated 12 hours after the detection of estrus. The breeding period for Control cows was 21 days. Two technicians inseminated cows with frozen semen from 6 Limousin sires. Sires were randomly assigned to each cow before the start of breeding so each bull was used equally among the 3 breed groups and the 2 treatments. Ten days following AI, cows were exposed to fertile bulls. Synchromate-B cows were palpated for pregnancy 40 days after insemination; whereas, all Control cows were palpated 40 days after the end of the 21-day AI period.

Results and Discussion

Synchronization with Synchromate-B resulted in a higher percentage of cows expressing estrus early in the 21-day breeding period. After implant removal, 84% of the Synchromate-B treated cows expressed estrus within 48 hours, while only 28% and 64% of the Control cows had exhibited estrus after the first and second week of breeding ($P<.05$). However, by the end of the 21-day breeding period, 82% of Control cows had exhibited estrus. Determination of estrus by visual observation of standing and by evidence of chalk removal from the tail head in the synchronized cows were equally effective methods of estrus detection. The percentage of Brahman breeding had no significant effect on pregnancy rate (Table 1). However, synchronization with Synchromate-B resulted in a lower overall pregnancy response when compared with cows bred on natural estrus ($P<.01$).

Technician differences contributed to a significant amount of the variation in pregnancy response. Technician fatigue may have affected Technician II as he achieved lower pregnancy rates in the synchronized cows when compared with Technician I (Table 2).

Semen quality and sire fertility also had a large effect on pregnancy rate ($P<.01$). The average pregnancy rate for the six bulls used in the study was 60% (Table 3).

Brahman cross cattle can be effectively synchronized with Synchromate-B and bred artificially with pregnancy rate as high as expected in synchronized British crossbred cattle. Several things must be considered before undertaking a synchronization program. Among them are quality and cost of semen, and the expertise of AI technicians. A

Table 1. Effect of Brahman percentage on pregnancy rate in Control and Synchromate-B treated cows.

	Control		Synchromate-B	
	No. of cows in group	Pregnant (%)	No. of cows in group	Pregnant (%)
0-Brahman	15	67 (10/15)	12	42 (5/12)
1/4-Brahman	35	57 (20/35)	32	44 (14/32)
1/2-Brahman	28	71 (20/28)	27	44 (12/27)
Total	78	64 (50/78)[a]	71	44 (31/71)[b]

[a,b] Means in a row with different superscripts differ (P<.01)

Table 2. Effect of technician on pregnancy rate in Control and Synchromate-B treated cows.

	Technician		
Treatment	I	II	Total
Control	80[a]	74[a]	78[a]
Synchromate-B	58[b]	26[b]	44[b]

[a,b]Means in a column with different superscripts differ (P<.10).

Table 3. Effect of sire on pregnancy rate.

Sire	Pregnant (%)
1	35
2	48
3	55
4	61
5	71
6	88
Average	60

skilled technician using quality semen can expect to get 50% to 55% of a group of cycling cows pregnant at the first insemination.

Synchronization with Synchromate-B will result in a significantly higher percentage of cows in estrus early in the breeding season. Although lower pregnancy rates would be expected, synchronized cows returning to estrus would have an additional opportunity to be bred, either naturally or artificially, approximately three weeks into the breeding season. Thus, a high percentage of pregnant cows would be grouped within a three-week calving period.

EFFECT OF HEAT STRESS ON EARLY EMBRYONIC DEVELOPMENT AND SURVIVAL IN THE BEEF COW

B.G. Biggers[1], D.S. Buchanan[2], R.P. Wettemann[3], M.T. Zavy[4], and R.D. Geisert[5]

Story in Brief

Thirty-two cyclic multiparous Hereford and Hereford X Angus cows were utilized to determine the effects of heat stress on early embryonic development and survival. On Day 7 of pregnancy, cows were fitted with indwelling jugular cannulae and placed in one of the following treatment groups: Control (22°C, 25% relative humidity), mild heat stress (37°C, 27% relative humidity) and severe heat stress (37°C, 40% relative humidity). Between days 8-16 of pregnancy, heat stressed cows had increased respiration rates, rectal temperatures, water intake and decreased hematocrit and plasma protein compared to controls. Plasma progesterone was elevated while thyroxine was decreased in severe heat stress when compared to mild stress and control groups. Cows were slaughtered on Day 17 of pregnancy to determine pregnancy status. There was a trend towards decreased conception rates with increasing thermal stress. Conceptus and corpus luteum wet weights were decreased in severe and mild heat stressed cows compared to controls. This study indicates that heat stress during early pregnancy (days 8-16) in the bovine can cause reduced conceptus weights and may increase embryonic mortality.

(Key Words: Heat Stress, Progesterone, Thyroxine, Conceptus, Corpus Luteum, Reproduction)

Introduction

Elevated environmental temperature and humidity close to the time of insemination result in reduced conception rates and altered hormone patterns in the beef cow. Previous work in the gilt and ewe indicates that high ambient temperature during early pregnancy results in reduced conceptus development, fetal degeneration and lower pregnancy rates. The blastocyst appears to be most susceptable to thermal stress during the first 2 to 3 weeks after insemination, a time period characterized by rapid embryonic development, growth, and attachment to the uterine endometrial surface. The purpose of this study was to determine the effect of elevated ambient temperatures during the second and third week of pregnancy on the maternal endocrine profiles and embryonic development in the beef cow.

Materials and Methods

Thirty-two cyclic multiparous Hereford and Hereford X Angus cows between 4 and 11 years of age were assigned randomly to either a control (C, n=11), mild heat stress (MHS, n=9) or severe heat stress (SHS, n=11) treatment. Estrous cycles were synchronized with Lutalyse[6] to group cows

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for placement in the environmental chamber, with the first day of estrus designated as Day 0 of pregnancy. Cows were pen mated to Angus and Hereford bulls of proven fertility. Following the insertion of an indwelling jugular cannulae on Day 7, groups of 3 or 4 cows from the same treatment were transported to the environmental chamber where treatments were applied from Day 8 through 16. Control groups were placed in a thermal neutral environment of 22±1°C and 25±10% relative humidity for 24 hours. Mild heat stress and severe heat stress treatment groups were maintained at 37±1°C between 0700-1900 hours which was decreased to 33±1°C between 1900-0700 hours to allow cows to dissipate some of the heat load during the evening hours. The relative humidity was maintained at 27±2% in the MHS environment while relative humidity was increased to 40±2% in the environment of the SHS groups. All cows were individually fed a 20% crude protein maintenance diet (17.6 kg/cow/day) consisting mainly of cottonseed hulls, rolled corn and soybean meal.

Rectal temperature, respiration rate and water intake were taken twice daily at 0700 and 1900 hours from Day 8 through 16. Blood samples (20 ml) were collected at 1900 hours for progesterone and thyroxine analysis. All samples were placed immediately on ice until centrifugation at 2,000 X g for 30 minutes. Plasma samples were stored at -20°C until analyzed. Hematocrit was immediately analyzed from the collected samples and the resulting plasma was used to analyze plasma protein using a refractometer. Plasma thyroxine and progesterone concentrations were quantified by radioimmunoassay. Rectal temperature was monitored with a digital rectal thermometer while respiration rate was measured by counting flank movements per minute. Water intake was monitored from a calibrated automatic drinking device. All cows were fed at 0700 hours with feed consumption measured at 1900 hours.

On Day 17, cows were transported to a local slaughter house where the uterus was recovered within 15 minutes after exanguination. The uterus was immediately placed on ice and transported to the laboratory (15 km). The uterus was trimmed free of the mesometrium and the contralateral and ipsilateral horn to the corpus luteum flushed separately with 20 ml of 0.9% saline. Pregnancy was confirmed by the presence of a conceptus which was immediately weighed (wet weight). The corpus luteum was dissected from the ovary and trimmed free of the surrounding connective tissue for measurement of tissue wet weight.

Physiological responses and plasma hormone trends of treatments were analyzed by least-squares analysis of variance. Day trends were characterized by polynomial curves, whereas individual treatment and treatment X day means were estimated as least-squares means. Data were analyzed with time used as a continuous independant variable.

Results and Discussion

The physiological responses in this experiment indicate that cows in both MHS and SHS groups were exposed to a higher effective heat load than Control cows (Table 1). The elevation of rectal temperatures indicate that the heat stressed groups were absorbing heat at a greater rate than could be dissipated, thus stimulating an increase in respiration rate as cows attempted to decrease their internal body temperature by respiratory evaporation. Water consumption increased in SHS cows and tended to increase with MHS as these cows would have a higher requirement to meet the needs for evaporatory water loss. Lower hematocrit and plasma protein concentrations in the heat stressed groups may have resulted from a increase in plasma volume.

Table 1. Least-squares means of physiological and hormonal responses to Treatment.

	Control	MHS	SHS
Respiration rate, B/min	56[a]	99[b]	103[b]
Rectal temperature, °C	38.9[a]	39.3[b]	39.8[b]
Water intake, L	114.7[a]	124.2[a]	154.1[b]
Hematocrit, %	31.5[a]	30.0[b]	26.5[b]
Plasma Protein, mg%	7.3[a]	7.0[b]	7.0[b]
Progesterone, ng/ml	6.6[a]	6.8[a]	7.5[b]
Thyroxine, ng/ml	48.3[a]	47.8[a]	42.7[b]
Pregnancy rate, %	83	64	50
Conceptus wet weight, g	0.1579[a]	0.1106[b]	0.0728[b]
Corpus luteum wet weight, g	3.39[c]	2.77[d]	2.80[d]

[a,b]Least-squares means with different superscripts are different (P<.01).
[c,d]Least-squares means with different superscripts are different (P<.10).

Cows in severe heat stress attempted to lower their heat load by adjusting circulating thyroxine levels (Table 1, Figure 1). The lowering of plasma thyroxine would result in decreasing the metabolism rate and the heat produced from metabolic processes.

Plasma progesterone concentrations in SHS cows were higher than the MHS and Control cows from Day 8 through 16 (Table 1, Figure 2). Even though MHS was not significantly different than Controls, concentrations of progesterone for MHS was intermediate between Control and SHS groups.

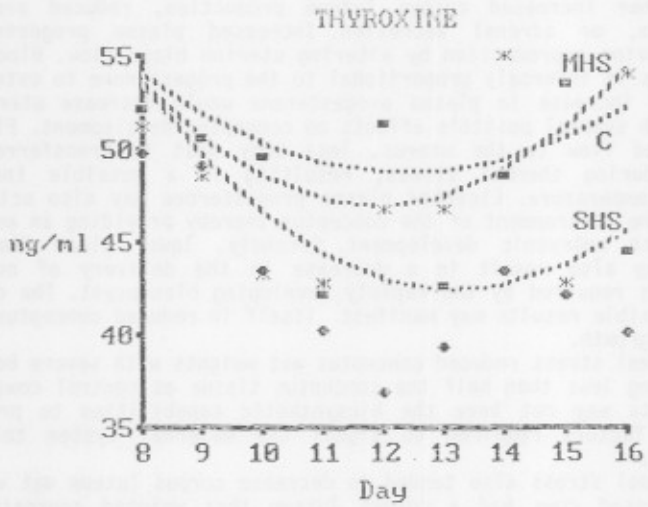


Figure 1. Least-squares regressions and least-squares means of thyroxine concentration (ng/ml) for control (C, ✱), mild heat stress (MHS, ■) and severe heat stress (SHS, ●) cows.

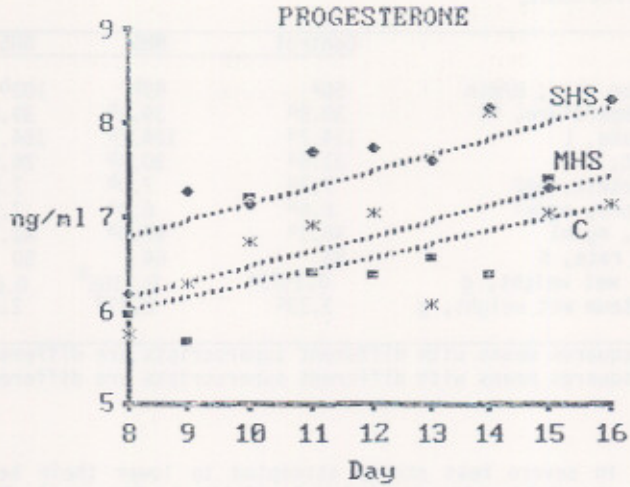


Figure 2. Least-squares regressions and least-squares means for the progesterone concentration (ng/ml) of control (C,✱), mild heat stress (MHS,■) and severe heat stress (SHS,●) cows.

It is possible that the elevation in progesterone concentration results from either increased corpus luteum production, reduced progesterone metabolism, or adrenal secretion. Increased plasma progesterone may affect bovine reproduction by altering uterine blood flow. Blood flow to the uterus is inversely proportional to the progesterone to estradiol-17B ratio. An increase in plasma progesterone would decrease uterine blood flow, with several possible effects on conceptus development. First, with less blood flow to the uterus, less body heat is transferred to the surface during thermal stress, resulting in a possible increase in uterine temperature. Elevated plasma progesterone may also act to alter the uterine environment of the conceptus thereby providing an environment hostile to embryonic development. Secondly, lower blood flow to the uterus may also result in a decrease in the delivery of nutritional substrates required by the rapidly developing blastocyst. The outcome of these possible results may manifest itself in reduced conceptus development and growth.

Thermal stress reduced conceptus wet weights with severe heat stress cows having less than half the conceptus tissue as control cows. Smaller blastocysts may not have the biosynthetic capabilities to produce the chemical factors required to signal the maternal system to maintain pregnancy.

Thermal stress also tended to decrease corpus luteum wet weights as heat stressed cows had a corpus luteum that weighed approximately .5 grams less than those of Controls. Reduced corpus luteum weights may indicate the release of prostaglandin produced by the uterus during heat stress. Should these prostaglandins escape the lumen of the uterus and enter the blood stream, their effect could be to regress the corpus

and enter the blood stream, their effect could be to regress the corpus luteum and terminate pregnancy.

The purpose of this study was not to mimic heat stressed situations that the bovine female would face naturally. We attempted to place the cows in the most thermally stressful situation possible and to determine whether or not we could in fact alter bovine early embryonic development and survival during the second and third week of pregnancy.

EFFECT OF RESTRICTED INTAKE ON CYCLIC OVARIAN ACTIVITY AND ESTRUS IN HEREFORD COWS

M.W. Richards[1], R.P. Wettemann[2], and H.M. Schoenemann[3]

Story in Brief

Multiparous Hereford cows (n=22) in moderate to good body condition were randomly allotted to maintain or lose weight under drylot conditions. Maintain cows received adequate feed to maintain initial body weight and lose cows were fed to lose 1% of their initial weight each week until cyclic ovarian luteal activity stopped. When approximately 75% of the lose group became anestrus, they received additional feed to gain weight until they resumed cyclicity. Body weights and body condition scores were recorded weekly and ovarian activity was assessed by evaluation of progesterone concentration in weekly plasma samples. Lose cows had reduced weight by 7 wk and reduced body condition by 14 wk when compared with maintain cows. Ovarian luteal activity ceased after 26 wk of reduced nutrient intake in 91% of the cows; cows had lost 24% of their initial weight and had a body condition of 3.5. Lack of ovarian activity was associated with absence of behavioral estrus. Estrous cycles resumed 9 wk after the beginning of increased nutrition; at which time, they weighed 12% less than at the start of the trial and had a body condition of 4.6. We conclude that anestrus occurs when nonlactating, Hereford cows lose weight and have a body condition of about 3.5. Fertile estrous cycles can be reinitiated by increased nutrient intake.

(Key Words: Anestrus, Beef Cow, Body Condition, Reproduction)

Introduction

Anestrus is a major cause of reduced pregnancy rates in cattle. The anestrous condition frequently results from reduced nutrient intake and depleted energy reserves. Although the precise physiological mechanisms controlling estrous cycles in domestic livestock are not clear, it appears that gonadotropin (pituitary hormone) secretion is altered. Reduced gonadotropin secretion results in decreased follicular development, absence of estrous activity, ovulation failure and subsequent inhibition of ovarian luteal activity.

The mechanisms whereby reduced nutrient intake alter brain function and subsequent steroid hormone synthesis have not been elucidated. Reduced pituitary function could lead to abnormal ovarian luteal activity. The objective of this study was to investigate the effects of reduced nutrient intake on estrous cycles and ovarian function in nonlactating, Hereford cows.

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Materials and Methods

Twenty-two nonpregnant, nonlactating Hereford cows were randomly assigned to maintain (M) or lose (L) body weight. Cows were in moderate to good body condition (BCS=5.5±.6; body weight (BW)= 926 lb) at the beginning of the trial. A complete ration (12% CP and 2.25 Mcal ME/kg of DM) was fed individually each day in a drylot for 41 weeks; groups were then pastured jointly on native range and supplemented with 2 lb/hd/d of a 40% protein cube.

Maintain cows were fed to maintain their initial BW and continue normal estrous cycles throughout the experiment. Lose cows were fed to lose approximately 1% of their initial BW weekly until 75% of the cows became anestrus; then, L cows were fed approximately 160% of the M amount. Lose cows received the gain ration until 70% of the anestrous cows resumed cyclic ovarian activity or expressed estrus.

Weights and body condition scores were recorded for all cows weekly for 45 consecutive weeks. Weight change percent was calculated as a percentage of a cow's initial weight. A minimum of 2 people assessed body condition weekly using the system where 1=emaciated and 9=obese. Weekly blood samples were taken via jugular venipuncture during the lose period. Twice weekly samples were taken during the regain period. Plasma samples were cooled on ice immediately after collection. Within 4 hr of collection, samples were centrifuged, plasma was decanted and stored at -20 C until assayed for progesterone by radioimmunoassay.

Androgenized cows fitted with chin-ball markers, weekly tail chalking, and visual observation were used to determine estrus. After the drylot period cows were pastured with fertile bulls fitted with chin-ball markers for 42 d of natural service. Pregnancy was diagnosed via rectal palpation 60 d after the end of breeding.

Results and Discussion

Lose cows were lighter ($P<.05$) than maintain cows by 7 wk of the trial (Table 1). By 30 wk the L group had lost 25.8% of their initial BW whereas M cows were similar to their initial weight (-1.7%). The effect of reduced nutrient intake on body condition was similar to its effect on weight change (Table 1). By 30 wk the L cows were 3 condition scores less than M cows (5.7 vs 2.7; M vs L, respectively; $P<.05$).

Reduced nutrient intake resulted in decreased ovarian function and estrous behavior. Cyclic ovarian luteal activity ended (progesterone concentration <1ng/ml for 3 consecutive wk) in 91% of the L group by 30 wk of restricted nutrition while 100% of the M cows had normal ovarian function at wk 30 (Table 2). Ovarian luteal activity ceased 26 ±2 wk after nutrient restriction began. Low cows had lost 24±3% of their initial weight and had a BCS of 3.5±.3. Lack of ovarian luteal activity was associated with anestrus.

It took approximately 10 wk of a high level of nutrition for L cows to regain enough weight and body condition to be similar to M cows (Table 1). Seventy-three percent of the L group had resumed estrous cycles by wk 8 of the regain period. Mean return to estrus was 9±4 wk from initiation of increased feeding. At resumption of estrous cycles, cows had regained 12±10% of their initial body weight and had achieved a body condition of 4.6±.5.

Table 1. Effect of restricted nutrient intake on weight change percent and body condition score.

	Weight change percent		Body condition score	
Week	Maintain	Lose	Maintain	Lose
Lose period				
5	.2	-5.7	5.5	5.5
10	-.3[a]	-9.0[b]	5.3	4.9
15	1.9[c]	-13.0[d]	5.7	4.8
20	.0[c]	-21.2[d]	5.7[a]	4.4[b]
25	-2.5[c]	-23.1[d]	5.8[c]	3.7[d]
30	-1.7[c]	-25.8[d]	5.7[c]	2.7[d]
Regain period				
5	-2.2[c]	-19.0[d]	5.6[c]	4.0[d]
10	2.0	-10.4	5.6	4.8
15	11.6	.7	5.8	5.0
17	16.9	6.5	5.8	5.2

[a,b]Treatment influenced the characteristic.

[c,d]Treatment influenced the characteristic.

Table 2. Effect of nutrient intake on cyclic ovarian activity (OA).

	Percent with OA	
Week	Maintain	Lose
Lose period		
5	82	100
10	100	100
15	100	100
20	100	100
25	100	91
30	100[a]	9[b]
Regain period		
5	100[a]	27[b]
10	91[c]	64[d]
15	91	82
17	100	91

[a,b]Treatment effect.

[c,d]Treatment effect.

Plasma progesterone concentration greater than 1 ng/ml for 2 consecutive wk is an indication of ovarian luteal activity. Ovarian luteal activity occurred 10±5 wk after implementation of increased nutrition; at which point, cows had regained 16% of their initial weight and achieved a body condition of 4.9±1.2. First estrus was associated with ovarian luteal activity in 8 of the 8 cows that were positively identified as standing to be mounted by other animals. Six of 8 cows

had a normal cycle (17-24 d). Two of 8 cows had a cycle length of approximately 42 d. This extended length may be because the cows did not exhibit estrus or were not observed in estrus.

First service pregnancy rate was similar for both groups (82 vs 86, M and L, respectively). This indicates that infertility due to nutrient restriction can be reversed when cows gain enough weight and condition to resume normal estrous cycles.

Nutrient intake significantly influences cyclic ovarian activity and estrus in beef cows. Nonlactating, nonpregnant cows that were allowed to reach a body condition score of 3.5 ceased to exhibit normal estrous behavior. Normal estrous cycles were reinitiated by feeding nonlactating cows to achieve an average body condition score of 4.6.

FACTORS AFFECTING MOBILIZATION OF BODY FAT IN LACTATING BEEF COWS

J.C. Garmendia[1], R.P. Wettemann[2], K.S. Lusby[3], J.C. Baker[4] and R.D. Geisert[5]

Story in Brief

Mature postpartum anestrous Hereford cows were used to determine the effect of insulin injections, glucose infusion, feeding additional energy and protein (flushing) and weaning on the concentrations of glucose, insulin and non-esterified fatty acids in plasma or serum. Neither treatment nor day of sampling significantly affected concentrations of glucose in plasma. Treatments influenced non-esterified fatty acids and insulin. Glucose infusion and feeding additional protein and energy increased serum concentrations of insulin and decreased plasma concentrations of non-esterified fatty acids.

(Key Words: Beef Cows, Body Fat, Post Partum, Reproduction)

Introduction

The supply of energy during the first weeks after parturition is very important in beef cows. The requirements for energy are difficult to meet in early spring calving cows because of the low quality of dry standing forage available. Frequently, the cow cannot eat enough feed to supply the energy needed for lactation and body reserves are mobilized to supply the deficit.

Energy deficiency is well documented as a factor which affects reproductive performance of beef cows. Changes in concentrations of glucose and non-esterified fatty acids (NEFA) in plasma may be used to evaluate the energy status of the postpartum cow. The objective of this experiment was to evaluate the effect of insulin injections, glucose infusion, feeding additional energy and protein (flushing) and weaning on the concentrations of glucose and NEFA in plasma and insulin in serum of postpartum beef cows.

Materials and Methods

Thirty mature anestrous Hereford cows with non-functional ovaries at 25 days post partum were used in this study. Cows received rations during late pregnancy so that they had body condition scores of 5 (1 = emaciated and 9 = obese) at parturition. Such cows usually exhibit their first postpartum estrus between 40 and 70 days post partum. On day 25 post partum, cow and calf pairs were transported 10 km from range pastures and pairs were maintained in individual pens in a total confinement building with 14 h of fluorescent light daily.

On day 25 post partum, five cows were blocked to each of the six treatments based on calving date: (1) Infused with 40% glucose solution (500 grams of glucose per day) continuously via a jugular cannula for 14

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days (days 29 - 42 post partum) to increase plasma glucose concentration by about 10 mg% (to about 70 mg%); (2) cows were injected twice daily at 12 h intervals with 50 iu insulin (zinc protamine) during days 29 - 42 post partum; (3) cows were fed an additional 5 kg of a 20% crude protein diet daily from 25 - 42 days post partum; (4) calves were weaned from the cows at 35 days; (5) infusion control cows were infused via a jugular cannula with saline solution from 29 - 42 days post partum and (6) non-infused control cows. Cows and calves were constantly together except for animals assigned to treatment 4.

Jugular cannulae were placed in cows on day 25 postpartum. Two cannulae were placed in cows assigned to treatments 1 and 5 and one cannula in the other cows. Plasma glucose and NEFA and serum insulin were monitored in samples taken daily between 25 and 42 days post partum. On day 42, postpartum cows were returned to range pastures.

Results and Discussion

Neither treatment nor day of sampling significantly affected postpartum concentrations of plasma glucose. Glucose in plasma tended to be greater in cows that received the glucose infusion (73.9 mg/%). Cows treated with insulin had the greatest variation in concentrations of glucose.

Treatments and day significantly influenced concentrations of NEFA ($P < .01$; Table 1). Glucose infusion decreased ($P < .01$) NEFA in plasma (482 uEq/1) when compared with cows that received saline infusion (644 uEq/1). This indicates that fat mobilization was reduced in cows given additional glucose. Similarily, flushing also decreased ($P < .01$) mobilization of depot fat (533 uEq/1) compared to control cows (673 uEq/1). Treatments affected serum insulin concentrations. Glucose infusion and feeding additional energy significantly increased ($P < .05$) serum insulin when compared with control cows. Concentrations of NEFA decreased with day of treatment. This change may be associated with a change of environment and diet since cows were moved from range pastures to the Nutrition Physiology Research Center at the start of the trial. Diet was changed from dry range grass, hay and cottonseed meal to pelleted alfalfa as the complete ration.

In conclusion, plasma concentrations of NEFA may be useful to evaluate the energy status of postpartum cows. Concentrations of NEFA in plasma were reduced by continuous glucose infusion or feeding additional energy and protein. This suggests that less body fat stores were mobilized when cows were given additional energy.

Table 1. Concentrations of glucose, NEFA and insulin in postpartum cows during treatments (13 days).

Treatment	Glucose (mg/%)	NEFA (uEq/L)	Insulin (ng/ml)
Control	67.4	673^{b}	2.0^{b}
Saline Infusion	55.8	644^{b}	1.5^{b}
Glucose Infusion	73.9	482^{a}	6.4^{a}
Insulin	59.6	695^{ab}	3.6^{ab}
Weaning	68.0	568^{b}	3.2^{ab}
Flushing	70.2	533^{a}	6.2^{a}

^{ab}Means in a column with different superscripts differ ($P < .05$).

POSTPARTUM NUTRITION, BODY CONDITION AND REPRODUCTIVE PERFORMANCE OF FIRST CALF HEIFERS

R.P. Wettemann[1], K.S. Lusby[2], J.C. Garmendia[3], M.W. Richards[3], G.E. Selk[4] and R.J. Rasby[3]

Story in Brief

Forty Hereford and Angus x Hereford first calf 2-yr-old heifers calving in February and March were used in the first replicate of a study to evaluate the influence of body condition score at calving and nutrient intake post partum on reproduction and calf performance. Birth weights of calves were not influenced by body condition score at parturition. Heifers were fed to maintain or gain weight after calving. At the start of the breeding season, gain heifers were heavier (377 vs 313 kg) and had a greater body condition score (5.4 vs 4.7) than maintain heifers. Of the heifers calving with a body condition score of 4 and fed to maintain weight, fewer had ovarian activity during the breeding season compared with heifers that calved with a body condition score of 5 or 6 and maintained weight, or calved at a body condition score of 4, 5 or 6 and gained weight. Pregnancy rate was reduced in heifers with body condition score of 4 that maintained weight post partum (20%) compared to the other treatments (75-100%). These data suggest that calf birth weight is not influenced by body condition score between 4 and 6 at calving but reproductive performance may be altered.

(Key Words: Body Condition, First Calf Heifer, Nutrition, Post Partum, Reproduction)

Introduction

Body condition of beef cows at spring calving is an important factor that regulated reproductive performance. Weight gain after calving may influence pregnancy rate and the interval from calving to conception. The objectives of this study were to determine the influence of body energy reserves at calving and postpartum nutrition of first calf heifers on reproduction and calf performance.

Materials and Methods

Forty Hereford and Angus x Hereford heifers that calved as 2-yr-olds during February and March, 1985 were used in this study. About 3 months prior to the initiation of the calving season, the cows were blocked based on body condition score (BCS, 1=emaciated, 9=obese) and breed and divided into two groups. They were fed so heifers would calf with BCS between 4 and 6.

At calving, heifers were again blocked based on BCS and breed and allotted to either maintain weight or gain (.5 kg/day) during the postpartum period. Gain heifers were offered a 12% CP complete ration

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free choice and maintain heifers grazed pasture and received supplemental hay and 1.5 kg/d 41% CP cotton seed meal cubes. Progesterone was quantified in blood samples collected each week during the 60 day breeding season to determine ovarian luteal activity. Natural breeding commenced on May 1 when heifers were between 41 and 84 days post partum.

Results and Discussion

At calving the BCS of the heifers ranged from 4 to 6. Birth weights of the calves were not influenced by BCS at parturition. Birth weights, corrected for sex of calf, averaged 30.8, 30.4 and 30.7 kg for heifers with BCS of 4, 5 and 6, respectively. Calving difficulty and loss of calves at birth were not influenced by BCS. Calf loss averaged 10% for all treatment.

During the four weeks before the start of breeding, maintain heifers actually lost .2 kg/d and gain heifers gained .8 kg/d. At the start of the breeding season, gain heifers were heavier (377 vs 313 kg; P<.01) and had a greater BCS (5.4 vs 4.7; P<.01) than maintain heifers.

Body condition score at calving and nutrient intake after calving influenced reproductive performance (Table 1). Fewer heifers that calved with a BCS of 4 and were fed to maintain weight had ovarian luteal activity during the breeding season compared with heifers on the other treatments (BCS and postpartum nutrition). Pregnancy rate tended to be reduced in heifers with a BCS of 4 that maintained weight compared to the other heifers.

Weaning weight of the calves was not influenced by BCS of the heifers at calving. However, calves from heifers that were fed to gain weight after calving were heavier at weaning (170 vs 164 kg) compared to calves from heifers fed to maintain weight during the first 85 days after calving.

This trial suggests that calf birth weight is not influenced by body energy reserves of first calf heifers when they have BCS between 4 and 6 at parturition. Reproductive performance is influenced by BCS and postpartum nutrition. This trial will be replicated during the spring, 1986 calving season.

Table 1. Reproductive Performance of heifers that calved with a body condition score of 4, 5 or 6 and were fed to maintain (M) or gain (G) weight post partum.

Criteria	BCS					
	4		5		6	
	M	G	M	G	M	G
Heifers (no)	5	4	8	11	4	3
OA during breeding (%)[a]	20	100	75	91	100	100
Onset OA (da)[b]	101	100	94	90	96	76
Pregnancy Rate (%)[c]	20	100	75	82	75	100

[a]Ovarian luteal activity determined by concentration of progesterone in plasma. BCS x Nut (P<.05).
[b]Days from parturition until concentration of progesterone in plasma indicated ovarian luteal activity.
[c]BCS x Nut (P<.12).

THE IMPORTANCE OF BODY CONDITION AT CALVING ON REPRODUCTION IN BEEF COWS

G. E. Selk[1], R. P. Wettemann[2], K. S. Lusby[3], and R. J. Rasby[1]

Story in Brief

Body condition scores at calving were related to pregnancy rate and days from calving to subsequent conception in 110 cows. Pregnancy rates were reduced (50%) in cows that were body condition score = 4 at calving compared to 81%, 88%, and 90% for cows with body condition score = 5, 6, and 7, respectively. Days from calving to conception were not significantly different for cows calving in body condition score greater than 5.3 vs. cows with body condition score less than 5.3 (89 and 100, respectively) but pregnancy rates were different (90% and 66%, respectively). Additional feed costs to maintain body condition above 5.3 were compensated and returned an additional $27.00 per cow in the herd.

(Key Words: Beef Cow, Body Condition, Reproduction)

Introduction

Body condition at the time of calving has been related to reproductive performance in beef cows. The processes of fetal development, parturition, lactation, and involution of the reproductive tract are all physiological stresses. These stresses require the availability and use of substantial quantities of energy to enable cows to be re-bred within 85 days. Additional energy intake, as grain or forages, will be costly if they must provide all of the calories needed to meet these requirements. Energy to meet some of these needs must be provided by stored body energy or fat (condition). Consequently, if nutrient intake after calving is equal, cows with extra body energy stores will meet the caloric needs of parturition, lactation, reproductive tract repair and re-breeding more readily than thin cows. With this thought in mind, a study was undertaken to quantify the differences in reproduction in cows of various body conditions (or fatness) at calving.

Materials and Methods

Body condition scores and reproductive performance from 110 Hereford cows (65 cows in year one; 45 cows in year two) were analyzed. Cows were weighed and body condition scores (BCS; scale: 1 = emaciated; 9 = obese) were assigned biweekly from fall (Nov 15) through calving in March and April. Cows were blocked by age, weight, and BCS into four nutritional treatments designed to create differences in body condition at calving. All cows were wintered on standing native range near Stillwater, Oklahoma. One fourth of the cows (M) were fed (cottonseed

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meal, 41% crude protein) to maintain fall weight to precalving. The remainder of the cows were supplemented to lose 5% of the fall weight by Jan 20 (6 weeks prepartum), then were divided into three other supplementation groups. One group was further restricted in nutrient intake (LL) to lose another 5% of fall weight by calving. Cows in the LM group were fed with the M cows the last 6 weeks prepartum, while those in LH treatment group were fed 140% of the supplement received by the M cows. Cows were fed free choice grass hay and 4 pounds of supplement after calving until summer pastures were available.

Groups of two or more bulls (approximately 20 cows/bull) were rotated among breeding pastures starting on May 1. Pregnancy was determined by rectal palpation 60 days after the end of the 90 day breeding season. The dates of conception were calculated from the next year's calving date minus a 281 day gestation. Body condition scores were assigned in half-score increments, by two or more technicians and then averaged.

Previous research had indicated that cows with BCS greater than 5.3 at calving had a greater likelihood of becoming pregnant than cows with lesser body condition. Therefore cows in this analysis were divided at 5.3 BCS at calving to examine differences in pregnancy rate, days to conception, and return to management and labor.

Results and Discussion

Cows in both years had similar BCS at initiation of the winter supplement program (6.4 and 6.2, respectively). The range of average precalving BCS for treatment groups was 5.0 for LM cows in year two to 6.6 for M cows in year one. Fourteen cows calved in a BCS less than 5.0. The majority of the cows were in the BCS of 5 and 6 (43 cows in each). Only 10 cows were classified as BCS greater than or equal to 7 at the time of calving. Pregnancy rates for cows in the various BCS at calving are presented in Figure 1. Cows calving in BCS less than 5.0 had the lowest pregnancy rates (50%) compared to cows in other BCS groups. There is little if any advantage in pregnancy rate for cows calving in a BCS 7 compared to those with BCS 6.

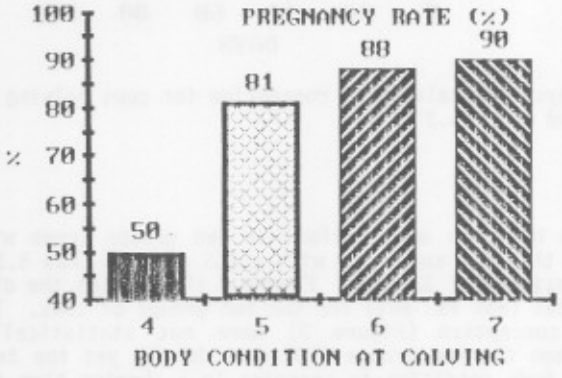


Figure 1. Pregnancy rates (percentage of cows) for cows calving as BCS = 4,5,6, and 7

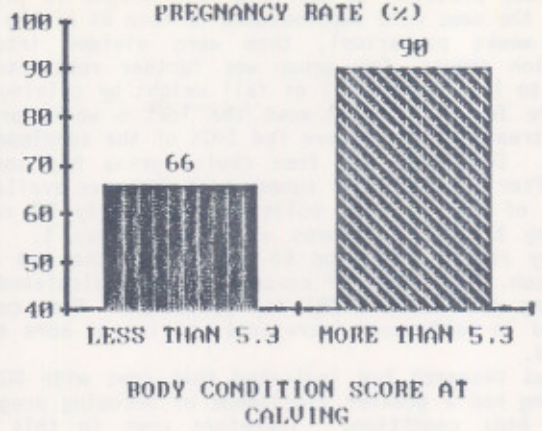


Figure 2. Pregnancy rates (percentage of cows) for cows calving as BCS < 5.3 and BCS > 5.3

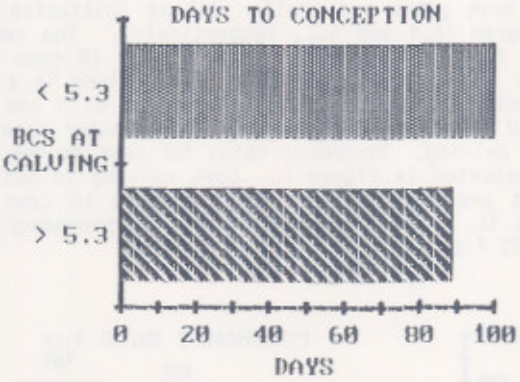


Figure 3. Days from calving to conception for cows calving as BCS < 5.3 and BCS > 5.3

When the cows were divided in two groups (cows with a BCS at calving less than 5.3 and those with a BCS greater than 5.3), the lower BCS group consisted of 32 cows. Figure 2 illustrates the differences in pregnancy rates (66% vs 90%) for the two groups of cows. The days from calving to conception (Figure 3) were not statistically different ($P<.05$) between the two groups (100 d vs 89 d), yet the trend for cows with greater body condition to conceive in a shorter time is consistent with previous findings (Dunn and Kaltenbach, 1980). Body condition at calving is an important factor influencing reproductive performance in beef cows during their next breeding season.

Economic Considerations

The cost effectiveness of achieving the greater BCS at calving, with extra hay and supplement inputs, were examined using several important assumptions:

1. Cows found nonpregnant via palpation were left in the herd for the subsequent year. All cows found pregnant maintained the pregnancy and weaned a calf.
2. Receipts from the calf crop were computed by a market value for all calves. The ratio of steer to heifer calves sold is 1:1.
3. Steer calves were valued at $8.00/cwt more than heifer calves.
4. Calves from cows with greater BCS were 10% heavier at weaning due to increased milk production, and the calves average 11 days older at weaning. The heavier calves were priced $1.00/cwt less than lighter calves.
5. Cows with less than 5.3 BCS at calving had a 70% pregnancy rate, and cows with greater than 5.3 BCS at calving had a 90% pregnancy rate.
6. Cows with greater than BCS of 5.3 (at calving) consumed an average of 3 lbs cottonseed meal (41% C.P.; @$180/Ton) per day for 165 days (such as fed to M cows described above) and 2.5% of body weight in grass hay (@$40/Ton) during 70 days.
7. Cows with less than BCS of 5.3 consumed an average of 2 lbs cottonseed meal per day for 165 days (such as fed to LL cows described above) and 2% of body weight in grass hay for 25 days of inclement weather.
8. Pastures were rented and 75% of operating capital was borrowed at 14% interest (A.P.R.) for 9 months.
9. Fixed costs consisted of interest on investment, insurance, depreciation, and taxes.

Table 1 compares the generalized inputs and receipts from cows fed to maintain a fall body condition score (>5.3) until calving compared to cows expected to lose body condition to less than 5.3 at calving. The sizeable fixed costs (much of which is interest on borrowed capital) causes both groups of cows to be non-profitable. However, the extra variable costs incurred with cows fed to maintain body weight are more than compensated with the increased calf sales.

Table 1. Economic comparisons (per cow) of cows fed to maintain a BCS greater than 5.3 at calving with cows fed to lose body condition and calve at less than 5.3

	Cows > 5.3	Cows< 5.3
Variable costs	$192.07	$149.73
Fixed costs	97.27	97.27
Total costs	289.34	247.00
Receipts	249.16	179.16
Return to Management	-40.18	-67.84

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DIETARY PROTEIN AND REPRODUCTIVE EFFICIENCY OF DAIRY CATTLE
2nd Year of a Two Year Study

E.P. Aalseth[1], H.J. Howard[2], L. Dawson[3], G.D. Adams[4] and L.J. Bush[5]

Story in Brief

During the second year of a 2-year study, 62 dairy cows were fed either 15 or 20% crude protein diets from 10 ± 4 to 145 days postpartum. Milk production was increased slightly by feeding the higher crude protein diet. Nutritional stress as indicated by body weight and condition score and feed intake were not affected by diet. However, nitrogen metabolism was enhanced as evidenced by a 10 mg/100 ml increase in plasma urea when cows consumed the high protein diet. Reproductive performance as indicated by services per conception, intervals to first estrus and to conception was not influenced by diet. There does not appear to be antagonism between dietary protein requirements for lactation and reproduction.

(Key Words: Dietary Protein, Fertility, Days Open)

Introduction

The feeding program for high producing dairy cows is designed to provide adequate dietary constituents for efficient milk production. During the first 2 to 3 months of lactation, high producing dairy cows cannot consume enough feed to meet the demands of lactation. To provide the additional metabolites needed for the rapid increase in milk production that occurs at this time, cows mobilize adipose tissue and body protein. Feeding high protein rations is one way to increase the supply of dietary constituents cows can devote to milk production. The current dietary protein recommendation for cows producing 66 to 110 lbs of milk/day range from 14 to 22% of the ration on a dry matter basis (NRC, 1978).

Recently, some limited evidence indicated that reproductive efficiency was reduced when rations of 16% or more crude protein were fed (Folman et al., 1981; Jordan and Swanson, 1979). As services per conception were increased by 0.8 to 1 unit, it appeared that high dietary protein had interfered with fertilization and/or caused early embryonic mortality. These effects might be explained by changes in the uterine environment that are induced by high dietary protein (Jordan et al., 1983). Such a possible conflict between the dietary requirements for reproduction and lactation is of real concern to dairymen. A two-year experiment was conducted to determine whether or not high dietary protein is detrimental to the reproductive performance of lactating dairy cows when compared to moderate protein. In the first year of this study, high dietary protein did not appear to interfere with reproduction (Howard et al., 1985). This report covers the second year of this study.

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Materials and Methods

Fourteen Ayrshire and 49 Holstein cows of second and greater lactation were fed either a moderate (15%) or high (20%) crude protein diet. Diets were fed from 10 ± 4 days postpartum through the first 145 days of lactation. The complete mixed ration consisted of 45% sorghum silage and 55% grain concentrate on a dry matter basis. Calculated values of net energy for lactation were 0.66 and 0.67 Mcal/lb for the 15 and 20% crude protein diets, respectively. The percentages of wheat middlings and soybean meal in the concentrate mixture were varied to generate the desired levels of protein (Table 1). Cows were fed three times daily to the limit of consumption. Daily feed intake and feed refusals were recorded and weekly average dry matter and protein intake were determined. Body condition was evaluated by the system of Aalseth et al. (1983) whereby cows were scored on a scale of 1 to 9 (1 = extremely thin; 9 = over conditioned). Along with body weight, body condition was determined every two weeks as a measure of nutritional stress. Weekly plasma urea levels were measured to evaluate the effects of the diets on nitrogen metabolism. Weekly average milk production was calculated from daily milk production. Milk fat and protein were measured from samples of four consecutive milkings each week.

To evaluate reproductive performance, cows were palpated weekly to monitor uterine involution, ovarian function and pregnancy. Cows were observed twice daily for behavioral estrus and artificially inseminated with the same freeze lot of semen (within breed) at each estrus occurring 55 or more days postpartum by predominately one inseminator.

Table 1. Percentage (as fed) of grain/soybean meal concentrate.

Ingredients	% Crude Protein	
	15	20
Soybean Meal	23.5	53.0
Wheat Middlings	29.5	----
Corn, Ground	27.0	27.0
Oats, Crimped	5.0	5.0
Cottonseed Hulls	5.0	5.0
Molasses, Liquid	5.0	5.0
Limestone	1.5	1.5
Dicalcium Phosphate	1.3	1.3
Sodium Bicarbonate	1.0	1.0
Salt	0.7	0.7
Magnesium Oxide	0.5	0.5

Results and Discussion

These data represent the second year of a two-year study. Production and nutritional data were averaged for both breeds over the experimental period (Table 2). Both 4% fat corrected and actual milk production were increased 2-3 lbs by feeding the high protein diet. However, neither milk fat or milk protein percent were altered by diet. Actual percent crude protein in the diet averaged 14.2 and 19.1% on a dry basis in the moderate and high protein diets, respectively. Dry

Table 2. Effect of dietary protein level on production and nutrition performance parameters.

	% Crude Protein	
	15	20
Cows per treatment	32	31
Dietary crude protein (% dry matter)	14.2± .1[a]	19.1± .1
Dry matter intake (lb/day)	52.4± 1.1	51.7± 1.0
Actual milk (lb/day)	64.4± 1.9	67.2± 2.0
4% fat corrected milk (lb/day)	63.8± 1.9	65.7± 1.7
Milk fat %	3.97± .07	3.84 ± .05
Milk protein %	3.08 ± .05	3.10 ± .06
Body weight (lb)	1425± 9	1399± 8
Body condition score (1-9 scale)	5.1± .1	5.0± .1
Plasma urea (mg/100ml)	13.9 ± .3	22.6 ± .5

[a] ± S.E.M.

matter intake was comparable between the two diets. As average body weight and condition score were similar between diets and changed little throughout the experiment, nutritional stress was the same and negligible for all cows. Plasma urea was elevated about 10 mg/100 ml in cows consuming the high protein diet indicating that nitrogen metabolism had been shifted to excrete the additional ammonia produced.

Reproductive performance as affected by diet consumed is shown in Table 3. Diet did not affect ovarian function as indicated by interval to first estrus (Table 3). Similarity in services per conception in all cows as well as cows conceiving during the experiment demonstrated that fertilization rate and early embryonic mortality were not detrimentally affected by feeding high dietary protein. Good reproductive performance was further demonstrated in the short interval from calving to conception observed in cows fed both diets. Services per conception on cows conceiving during the 90-day breeding period of the experiment is perhaps a better indication of fertility as cows not conceiving are eliminated. Such cows probably had fertility problems independent of possible dietary effects. Reproductive performance was similar to that observed during the previous year of this experiment (Howard et al., 1985), and was uninfluenced by protein level in the diet.

Table 3. Reproductive performance of dairy cattle fed moderate and high levels of crude protein.

	% Crude Protein	
	15	20
Cows per treatment	32	31
Interval to first estrus (days)[b]	41.1±4.3[a]	46.6±4.5
Interval calving to conception[b]	81.6±4.4	79.6± 4.4
% pregnant on experiment[c]	97	89.6
Services/conception (cows conceiving)	1.50± .14	1.62± .18
Services/conception (all cows)[c]	1.53± .14	1.74± .17

[a] ±S.E.M.
[b] Cows treated for cyst or retained corpora lutea were eliminated.
[c] Cows with disorders precluding conception and pregnancy diagnosis were eliminated.

In summary, after completing the second year of this experiment involving a total of 145 cows (both years), there does not appear to be any antagonism between the dietary protein requirements for lactation and those of reproduction.

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FACTORS INFLUENCING POSTPARTUM REPRODUCTIVE PERFORMANCE OF SANTA GERTRUDIS COWS

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Story in Brief

Ninety-eight pregnant (85 to 160 d of gestation), Santa Gertrudis females at two locations were used to determine the influence of body weight and body condition during gestation and feeding additional energy after calving on reproductive performance. Routine ranch management and feeding procedures were followed except for the feeding of a high energy diet (flushing) to one half of the cows for 28 days commencing 14 days prior to the beginning of the breeding period.

Change in body weight was related to body condition score change in Santa Gertrudis cows. Body weight change accounted for 55 percent of the variation in body condition score change from mid-late gestation to breeding. Flushing reduced body weight and body condition loss after calving but did not influence reproductive performance. Pregnancy rate and ovarian luteal activity were not influenced by weight or condition changes either before or after calving. Precalving weight change influenced the interval from calving to conception. Feeding additional energy did not influence calf weights at breeding or adjusted weaning weights.

(Key Words: Body Condition Score, Cow, Post Partum, Reproduction)

Introduction

About 25-30 percent of the beef cows in the U.S. do not wean a calf each year, primarily a result of cows not conceiving during the breeding period. Postpartum anestrus is a major factor preventing cows from becoming pregnant.

There is a close relationship between body condition score and body energy reserves, and the magnitude of change in body weight and body condition are indicators of subsequent reproductive performance in beef cows. Breed type of cattle influences reproductive and nutritional processes and the relationships between body weight and body condition and reproductive performance may differ between breeds.

The primary objective of this study was to evaluate the relationships between body weight and body condition changes in Santa Gertrudis cows and to relate these parameters to reproductive performance. A second objective was to determine if feeding additional energy after calving influenced reproductive and calf performance.

Materials and Methods

Experiment 1

Fifty-three, first-calf Santa Gertrudis heifers, approximately 3 years of age, located on the King Ranch in south Texas were used in this

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experiment. Heifers calved between December, 1983 and March, 1984 and grazed bluestem pasture. Routine herd management and feeding procedures for the ranch were followed.

Heifers were weighed and body condition score (1=thin, 9=fat) was determined at four periods during the experiment: (1) midgestation (9/20/83), (2) precalving (12/7/83), (3) breeding (4/17/84) and (4) weaning (8/21/84). At the precalving period, one group of heifers was assigned to the control treatment and the second group was designated to receive additional energy supplement (flush). From February 27 to March 26, 1984 (28 d) heifers assigned to the flushed treatment received an additional 5 kg/d (as-fed) of a 12 percent crude protein, 81 percent TDN ration.

The breeding period began March 12, 1984 and ended on August 20, 1984. Two mature Santa Gertrudis bulls of known fertility were used in each treatment group to minimize the influence of bull fertility on reproductive performance. Pregnancy status was determined by rectal palpation at weaning and the interval from calving to conception was calculated by subtracting 283 d from the 1984-1985 calving date.

One blood sample was obtained from each heifer by puncture of the tail vein near the beginning of the breeding period to determine the proportion of heifers with ovarian activity. A concentration of progesterone greater than or equal to 2 ng/ml of serum was considered to be an indicator of ovarian luteal activity. Calves were weighed and identified at birth and remained with their dams on pasture without supplemental grain.

Experiment 2

Forty-five mature, Santa Gertrudis cows located at L&L Farms, in northwest Arkansas, were used in this experiment. Cows calved between March and May 1984 and were maintained on tall fescue pasture from January until September. Cows grazed bermudagrass pasture from September until November. Herd management and feeding procedures for the ranch were followed.

Body weights and body condition scores were determined at four periods during this study: (1) late gestation (1/24/84), (2) precalving (3/9/84), (3) breeding (6/6/84) and (4) weaning (11/27/84). At the precalving period, one group of cows was assigned the control treatment and the other group was designated to receive additional energy supplement (flush). From May 17 to June 15, 1984 (28 d) cows in the flush group received an additional 5 kg/d (as-fed) of a 20 percent crude protein, 81 percent TDN ration.

The breeding period began on May 28, 1984 and ended on August 1, 1984. Cows in each group were mated to one mature Santa Gertrudis bull of known fertility. Pregnancy status was determined at weaning by rectal palpation. The interval from calving to conception was determined by subtracting 283 d from the 1985 calving date. Two blood samples were collected from each cow at an 11 d interval near the beginning of breeding to determine ovarian luteal activity.

Results and Discussion

Body weights were similar for control and flushed heifers in experiment 1 at the start of the experiment (Figure 1) and both groups of heifers were in good body condition (BCS = 6.5). Body weights of

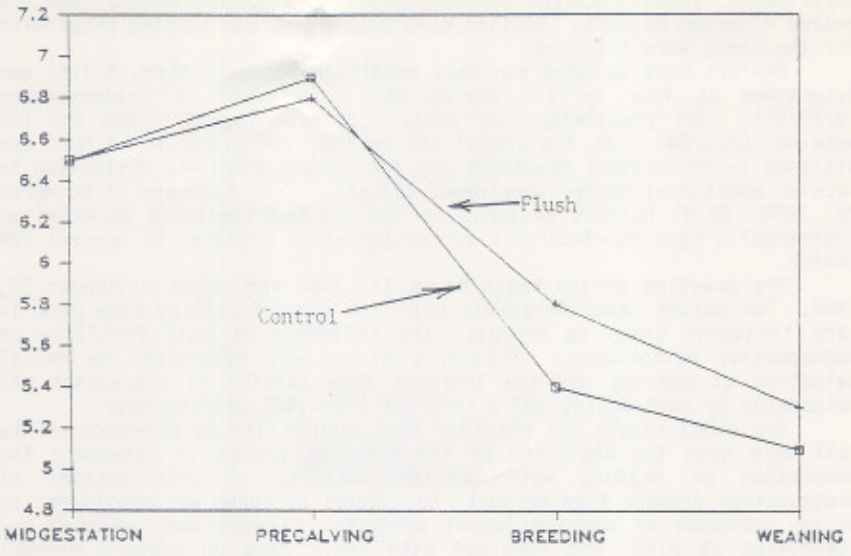


Figure 1. Body weights (kg) of Santa Gertrudis heifers (Experiment 1).

heifers were not measured at the precalving period, however the increase in body condition score for heifers in both groups (Figure 2) would suggest body weight increased from midgestation to precalving.

Short term feeding of additional energy (flushing) affected both body weight and body condition changes of the heifers. Flushed heifers lost less ($P<.009$) weight (-50 kg) compared to control heifers (-77 kg) from midgestation until breeding. Control heifers tended ($P<.13$) to be lighter (469 kg) than flushed heifers (494 kg) near the beginning of breeding.

Changes in body condition were related to weight changes from midgestation to breeding for heifers on both treatments. Flushed heifers lost less ($P<.09$) body condition (-1.0 units of BCS) compared to control heifers (-1.5 units of BCS) from precalving to breeding and BCS was greater ($P<.07$) for flushed heifers (5.8) compared to control heifers (5.4) near the beginning of breeding.

Heifers on both treatments lost body condition from breeding to weaning and condition loss was similar for control and flushed heifers. Body weights were similar for control (475 kg) and flushed heifers (486 kg) at weaning.

The breeding program at the ranch dictated which cows would be assigned to each breeding pasture and nutritional treatment for experiment 2. This assignment resulted in heavier cows on the flush treatment at the beginning of the experiment (649 kg) compared to cows on the control treatment (601 kg; Figure 3). Both groups of cows were in good body condition (BCS = 6.3; Figure 4) at the beginning of the experiment.

From late gestation to precalving, weight change was slightly greater ($P<.07$) for cows assigned to the group to be flushed after

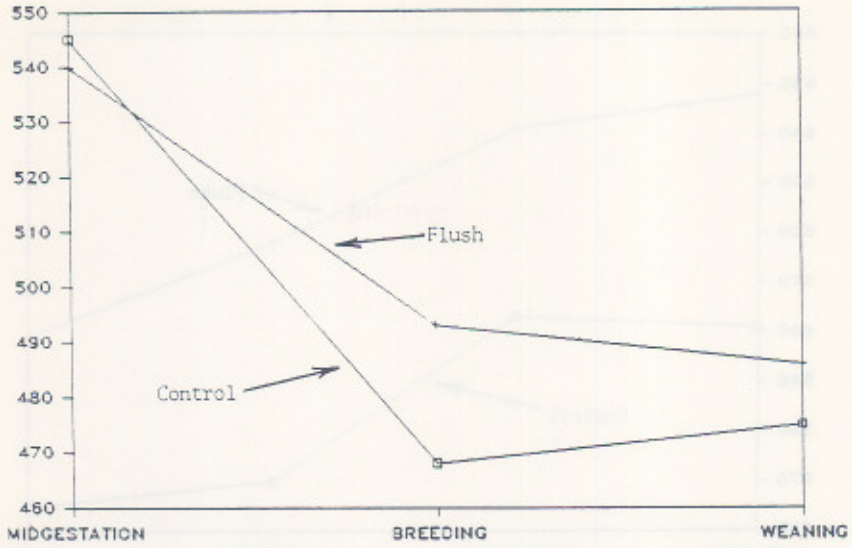


Figure 2. Body condition scores of Santa Gertrudis heifers (Experiment 1).

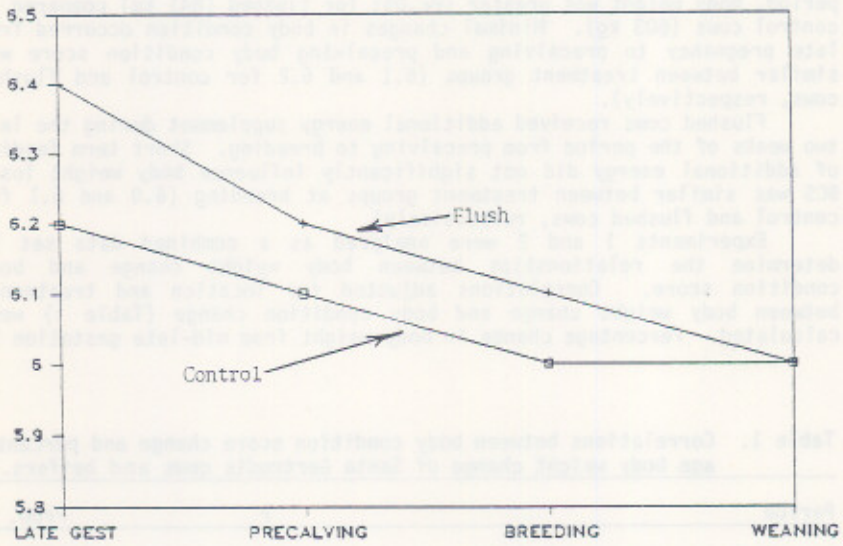


Figure 3. Body weights (kg) of Santa Gertrudis cows (Experiment 2).

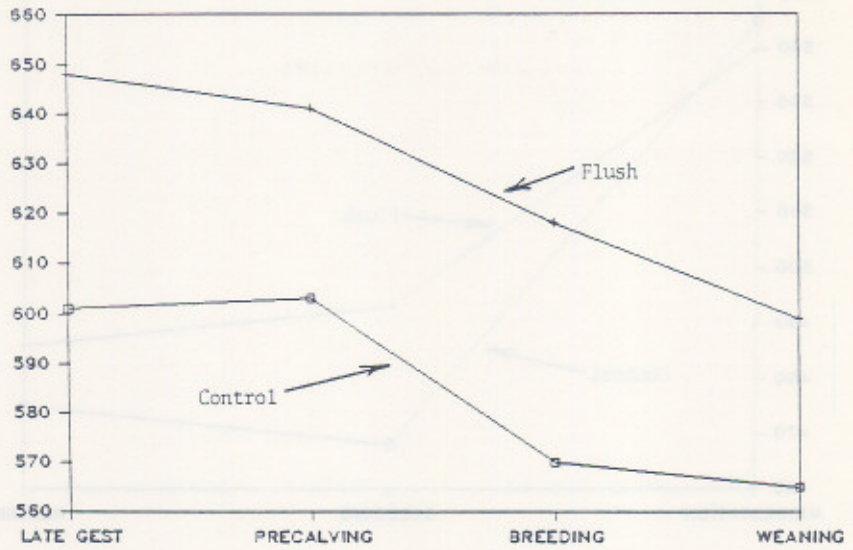


Figure 4. Body condition scores of Santa Gertrudis cows (Experiment 2).

calving (-7 kg) compared to control cows (1 kg). At the precalving period, body weight was greater ($P<.05$) for flushed (641 kg) compared to control cows (603 kg). Minimal changes in body condition occurred from late pregnancy to precalving and precalving body condition score was similar between treatment groups (6.1 and 6.2 for control and flushed cows, respectively).

Flushed cows received additional energy supplement during the last two weeks of the period from precalving to breeding. Short term feeding of additional energy did not significantly influence body weight loss. BCS was similar between treatment groups at breeding (6.0 and 6.1 for control and flushed cows, respectively).

Experiments 1 and 2 were analyzed as a combined data set to determine the relationships between body weight change and body condition score. Correlations adjusted for location and treatment, between body weight change and body condition change (Table 1) were calculated. Percentage change in body weight from mid-late gestation to

Table 1. Correlations between body condition score change and percentage body weight change of Santa Gertrudis cows and heifers.

Period	r	Prob.
Mid-late pregnancy to Breeding	.66	.0001
Breeding to Weaning	.59	.0001
Mid-late pregnancy to Weaning	.71	.0001

breeding accounted for 55 percent of the variation in body condition score change. Furthermore, each 1 unit change in body condition score could be associated with about a 13 percent change in live weight.

Reproductive Performance

Reproductive performance of heifers in experiment 1 is summarized in Table 2. All heifers were in good body condition and excellent pregnancy rates were obtained for heifers on both treatments.

The percentage of heifers with greater than 2 ng/ml of progesterone at the time of bleeding was not influenced by the flushing treatment. Likewise, absolute body weight and body condition either prepartum or near the beginning of breeding did not influence the proportion of heifers with greater than 2 ng/ml of progesterone. Based on the 1984-1985 calving dates, 91 percent and 60 percent of heifers on control and flushed treatments, respectively, had conceived by the time blood samples were taken. It appears that a high percentage of heifers on both treatments had regular ovarian cycles.

Although not significantly different between treatment groups, the interval to conception was slightly greater for flushed heifer (92.5 ± 7.0 d) compared to control heifers (78 ± 5.5 d). The primary factor influencing the interval from calving to conception between treatment groups was days postpartum of heifers at the beginning of breeding. Days postpartum were greater for flushed (54.0± 8.1 d) compared to control heifers (35.5 ± 11.7 d). Thus, a greater interval from calving to the beginning of breeding for the flushed compared to the control heifers is the probable cause of the greater interval from calving to conception for the flushed heifers.

The interval from calving to conception was not influenced by BCS at midgestation, precalving or near the beginning of breeding. However,

Table 2. Reproductive performance of Santa Gertrudis heifers (Experiment 1).

Item	Treatment			
	Control		Flushed	
	N[a]		N	
Percentage of heifers with greater than 2 ng/ml progesterone at time of breeding	25	72.0	27	70.3
Pregnancy Rate (%)[b]	25	100	28	96.4
Days postpartum at beginning of breeding for heifers used to determine the interval from calving to conception	12	35.5±11.7[c]	21	54.0±8.1
Interval from calving to conception	12	78.0±5.5	21	92.5±7.0

[a] Number of animals used for the observation.
[b] Determined by rectal palpation at weaning.
[c] Mean ± S.E.

change in body weight from midgestation to precalving affected ($P<.05$) the postpartum interval to conception. Regression analyses indicated that for each 10 percent loss in body weight from midgestation to breeding, the interval from calving to conception increased by 13 days.

Pregnancy rate for all heifers in this experiment was maximal. Thus, the short term feeding of additional energy did not affect the percentage of heifers which became pregnant. The lack of an effect of flushing in this study may be due to the increase in body condition from midgestation to precalving.

Pregnancy rate of heifers was not significantly influenced by body weight, weight changes, body condition and body condition changes at any time during this study. The lack of effect of these factors on pregnancy rate would likely be expected since heifers were in good to moderate body condition both precalving and at breeding.

Reproductive performance of cows in experiment 2 is presented in Table 3. The percentage of cows with ovarian luteal activity near the beginning of breeding was not influenced by treatment.

BCS and changes in BCS before and after calving did not affect the incidence of ovarian activity near the beginning of breeding. This could be expected since changes in body condition from late gestation until breeding were minimal. Ovarian luteal activity was related ($P<.07$) to weight loss from precalving to breeding and ovarian function was greater in cows that lost weight. The reason for this response is not known.

The interval to conception was slightly shorter ($P<.14$) for control cows (78 ± 5.0 d) compared to flushed cows (89.6 ± 4.5 d) but BCS and condition changes did not influence the interval. The interval from calving to conception was affected ($P<.06$) by body weight change from precalving to breeding. For each 10 percent loss in body weight from precalving to breeding, the interval to conception was increased by 16 days.

Table 3. Reproductive performance of Santa Gertrudis cows (Experiment 2).

Item	Treatment			
	Control		Flushed	
	N[a]		N	
Percentage of cows with ovarian luteal activity near the beginning of breeding[b]	17	88.2	28	82.1
Pregnancy rate (%)[c]	17	58.8	28	67.8
Pregnancy rate for cows with ovarian activity near the beginning of breeding (%)	15	66.6	23	82.6
Interval from calving to conception	12	78.5± 5.8[d]	19	89.6± 4.5

[a] Number of animals used for the observation.
[b] Ovarian activity characterized by concentration of progesterone in serum equal to or exceeding 2 ng/ml.
[c] Determined by rectal palpation at weaning.
[d] Mean ± S.E.

Pregnancy rate of cows was not influenced by treatment, however, when expressed as a percentage of cows with ovarian activity near the beginning of breeding, pregnancy rate was greater for flushed (82.6 percent) compared to control cows (66.6 percent). Body weight, body condition and changes in weight or condition did not significantly influence pregnancy rate. Cows were in good body condition prior to calving and condition change was minimal from late pregnancy to weaning. Results for both experiments 1 and 2 were similar. Minimal changes in body weight and body condition which occurred resulted in little variation in these parameters, and limited influence of the parameters on reproductive performance.

The less than optimal pregnancy rates of cows on both treatments in experiment 2 probably is related to environmental factors. Cows in this study grazed tall fescue pasture during the breeding season and early pregnancy. An endophytic fungus, which is present in a large percentage of tall fescue, results in toxins which may reduce animal performance. The presence of these compounds has been associated with elevated body temperature and reduced reproductive efficiency.

Tall fescue that is toxic, results in depressed concentration of prolactin in cattle and sheep. To determine whether the less than optimal fertility of cows in experiment 2 may be related to toxic fescue pasture, concentrations of prolactin in serum were quantified in blood samples from cows assigned to experiment 1 (King Ranch) and experiment 2 (L&L Farms). In addition, prolactin was quantified in serum samples from postpartum Angus and Hereford cows at Stillwater, Oklahoma. The samples in Oklahoma were collected during the same weeks as the samples for experiment 2 (Table 4). Concentrations of prolactin were suppressed in cows on experiment 2 that grazed fescue compared with cows in experiment 1 and cows in Oklahoma that grazed pastures composed mostly of blue stem grass. In addition, concentrations of prolactin were less in cows on experiment 2 that did not conceive compared to cows that became pregnant ($P<.10$). Cows that received the additional 5 kg of supplement daily had greater concentrations ($P<.05$) of prolactin than cows that did not receive supplement. Pregnancy rate was also greater for supplemented cows that had ovarian luteal activity at the start of breeding. These data indicate that the less than optimal fertility of cows in experiment 2 may have been related to toxic effects of the fescue pasture that they grazed.

Calf Performance

Feeding of additional energy during breeding did not influence preweaning calf growth in either experiment. In experiment 1, adjusted 205-day weaning weights (242 vs 240 kg for control and flushed calves, respectively) were not significantly different. From the beginning of breeding to weaning, calves on both treatments in experiment 2 were offered a free choice creep ration. Adjusted 205-day weaning weight (254 vs 270 kg for control and flushed calves, respectively) were not significantly different between the treatment groups. Although actual milk production was not measured, it would appear that if adequate forage is available and minimal supplement is provided, calf growth of Santa Gertrudis cows is not increased by feeding additional energy.

Table 4. Concentrations of prolactin in serum of postpartum cows.

Location	Treatment	Date Sampled	No. Cows	ng/ml
King Ranch (Expt. 1)	Pregnant	April 17	20[b]	284±30
L&L Farms (Expt. 2)	Pregnant-Control	June 6, 18	11[b]	52±15
	Pregnant-Flush	June 6, 18	18[b]	75±10
	Non-Pregnant-Control	June 6, 18	7[b]	30±3
	Non-Pregnant-Flush	June 6, 18	11[b]	55±6
Stillwater, Oklahoma	Pregnant	June 8, 15	16[b]	88±8

[a]Samples were obtained during the breeding season and reproductive status was determined 4 to 6 months later. Flush treatment was feeding an addition 5 kg of a 20 percent protein ration daily for 4 weeks.

[b]Two samples were obtained from each cow at a 7 or 12 day interval.

INFLUENCE OF BODY CONDITION OF BEEF COWS ON PITUITARY AND OVARIAN FUNCTION

R. J. Rasby[1], J. W. Wagner[2], R. P. Wettemann[3], R. D. Geisert[4], and K. S. Lusby[5]

Story in Brief

Nonpregnant Hereford cows were used to determine the effect of body condition on reproductive function. At the beginning of the experiment, body condition score of cows averaged 5±.2 (1= emaciated; 9=obese). From July to November 1, cows were fed to either lose weight and body condition (Thin; body condition score 4 or less; n=22), maintain weight and body condition (Moderate; body condition score 5 to 6; n=24), or gain weight and body condition (Fat; body condition score 6 or greater; n=24). Beginning November 1, each cow received a complete ration to maintain her November weight and body condition. Cows group were slaughtered in December (6 Thin, 8 Moderate, and 8 Fat cows) and the subsequent March (16 cows per group). Before slaughter, cows were synchronized by giving two injections of prostaglandin $F_{2\alpha}$ 11 days apart. Six days after the second prostaglandin injection, cows were treated with 100 ug of GnRH. At slaughter the pituitary, ovaries, and carcass were obtained. Fat cows had heavier dry ovarian and wet corpora lutea weights, greater condition scores, and more carcass energy than Moderate or Thin cows. Pituitary luteinizing hormone content did not differ among groups. However, luteinizing hormone response after gonadotropin releasing hormone differed between Thin versus Moderate and Fat cows. These data suggest that body condition influences ovarian and corpus luteum weight and luteinizing hormone response to GnRH.

(Key Words: Body Condition, Beef Cow, Reproductive Function)

Introduction

Nutrient intake, as reflected in body condition, influences reproductive performance of beef cows. Cows that calve in thin body condition have longer intervals from calving to rebreeding. The relationship between body condition of cows and hormone synthesis and/or secretion remains unclear. Pituitary activity appears to be the limiting factor in initiating follicular activity after calving. Underfeeding cows after calving may reduce luteal function and ovarian responsiveness to luteinizing hormone (LH). Restricting energy to beef cows may influence the release of LH from the anterior pituitary; in contrary, some studies indicate that energy does not influence the concentration of LH in serum. This experiment was designed to determine the influence of body condition (fat reserve) of nonpregnant beef cows on pituitary and ovarian function.

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[3]Regents Professor, [4]Assistant Professor, [5]Associate Professor

Materials and Methods

Nonpregnant Hereford cows slaughtered in 1982-83 (n=34) and 1983-84 (n=36) were used to determine the effect of body condition on pituitary and ovarian parameters. Prior to initiating the trial each year, cows were randomly assigned to one of three feeding regimes to alter weight and body condition. From mid-summer to November 1 of each year, cows were fed to either lose weight and body condition (Thin; body condition score 4 or less; n=11), maintain weight and body condition (Maintain; body condition score 5 to 6; n=12), or gain weight and body condition (Fat; body condition 6 or greater; n=12; Table 1). From November 1 until slaughter, cows were weighed and condition scored weekly and each cow received a complete ration (Table 1) so as to maintain weight and body condition. Cows were slaughtered in December (6 Thin, 8 Moderate, and 8 Fat cows) and the subsequent March (16 cows per group).

Prior to slaughter cows were synchronized by giving two injections of prostaglandin $F_2\alpha$ 11 days apart. Five days after the second prostaglandin treatment (approximately day two of the estrous cycle), each cow was fitted with a jugular cannula. Six days after the second prostaglandin injection, cows were treated with 100 ug of GnRH (im). Three serum samples were obtained 15 minutes apart prior to GnRH treatment. After GnRH treatment, serum samples were obtained every 15 minutes for 2 hours followed by sampling every 30 minutes for an additional four hours. Concentration of LH in serum was quantified by radioimmunoassay.

On approximately day 5 of the estrous cycle, cows were slaughtered. The pituitary gland was removed and total and anterior pituitary wet weights were determined. The anterior pituitary was frozen on dry ice,

Table 1. Feeding schedule.

	Body Condition		
	Thin	Moderate	Fat
Cows, no	11	12	12
July 1, 1982 to November 1, 1982	wheat straw ad libitum	.5 kg CSM[a]/ head/day + 6.4 kg prairie hay/head/day	2.2 kg CSM/ head/day + prairie hay ad libitum[b]
November 1, 1982	each cow received a complete ration[c] to maintain weight until slaughter		

[a]41% cottonseed meal cube.
[b]During the second year, fat cows received 1.5 kg CSM/hd/da and grazed native range between June 1 and September 1.
[c]Composition of the complete ration: 40% rolled corn, 35% dehydrated alfalfa pellets, 21.7% cottonseed hulls, 3.0% cane molasses, and .3% salt, TM.

stored at -20 C, and LH content was quantified by radioimmunoassay. Dry ovarian, wet corpora lutea, and follicular fluid weights were determined.

Results and Discussion

From mid-summer to November 1, Thin cows lost 176 lbs and about 2 condition scores, Fat cows gained about 176 lbs and 2 condition scores, and Moderate cows maintained weight and body condition. From November 1 until the time of slaughter, all cows maintained their weight and body condition (Table 2). Total carcass energy content differed ($P<.001$) among treatment groups (Table 2). Fat cows had the greatest carcass energy content, followed by Moderate cows. Thin cows had the least amount of carcass energy.

The analysis of reproductive parameters included cows that exhibited ovarian luteal activity as indicated by plasma progesterone equal to or greater than 1 ng/ml at the first or second prostaglandin injection or at the time of GnRH treatment. Therefore, 22 cows in the Thin group, 24 cows in the Moderate group, and 24 cows in the Fat group were included in the analysis.

Fat cows had the heaviest ($P<.001$) dry ovarian tissue weights and Thin cows had the lightest (Table 3). Moderate cows had dry ovarian weights intermediate to the Thin and Fat cows. This suggests that nutrient availability to maintain cell structure and integrity or synthesis and/or secretion of pituitary hormones necessary to maintain ovarian cellular activity may differ in Thin cows. In conjunction, blood flow to the ovary may be different in Thin cows; therefore, altering the amount of nutrients and hormones reaching the ovary in Thin cows.

Table 2. Weights and condition scores of experimental cows.

	Group		
	Thin	Moderate	Fat
November 1st condition score	$3.2\pm.1^{a}$	$5.3\pm.1^{b}$	$6.9\pm.1^{c}$
Condition score at slaughter	$3.4\pm.1^{a}$	$5.3\pm.1^{b}$	$7.1\pm.1^{c}$
November 1st weight (lb)	750 ± 20^{a}	869 ± 20^{b}	1060 ± 23^{c}
Weight at slaughter (lb)	751 ± 20^{a}	869 ± 20^{b}	1066 ± 23^{c}
Carcass energy content (Mcal)	249 ± 6^{a}	430 ± 5^{b}	714 ± 7^{c}

^{abc}Numbers in rows with different superscripts differ ($P<.01$).

Table 3. Ovarian characteristics for thin, moderate, and fat cows.

	Group		
	Thin	Moderate	Fat
Total dry ovarian weight (g)	1.79±.18[a]	2.07±.17[ab]	2.43±.22[b]
Corpus luteum weight (g)	1.02±.37[c]	2.00±.30[d]	1.93±.33[d]

[ab]Numbers in rows with different superscripts differ (P<.001).
[cd]Numbers in rows with different superscripts differ (P<.09).

Cows in Fat or Moderate body condition tended to have heavier (P<.09) corpora lutea than did Thin cows (Table 3). This difference may be caused by reduced amounts of nutrients and/or hormones reaching the ovary or reduced ovarian blood flow in Thin cows. However, it is possible that Thin cows do not respond to prostaglandin the same as Moderate or Fat cows. For instance, if a Thin cow ovulates 24 or 36 hours later than a Moderate or Fat cow the corpus luteum weight would be lighter at slaughter.

Analysis of follicular fluid weight (an indicator of follicle number and size) indicated a treatment by season interaction. In December, Thin cows had less (P<.05) follicular fluid than Moderate or Fat cows (Table 4). However, in March, follicular fluid weights did not differ among groups. Thin cows slaughtered in December lost weight and body condition prior to November 1 then maintained weight and body condition until slaughter. Thin cows slaughtered in March maintained

Table 4. Follicular fliud weights (g) of ovaries from cows slaughtered in December or March.

Group	December	March
Thin	1.83±.35[a]	2.42±.32
Moderate	2.66±.42[ab]	1.84±.30
Fat	3.65±.44[b]	2.51±.44

[ab]Numbers in columns with different superscripts differ (P<.05).

weight and body condition for about four months before slaughter. Loss in weight and body condition followed by a short time of maintaining weight and condition may alter the pituitary-ovarian axis for Thin cows slaughtered in December.

Whole pituitary weight, anterior pituitary weight, and pituitary LH content did not differ among groups (Table 5). However, pituitary responsiveness to GnRH treatment differed ($P<.01$) between cows in Thin versus Moderate and Fat body condition (Figure 1). Greater concentra-

Table 5. Pituitary characteristics of cows with thin, moderate, and fat body condition.

	Group		
	Thin	Moderate	Fat
Whole pituitary weight (g)	2.33±.07	2.40±07	2.54±.08
Anterior pituitary weight (g)	1.96±.07	1.92±.06	2.03±.07
Pituitary LH content (mg)	3.05±.33	2.78±.30	3.66±.36

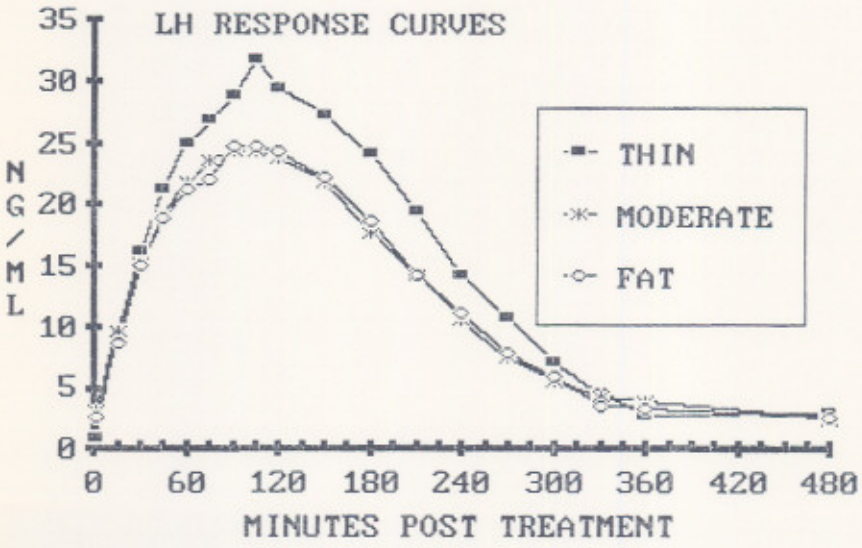


Figure 1. LH response curves after GnRH treatment of cows with thin moderate or fat body condition.

tions of LH after GnRH treatment in Thin cows may be related to greater pituitary stores of LH that are not released in Thin cows until treated with GnRH. This indicates a reduced secretion of GnRH from the hypothalamus of Thin cows. However, because pituitary content of LH was similar for cows in all body conditions, greater serum LH in Thin cows may be a result of release of a similar amount of LH but into a smaller volume of blood.

In conclusion, body condition influenced dry ovarian and wet corpus luteum weight and pituitary response to GnRH. However, body condition did not influence pituitary LH content. Reduced ovarian and corpora lutea weights suggests that those hormones necessary for maintaining ovarian and corpus luteum functions may be altered in Thin cows; therefore, brain centers (hypothalamus) involved with synthesis and/or secretion of releasing hormones may be influenced by body condition.

INFLUENCE OF GROWTH AT DIFFERENT pH LEVELS ON STORAGE STABILITY OF *LACTOBACILLUS ACIDOPHILUS* IN REFRIGERATED MILK

C. N. Rich[1] and S. E. Gilliland[2]

Story in Brief

A broth medium was used to grow *Lactobacillus acidophilus* at pH 5.0, 5.5, 6.0, 6.5 or 7.0. Concentrated cultures prepared when the culture had reached maximum population in the fermentor were stored at -196 C for 28 days with no loss in viability or bile resistance.

After 28 days of storage the frozen concentrated cultures were thawed and added to sterile, cold 10 percent non-fat milk solids at a population of approximately 2 x 10^6/ml and stored at 5 C. Cells from the culture which had been grown at pH 5 were much more stable during storage than were cells from cultures grown at the higher pH levels.

(Key Words: *Lactobacillus acidophilus*, Concentrated cultures, Acidophilus-milk.)

Introduction

Frozen concentrated cultures used for the preparation of a non-fermented food, such as acidophilus milk, should possess a number of desirable attributes in order to serve as a beneficial dietary adjunct. They should maintain stability during growth, remain viable and bile resistant during freezing and storage as a concentrated culture and during subsequent storage in the food product. Growth conditions including medium composition, pH temperature, oxidation - reduction potential and incubation time can influence such desirable attributes of the culture. Additionally, freezing and storage conditions also can influence the desirable attributes of the culture.

The purpose of this study was to determine the effect of pH during growth on the survival of cells of *Lactobacillus acidophilus* frozen and stored at -196 C and subsequently during storage in refrigerated pasteurized low-fat milk.

Materials and Methods

Cells of *Lactobacillus acidophilus* NCFM were grown at 37 C in a fermentor containing 4 liters of PMN broth with pH being maintained by an automatic pH control unit adding a sterile neutralizer solution as needed. The neutralizer solution contained 20 percent Na_2CO_3 in 10 percent NH_4OH. The PMN broth contained 5 percent Peptonized Milk Nutrient (Sheffield Products), 2 percent Primatone (Sheffield Products), 2 percent lactose, 0.1 percent yeast extract and 0.1% Tween 80 (polysorbitan monoleate). The initial pH of the medium was 6.0 and was adjusted to the desired level prior to inoculation by adding either sterile 20 percent lactic acid solution or the alkaline neutralizer solution as required. The four liters of broth was

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inoculated with 40 ml of freshly prepared culture of L. acidophilus NCFM which had been incubated at 37 C for 18 hr. The inoculated medium was incubated at 37 C with the pH being maintained at the desired level throughout the incubation period. Starting at 10 hr, samples were taken from the fermentor at 2 hr intervals so the growth could be monitored by turbidimetric readings and by plate counts. Five pH levels were evaluated: pH 5.0, 5.5, 6.0, 6.5 and 7.0. Three replicates of each level were performed.

One liter of the broth culture was removed from the fermentor when turbidimetric readings indicated maximum growth had been reached. Cells were harvested by centrifugation and a concentrated culture was prepared by resuspending the cell pellet in twice its weight of sterile cold 10 percent non-fat milk solids. The concentrated culture was dispensed in 2 g quantities, frozen and stored in liquid nitrogen. Plate counts on PMN agar were made prior to freezing and after 28 days storage. PMN agar was prepared by adding 15 g of agar to one liter of PMN broth prior to sterilization. The plates were incubated aerobically at 37 C for 48 hr.

On the 28th day of frozen storage, concentrated culture was removed and thawed by immersion in tap water at 25 C. Sufficient concentrated culture was then added to the cold milk to attain a population of approximately 2 x 10^6/ml. The bottles were stored at 5 C and removed on days 1, 7, 14 and 21 to determine numbers of lactobacilli by plate counts on PMN agar.

Results and Discussion

The highest numbers of cells and greatest stability during growth for 24 hr was observed for cells grown at pH 5.0, while the lowest numbers and greatest fluctuation during growth was at pH 7.0 (Figure 1). Growth at pH 5.5, 6.0 and 6.5 produced higher populations than growth at pH 7.0 but appeared to fluctuate or decline more than did cultures maintained at pH 5.0. The culture grown at pH 5 had attained maximum population at 10 hr.

No significant changes ($P<.05$) were observed in total numbers of lactobacilli or bile resistant lactobacilli during frozen storage (Table 1). However, concentrated cultures produced from cells grown at pH 7.0 exhibited a slight decline in number during the 28 days of storage at -196 C.

Table 1. Survival of Lactobacillus acidophilus NCFM in concentrated cultures during storage at -196 C.

	Log_{10} Count/g[a]				
Days	pH 5.0[b]	pH 5.5	pH 6.0	pH 6.5	pH 7.0
0	10.50	10.57	10.47	10.31	10.12
1	10.53	10.56	10.41	10.31	9.96
28	10.48	10.58	10.42	10.28	10.04

[a]Each value = average from 3 trials.
[b]pH at which cells were grown.

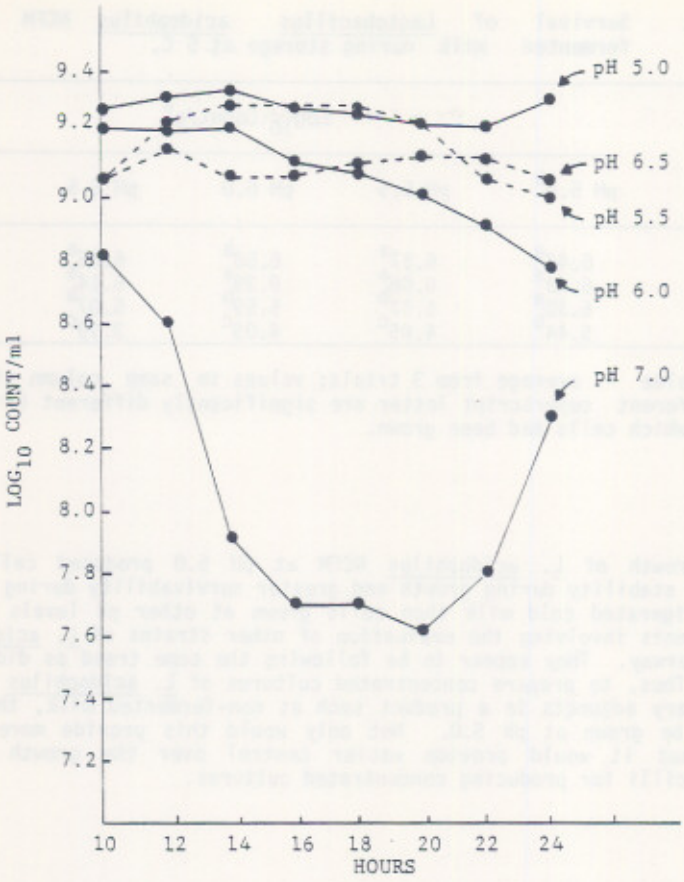


Figure 1. Comparison of growth of Lactobacillus acidophilus NCFM at various pH levels in PMN broth (Each point represents an average from 3 trials).

Survivability of cells in refrigerated milk was determined by enumeration of lactobacilli at 7 day intervals for 21 days after inoculation with the concentrated culture. Results show considerable differences in survival of cells grown at different pH levels. Cells at pH 5.5, 6.0, 6.5 and 7.0 showed steady decline in numbers throughout the period tested (Table 2). The decreases were significant for days 14 and 21 ($P<.05$).

Cells grown at pH 5.0 showed little or no decrease in cell number after 14 days storage in refrigerated milk at 5 C. Evidence of decreased stability ($P<.05$) was observed for cells stored 21 days but decreases were not as great as at other pH levels.

Table 2. Survival of *Lactobacillus acidophilus* NCFM in non-fermented milk during storage at 5 C.

Days	Log_{10} Count/g[a]				
at 5 C	pH 5.0[b]	pH 5.5	pH 6.0	pH 6.5	pH 7.0
1	6.47[a]	6.37[a]	6.58[a]	6.26[a]	6.30[a]
7	6.43[a]	6.06[a]	6.39[a]	6.14[a]	6.05[ab]
14	6.30[a]	5.37[b]	5.59[b]	5.07[b]	5.38[b]
21	5.44[b]	4.05[c]	4.09[c]	3.99[c]	4.96[c]

[a]Each value = average from 3 trials; values in same column followed by different superscript letter are significantly different ($P<.05$).
[b]pH at which cells had been grown.

Growth of *L. acidophilus* NCFM at pH 5.0 produced cells with greater stability during growth and greater survivability during storage in refrigerated cold milk than cells grown at other pH levels tested. Experiments involving the evaluation of other strains of *L. acidophilus* are underway. They appear to be following the same trend as did strain NCFM. Thus, to prepare concentrated cultures of *L. acidophilus* for use as dietary adjuncts in a product such as non-fermented milk, the cells should be grown at pH 5.0. Not only would this provide more stable cells but it would provide easier control over the growth of the lactobacilli for producing concentrated cultures.

STRUCTURED BEEF STEAKS WITH FOOD GRADE COLLAGEN

B.R. Rao[1] and R.L. Henrickson[2]

Story In Brief

Food grade collagen, in the form of an enzymatically hydrolyzed powder, a native 10% paste or a dry fibrous material, was added to chunked beef chuck at 0, 1, 2, 3, 4, 6 or 8 percent level to make structured beef steak. Meat containing hydrolyzed collagen powder while improving the cooked yield decreased the bind value and Kramer shear value of the cooked steak. The color of the uncooked steak was not affected. Native collagen paste improved the cooked yield and bind value. The Kramer shear value of the cooked steak and the surface color of the uncooked steak were not affected. The addition of dry fibrous collagen to chunked beef resulted in a higher cooked yield of roasts only at 8% level but the bind and shear value were decreased. The surface color value of the uncooked steak decreased with increasing levels of collagen. Based on this study it was concluded that the native collagen 10% paste could be used to manufacture uncooked structured beef steak with desirable surface color, good bind and cooked texture.

[Key Words: Collagen, Structured Beef]

Introduction

Beef steak is one of the most desired consumer products and is expensive since only a limited volume of high quality muscle exists in the carcass. The meat industry is constantly striving to upgrade the lower priced cuts by processing them into products with steak like texture. Restructuring permits one to take lower value cuts to be upgraded into desirable meat products of uniform shape, size, texture and therefore economic value. There is an increasing demand in the hotel, restaurant and institutional trade for restructured meat. This demand is expected to increase in view of the availability of a steak with desired levels of fat and nutrients, shape, size and texture. Several techniques such as grinding, flaking, chunking and reforming the meat into steaks are used. Massaging and tumbling to disrupt the muscle fiber, releasing of salt soluble protein, coating of meat with soluble protein and heat coagulating the protein coat by cooking to form a binding matrix are other techniques. Chemicals like sodium chloride to increase the extractability of salt soluble protein and polyphosphates to improve the juiciness and cooking yield are used in conjunction with other techniques in making restructured products.

Some of the above techniques have undesirable side effects. For example massaging and tumbling in presence of atmospheric oxygen incorporates oxygen in the products and may cause oxidative changes on storage. Sodium chloride while facilitating the extraction of salt soluble protein may cause undesirable color changes on storage. The meat industry is searching for more economical ways to produce these products with minimal undesirable side effects.

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[1]Research Associate [2] Professor

The purpose of this investigation was to use food grade collagens for manufacturing structured beef steaks without the addition of any other chemicals.

Materials and Methods

Food grade collagens, in the form of an enzymatically hydrolyzed powder, native 10% paste and dry fibrous material, were obtained from a private manufacturer[a]. Good grade beef chucks were obtained from a local meat packer.

The beef chucks were deboned, excess fat and connective tisssue trimmed and passed through a hand operated blade tenderizer twice. The tenderized meat was ground through the kidney plate of a meat grinder once. The meat chunks were mixed with each of the collagens at 0, 1, 2, 3, 4, 6 or 8% level in a paddle type mixer for 20 min. The mixture was hand stuffed into 4 in fibrous casings and frozen in a blast freezer for 24 hr. The frozen logs were tempered at -3 C for 24 hr and pressed at 2000 psi for 2 min. in a carver press and refrozen at -12 C for 24 hr. One half of the frozen logs were cut transversely into 1 in. steaks and the other half was used as a roast for subsequent cooking. The experiment was repeated three times.

Cooking

The frozen roasts were cooked in a convection oven to an internal temperature of 70 C. The temperature was monitored with copper constant temperature probes inserted into approximately the geometric center. The frozen steaks were cooked on an electric broiler to the same internal temperature (70 C). Cooked yield was calculated by weighing the roasts or steaks before and after cooking. Triplicate samples were used for each of the collagen levels.

Bind Values

The cooked roasts were cut into 1 in slices transversely and each slice was used to measure the bind value. The cooked slice was mounted on a cylindrical hollow plastic holder (3 in. dia.) with sharp needles on its circumference spaced about 3 mm apart. The needles held the slice in position. The plastic holder with the meat slice was kept in position under the cross head of an Instron Universal Testing Machine. The cross head was fitted with a cylindrical plunger having a rounded end (1 in. dia.). The cross head and chart speed were adjusted to move at 100 mm/min. The peak force in kg was measured and recorded when the plunger penetrated to break the meat chunks and expressed as bind value in kg. The bind value for the cooked steaks was measured similarly. All measurements were taken on triplicate samples.

Kramer Shear Values

The tenderness of the cooked roasts and steaks was measured by placing a one inch square piece in a Kramer shear cell fixed to an Instron Universal Testing Machine and recording the peak force required for the shear. The tenderness values of triplicate samples were expressed as kg/g.

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[a]Courtesy, Marsales Siegler, Seton Company Philadelphia, PA.

Chemical Composition

The uncooked and cooked samples were analyzed for protein, fat and moisture following the AOAC methods. The pH of the uncooked samples was measured using a Fisher pH meter with a combination glass electrode. All measurements were in triplicate.

Surface Color

The surface color of the uncooked steaks was measured on the L, a, b scale using a Hunter Lab tristimulus colorimeter. The frozen steaks wrapped in freezer paper were thawed overnight in a cooler at 5 C. After unwrapping, the steaks were allowed to bloom for 30 min. at room temperature (23 C) before placing them under the optical port of the colorimeter.

Results and Discussion

Cooked Products with Hydrolyzed Collagen

The addition of hydrolyzed collagen powder to the beef chunks did not affect ($P>0.05$) the protein, fat and moisture content of the cooked structured products (Table 1). The cooked yield was not significantly

Table 1. Chemical composition, yield, bind, Kramer shear values of cooked and surface color of uncooked structured beef with hydrolyzed collagen.

Coll lev	Prot	Fat	Moist	Cooked yield		Bind kg		Kramer shear-kg		Color 'a' value
				R	S	R	S	R	S	
%	%	%	%	%	%					
0	31.9	7.0	60.4	72.0	61.7^{b}	3.7^{a}	6.1^{a}	6.8^{a}	9.4	12.0
1	30.6	6.6	61.8	79.0	65.5^{b}	3.4^{b}	5.8^{a}	6.4^{a}	7.2	12.4
2	30.0	6.8	62.1	77.8	66.4^{b}	3.4^{b}	3.9^{b}	6.7^{a}	7.2	13.2
3	31.7	6.4	60.7	76.6	67.3^{b}	3.4^{b}	4.7^{b}	6.9^{a}	7.1	12.4
4	30.3	6.1	62.6	77.9	69.8^{a}	3.0^{b}	4.2^{b}	6.3^{b}	7.5	13.2
6	32.5	5.3	61.2	72.2	72.4^{a}	2.6^{b}	3.8^{b}	6.2^{b}	6.8	13.0
8	34.9	5.3	58.8	71.8	69.1^{a}	2.8^{b}	3.5^{b}	5.7^{b}	6.6	12.4

R=roast; S=steak
Color = Hunter 'a' value, redness-greenness
^{a,b} Means in each column with no. or same superscript letter are not different ($P>0.05$)

affected when the products were cooked as roasts but the steak yield increased ($P<0.05$) as the collagen level increased from 4% to 8% suggesting that the added collagen helped to improve the water binding capacity of the meat proteins. The bind value and Kramer shear value showed a significant decline with increasing levels of collagen. Even though the protein level remained the same, some of the functional properties of the muscle proteins were altered. Myosin is the muscle protein mainly responsible for binding of the meat chunks. During mixing some myosin is extracted and forms a matrix between the meat chunks. Cooking coagulates the myosin and thus binds the meat chunks. The added collagen would have diluted this effect resulting in weaker binding. The decreased shear values is likely due to improved water holding.

Surface color of the uncooked steak was not affected ($P>0.05$) due to the addition of collagen.

Cooked Products with Native Collagen Paste

The chemical composition (Table 2) of cooked products was not affected ($P>0.05$) by the addition of collagen. The cooked yield of roasts increased significantly with increased levels of collagen between

Table 2. Chemical composition, yield, bind, Kramer shear values of cooked and surface color of uncooked structured beef with native collagen paste 10%.

Coll lev	Prot	Fat	Moist	Cooked yield		Bind kg		Kramer shear-kg		Color 'a'
				R	S	R	S	R	S	value
%	%	%	%	%	%					
0	31.8	6.9	60.4	72.0[b]	61.7[a]	3.7	6.1	6.8	9.4	11.7
1	28.3	6.3	64.4	74.0[b]	61.8[a]	3.8	6.5	6.9	9.1	11.5
2	29.8	5.8	63.3	74.1[b]	59.7[b]	4.0	6.4	7.0	9.7	11.6
3	31.4	5.6	61.9	73.2[b]	60.5[b]	4.5	6.9	7.2	9.2	11.8
4	31.9	5.0	62.1	74.6[a]	60.3[b]	4.8	6.8	6.5	8.7	12.0
6	32.5	5.2	59.7	74.5[a]	59.8[b]	4.8	6.4	6.8	9.1	11.7
8	32.5	6.1	60.3	74.8[a]	59.1[b]	5.7	6.3	6.5	8.9	12.0

R=roast; S=steak
Color = Hunter 'a' value, redness-greenness
[a,b] Means in each column with no or same superscript letter are not different ($P>0.05$)

4 to 8% while that of steaks showed significant decline with increased collagen levels. These differences may be due to the different methods of cooking. The roasts were cooked at a relatively lower temperature while the steak surface was exposed to high temperature during electric broiling. The bind value, Kramer shear value and Hunter color value remained same as that of controls at all levels of added collagen.

Dry Fibrous Collagen

The addition of dry fibrous collagen did not affect ($P>0.05$) the chemical composition of cooked products (Table 3). The cooked yield of roasts showed a significant increase only at the 8% level of added collagen while there were no differences ($P>0.05$) when the products were cooked as steaks. The bind values of roasts and steaks at all levels of added collagen decreased ($P<0.05$) compared to controls suggesting that the collagen interfered with the binding ability of muscle proteins. The shear values of both roasts and steaks decreased ($P<0.05$) with increasing levels of added collagen. The Hunter 'a' values significantly decreased at collagen levels between 4 to 8%. The grayish white color of collagen diluted red pigment of myoglobin.

Table 3. Chemical composition, yield, bind, Kramer shear values of cooked and surface color of uncooked structured beef with dry fibrous collagen.

Coll lev	Prot	Fat	Moist	Cooked yield		Bind kg		Kramer shear-kg		Color 'a' value
				R	S	R	S	R	S	
%	%	%	%	%	%					
0	31.3	7.0	60.5	72.0^{b}	61.7	3.7^{a}	6.1^{a}	6.8^{a}	9.4^{a}	11.4^{a}
1	31.9	6.2	60.9	70.9^{b}	63.0	2.3^{b}	2.6^{b}	4.2^{b}	8.0^{a}	9.8^{a}
2	31.7	6.7	61.5	70.2^{b}	65.9	2.4^{b}	3.0^{b}	4.4^{b}	5.0^{b}	8.9^{a}
3	31.8	6.5	60.5	75.2^{b}	65.9	2.6^{b}	2.9^{b}	4.0^{b}	4.8^{b}	8.7^{a}
4	32.3	6.5	59.8	72.2^{b}	67.3	2.5^{b}	2.2^{b}	3.5^{b}	4.6^{b}	8.1^{b}
6	32.2	6.6	60.1	75.4^{b}	69.4	2.5^{b}	1.7^{b}	4.0^{b}	4.2^{b}	7.2^{b}
8	31.1	5.4	62.4	76.2^{a}	72.1	2.9^{b}	1.5^{b}	3.9^{b}	3.8^{b}	6.6^{b}

R=roast; S=steak
Color = Hunter 'a' value, redness-greenness
^{a,b} Means in each column with no or same superscript letter are not different ($P>0.05$)

Conclusions

The cooked yield increased with increasing levels of hydrolyzed collagen in the structured meat product while the bind value and Kramer shear value declined. The surface color of the uncooked steaks was not affected. The native collagen paste when added to the structured meat improved the cooked yield of roasts as the collagen content increased while the bind, shear value and the surface color of uncooked steaks was not affected. The dry fibrous collagen while improving the cooked yield of roasts only at 8% level, decreased the bind value, Kramer shear value and surface color of the uncooked steaks.

Based on this study it may be concluded that the native collagen 10% paste may be a suitable raw material that could be used in manufacturing structured beef steaks without any other additives to improve yields, bind or color.

Acknowledgements: This research was financed in part by The Seton Company Philadelphia, PA.

GROWTH AND DEVELOPMENT OF WEANLING HORSES FED VARYING ENERGY AND PROTEIN LEVELS

S.R. Boren[1], D.R. Topliff[2], D.W. Freeman[3] and R.J. Bahr[4]

In order to compete in today's horse industry, horsemen are placing increasing demands on young horses by attempting to grow larger foals at earlier ages, although little research has been done on the effects of maximum growth rates on bone development and the subsequent soundness of these horses. While protein requirements have been extensively studied, little work has been done with protein to energy relationships necessary for maximum, sound development of young horses.

A trial is underway comparing the performance of weanling horses fed two corn based diets and one oat based diet. The two corn diets are identical in energy content, but contain different levels of crude protein. The protein to calorie ratios (grams protein/million calories) are 52 and 42 respectively. While the oat diet is lower in energy, it still maintains a protein to calorie ratio of 52. In addition, high quality alfalfa hay is fed with each diet in a 75:25 ratio of concentrate to hay.

Fifteen Quarter Horse weanlings were grouped by foaling date and sex and assigned to a completely randomized block design experiment. Horses were weaned at 3 months of age and housed in individual stalls during a 6 month feeding period. The appropriate experimental diet is offered at 2.25% of body weight in two equal feedings daily and horses are measured weekly for weight gain and height at the withers, shoulder, knee, hip and hock. Additional ultrasonic measurements for fat thickness are taken in three anatomical sites at four, seven, and ten months of age and each horse is radiographed in four locations on the foreleg to estimate bone density, cortical thickness, and bone mineral content. Radiographs are also examined for signs of clinical epiphysitis. Results of this experiment should provide useful information on levels of crude protein and energy necessary for maximum, sound growth.

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Amino Acid Supplementation of High Wheat Concentrate Mixtures for Dairy Cows

T. Nalsen[1], L.J. Bush[2] and G.D. Adams[3]

The availability of surplus wheat is a determining factor for the use of this grain as a livestock ration. However, to what extent wheat can be substituted for other grains and yet maintain productivity in lactating dairy cows has yet to be defined. In recent studies at OSU, milk yield declined in response to an increase in the amount of wheat in the ration. The amount of rumen undegradable protein (RUP) and, in particular, the amount of lysine was reduced in the rations wherein wheat was substituted for corn and some soybean meal. Whether or not this is responsible for a decline in milk yield when cows are fed rations containing a large amount of wheat remains to be determined.

A feeding trial is currently in progress to compare the performances of lactating dairy cows fed high wheat concentrate mixtures. The experimental rations are:

a) Positive control (corn as principal grain)
b) Negative control (high wheat concentrate mixture having low RUP and low rumen undegradable lysine content)
c) High wheat mixture with supplemental protected lysine[4]
d) High wheat mixture with supplemental protected lysine and RUP equal to the positive control

The rations consist of 55% concentrate and 45% sorghum silage on a dry matter basis. A total of 24 cows in their second or greater lactation are used in a switchback trial with three periods of 4 weeks each. The cows are being fed individually in three portions at 8-hour intervals. Measurement criteria are: milk yield and composition, feed intake, weight change, body condition change, concentration of lysine and urea in blood plasma, ruminal fluid pH and volatile fatty acid concentration, and nutrient digestibility.

This study should provide information to increase the potential for using high levels of wheat in high energy rations for dairy cows.

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[4]Product of Chemicals Division, Eastman Kodak Company

CHARACTERISTICS OF THE LACTOSE HYDROLYZING ENZYME OF *LACTOBACILLUS ACIDOPHILUS*

J. W. Nielsen[1] and S. E. Gilliland[2]

Cells of *Lactobacillus acidophilus* added to milk can improve lactose utilization in persons who can not adequately digest it. To provide information for most effective use of this organism in such manner it is desirable to know as much as possible about the lactose hydrolyzing enzyme involved. Our objective in this study was to isolate and characterize the enzyme(s) involved.

A crude extract containing β-galactosidase (β-gal) was obtained by growing *Lactobacillus acidophilus* NCFM in a peptonized milk broth and lysing the resulting cells with lysozyme. The enzyme was then purified by ammonium sulfate precipitaion and ion exchange chromatography. The rate of hydrolysis of o-nitrophenyl-β-D-galactropyranoside (ONPG) was used to measure enzyme activity. Maximum activity occurred when the enzyme was incubated with magnesium ions and mercaptoethanol in pH 6.6 sodium phosphate buffer at 37 C. Gel filtration chromatographic analysis indicated a molecular weight of 5.7×10^5. Lactose and galactose both stimulated enzyme activity while glucose inhibited activity. Similar results were obtained when β-gal activity of *L. acidophilus* NCFM was compared to the activity of β-gal from two other strains of *L. acidophilus*. β-D-phospho-galactoside galactohydrolase (β-Pgal) activity was not detected in any of the strains.

Additional experiments are needed to determine factors which influence stability of the enzyme. This should provide information to improve the use of *L. acidophilus* as a dietary adjunct in milk to insure that the "lactose malabsorber" receives a product having adequate enzyme activity to be most beneficial in improving the utilization of lactose. This product should enable them to include milk as a regular part of their diet.

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Brush Management Systems

F.T. McCollum[1], D.M. Engle[2], and J.F. Stritzke[2]

1985 marked the first complete year of research at the Cross Timbers Experimental Range (CTER) southwest of Stillwater. This 1760 ac range area is the site of an ongoing cooperative research project involving animal and range scientists from the Animal Science and Agronomy Departments. Current research involves the study of brush management systems for the Cross Timbers resource area. Vegetation of the CTER was inventoried and described by Ewing et al. (1984). The area was then divided into twenty-two 80ac pastures; two of the pastures were designated as holding pastures while the other twenty pastures were divided into four groups of five pastures each. Within each group, a pasture was assigned to one of five brush treatments: 1) control- no treatment, 2) 2lb/ac tebuthiuron, 3) 2lb/ac tebuthiuron + annual spring burning, 4) 2lb/ac triclopyr, 5) 2lb/ac triclopyr + annual spring burning. Pastures are burned in late March-early April of each year. Herbicides were applied in spring and summer of 1983 while spring burning was initiated in 1985. In addition, grazing with stocker cattle began in 1985. The annual grazing season will begin in late April and extend to around the 1st of October. In 1985, 325 head of stockers were grazed on the area.

Range scientists began collecting data on vegetation and soil responses in 1983 while, as indicated earlier, 1985 was the first year for livestock response data. Data include: soil water relations, percent kill and resprouting of various woody plant species, herbage yield and species composition of range plants on prairie and savannah range sites, nutrient composition of important plant species, and botanical compostion of cattle diets. In addition, carrying capacity and cattle performance on the treated and untreated areas is being monitored. Data collection will continue for several years and will expand to include other measurements not listed above. Ultimately the study will provide valuable insight about basic aspects of range/livestock responses to brush management but will also yield information about the effective life of various treatments, livestock production during that period and the economic feasiblity of such treatments.

[1]Animal Science Department [2]Agronomy Department

SIMULATED SHORT DURATION GRAZING

F.T. McCollum[1] and R.L. Gillen[2]

Rotational grazing of rangelands is not a new idea. However, in recent years interest in intensive, short duration grazing has increased. Properly implemented, this method of grazing has the potential to increase the efficiency of range forage utilization and also improve the efficiency of livestock management and production.

In 1985, a study was initiated to compare the influence of six simulated short duration grazing programs on vegetation dynamics and cattle diets on tallgrass prairie in central Oklahoma. This is a cooperative effort involving members of the Agronomy and Animal Science Departments. The study involves 3 replications of 6 grazing treatments. The treatments are two stocking rates (1.3 and 1.8 times normal) combined with three grazing schedules (2, 3, or 4 rotation cycles during a 5 month grazing season). The pasture layout does not include 6 different grazing cells. Instead, each study pasture represents the fourth pasture in an 8-pasture rotation system. Cattle are grazed and removed from the study pastures in the same way they would enter and leave the pasture in a normal rotation. Each study pasture is grazed for 19 days during the summer. Two-cycle pastures are grazed 6 days initially, rested 63 days then grazed 13 days; 3-cycle pastures are grazed 4 days, rested 34 days, grazed 6 days, rested 51 days then grazed 9 days; 4-cycle pastures are grazed 3 days, rested 24 days, grazed 4 days, rested 31 days, grazed 5 days, rested 41 days then grazed 7 days. Diet samples are being collected throughout each of the grazing periods to determine the effects of length of period and stocking pressure on diet composition. Likewise, standing crop dynamics and defoliation patterns are being monitored as indicators of grazing impacts on the plant community.

It is not possible to develop a strict "recipe" for short duration grazing. However, the information from this study will provide some basis for developing and implementing these intensive grazing systems.

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[1]Animal Science Department [2]Agronomy Department

SPERM MORPHOLOGY AND TRANSPORT IN THE DAIRY COW AS RELATED TO FERTILIZATION

E.P. Aalseth[1], G.D. Adams[2], B.A. Lessley[3] and R. McNew[4]

Reducing average services per conception of dairy cows from 2.0 to 1.5 has been estimated to be worth 20 million dollars a year to U.S. dairymen. While 60% of cows conceive to a service under optimum conditions, about 13% experience fertilization failure. When fertilization failure occurs, inadequate sperm transport has been indicated by the absence of sperm in the zona pellucida of unfertilized oocytes and at the site of fertilization around the time of ovulation. Increasing sperm numbers in the oviduct increases fertilization rates of rabbits, sheep and pigs. Extending these concepts to reduce fertilization failure in cattle requires methods of studying sperm transport and knowledge of the transport mechanisms, especially in relation to artificial insemination.

Bulls that produce poor quality semen have lower conception rates due mostly to greater fertilization failure. Efforts to improve semen evaluation criteria and the functional quality of sperm inseminated can only enhance the reproductive efficiency of dairy cattle.

The objective of the first experiment is to characterize sperm distribution within and expulsion from the cow reproductive tract after artificial insemination. Dairy cows will be inseminated with 40×10^6 sperm and the discharged mucus and urine recovered for the next 12 hours. At the end of this period, the cow will be sacrificed and sperm remaining in the tract will be flushed from the vagina, cervix, uterus and oviducts. Relationships between sperm numbers discharged and in different tract regions will be examined.

The objective of the second experiment is to evaluate the effect of the smooth muscle stimulant, oxytocin, on sperm transport and expulsion from the cow reproductive tract. Oxytocin has been shown to improve fertility, potentially through improved sperm transport. Zero, 1, 4 or 16 iu of oxytocin will be given at the time of insemination. Sperm distribution will be determined as for experiment 1.

Experiment 3 is designed to evaluate methodology for inducing anterior acrosomal swelling on ejaculated bull sperm in relation to cryopreservation. This is a unique acrosomal change with undescribed significance to the fertility of bull sperm. It could be an undescribed form of deterioration or a beneficial change that would inhance the fertility of bull sperm. The experiment would determine if such altered sperm could occur due to mistakes at certain steps of commercial semen processing. It would also develop procedures by which sperm with swollen anterior acrosomes could be cryopreserved. Such a step is essential to conducting fertility trials which would describe the practical significance of this acrosomal change.

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ACKNOWLEDGEMENTS

Many companies, organizations and individuals have contributed money, materials and(or) services to aid Animal Science Research. These contributions were instrumental in furthering the programs of the department and are gratefully acknowledged. On campus, the cooperation of staff in other colleges and other departments in the College of Agriculture was important in the design and implementation of several projects.

Studies at the Southwestern Livestock and Forage Research Station at El Reno, Oklahoma, were conducted in cooperation with USDA-ARS Texas-Oklahoma Area. Several studies were part of regional research projects.

The following is a listing of those who contributed to the research program of the Animal Science Department during the preceding year.

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TANABE U.S.A., INC., San Diego, CA
W.D. SPEER, Tulsa, OK
WEST DESIGN CHEMICAL, INC., Fairway, KS

Supplied cattle for shipping fever research at Pawhuska, OK

Chuck Drummond, Pawhuska, OK
Bob Dean, Claremore, OK
Stuart Land & Cattle, Pawhuska, OK
Dick Surber, Pawhuska, OK
Butch Savage, Pawhuska, OK
Tom Hinchey, Guymon, OK
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P. Larry Claypool
Ronald W. McNew

TABLE OF EQUIVALENTS

U.S. Metric		Metric U.S.	
Length:			
1 inch	2.54 centimeters	1 millimeter	0.03937 inch
1 foot	30.48 centimeters	1 centimeter	0.3937 inch
	0.3048 meters	1 meter	39.37 inches
1 yard	0.9144 meters		3.281 feet
1 mile	1609.34 meters		1.094 yards
	1.609 kilometers	1 kilometer	0.6214 mile
Area:			
1 square inch	6.452 sq. centimeters	1 sq. centimeter	0.155 sq. inch
1 sq. foot	0.0929 sq. meter	1 sq. meter	1.196 sq. yards
1 sq. yard	0.8361 sq. meter		10.764 sq. feet
1 acre	0.4047 hectare	1 hectare	2.471 acres
1 sq. mile	259.0 hectares	1 sq. kilometer	0.386 sq. mile
			247.1 acres
Volume:			
1 cubic inch	16.387 cu. centimeter	1 cu. centimeter	0.061 cu. inch
1 cu. foot	0.0283 cu. meter	1 cu. meter	35.315 cu. feet
1 cu. yard	0.7646 cu. meter		1.308 cu. yards
1 fluid ounce	29.573 milliliters	1 milliliter	0.0338 ounce
1 pint	0.4732 liter	1 liter	33.81 ounces
1 quart	0.9463 liter		2.1134 pints
1 gallon	3.7853 liters		1.057 quarts
			0.2642 gallon
		1 kiloliter	264.18 gallons
Weight:			
1 ounce	28.50 grams	1 gram	0.03527 ounce
1 pound	453.592 grams	1 kilogram	35.274 ounces
	0.4536 kilogram		2.205 pounds
1 ton	907.2 kilograms	1 metric ton (1,000 kg)	2204.6 pounds